Petition to Amend 7 CFR §205.601 to Add Polyoxin D Zinc Salt as a Synthetic Substance Allowed for Use In Organic Crop Production
(May 31, 2016)

NON-CONFIDENTIAL

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GRAPES, BERRIES, AND SMALL FRUITS

LEAFY GREENS

POME FRUITS

POTATOES

STONE FRUITS

TOMATOES

PROPOSED LISTING UNDER 7 CFR §205.601

Kaken Pharmaceutical Co., Ltd. (Kaken) proposes:

- Inclusion of polyoxin D zinc salt in the list of synthetic substances allowed for use in organic crop production (7 CFR §205.601) for control of fungal plant diseases on growing crops; and
- Annotation to the listing in 7 CFR §205.601 to permit the use of polyoxin D zinc salt for post-harvest use.

Scope of the Proposed Listing

The petitioned substance is limited to polyoxin D zinc salt (CAS No. 146659-78-1). The petitioned substance does *not* include:

- Polyoxin complex which:
    - Contains *no* polyoxin D zinc salt; and
    - Is registered for use as a pesticide in selected countries outside the United States, especially Asia; and
- Other polyoxins (polyoxins A to C and polyoxins E to N).

Category for the Proposed Listing

The most applicable Organic Food Product Act category of exemption for prohibited substances in organic production and handling operations [7 U.S.C. § 6517(c)(1)(B)(i)] is "toxins derived from bacteria."

PROPOSED ORGANIC USES AND APPLICATION RATES

Pre-Harvest Use

Polyoxin D zinc salt is proposed for application to growing fruit and vegetable crops at up to and including:

- 0.72 ounces polyoxin D zinc salt per application; and
- 4.32 ounces polyoxin D zinc salt per season.

Post-Harvest Use

Polyoxin D zinc salt is also proposed for post-harvest uses on organic crops according to the directions of use on the Polyoxin D Zinc Salt 5SC Post-Harvest Fungicide label (EPA Reg. No. 68173-5). All of the inert ingredients in this formulation are allowed in formulations for organic use.

Currently, the registered uses are:

- Pome Fruits (all members of Crop Group 11) for control of Botrytis and Alternaria;
- Pomegranates for control of Botrytis; and
- Stone Fruits (all members of Crop Group 12) for control of Botrytis and suppression of Rhizoctonia and sour rot.

Label expansion is anticipated.

Currently, the post-harvest application methods include:

- In-line dip;
- Drench; and
- Aqueous spray.

Currently, the maximum registered post-harvest application rate is 0.88 oz polyoxin D zinc salt per 100 gallons treatment solution (16 fl oz 5SC formulation/100 gallons of treatment solution).

Confirmatory efficacy trials are planned for the 2016 use season.

Home and Garden Use

Novel 0.5%SC Fungicide (EPA Registration No. 70051-116) containing 0.5% polyoxin D zinc salt is registered by Certis USA, L.L.C. All of the inert ingredients in this formulation are allowed in formulations for organic use. Uses include:

- Vegetables, fruits, and nuts in home gardens;
- Flowers, foliage plants, shrubs, roses, and other ornamental plants (indoors and outdoors); and
- Turf grasses in residential lawns.

Novel 0.5%SC Fungicide is applied as a foliar spray or as a soil drench at a maximum of 2 teaspoons per quart.

HISTORY: PREVIOUS ACTIVITY AND PREVIOUSLY SUBMITTED DOCUMENTS

Polyoxin D zinc salt has been previously considered by the National Organic Program (NOP). Key dates and activities are summarized below.

Date	Activity
2012/01/25	Petition proposing use as a non-synthetic material for use in organic crop production was submitted by Kaken.
2012/03/04	Amended petition proposing use of polyoxin D zinc salt as a synthetic material for use in organic crop production was submitted by Kaken.
2012/12/23	Technical Evaluation Report was issued by the National Organic Program.
2013/01/23	Reply to the Technical Evaluation Report (page 5 revised) was submitted by Kaken
2013/01/29	Crops Subcommittee recommendation was issued.
2013/02/25	NOP letter advises Kaken of the April 9-11, 2013 public hearing.
2013/03/06	Kaken submitted written comments for the public hearing.
2013/03/19	Kaken submitted additional written comments for the public hearing.
2013/03/22	Non-target organism study reports were submitted by Kaken.
2013/04/04	Earthworm study report summary was submitted by Kaken.
2013/04/10	Public hearing.
2013/04/11	NOSB vote to: • Classify polyoxin D zinc salt as a synthetic material; and • Recommend denial for use in organic crop production.

This petition references the March 4, 2012 amended petition which is available on the Internet at:
https://www.ams.usda.gov/rules-regulations/organic/national-list/p
and the relevant link is identified as Polyoxin D Zinc Salt (PDF).

NOSB CROPS SUBCOMMITTEE'S 1/29/2013 EVALUATION AND KAKEN'S CURRENT REPLY

The January 29, 2013 Crops Subcommittee's Recommendation includes discussion of polyoxin D zinc salt regarding the NOSB evaluation criteria for substances added to the National List. They include:

- Category 1. Adverse impacts on humans and the environment criteria?
- Category 2. Is the substance essential for organic production?
- Category 3. Is the substance compatible with organic production practices?
- Category 4. Is the commercial supply of an agricultural substance as organic, fragile or potentially unavailable.

Page 2 and pages 11-12 of the January 29, 2013 Crops Subcommittee's Recommendation conclude:

- Category 1 was satisfied;
- Categories 2 and 3 were not satisfied; and
- Category 4 is not applicable.

The January 29, 2013 Crops Subcommittee's Recommendation includes a tabular summary of its analyses of Categories 2 and 3 and is provided below with notations to new data in this petition.

Please see:

- Attachment 1.a for Kaken's January 23, 2013 reply (page 5 revised);
- Attachment 1.b for Kaken's March 6, 2013 written comment for the public hearing;
- Attachment 1.c for Kaken's March 19, 2013 additional written comments for the public hearing;
- Attachment 1.d for non-target organism study reports submitted March 22, 2013; and
- Attachment 1.e for the earthworm study report summary submitted April 4, 2013.

Category 2. Is the substance essential for organic production?					Notes/Update
Question	Yes	No	N/A	Documentation	
1. Is the substance formulated or manufactured by a chemical process? [6502 (21)] 2. Is the substance formulated or manufactured by a process that chemically changes a substance extracted from naturally occurring plant, animal, or mineral, sources? [6502 (21)]	X	X		Included in a new document received on January 18, 2013 from the petitioner it states on page 5 section 1.1, that, polyoxin D is made from an aerobic fermentation process, thus a natural process. However, they do state that they do not know whether the zinc salt is from a mined or from a recycled zinc source. The TR states that the manufacturing process has at least one step that would be similar to other *Streptomyces* products that are classified as synthetic on section 205.601 of the National List: streptomycin and tetracycline (terramycin). Similarly, polyoxin D Zinc Salt may also be classified as a synthetic. TR lines 146-148. It would appear that polyoxin D may be non-synthetic, but it would be assumed that the zinc salt would be synthetic, due to the lack of being able to properly verify its source.	Kaken accepts the NOSB's classification of polyoxin D zinc salt as a synthetic substance. Kaken notes that polyoxin D(without the zinc) meets the NOP definition of non-synthetic. The simple chemical reaction to add the zinc to reduce the water solubility and thus provide longer time on the plant surface results in a synthetic classification. Polyoxin D zinc salt does not contain any metal of toxicological concern as an impurity.
3. Is the substance created by naturally occurring biological processes? [6502 (21)]		X		It is produced from a natural occurring soil microorganism *Streptomyces cacaoi* by a controlled fermentation process, according to the TR lines 119 – 120. (TR July 11, 2012) The petition states that polyoxin D Zinc Salt is isolated from a broth (extraction media) and then dried. Actual process is part of their CBI information. One part of the TR states that a review of all the structural forms of polyoxin does not include the Zinc Salt as a natural product (Worthington, 1988). TR lines 141-142. Also, refer to the answers as stated in Category 2, Question 1 & 2.	Kaken accepts the NOSB's classification of polyoxin D zinc salt as a synthetic substance. Kaken notes that polyoxin D(without the zinc) meets the NOP definition of non-synthetic. The simple chemical reaction to add the zinc to reduce the water solubility and thus provide longer time on the plant surface results in a synthetic classification. Polyoxin D zinc salt does not contain any metal of toxicological concern as an impurity.
4. Is there a natural source of the substance? [§205.600 b.1]		X	X		
5. Is there an organic substitute? [§205.600 b.1]			X		
6. Is the substance essential for handling of organically produced agricultural products? [§204.600 b.6]			X		

Category 2. Is the substance essential for organic production?					Notes/Update
Question	Yes	No	N/A	Documentation	
7. Is there a wholly natural substitute product? [§6517 c (1)(A)(ii)]	X	X		• There is a natural occurring quinone plumbagin, isolated as a botanical that is comparable to polyoxin D (Dekeyser and Downer 1994), but it is not commercially available in the US at this time.	Plumbagin is not currently registered as a pesticide. Polyoxin D zinc salt is ***not*** a miticide. The cited reference discusses miticides and does not appear to be relevant to polyoxin D zinc salt.
				• There are coppers and sulfur materials currently allowed for use. TR 321-328. (TR July 11, 2012)	Coppers and sulfur are allowed synthetic materials. (See 7 CFR §205.601.) Please see the value/efficacy data summaries (page 50-427) for information on non-synthetic and synthetic OMRI-listed alternative products.
8. Is the substance used in handling, not synthetic, but not organically produced?			X		
9. Are there any alternative substances? [§6518 m.6]	X			There are other alternative substances available. The TR lists several that are currently allowed: JMS Stylet Oil, Dow's M-Pede, Regalia, Sonata, and Kaligreen to name just a few. See TR July 12, 2012 table: Comparison of the Endorse WDG label with Alternative Pesticides, located between lines 355-356. The efficacy of each of these materials is not listed.	Please see the value/efficacy data summaries (page 50-427) for information on OMRI-listed non-synthetic and synthetic alternatives. Polyoxin D zinc salt formulations proposed for organic use are limited to EPA Reg. Nos. 68173-4 (pre-harvest use formulation; 5SC), 68173-5 (post-harvest use formulation; 5SC), and 70051-116 (home and garden formulation; 0.5SC). Endorse WDG is ***not*** proposed for organic use and is not eligible for organic use based upon the inert ingredients.
10. Is there another practice that would make the substance unnecessary? [§6518 m.6]	X	X		(TR lines 376-391) The TR lists several possible practices that could be used possibly in place of polyoxin D Zinc Salt. Antibiosis – using the live organisms rather than their extracts. This seems to be more consistent with organic farming principles. (Milner, et al. 1997) Also beneficial antagonistic *Streptomyces* spp – but commercial development is slow in coming. (Liu, et al., 1997) (TR July 11, 2012) Also, crop rotation, crop nutrient management practices, sanitation to remove disease vectors, selection of resistant species and varieties (where applicable) beneficial antagonistic bacteria, monitoring. TR 367-382	Please see the value/efficacy data summaries including the descriptions of cultural practices for mitigating disease (page 50-427). For many uses, cultural practices alone are not always sufficient to achieve disease control.
N/A: If a substance under review is for crops or livestock production, all of the questions from §205.600(b) are not applicable.					

Category 3. Is the substance compatible with organic production practices?					Notes/Update
Question	Yes	No	N/A	Documentation	
1. Is the substance compatible with organic handling [§205.600 b.2]			X		

2. Is the substance consistent with organic farming and handling? [§6517 c (1)(A)(iii); 6517 c (2)(A)(ii)]	X	X		• There are concerns with the possible impact on beneficial soil organisms.	Please see:
					• Attachment 1a, page 21-24 of 136;
					• Attachment 1b, page 15 of 40;
					• Attachment 1e for the earthworm study report summary;
					• Summaries of the following *new information*:
					  • Nitrogen fixation and carbon transformation in soil (page 37-39);
					  • Effects of soil fungi, including soil fungi (page 40-41); and
					  • A discussion of the environmental exposure to zinc (page 41-42).

				• Toxic to bees. (TR lines 305-309)	Please see: • Attachment 1a, page 25-26 of 136; • Attachment 1b, pages 4, 10, 26, and 27 of 40; • Attachment 1c, page 2; • Attachment 1d for reports regarding toxicity studies to green lacewing, marmalade hoverfly, silkworm, and wolf spider; • Attachment 4a, EPA's 5/11/2012 review, pages 3 and 14-15 of 21; and • Summary of *new data* on beneficial insects (honey bees, ladybird beetles, and *Apelinus mali* (page 43-48).
				• EPA exempts it from tolerance (40 CFR 180.1285). Also in a petition Addendum dated October 2, 2012 the EPA has granted the petitioner an expanded exemption of tolerance to "all food commodities" and given expanded uses for all food and feed crops pre-harvest and post-harvest.	
3. Is the substance compatible with a system of sustainable agriculture? [§6518 m.7]	X	X		No, because it is not a unnecessary synthetic input. Also, because it does show toxicity to fungi and bees. However, some felt it was a useful tool as part of a rotational disease control program.	Polyoxin D zinc salt is a reduced risk alternative to current OMRI-listed alternative products. It offers a unique, non-toxic mode of action that will be important for integrated pest management and resistance management programs. Efficacy data are provided. Treated crops may be exported to Canada and Mexico. Please see page 12-427. Please see item 2 above regarding beneficial soil fungi and honey bees.
4. Is the nutritional quality of the food maintained with the substance? [§205.600 b.3]			X		
5. Is the primary use as a preservative? [§205.600 b.4]			X		

Category 3. Is the substance compatible with organic production practices?					Notes/Update
Question	Yes	No	N/A	Documentation	
6. Is the primary use to recreate or improve flavors, colors, textures, or nutrient values lost in processing (except when required by law, e.g., vitamin D in milk)? [§205.600 b.4]			X		
7. Is the substance used in production, and does it contain an active synthetic ingredient in the following categories: a. copper and sulfur compounds;		X			
b. toxins derived from bacteria;	X			According to the TR (TR line 110) polyoxin D is a toxin derived from a bacteria (*Streptomyces cacaoi* var. asoensis) (TR July 11, 2012).	Kaken agrees that this is the most relevant category.
c. pheromones, soaps, horticultural oils, fish emulsions, treated seed, vitamins and minerals?		X			
d. livestock parasiticides and medicines?		X			
e. production aids including netting, tree wraps and seals, insect traps, sticky barriers, row covers, and equipment cleaners?		X			
N/A: If a substance under review is for crops or livestock production, all of the questions from §205.600(b) are not applicable.					

CLASSIFICATION AS A SYNTHETIC MATERIAL

Kaken accepts the National Organic Program's classification of polyoxin D zinc salt as a synthetic material.

Polyoxin D is produced via a fermentation process and meets the National Organic Program's definition of a non-synthetic material. Polyoxin D is very water soluble and would be readily washed off the surface of treated crops by rain water and supplemental irrigation water. Early "wash off" would reduce polyoxin D's control of fungal pathogens of crops. To reduce the water solubility, Kaken converts polyoxin D to polyoxin D zinc salt via a simple chemical reaction. This simple chemical reaction causes polyoxin D zinc salt to be a synthetic material as defined by the National Organic Program.

Kaken does not control the production of the zinc used in the conversion of polyoxin D to polyoxin zinc salt. Therefore, Kaken cannot confirm that the purchased zinc source is mined or recycled.

Kaken has quality control standards. Kaken has conducted analyses for metal impurities of toxicological concern, *e.g.*, lead, arsenic, and cadmium. The product specifications for all products containing polyoxin D zinc salt submitted to and approved by the US Environmental Protection Agency do *not* permit metal of toxicological concern as a listed impurity.

NEW IN THIS PETITION

Summaries of the following *new* data are included in this petition:

- Soil studies;
- Beneficial insect studies;
- Value data, use-by-use;
- Efficacy studies, use-by-use; and
- OMRI-listed alternative products (non-synthetic and synthetic), use-by-use.

In addition, this petition updates the previously submitted petition and expands upon previously submitted information:

- Regulatory status (updated);
- Mode of action data summary (expanded).

Also, this petition responds to comments made by members of the NOSB during the February 25, 2013 public hearing.

REQUEST FOR AN AMENDED TECHNICAL EVALUATION REPORT

Kaken requests an amended Technical Evaluation Report for consideration by the Crops Subcommittee and the entire National Organic Standards Board. An amended Technical Evaluation Report is appropriate for the following reasons:

1. New data and updated information are included with this petition.
2. Kaken Pharmaceutical Co., Ltd. (Kaken) provided detailed comments and further data to address statements included in the December 23, 2012 Technical Evaluation Report and the January 29, 2013 Crops Subcommittee recommendation. (Please see Attachment 1.) The Technical Evaluation Report and the Crops Subcommittee recommendation were not previously amended based upon consideration of Kaken's comments.

3. The December 23, 2012 Technical Evaluation Report included comments on substances *outside* the scope of the petition, *i.e.*:
   - Polyoxin Complex which:
     - Contains no polyoxin D and no polyoxin D zinc salt; and
     - Has significantly different pesticidal efficacy than polyoxin D zinc salt; and
   - Polyoxins other than polyoxin D.

UPDATES

Updates: US EPA Regulatory Approvals

Kaken is the owner of the EPA registration data for polyoxin D zinc salt and the worldwide exclusive producer of polyoxin D zinc and its agricultural formulations.

Polyoxin D zinc salt is used exclusively for fungal pest control on crops. US EPA first registration dates for Polyoxin D Zinc Salt Technical and its formulations and the associated registered uses are summarized below.

EPA First Reg. Date	EPA Reg. No.	EPA Primary Brand Name	EPA Registered Uses	Proposed for Organic Use?	Note
1997/08/20	68173-1	Polyoxin D Zinc Salt Technical	Manufacturing use.	Yes	
1997/08/20 2002/09/24	68173-2 66330-41	Endorse Wettable Powder Fungicide	Turf. Later expanded to include ornamentals.	No	
2005/10/27 2005/10/27	68173-3 66330-56	Endorse Water Dispersible Granules [1]	Turf, ornamentals. Later expanded to include selected fruit, tree nut, and vegetable crops. Later further expanded to include most fruit, tree nut and vegetable crops.	No	
2012/09/27	68173-4	Veggieturbo 5SC Suspension Concentrate Fungicide [2]	Pre-harvest agricultural use on most fruit and vegetable crops.	Yes	New
2014/03/05	70051-116	Novel 0.5%SC Fungicide	Residential use for food crops, turf, and ornamentals.	Yes	New
2014/12/11	68173-5	Polyoxin D Zinc Salt 5SC Post-Harvest Fungicide	Post-harvest use for selected fruit crops.	Yes	New

1. Supplemental distributor brand names include PH~D Fungicide.
2. Supplemental distributor brand names include Oso 5%SC Fungicide and Tavano 5%SC Fungicide.

Please see Attachment 2 for a copy of the current EPA registered labels.

Please note that the following EPA registered trade names were *not* included in the September 23, 2012 Technical Evaluation Report:

- Veggieturbo 5SC Suspension Concentrate Fungicide (EPA Reg. No. 68173-4);
- Oso 5%SC Fungicide (EPA Reg. No. 68173-4-70051);
- Tavano 5%SC Fungicide (EPA Reg. No. 68173-4-70051);
- Polyoxin D Zinc Salt Post-Harvest Fungicide (EPA Reg. No. 68173-5); and
- Novel 0.5%SC Fungicide (EPA Reg. No. 70051-116).

Please also note the primary brand names and registration numbers for the formulations planned for submission to OMRI following an affirmative decision by the National Organic Program are limited to:

- EPA Reg. No. 68173-4: Veggieturbo 5SC Suspension Concentrate Fungicide;
- EPA Reg. No. 68173-5: Polyoxin D Zinc Salt 5SC Post-Harvest Fungicide; and
- EPA Reg. No. 70051-116: Novel 0.5%SC Fungicide.

All of the inert ingredients in these formulations are permitted in organic pesticide products.

Please see Attachment 3 for a copy of the proposed amended label for Veggieturbo 5SC Suspension Concentrate Fungicide which includes proposed new disease claims. No data are required to be submitted ro EPA to support this proposed label amendment. (Supporting efficacy data are included in this petition.) Kaken anticipates EPA acceptance of the proposed amended label by approximately August 17, 2016.

EPA has published in the Federal Register the following tolerance exemption final rules regarding residues of polyoxin D zinc salt (40 CFR §180.1285):

Date	EPA Tolerance Exemption for Polyoxin D Zinc Salt
2008/11/19	"An exemption from the requirement of a tolerance is established for the residues of the biochemical pesticide polyoxin D zinc when used as a fungicide on almonds, cucurbit vegetables, fruiting vegetables, ginseng, grapes, pistachios, pome fruits, potatoes and strawberries."
2012/09/12	"An exemption from the requirement of a tolerance is established for the residues of polyoxin D zinc salt in or on all food commodities when applied as a fungicide and used in accordance with good agricultural practices."

Update: International Regulatory Status

Kaken is actively supporting expanded international use and international MRLs for polyoxin D zinc salt.

County	Status
Japan Taiwan	Registered for use on selected food crops.
Mexico	Registered for use on selected food crops. MRL exemption for all crops (pre-harvest and post-harvest).
Canada	Import MRL application pending for all crops (pre-harvest and post-harvest) is pending. PMRA's decision is anticipated during August 2016.
	Applications for use on selected crops, turf and ornamentals is pending. PMRA's decision is anticipated by late May 2017.
Korea	Registered. Import MRL application is pending. Decision is anticipated by December 2016.
New Zealand	Registration for use on selected food crops is pending. Import MRL application is pending.
Chile India	Applications for use on selected food crops are in preparation. Submission during 2016 is anticipated.
European Union	Import MRL application is in preparation.

Update: Current International Uses and Maximum Residue Limits (MRLs)

Internationally Registered Uses of Polyoxin D Zinc Salt and Associated MRLs							
Country	Brand Name	Use	Max. Apps/ Season	Max. Rate/ App (g AI/ha)	Max. Rate/ Season (g AI/ha)	PHI (Days)	MRL (ppm)
Japan	Polyoxin Z (WDG)	Cabbage	3	150	450	14	0.1 (Note 1)
		Cucumber	3	150	450	1	
		Lettuce	3	150	450	14	
		Green onion/ *Allium fistulosum*	3	150	450	14	0.2 (Note 1)
Korea	Yougil BIO (WP)	Apple	5	90	450	21	Note 2
		Cucumber	3	90	270	3	
		Ginseng	2	225	450	45	
		Gromwell *	5	45	225	21	
		Melon	5	90	450	7	
		Onion, Welsh	4	45	180	7	
		Persimmon	5	90	450	14	
		Raspberry	3	90	270	3	
		Rice	3	34	102	30	
		Watermelon	5	90	450	7	
	Pururun (WDG)	Apple	5	200	1,000	14	
		Cucumber	3	100	300	2	
		Watermelon	4	100	400	7	
		Black raspberry	3	200	600	14	
Taiwan	Polika (WP)	Asparagus	NS	68	NS	NS	Exempt A
		Rice	NS	28	NS	NS	
	Suwon (WDG)	Melon	NS	57	NS	NS	
Mexico	Endorse WDG	Blackberry	Note 3	90	NS	0	Exempt B
		Blueberry	Note 3	90	NS	0	
		Cassis	Note 3	90	NS	0	
		Eggplant	Note 3	169	NS	0	
		Pepper	Note 3	169	NS	0	
		Pepper, hot	Note 4	169	NS	0	
		Raspberry	Note 3	90	NS	0	
		Strawberry	Note 4	90	NS	0	
		Tomato	Note 4	169	NS	0	
New Zealand	Esteem (5SC)	Apple	6	100	600	0	Exempt C
		Grape	6	100	600	0	

AI = Active ingredient = Polyoxin D Zinc Salt.
NA = Not applicable.
NS = Not Specified.
* = Gromwell is used in Chinese medicine and is similar to Ginseng.
Note 1: Provisional MRL based upon potency (w/w).
Note 2: Korea: No current MRL for any crop treated with polyoxin D zinc salt or polyoxin complex.
Note 3: Minimum 7-day retreatment interval.
Note 4: Minimum 6-day retreatment interval.
Exempt A: Taiwan: Law does not require an MRL for polyoxin D zinc salt, though MRLs are generally required for pesticide residues.
Exempt B: Mexico: Mexico refers to EPA's regulatory decisions (tolerance exemption for all foods for polyoxin D zinc salt) regarding foods coming from the US.
Exempt C: New Zealand: New Zealand EPA has made a decision that no acceptable daily exposure (ADE) limits are required to be set because risks to human health are negligible. New Zealand ACVM decision on the establishment of a tolerance exemption is anticipated to be made by September 2016.

Update: Status in Organic Agriculture

Worldwide, polyoxin D zinc salt has *no* history of use in organic agriculture.

COMBINATIONS OF THE SUBSTANCE

Inert Ingredients

All of the inert ingredients in the following formulations:

- Veggieturbo 5SC Suspension Concentrate Fungicide (EPA Reg. No. 68173-4);
- Polyoxin D Zinc Salt 5SC Post-Harvest Fungicide (EPA Reg. No. 68173-5); and
- Novel 0.5%SC Fungicide (EPA Reg. No. 70051-116)

are on EPA Inert Ingredient List 4a or 4b (inerts of minimal concern) and therefore meet the requirements of 7 CFR §205.601(m). Assuming a favorable decision regarding this petition, OMRI applications are anticipated for these formulations.

The following formulations contain at least one inert ingredient *not* permitted in organic formulations and are *not* proposed for use in organic agriculture:

- Endorse Wettable Powder Fungicide (EPA Reg. Nos. 68173-2 and 66330-41);
- Endorse Water Dispersible Granules (EPA Reg. Nos. 68173-3 and 66330-56).
-

Tank Mixes

Veggieturbo 5SC Suspension Concentrate Fungicide may be applied with adjuvants. Examples of adjuvants used in recently conducted efficacy studies include Kinetic, R-56, and SB 56.

Veggieturbo 5SC Suspension Concentrate Fungicide may be tank-mixed with fertilizers and with other pesticide products, including OMRI-listed pesticide products. Kaken is not aware of any potential tank-mix partners with which Veggieturbo 5SC Suspension Concentrate Fungicide is not compatible. Nonetheless, users should test for compatibility before preparing tank mixes.

MODE OF ACTION

Specificity

Polyoxins are a group of structurally similar compounds with marked differences in their activities toward various fungi that are pathogenic to crops.

Test Organism	Disease	Minimum Inhibitory Concentration (µg/mL) of Polyoxins [Ref: Misato (1967)]								
		A	B	C	D	E	F	G	H	I
Pellicularia sasakii	Collar rot, Root rot, Damping off, Wire stem	12.5	1.56	>100	<1.56	1.56	50	1.56	50	>100
Piricularia oryzae	Rice sheath blight	3.12	6.25	>100	3.12	12.5	25	6.25	3.12	>100
Cochliobolus miyabeanus	Brown leaf spot of rice	3.12	3.12	>100	6.25	12.5	6.25	3.12	25	>100
Alternaria kikuchiana	Japanese pear black spot	50	12.5	>100	50	50	>100	6.25	12.5	>100
Physalospora laricina	Shoot blight of trees	25	3.12	>100	100	50	>100	6.25	12.5	>100
Cladosporium fulvum	Leaf mold of tomato	3.12	1.56	>100	100	25	25	3.12	6.25	>100
Glomerella cingulata	Glomerella leaf spot and bitter rot of apples	>100	>100	>100	>100	>100	>100	>100	>100	>100
Fusarium oxysporum	Fusarium wilt	>100	>100	>100	>100	>100	>100	>100	>100	>100

Based upon the above data:

1. Polyoxin D is most effective against *Pellicularia sasakii* (MIC <1.56 µg/L) and *Piricularia oryzae* (MIC = 3.12 µg/L).
2. Polyoxin D is *not* effective against *Glomerella cingulata* and *Fusarium oxysporum* (MIC > 100 µg/L).
3. There are clear differences in the sensitivity of fungal plant pathogens to different polyoxins. For example, *Physalospora laricina* and *Cladosporium fulvum* have:
   - Relatively high sensitivity to polyoxins A, B, G, and H; and
   - Relatively low sensitivity to polyoxin D.
4. Polyoxin C and polyoxin I are *not* effective against any of the tested pathogens.

Base upon unpublished data by Takahashi (1972), a mixture of polyoxin D, E and F containing 80% polyoxin D did not inhibit the growth of any of the tested bacterial pathogens or yeast pathogens at doses at 100 µg/mL.

Pathogen Type		Pathogen	Minimum Inhibitory Concentration (µg/mL)
Bacteria	Gram positive	*Bacillus subtilis* PCI-219	>100
		Staphylococcus aureas FDA-209P	>100
		Staphylococcus aureas HEATLEY	>100
		Mycobacterium phlei CCM-1889	>100
		Micrococcus flavus	>100
		Sarcina lutea	>100
		Erwinia aroideae	>100
	Gram negative	*Escherichia coli* NIHJ	>100
		Pseudomonas fluorscens NRRL-B-10	>100
		Klebsiella pneumoniae PCI-602	>100
		Xanthomonas citri	>100
Yeast		*Candida albicans* IPCR	>100
		Candida steratoides	>100
		Endomyces magnusii	>100
		Saccharomyces sp.	>100
Source: Minimum Inhibitory Concentrations (MIC) of Polyoxins Against Bacteria, Yeast and Fungi (MRID No. 43261802).			

During 2005, Kaken conducted an additional inhibitory concentration study in bacteria using polyoxin D (94.6% purity, by HPLC). For all tested bacteria:

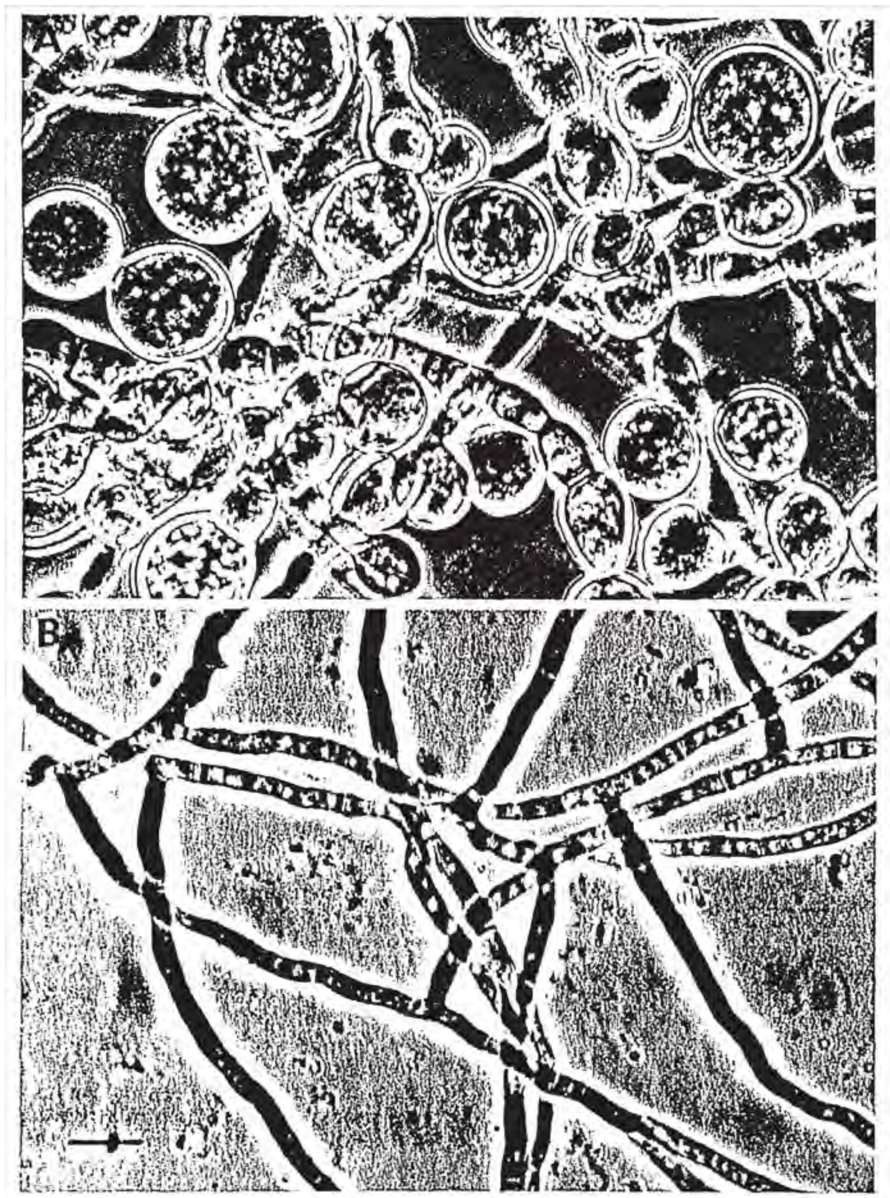
- No growth inhibition was observed, and
- The minimum inhibitory concentration was determined to be greater than 400 µg/mL.

It was concluded that polyoxin D is <u>*inactive*</u> in bacteria.

Bacterium Type	Bacterium Name	Minimum Inhibitory Concentration (µg/mL)
Aerobic bacteria	*Staphylococcus* ~ureus ATCC25923	>400
	Enterococcus faecalis ATCC 19433	>400
	Streptococcus pneumonia ATCC49619	>400
	Bacoilus subtilis ATCC6633	>400
	Escherichia coli ATCC25922	>400
	Enterobacter aeroganes ATCC13048	>400
	Serratia marcescens ATCC 13880	>400
	Salmonella chileraesuis serotype Enteritidis *(Salmonella enteritidis)* ATCC13076	>400
	Vibrio parahaemolyticus ATCC 17802	>400
	Pseudomonas aeruginosa ATCC27853	>400
Anaerobic bacteria	*Clostridium perfrigens* 110520	>400
	Lactobacillus acidophilus ATCC4356	>400
	Bacteroides fragilis ATCC25285	>400
Acid-fast bacteria	*Mycobacterium avium* ATCC25291	>400
Source: Minimum Inhibitory Concentration (MIC) of Polyoxin D Against Various Bacteria (MRID No. 48653308).		

Morphological Impacts of Polyoxin D on Sensitive Fungi

Cochliobolus miyabeanus grown in the presence and absence of polyoxin D have very different appearances under a microscope. In the presence of polyoxin D (top photo below), protoplast-like structures are observed. In the absence of polyoxin D (bottom photo below), the mycelia are thread-like. (Endo *et al.* 1970.)



Polyoxin D Inhibition of Cell Wall Biosynthesis

Sasaki *et al.* (1968) determined that polyoxin D inhibits the incorporation of ^{14}C-glucosamine in *Cochliobolus miyabeanus*. Ninety percent inhibition was observed at 5 µg polyoxin D/mL. Glucosamine is a precursor to chitin synthesis, and chitin is a main component of the cell wall of a group of fungi. Therefore, the data strongly suggested that polyoxin D inhibits cell wall synthesis.

Endo and Misato (1969) demonstrated that in *Neurospora crassa*:

1. Polyoxin D *selectively inhibits* the synthesis of chitin at levels that are comparable with those required for antifungal activity; and
2. The primary effect of polyoxin D is the *competitive inhibition* of chitin synthetase.

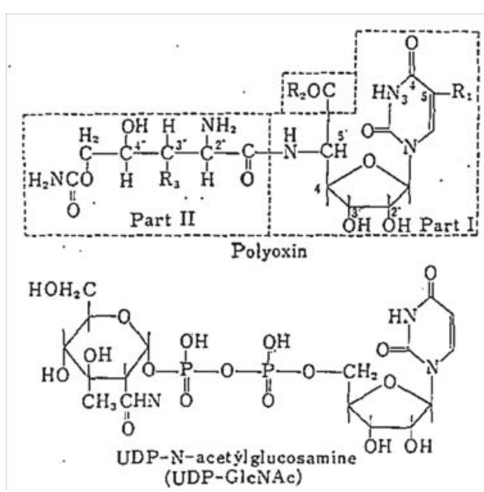
In addition, they noted that glucosamine must be converted to uridine diphosphate-N-acetylglucosamine (abbreviated UDP-GlcNAc in the literature) before it can be converted to chitin.

Endo *et al.* (1970) demonstrated that in *Neurospora crassa*:

1. Polyoxin D strongly inhibits chitin synthetase (UDP-N-acetylglucosamine: chitin N-acetylglucosamine transferase, EC 2.4.1.16) in cell-free experiments; and
2. The inhibition of polyoxin D is:
   a. Due to competitive inhibition with respect to uridine diphosphate-N-acetylglucosamine; and
   b. Specific to chitin synthetase.

Also, they noted that the formation of osmotically sensitive, protoplast-like structures of *Cochliobolus miyabeanus* grown in the presence of polyoxin D (see photo, above) suggests that the primary site of action of polyoxin D is in the formation of cell wall structures.

Hori *et al.* (1971) evaluated chitin synthetase inhibition in *Piricularia oryzae* and *Neurospora crassa* as a function of the chemical structure of polyoxins.



Based upon kinetic evaluations, Hori *et al.* (1971) determined that:

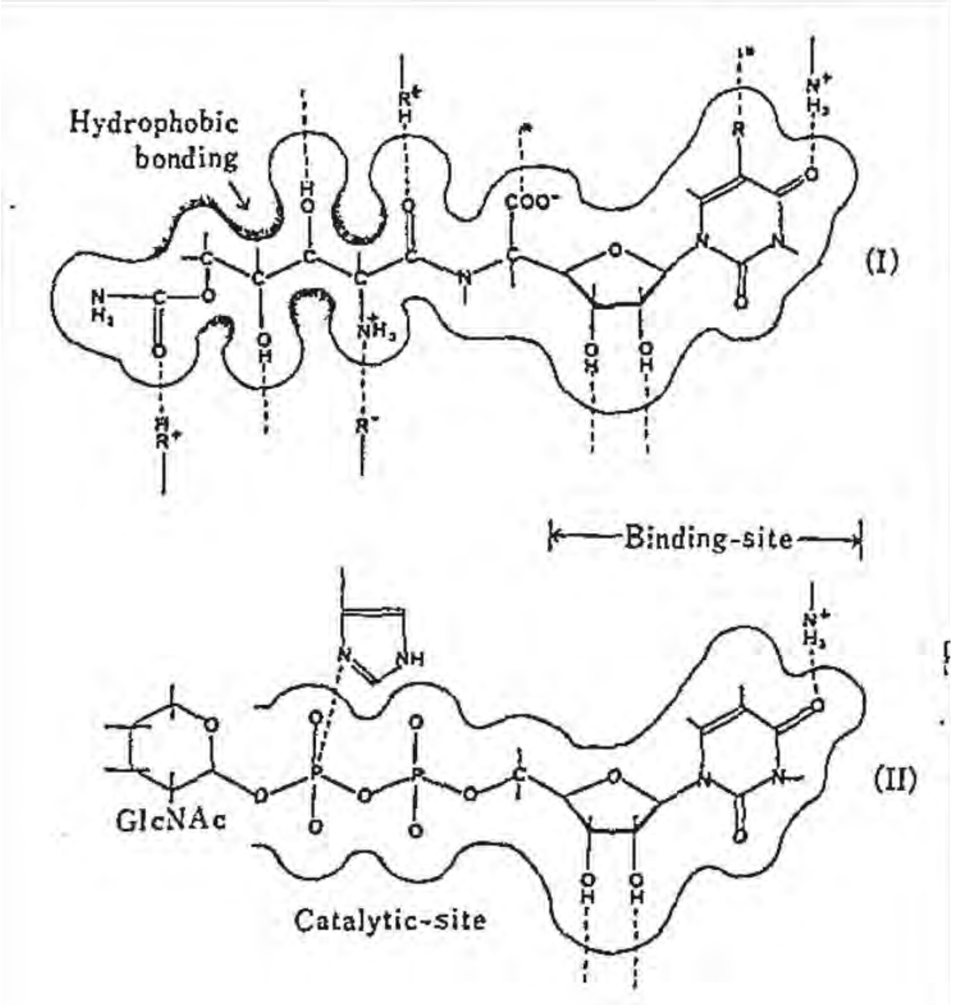
1. The inhibition of chitin synthetase by polyoxins is presumably due to the competition at the binding site of the chitin synthetase molecule between Part I of the polyoxin structure (see figure above) and the structurally similar nucleoside moiety of uridine diphosphate-N-acetylglucosamine;
2. Part I, $R_{1,}$ and R_2 of the polyoxin structure (see figure above) may markedly enhance the binding of Part I of the polyoxin structure to the chitin synthetase binding site, though it is unclear if Part I, $R_{1,}$ and R_2 of the polyoxin structure attach to the chitin synthetase binding site; and
3. For fungi with naturally higher concentrations of uridine diphosphate-N-acetylglucosamine, the competition between polyoxin D and uridine diphosphate-N-acetylglucosamine for the binding site of the chitin synthetase molecule favors uridine diphosphate-N-acetylglucosamine, presumably explaining while some fungi are sensitive to polyoxin D and others are not.

Hori *et al.* (1974a) evaluated the pH dependence of the inhibitory effects of polyoxins on chitin synthetase. They determined:

1. The ionized amino group at the C-2" position plays a very important role in the binding of polyoxins to chitin synthetase;
2. The carbonyl oxygen atoms at C-1" and of the carbamoyloxy group probably participated in the hydrogen bond formation with the enzyme; and
3. The interaction between the carboxyl group at C-5' and the enzyme was largely independent of pH.

These results suggested that a non-ionized imidazole group (pKa = 6.3) and an ionized amino group (pKa = 7.7) of chitin synthetase are involved in the enzyme reaction.

The proposed mechanism of interaction between polyoxin (top structure in the figure below) or uridine diphosphate-N-acetylglucosamine (bottom structure in the figure below) and the active center of chitin synthetase is summarized in the figure below.



Hori *et al.* (1974b) conducted further kinetic investigations that suggest that:

1. There is a specific binding site on the chitin synthetase molecule that corresponds to the uridine moiety of uridine diphosphate-N-acetylglucosamine; and
2. The pyrimidine nucleoside of polyoxin is also bound at the same specific binding site on the chitin synthetase molecule.

Teraoka *et al.* (1988) conducted research that supports the postulated competitive inhibition of chitin synthetase as the mode of action of polyoxin D.

<u>Fungicide Resistance Action Committee (FRAC) Code</u>

Polyoxin D zinc salt has been assigned Code 19 by the Fungicide Resistance Action Committee. No other pesticide active ingredient registered for use in North America has the same FRAC Code (mode of action).

Conclusion

Polyoxin D zinc salt has a NON-TOXIC MODE OF ACTION. *Polyoxin D zinc salt does not kill target fungal plant pathogens. Instead, polyoxin D zinc salt stops the growth of sensitive fungal plant pathogens*.

Uridine diphosphate-N-acetylglucosamine binds with fungal chitin synthetase in the normal biosynthesis of chitin in fungi. In susceptible fungi, polyoxin D competes with uridine diphosphate-N-acetylglucosamine for the chitin synthetase binding sites, resulting in insufficient chitin for normal cell wall growth and loss of pathogenicity.

Bacteria contain no chitin. The above mode of action of polyoxin D is consistent with the observed absence of activity of polyoxin D in bacteria.

Yeasts contain chitin. Nonetheless, there has been no observed activity of polyoxin D against pathogenic yeast. Based upon the above summarized data, possibly this results from naturally high levels of uridine diphosphate-N-acetylglucosamine in yeast that favor uridine diphosphate-N-acetylglucosamine rather than polyoxin D in the competition for chitin synthetase binding sites. Alternatively, the shape of the chitin synthetase binding site in yeast may be slightly different than in susceptible fungi, resulting in polyoxin D having low binding affinity for the chitin synthetase binding site in yeast.

Polyoxin D zinc salt's combined features of a nontoxic mode of action and a unique mode of action make polyoxin D zinc salt an important tool for growers for:

- *Integrated pest management (IPM); and*
- *Resistance management.*

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Sasaki, S., *et al.* (1968).
Studies on Polyoxin Action Part I: Effect on Respiration and Synthesis of Protein, Nucleic Acids and Cell-Wall of Fungi. *Nippon Nogeikagaku Kaishi*, Vol. 42, No. 10, pp. 633-638.

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Teraoka, T., *et al.* (1988).
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NOT AN ANTIBIOTIC

Minimum Inhibitory Concentration Data

Kaken has conducted and submitted to EPA two Maximum Inhibitory Concentration (MIC) studies of polyoxin D zinc salt.

- Minimum Inhibitory Concentrations (MIC) of Polyoxins Against Bacteria, Yeast and Fungi (MRID No. 43261802); and
- Minimum Inhibitory Concentration (MIC) of Polyoxin D Against Various Bacteria (MRID No. 48653308).

The data are summarized above in this petition. For completeness, they are also provided again below.

Base upon unpublished data by Takahashi (1972), a mixture of polyoxin D, E and F containing 80% polyoxin D did not inhibit the growth of any of the tested bacterial pathogens or yeast pathogens at doses at 100 μg/mL.

Pathogen Type		Pathogen	Minimum Inhibitory Concentration (μg/mL)
Bacteria	Gram positive	*Bacillus subtilis* PCI-219	>100
		Staphylococcus aureas FDA-209P	>100
		Staphylococcus aureas HEATLEY	>100
		Mycobacterium phlei CCM-1889	>100
		Micrococcus flavus	>100
		Sarcina lutea	>100
		Erwinia aroideae	>100
	Gram negative	*Escherichia coli* NIHJ	>100
		Pseudomonas fluorscens NRRL-B-10	>100
		Klebsiella pneumoniae PCI-602	>100
		Xanthomonas citri	>100
Yeast		*Candida albicans* IPCR	>100
		Candida steratoides	>100
		Endomyces magnusii	>100
		Saccharomyces sp.	>100
Source: Minimum Inhibitory Concentrations (MIC) of Polyoxins Against Bacteria, Yeast and Fungi (MRID No. 43261802).			

During 2005, Kaken conducted an additional inhibitory concentration study in bacteria using polyoxin D (94.6% purity, by HPLC). For all tested bacteria, no growth inhibition was observed, and the minimum inhibitory concentration was determined to be greater than 400 μg/mL. It was concluded that polyoxin D is ***inactive*** in bacteria.

Bacterium Type	Bacterium Name	Minimum Inhibitory Concentration (µg/mL)
Aerobic bacteria	*Staphylococcus* ~ureus ATCC25923	>400
	Enterococcus faecalis ATCC 19433	>400
	Streptococcus pneumonia ATCC49619	>400
	Bacoilus subtilis ATCC6633	>400
	Escherichia coli ATCC25922	>400
	Enterobacter aeroganes ATCC13048	>400
	Serratia marcescens ATCC 13880	>400
	Salmonella chileraesuis serotype Enteritidis *(Salmonella enteritidis)* ATCC13076	>400
	Vibrio parahaemolyticus ATCC 17802	>400
	Pseudomonas aeruginosa ATCC27853	>400
Anaerobic bacteria	*Clostridium perfrigens* 110520	>400
	Lactobacillus acidophilus ATCC4356	>400
	Bacteroides fragilis ATCC25285	>400
Acid-fast bacteria	*Mycobacterium avium* ATCC25291	>400
Source: Minimum Inhibitory Concentration (MIC) of Polyoxin D Against Various Bacteria (MRID No. 48653308).		

If polyoxin D were effective as an antibiotic, polyoxin D would demonstrate inhibition of human and animal pathogens at concentrations of 100 µg/mL and certainly at concentrations of 400 µg/mL. *However, no inhibition of human and animal pathogens was observed. Therefore, polyoxin D zinc salt is NOT even a CANDIDATE for development as an antibiotic.*

EPA's Review of the Minimum Inhibitory Concentration Data

Pages 4-5 the May 11, 2012 EPA science review (see Attachment 4a) states:

> *"The mode of action of Polyoxin D and its zinc salt is the inhibition of chitin synthesis in the cell walls of fungi, some of which are pathogenic to plants. Polyoxin D and its zinc salt do not inhibit the synthesis of chitin in animals that contain chitin, and it does not affect mammals because mammalian cells have plasma membranes that do not contain chitin. Polyoxin D Zinc Salt is used exclusively on plants as an anti-fungal agent in the United States and elsewhere. It is not effective as an antibacterial agent, and it has never been used as an antibiotic in human or veterinary medicine. The data reported on minimum inhibitory concentrations in numerous species of bacteria, yeast, and fungi demonstrated no effectiveness in inhibiting bacteria and yeast, but in the 14 fungal species tested, effectiveness of inhibition ranged from highly effective to ineffective."*

> *"In tests on 14 bacterial species (10 aerobic, 3 anaerobic, and 1 acid-fast), there was no demonstrated inhibition of bacterial growth in agar at concentrations up to 400 µg/mL (MRID 48653308). The species tested included pathogenic, intestinal, and other general bacteria that exist widely in nature. As expected, because bacteria contain no chitin, polyoxin D appears to have no effect on bacterial growth."*

NOP December 23, 2012 Technical Evaluation Report

Polyoxin D was discovered at a time when there was considerable research interest in antibiotics. The published literature includes many statements that polyoxin D zinc salt is an antibiotic or a possible antibiotic. However:

- A *hypothesis* that polyoxin D or polyoxin D zinc salt *might* be effective as a antibiotic does *not* cause polyoxin D or polyoxin D zinc salt to be an antibiotic.

- There is *no evidence* that demonstrates that polyoxin D or polyoxin D zinc salt has efficacy as an antibiotic for control of human or veterinary pathogens in humans, livestock, or companion animals.

- There are maximum inhibitory concentration data that demonstrate the polyoxin D is not even a candidate for development as an antibiotic.

- *If polyoxin D or polyoxin D zinc salt were an antibiotic, there would be clinical trials in laboratory animals trials and possibly humans demonstrating efficacy as an antibiotic. No such clinical trials exist.*

- Worldwide, polyoxin D zinc salt is produced exclusively by Kaken Pharmaceutical Co., Ltd.
  - Kaken has evaluated polyoxin D for possible use as an antibiotic and determined that is not effective as an antibiotic.
  - Kaken's primary business in pharmaceuticals. Kaken knows how to bring pharmaceuticals to the market place. Nonetheless, polyoxin D and polyoxin D zinc salt have *never* been marketed as a pharmaceutical (antibiotic) for human or veterinary medicine.
  - The inclusion of "Pharmaceutical" in "Kaken Pharmaceutical Co., Ltd." does not cause all products produced by Kaken to be pharmaceuticals or antibiotics.
  - Kaken's technical expertise is in fermentation technology. Polyoxin D is produced via a fermentation process and then converted to polyoxin D zinc salt via a simple chemical reaction.
  - Polyoxin D zinc salt is a member of Kaken's agrochemicals product line. For over 40 years, polyoxin D zinc salt has been marketed *exclusively* for control or suppression of fungal *crop* pathogens.

EFFECTS ON HUMAN HEALTH

Acute and Chronic Effects

The absence of human health effects is succinctly stated by EPA on page 56131 of the September 12, 2012 Federal Register. (See Attachment 4b.) The final rule regarding the significantly expanded tolerance exemption for polyoxin D zinc salt states:

> *"Dietary risks to humans are considered negligible based on the lack of dietary toxicological endpoints for polyoxin D zinc salt and its non-toxic mode of action as a fungi-specific chitin synthetase inhibitor that passes through mammalian digestive systems. <u>No significant acute, subchronic, mutagenic, immunotoxic, developmental, or chronic dietary toxicity hazards were identified</u> in the studies submitted to support this expansion of the tolerance exemption or the previous tolerance exemption (73 FR 69562). Based on polyoxin D zinc salt's lack of dietary toxicity hazards for mammals, no aggregate dietary exposure concerns are expected."* (Emphasis added.)

This means that polyoxin D zinc salt has a very high level of safety for humans and other mammals. Also, the scope of the toxicology data submitted to EPA exceeds that of most active ingredients registered by the US EPA's Biopesticides and Pollution Prevention Division (BPPD). The extensive toxicology data for polyoxin D zinc salt provides a very strong demonstration of polyoxin D zinc salt's very low mammalian toxicity.

Dermal Sensitization

Dermal sensitization tests are standard tests required for EPA registration of pesticides under Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). The results of dermal sensitization tests are:

- Yes/No in character (is a dermal sensitizer vs. not a dermal sensitizer);
- Unlike other toxicology studies because they are not expressed based upon a dose;
- Not used in human risk assessments (due to the yes/no character of the results); and
- Reflected in the Hazards to Humans and Domestic Animals section of FIFRA regulated labels.

The observations in the dermal sensitization study for the polyoxin D zinc salt 5SC formulation (MRID No. 48781110) were rated according to the following criteria:

Erythema	Score
No reaction	0
Very faint, usually nonconfluent	0.5
Faint, usually confluent	1
Moderate	2
Strong, with or without edema	3

The mean score for the polyoxin D zinc salt 5SC formulation was <u>*only 0.4*</u>. Using the Yes/No nature of dermal sensitization studies, the polyoxin D zinc salt 5SC formulation was determined to be a mild dermal sensitizer in Guinea pigs.

Based upon the above data, the EPA registered label for VEGGIETURBO 5SC Suspension Concentrate Fungicide (EPA Reg. No. 68173-4) states:

> "Prolonged or frequently repeated skin contact may cause allergic reactions in some individuals."

DEGRADATION AND HALF-LIVES

The September 23, 2012 Technical Evaluation Report includes:

> *"Data reviewed by EPA indicated that polyoxin D Zinc Salt biodegrades within 2-3 days of application, with a low toxicity profile [73 FR 69559]."*

During the April 10, 2013 public hearing, a member of the NOSB expressed concern regarding the 2.3 day aqueous photolysis half-life of polyoxin D zinc salt. To a NOSB member, this appeared to be a long time.

The degradation data for polyoxin D were summarized in the original 2012 NOP petition and are provided below.

Degradation Route	Half-life (days)	pH	Conditions
Hydrolysis	32.5	7.0	Neutral, 25°C
	9.1	9.0	Basic, 25°C
Aqueous photolysis	4.0	5.0	Acidic, Sterile
	2.3	7.0	Neutral, Sterile
	1.3	9.0	Basic, Sterile
Aerobic soil metabolism	15.9		Microbially active
	59.2		Sterile

Kaken has no new degradation data. However, background information regarding degradation data may be helpful. A half-life is the length of time needed for the subject material to decrease by half (50%) under the specified conditions.

For polyoxin D, the aqueous photolysis half-life under neutral (pH 7.0) sterile conditions is 2.3 days. As an example, assume the initial quantity of polyoxin D zinc salt is 100 units (100%). By day 16, less than 1 unit (less than 1%) of the initial quantity of pesticide would remain. Please see the table below for the calculation of the quantity remaining.

Time (Days)	Quantity Remaining (%)
0	100
2.3	50
4.6	25
6.9	12.5
9.2	6.25
11.5	3.125
13.8	1.5625
16.1	0.78125

In the environment, degradation is generally occurring simultaneously via multiple routes. The fastest degradation route will "drive" the total time needed for degradation under actual environmental conditions.

Pesticide users want the applied pesticide to be present:

- Long enough to do its job *without* needing to make another application; but
- Short enough that the product does *not* accumulate in the environment.

Many pesticide users may consider the environmental degradation properties of polyoxin D zinc salt to be optimal.

EFFECTS ON SOIL

Polyoxin D Zinc Salt 5SC Fungicide has no adverse effects on soil when used according to the directions for use.

Nitrogen Fixation and Carbon Transformation in Soil

Kaken conducted the following study to support international registrations of Polyoxin D Zinc Salt 5SC Fungicide:

> Lennart Schulz
> Effects of VEGGIETURBO 5 SC Suspension Concentrate Fungicide on the Activity of Soil Microflora (Nitrogen and Carbon Transformation Test)
> BioChem Agrar
> November 11, 2014

No adverse effects were observed on nitrogen fixation in soil (measured as NO_3-N production) and carbon transformation in soil (measured as O_2 consumption). A copy of the study summary is provided below.

Study title:	Effects of VEGGIETURBO 5 SC Suspension Concentrate Fungicide on the Activity of Soil Microflora (Nitrogen and Carbon Transformation Tests)	
Guidelines:	OECD 216 (2000); OECD 217 (2000)	
BioChem Project No.:	14 10 48 074 C/N	
Test item:	VEGGIETURBO 5 SC Suspension Concentrate Fungicide (VEGGIETURBO 5 SC)	
Lot No.:	H2B003	
Formulation type:	Suspension concentrate	
Active ingredient (A.I.)/content:	Polyoxin D Zinc Salt	50 g/kg (nominal), 5.08 % w/w (analysed)
Test soil:	Biologically active agricultural soil: loamy sand (DIN 4220) / sandy loam (USDA), pH 6.2, 1.40% C_{org}, WHC: 36.15 g/100 g dry soil.	
Test design:	Nitrogen transformation test The test was performed in accordance to the OECD guideline 216 (2000). Determination of the nitrogen transformation (NO_3-nitrogen production) in soil enriched with lucerne meal (concentration in soil 0.5%). Comparison of test item treated soil with a non-treated soil. Three replicates per treatment and concentration. NH_4-nitrogen, NO_3- and NO_2-nitrogen were determined by using the Autoanalyzer (BRAN+LUEBBE). Sampling scheme: 0, 7, 14 and 28 days after treatment.	

	Carbon transformation test The test was performed in accordance to the OECD guideline 217 (2000). Determination of carbon transformation in soil after addition of glucose. Comparison of test item treated soil with a non-treated soil. Three replicates per treatment and concentration. A respirometer system (BSB digi, SELUTEC) was used to determine the O_2-consumption over a period of 12 hours at different sampling intervals. Sampling scheme: 0, 7, 14 and 28 days after treatment.
Test concentrations:	Control, 1.31 mg test item/kg dry soil (corresponding to 0.946 L (0.984 kg) test item/ha, nominally equivalent to 50 g A.I./ha) and 6.56 mg test item/kg dry soil (corresponding to 4.73 L (4.92 kg) test item/ha, nominally equivalent to 250 g A.I./ha). Test concentrations related to a soil depth of 5 cm and a soil density of 1.5 g/cm^3.
Endpoints:	Effects on NO_3-nitrogen production and O_2-consumption after 28 days of exposure.
Reference item:	Dinoterb (purity: 98.0% ± 0.5 analysed). The reference item was tested in a separate study at concentrations of 6.80, 16.00 and 27.00 mg/kg.
Test conditions:	Water content: approx. 45% of its maximum water holding capacity; Nitrogen transformation test: Water content: 15.40 - 16.11 g/100 g dry soil; pH: 5.9 - 6.0 Carbon transformation test: Water content: 15.25 - 16.31 g/100 g dry soil; pH: 6.0- 6.1 Soil samples were incubated at 19.1 - 21.8°C while stored in test vessels in the dark.
Statistics:	Calculation of mean values per treatment, standard deviations, coefficients of variation.
Dates of work:	Experimental start: 11.07.2014 Experimental completion: 08.08.2014

Results

No adverse effects of the test item on nitrogen and carbon transformation in soil were observed at both test concentrations (1.31 mg/kg dry soil and 6.56 mg/kg dry soil) after 28 days.

The results are summarized in Table 1 and Table 2.

Table 1: Effects on nitrogen fixation rate in soil after treatment with the test item

Time Interval (Days)	Control	1.31 mg test item/kg soil dry weight equivalent to 0.946 L test item/ha		6.56 mg test item/kg soil dry weight equivalent to 4.73 L test item/ha	
	NO_3-N (mg/kg soil dry weight)	NO_3-N (mg/kg soil dry weight) [1]	Deviation from Control (%)	NO_3-N (mg/kg soil dry weight) [1]	Deviation from Control (%)
0-7	32.37	32.57	+0.6	33.67	+4.0
0-14	43.93	41.67	-5.2	43.57	-0.8
0-28	59.57	62.17	+4.4	63.20	+6.1

The calculations were performed with non-rounded values.
[1] Measured values sampling day “x” - measured values sampling day 0, mean of 3 replicates.
No statistically significant differences between the control and the test item treatments were determined (Student t-test, $p<0.05$).

In a separate study the reference item Dinoterb caused a stimulation of nitrogen transformation of +47.3%, +67.7% and +35.1% at 6.80 mg, 16.00 mg and 27.00 mg Dinoterb per kg soil dry weight, respectively, determined 28 days after application.

Table 2: Effects on carbon transformation in soil after treatment with the test item

Time Interval (Days)	Control	1.31 mg test item/kg soil dry weight equivalent to 0.946 L test item/ha		6.56 mg test item/kg soil dry weight equivalent to 4.73 L test item/ha	
	O_2 consumption (mg/kg soil dry weight/hour)	O_2 consumption (mg/kg soil dry weight/hour)	Deviation from Control (%) [1]	O_2 consumption (mg/kg soil dry weight/hour)	Deviation from Control (%) [1]
0	14.29	14.70	+2.8	14.12	-1.2
7	13.29	13.81	+4.0	13.71	+3.2
14	13.11	13.50	+2.9	13.38	+2.0
28	11.62	11.94	+2.7	11.54	-0.6

The calculations were performed with non-rounded values.
[1] Based on O_2 consumption; - = inhibition; + = stimulation
No statistically significant differences between the control and the test item treatments were determined (Student t-test, $p<0.05$).

In a separate study the reference item Dinoterb caused an inhibition of carbon transformation of -40.5% and -38.6% at 16.00 mg and 27.00 mg Dinoterb per kg soil dry weight, respectively, 28 days after application.

<u>Conclusion</u>
The test item caused no adverse effects (deviation from control <25%, OECD 216/217) on soil nitrogen transformation (measured as NO_3-N-production) and on soil carbon transformation (measured as O_2 consumption) at the end of the 28-day incubation period.

The study was performed in a field soil at concentrations up to an equivalent field application rate of 4.73 L (4.92 kg) test item/ha (nominally equivalent to 250 g A.I./ha).

Beneficial Soil Fungi

The following study was conducted to address the NOSB's concerns regarding possible effects of polyoxin D zinc salt on beneficial soil fungi:

> Cynthia Smith, Tom Prychitko, Ph.D., and K. Takei
> Polyoxin D Zinc Salt 5SC Fungicide: Evaluation of Potential Impacts on Soil Fungi
> Helix Biological Laboratory
> September 28, 2015

No adverse effects on beneficial soil fungi were observed. The report summary is provided below.

VEGGIETURBO 5SC Suspension Concentrate Fungicide (EPA Reg. No. 68173-4) containing nominally 5.0% polyoxin D zinc salt is registered in the United States for use as a foliar spray to control listed fungal pathogens on most fruit and vegetable crops. A synonym for this formulation is CX10440.

When Kaken Pharmaceutical Co., Ltd. proposed the use of polyoxin D zinc salt for use in organic agriculture, a member of the National Organic Standards Board expressed concern that polyoxin D zinc salt might have an adverse effects on beneficial soil fungi. This study was undertaken to provide data to address this concern.

The objectives of this study were:

1. To evaluate the treatment related effects, if any, of the use of the test substance, CX10440, on soil fungi, including beneficial soil fungi, from two difference soil field locations (a coastal state and a mid-western state); and
2. If treatment related effects are observed, to determine the time needed for recovery from the observed effects.

Two sites were selected that would qualify for organic crop production. No pesticides and no fertilizers had been applied during the previous 3 years. The two sites had different soil types:

1. The site near Yakima, Washington had sandy loam soil with 1.9% organic matter. The pH of the soil was 7.8 (slightly alkaline).
2. The site near Madison, Wisconsin had silty clay loam soil with 3.8% organic matter. The pH of the soil was 5.4 (acidic).

The test sites were tilled to produce bare soil plots. Using ground spray equipment, the test substance was applied to the bare soil at the EPA registered maximum label rate (13.0 fl. oz. test substance/acre = 0.72 oz. a.i./acre). Under actual use conditions, the treated crop would intercept most of the fungicide spray. Therefore, the exposure of soil to polyoxin D zinc salt in this study exceeded the maximum exposure of soil to polyoxin D zinc salt resulting from EPA registered use of the test substance.

The soil samples were cultured using malt yeast extract agar which is selective for the growth of fungi. The resulting fungal colonies had normal appearance. The test substance did not adversely effect the morphology of the fungal colonies.

The test substance did not adversely effect the viability of the soil fungi. There was no statistically significant difference in the number of fungal colonies in the control vs treated soil samples for samples collected on Days 0, 1, 7,14, 21, and 28. Interestingly, treatment with the test substance resulted in a statistically significant *increase* in the number of viable soil fungi on Day 3 at both the Washington and Wisconsin sites. The reduction of viability of soil fungi that might be anticipated following exposure to most fungicides was *not* observed following exposure to the test substance. Instead, a brief and reversible statistically significant increase in soil fungal viability was observed. This is consistent with the non-toxic mode of action of polyoxin D zinc salt, *i.e.*, it reversibly stops the growth of susceptible fungi without killing the fungus.

The evaluation of the appearance and number of cultured fungal colonies did *not* differentiate between beneficial and pathogenic soil fungi. Polymerase chain reaction analysis was used to qualitatively confirm that the soil fungi included beneficial soil fungi. The intergenic spacer region gene which is unique to *beneficial* fungi was determined to be present in the fungi from both the control and treated soil samples.

This study therefore demonstrated that VEGGIETURBO 5SC Suspension Concentrate Fungicide (EPA Reg. No. 68173-4) containing nominally 5.0% polyoxin D zinc salt, when applied to soil at the maximum application rate (0.72 oz. a.i./acre), did *not* adversely effect beneficial soil fungi.

Zinc

During the April 10, 2013 pubic hearing, a member of the NOSB noted that organic growers have problems with the accumulation of copper in soil and asked about potential accumulation of zinc in the soil resulting from repeated use of polyoxin D zinc salt.

The molecular formula polyoxin D zinc salt (CAS No.146659-78-1) is $C_{17}H_{23}N_5O_{14} \cdot Zn$. For one molecule of polyoxin D zinc salt:

- The weight of polyoxin D zinc salt is 587.08 amu; and
- The weight of the zinc portion is 65.37 amu.

Zinc comprises 11.07% of the weight of polyoxin D zinc salt.

(65.37 / 587.08) x 100 = 11.07

For Veggieturbo 5SC Suspension Concentrate Fungicide (EPA Reg. No. 68173-4):

- The maximum single application rate is 0.72 oz ai/acre/application;
- The maximum zinc application rate is 0.084 oz zinc/acre/app;
- The maximum number of applications per season is 6; and
- The maximum seasonal application rate of zinc is 0.4782 oz zinc/acre/season.

(0.72 oz a.i./acre/app) x (11.07 oz zinc / 100 oz polyoxin D zinc salt) = 0.084 oz zinc/acre/app

(0.80 oz zinc/acre/app) x (6 apps/season) = 0.50 oz zinc/acre/season

As an example copper product, consider NU Cop 50 WP (EPA Reg. No. 45002-7).

- The formulation contains 77.0% copper hydroxide which the label states is equivalent to 50% metallic copper.
- The maximum single application rate for control of fungal diseases is 20 lb formulation/acre (*e.g.*, peaches and nectarines). This is equivalent to 160 oz copper/acre/application. (See calculation below.)
- The label does not establish a maximum number of applications per season. Assuming 10 applications per season, the maximum copper application rate per season is 1600 oz copper/acre/season. (See calculation below.)

(20 lb formulation/acre/app) x (50 lb copper/100 lb formulation) x (16 oz copper/lb copper) = 160 oz copper/acre/application

(160 oz copper/acre/application) x (10 apps/season) = 1600 oz copper/acre/season

For this example:

- The copper single application rate is 1905-fold higher than the zinc single application rate for polyoxin D zinc salt; and
- The copper seasonal application rate is 3200-fold higher than the zinc seasonal application rate for polyoxin D zinc salt.

(160 oz copper/acre/application) / (0.084 oz zinc/acre/app) = 1905-fold difference

(1600 oz copper/acre/season) / (0.50 oz zinc/acre/season) = 3200-fold difference

As noted by George Rehm and Michael Schmitt of the University of Minnesota Extension (http://www.extension.umn.edu/agriculture/nutrient-management/micronutrients/zinc-for-crop-production/):

> *Zinc (Zn) is an essential nutrient required in some fertilizer programs for crop production in Minnesota. While some soils are capable of supplying adequate amounts for crop production, addition of zinc fertilizers is needed for others. In Minnesota, Zn may be needed in fertilizer programs for production of corn, sweet corn, and edible beans. Several research projects have focused on the use of this nutrient, and much of the following information is based on the results of that research.*
>
> *The specific role of Zn in growth and development of plants is not known. This nutrient is an important component of various enzymes that are responsible for driving many metabolic reactions in all crops. Growth and development would stop if specific enzymes were not present in plant tissue.*
>
> *Zinc, however, is needed in very small amounts. Plant uptake of this nutrient is calculated in terms of ounces per acre instead of pounds per acre. Therefore, Zn is classified as a micronutrient.* [Emphasis added.]

When used according to the directions for use, polyoxin D zinc salt provides a maximum of 0.084 oz zinc/acre/application. This is consistent with application of zinc to soil as a micronutrient, *i.e.*, ounces per acre. No accumulation of zinc in soil is anticipated via the registered use of polyoxin D zinc salt. Instead, it is anticipated that the treated crops will absorb the zinc from polyoxin D zinc salt as a needed micronutrient for incorporation into essential plant enzymes.

EFFECTS ON BENEFICIAL INSECTS

The following studies of the effects of polyoxin D zinc salt on beneficial insects were completed after the April 10, 2013 NOSB public hearing for polyoxin D zinc salt:

1. Pfeiffer, S.
Polyoxin D Zinc Salt Technical- Acute Contact Toxicity to the Honeybee, *Apis mellifera* L. under Laboratory Conditions
September 19, 2014

2. William A. Donahue, Jr., Ph.D.
Polyoxin D Zinc Salt Technical: A Laboratory Study to Evaluate the 3-Day Acute Toxicity and Developmental Effects on Adult and Third Instar Larvae Ladybird Beetles, Family Coccinellidae.
Sierra Research Laboratories, Inc.
February 18, 2015

3. William A. Donahue, Jr., Ph.D.
Polyoxin D Zinc Salt 5SC Fungicide: Life-Cycle Toxicity Study in Multicolored Asian Ladybird Beetle Larvae, *Harmonia axyridis*.
Sierra Research Laboratories, Inc.
March 29, 2016

4. Rogers DJ, Gosling MJ, and Walker JTS
The Response of *Aphelinus mali* to Residues of Esteem™
Plant and Food Research
June 2015

Honeybees: EPA's Hazard Classifications
EPA requires acute toxicity studies of honeybees and categorizes the hazards to honeybees based upon the following criteria:

EPA Classification	Criteria [A]
Practically non-toxic	$LD_{50} \geq 11$ μg/bee
Moderately toxic	$LD_{50} > 2$ μg/bee
Highly toxic	$LD_{50} < 2$ μg/bee

A. US EPA, PMRA, CDPR. (2014) Guidance for Assessing Pesticide Risks to Bees.

Honeybees: Acute Oral Toxicity

As noted in the original NOP petition, an acute oral toxicity study (MRID No. 48660404) was conducted to examine the toxicity of polyoxin D zinc salt to the honeybee *(Apis mellifera).*

Adult honeybees were used for the tests. They were purchased from the Apiculture Institute Co., Ltd., maintained in the Institute of Japan Plant Protection Association, and fed as required with 50% sucrose solution and substitute pollen.

Polyoxin D Zinc Salt Technical, the test material, was diluted with 50% sucrose solution to 5 different concentration levels ranging from 150 to 9.375 μg/20 μL. As a control material, dimethoate reference standard was diluted with 50% sucrose solution to 4 different concentration levels ranging from 0.18 to 0.09216 μg/20 μL. Both samples were administered at 200 μL/10 bees. After administration for 3 hrs, these solutions were exchanged for 50% sucrose solution without test material. Real dosages were calculated using intakes of test material solutions per 10 bees and the specific gravity of test material solutions.

During the treatment period and after the administration of test material solution, honeybees were maintained in an incubator at the temperature of 25 ± 2°C and in the relative humidity range of approx. 70% to 80% and under dark conditions. The numbers of surviving, dead, and abnormal bees were examined after 4, 24, 48, 72, and 96 hrs from commencement of administration.

The LD_{50} values and 95% confidence limits for Polyoxin D Zinc Salt Technical are as follows:

Time After Dosing (Hours)	Polyoxin D Zinc Salt Technical	
	LD_{50} (µg/Bee)	95% Confidence Limit (µg/Bee)
24	88.105	54.371 to 107.591
48	32.885	28.519 to 37.643
72	33.037	28.610 to 37.824
96	28.774	24.818 to 33.083

The very high acute oral LD_{50} values for Polyoxin D Zinc Salt Technical determined in this study demonstrate the very low acute oral toxicity of Polyoxin D Zinc Salt Technical to honeybees. Using US EPA's hazard classification system for acute LD_{50} data for honeybees (above), Polyoxin D Zinc Salt Technical is ***practically non-toxic*** to honeybees when honeybees are exposed ***orally*** to polyoxin D zinc salt.

Honeybees: Acute Contract Toxicity

An acute contact toxicity study in honeybees was conducted. No adverse effects were observed. The report summary is provided below. The study concludes that the acute contact LD_{50} of Polyoxin D Zinc Salt Technical is > 100 µg a.i./bee. Using EPA's classification system for acute honeybee toxicity studies (above), polyoxin D zinc salt is ***practically non-toxic*** to honeybees when honeybees are exposed via ***contact*** with residues of polyoxin D zinc salt on plant surfaces.

Report: PFEIFFER, S. (2014); Polyoxin D Zinc Salt Technical- Acute Contact Toxicity to the Honeybee, *Apis mellifera* L. under Laboratory Conditions

Source: Eurofins Agroscience Services EcoChem GmbH, Niefern-Öschelbronn, Germany, unpublished report No: S14-01418, issued on 19 SEP, 2014

Guidelines: OECD Guideline No. 214 (1998)

Deviation: Deviation to the Guideline: Since the reference item is known to be toxic to honeybees, effects are expected. Moreover, the doses tested cover the range of the expected LD_{50} values; therefore, sub-lethal effects in the reference item treatment were not recorded. The results do not include a graphic display, since it adds no further information.

GLP: Yes (certified laboratory)

Material and Methods:

Test item: Polyoxin D Zinc Salt Technical Batch No.: PSB-745
Active ingredient: Zinc 5-(2-amino-5-O-carbamoyl-2-deoxy-L-xylonamide)-5-deoxy-1-(1,2,3,4-tetrahydro-5-carboxy-2,4-dioxopyrimidinyl)-ß-D-allofuranuronic acid
Content of a.i. (analysed): 22.3% w/w

Test species:	Honeybee (*Apis mellifera* L.); young adult worker bees; deriving from a healthy colony.
Test design:	Contact toxicity test: Dose-response test; duration contact toxicity tests 48 hours, five doses with 4 replicates for the test item, 4 doses with 4 replicates for the positive control and 4 replicates for the negative control. Each replicate consisted of 10 bees. Assessment of mortality 4, 24, and 48 hours after test start.
Positive control:	Perfekthion/BAS 152 11 I (dimethoate, analysed 400.9 g/L)
Test doses:	Negative control: Contact toxicity test: tap water
Test item:	Contact toxicity test: 6.25, 12.5, 25, 50 and 100 µg a.i./bee
Positive control:	Contact toxicity test: 0.10, 0.14, 0.19 and 0.25 µg a.i./bee
Test conditions:	Temperature: 24.3 – 25.7°C Relative humidity: 52.0 – 61.3% Photoperiod: 24 h darkness, except during application and assessments.
Statistics:	The LD_{50} values with 95% confidence intervals were calculated by means of a probit analysis using the statistic program ToxRat Professional 2.10.
Date of work:	06 MAY 2014 to 08 MAY 2014
Conclusions:	Polyoxin D Zinc Salt Technical was tested in an acute contact toxicity test on honeybees. The 48 h LD_{50} of Polyoxin D Zinc Salt Technical was determined to be > 100 µg a.i./bee in the contact toxicity test.

Honeybees: EPA Label Statements

EPA requires a bee hazard statement in the environmental hazards section of the label for all FIFRA regulated products that are highly or moderately toxic to honeybees.
(See the EPA Label Review Manual, Chapter 8, beginning on page 8-8.
https://www.epa.gov/pesticide-registration/label-review-manual)

None of the labels for products containing polyoxin D zinc salt have a bee hazard statement. This is further confirmation that EPA has classified polyoxin D zinc salt and its formulations as *practically non-toxic to honeybees*.

Ladybird Beetles

During the April 10, 2013 public hearing, a member of the NOSB expressed concern regarding the possible adverse effects on ladybird beetles. Kaken commissioned two studies of the effects of polyoxin D zinc salt on lady bird beetles:

1. Polyoxin D Zinc Salt Technical: A Laboratory Study to Evaluate the 3-Day Acute Toxicity and Developmental Effects on Adult and Third Instar Larvae Ladybird Beetles, Family *Coccinellidae*
2. Polyoxin D Zinc Salt 5SC Fungicide: Life-Cycle Toxicity Study in Multicolored Asian Ladybird Beetle Larvae, *Harmonia axyridis*

No adverse effects on ladybird beetles were observed in either study. Summaries of the studies are provided below.

Acute Effects

A non-target insect toxicity test was initiated to evaluate any adverse effects of Polyoxin D Zinc Salt Technical against adult and larval lady bird beetles (Coleoptera: Coccinellidae). Polyoxin D Zinc Salt Technical was diluted in water to a final concentration equivalent to 150 mg of active ingredient (a.i.) per liter of water and mixed thoroughly. The test solution and the water control were then poured out into a glass Petri dish for immersion of the test insects.

Total immersion of ladybird beetle adults and third instar larvae in 150 mg a.i./L aqueous solutions of Polyoxin D Zinc Salt Technical for 5 seconds resulted in:

1. No mortality three days after treatment of both the adults and third instar larvae.
2. No adverse effects on development (emergence as adults) of third instar larvae.

Chronic (Life-Cycle) Effects

A non-target insect toxicity study was initiated to evaluate potential chronic adverse effects of Veggieturbo 5SC Suspension Concentrate Fungicide containing 5.0% polyoxin D zinc salt which is distributed in the United States by Certis USA, L.L.C. as Oso 5%SC Fungicide (EPA Registration No. 67075-4-70051). The Certis research code for this formulation is CX-10440. For simplicity, this formulation is referred to as Polyoxin D Zinc Salt 5SC Fungicide.

The test group was comprised of ten replicates of egg masses of Multicolored Asian Ladybird beetles, *Harmonia axyridis,* (Coleoptera: Coccinellidae), with 13 to 27 eggs per egg mass. The water control group was comprised of ten replicates of egg masses with 14 to 23 eggs per egg mass. The test substance was applied at a rate equivalent to 13.0 fl. oz./acre (maximum label rate) to ladybird beetle eggs on Day 0 and to the resulting larvae on Day 5 and Day 12. Water was applied in the water control at the same rate. The test substance solution and the water control were applied using a compressed air sprayer.

The observed hatch rates on test Day 4 were 72.7% in the treated group compared to 65.1% in the water control group. These results were not statistically different. The test substance applied at the maximum label rate did not adversely affect hatching of ladybird beetle eggs.

On Day 5 for each replicate, ten first instar ladybird beetle larvae were transferred to a container with two strawberry plants. There were ten test replicates and ten control replicates. Throughout the study, green peach aphids were introduced as a food source for the ladybird beetle larvae. The aphids also helped minimize cannibalism by the ladybird beetle larvae.

On Day 5, the test strawberry plants were treated with the test substance at the equivalent of 13.0 fl. oz./acre and the control replicates were treated with water at the equivalent rate. The first instar ladybird beetles were then immediately introduced to the treated strawberry plants with live green peach aphids.

On Day 12, the test strawberry plants with ladybird beetle larvae were retreated with the test substance at the equivalent of 13.0 fl. oz./acre and the control replicates were treated with water at the equivalent rate.

On Day 19 and Day 26, percent emergence of ladybird beetle larvae as adults was recorded. On Day 26, 64.0% emergence was observed in the test group and 67.0% emergence was observed in the water control group. These values are not statistically different.

The test substance applied at the maximum label rate (13.0 fl. oz./acre) a total of three times did *not* adversely affect:

- The number of ladybird beetle eggs that hatched;
- The development of ladybird beetle larvae and pupae; and
- The number of ladybird beetles that emerged as adults.

Effects on *Aphelinus mali*

The effects of polyoxin D Zinc Salt 5SC Fungicide (a.k.a. Esteem in New Zealand) on *Aphelinus mali* were evaluated to support registration in New Zealand. No adverse effects were observed. The report summary is provided below.

The parasitoid *Aphelinus mali* is vital for the successful biological control of woolly apple aphid (*Eriosoma lanigerum*) in New Zealand apple orchards. Woolly apple aphid is normally well controlled by *Aphelinus mali*, but there were serious outbreaks in the 2007–08 season, which coincided with the introduction of a new insecticide for codling moth control to satisfy residue restrictions. Studies conducted at this time demonstrated that Delegate™ (a.i. 250 g/kg spinetoram) was toxic to *Aphelinus mali* and suggested it was implicated in the woolly apple aphid control problems observed. Subsequently, comprehensive bioassays have confirmed the acute toxicity of carbaryl and diazinon, which had also been used in the area where the woolly apple aphid outbreaks occurred, and shown that carbaryl had high persistent residual toxicity to *Aphelinus mali* even after 28 days of field-weathering. This project sought to determine if residues of Esteem™ (polyoxin), a broad-spectrum fungicide, caused any mortality to *Aphelinus mali* in the same type of bioassay.

Esteem was applied at the label rate until run-off by a motorised knapsack sprayer to the bottom tier of unsprayed mature apple trees. After the products had dried, apple leaves with residues were sampled and field-collected *Aphelinus mali* were exposed to insecticide residues on the apple leaf within a Petri dish to determine toxicity, and were compared with an untreated control. *Aphelinus mali* mortality after exposure to Esteem on an apple leaf was very low (4.7%). Mortality from Esteem was not significantly different from the control mortality. In contrast, exposure to both diazinon and carbaryl resulted in almost 100% mortality in the similar type of experiment conducted in 2009. Based upon the bioassay results reported here, Esteem is unlikely to disrupt biological control of woolly apple aphid by *Aphelinus mali*.

BROAD SPECTRUM

During the April 10, 2013 public hearing, a member of the NOSB expressed concern that polyoxin D zinc salt was a broad spectrum substance and would “kill everything.”

As noted in the discussion of the mode of action, polyoxin D zinc salt has a *non-toxic* mode of action. Polyoxin D zinc salt does *not* kill fungi. Instead, it stops *sensitive* fungi from growing by acting as a competitive inhibitor for an enzyme binding site associated with the production of chitin which is needed for fungal growth.

Fungi vary in their sensitivity to polyoxin D zinc salt. Polyoxin D Zinc Salt 5SC Fungicide is registered for suppression (not control) for the following uses:

Polyoxin D Zinc Salt 5SC Fungicide Suppression Claims		
Crop	Disease Name	Pathogen Name
Berries and small fruits	Anthracnose leaf & fruit rot	*Colletotrichum* spp.
Bulb vegetables	Downy mildew	*Peronospora* spp.
Fruiting vegetables	Anthracnose	*Colletotrichum* spp.
	Late blight	*Phytophthera infestans*
	Southern blight	*Sclerotium rolfsii*
	Verticillium wilt	*Verticillium dahliae*
Leafy vegetables	Downy mildew	*Bremia lactucae* and *Peronospora* spp.
Pome fruits	Scab	*Venturia* spp.
	Cedar apple rust	*Gymnosporangium juniperi-virginianae*
	White rot	*Botryosphaeria dothidea*
Potatoes	Late blight	*Phytophthera infestans*

Based upon the non-toxic mode of action of polyoxin D zinc salt and the maximum inhibitory concentration studies, polyoxin D zinc salt is *not* efficacious for the control of bacteria and yeasts. Examples crop diseases causes by bacteria and thus *not* controlled by polyoxin D zinc salt include:

Examples of Diseases NOT Controlled or Suppressed by Polyoxin D Zinc Salt		
Pathogen Name	Disease Name	Example Host Crop
Erwinia amylovora	Fireblight	Apples
Erwinia sp.	Bacterial canker	Tomato
Pseudomonas syringae	Bacterial blight	Blueberries
Streptomyces scabiei	Scab	Potato
Xanthomonas spp.	Xanthomonas leaf spot	Lettuce

PRE-HARVEST USES: VALUE & EFFICACY SUMMARY WITH IDENTIFICATION OF ALTERNATIVES

OVERVIEW OF POLYOXIN D ZINC SALT 5SC FUNGICIDE

Overview of Polyoxin D Zinc Salt 5SC Fungicide: Efficacy Data

Polyoxin D Zinc Salt 5SC Fungicide is also known as:

- Veggieturbo 5SC Suspension Concentrate Fungicide;
- Oso 5%SC Fungicide;
- Tavano 5%SC Fungicide; and
- CX-10440.

Efficacy trials conducted using Polyoxin D Zinc Salt 5SC Fungicide are briefly summarized below. More detailed summaries are provided in the more detailed pathogen/disease/crop uses summaries.

Pathogens are listed in alphabetical order by their scientific names. When efficacy trials were conducted using more than one host plant, the host plants are listed in alphabetical order by common name.

Please note:

- Efficacy data regarding the polyoxin D zinc salt WDG formulation (a.k.a. PH~D and Affirm) have been *not* been included because the WDG formulation includes at least one inert ingredient that is not acceptable for use in organic crop production.
- Efficacy trials that include use of polyoxin D Zinc Salt 5SC Fungicide as part of a treatment program with products with other active ingredients have *not* been included in the summarized efficacy results because the measured efficacy cannot be attributed to polyoxin D zinc salt only.

Efficacy of Polyoxin D Zinc Salt 5SC Fungicide Applied as a Foliar Spray to Growing Food Crops Using Ground Application Equipment

Pathogen	Disease	Crop	Trial No.	State	Formulation [1]	No. App.	Application Interval (Days)	Application Rate fl oz/ acre	Application Rate g a.i./ ha	Mean Control (%)	Mean Yield Increase (%)	Application Type(s)	Inocu-lated?	Max. Pest Pressure in UTC (%)	Phyto-tox ?	Publication Status	Notes
Albugo occidentalis	White rust	Spinach (#1)	CER-2014-063	TX	Oso	4	5 - 9	6.5	25	53	NA	Curative	No	100	No	Not published. Permission received.	Disease present before first application.
								Mean		53 (n = 1)							New pest.
Alternaria solani	Early blight	Potatoes (#1)	CER-2011-029	MI	CX-10440	8	7	3.8	15	19.3	26.4	Preventative and curative	No	45.0	No	PDMR 6:V107	
								7.5	29	22.2	6.9						
		Potatoes (#2)	CER-2011-030	PA	CX-10440	4	14 - 18	3.75	14	18.1	NA	Preventative and curative	Yes	AUDPC = 922.6	No	PDMR 6:V113	
								7.5	29	39.7	NA						
		Potatoes (#3)	CER-2012-028	PA	CX-10440	7	7 - 8	6.5	29	41.9	13.5	Preventative and curative	Yes	AUDPC = 340	No	PDMR 7:V105	
								13	50	41.9	6.5						
		Tomatoes (#1)	CER-2014-095	FL	Oso	8	6 - 9	6.5	50	38.4	NA	Preventative and curative	Yes	55.0	No	PDMR 9:V072	
								Mean		31.6 (n = 7)	11.6 (n = 4)						
Alternaria spp.	Alternaria fruit rot	Blueberries (#1)	CER-2012-049	MI	CX-10440	5	10 - 39	6.5	25	31	NA	Preventative	No	48.5	No	PDMR 7:SMF014	Pre-harvest treatment. Post-harvest evaluation.
								13.0	50	51	NA						
								Mean		41 (n = 2)							
Botrytis cinerea	Gray mold	Blueberries (#1)	CER-2015-009	OR	Oso + Kinetic (sticker/ spreader)	12	Typically 6-8	5.6	22	72	NA	Preventative	No	7.8	No	PDMR 10:SMF027	2016 field trial is planned.
						7	13-15	5.6	22	87	NA						
	Bunch rot	Grapes (#1)	CER-2013-002	CA	Tavano 5% SC	4	37-56	6.5	25	89.0	NA	Preventative	No	30.00	No	PDMR 9:SMF001	
								13	50	92.8	NA						
	Bunch rot	Grapes (#2)	CER-2013-021	CA	Tavano 5% SC	6	18-21	6.5	25	83.2	NA	Preventative and curative	No	20.8	No	Certis data; not published.	
								13	50	78.1	NA						
	Bunch rot	Grapes (#3)	CER-2014-045	NY	Tavano 5% SC	4	13 - 43	6.5	25	37	NA	Preventative and curative	No	76.3	No	Not published. Permission received.	
	Bunch rot	Grapes (#4)	CER-2015-115	NY	OSO	4	14 - 41	6.5	25	69	NA	Preventative	No	96	No	Not published. Permission received.	
	Bunch rot	Grapes (#5)	CER-2015-140	MI	Oso 5%SC + Super Spread	4	20 - 29	6.5	50	56	NA	Preventative	No	25	No	PDMR 10:SMF011	
	Gray mold	Lettuce (#1)	CER-2011-014	CA	CX-10440	4	10 - 11	3.75	14	30.0	6.1	Preventative	No	52.62	No	Certis data; not published.	2016 greenhouse trial is planned.
								7.5	29	41.7	6.5						
	Tan spot	Potatoes (#1)	CER-2011-029	MI	CX-10440	8	7	3.8	15	74.9	26.4	Preventative	No	35.0	No	PDMR 6:V107	
								7.5	29	71.4	6.9						
	Botrytis fruit rot	Raspberries (#1)	IND-2015-rasp	WA	Oso	6	10	12	46	51.1	NA	Preventative	No	19.0	No	Authorized.	

Efficacy of Polyoxin D Zinc Salt 5SC Fungicide Applied as a Foliar Spray to Growing Food Crops Using Ground Application Equipment

Pathogen	Disease	Crop	Trial No.	State	Formulation [1]	No. App.	Application Interval (Days)	Application Rate		Mean Control (%)	Mean Yield Increase (%)	Application Type(s)	Inocu-lated?	Max. Pest Pressure in UTC (%)	Phyto-tox ?	Publication Status	Notes
								fl oz/ acre	g a.i./ ha								
	Gray mold	Strawberries (#1)	CER-2012-070	CA	CX-10440	5	7 - 8	3.75	14	40.22	NA	Preventative and curative	No	17.79	No	Certis data; not published.	2016 field trial is planned.
								6.5	25	25.44	NA						
	Gray mold	Strawberries (#2)	CER-2014-038	FL	Oso	14	7	6.5	25	27.2	28.1	Preventative and curative	No	49.5	No	PDMR 9:SMF020	
	Gray mold	Strawberries (#3)	Adaskaveg, 2013	CA	Tavano	NR	NR	NR	NR	Moderate and Variable	NA	Not reported	NR	NR	NR	Internet (Adaskaveg)	
									Mean	60 (n = 17)	15 (n = 5)						2016 trials are planned.
Bremia lactucae	Downy mildew	Lettuce (#1)	CER-2011-046	CA	CX-10440	4	14 - 15	3.75	14	47.5	NA	Preventative and curative	No	100	No	Certis data; not published.	
								7.5	29	33.7	NA						
		Lettuce (#2)	CER-2013-014	CA	Oso	8	7	6.5	25	50	NA	Preventative and curative	No	12.58 lesions/ head	No	Certis data; not published.	
								13	50	62	NA						
		Lettuce (#3)	CER-2013-032	CA	Oso + Syl-Tak (surfactant)	4	6 - 10	13	50	46.2	NA	Preventative	No	4.26 lesions/ head	No	Not published. Permission received.	
									Mean	47.9 (n = 5)							
Colephoma empetri; *Colletotrichum* spp.; *Phomosis vaccinii*; *Phyllosticta vaccinii*; and *Physalospora vaccinii*	Fruit rot complex	Cranberries (#1)	IND-2014-166	WI	Tavano 5SC	2	9	6.5	25	50	0	Preventative	No	18.1	No	PDMR 9:SMF015	
		Cranberries (#2a)	CER-2015-104	WI	Oso + X77 (spreader)	2	19	6.5	25	84.3	0	Preventative	No	23.6	No	PDMR 10:SMF008	Warrens
					Oso			13	50	60.6	-1.9						
		Cranberries (#2b)	CER-2015-104	WI	Oso + X77 (spreader)	2	14	6.5	25	90.2	34.9	Preventative	No	45.0	No	PDMR 10:SMF008	Valley Junction
		Cranberries (#2c)	CER-2015-104	WI	Oso + X77 (spreader)	2	9	6.5	25	68.5	2.1	Preventative	No	30.5	No	PDMR 10:SMF008	Plainfield
					Oso			13	50	63.9	-2.4						
		Cranberries (#2d)	CER-2015-104	WI	Oso + X77 (spreader)	2	19	6.5	25	78.4	29.0	Preventative	No	22.2	No	PDMR 10:SMF008	Oakdale
					Oso			13	50	81.1	29.5						
									Mean	72 (n = 8)	15 (n = 6)						New pest; 2016 research planned.
Colletotrichum orbiculare	Anthracnose	Watermelon	CER-2014-057	TX	Oso + Capsil (surfactant)	7	6 - 11	6.5	25	82	3.3	Preventative and curative	No	1.38 (Scale of 0 to 5)	No	Not published. Permission received.	Phytotoxicity observed in alternative treatment program: chlorothalonil + mancozeb + zoxamide.
									Mean	82 (n = 1)	3.3 (n = 1)						

Efficacy of Polyoxin D Zinc Salt 5SC Fungicide Applied as a Foliar Spray to Growing Food Crops Using Ground Application Equipment																	
Pathogen	Disease	Crop	Trial No.	State	Formulation [1]	No. App.	Application Interval (Days)	Application Rate		Mean Control (%)	Mean Yield Increase (%)	Application Type(s)	Inocu-lated?	Max. Pest Pressure in UTC (%)	Phyto-tox ?	Publication Status	Notes
								fl oz/ acre	g a.i./ ha								
Corynespora cossiicola	Target spot	Tomatoes (#1)	CER-2014-095	FL	Oso	8	6 - 9	6.5	25	38.4	NA	Preventative and curative	Yes	55.0	No	PDMR 9:V072	
									Mean	38.4 (n = 1)							New pest.
Didymella bryoniae	Gummy stem blight	Cantaloupe (#1)	IND-2012-125	Green-house	CX-10440	1	Not Applicable	14	54	86.7	NA	Preventative	Yes	100		Permission received. Submitted to Plant Health Progress.	Phytotoxicity observed for alternatives: Amicarb and Organocide .
		Cucumber (#1)	BCGGA-2015-02	Green-house	Oso	4	7	13.7	50	61.0	20.3	Preventative and curative	Yes	90.8	No	Canadian Journal Plant Pathology	
						2	14	13.7	50	60.7	15.8						
						2	14	20.5	75	58.9	21.9						
		Watermelon (#1)	CER-2011-028	SC	CX-10440	7	7 - 12	27	27	33.6	NA	Preventative and curative	Yes	99.9	No	PDMR 6:V023	
								54	51	62.5							
		Watermelon (#2)	CER-2012-051	GA	CX-10440	7	5 - 9	6.5	25	25.7	NA	Curative	Yes	85.0	No	Submitted to Plant Health Congress. Permission received.	Inoculated 20 days before first fungicide treatment.
								13.0	50	30.6							
									Mean	52 (n = 8)	19 (n = 3)						
Erysiphe necator	Powdery mildew	Grapes (#1)	CER-2011-013	CA	CX-10440	8	10 - 11	3.75	14	78.3	NA	Preventative and curative	No	70.3	No	Certis data; not published.	
								7.5	29	74.6							
		Grapes (#2)	CER-2012-069	CA	CX-10440	8	9 - 11	13	50	96.67	NA	Preventative and curative	No	30.00	No	Certis data; not published.	Wine was analyzed.
		Grapes (#3)	CER-2013-021	CA	Tavano	5	18 - 21	6.5	25	44.2	NA	Preventative and curative	No	100	No	Certis data; not published.	
								13	50	73.6	NA						
		Grapes (#4)	CER-2015-019	OR	Oso + Sylguard (surfactant)	6	13 - 15	6.5	25	67	NA	Preventative and curative	No	87.5	No	Certis data; not published.	
		Grapes (#5)	CER-2015-140	MI	Oso + Super Spread (surfactant)	4	20 - 29	6.5	25	56	NA	Preventative	No	37	No	PRMR 10:SMF011	
									Mean	70 (n = 7)							2016 trials are planned.
Geastrumia polystigmatus, etc.	Sooty blotch Complex	Apples (#1)	CER-2012-025	VA	CX-10440	9	12 - 28	6.5	25	79	NA	Preventative and curative	No	94	No	PDMR 7:PF034	
								13	50	56							
									Mean	68 (n = 2)							
Golovinomyces cichoracearum	Powdery mildew	Lettuce (#1)	CER-2012-074	AZ	CX-10440	4	8 - 11	3.75	14	69	NA	Preventative and curative	No	3.9 (0-5 scale)	No	PMDR 8:V199	
								6.5	25	69							
									Mean	69 (n = 2)							

Efficacy of Polyoxin D Zinc Salt 5SC Fungicide Applied as a Foliar Spray to Growing Food Crops Using Ground Application Equipment

Pathogen	Disease	Crop	Trial No.	State	Formulation [1]	No. App.	Application Interval (Days)	Application Rate		Mean Control (%)	Mean Yield Increase (%)	Application Type(s)	Inocu-lated?	Max. Pest Pressure in UTC (%)	Phyto-tox ?	Publication Status	Notes
								fl oz/ acre	g a.i./ ha								
Leviellula taurica	Powdery mildew	Tomatoes	CER-2012-016	CA	CER-2012-016	3	9 - 14	13	50	47.3	14.5	Curative	No	93.5	No	Not published. Permission received.	See also *Odium neolycopersici*.
									Mean	47.3 (n = 1)	14.5 (n = 1)						
Monilinia fructicola and *Monilinia laxa*	Brown rot - blossom blight	Cherries (#1)	CER-2015-035	OR	Oso + Induce (wetter/ sticker)	7	7 - 14	6.5	25	96.5	NA	Preventative and curative	No	14.3	No	PDMR 10:STF009	Applications initiated before bloom.
	Brown rot - fruit rot									78.3				6.0			Pre-harvest treatment. Post-harvest evaluation.
	Brown rot - blossom blight	French prunes (#1)	CER-2013-121	CA	CX-10440	1	NA	6	23	85.9	NA	Curative	Yes	65.1	No	UC Repository 07 CPB 6	Inoculated 24 hr before first treatment.
										97.3		Preventative	Yes	63.8			Inoculated 4 hr after first treatment.
									Mean	89.5 (n = 4)							New pest.
Monilinia fructicola	Brown rot - Fruit	Nectarines (#1)	CER-2013-119	CA	CX-10440	1	NA	3.5	13	18	NA	Preventative	Yes (post-harvest)	85.3	No	Internet (Adaskaveg, 2013)	Pre-harvest treatment. Post-harvest inoculation and evaluation.
								13	50	20							
		Peaches (#1)						3.5	13	13				67.9			
								13	50	19							
									Mean	18 (n = 4)							New pest .
Monilinia oxycocci	Cottonball	Cranberries (#1)	IND-2014-165	WI	Tavano 5SC	2	14	6.5	25	16	NA	Preventative	No	32	No	PDMR 9:SMF014	City Point
								6.5	25	38				21			Warrens
		Cranberries (#2)	IND-2015-208	WI	Oso + X77 (spreader)	2	9	6.5	25	54.8	17.3	Preventative	No	16.6	No	PDMR 10:SMF007	
					Oso			6.5	25	68.1	22.0						
									Mean	44 (n = 4)	19.7 (n = 2)						New pest.
Monilinia vaccinii-corymbosi	Mummyberry	Blueberries (#1)	CER-2015-008	OR	Oso + Induce (wetter/ sticker)	9	4 - 8	5.6	21.6	21.3	NA	Preventative and curative	No	34.8	No	PDMR 10:SMF026	
		Blueberries (#2)	CER-2015-143	MI	Oso + LI 700 (adjuvant)	5	7 - 14	6.5	25	94	NA	Preventative	No	46.5 mummies/ bush	No	PDMR 10:SMF009	
									Mean	58 (n = 2)							
Odium neoplycopersici	Powdery mildew	Tomatoes (#1)	BCGGA-2015-03	Green-house	Oso	4	7	4.1	15	84.8	3.5	Preventative and curative	Yes	62.5	No	Canadian Journal Plant Pathology	See also *Leviellula taurica*.
								6.8	25	86.9	11.4						
								13.7	50	90.2	14.8						
						2	14	13.7	50	82.5	-6.3						
								20.5	75	82.9	19.3						
									Mean	85.5 (n = 5)	8.5 (n = 5)						

Efficacy of Polyoxin D Zinc Salt 5SC Fungicide Applied as a Foliar Spray to Growing Food Crops Using Ground Application Equipment

Pathogen	Disease	Crop	Trial No.	State	Formulation [1]	No. App.	Application Interval (Days)	Application Rate fl oz/ acre	Application Rate g a.i./ ha	Mean Control (%)	Mean Yield Increase (%)	Application Type(s)	Inocu-lated?	Max. Pest Pressure in UTC (%)	Phyto-tox ?	Publication Status	Notes
Phytophthora infestans	Late blight	Potatoes (#1)	CER-2012-027	PA	CX-10440	5	7	13	50	10.1	13.9	Preventative and curative	Yes	AUDPC: 1612	No	PDMR 7:V094	
		Tomatoes (#1)	CER-2011-027	FL	CX-10440	4	6 - 8	7.5	29	64.3	NA	Preventative	No	546.0 lesions/ plot	No	Not published. Permission received.	
								Mean		37.2 (n = 2)	13.9 (n = 1)						
Podosphaera aphanis	Powdery mildew	Blackberries (#1)	CER-2012-060	OR	CX-10440	3	12 - 14	3.75	12.5	42	NA	Preventative	No	60.0	No	Certis data; not published.	
								6.5	25	58							
		Strawberries (#1)	CER-2012-070	CA	CX-10440	5	7 - 8	3.75	14	26.31	NA	Preventative and curative	No	100	No	Certis data; not published	See also *Sphacelotheca* sp. (Powdery mildew)/ Strawberries.
								6.5	25	23.75							
		Strawberries (#2)	CER-2013-008	CA	CX-10440	7	6 - 43	6.5	25	93.5	NA	Preventative and curative	No	70	No	Certis data; not published.	
								13	50	80							
								Mean		54 (n = 6)							
Podosphaera clandestina	Powdery mildew	Cherries (#1)	CER-2015-032	WA	Oso + R-56 (spreader/ sticker)	4	14 - 15	6.5	25	60.0	NA	Preventative and curative	No	89.0	No	Certis data; not published.	
								Mean		60.0 (n = 1)							
Podosphaera leucotricha	Powdery mildew	Apples (#1)	CER-2012-020	WA	CX-10440	5	6 - 14	6.5	25	56	NA	Preventative and curative	No	35.5	No	Certis data; not published.	
								13.0	50	54							
		Apples (#2)	CER-2015-012	WA	Oso	5	8 - 27	6.5	25	50.2	NA	Preventative and curative	No	61.3	No	Certis data; not published.	78.2% control in fruit.
		Apples (#3)	CER-2015-034	WA	Oso + sticker/ spreader (R-56 or SB56; not specified)	6	13 - 19	6.5	25	40.5	NA	Preventative and curative	No	30.8	No	Certis data; not published.	
								Mean		50 (n = 4)							
Podosphaera xanthii	Powdery mildew	Cucumbers (#1)	R-14-10-0	Green-house	Veggieturbo 5SC	2	7	6.5	25	80	NA	Curative	Yes	80.0	No	Kaken data; not published.	Disease confirmed before first treatment.
								13	50	81							
		Pumpkins (#1)	CER-2015-145	IL	Oso + Activator (non-ionic surfactant)	7	6 - 8	6.5	25	67	NA	Preventative and curative	No	30	No	Not published. Permission received.	
		Pumpkin (#2)	CER-2015-149	GA	Oso	5	7	6.5	25	51.7	NA	Preventative	No	72.5 (0 to 100 scale; 100 = Plant mortality.	No	Not published. Permission received.	
								Mean		69 (n = 4)							

Efficacy of Polyoxin D Zinc Salt 5SC Fungicide Applied as a Foliar Spray to Growing Food Crops Using Ground Application Equipment

Pathogen	Disease	Crop	Trial No.	State	Formulation [1]	No. App.	Application Interval (Days)	Application Rate fl oz/acre	Application Rate g a.i./ha	Mean Control (%)	Mean Yield Increase (%)	Application Type(s)	Inocu-lated?	Max. Pest Pressure in UTC (%)	Phyto-tox ?	Publication Status	Notes
Pseudoperonospora cubensis	Downy mildew	Cucumber (#1)	CER-2012-067	DE	CX 10440	5	5 - 7	6.5	25	57.1	37.1	Preventative	No	17.5	No	Not published. Permission received.	
								13	50	37.1	18.0						
		Pumpkin (#1)	CER-2015-145	IL	Oso + Activator (non-ionic surfactant)	7	6 - 8	6.5	25	78	NA	Preventative and curative	No	20.75	No	Not published. Permission received.	
									Mean	57 (n = 3)	27.6 (n = 2)						
Sclerotinium rolfsii	Southern blight	Squash	CER-2012-050	GA	CX-10440	9	7	6.5	25	59	482	Preventative	No	2 on a 1 to 10 scale	No	Certis data; not published.	Foliar treatment
								13	50	82	552						
									Mean	71 (n = 2)	517 (n = 2)						
Sphacelotheca sp.	Powdery mildew	Strawberries (#1)	CER-2013-008	CA	CX-10440	7	7 - 10	6.5	25	94	NA	Preventative and curative	No	70	No	Certis data; not published	See also *Podosphaera aphanis* (Powdery mildew) / Strawberries
								13	50	80							
		Strawberries (#2)	CER-2012-070	CA	CX-10440	5	7 - 8	3.75	14	26.31	NA	Preventative and curative	No	100	No	Certis data; not published.	
								6.5	25	23.75							
									Mean	56 (n = 4)							
Venturia inaequalis	Scab	Apples (#1)	CER-2012-025	VA	CX-10440	9	12 - 28	6.5	25	53	NA	Curative	No	87	No	PDMR 7:PF034	Scab was present before the first fungicide application.
								13	50	22							
									Mean	38 (n = 2)							
Zygophiala jamaicensis	Fly speck	Apples (#1)	CER-2012-025	VA	CX-10440	9	12 - 20	6.5	25	93	NA	Preventative and curative	No	87	No	PDMR 7:PF034	
								13	50	70	NA						
									Mean	82 (n = 2)							

1. “Veggieturbo 5SC Suspension Concentrate Fungicide” is Kaken’s EPA registered brand name for Polyoxin D Zinc Salt 5SC Fungicide.
“Oso 5%SC Fungicide” and “Tavano 5%SC Fungicide” are Certis USA, L.L.C. supplemental distributor brand names for Polyoxin D Zinc Salt 5SC Fungicide.
“CX-10440" is the Certis USA, L.L.C. formulation code for Polyoxin D Zinc Salt 5SC Fungicide.

NR. Not reported.

Preventative and curative. Treatments include at least one application after disease was observed.
Curative. Disease was confirmed to be present before the first treatment was applied.

Overview of Polyoxin D Zinc Salt 5SC Fungicide: EPA Label Statements

Polyoxin D Zinc Salt 5SC Fungicide: Hazards to Humans

Polyoxin D Zinc Salt 5SC Fungicide has EPA Category IV (best case result) for the following acute mammalian toxicology studies:

- Acute oral toxicity;
- Acute dermal toxicity;
- Acute inhalation toxicity;
- Eye irritation; and
- Dermal irritation.

Therefore, no first aid statement is required by EPA.

Polyoxin D Zinc Salt 5SC Fungicide: Dermal Sensitization

The dermal sensitization report for Polyoxin D Zinc Salt 5SC Fungicide states:

> "The test substance produced very faint to faint erythema in 15 of 20 Test animals, but no reaction in any Naive control animals after the challenge treatment. Therefore, Polyoxin D Zinc Salt SSC is a mild sensitizer in guinea pigs."

The Polyoxin D Zinc Salt 5SC Fungicide label states:

> "Prolonged or frequently repeated skin contact may cause allergic reactions in some individuals."

Polyoxin D Zinc Salt 5SC Fungicide: Environmental Hazards

The Polyoxin D Zinc Salt 5SC Fungicide label for retail size containers states:

> "This pesticide is moderately toxic to aquatic invertebrates and fish."

Polyoxin D Zinc Salt 5SC Fungicide: Phytotoxicity Hazards

Polyoxin D Zinc Salt 5SC Fungicide has *no* phytotoxicity hazard statement. Polyoxin D Zinc Salt has been used commercially for over 40 years with no observed phytotoxicity. The

Polyoxin D Zinc Salt 5SC Fungicide: Physical-Chemical Hazards and Other Storage Restrictions

The Polyoxin D Zinc Salt 5SC Fungicide has *no* physical-chemical hazards statement or other storage restrictions.

Polyoxin D Zinc Salt 5SC Fungicide: User Convenience and Other Considerations

The Polyoxin D Zinc Salt 5SC Fungicide label has *no* significant restrictions that limit use in ways that limit user convenience.

The Polyoxin D Zinc Salt 5SC Fungicide offers the following user conveniences:

- Tolerance exemption on all crops;
- Directions for use on most fruit and vegetable crops;
- Zero-day PHI;
- 4-hour worker re-entry interval;
- Minimal personal protective equipment (PPE); and
- No application buffer zones.

OVERVIEW OF OMRI-LISTED ALTERNATIVES

Overview of OMRI-Listed Alternatives: Non-Synthetic

Non-Synthetic EPA Registered OMRI-Listed Alternatives Summary Table					
FRAC Code	Active Ingredient	NOP Status	Product Name	EPA Reg. No.	Product Label Statements
44	*Bacillus amyloliquefaciens* str. D747	Non-synthetic	Double Nickel 55	70051-108	Causes moderate eye irritation. Dermal sensitizer. Broad-spectrum preventative fungicide. Do not use highly alkaline or highly acidic water to mix sprays. Use a buffering agent if necessary to maintain neutrality (pH 6 to 8) of water in the tank.
			Double Nickel LC	70051-114	Harmful if absorbed through skin. Harmful if inhaled. Dermal sensitizer. Broad-spectrum preventative fungicide.
	Bacillus pumilus str. QST 2808	Non-synthetic	Sonata ASO	264-1153	Harmful if inhaled. Mixers/loaders and applicators must wear a dust/mist filtering respirator meeting NIOSH standards of at least N-95, R-95, or P-95. Repeated exposure to high concentrations of microbial proteins can cause allergic sensitization. Maintain a spray solution pH between 4.5 and 8.5.
	Bacillus subtilis str. QST 713	Non-synthetic	Optiva	62592-26	Causes moderate eye irritation. Dermal sensitizer. Broad spectrum preventative product.
			Rhapsody ASO	246-1155	Harmful if inhaled. Broad spectrum, preventative product for the control or suppression of many important plant diseases.
			Serenade ASO	264-1152	Broad spectrum preventative fungicidal and bactericidal product.
			Serenade MAX	69592-11	Dermal sensitizer. Broad spectrum preventative fungicidal and bactericidal product.
			Serenade Optimum	264-1160	
	Bacillus subtilis var. *amyloliquefaciens* str. FZB24	Non-synthetic	Taegro ECO	70125-5	WARNING signal word. Causes skin irritation. Causes moderate eye irritation. Consists of living microbes. Store at room temperature and use before the expiration date. Avoid temperatures exceeding 73°F (23°C). Do not freeze. For suppression only. Most effective in low to medium disease situation.
P5	*Reynoutria sachalinensis*	Non-synthetic	Regalia Biofungicide	84059-3	Causes moderate eye irritation. Preventative rather than a curative application. Apply prior to disease infestation to protect the growing leaf tissue. Avoid freezing. Apply prior to disease infestation.
Not classified; Biological	*Aureobasidium pullulans* strains DSM 14940 and DSM 14941	Non-synthetic	Botector	86174-3	Harmful if swallowed or absorbed through the skin. Applicators and other handlers must wear a NIOSH-approved respirator. Repeated exposure to high concentrations of microbial proteins can cause allergic sensitization. Do not apply by ground within 25 feet of lakes; reservoirs; rivers; permanent streams, marshes or natural ponds; estuaries and commercial fish farm ponds. Do not cultivate within 10 feet of the aquatic areas to allow growth of a vegetative filter strip. Must be stored out of direct sunlight in a cool dry place. Do not freeze. From date of manufacture, product can be stored: 10 months at room temperature (47-68°F; 9-20°C) or 24 months at cold temperature (34-46°F; 1-8°C).
	Gliocladium catenulatum str. J1446	Non-synthetic	Prestop Biofungicide	64137-11	Harmful if swallowed. Applicators and other handlers must wear a NIOSH-approved respirator with any N, P, R or HE filter. Consists of live microbes. Store below 46°F (8°C) for up to 6 months. Immediately use the entire package's content after opening. Foliar spray prohibited on listed crops; use limited to soil treatments. Do not tank mix with any pesticides or concentrated fertilizers. Do not use most chemical pesticides within 1-4 days of application.
	Streptomyces griseoviridis	Non-synthetic	Mycostop Biofungicide	64137-5	Harmful if inhaled. Causes moderate eye irritation. Applicators and other handlers must wear a dust/mist filtering respirator. Do not tank mix with other pesticides or with concentrated fertilizers. Consists of live microbes. Store below 46°F (8°C). Do not store open packets since product will lose its activity. Do not tank mix with any pesticides or with concentrated fertilizers.
	Streptomyces lidicus	Non-synthetic	Actinovate AG	73314-1	Avoid contact with skin, eyes, or clothing. Avoid breathing dust or spray mist. Mixer/loaders and applicators must wear a dust/mist filtering respirator meeting NIOSH standards of at least N-95, R-95, or P-95. Repeated exposure to high concentrations of microbial proteins can cause allergic sensitization. Keep from overheating or freezing. Optimum storage temperature is 40°F to 85°F. Contains live spores of a microbe. Best results will be obtained if the product is used prior to disease onset. Becomes active in soil or on the plant foliage when the temperatures are above 45°F and is not effective when temperatures remain cold. Do not apply soil fumigants to treated areas.

Non-Synthetic EPA Registered OMRI-Listed Alternatives Summary Table

FRAC Code	Active Ingredient	NOP Status	Product Name	EPA Reg. No.	Product Label Statements
Not classified; Bio-surfactant	Rhamnolipid biosurfactant	Non-synthetic	Zonix	72431-1	DANGER signal word. Corrosive. Causes irreversible eye damage. Store out of direct sunlight and away from heat sources. Keep from overheating or freezing. Do not use for the control or prevention of late blight (*Phytophthora* spp.) when ambient temperatures are over 80°F. At above 80°F, that organism moves out of the zoospore stage and the product will not be efficacious.
Not classified; Botanical oil	Cinnamon oil	Non-synthetic	Cinnerate	N/A. FIFRA §25(b) pesticide.	May cause eye and skin irritation. May cause dermal sensitization. Store upright at room temperature. Avoid exposure to extreme temperatures. Do not expose to light and keep away from any heat source. Do not mix with oxidizing, strong acidic or basic materials. Broad spectrum, contact foliar fungicide. All applications should be preceded by a phytotoxicity check to ensure that the material is safe for the particular plant variety.
	Clove oil, Rosemary oil, Peppermint oil	Non-synthetic	BacStop EF400	N/A. FIFRA §25(b) pesticide.	Causes temporary eye and skin irritation. Wear protective eye wear and chemical resistant gloves. Store at temperatures between 41°F and 85°F (5°C and 30°C).
	Cottonseed oil, Corn oil, and Garlic oil	Non-synthetic	Mildew Cure	N/A. FIFRA §25(b) pesticide.	Avoid contract with skin, eyes, and clothing. Do not apply this product to seedlings or very young plants. Do not apply at less than 7-day intervals.
	Neem oil	Non-synthetic	Trilogy	70051-2	Causes moderate eye irritation. Hazardous to fish and aquatic invertebrates. Toxic to bees exposed to direct treatment. Broad spectrum. Exercise care in timing applications during early morning/late evening to minimize the potential for leaf burn. Use care on plants with tender tissue. Check for leaf burn in small scale trials prior to use. Do not apply to sensitive plant species. Do not apply to wilted or otherwise stressed plants, or to newly transplanted materials or crops prior to root establishment. For optimal performance, do not mix with cold water (less than 45°F). Do not store below 40°F (4°C). Do not use or store near heat or open flame. Growth stage use restrictions for grapes and stone fruit.
	Rosemary oil, Clove oil, and Thyme oil	Non-synthetic	Sporatec	N/A. FIFRA §25(b) pesticide.	May be harmful if swallowed. Avoid contact with eyes, skin, and clothing. Avoid breathing vapors or spray mist. May be toxic to bees. Minimum risk to fish and aquatic organisms. Do not apply on plants when the temperature is 90°F or above. Do not apply to wilted or otherwise stressed plants, or to newly transplanted materials prior to root establishment. Check for leaf and flower burn in small-scale trials before conducting large-scale application. For optimal performance, do not mix with cold water (less than 45°F). Do not use, pour, spill or store near heat or open flames.
	Sesame oil	Non-synthetic	Organocide 3-in-1	N/A. FIFRA §25(b) pesticide.	Insecticide, miticide, and fungicide. If spraying on severely stressed or damaged plants, consider using a lower rate such as 1 oz. per gallon to avoid adding additional stress. For best results, spray in the early morning.
Not classified; Organic acid	Citric acid	Non-synthetic	Nuke Em	N/A FIFRA §25(b) fungicide.	Do not spray on top of other insecticides. Do not mix with other insecticides. Store out of direct sunlight. Not for sale in Mississippi, Indiana or New Mexico. Makes a powdery mildew claim for all crops.

Overview of OMRI-Listed Alternatives: Non-Synthetic: Hazards to Humans

The precautionary statements for FIFRA regulated products are determined by the acute oral toxicity, acute dermal toxicity, acute inhalation toxicity, eye irritation, and dermal irritation study results. Based upon the product labels, Polyoxin D Zinc Salt 5SC Fungicide is less acutely toxicity than the fifteen non-synthetic competitive fungicide products listed below.

Brand Name	Signal Word	EPA Acute Mammalian Toxicity Label Statement
Zonix	DANGER	Causes irreversible eye damage.
Taegro ECO	WARNING	Causes skin irritation. Causes moderate eye irritation.
Botector	CAUTION	Harmful if swallowed or absorbed through skin.
Prestop Biofungicide	CAUTION	Harmful if swallowed.
Mycostop Biofungicide	CAUTION	Harmful if inhaled. Causes eye irritation.
Rhapsody ASO	CAUTION	Harmful if inhaled.
Double Nickel LC	CAUTION	Harmful if absorbed through skin. Harmful if inhaled.
Double Nickel55 Optiva Regalia Biofungicide Trilogy	CAUTION	Causes moderate eye irritation.
Sporatec	CAUTION	May be harmful if swallowed.
Cinnerate	CAUTION	May cause eye and skin irritation.
BacStop EF 400	NA [FIFRA §25(b)]	Causes temporary eye and skin irritation.

Products exempt from regulation under FIFRA §25(b) are not required to conduct and submit the same studies that are required for FIFRA regulated products. For the FIFRA §25(b) products, the acute toxicity is not clear from the product label, and possibly the formulations has not been tested for acute toxicity.

Overview of OMRI-Listed Alternatives: Non-Synthetic: Dermal Sensitization

The OMRI-listed alternatives with non-synthetic active ingredients are summarized below with regard to their dermal sensitization properties based upon the product labels. Please note that products exempt from regulation under FIFRA §25(b) are *not* required by EPA to:

- Conduct dermal sensitization studies; and
- Label products as dermal sensitizers if indicted by any relevant dermal sensitization data.

Sensitizer	Non-sensitizer	No information [FIFRA §25(b)]
Double Nickel 55 Double Nickel LC Optiva Serenade Max Serenade Optimum Botector Actinovate AG Cinnerate	Rhapsody ASO Serenade ASO Taegro Eco Regalia Biofungicide Prestop Biofungicide Mycostop Biofungicide Trilogy Zonix	Mildew Cure Sporatec Organocide 3-in-1 Nuke Em

Overview of OMRI-Listed Alternatives: Non-Synthetic: Environmental Hazards

The retail container size label for Polyoxin D Zinc Salt 5SC Fungicide includes the following complete environmental hazards statement:

> "For terrestrial use. This pesticide is moderately toxic to aquatic invertebrates and fish. Do not apply directly to water, or to areas where surface water is present or to intertidal areas below the mean high water mark. Do not contaminate water when disposing of equipment wash water or rinsate. Do not allow runoff into lakes, streams, ponds or public waterways. Drift and runoff may be hazardous to aquatic organisms in water adjacent to treated areas."

The abbreviated statement for comparison purposes is:

> "This pesticide is moderately toxic to aquatic invertebrates and fish."

This statement defines the hazard. The balance of the complete statement provides directions for risk mitigation.

The following abbreviated environmental hazard statements appear on the following OMRI-listed alternatives with non-synthetic active ingredients:

Product Name	Environmental Hazard Statements: OMRI-Listed Alternatives with Non-synthetic Active Ingredients
Botector [1]	Do not apply by ground within 25 feet of lakes; reservoirs; rivers; permanent streams, marshes or natural ponds; estuaries and commercial fish farm ponds. Do not cultivate within 10 feet of the aquatic areas to allow growth of a vegetative filter strip.
Trilogy	Hazardous to fish and aquatic invertebrates. Toxic to bees exposed to direct treatment.
Sporatec	May be toxic to bees. Minimum risk to fish and aquatic organisms.

1. Buffer Zone Requirement statements. No hazard is identified in the Environmental Hazards section of the label.

Overview of OMRI-Listed Alternatives: Non-Synthetic: Phytotoxicity Hazards

The following phytotoxicity hazard statements appear on the following OMRI-listed alternatives with non-synthetic active ingredients:

Product Name	Phytotoxicity Hazard Statement
Cinnerate	All applications should be preceded by a phytotoxicity check to ensure that the material is safe for the particular plant variety.
Mildew Cure	Do not apply this product to seedlings or very young plants.
Trilogy	Exercise care in timing applications during early morning/late evening to minimize the potential for leaf burn. Use care on plants with tender tissue. Check for leaf burn in small scale trials prior to use. Do not apply to sensitive plant species. Do not apply to wilted or otherwise stressed plants, or to newly transplanted materials or crops prior to root establishment.
Sporatec	Do not apply on plants when the temperature is 90°F or above. Do not apply to wilted or otherwise stressed plants, or to newly transplanted materials prior to root establishment. Check for leaf and flower burn in small-scale trials before conducting large-scale application.
Organocide 3-in-1	If spraying on severely stressed or damaged plants, consider using a lower rate such as 1 oz. per gallon to avoid adding additional stress. For best results, spray in the early morning.

Overview of OMRI-Listed Alternatives: Non-Synthetic: Physical-Chemical Hazards and Other Storage Restrictions

The following physical-chemical hazards and other storage restriction statements appear on the following OMRI-listed alternatives with non-synthetic active ingredients:

Product Name	Physical Hazards and Other Storage Restrictions
Taegro Eco	Consists of living microbes. Store at room temperature and use before the expiration date. Avoid temperatures exceeding 73°F (23°C). Do not freeze.
Regalia Biofungicide	Avoid freezing.
Botector	Must be stored out of direct sunlight in a cool dry place. Do not freeze. From date of manufacture, product can be stored: 10 months at room temperature (47-68°F; 9-20°C) or 24 months at cold temperature (34-46°F; 1-8°C).
Prestop Biofungicide	Consists of live microbes. Store below 46°F (8°C) for up to 6 months. Immediately use the entire package's content after opening.
Mycostop Biofungicide	Consists of live microbes. Store below 46°F (8°C). Do not store open packets since product will lose its activity.
Zonix	Store out of direct sunlight and away from heat sources. Keep from overheating or freezing.
Actinovate	Keep from overheating or freezing. Optimum storage temperature is 40°F to 85°F. Contains live spores of a microbe.
Cinnerate	Store upright at room temperature. Avoid exposure to extreme temperatures. Do not expose to light and keep away from any heat source. Do not mix with oxidizing, strong acidic or basic materials.
Trilogy	Do not store below 40°F (4°C). Do not use or store near heat or open flame.
Sporatec	Do not use, pour, spill or store near heat or open flames.
BacStop EF 400	Store at temperatures between 41°F and 85°F (5°C and 30°C).

Overview of OMRI-Listed Alternatives: Non-Synthetic: User Convenience and Other Considerations

Polyoxin D Zinc Salt 5SC Fungicide requires minimal personal protective equipment and can be applied under most weather conditions thought to be suitable for making pesticide spray applications. No spray solution buffering is required or recommended. Polyoxin D Zinc Salt 5SC Fungicide has curative efficacy for some crop/disease combinations.

Product Name	User Convenience and Other Considerations
Double Nickel 55	Broad-spectrum preventative fungicide. Do not use highly alkaline or highly acidic water to mix sprays. Use a buffering agent if necessary to maintain neutrality (pH 6 to 8) of water in the tank.
Double Nickel LC Optiva Rhapsody ASO	Broads spectrum preventative fungicide.
Serenade ASO Serenade MAX	Broad spectrum fungicidal and bactericidal product.
Taegro Eco	Avoid temperatures exceeding 73°F (23°C). For suppression only. Most effective in low to medium disease situation.
Regalia Biofungicide	Preventative rather than a curative applications. Apply prior to disease infestation to protect the growing leaf tissue.
Botector	Applicators and other handlers must wear a respirator.
Prestop Biofungicide	Applicators and other handlers must wear a respirator. Foliar spray prohibited on listed crops; use limited to soil treatments. Do not tank mix with any pesticide or concentrated fertilizers. Do not use most chemical pesticides within 1-4 days of application.
Mycostop Biofungicide	Applicators and other handlers must wear a respirator. Do not tank mix with any pesticides or with concentrated fertilizers. Suppression only.
Zonix	Do not use for the control or prevention of late blight (*Phytophthora* spp.) when ambient temperatures are over 80°F. At above 80°F, that organism moves out of the zoospore stage and the product will not be efficacious.
Actinovate	Applicators and other handlers must wear a respirator. Best results will be obtained if the product is used prior to disease onset. Becomes active in soil or on the plant foliage when the temperatures are above 45°F and is not effective when temperatures remain cold. Do not apply soil fumigants to treated areas.
Cinnerate	Broad spectrum, contact foliar fungicide.
Trilogy Sporatec	For optimal performance, do not mix with cold water (less than 45°F).
Organocide 3-in-1	For best results, spray in the morning.
Nuke Em	Do not spray on top of other insecticides. Do not mix with other insecticides. Not for sale in Mississippi, Indiana or New Mexico.
BacStop EF400	Wear protective eye wear and chemical resistance gloves.

Overview of OMRI-List Alternatives: Synthetic

Allowed Synthetic (7CFR §205.601) EPA Registered OMRI-Listed Alternatives Summary Table					
FRAC Code	Active Ingredient	NOP Status	Product Name	EPA Reg. No.	Product Label Statements
M1	Basic copper sulfate	Allowed synthetic (7CFR §205.601)	Basic Copper 53	45002-8	WARNING signal word. Causes substantial but temporary eye injury. Harmful if absorbed through skin or inhaled. Dermal sensitizer. Toxic to fish and aquatic organisms. Apples: Under conditions where copper injury is likely to occur, add additional lime. Cherries: Do not apply non-dormant sprays to sweet cherries or the English Morelo variety as severe crop injury may result.
	Copper hydroxide	Allowed synthetic (7CFR §205.601)	Nu-Cop 50 WP	42002-7	DANGER signal word. Corrosive. Causes irreversible eye damage. Harmful if swallowed, absorbed through skin, or inhaled. Skin sensitizer. Toxic to fish and aquatic organisms. Effectiveness reduced at pH greater than 9.0. Product should not be applied in spray water having a pH of less than 6.5 as phytotoxicity may result. Cucurbits: Crop injury may occur form application at higher rates and shorter intervals. Grapes: Slight to severe foliage injury may occur on copper sensitive varieties.
			Champ WG	55146-1	DANGER signal word. Corrosive. Causes irreversible eye damage. Harmful if inhaled. Skin sensitizer. Toxic to fish and aquatic organisms. Caneberries: Crop injury may occur if applied to foliage under certain conditions such as hot or prolonged moist periods. Cucurbits: Crop injury may occur form application at higher rates and shorter intervals. Grapes: Slight to severe foliage injury may occur on copper sensitive varieties.
	Copper hydroxide, Copper oxychloride	Allowed synthetic (7CFR §205.601)	Badge X2	80289-12	WARNING signal word. May be fatal if swallowed. Causes substantial but temporary eye injury. Harmful if absorbed through skin. Harmful if inhaled. Toxic to fish and aquatic organisms. Product must not be applied in a spray solution having a pH of less than 6.5 as phytotoxicity may occur. Do not tank mix product with Aliette® fungicide for use on any registered crops or ornamentals unless appropriate precautions have been taken to buffer the spray solution because severe phytotoxicity may result. Apples: Moderate to severe crop injury may occur from late application. Caneberries: Crop injury may occur if applied to foliage under certain environmental conditions such as hot or prolonged moist periods. Cherries: Do not apply to sweet cherry or the English Morello variety as severe injury will result. Moderate to severe injury such as leaf spotting and defoliation may occur from post-bloom applications. Cucurbits: Crop injury may occur from application at higher rates and shorter intervals. Grapes: Foliage injury may occur on copper sensitive varieties. Lettuce: Slight injury may occur under adverse conditions. Spinach: Flecking may occur on spinach leaves. Strawberries: Discontinue applications if signs of crop injury appear. Stone Fruits: Do not apply after full bloom or injury may occur.
	Copper octanoate	Allowed synthetic (7CFR §205.601)	Cueva Fungicide Concentrate	67702-2-70051	Harmful if swallowed or absorbed through skin. Toxic to fish and aquatic organisms. May cause some copper toxicity on some plant species. Store away from open fire or flame. Product may be damaged by freezing. Do not store product below 4°C. Do not mix with chelated or liquid fertilizers. Use caution when using product with other fungicides and insecticides. Grapes: Do not mix with lime. Certain Vinifera and French Hybrid varieties may be sensitive to copper sprays resulting in marginal leaf burn.

Allowed Synthetic (7CFR §205.601) EPA Registered OMRI-Listed Alternatives Summary Table					
FRAC Code	Active Ingredient	NOP Status	Product Name	EPA Reg. No.	Product Label Statements
	Copper sulfate pentahydrate	Allowed synthetic (7CFR §205.601)	CS 2005	66675-3	DANGER signal word. Corrosive. Causes irreversible eye damage and skin irritation. Harmful if swallowed, inhaled or absorbed through the skin. Dermal sensitizer. Toxic to fish and aquatic organisms. Do not mix with acidic compounds. Do not mix with pot ash. Crop injury statements. Store away from excessive heat. Product will freeze. Store and handle product in 316L stainless steel, fiberglass, PVC's, polypropylenes or plastic equipment. Keep away from galvanized pipe and any nylon storage handling equipment. Apples: Moderate to severe crop injury may occur from late application. Caneberries: Crop injury may occur if applied to foliage under certain environmental conditions such as hot or prolonged moist periods. Cherries: Do not apply to sweet cherry or the English Morello variety as severe injury will result. Moderate to severe injury such as leaf spotting and defoliation may occur from post bloom applications. Cucurbits: Crop injury may occur from application at higher rates and shorter intervals. Grapes: Foliage injury may occur on copper sensitive varieties. Strawberries: Discontinue applications if signs of crop injury appear. Stone fruits: Do not apply after full bloom or injury may occur.
			Copper Sulfate Crystals	56576-1	DANGER signal word. Corrosive. Causes eye damage and skin irritation. Harmful if swallowed. Toxic to fish. Crop injury statements. Grapes: Bordeaux mixture will exhibit some phytotoxicity on most varieties.
			Quimag Quimicos Aguila Copper Sulfate Crystals	73385-3	DANGER signal word. Corrosive. Causes irreversible eye damage. May be fatal if swallowed. Causes skin irritation. Dermal sensitizer. Toxic to fish and aquatic invertebrates. Endangered species restriction. Grapes: Bordeaux mixture will exhibit some phytotoxicity on most varieties.
	Cupric hydroxide	Allowed synthetic (7CFR §205.601)	Nu-Cop 50DF	45002-4	DANGER signal word. Corrosive. Causes irreversible eye damage. Harmful if swallowed or absorbed through skin. Dermal sensitizer. Toxic to fish and aquatic organisms. Effectiveness reduced at pH greater than 9.0. Product should not be applied in spray water having a pH of less than 6.5 as phytotoxicity may result. Berries: Crop injury may occur if applied to foliage under certain conditions such as hot or prolonged moist periods. Cherries: To avoid injury, do not apply after full bloom. Grapes: Foliage injury may occur on copper sensitive varieties. Leafy greens: Flecking and/or yellowing of leaves may occur. Injury may be severe enough to reduce crop value.
			Nu-Cop HB	42750-132	DANGER signal word. Corrosive. Causes irreversible eye damage. Harmful if swallowed, absorbed through skin, or inhaled. Product should not be applied in spray water having a pH of less than 6.5 as phytotoxicity may result. Apricots: To avoid crop injury, do not apply after full bloom. Caneberries: Crop injury may occur if applied to foliage under hot or moist environmental conditions. Cucurbits: Discontinue use if injury occurs. Grapes: Foliage injury may occur on copper sensitive varieties. Lettuce: Flecking and/or yellowing of leaves may occur. Injury may be severe enough to reduce crop value. Strawberries: Discontinue applications if signs of crop injury appear.
	Cuprous oxide	Allowed synthetic (7CFR §205.601)	Nordox 75 WG	48142-4	Harmful if swallowed or absorbed through skin. Causes eye irritation. Do not apply in a spray solution with a pH of less than 6.5. Apricots: Slight leaf injury may occur. Grapes: Foliage injury may occur on copper sensitive varieties. Lettuce: Slight injury may occur under adverse weather conditions.

Allowed Synthetic (7CFR §205.601) EPA Registered OMRI-Listed Alternatives Summary Table					
FRAC Code	Active Ingredient	NOP Status	Product Name	EPA Reg. No.	Product Label Statements
M2	Calcium polysulfide	Allowed synthetic (7CFR §205.601)	Rex Lime Sulfur Solution	71096-6	DANGER signal word. Corrosive. Causes irreversible eye damage. Causes skin burns. Harmful if swallowed or if absorbed through skin. Toxic to fish. Do not mix with acids or phosphate fertilizer products. Deadly and potentially extremely flammable hydrogen sulfide gas may be emitted. Do not store near fertilizers. Crop injury statements.
	Sulfur	Allowed synthetic (7CFR §205.601)	Acoidal	62562-4	Harmful if swallowed, inhaled, or absorbed through skin. Toxic to fish and aquatic organisms. Sulfur dust suspended in air ignites easily. Keep away from heat, sparks, or flames. Do not smoke while applying this product. Sulfur may cause severe fruit and foliage injury to certain crops. Sulfur may burn foliage when temperature is high. Do not apply within 2 weeks of an oil spray treatment.
			Cosavet-DF	70905-1	Harmful if swallowed, inhaled, or absorbed through skin. Causes moderate eye irritation. Sulfur dust suspended in air ignites easily. Keep away from heat, sparks, or flames. Do not smoke while applying this product. Sulfur may cause severe fruit and foliage injury on certain crops. Sulfur may burn foliage when temperature is high. Do not apply if temperatures during or within 3 days after application are expected to exceed 90°F.
			Defend DF	62562-8	Harmful if swallowed, inhaled, or absorbed through skin. Toxic to fish and aquatic organisms. Sulfur dust suspended in air ignites easily. Keep away from heat, sparks, or flames. Do not smoke while applying this product. Sulfur may cause severe fruit and foliage injury to certain crops. Sulfur may burn foliage when temperature is high. Do not apply within 2 weeks of an oil spray treatment.
			Kumulus DF	51306-352-66330	Harmful if swallowed. Avoid breathing spray mist. Avoid contact with eyes, skin, and clothing. Do not apply within 2 weeks of an oil spray treatment. Do not store above 104°F. Store away from heat, sparks, and open flame.
			Micro Sulf	55146-75	Harmful if swallowed, inhaled, or absorbed through skin. Causes eye irritation. Risk of crop injury if temperature exceeds 90°F within 3 days following application. Do not use on any crop unless sulfur has been shown to be safe in your locality. Do not apply within 14 days of an oil spray. Keep away from heat, sparks, or flames. Do not smoke while applying this product.
			Microthiol Disperss	70506-187	Harmful if swallowed, inhaled, or absorbed through skin. Risk of crop injury if temperature exceeds 90°F within 3 days following application. Do not use on any crop unless sulfur has been shown to be safe in your locality. Do not store near flammable materials. Do not store in a manner where cross-contamination with other pesticides, fertilizers, food or feed could occur. Restrictions regarding application time before and after an oil spray treatment.
			Thiolux	34704-1079	Harmful if swallowed, inhaled, or absorbed through skin. Causes eye irritation. Sulfur may case severe fruit and foliage injury to certain crops. Risk of crop injury if temperature exceeds 90°F within 3 days following application. Do not apply within 14 days of an oil spray. Sulfur dust suspended in air easily ignites. Keep away from heat, sparks, or flames. Do not smoke while applying this product.
Not classified; Inorganic salt	Potassium bicarbonate	Allowed synthetic (7CFR §205.601)	EcoMate Amicarb O	5905-541	Harmful if swallowed. Causes moderate eye irritation. Broad spectrum contact foliar fungicide. Prevent exposure to moisture during storage. Avoid contamination with other pesticides and fertilizers.
			Kaligreen	70231-1	Harmful if swallowed, absorbed through skin, or inhaled. Do not mix with highly acidic products as effectiveness may be compromised. Use of a buffering agent for acidification of a tank mixture may also decrease effectiveness. Crop injury may result due to certain environmental or growing conditions, manner of use or application.
			Milstop	70870-1-68539	Harmful if swallowed. Causes moderate eye irritation. Broad spectrum contact foliar fungicide. Do not mix with other soluble pesticides or fertilizers. Not compatible with mild alkaline solutions. Acidification of solution will cause reduced product performance. Prevent exposure to moisture during storage. Avoid contamination with other pesticides and fertilizers.
	Potassium silicate	Allowed synthetic (7CFR §205.601)	Sil-Matrix	82100-1	Causes moderate eye irritation. Avoid contact with glass. Remove promptly from glass surfaces. Store product above 40°F. Do not store in aluminum, fiberglass, copper, brass, zinc, or galvanized containers. Protect from excessive heat. Broad spectrum preventative fungicide.
Not classified; Organic salt	Potassium salts of fatty acids	Allowed synthetic (7CFR §205.601)	M-Pede	10163-324	WARNING signal word. Causes substantial but temporary eye injury and skin irritation. May be hazardous to aquatic invertebrates. Do not use with sulfur or within 3 days of a sulfur application. Apply M-Pede solutions to wet (minimize run-off) to decrease the potential for injury on foliage, fruit and flowers of sensitive plants. Avoid application to new transplants and unrooted cuttings.

Allowed Synthetic (7CFR §205.601) EPA Registered OMRI-Listed Alternatives Summary Table					
FRAC Code	Active Ingredient	NOP Status	Product Name	EPA Reg. No.	Product Label Statements
Not classified; Oxidizing agent	Hydrogen dioxide, Peroxyacetic acid	Allowed synthetic (7CFR §205.601)	Oxidate 2.0	70299-2	DANGER signal word. Causes irreversible eye damage. May be fatal if swallowed. Causes skin irritation or temporary discoloration of exposed skin. Highly toxic to bees and other beneficial insects. Toxic to fish. Toxic to birds who eat treated seed on soil surface. Strong oxidizing agent. Do not use in undiluted form. Never bring undiluted product in contact with other pesticides, cleaners or oxidative agents. May react with residues of metal-based fungicides or supplements. Allow at least 24 hrs. after application of metal-based products. Do not spray during conditions of intense heat, drought, or poor plant vigor (or vine canopy). Do not apply in conjunction with any other pesticides or fertilizers. Do not allow product to become overheated in storage. Do not store in a manner where cross-contamination with other pesticides or fertilizers could occur. Apply consecutive applications until control is achieved; then apply preventative treatments.
	Hydrogen peroxide, Hydrogen dioxide	Allowed synthetic (7CFR §205.601)	Perpose Plus	86729-1	DANGER signal word. Causes irreversible eye damage and skin burns. May be fatal if absorbed through the skin. Harmful if swallowed. Do not breathe vapor from concentrate. Toxic to birds, mammals, fish and aquatic life. At temperatures exceeding 156°F, decomposition releases oxygen. The oxygen released could initiate or promote combustion of other materials. Store away from combustibles. Broad spectrum algaecide and fungicide. Apply curative rates for 3 consecutive days (drenching the entire plant) followed by weekly preventative treatments.
Not classified; Petroleum oils	Mineral oil	Allowed synthetic (7CFR §205.601)	Glacial Spray Fluid	34704-849	Harmful is swallowed, absorbed through skin, or inhaled. Causes eye irritation. Prolonged or repeated skin contact may cause allergic reaction in some individuals. Potential skin sensitizer. Drift and runoff may be hazardous to aquatic organisms in water adjacent to treated areas. Do not apply in undiluted form. Sensitive foliage may be injured. Do not spray oil sensitive varieties. Crop injury prevention use restrictions. Do not make oil application within 2 weeks prior to or after an application of sulfur. Use restrictions regarding sulfur and specified conventional active ingredients. Grapes: Do not tank mix oil and copper more than once/season. Do not use oil and copper together with fruit present.
			PureSpray Green	69526-9	Harmful if swallowed or absorbed through skin. Prolonged or repeated skin contact may cause allergic reaction in some individuals. Drift and runoff may be hazardous to aquatic organisms in water adjacent to treated areas. Use extreme care when using concentrate sprays as the potential for crop phytotoxicity is increased. Avoid excess heat. Do not spray during or immediately prior to hot or freezing weather (over 95°F or under 32°F), hot dry winds, rain or other unsuitable conditions. Do not overspray or double spray. Spray plants only when they are in vigorous condition and when their moisture condition is suitable. Before using, make certain spray tank is free of sulfur residues. Do not apply micronized sulfur within 10 days of an oil application. Do not apply oil within 14 days of an application of wettable or dusting sulfur. Do not apply to oil sensitive varieties. See label for additional compatibility restrictions regarding many conventional active ingredients. Grapes: Do not apply within 14 days of harvest. Do not tank mix oil and copper more than once/season. Do not use oil and copper together with fruit present.
	Paraffinic oil	Allowed synthetic (7CFR §205.601)	Organic JMS Stylet Oil	65564-1	Harmful if swallowed. Toxic to fish. Do not freeze. Do not spray wet foliage. Do not spray when freezing temperatures are anticipated within 48 hours of an oil application, above 90°F (32°C) or when plants are under heat or moisture stress. Do not apply to vegetables when the temperature is below 50°F (10°C). Do not apply micronized sulfur within 10 days of an oil application. Do not apply oil within 14 days of an application of wettable or dusting sulfur. Do not apply to oil sensitive varieties. See label for additional compatibility restrictions. Grapes: Do not use copper and oil when fruit is present. Do not apply micronized sulfur within 10 days of an oil application. Do not apply oil with 14 days of an application of wettable or dusting sulfur.
	Petroleum oil	Allowed synthetic (7CFR §205.601)	SuffOil-X	48813-1-68539	Harmful if absorbed through skin. Prolonged or frequently repeated skin contact may cause allergic reactions in some individuals. Do not use in combination with any product containing sulfur. Do not use with any product whose label recommends the use of no oils. Do not use in combination with NPK foliar fertilizer applications. Do not apply during periods of drought or when plants exhibit moisture stress. Fungicide, insecticide, and miticide.
			TriTek	48813-1	

Overview of OMRI-List Alternatives: Synthetic: Hazards to Humans

Polyoxin D Zinc Salt 5SC Fungicide has lower acute toxicity than the following allowed synthetic OMRI-listed alternatives. The synthetic alternatives are listed in largely descending acute toxicity.

Brand Name	Signal Word	EPA Acute Mammalian Toxicity Label Statement
Rex Lime Sulfur Solution	DANGER	Corrosive. Causes irreversible eye damage. Causes skin burns. Harmful if swallowed or if absorbed through skin.
Oxidate 2.0	DANGER	Causes irreversible eye damage. May be fatal if swallowed. Causes skin irritation or temporary discoloration of exposed skin.
Perpose Plus	DANGER	Causes irreversible eye damage and skin burns. May be fatal if absorbed through the skin. Harmful if swallowed.
Quimag Quimicos Aguila Copper Sulfate Crystals	DANGER	Corrosive. Causes irreversible eye damage. May be fatal if swallowed. Causes skin irritation.
CS 2005	DANGER	Corrosive. Causes irreversible eye damage and skin irritation. Harmful if swallowed, inhaled or absorbed through the skin.
Nu-Cop 50 WP Nu-Cop HB	DANGER	Corrosive. Causes irreversible eye damage. Harmful if swallowed, absorbed through skin, or inhaled.
Rex Lime Sulfur Solution	DANGER	Corrosive. Causes irreversible damage. Causes skin burns. Harmful if swallowed or if absorbed through skin.
Nu-Cop 50DF	DANGER	Corrosive. Causes irreversible eye damage. Harmful if swallowed or absorbed through skin.
Champ WG	DANGER	Corrosive. Causes irreversible eye damage. Harmful if inhaled.
Badge X2	WARNING	May be fatal is swallowed. Causes substantial but temporary eye injury. Harmful if absorbed through skin. Harmful if inhaled.
M-Pede	WARNING	Causes substantial but temporary eye injury and skin irritation.
Glacial Spray Fluid	CAUTION	Harmful if swallowed, inhaled, or absorbed through skin. Causes eye irritation.
Cosavet-DF	CAUTION	Harmful if swallowed, inhaled, or absorbed through skin. Causes moderate eye irritation.
Acoidal Defend DF Micro Sulf Microthiol Disperss Kaligreen	CAUTION	Harmful if swallowed, inhaled, or absorbed through skin.
Nordox 75 WG Thiolux	CAUTION	Harmful if swallowed or absorbed through skin. Causes eye irritation.
Cueva Fungicide Concentrate PureSpray Green	CAUTION	Harmful if swallowed or absorbed through skin.
Ecomate Amicarb O Milstop	CAUTION	Harmful if swallowed. Causes moderate eye irritation.
Kumulus DF Organic JMS Style Oil	CAUTION	Harmful if swallowed.
SuffOil-X TeiTek	CAUTION	Harmful if absorbed through skin.
Sil-Matrix	CAUTION	Causes moderate eye irritation.

Overview of OMRI-List Alternatives: Synthetic: Dermal Sensitization

Synthetic alternatives with dermal sensitization label statements are summarized below.

Product Name	Dermal Sensitization Label Statements
Nu-Cop 50 WP Champ WG CS 2005 Quimag Quimicos Aguila Copper Sulfate Crystals Nu-Cop 50DF	Skin (dermal) sensitizer.
Glacial Spray Fluid	Potential skin sensitizer.
PureSpray Green	Prolonged or repeated skin contact may cause allergic reaction in some individuals.
SuffOil-X TriTek	Prolonged or frequently repeated skin contact may cause allergic reactions in some individuals.

Overview of OMRI-List Alternatives: Synthetic: Environmental Hazards

The following environmental hazard statements appear on the labels for OMRI-listed alternatives with synthetic active ingredients. The environmental hazard statements are listed in approximately descending level of environmental hazard.

Product Name	Environmental Hazards
Oxidate 2.0	Highly toxic to bees and other beneficial insects. Toxic to fish. Toxic to birds who eat treated seed on soil surface.
Perpose Plus	Toxic to birds, mammals, fish and aquatic life.
Quimag Quimicos Aguila Copper Sulfate Crystals	Toxic to fish and aquatic invertebrates. Endangered species restriction.
Basic Copper 53 Nu-Cop 50 WP Champ WG Badge X2 Cueva Fungicide Concentrate CS 2005 Nu-Cop 50DF Defend DF	Toxic to fish and aquatic organisms.
Copper Sulfate Crystals Rex Lime Sulfur Solution Organic JMS Stylet Oil	Toxic to fish.
M-Pede	May be hazardous to aquatic invertebrates.
Glacial Spray Fluid PureSpray Green	Drift and runoff may be hazardous to aquatic organisms in water adjacent to treated areas.

Overview of OMRI-List Alternatives: Synthetic: Phytotoxicity Hazards

The following phytotoxicity hazard statements appear on the labels for OMRI-listed alternatives with synthetic active ingredients.

Product Name	Phytotoxicity Hazards
Basic Copper 53	Apples: Under conditions where copper injury is likely to occur, add additional lime. Cherries: Do not apply non-dormant sprays to sweet cherries or the English Morelo variety as severe crop injury may result.
Nu-Cop 50 WP	Product should not be applied in spray water having a pH of less than 6.5 as phytotoxicity may result. Cucurbits: Crop injury may occur form application at higher rates and shorter intervals. Grapes: Slight to severe foliage injury may occur on copper sensitive varieties.
Champ WG	Caneberries: Crop injury may occur if applied to foliage under certain conditions such as hot or prolonged moist periods. Cucurbits: Crop injury may occur form application at higher rates and shorter intervals. Grapes: Slight to severe foliage injury may occur on copper sensitive varieties.
Badge X2	Product must not be applied in a spray solution having a pH of less than 6.5 as phytotoxicity may occur. Do not tank mix product with Aliette® fungicide for use on any registered crops or ornamentals unless appropriate precautions have been taken to buffer the spray solution because severe phytotoxicity may result. Apples: Moderate to severe crop injury may occur from late application. Caneberries: Crop injury may occur if applied to foliage under certain environmental conditions such as hot or prolonged moist periods. Cherries: Do not apply to sweet cherry or the English Morello variety as severe injury will result. Moderate to severe injury such as leaf spotting and defoliation may occur from post-bloom applications. Cucurbits: Crop injury may occur from application at higher rates and shorter intervals. Grapes: Foliage injury may occur on copper sensitive varieties. Lettuce: Slight injury may occur under adverse conditions. Spinach: Flecking may occur on spinach leaves. Strawberries: Discontinue applications if signs of crop injury appear. Stone Fruits: Do not apply after full bloom or injury may occur.
Cueva Fungicide Concentrate	May cause some copper toxicity on some plant species. Certain Vinifera and French Hybrid varieties may be sensitive to copper sprays resulting in marginal leaf burn.
CS 2005	Apples: Moderate to severe crop injury may occur from late application. Caneberries: Crop injury may occur if applied to foliage under certain environmental conditions such as hot or prolonged moist periods. Cherries: Do not apply to sweet cherry or the English Morello variety as severe injury will result. Moderate to severe injury such as leaf spotting and defoliation may occur from post bloom applications. Cucurbits: Crop injury may occur from application at higher rates and shorter intervals. Grapes: Foliage injury may occur on copper sensitive varieties. Strawberries: Discontinue applications if signs of crop injury appear. Stone fruits: Do not apply after full bloom or injury may occur.
Copper Sulfate Crystals	Grapes: Bordeaux mixture will exhibit some phytotoxicity on most varieties.
Quimag Quimicos Aguila Copper Sulfate Crystals	Grapes: Bordeaux mixture will exhibit some phytotoxicity on most varieties.

Product Name	Phytotoxicity Hazards
Nu-Cop 50DF	Product should not be applied in spray water having a pH of less than 6.5 as phytotoxicity may result. Berries: Crop injury may occur if applied to foliage under certain conditions such as hot or prolonged moist periods. Cherries: To avoid injury, do not apply after full bloom. Grapes: Foliage injury may occur on copper sensitive varieties. Leafy greens: Flecking and/or yellowing of leaves may occur. Injury may be severe enough to reduce crop value.
Nu-Cop HB	Product should not be applied in spray water having a pH of less than 6.5 as phytotoxicity may result. Apricots: To avoid crop injury, do not apply after full bloom. Caneberries: Crop injury may occur if applied to foliage under hot or moist environmental conditions. Cucurbits: Discontinue use if injury occurs. Grapes: Foliage injury may occur on copper sensitive varieties. Lettuce: Flecking and/or yellowing of leaves may occur. Injury may be severe enough to reduce crop value. Strawberries: Discontinue applications if signs of crop injury appear.
Nordox 75 WG	Do not apply in a spray solution with a pH of less than 6.5. Apricots: Slight leaf injury may occur. Grapes: Foliage injury may occur on copper sensitive varieties. Lettuce: Slight injury may occur under adverse weather conditions.
Acoidal	Sulfur may cause sever fruit and foliage injury to certain crops. Sulfur may burn foliage when temperature is high. Do not apply within 2 weeks of an oil spray treatment.
Cosavet-DF	Sulfur may cause sever fruit and foliage injury on certain crops. Sulfur may burn foliage when temperature is high. Do not apply if temperatures during or within 3 days after application are expected to exceed 90°F.
Defend DF	Sulfur may cause sever fruit and foliage injury to certain crops. Sulfur may burn foliage when temperature is high. Do not apply within 2 weeks of an oil spray treatment.
Kumulus DF	Do not apply within 2 weeks of an oil spray treatment.
Micro Sulf	Risk of crop injury if temperature exceeds 90°F within 3 days following application. Do not use on any crop unless sulfur has been shown to be safe in your locality. Do not apply within 14 days of an oil spray.
Microthiol Disperss	Risk of crop injury if temperature exceeds 90°F within 3 days following application. Do not use on any crop unless sulfur has been shown to be safe in your locality. Restrictions regarding application time before and after an oil spray treatment.
Thiolux	Sulfur may case severe fruit and foliage injury to certain crops. Risk of crop injury if temperature exceeds 90°F within 3 days following application. Do not apply within 14 days of an oil spray.
Kaligreen	Crop injury may result due to certain environmental or growing conditions, manner of use or application.
M-Pede	Do not use with sulfur or within 3 days of a sulfur application. Apply M-Pede solutions to wet (minimize run-off) to decrease the potential for injury on foliage, fruit and flowers of sensitive plants. Avoid application to new transplants and unrooted cuttings.

<table>
<tr><th>Product Name</th><th>Phytotoxicity Hazards</th></tr>
<tr><td>Glacial Spray Fluid</td><td>Sensitive foliage may be injured. Do not spray oil sensitive varieties. Crop injury prevention use restrictions. Do not make oil application within 2 weeks prior to or after an application of sulfur. Use restrictions regarding sulfur and specified conventional active ingredients.
Grapes: Do not tank mix oil and copper more than once/season. Do not use oil and copper together with fruit present.</td></tr>
<tr><td>PureSpray Green</td><td>Use extreme care when using concentrate sprays as the potential for crop phytotoxicity is increased. Avoid excess heat. Do not spray during or immediately prior to hot or freezing weather (over 95°F or under 32°F), hot dry winds, rain or other unsuitable conditions. Do not overspray or double spray. Spray plants only when they are in vigorous condition and when their moisture condition is suitable. See label for additional compatibility restrictions regarding many conventional active ingredients. Before using, make certain spray tank is free of sulfur residues. Do not apply micronized sulfur within 10 days of an oil application. Do not apply oil within 14 days of an application of wettable or dusting sulfur. Do not apply to oil sensitive varieties.
Grapes: Do not apply within 14 days of harvest. Do not tank mix oil and copper more than once/season. Do not use oil and copper together with fruit present.</td></tr>
<tr><td>Organic JMS Stylet Oil</td><td>Do not apply micronized sulfur within 10 days of an oil application. Do not apply oil within 14 days of an application of wettable or dusting sulfur. Do not apply to oil sensitive varieties.
Do not spray wet foliage.
Do not spray when freezing temperatures are anticipated within 48 hours of an oil application, above 90°F (32°C) or when plants are under heat or moisture stress. Do not apply to vegetables when the temperature is below 50°F (10°C).
See label for additional compatibility restrictions.
Grapes: Do not use copper and oil when fruit is present. Do not apply micronized sulfur within 10 days of an oil application. Do not apply oil with 14 days of an application of wettable or dusting sulfur.</td></tr>
<tr><td>SuffOil-X</td><td rowspan="2">Do not use in combination with any product containing sulfur. Do not use with any product whose label recommends the use of no oils. Do not use in combination with NPK foliar fertilizer applications. Do not apply during periods of drought or when plants exhibit moisture stress.</td></tr>
<tr><td>TriTek</td></tr>
</table>

Overview of OMRI-List Alternatives: Synthetic: Physical-Chemical Hazards and Other Storage Restrictions

Product Name	Physical Hazards, Storage Restrictions, and Compatibility Label Statements
Nu-Cop 50 WP Nu-Cop 50DF	Effectiveness reduced at pH greater than 9.0.
Cueva Fungicide Concentrate	Store away from open fire or flame. Product may be damaged by freezing. Do not store product below 4°C. Do not mix with chelated or liquid fertilizers. Use caution when using product with other fungicides and insecticides. Grapes only: Do not mix with lime.
CS 2005	Do not mix with acidic compounds. Do not mix with pot ash. Store away from excessive heat. Product will freeze. Store and handle product in 316L stainless steel, fiberglass, PVC's, polypropylenes or plastic equipment. Keep away from galvanized pipe and any nylon storage handling equipment.
Rex Lime Sulfur Solution	Do not mix with acids or phosphate fertilizer products. Deadly and potentially extremely flammable hydrogen sulfide gas may be emitted. Do not store near fertilizers.
Acoidal Cosavet-DF Defend DF	Sulfur dust suspended in air ignites easily. Keep away from heat, sparks, or flames. Do not smoke while applying this product.
Kumulus DF	Do not store above 104°F. Store away from heat, sparks, and open flame.
Micro Sulf	Keep away from heat, sparks, or flames. Do not smoke while applying this product.
Microthiol Disperss	Do not store near flammable materials. Do not store in a manner where cross-contamination with other pesticides, fertilizers, food or feed could occur.
Thiolux	Sulfur dust suspended in air easily ignites. Keep away from heat, sparks, or flames. Do not smoke while applying this product.
EcoMate Amicarb O	Prevent exposure to moisture during storage. Avoid contamination with other pesticides and fertilizers.
Kaligreen	Do not mix with highly acidic products as effectiveness may be compromised. Use of a buffering agent for acidification of a tank mixture may also decrease effectiveness.
Milstop	Do not mix with other soluble pesticides or fertilizers. Not compatible with mild alkaline solutions. Acidification of solution will cause reduced product performance. Prevent exposure to moisture during storage. Avoid contamination with other pesticides and fertilizers.
Sil-Matrix	Avoid contact with glass. Remove promptly from glass surfaces. Store product above 40°F. Do not store in aluminum, fiberglass, copper, brass, zinc, or galvanized containers. Protect from excessive heat.
Oxidate 2.0	Strong oxidizing agent. Do not use in undiluted form. Never bring undiluted product in contact with other pesticides, cleaners or oxidative agents. May react with residues of metal-based fungicides or supplements. Allow at least 24 hrs. after application of metal-based products. Do not spray during conditions of intense heat, drought, or poor plant vigor (or vine canopy). Do not apply in conjunction with any other pesticides or fertilizers. Do not allow product to become overheated in storage. Do not store in a manner where cross-contamination with other pesticides or fertilizers could occur.
Perpose Plus	At temperatures exceeding 156°F, decomposition releases oxygen. The oxygen released could initiate or promote combustion of other materials. Store away from combustibles.
Organic JMS Stylet Oil	Do not freeze.

Overview of OMRI-List Alternatives: Synthetic: Broad Spectrum

For the synthetic OMRI-listed alternatives, the user convenience considerations are addressed largely in the Phytotoxicity Hazards and Physical Hazards, Storage Restrictions, and Compatibility Label Statements sections above. Please see summary below for a summary of the products with labels that claim the product to be a "broad spectrum" product.

Product Name	Broad Spectrum Product Label Statements
EcoMate Amicarb O	Broad spectrum contact foliar fungicide.
Milstop	Broad spectrum contact foliar fungicide.
Sil-Matrix	Broad spectrum preventative fungicide.
Perpose Plus	Broad spectrum algaecide and fungicide.
SuffOil-X TriTek	Fungicide, insecticide, and miticide.

PATHOGEN (DISEASE) / CROP DATA

Albugo occidentalis **(WHITE RUST) / SPINACH**

Albugo occidentalis **(White Rust) / Spinach: Time for Concern**
(Source: 2015 Organic Production and IPM Guide for Spinach, Cornell University Cooperative Extension)

Season long, especially if over-wintered inoculum source is present. Disease is favored by warm (72°F), sunny days followed by cool nights with dew. Spores are more viable when they experience a period of drying but will not germinate until leaves are wet.

Albugo occidentalis **(White Rust) / Spinach: Key Characteristics**
(Source: 2015 Organic Production and IPM Guide for Spinach, Cornell University Cooperative Extension)

Oospores may survive one year or more in New York in soil and infested crop debris, leading to primary infection of leaves closest to the soil. Symptoms of this fungus are small yellow spots on upper leaf surfaces and white pustules most commonly on lower leaf surfaces and petioles. As disease develops, pustules release spores that create secondary infections in other plants if conditions are favorable for spore germination. Different races can occur.

Albugo occidentalis **(White Rust) / Spinach: Life-Cycle**
(Source: Howard F. Schwartz and David H. Gent. White Rust Spinach. From Bugwoodwiki. March 2, 2015)

Albugo occidentalis is more closely related to downy mildew-type pathogens than the true rust pathogens. The source of the white rust pathogen that initiates epidemics is not known, but the pathogen is known to survive in infested crop debris as dormant resting structures (oospores) and, in milder climates, as mycelia and sporangia. Oospores are thought to be disseminated by splashing rain and irrigation water, and possibly by blowing soil. In warmer climates, sporangia produced on weeds can be deposited onto spinach by wind, whereupon they germinate and produce a mobile spore called a zoospore. Zoospores penetrate plants through natural openings, eventually germinate, and form mycelia in spinach tissues. Disease is favored by cool to moderate temperatures (50 to 68ºC) and abundant rainfall.

Diseased spinach plants produce windblown sporangia that serve as secondary inoculum, infecting other plants and beginning the disease cycle again. Oospores eventually form in diseased tissue and overwinter in infested crop debris and the soil.

Albugo occidentalis **(White Rust) / Spinach: Relative Risk**
(Source: 2015 Organic Production and IPM Guide for Spinach, Cornell University Cooperative Extension)

Considered a sporadic but very important disease of spinach because spots reduce crop quality and can make spinach unmarketable.

Albugo occidentalis **(White Rust) / Spinach: Management Options**
(Source: 2015 Organic Production and IPM Guide for Spinach, Cornell University Cooperative Extension)

Management Option	Recommendation for White Rust
Site selection	Do not plant spring crop near over-wintered fields.
Crop rotation	A three-year crop rotation will reduce pathogen inoculum.
Resistant varieties	Plant resistant varieties.
Seed selection	Fungus is not seed borne but may occur as a surface contaminant of seed produced in the eastern United States. However, most seed is grown in the western U.S. where white rust does not occur. If contamination is suspected, chlorine or hot-water seed treatment may be necessary, but check with your certifier for restrictions on use of chlorine.
Scouting/thresholds	Thresholds and scouting protocols have not been established for organic production.
Weed control	The only other known host of this species of white rust is Strawberry Blite, *Chenopodium capitatum* (L.) Asch.
Harvest	Use clean packing crates, boxes, etc. to avoid adding inoculum or new races of rust to the field. Use clean harvesting knives and equipment.
Postharvest	Deep plowing will speed rotting of infected plant debris.

Albugo occidentalis **(White Rust) / Spinach: Biological Control**
(Source: Howard F. Schwartz and David H. Gent. White Rust Spinach. From Bugwoodwiki. March 2, 2015)

No biological control strategies have been developed for white rust of spinach.

Albuga occidentalis (White Rust) / Spinach: OMRI-Listed Fungicides for Use in the United States										
FRAC Code	Source: 2015 Organic Production and IPM Guide for Spinach, Cornell Univ. Cooperative Extension							Source: EPA Label		NOP Status
	Active Ingredient	Product Name	Product Rate/Acre	PHI (Days)	REI (Days)	Efficacy	Comments	EPA Reg. No.	Comments	
44	*Bacillus subtilis* str. QST 713	Serenade ASO	2-6 qt	0	4	Not reviewed or no research available	Repeat on 2-10 day intervals as needed.	264-1152	Broad spectrum preventative fungicidal and bactericidal product.	Non-synthetic
		Serenade MAX	1-3 lb	0	4	Not reviewed or no research available	Repeat on 2-10 day intervals as needed.	69592-11	Dermal sensitizer. Broad spectrum preventative fungicidal and bactericidal product.	
P5	*Reynoutria sachalinensis*	Regalia Biofungicide	0.5-4 qt	0	4	Not reviewed or no research available	Apply in 50 to 100 gal water per acre.	84059-3	Causes moderate eye irritation Preventative rather than a curative application. Apply prior to disease infestation to protect the growing leaf tissue. Avoid freezing. Apply prior to disease infestation.	Non-synthetic
Not classified; Botanical oil	Cinnamon oil	Cinnerate	13-30 fl oz/ 100 gal water	0	0	Not reviewed or no research available	Apply 100-60 gal of spray/acre.	N/A. FIFRA §25(b) product.	May cause eye and skin irritation. May cause dermal sensitization. Store upright at room temperature. Avoid exposure to extreme temperatures. Do not expose to light and keep away from any heat source. Do not mix with oxidizing, strong acidic or basic materials. Broad spectrum, contact foliar fungicide. All applications should be preceded by a phytotoxicity check to ensure that the material is safe for the particular plant variety.	Non-synthetic
	Neem oil	Trilogy	0.5-1.0% solution	0	4	Not reviewed or no research available	Use 25-100 gal water per acre. Maximum use of 2 gal/ acre/application.	70051-2	Causes moderate eye irritation. Hazardous to fish and aquatic invertebrates. Toxic to bees exposed to direct treatment. Broad spectrum. Exercise care in timing applications during early morning/late evening to minimize the potential for leaf burn. Use care on plants with tender tissue. Check for leaf burn in small scale trials prior to use. Do not apply to sensitive plant species. Do not apply to wilted or otherwise stressed plants, or to newly transplanted materials or crops prior to root establishment. For optimal performance, do not mix with cold water (less than 45°F). Do not store below 40°F (4°C). Do not use or store near heat or open flame.	Non-synthetic
M1	Basic copper sulfate	Basic Copper 53	2-4 lb	0	24	Effective in half or more of recent university trials		45002-8	WARNING signal word. Causes substantial but temporary eye injury. Harmful if absorbed through skin or inhaled. Dermal sensitizer. Toxic to fish and aquatic organisms.	Synthetic

Albuga occidentalis (White Rust) / Spinach: OMRI-Listed Fungicides for Use in the United States										
FRAC Code	Source: 2015 Organic Production and IPM Guide for Spinach, Cornell Univ. Cooperative Extension							Source: EPA Label		NOP Status
	Active Ingredient	Product Name	Product Rate/Acre	PHI (Days)	REI (Days)	Efficacy	Comments	EPA Reg. No.	Comments	
	Copper hydroxide	Nu-Cop 50 WP	2-4 lb	1	24	Effective in half or more of recent university trials	Apply every 7-10 days.	42002-7	DANGER signal word. Corrosive. Causes irreversible eye damage. Harmful if swallowed, absorbed through skin, or inhaled. Skin sensitizer. Toxic to fish and aquatic organisms. Product should not be applied in spray water having a pH of less than 6.5 as phytotoxicity may result. Effectiveness reduced at pH greater than 9.0.	Synthetic
		Champ WG	1-1.58 lb	0	48	Effective in half or more of recent university trials	Repeat at 7-10 day intervals as needed. Flecking may occur on spinach leaves.	55146-1	DANGER signal word. Corrosive. Causes irreversible eye damage. Harmful if inhaled. Skin sensitizer. Toxic to fish and aquatic organisms.	
	Copper hydroxide, Copper oxychloride	Badge X2	1.75-1.25 lbs	0	48	Effective in half or more of recent university trials	Flecking may occur on spinach leaves.	80289-12	WARNING signal word. May be fatal if swallowed. Causes substantial but temporary eye injury. Harmful if absorbed through skin. Harmful if inhaled. Toxic to fish and aquatic organisms. Product must not be applied in a spray solution having a pH of less than 6.5 as phytotoxicity may occur. Do not tank mix product with Aliette® fungicide for use on any registered crops or ornamentals unless appropriate precautions have been taken to buffer the spray solution because severe phytotoxicity may result. Spinach: Flecking may occur on spinach leaves.	Synthetic
	Copper octanoate	Cueva Fungicide Concentrate	0.5-2.0 gal/ 100 gal water	0	4	Effective in half or more of recent university trials	Apply spray mix at 50-100 gallons of water per acre.	67702-2-70051	Harmful if swallowed or absorbed through skin. Toxic to fish and aquatic organisms. May cause some copper toxicity on some plant species. Store away from open fire or flame. Product may be damaged by freezing. Do not store product below 4°C. Do not mix with chelated or liquid fertilizers. Use caution when using product with other fungicides and insecticides.	Synthetic

Albuga occidentalis (White Rust) / Spinach: OMRI-Listed Fungicides for Use in the United States										
FRAC Code	Source: 2015 Organic Production and IPM Guide for Spinach, Cornell Univ. Cooperative Extension							Source: EPA Label		NOP Status
	Active Ingredient	Product Name	Product Rate/Acre	PHI (Days)	REI (Days)	Efficacy	Comments	EPA Reg. No.	Comments	
	Copper sulfate pentahydrate	CS 2005	19.2-25.6 oz	0	48	Effective in half or more of recent university trials	Flecking may occur on spinach leaves.	66675-3	DANGER signal word. Corrosive. Causes irreversible eye damage and skin irritation. Harmful if swallowed, inhaled or absorbed through the skin. Dermal sensitizer. Toxic to fish and aquatic organisms. Do not mix with acidic compounds. Do not mix with pot ash. Crop injury statements. Store away from excessive heat. Product will freeze. Store and handle product in 316L stainless steel, fiberglass, PVC's, polypropylenes or plastic equipment. Keep away from galvanized pipe and any nylon storage handling equipment.	Synthetic
	Cupric hydroxide	Nu-Cop HB	1-1.5 lb	0	24	Effective in half or more of recent university trials	Repeat at 7-10 day intervals as needed.	42750-132	DANGER signal word. Corrosive. Causes irreversible eye damage. Harmful if swallowed, absorbed through skin, or inhaled. Product should not be applied in spray water having a pH of less than 6.5 as phytotoxicity may result.	Synthetic
	Cuprous oxide	Nordox 75 WG	1.25-2 lb	0	12	Effective in half or more of recent university trials	Apply every 7-10 days.	48142-4	Harmful if swallowed or absorbed through skin. Causes eye irritation. Do not apply in a spray solution with a pH of less than 6.5.	Synthetic
M2	Sulfur	Acoidal	4-6 lb	0	24	Not reviewed or no research available		62562-4	Harmful if swallowed, inhaled, or absorbed through skin. Toxic to fish and aquatic organisms. Sulfur dust suspended in air ignites easily. Keep away from heat, sparks, or flames. Do not smoke while applying this product. Sulfur may cause severe fruit and foliage injury to certain crops. Sulfur may burn foliage when temperature is high. Do not apply within 2 weeks of an oil spray treatment.	Synthetic
		Defend DF	4-6 lb	0	24	Not reviewed or no research available		62562-8		
		Micro Sulf	4-6 lb	0	24	Not reviewed or no research available	Repeat at 7-10 day intervals as needed.	55146-75	Harmful if swallowed, inhaled, or absorbed through skin. Causes eye irritation. Risk of crop injury if temperature exceeds 90°F within 3 days following application. Do not use on any crop unless sulfur has been shown to be safe in your locality. Do not apply within 14 days of an oil spray. Keep away from heat, sparks, or flames. Do not smoke while applying this product.	

Albuga occidentalis (White Rust) / Spinach: OMRI-Listed Fungicides for Use in the United States										
FRAC Code	Source: 2015 Organic Production and IPM Guide for Spinach, Cornell Univ. Cooperative Extension							Source: EPA Label		NOP Status
	Active Ingredient	Product Name	Product Rate/Acre	PHI (Days)	REI (Days)	Efficacy	Comments	EPA Reg. No.	Comments	
Not classified; Oxidizing agent	Hydrogen dioxide, Peroxyacetic acid	Oxidate 2.0	Initial/Curative: 128 fl oz/ 100 gal water; 30-100 gal solution/ acre Preventative: 40-128 fl oz/ 100 gal water; 30-100 gal solution/ acre	0	Until dry	Not reviewed or no research available	Apply 30-100 gallons spray solution per treated acre. Begin applications at curative rate, reduce to preventative rate after three applications.	70299-2	DANGER signal word. Causes irreversible eye damage. May be fatal if swallowed. Causes skin irritation or temporary discoloration of exposed skin. Highly toxic to bees and other beneficial insects. Toxic to fish. Toxic to birds who eat treated seed on soil surface. Strong oxidizing agent. Do not use in undiluted form. Never bring undiluted product in contact with other pesticides, cleaners or oxidative agents. May react with residues of metal-based fungicides or supplements. Allow at least 24 hrs. after application of metal-based products. Do not spray during conditions of intense heat, drought, or poor plant vigor (or vine canopy). Do not apply in conjunction with any other pesticides or fertilizers. Do not allow product to become overheated in storage. Do not store in a manner where cross-contamination with other pesticides or fertilizers could occur. Apply consecutive applications until control is achieved (1- to 3-day intervals); then apply preventative treatments (5-day intervals).	Synthetic
	Hydrogen peroxide, Hydrogen dioxide	Perpose Plus	Initial/ Curative: 1 fl oz/gal Weekly/ Preventative: 0.25-0.33 fl oz/gal	0	Until spray has dried	Not effective in any known trials	Hydrogen peroxide products effective in 0/1 trial. For initial or curative use, apply higher rate for 1 to 3 consecutive days. Then follow with weekly/preventative treatment. For weekly or preventative treatments, apply lower rate every five to seven days. At first sign of disease, use curative rate then resume weekly preventative treatment.	86729-1	DANGER signal word. Causes irreversible eye damage and skin burns. May be fatal if absorbed through the skin. Harmful if swallowed. Do not breathe vapor from concentrate. Toxic to birds, mammals, fish and aquatic life. At temperatures exceeding 156°F, decomposition releases oxygen. The oxygen released could initiate or promote combustion of other materials. Store away from combustibles. Broad spectrum algaecide and fungicide. Apply curative rates for 3 consecutive days (drenching the entire plant) followed by weekly preventative treatments.	Synthetic

Albugo occidentalis **(White Rust) / Spinach: Efficacy Trials**

Albugo occidentalis (White Rust) / Spinach #1: CER-2014-063

a. Design

Albugo occidentalis (White Rust) / Spinach #1: CER-2014-063: Design			
Title:	2014-2015 Fungicide Trial for Control of Spinach White Rust		
Authors and affiliations:	Larry Stein and Marcel Valdez, Texas A&M AgriLife Extension Service Devin Kerstetter and Tyler Knight, Del Monte Corporation		
Publication:	Not published. Permission received.		
Location:	Del Monte Research Farm near Crystal City, TX, USA		
Crop:	Spinach (Viroflay)		
Disease name:	White rust		
Pathogen:	*Albugo occidentalis*		
Test plot design:	Not reported		
Number of replicates:	Not reported		
Application equipment:	Foliar spray		
Spray volume:	15 gal/acre		
Number of applications:	4		
Chronology:	Application Dates	Application Interval	Evaluation Dates
	12/08/2014		12/22/2014
	12/17/2014	9 days	12/30/2014
	12/22/2014	5 days	01/14/2015
	12/30/2014	8 days	01/20/2015

b. Results

Albugo occidentalis (White Rust) / Spinach #1: CER-2014-063: Results								
Treatment	Rate/ Acre	g a.i./ ha	Active Ingredient	FRAC Code	Disease Rating (0-10 scale)			
					12/22/ 2014	12/30/ 2014	01/14/ 2015	01/20/ 2015
Untreated control			Not Applicable		8.0 d	10.0 f	10.0 g	10.0
Oso	6.5 fl oz	25	Polyoxin D zinc salt	19	3.3 abc	3.5 a-d	4.8 cde	5.8
Exirel	13.5 oz		Cyantraniliprole	28	5.0 c	6.8 e	7.5 f	9.0
Disease rating scale: 0 = No disease; 10 = Crop totally destroyed. Treatment means followed by the same letter are not statistically different. The statistical method and criteria were not reported.								

The report notes:

- White rust was observed in the plots in early December, 2014; and
- Performance probably would have been better if treatments were applied prior to infection.

Therefore, the treatments were curative.

No phytotoxicity was reported.

c. Discussion and Conclusions

Spinach was grown in Texas under conditions to promote disease development. The white rust rating in the untreated control was 10 (total crop loss) on a scale of 0 to 10.

Treatments of Polyoxin D Zinc Salt 5SC Fungicide applied curatively at 6.5 fl oz/acre (25 g a.i./ha). Four treatments applied at 5-day to 9-day intervals provided:

- White rust disease ratings of 3.3 to 5.8 which was equivalent to 58% control for the December 22, 2014 rating;
- Mean 53% (range 42% to 65%) control for the ratings when the untreated control crop was completely destroyed; and
- Statistically superior control compared to the untreated control and also treatment with cyantraniliprole.

No phytotoxicity was reported.

Alternaria solani (EARLY BLIGHT) / POTATOES

Alternaria solani (Early blight) / Potatoes: Introduction

(Source: 2015 Organic Production and IPM Guide for Potatoes, Cornell University Cooperative Extension)

Time for Concern: Early to mid-July through harvest in warm and humid weather.

Key Characteristics: This fungus causes leaf lesions that are dark brown and appear leathery with faint, concentric rings giving a "target-spot" effect. Spots grow to ½ inch. Under prolonged warm and humid conditions, spots may enlarge or coalesce, causing leaf yellowing and early senescence. Severe defoliation will reduce yields. Tuber infections appear as small, irregular, brownish black spots that are usually sunken. The rotted tuber tissue is firm, hard, and somewhat corky. Tuber infection is much less common than foliar infection. Early blight overwinters in infected plant debris and potato tubers.

Relative Risk: Prevalent in most growing seasons, but in comparison with late blight, this disease is less serious. There is a high risk for significant defoliation and yield reduction when susceptible varieties are grown in a warm, wet year.

Alternaria solani (Early Blight) / Potatoes: Disease Cycle

(Source: Early Blight Fact Sheet, Cornell University Cooperative Extension, July 1984)

The fungus overwinters either on potato tubers or in dead, infected plant debris either in the soil or on the soil surface. The concentration of initial or primary inoculum from these reservoirs is usually low. Therefore, primary infection is difficult to predict since early blight is less dependent upon specific weather conditions than late blight. Environmental factors and plant vigor also help to determine when the first early blight lesions are found. Infection can occur from early to mid July in New York when frequent rains or dews occur and daytime temperatures remain near 75-80°F. The fungus can penetrate the leaf surface directly through the epidermis and spots begin appearing in 2-3 days. Lesions are most numerous and pronounced on lower, older, and less vigorous leaves and on early maturing varieties. The lesions are dark brown and appear leathery with faint, concentric rings giving a "target-spot" effect. At first the spots are small (1 /8" in diameter) and oval or angular in shape, but later the spots can enlarge to about ½". In many cases they are bounded by the larger leaf veins. More spores are produced on the early blight spots and lesions may coalesce, greatly increasing the secondary spread of wind-borne conidia between plants and between fields. At harvest time, spores from blighted vines may be deposited onto tubers. These spores germinate during wet and warm weather and invade the tissue, primarily through cuts, bruises, or wounded surfaces.

Tuber infections appear as generally small, irregular, brownish—black spots which are usually slightly sunken (approx. 1/16"). Externally, the spots resemble those caused by late blight, but internally they are shallower and darker in color. The rotted tuber tissue is firm, hard, and somewhat corky. Early blight tuber rot develops slowly and may not be severe until quite late into the storage period. This decay may allow the entry of secondary organisms such as Fusarium fungi and soft rot bacteria.

Alternaria solani **(Early Blight) / Potatoes: Management Options**
(Source: 2015 Organic Production and IPM Guide for Potatoes, Cornell University Cooperative Extension)

Management Option	Recommendation for Early Blight
Scouting/Thresholds	Record the occurrence and severity of early blight. Thresholds have not been established for organic production.
Site selection	Select well-drained fields. Avoid planting adjacent to other solanaceous hosts such as tomato and eggplant, or adjacent to fields that were infected with early blight in the previous season, since these fields may serve as inoculum sources.
Planting	Plant rows in an east-west direction and used wide row spacing, 36 inches, to reduce prolonged leaf wetness.
Crop rotation	Minimum two-year rotation without potatoes, tomatoes, or eggplants if severe outbreaks have occurred.
Resistant varieties	Potato varieties differ in their susceptibility to early blight. Late maturing varieties are usually more resistant to early blight.
Seed selection/ Treatment	Plant phytosanitary certified seed.
Irrigation	Drip irrigation or very early morning overhead irrigation, which will allow the leaves to be dry for long periods, is preferred.
Vine killing	Allowing tubers to mature in the ground for at least two weeks after the vines die can reduce infection to tubers. Dig when the vines are dry.
Harvest	Avoid wounding tubers during harvest and post harvest operations.
Sanitation	Plow under all plant debris and volunteer potatoes immediately after harvest.
Storage	Examine tubers and discard infected tubers before storage. Periodically check stored tubers for disease symptoms.
Notes	Environmental stresses such as drought and nitrogen and phosphorous deficiencies increase susceptibility to early blight.

Alternaria solani **(Early Blight) / Potatoes:** OMRI-Listed Fungicides for Use in the United States										
FRAC Code	Source: 2015 Organic Production and IPM Guide for Potatoes, Cornell University Cooperative Extension							Source: EPA Label		NOP Status
	Active Ingredient	Product Name	Product Rate/Acre	PHI (Days)	REI (Days)	Efficacy	Comments	EPA Reg. No.	Comments	
44	*Bacillus amyloliquefaciens* str. D747	Double Nickel 55	0.25-3 lb	0	4	Not reviewed or no research available.	Suppression only.	70051-108	Causes moderate eye irritation. Dermal sensitizer. Broad-spectrum preventative fungicide. Do not use highly alkaline or highly acidic water to mix sprays. Use a buffering agent if necessary to maintain neutrality (pH 6 to 8) of water in the tank.	Non-synthetic
		Double Nickel LC	0.5-6 qt	0	4	Not reviewed or no research available.	Suppression only.	70051-114	Harmful if absorbed through skin. Harmful if inhaled. Dermal sensitizer. Broad-spectrum preventative fungicide.	
	Bacillus subtilis str. QST 713	Optiva	14-24 oz	0	4	Not reviewed or no research available.	Suppression only. Repeat on a 5-7 day interval or as needed.	62592-26	Causes moderate eye irritation. Dermal sensitizer. Broad spectrum preventative product.	Non-synthetic
		Serenade ASO	2-6 qt	0	4	Not reviewed or no research available.	For suppression, begin applications on after emergence and when conditions are conducive to disease development. Repeat on a 5-day to 7-day intervals or as needed.	264-1152	Broad spectrum preventative fungicidal and bactericidal product.	
		Serenade MAX	1-3 lb	0	4	Not reviewed or no research available.		69592-11	Dermal sensitizer. Broad spectrum preventative fungicidal and bactericidal product.	
P5	*Reynoutria sachalinensis*	Regalia Biofungicide	1-4 qt	0	4	Not reviewed or no research available.	Apply every 5-7 days.	84059-3	Causes moderate eye irritation. Preventative rather than a curative application. Apply prior to disease infestation to protect the growing leaf tissue. Avoid freezing.	Non-synthetic
Not classified; Biological	*Streptomyces lydicus* WYEC 108	Actinovate AG	3-12 oz	0	1 or until solution has dried	Not effective in any known trials.	*Streptomyces lydicus* products effective in 0/1 trial. Reapply every 7-14 days. Use a spreader sticker.	73314-1	Avoid contact with skin, eyes, or clothing. Avoid breathing dust or spray mist. Mixer/loaders and applicators must wear a dust/mist filtering respirator meeting NIOSH standards of at least N-95, R-95, or P-95. Repeated exposure to high concentrations of microbial proteins can cause allergic sensitization. Keep from overheating or freezing. Optimum storage temperature is 40°F to 85°F. Contains live spores of a microbe. Best results will be obtained if the product is used prior to disease onset. Becomes active in soil or on the plant foliage when the temperatures are above 45°F and is not effective when temperatures remain cold. Do not apply soil fumigants to treated areas.	Non-synthetic

Alternaria solani **(Early Blight) / Potatoes:** OMRI-Listed Fungicides for Use in the United States										
FRAC Code	Source: 2015 Organic Production and IPM Guide for Potatoes, Cornell University Cooperative Extension							Source: EPA Label		NOP Status
	Active Ingredient	Product Name	Product Rate/Acre	PHI (Days)	REI (Days)	Efficacy	Comments	EPA Reg. No.	Comments	
Not classified; Botanical oil	Neem oil	Trilogy	0.5-1.0% solution in 25-100 gal water	0	4	Not reviewed or no research available.	Limited to a maximum of 2 gallons/acre/application.	70051-2	Causes moderate eye irritation. Hazardous to fish and aquatic invertebrates. Toxic to bees exposed to direct treatment. Do not use or store near heat or open flame.	Non-synthetic
M1	Basic copper sulfate	Basic Copper 53	3-6 lb	0	24	Effective in less than half of recent university trials.		45002-8	WARNING signal word. Causes substantial but temporary eye injury. Harmful if absorbed through skin or inhaled. Dermal sensitizer. Toxic to fish and aquatic organisms.	Synthetic
	Copper hydroxide	Nu-Cop 50 WP	Light infestation: 1-1.5 lb Heavy infestation: 3-4 lb	1	24	Effective in less than half of recent university trials.	Apply every 7-10 days when plants are 6 inches high. Lower rate where disease is light and higher where disease pressure is more severe.	42002-7	DANGER signal word. Corrosive. Causes irreversible eye damage. Harmful if swallowed, absorbed through skin, or inhaled. Skin sensitizer. Toxic to fish and aquatic organisms. Product should not be applied in spray water having a pH of less than 6.5 as phytotoxicity may result. Effectiveness reduced at pH greater than 9.0.	Synthetic
		Champ WG	1-4 lb	0	48	Effective in less than half of recent university trials.	Apply 1-1.5 lb/acre where disease is light and up to 3 to 4 lb/acre where disease is more severe. Application at rates and timing recommended for control of early and late blight may provide suppression of Colorado potato beetle.	55146-1	DANGER signal word. Corrosive. Causes irreversible eye damage. Harmful if inhaled. Skin sensitizer. Toxic to fish and aquatic organisms.	
	Copper hydroxide, Copper oxychloride	Badge X2	0.5-1.75 lbs	0	48	Effective in less than half of recent university trials.		80289-12	WARNING signal word. May be fatal if swallowed. Causes substantial but temporary eye injury. Harmful if absorbed through skin. Harmful if inhaled. Toxic to fish and aquatic organisms. Product must not be applied in a spray solution having a pH of less than 6.5 as phytotoxicity may occur. Do not tank mix product with Aliette® fungicide for use on any registered crops or ornamentals unless appropriate precautions have been taken to buffer the spray solution because severe phytotoxicity may result.	Synthetic

Alternaria solani **(Early Blight) / Potatoes:** OMRI-Listed Fungicides for Use in the United States										
FRAC Code	Source: 2015 Organic Production and IPM Guide for Potatoes, Cornell University Cooperative Extension							Source: EPA Label		NOP Status
	Active Ingredient	Product Name	Product Rate/Acre	PHI (Days)	REI (Days)	Efficacy	Comments	EPA Reg. No.	Comments	
	Copper octanoate	Cueva Fungicide Concentrate	0.5-2.0 gal/ 100 gal water	0	4	Effective in less than half of recent university trials.	Apply at 50-100 gallons of spray mix/acre.	67702-2-70051	Harmful if swallowed or absorbed through skin. Toxic to fish and aquatic organisms. May cause some copper toxicity on some plant species. Store away from open fire or flame. Product may be damaged by freezing. Do not store product below 4°C. Do not mix with chelated or liquid fertilizers. Use caution when using product with other fungicides and insecticides. Do not reapply within 5 days.	Synthetic
	Copper sulfate pentahydrate	CS 2005	19.2-32 oz	0	48	Effective in less than half of recent university trials.		66675-3	DANGER signal word. Corrosive. Causes irreversible eye damage and skin irritation. Harmful if swallowed, inhaled or absorbed through the skin. Dermal sensitizer. Toxic to fish and aquatic organisms. Do not mix with acidic compounds. Do not mix with pot ash. Store away from excessive heat. Product will freeze. Store and handle product in 316L stainless steel, fiberglass, PVC's, polypropylenes or plastic equipment. Keep away from galvanized pipe and any nylon storage handling equipment.	Synthetic
	Cupric hydroxide	Nu-Cop 50DF	2 lb	1	24	Effective in less than half of recent university trials.		45002-4	DANGER signal word. Corrosive. Causes irreversible eye damage. Harmful if swallowed or absorbed through skin. Dermal sensitizer. Toxic to fish and aquatic organisms. Effectiveness reduced at pH greater than 9.0. Product should not be applied in spray water having a pH of less than 6.5 as phytotoxicity may result.	Synthetic
		Nu-Cop HB	0.5-2 lb	1	24	Effective in less than half of recent university trials.		42750-132	DANGER signal word. Corrosive. Causes irreversible eye damage. Harmful if swallowed, absorbed through skin, or inhaled. Crop in jury statements.	
	Cuprous oxide	Nordox 75 WG	0.66-4 lb	0	12	Effective in less than half of recent university trials.	Apply every 7-10 days when plants are 6 inches high until harvest.	48142-4	Harmful if swallowed or absorbed through skin. Causes eye irritation. Do not apply in a spray solution with a pH of less than 6.5.	Synthetic

Alternaria solani **(Early Blight) / Potatoes:** OMRI-Listed Fungicides for Use in the United States										
FRAC Code	Source: 2015 Organic Production and IPM Guide for Potatoes, Cornell University Cooperative Extension							Source: EPA Label		NOP Status
	Active Ingredient	Product Name	Product Rate/Acre	PHI (Days)	REI (Days)	Efficacy	Comments	EPA Reg. No.	Comments	
Not classified; Inorganic salt	Potassium bicarbonate	EcoMate Amicarb O	2.5-5 lb/100 gal water	0	4	Not reviewed or no research available.	Apply mixed solution at a minimum of 20 gal/acre.	5905-541	Harmful if swallowed. Causes moderate eye irritation. Broad spectrum contact foliar fungicide. Prevent exposure to moisture during storage. Avoid contamination with other pesticides and fertilizers.	Synthetic
Not classified; Oxidizing agent	Hydrogen dioxide, Peroxyacetic acid	Oxidate 2.0	Initial/ Curative: 128 fl oz/ 100 gal water; 30-100 gal solution/ acre Preventative: 40-128 fl oz/ 100 gal water; 30-100 gal solution/ acre	0	Until dry	Not reviewed or no research available.	Begin when plants are small. Apply first three treatments using the curative rate at 5-day intervals. Reduce rate to 32 fl oz/100 gal preventative rate after completion of third treatment and maintain 5-day interval spray cycle until harvest.	70299-2	DANGER signal word. Causes irreversible eye damage. May be fatal if swallowed. Causes skin irritation or temporary discoloration of exposed skin. Highly toxic to bees and other beneficial insects. Toxic to fish. Toxic to birds who eat treated seed on soil surface. Strong oxidizing agent. Do not use in undiluted form. Never bring undiluted product in contact with other pesticides, cleaners or oxidative agents. May react with residues of metal-based fungicides or supplements. Allow at least 24 hrs. after application of metal-based products. Do not spray during conditions of intense heat, drought, or poor plant vigor (or vine canopy). Do not apply in conjunction with any other pesticides or fertilizers. Do not allow product to become overheated in storage. Do not store in a manner where cross-contamination with other pesticides or fertilizers could occur. Apply consecutive applications until control is achieved; then apply preventative treatments.	Synthetic

Alternaria solani **(Early Blight) / Potatoes:** OMRI-Listed Fungicides for Use in the United States										
FRAC Code	Source: 2015 Organic Production and IPM Guide for Potatoes, Cornell University Cooperative Extension							Source: EPA Label		NOP Status
	Active Ingredient	Product Name	Product Rate/Acre	PHI (Days)	REI (Days)	Efficacy	Comments	EPA Reg. No.	Comments	
	Hydrogen peroxide, Hydrogen dioxide	Perpose Plus	Initial/ Curative: 1 fl oz/gal Weekly/ Preventative: 0.25-0.33 fl oz/gal	0	Until spray has dried	Not reviewed or no research available.	For initial use, apply higher rate for 1 to 3 consecutive days. Then follow with weekly/ preventative treatment. For weekly or preventative treatments, apply lower rate every five to seven days. At first signs of disease, use curative rate then resume weekly preventative treatment.	86729-1	DANGER signal word. Causes irreversible eye damage and skin burns. May be fatal if absorbed through the skin. Harmful if swallowed. Do not breathe vapor from concentrate. Toxic to birds, mammals, fish and aquatic life. At temperatures exceeding 156°F, decomposition releases oxygen. The oxygen released could initiate or promote combustion of other materials. Store away from combustibles. Broad spectrum algaecide and fungicide. Apply curative rates for 3 consecutive days (drenching the entire plant) followed by weekly preventative treatments.	Synthetic

Alternaria solani **(Early blight) / Potatoes: Efficacy Trials**

Alternaria solani (Early Blight) / Potatoes #1: Trial No. CER-2011-029

a. Trial Design

<table>
<tr><th colspan="6">Alternaria solani (Early Blight) / Potatoes #1: Trial No. CER-2011-029: Design</th></tr>
<tr><td>Title:</td><td colspan="5">Evaluation of Fungicide Programs for Potato Early Blight, Brown Spot and Tan Spot Control: 2011</td></tr>
<tr><td>Authors and affiliation:</td><td colspan="5">W. W. Kirk and R. L. Schafer
Department of Plant Pathology
Michigan State University
East Lansing, Michigan, USA</td></tr>
<tr><td>Publication:</td><td colspan="5">PDMR 6:V107</td></tr>
<tr><td>Location:</td><td colspan="5">East Lansing, Michigan, USA</td></tr>
<tr><td>Crop:</td><td colspan="5">Potato (variety ‘Russet Norkotah’)</td></tr>
<tr><td>Disease name (Pathogen):</td><td colspan="5">Early blight (Alternaria solani)
Brown leaf spot (Alternaria alternata)</td></tr>
<tr><td>Test plot design:</td><td colspan="5">Randomized complete block</td></tr>
<tr><td>Number of replicates:</td><td colspan="5">4</td></tr>
<tr><td>Application equipment:</td><td colspan="5">R&D spray boom</td></tr>
<tr><td>Spray solution volume:</td><td colspan="5">25 gal/acre (234 L/ha)</td></tr>
<tr><td>Number of applications:</td><td colspan="5">8</td></tr>
<tr><td>Application interval:</td><td colspan="5">7 days</td></tr>
<tr><td rowspan="2">Chronology:</td><td>Planting Date</td><td>Emergence Date</td><td>Fungicide Applications</td><td>Disease Evaluations</td><td>Harvest Date</td></tr>
<tr><td>05/25/2011</td><td>06/10/2011</td><td>07/05/2011 A
07/12/2011 B
07/19/2011 C
07/25/2011 D
08/01/2011 E
08/08/2011 F
08/16/2011 G
08/23/2011 H
08/30/2011 I</td><td>09/12/2011</td><td>10/22/2011</td></tr>
</table>

b. Results

Alternaria solani (Early Blight) / Potatoes #1: Trial No. CER-2011-029: Results

Treatment	Rate/ Acre	g a.i./ ha	Active Ingredient	FRAC Code	App. Code	Early Blight/ Brown Leaf Spot (Alternaria)		Yield (cwt/ acre)	Yield Increase (%)
						Incidence (%)	Control (%)		
Untreated Control						45.0 a		231 b	
CX-10440 5SC (Note 1)	3.8 fl oz	15	Polyoxin D zinc salt	19	ABCDEFGHI	36.3 ab	19.3	292 ab	26.4
CX-10440 5SC (Note 1)	7.5 fl oz	29	Polyoxin D zinc salt	19	ABCDEFGHI	35.0 bc	22.2	247 b	6.9
Echo ZN 4.17SC	1.5 pt		Chlorothalonil	M5	ABCDEFGHI	26.3 cd	41.6	277 ab	19.9
Echo ZN 4.17SC	1.5 pt		Chlorothalonil	M5	ABCDEFGHI	33.8 bc	24.9	258 ab	11.7
Scala 60 SC	7 fl oz		Pyrimethalin	9	EG				
Tanos 50WG	6 oz		Famozadone	11	ABCDEFGHI	10.0 e-h	77.8	266 ab	15.2
Manzate 75WG	1.5 lb		Cymoxanil	27					
Echo ZN 4.17SC	2.12 pt		Chlorothalonil	M5	ACEI	8.8 e-h	80.4	317 a	37.2
Priaxor 4.17 SC	4 fl oz		Fluxapryoxad	7	BF				
			Pyraclostrobin	11					
Echo ZN 4.17SC	2 pt		Chlorothalonil	M5					
Dithane Rainshield 75DF	2 lb		Mancozeb	M3	GH				
Super Tin 80 WP	2.5 oz		Triphenyltin hydroxide	30					

Values followed by the same letter are not significantly different at p= 0.05 (Fishers LSD).

Note 1: The list of treatments includes "CX-10440 11.3 SC." This is a typographical error. The treatment should have been described as "CX-10440 5SC." The only liquid formulation of polyoxin D zinc salt is the 5.0% SC formulation. The Certis USA, L.L.C. research code for the formulation is CX-10440. This formulation is also known as Polyoxin D Zinc Salt 5SC Fungicide. (The 11.3% formulation is an older formulation and is the water dispersible granule formulation, *i.e.*, a dry formulation.)

The report notes:

- Early blight severity values accumulated from emergence on June 10, 2011 to September 12, 2011 (evaluation date) were 3592; and
- Early blight developed steadily during August, and untreated controls reached about 45% foliar infection by September 12, 2011.

Therefore, the treatments were preventative and curative.

No phytotoxicity was observed.

c. Discussion and Conclusions

Potatoes grown in Michigan were evaluated for control of early blight (*Alternaria solani*) and brown spot (*Alternaria alternata*). Combined early blight plus brown leaf spot incidence in the untreated control was 45.0%.

Treatments of Polyoxin D Zinc Salt 5SC Fungicide were applied preventatively and curatively. Eight treatments at 7-day intervals applied at:

- 3.8 fl oz/acre (15 g a.i./ha) provided 19.3% control of early blight and 26.4% increased yield; and
- 7.5 fl oz/acre (29 g a.i./ha) provided 22.2% control of early blight and 6.9% increased yield.

The early blight disease control provided by polyoxin D zinc salt was:

- Statistically equivalent to that of chlorothalonil plus pyrimethalin; and
- Statistically less than the control provided by:
  - Chlorothalonil (alone);
  - Famozadone alternated with cymoxalin; and
  - A treatment program that included chlorothalonil, fluxaproxad, pyraclostrobin, mancozeb, and triphenyltin hydroxide.

No phytotoxicity was observed.

Alternaria solani (Early Blight) / Potatoes #2: Trial No. CER-2011-030

a. Design

Alternaria solani (Early Blight) / Potatoes #2: Trial No. CER-2011-030: Design		
Title:	Evaluation of Fungicides for Control of Potato Early Blight, 2011	
Authors and affiliation:	X.S. Qu, M.W. Peck, and B.J. Christ Department of Plant Pathology The Pennsylvania State University University Park, PA 16802, USA	
Publication:	PDMR 6:V113	
Location:	University Park, PA 16802, USA	
Crop:	Potato (cultivar ‘Atlantic’)	
Disease name:	Early blight	
Pathogen:	*Alternaria solani*	
Test plot design:	Randomized complete block	
Number of replicates:	4	
Application equipment:	Tractor-mounted nitrogen pressured side boom sprayer	
Spray volume:	45 gal/acre (421 L/ha)	
Inoculation:	Inoculated with a mixture of three isolates of *Alternaria solani* (1.28 x 10^5 conidia/ fl oz = 4.33 x 10^3 conidia/mL). (Date not specified.)	
Number of applications:	4 or 7	
Application interval:	Polyoxin D zinc salt: 14 to 18 days All except polyoxin D zinc salt: 7 to 10 days	
Chronology:	Application Dates	Disease Assessments Dates
	A 08/04/2011 B 08/11/2011 C 08/18/2011 D 08/26/2011 E 09/02/2011 F 09/12/2011 G 09/20/2011	 08/18/2011 08/27/2011 09/03/2011 09/12/2011 09/26/2011

b. Results

Alternaria solani (Early Blight) / Potatoes #2: Trial No. CER-2011-030: Results							
Treatment	Rate/ Acre	g a.i./ ha	Active Ingredient	FRAC Code	Application Timing	AUDPC	% Control
Untreated Control						922.6 a	
CX-10440 [1]	3.75 fl oz	14	Polyoxin D zinc salt	19	ACEG	755.9 ab	18.1
CX-10440 [1]	7.5 fl oz	29	Polyoxin D zinc salt	19	ACEG	556.3 bc	39.7
Bravo Weather Stik 6SC	1.5 pt		Chlorothalonil	M5	ABCDEFG	442.9 cd	54.2
Cabrio Plus	2.0 lb		Pyraclostrobin	11	ABCDEFG	212.9 de	76.9
			Metiram	M2			
Priaxor 500SC	4.0 fl oz		Fluxapryoxad	7	ABCDEFG	200.3 de	78.3
			Pyraclostrobin	11			
Endura 70WG	3.5 oz		Boscalid	7	ABCDEFG	367.6 cde	60.2
Headline SC	6.0 fl oz		Pyraclostrobin	11	ABCDEFG	299.5 cde	67.5

AUDPC = Area under the disease progression curve.
1. CX-10440 is the Certis USA, L.L.C. code for Polyoxin D Zinc Salt 5SC Fungicide.

No phytotoxicity was observed.

c. Discussion and Conclusions

Potatoes grown in Pennsylvania were evaluated for control of early blight (*Alternaria solani*). The test plots were inoculated with three isolates of *Alternaria solani*. Area under the disease suppression curve data were reported. The disease pressure was sufficient to observe statistical differences between the fungicide treatments and the untreated control.

Treatments of Polyoxin D Zinc Salt 5SC Fungicide were applied preventative and curatively. Four treatments applied at 14-day to 18-day intervals had a positive dose-response.

- Treatments at 3.75 fl oz/acre (14 g a.i./ha) provided 18.1% control.
- Treatments at 7.5 fl oz/acre (29 g a.i./ha) provided 39.7% control.

For all other fungicides, a total of 7 treatments were applied at 7-day to 10-day intervals.

Polyoxin D Zinc Salt 5SC Fungicide applied at 7.5 fl oz/acre provided control of early blight on potatoes that was:

- Statistically equivalent to the control provided by separate treatments of chlorothalonil, boscalid, and pyraclostrobin; and
- Statistically less than the control provided by pyraclostrobin plus metiram and of fluxapryoxad plus pyraclostrobin.

No phytotoxicity was observed.

Alternaria solani (Early Blight) / Potatoes #3: Trial No. CER-2012-028

a. Design

<table>
<tr><th colspan="6">Alternaria solani (Early Blight) / Potatoes #3: Trial No. CER-2012-028: Design</th></tr>
<tr><td>Title:</td><td colspan="5">Evaluation of Fungicide for Control of Potato Early Blight, 2012</td></tr>
<tr><td>Authors and affiliation:</td><td colspan="5">X. S. Qu, M. W. Peck, and B. J. Christ
Department of Plant Pathology
The Pennsylvania State University
University Park, PA 16802, USA</td></tr>
<tr><td>Publication:</td><td colspan="5">PDMR 7:V105</td></tr>
<tr><td>Location:</td><td colspan="5">University Park, PA 16802, USA</td></tr>
<tr><td>Crop:</td><td colspan="5">Potato (cultivar ‘Atlantic’)</td></tr>
<tr><td>Disease names:</td><td colspan="5">Early blight</td></tr>
<tr><td>Pathogen:</td><td colspan="5">Alternaria solani</td></tr>
<tr><td>Test plot design:</td><td colspan="5">Randomized complete block</td></tr>
<tr><td>Number of replicates:</td><td colspan="5">4</td></tr>
<tr><td>Application equipment:</td><td colspan="5">Tractor-mounted nitrogen-pressurize side boom sprayer</td></tr>
<tr><td>Spray volume:</td><td colspan="5">45 gal/acre (421 L/ha)</td></tr>
<tr><td>Inoculation:</td><td colspan="5">Inoculated 2 days after the first fungicide treatments.
(4.07×10^4 conidia/fl oz = 1.38×10^3 conidia/mL)</td></tr>
<tr><td>Number of applications:</td><td colspan="5">7</td></tr>
<tr><td>Application interval:</td><td colspan="5">7 to 8 days.</td></tr>
<tr><td rowspan="2">Chronology:</td><td>Planting Date</td><td>Application Dates</td><td>Inoculation Date</td><td>Disease Assessment Dates</td><td>Harvest Date</td></tr>
<tr><td>06/08/2012</td><td>08/07/2012
08/14/2012
08/21/2012
08/28/2012
09/04/2012
09/11/2012
09/19/2012</td><td>08/09/2012</td><td>08/16/2012
08/23/2012
09/01/2012
09/07/2012
09/14/2012
09/22/2012</td><td>10/05/2012</td></tr>
</table>

b. Results

Alternaria solani (Early Blight) / Potatoes #3: Trial No. CER-2012-028: Results								
Treatment	Rate/ acre	g a.i./ ha	Active Ingredient	FRAC Code	AUDPC	% Control	Yield (cwt/acre)	Yield Increase (%)
Untreated Control					680 a		340 d	
CX-10440 [1]	6.5 fl oz	29	Polyoxin D zinc salt	19	395 b	41.9	386 bcd	13.5
CX-10440 [1]	13 fl oz	50	Polyoxin D zinc salt	19	395 b	41.9	362 cd	6.5
Bravo	1.5 pt		Chlorothalonil	M5	230 c	66.2	416 abc	22.4
Priaxor 500 SC	4.0 oz		Fluxapyroxad	7	117 d	82.8	436 ab	28.2
			Pyraclostrobin	11				
Cabrio Plus	2.0 lb		Pyraclostrobin	11	110 d	83.8	459 a	35.0
			Metiram	M3				

AUDPC = Area under the disease progress curve from August 18, 2012 to September 26, 2012.
cwt/A = Hundred weight per acre for tubers with diameter greater than 1.875 inches.
Means followed by the same latter are not significantly different at *P* = 0.05 as determined by Fisher's protected least significant difference test.
1. CX-10440 is the Certis USA, L.L.C. code for Polyoxin D Zinc Salt 5SC Fungicide.

No phytotoxicity was reported.

c. Discussion and Conclusions

Potatoes grown in Pennsylvania were evaluated for control of early blight (*Alternaria solani*). Two days after the first application, the test plots were inoculated with three isolates of *Alternaria solani*. Results were reported as area under the disease progression curve. The disease pressure was sufficient to observe differences between the fungicide treatments and the untreated control.

Polyoxin D Zinc Salt 5SC Fungicide treatments were applied preventatively and curatively. Seven treatments applied at 7-day to 8-day intervals did not result in a positive dose response.

- Treatment at 6.5 fl oz/acre (29 g a.i./ha) provided 41.9% control of early blight of potatoes and 13.5% increased yield.
- Treatment at 13 fl oz/acre (29 g a.i./ha) also provided 41.9% control of early blight of potatoes and a smaller 6.5% increased yield.

The early blight disease control was statistically greater than the untreated control though statically less than the control provided by chlorothalonil, by fluxapyroxad plus pyraclostrobin, and by pyraclostrobin plus metiram.

At both rates, the increased yields in the Polyoxin D Zinc Salt 5SC Fungicide treatments were not statistically different that the untreated control. However, yield increases from Polyoxin D Zinc Salt 5SC Fungicide treatments were statistically equivalent to yield increases from chlorothalonil and from fluxapyroxad plus pyraclostrobin treatment. Treatments with pyraclostrobin plus metiram provided statistically greater yield increases.

No phytotoxicity was reported.

Alternaria solani and *A. tomatophila* (EARLY BLIGHT) / TOMATOES

Alternaria solani and *A. tomatophila* (Early blight) / Tomatoes: Introduction
(Source: Fulya Baysal-Gurel and Sally Miller, Early Blight Management for Organic Tomato Production, Organic Agriculture, September 16, 2010.)

Early blight is caused by *Alternaria solani* and *A. tomatophila*, which survive between crops on infected crop residues and on solanaceous host weeds. These fungi can also be carried on tomato seed. Early blight is common on tomatoes and potatoes, and it occasionally infects eggplants and peppers. It causes direct losses by the infection of fruits and indirect losses through leaf lesions, which reduce plant vigor. The disease is favored by warm temperatures and extended periods of leaf wetness from frequent rain, overhead irrigation, or dew. The fungal spores can be spread by wind and rain, irrigation, insects, workers, and on tools and equipment. Once the primary infections have occurred, they become the most important source of new spore production and are responsible for rapid disease spread. Early blight can develop quickly mid- to late season and is more severe when plants are stressed by poor nutrition, drought, other diseases, or pests.

Alternaria solani and *A. tomatophila* (Early blight) / Tomatoes: Symptoms
(Source: Fulya Baysal-Gurel and Sally Miller, Early Blight Management for Organic Tomato Production, Organic Agriculture, September 16, 2010.)

Early blight first appears as small brown-to-black lesions on older foliage. The tissue surrounding the primary lesions may become bright yellow, and when lesions are numerous, entire leaves may become chlorotic. As the lesions enlarge, they often develop concentric rings giving them a bull's-eye or target-spot appearance. When conditions are favorable for disease development, lesions can become numerous and plants defoliate, reducing both fruit quantity and quality. Fruit can become infected either in the green or ripe stage through the stem attachment. Lesions can become quite large, involve the whole fruit, and have characteristic concentric rings. Infected fruit often drops, and losses of immature fruit may occur. Fruit on defoliated plants are also subject to sunscald. Stems and petioles affected by early blight have elliptical concentric lesions, which severely weaken the plant. Lesions at the base of emerging seedlings can cause collar rot. If this arises consecutively on many seedlings, it may indicate contamination of tomato seeds or soil used for planting.

Alternaria solani and *A. tomatophila* (Early blight) / Tomatoes: Disease Management
(Source: Fulya Baysal-Gurel and Sally Miller, Early Blight Management for Organic Tomato Production, Organic Agriculture, September 16, 2010.)

Crop Rotation: Early blight is a soilborne disease, so rotation can be a good management tool. A good practice is to treat members of the same plant family as a group and rotate based on groups rather than individual crops. Solanaceous crops include tomatoes, potatoes, peppers, chilies, eggplants, and tobacco. Using a three or four year crop rotation with non-solanaceous crops will allow infested plant debris to decompose in the soil. Rotations with small grains, corn, or legumes are preferable.

Organic Amendments: Good quality compost improves soil structure and its ability to hold water and nutrients; it also supports microorganisms that contribute to biological control. Our research has shown that early blight severity was less in tomato plants grown in compost-amended soil in the high tunnel than in non-amended soil. Furthermore, incorporating the amendments into soil increased the total and marketable yield.

Sanitation: Early blight survives between crops in or on the residue from diseased plants, so it is important to remove diseased plants or destroy them immediately after harvest. Alternatively, bury diseased crop debris by deep-plowing to reduce spore levels available for infection of new plants. Solanaceous weeds, such as jimsonweed, horse nettle, groundcherry, and the numerous nightshades, should be eliminated as they may harbor pathogen inoculum. Volunteer potatoes and tomatoes can also be a source of inoculum for early blight. Frequent disinfection of pruning tools should be disinfected frequently during use to help prevent the spread of spores. Stakes and cages can be disinfected each season before use with an approved product, such as ethanol, hydrogen peroxide, or peracetic acid. Disinfection with sodium hypochlorite (bleach) at 0.5% is effective, but must be followed by rinsing.

Alternaria solani (Early Blight) / Tomatoes: OMRI-Listed Fungicides for Use in the United States **(No efficacy data have been identified or evaluated.)**								
FRAC Code	Source: EPA Label							NOP Status
	Active Ingredient	Product Name	Product Rate/Acre	PHI (Days)	REI (Hours)	EPA Reg. No.	Comments	
44	*Bacillus amyloliquefaciens* str. D747	Double Nickel 55	0.25-3 lb	0	4	70051-108	Causes moderate eye irritation. Dermal sensitizer. Broad-spectrum preventative fungicide. Do not use highly alkaline or highly acidic water to mix sprays. Use a buffering agent if necessary to maintain neutrality (pH 6 to 8) of water in the tank. Suppression only; for improved control mix or rotate with chemical fungicide approved for such use.	Non-synthetic
		Double Nickel LC	Complete coverage of plant	0	4	70051-114	Harmful if absorbed through skin. Harmful if inhaled. Dermal sensitizer. Broad-spectrum preventative fungicide. Suppression only.	
	Bacillus pumilus str. QST 2808	Sonata ASO	2-4 qt	0	4	264-1153	Harmful if inhaled. Mixers/loaders and applicators must wear a dust/mist filtering respirator meeting NIOSH standards of at least N-95, R-95, or P-95. Repeated exposure to high concentrations of microbial proteins can cause allergic sensitization. Maintain a spray solution pH between 4.5 and 8.5. Suppression only.	Non-synthetic
	Bacillus subtilis str. QST 713	Optiva	14-24 oz	0	4	62592-26	Causes moderate eye irritation. Dermal sensitizer. Broad spectrum preventative product. For suppression, begin application when plants are 4 to 6 inches high. Repeat applications on a 5- to 7-day interval or as needed. For improved performance, use in a tank mix or rotational program with other registered fungicides. Use shorter spray intervals under conditions conducive to rapid disease development.	Non-synthetic
		Serenade ASO	2-6 qt	0	4	264-1152	Broad spectrum preventative fungicidal and bactericidal product. For suppression, begin applications when plants are 4 to 6 inches high. Repeat applications on 5- to 7-day intervals or as needed. For improved performance, use in a tank-mix or rotational program with other registered fungicides. Use the stated shorter spray intervals under conditions conducive to rapid disease development.	
		Serenade MAX	1-3 lb	0	4	69592-11	Dermal sensitizer. Broad spectrum preventative fungicidal and bactericidal product. For suppression begin applications when plants are 4 to 6 inches high. Repeat applications on 5 to 7 day intervals or as needed. For improved performance use in a tank mix or rotational program with other registered fungicides. Use shorter spray intervals under conditions conducive to rapid disease development.	
	Bacillus subtilis var. *amyloliquefaciens* str. FZB24	Taegro ECO	2.6-5.2 oz	0	4	70127-5-100	WARNING signal word. Causes skin irritation. Causes moderate eye irritation. Consists of living microbes. Store at room temperature and use before the expiration date. Avoid temperatures exceeding 73°F (23°C). Do not freeze. For suppression only. Most effective in low to medium disease situation. Start applications prior to disease or at disease establishment. Start applications prior to disease or at disease establishment.	Non-synthetic
P5	*Reynoutria sachalinensis*	Regalia Biofungicide	1-3 qt in 25-100 gal water/acre	0	4	84059-3	Causes moderate eye irritation. Preventative rather than a curative application. Apply prior to disease infestation to protect the growing leaf tissue. Avoid freezing. Repeat of 7-10 day intervals. Tank mix with other registered fungicides for improved disease control under heavy pressure. Apply prior to disease infestation.	Non-synthetic

Alternaria solani (Early Blight) / Tomatoes: OMRI-Listed Fungicides for Use in the United States (No efficacy data have been identified or evaluated.)								
FRAC Code	Source: EPA Label							NOP Status
	Active Ingredient	Product Name	Product Rate/Acre	PHI (Days)	REI (Hours)	EPA Reg. No.	Comments	
Not classified; Botanical oil	Neem oil	Trilogy	Not specified	0	4	70051-2	Causes moderate eye irritation. Hazardous to fish and aquatic invertebrates. Toxic to bees exposed to direct treatment. Broad spectrum. Exercise care in timing applications during early morning/late evening to minimize the potential for leaf burn. Use care on plants with tender tissue. Check for leaf burn in small scale trials prior to use. Do not apply to sensitive plant species. Do not apply to wilted or otherwise stressed plants, or to newly transplanted materials or crops prior to root establishment. For optimal performance, do not mix with cold water (less than 45°F). Do not store below 40°F (4°C). Do not use or store near heat or open flame.	Non-synthetic

Alternaria solani (Early Blight) / Tomatoes: OMRI-Listed Fungicides for Use in the United States
(No efficacy data have been identified or evaluated.)

FRAC Code	Source: EPA Label							NOP Status
	Active Ingredient	Product Name	Product Rate/Acre	PHI (Days)	REI (Hours)	EPA Reg. No.	Comments	
M1	Basic copper sulfate	Basic Copper 53	2-4 lb	0	24	45002-8	WARNING signal word. Causes substantial but temporary eye injury. Harmful if absorbed through skin or inhaled. Dermal sensitizer. Toxic to fish and aquatic organisms. Begin making application in seedbed or in the field before disease appears. Repeat at 7 to 10 day intervals as needed.	Synthetic
	Copper hydroxide	Nu-Cop 50 WP	2-3 lb	1	24	42002-7	DANGER signal word. Corrosive. Causes irreversible eye damage. Harmful if swallowed, absorbed through skin, or inhaled. Skin sensitizer. Toxic to fish and aquatic organisms. Product should not be applied in spray water having a pH of less than 6.5 as phytotoxicity may result. Effectiveness reduced at pH greater than 9.0. Apply at 7-10 day intervals. Use more frequent application when disease pressure is high.	Synthetic
		Champ WG	1-4 lb	0	48	55146-1	DANGER signal word. Corrosive. Causes irreversible eye damage. Harmful if inhaled. Skin sensitizer. Toxic to fish and aquatic organisms. Begin when disease first threatens and repeat at 7 to 10 day intervals depending on disease severity.	
	Copper hydroxide, Copper oxychloride	Badge X2	0.5-1.75 lbs	0	48	80289-12	WARNING signal word. May be fatal if swallowed. Causes substantial but temporary eye injury. Harmful if absorbed through skin. Harmful if inhaled. Toxic to fish and aquatic organisms. Begin when disease first threatens and repeat at 3 to 10 day intervals depending on disease severity. Product must not be applied in a spray solution having a pH of less than 6.5 as phytotoxicity may occur. Do not tank mix product with Aliette® fungicide for use on any registered crops or ornamentals unless appropriate precautions have been taken to buffer the spray solution because severe phytotoxicity may result.	Synthetic
	Copper octanoate	Cueva Fungicide Concentrate	0.5-2.0 gal/ 100 gal water	0	4	67702-2-70051	Harmful if swallowed or absorbed through skin. Toxic to fish and aquatic organisms. May cause some copper toxicity on some plant species. Store away from open fire or flame. Product may be damaged by freezing. Do not store product below 4°C. Do not mix with chelated or liquid fertilizers. Use caution when using product with other fungicides and insecticides. Do not reapply within 3 days.	Synthetic
	Copper sulfate pentahydrate	CS 2005	19.2-32 oz	0	48	66675-3	DANGER signal word. Corrosive. Causes irreversible eye damage and skin irritation. Harmful if swallowed, inhaled or absorbed through the skin. Dermal sensitizer. Toxic to fish and aquatic organisms. Do not mix with acidic compounds. Do not mix with pot ash. Store away from excessive heat. Product will freeze. Store and handle product in 316L stainless steel, fiberglass, PVC's, polypropylenes or plastic equipment. Keep away from galvanized pipe and any nylon storage handling equipment. Begin applications when disease first threatens and repeat at 5 to 10 day intervals or as needed depending on disease severity. Use the higher rates when conditions favor disease.	Synthetic

Alternaria solani (Early Blight) / Tomatoes: OMRI-Listed Fungicides for Use in the United States
(No efficacy data have been identified or evaluated.)

FRAC Code	Source: EPA Label							NOP Status
	Active Ingredient	Product Name	Product Rate/Acre	PHI (Days)	REI (Hours)	EPA Reg. No.	Comments	
	Cupric hydroxide	Nu-Cop 50DF	2-3 lb	1	24	45002-4	DANGER signal word. Corrosive. Causes irreversible eye damage. Harmful if swallowed or absorbed through skin. Dermal sensitizer. Toxic to fish and aquatic organisms. Effectiveness reduced at pH greater than 9.0. Product should not be applied in spray water having a pH of less than 6.5 as phytotoxicity may result. Begin when disease first threatens and repeat at 7 to 10 day intervals or as needed depending on disease severity. Use higher rate for severe disease.	Synthetic
		Nu-Cop HB	0.5-2 lb	1	24	42750-132	DANGER signal word. Corrosive. Causes irreversible eye damage. Harmful if swallowed, absorbed through skin, or inhaled. Crop injury statements. Begin when disease first threatens and repeat at 7-10 day intervals or as needed depending on disease severity. Use higher rate for severe disease.	
	Cuprous oxide	Nordox 75 WG	0.66-4 lb	0	12	48142-4	Harmful if swallowed or absorbed through skin. Causes eye irritation. Do not apply in a spray solution with a pH of less than 6.5. Apply prior to the appearance of disease and repeat at 7-10 day intervals.	Synthetic
Not classified; Inorganic salt	Potassium bicarbonate	EcoMate Amicarb O	2.5-5 lb/100 gal water	0	4	5905-541	Harmful if swallowed. Causes moderate eye irritation. Broad spectrum contact foliar fungicide. Prevent exposure to moisture during storage. Avoid contamination with other pesticides and fertilizers.	Synthetic
Not classified; Oxidizing agent	Hydrogen dioxide, Peroxyacetic acid	Oxidate	0.5 - 1 gal / 100 gal water (foliar application)	0	Until dry	70299-2	DANGER signal word. Causes irreversible eye damage. May be fatal if swallowed. Causes skin irritation or temporary discoloration of exposed skin. Highly toxic to bees and other beneficial insects. Toxic to fish. Toxic to birds who eat treated seed on soil surface. Strong oxidizing agent. Do not use in undiluted form. Never bring undiluted product in contact with other pesticides, cleaners or oxidative agents. May react with residues of metal-based fungicides or supplements. Allow at least 24 hrs. after application of metal-based products. Do not spray during conditions of intense heat, drought, or poor plant vigor (or vine canopy). Do not apply in conjunction with any other pesticides or fertilizers. Do not allow product to become overheated in storage. Do not store in a manner where cross-contamination with other pesticides or fertilizers could occur. Apply consecutive applications until control is achieved; then apply preventative treatments.	Synthetic

Alternaria solani and *A. tomatophila* (Early Blight) / Tomatoes: Efficacy Trials

Alternaria solani and *A. tomatophila* (Early Blight) / Tomatoes #1: Trial No. CER-2014-095

a. Design

Alternaria tomatophila (Early Blight) / Tomatoes #1: Trial No. CER-2014-095: Design				
Title:	Evaluation of Fungicides for the Management of Common Foliar Fungal Diseases of Tomato, Spring 2014			
Authors and affiliation:	G. E. Vallad, F. M. Aguiar, *et al*. University of Florida, GDREC Wimauma, FL 33598			
Publication:	PDMR 9:V072			
Location:	Balm, FL, USA			
Crop:	Tomato			
Pathogen and disease name:	*Alternaria tomatophila* (Early blight) *Corynespora cassiicola* (Target spot)			
Test plot design:	Randomized complete block			
Number of replicates:	4			
Application equipment:	High-volume tractor sprayer			
Spray volume:	60, 90, and 120 gal/acre (210 psi)			
Number of applications:	8			
Chronology:	Application Dates	Application Interval	Disease Assessment Dates	Inoculation Date
	03/20/2014		04/03/2014	03/24/2014
	03/27/2014	7 days	04/11/2014	
	04/02/2014	6 days	04/24/2014	
	04/11/2014	9 days	05/08/2014	
	04/17/2014	6 days	05/29/2014	
	04/24/2014	7 days		
	05/01/2014	7 days		
	05/08/2014	7 days		
Inoculants:	10^5 spores/mL suspension: *Alternaria tomatophila* (Early blight) *Corynespora cassiicola* (Target spot)			
Disease assessment methodology:	The severity of foliar disease was assessed as the percentage of canopy affected. Gray leaf spot (*Stemphylim solani*) symptoms were observed throughout the trial and were included in the in all disease rating because it became a predominant disease along with Target Spot. The Horsfall-Barratt scale was used for all ratings, but values were converted to mid-percentages prior to statistical analysis.			

b. Results

Alternaria tomatophila (Early Blight) / Tomatoes #1: Trial No. CER-2014-095: Results								
Treatment	Rate/ Acre	g a.i./ ha	Active Ingredient	FRAC Code	Foliar Disease Severity[1] (%) (5/8/2014)		AUDPC	
					Measured	Percent Control	Measured	Percent Control
Water treated control			Not Applicable		55.0 a		2055 a	
Oso	6.5 fl oz	25	Polyoxin D zinc salt	19	31.4 bc	42.9	1359 bc	33.9
Bravo Weatherstik	2 pt		Chlorothalonil	M5	37.5 ab	31.8	1451 b	29.4
Mettle	8 fl oz		Tetraconazole	3	31.4 bc	42.9	1352 bc	34.2
Equation	6.2 fl oz		Azoxystrobin	11	22.1 c	59.8	1070 bc	47.9
Quadris	6.2 fl oz		Azoxystrobin	11	37.5 ab	31.8	1240 bc	39.7
Priaxor	6 fl oz		Fluxapryoxad	7	37.5 ab	31.8	1328 bc	35.4
			Pyraclostrobin	11				
Endura	5 fl oz		Boscalid	7	26.6 bc	51.6	1045 bc	49.1
Quintec	6 fl oz		Quinoxyfen	13	26.3 bc	52.2	1006 c	51.0
Luna Tranquility	11 fl oz		Fluopyram	7	26.3 bc	52.2	1051 bc	48.9
			Pyrimethalin	9				
Fluopyram 500SC	6.8 fl oz		Fluopyram	7	37.5 ab	31.8	1388 bc	32.5
1. Foliar disease severity observations included target spot (*Corynespora cassiicola*), early blight (*Alternaria tomatophila*), and gray leaf spot (*Stemphylium solani*). Treatment means followed by the same letter are not statistically different according to Fisher's LSD test at $\alpha = 0.05$. AUDPC = Area Under the Disease Progression Curve.								

Early blight was first observed on April 3, 2014, *i.e.*, *before* the last 5 treatments. The treatments were therefore both preventative and curative.

No phytotoxicity was observed.

c. Discussion and Conclusions

Tomatoes were grown in Florida. The tomatoes were inoculated with a 10^5 spores/mL suspension of *Alternaria tomatophila* (early blight) and *Corynespora cassiicola* (target spot) four days after the initial fungicide treatment. The maximum measured foliar disease severity was 55.0% on May 8, 2014.

Treatments of Polyoxin D Zinc Salt 5SC Fungicide were applied preventatively and curatively. Eight treatments were applied at 6-day to 9-day intervals. The mean foliar disease control for target spot (*Corynespora cassiicola*), early blight (*Alternaria tomatophila*), and gray leaf spot (*Stemphylium solani*) combined was 42.9%. Based upon the area under the disease progression curve, polyoxin D zinc salt provided 33.9% foliar disease control. The average was 38.4% foliar disease control. This was statistically:

- Superior to the water treated control.
- Equivalent to all other treatments including 9 different active ingredients and 6 different modes of action.

No phytotoxicity was observed.

***Alternaria solani* and *A. tomatophila* (Early Blight) / Tomatoes: Grower Need**

Zero-day PHI products for use on greenhouse vegetables (Project No. B00024) was identified as a grower need at the IR-4 2015 Biopesticide Workshop.

Alternaria spp. (ALTERNARIA FRUIT ROT) / BLUEBERRIES

Alternaria spp. (Alternaria Fruit Rot) / Blueberries: Cause

(Source: Pscheidt, J.M. and Ocamb, C.M., Pacific Northwest Plant Disease Management, Alternaria Fruit Rot, 2016.)

Alternaria tenuissima, a fungus. This disease has caused severe losses in some Oregon fields, although it is not as common as ripe rot. The fungus overwinters as mycelium and spores in old, dried-up berries, dead twigs from the previous season's crop and on other plant debris. Infections can occur any time between late bloom through fruit maturity. Infections remain quiescent (latent) until fruit ripens. The disease often is not seen in the field but develops in storage or in transit to market.

Alternaria spp. (Alternaria Fruit Rot) / Blueberries: Symptoms

(Source: Pscheidt, J.M. and Ocamb, C.M., Pacific Northwest Plant Disease Management, Alternaria Fruit Rot, 2016.)

As fruit ripens, the first symptom is a shriveling or caving-in of the side of the berry. This deformity is generally located near the flower end of the berry. The damaged part may be covered with a blackish or dark greenish mass of spores that gives the surface of the berry a dull cast. Although berries may be dry in the field, the rot can become watery when harvested fruit is stored. Infected berries also tend to break open easily. Sometimes leaf lesions occur and are circular to irregularly shaped, tan to gray, about 0.25 inch or less in diameter, and surrounded by a reddish brown border. In most cases only lower leaves are affected.

Alternaria spp. (Alternaria Fruit Rot) / Blueberries: Cultural Control

(Source: Pscheidt, J.M. and Ocamb, C.M., Pacific Northwest Plant Disease Management, Alternaria Fruit Rot, 2016.)

Harvest promptly to prevent overripe fruit. Do not pick or handle fruit when it is wet. Hand harvesting results in less rot than machine harvesting. Avoid wounding or bruising fruit during harvest. Cool berries rapidly after harvest. Clean plant debris from picking buckets, packing lines and inspection belts frequently.

Alternaria sp. (Alternaria Fruit Rot) / Blueberries: OMRI-Listed Fungicides for Use in the United States **(No efficacy data have been identified or evaluated.)**								
FRAC Code	Source: EPA Label							NOP Status
	Active Ingredient	Product Name	Product Rate/Acre	PHI (Days)	REI (Days)	EPA Reg. No.	Comments	
44	*Bacillus amyloliquefaciens* str. D747	Double Nickel 55	0.25-3 lb	0	4	70051-108	Causes moderate eye irritation. Dermal sensitizer. Broad-spectrum preventative fungicide. Do not use highly alkaline or highly acidic water to mix sprays. Use a buffering agent if necessary to maintain neutrality (pH 6 to 8) of water in the tank. Suppression only; for improved control mix or rotate with chemical fungicide approved for such use.	Non-synthetic
		Double Nickel LC	Complete coverage of plant	0	4	70051-114	Harmful if absorbed through skin. Harmful if inhaled. Dermal sensitizer. Broad-spectrum preventative fungicide. Suppression only.	
	Bacillus pumilus str. QST 2808	Sonata ASO	2-4 qt	0	4	264-1153	Harmful if inhaled. Mixers/loaders and applicators must wear a dust/mist filtering respirator meeting NIOSH standards of at least N-95, R-95, or P-95. Repeated exposure to high concentrations of microbial proteins can cause allergic sensitization. Maintain a spray solution pH between 4.5 and 8.5.	Non-synthetic
	Bacillus subtilis str. QST 713	Optiva	14-24 oz	0	4	62592-26	Causes moderate eye irritation. Dermal sensitizer. Broad spectrum preventative product. Suppression only. Repeat applications on a 2- to 10-day interval.	Non-synthetic
		Serenade ASO	2-6 qt	0	4	264-1152	Broad spectrum preventative fungicidal and bactericidal product. Not for use in California.	
		Serenade MAX	1-3 lb	0	4	69592-11	Dermal sensitizer. Broad spectrum preventative fungicidal and bactericidal product. Repeat applications on 7 to 10 day intervals or as needed. For improved performance use in a tank mix or rotational program with other registered fungicides. Use shorter spray intervals under conditions conducive to rapid disease development.	
P5	*Reynoutria sachalinensis*	Regalia Biofungicide	1-4 qt	0	4	84059-3	Causes moderate eye irritation. Preventative rather than a curative application. Apply prior to disease infestation to protect the growing leaf tissue. Avoid freezing. Initiate application at green tip and continue applications on a 7–10-day. Tank mix with other registered fungicides for improved disease control under heavy pressure.	Non-synthetic
Not classified; Botanical oil	Neem oil	Trilogy	1 gal/ 100 gal water	0	4	70051-2	Causes moderate eye irritation. Hazardous to fish and aquatic invertebrates. Toxic to bees exposed to direct treatment. Broad spectrum. Exercise care in timing applications during early morning/late evening to minimize the potential for leaf burn. Use care on plants with tender tissue. Check for leaf burn in small scale trials prior to use. Do not apply to sensitive plant species. Do not apply to wilted or otherwise stressed plants, or to newly transplanted materials or crops prior to root establishment. For optimal performance, do not mix with cold water (less than 45°F). Do not store below 40°F (4°C). Do not use or store near heat or open flame.	Non-synthetic
Not classified; Inorganic salt	Potassium bicarbonate	EcoMate Amicarb O	2.5-5 lb/100 gal water	0	4	5905-541	Harmful if swallowed. Causes moderate eye irritation. Broad spectrum contact foliar fungicide. Prevent exposure to moisture during storage. Avoid contamination with other pesticides and fertilizers.	Synthetic

Alternaria spp. (Alternaria Fruit Rot) / Blueberries: Efficacy Trials

Alternaria spp. (Alternaria Fruit Rot) / Blueberries #1: Trial No. CER-2012-049

a. Design

Alternaria spp. (Alternaria Fruit Rot) / Blueberries #1: Trial No. CER-2012-049: Design				
Title:	Evaluating Fungicides for Control of Post-Harvest Fruit Rots in Blueberries, 2012			
Authors and affiliation:	A. M. C Schilder, J. M. Gillett, and R.W. Sysak Michigan State University East Lansing, MI			
Publication:	PDMR 7:SMF014			
Location:	Benton Harbor, MI			
Crop:	Blueberry (‘Rancocas’)			
Disease name:	Alternaria fruit rot			
Pathogen:	*Alternaria* spp.			
Test plot design:	Randomized complete block			
Number of replicates:	4			
Application equipment:	Research sprayer			
Spray volume:	40 gal/acre			
Number of applications:	5			
Chronology:	Application Dates	Growth Stage	Application Interval	Harvest Dates
	04/03/2012	Late pink bud		07/09/2012
	04/16/2012	Bloom	13 days	07/16/2012
	04/26/2012	20% petal fall	10 days	
	06/04/2012	Green fruit	39 days	
	06/18/2012	10% blue fruit	14 days	
Post-harvest disease assessment methodology:	50 ripe berries per subplot were harvested, placed equidistant on metal screens in aluminum trays, incubated at room temperature and 100% relative humidity, and rated for disease 12 days later.			

b. Results

Alternaria spp. (Alternaria Fruit Rot) / Blueberries #1: Trial No. CER-2012-049: Results							
Treatment	Rate/ Acre	g a.i./ ha	App. Timing	Active Ingredient	FRAC Code	Post-Harvest Incidence (%) (7/16/2012)	
						Measured	Percent Control
Untreated control				Not Applicable		48.5 a	
CX-10440 [1]	6.5 fl oz	25	1,2,3,4,5	Polyoxin D zinc salt	19	33.5 cd	31
CX-10440 [1]	13 fl oz	50	1,2,3,4,5	Polyoxin D zinc salt	19	23.5 e	52
Sil-Matrix	1%		1,2,3,4,5	Potassium silicate	NC	38.5 bc	21
Super Spread	90.06%		1,2,3,4,5	Adjuvant	NA		
Quash	2.5 oz		1,2,3,4,5	Metconazole	3	24.5 de	49
Bravo Weatherstik	4 pt		1	Chlorothalonil	M5	15.5 e	68
Pristine	23 oz		2, 5	Boscalid	7		
				Pyraclostrobin	11		
Captec 4L	2qt		3	Captan	M4		
Quash	2.5 oz		4	Metconazole	3		
Treatment means followed by the same letter are not statistically different according to Fisher's Protected LSD test at $P \leq 0.05$. 1. CX-10440 is the Certis USA, L.L.C. code for Polyoxin D Zinc Salt 5SC Fungicide.							

Alternaria fruit rot evaluations were conducted after the final treatment was applied. Therefore, the treatments are assumed to have been preventative.

No phytotoxicity was observed.

c. Discussion and Conclusions

Blueberries were grown in Michigan. Treatments were applied pre-harvest for post-harvest evaluation of Alternaria fruit rot of blueberries. Maximum Alternaria fruit rot incidence in the untreated controls was 48.5%.

Polyoxin D Zinc Salt 5SC Fungicide was applied preventatively. Five treatments were applied at 10-day to 39-day intervals. A positive dose-response was observed. Treatments at:

- 6.5 fl oz/acre (25 g a.i./ha) provided 31% post-harvest control of Alternaria fruit rot of blueberries; and
- 13.0 fl oz/acre (50 g a.i./ha) provided 51% post-harvest control of Alternaria fruit rot of blueberries.

The low rate, 6.5 fl oz/acre, was statistically:

- Superior to the untreated control;
- Equivalent to the control provided by potassium silicate plus adjuvant and to metconazole; and
- Less than the control provided by a treatment program that included chlorothalonil, boscalid, pyraclostrobin, captan, and metconazole.

The high rate, 13.0 fl oz/acre, was statistically:

- Superior to:
    - The untreated control;
    - The control provided by:
        - Potassium silicate plus adjuvant; and
        - Polyoxin D Zinc Salt 5SC Fungicide applied at 6.5 fl oz/acre (25 g a.i./ha); and
- Equivalent to the control provided by:
    - Metconazole; and
    - A treatment program that included chlorothalonil, boscalid, pyraclostrobin, captan, and metconazole.

No phytotoxicity was observed.

***Alternaria* spp. (Alternaria Fruit Rot) / Blueberries: Grower Need**

Control of Alternaria on blueberries (Project No. B00083) was identified as an organic grower need at the IR-4 2015 Biopesticide Workshop.

Botrytis cinerea (BOTRYTIS BLIGHT) / BLUEBERRIES

Botrytis cinerea (Botrytis Blight) / Blueberries: Disease Cycle

(Source: Philip F. Harmon, Botrytis Blossom Blight of Southern Highbush Blueberries, University of Florida Extension Service Documents PP198, August 2014.)

Botrytis blossom blight is an important disease of blueberries and several flowering ornamental plants. The fungus, *Botrytis cinerea*, most commonly infects and blights wounded or senescent plant tissues. As a blueberry bush blooms, corollas (the fused petal of the flowers) senesce and become quite susceptible to infection. Ideally the corolla should drop from the flower after pollination but before senescence occurs. Frost damage on tender new growth may wound the plant, delay petal drop, and facilitate infection by the fungus.

The pathogen survives well as a saprophyte (nonpathogenic phase) on dead host and non-crop plant material. Spores of the pathogen are abundant during blueberry bloom most years. Sanitation efforts to remove diseased and infested plant materials are good horticultural practices but would not significantly limit development of this disease.

Botrytis blossom blight can spread from the corolla into the ovary and eventually into the peduncle (stem of the immature berry). During periods of high relative humidity, conidia (spores) of the fungus are produced on infected plant parts. If the blight continues, an entire cluster of berries can be aborted. When disease is severe, the berry reduction can become economically important. After pollination of a flower and drop of the corolla, the risk of infection of the developing fruit is reduced. If progress of the blight is suppressed by environmental conditions, a fungicide application, or by plant defenses, disease progress may stop, but the fungus may lie dormant in the immature fruit. Infected berries are sometimes deformed and may develop further rot if environmental conditions later become favorable for disease. If the fruit is stored cool and humid for long periods after harvest, the fungus may then cause the gray fuzzy rot commonly observed on blueberries in grocery stores. Because of the relatively short interval from harvest to retail sales in Florida, the fruit rot stage of the disease is not typically a concern.

The development of Botrytis blight, like many other foliar fungal diseases, is highly dependent on environmental conditions. Infection and disease development are favored by extended periods of high relative humidity. Most years, blueberries in Florida are overhead irrigated for freeze protection during bloom. While sometimes necessary, frequent overhead irrigation at this time of year increases the likelihood of Botrytis blossom blight. Botrytis blossom blight is unusual because disease can occur at a wide range of temperatures. Favorable temperatures can range from as low as 32°F, where growth of the fungus is slow, to over 70°F. During bloom, periods of low temperatures combined with extended periods of high relative humidity result in more than 24 hours of leaf wetness and increased likelihood of significant disease development.

The severe outbreak of Botrytis blossom blight observed in Gainesville around March 4, 2004 was likely influenced by cool and wet weather. According to Florida Automated Weather Network (FAWN) data from the Alachua location, hourly temperatures between February 24 and 27 were (on average) 9°F lower in 2004 than the average of the hourly temperatures recorded the previous four years. In addition to the unusually low temperatures during this period, the hourly relative humidity remained above 90% for the entire time. In this example, the extended cool and wet period was favorable for disease development.

Botrytis cinerea (Botrytis Blight) / Blueberries: Disease Management
(Source: Philip F. Harmon, Botrytis Blossom Blight of Southern Highbush Blueberries, University of Florida Extension Service Documents PP198, August 2014.)

Blueberry cultivars differ in susceptibility to Botrytis blossom blight, but no one cultivar is completely resistant. In an average year in Florida, the economic loss due to Botrytis can be minimized by limited use of irrigation for freeze protection and judicious fungicide applications. Overhead irrigation extends periods of leaf wetness and favors disease development. Fungicide applications prior to, during, or immediately following extended cool wet periods during bloom can limit early infection. Untreated infections during bloom can lead to disease problems throughout the season. If Botrytis does become established at bloom, fungicide applications later in the season may be required to manage spread of the fungus to ripening berries. Applications at this time are less efficient and less effective for managing this disease than those at bloom.

Botrytis cinerea (Botrytis Blight) / Blueberries: Disease Management Options (Source: 2015 Organic Production and IPM Guide for Blueberries, Cornell Univ. Cooperative Extension)	
Scouting/thresholds	None established.
Variety susceptibility	No resistant varieties known.
Cultural management	Avoid high rates of nitrogen fertilizer. This leads to excessive succulent shoot growth, which is more susceptible to infection.
Chemical treatment	See the table below.

Botrytis cinerea (Botrytis Blight) / Blueberries: OMRI-Listed Fungicides for Use in the United States										
FRAC Code	Source: 2015 Organic Production and IPM Guide for Blueberries, Cornell University Cooperative Extension							Source: EPA Label		NOP Status
	Active Ingredient	Product Name	Product Rate/ Acre	PHI (Days)	REI (Days)	Efficacy	Comments	EPA Reg. No.	Comments	
44	*Bacillus amyloliquefaciens* str. D747	Double Nickel 55	0.25-3 lb	0	4	Not reviewed or no research available.		70051-108	Causes moderate eye irritation. Dermal sensitizer. Broad-spectrum preventative fungicide. Do not use highly alkaline or highly acidic water to mix sprays. Use a buffering agent if necessary to maintain neutrality (pH 6 to 8) of water in the tank.	Non-synthetic
		Double Nickel LC	0.5-6 qt	0	4	Not reviewed or no research available.		70051-114	Harmful if absorbed through skin. Harmful if inhaled. Dermal sensitizer. Broad-spectrum preventative fungicide.	
	Bacillus subtilis str. QST 713	Optiva	14-24 oz	0	4	Not reviewed or no research available.	Begin application prior to disease development and repeat on a 2-10 day interval or as needed.	62592-26	Causes moderate eye irritation. Dermal sensitizer. Broad spectrum preventative product.	Non-synthetic
		Serenade ASO	2-6 qt	0	4	Inconsistent efficacy results.	Begin application prior to the first sign of disease development and repeat at 7-10 day intervals or as needed. For improved performance, add an organic-approved surfactant to improve coverage.	264-1152	Broad spectrum preventative fungicidal and bactericidal product.	
		Serenade MAX	1-3 lb	0	4	Inconsistent efficacy results.	For improved performance, add an organic- approved surfactant to improve coverage.	69592-11	Dermal sensitizer. Broad spectrum preventative fungicidal and bactericidal product.	
		Serenade Optimum	14-20 oz	0	4	Inconsistent efficacy results.	Begin prior to disease development. Repeat on a 2-10 day interval or as needed.	264-1160		
P5	*Reynoutria sachalinensis*	Regalia Biofungicide	1-4 qt	0	4	Not reviewed or no research available.	Apply every 7-14 days at the first sign of disease.	84059-3	Causes moderate eye irritation. Preventative rather than a curative application. Apply prior to disease infestation to protect the growing leaf tissue. Avoid freezing.	Non-synthetic

Botrytis cinerea (Botrytis Blight) / Blueberries: OMRI-Listed Fungicides for Use in the United States										
FRAC Code	Source: 2015 Organic Production and IPM Guide for Blueberries, Cornell University Cooperative Extension							Source: EPA Label		NOP Status
	Active Ingredient	Product Name	Product Rate/ Acre	PHI (Days)	REI (Days)	Efficacy	Comments	EPA Reg. No.	Comments	
Not classified; Biological	*Streptomyces lydicus* WYEC 108	Actinovate AG	3-12 oz	0	1 or until solution has dried	Not reviewed or no research available.	For best results apply withy a spreader/sticker prior to onset of disease. Re-apply at 7-14 day intervals depending on disease pressure and environmental conditions.	73314-1	Avoid contact with skin, eyes, or clothing. Avoid breathing dust or spray mist. Mixer/loaders and applicators must wear a dust/mist filtering respirator meeting NIOSH standards of at least N-95, R-95, or P-95. Repeated exposure to high concentrations of microbial proteins can cause allergic sensitization. Keep from overheating or freezing. Optimum storage temperature is 40°F to 85°F. Contains live spores of a microbe. Best results will be obtained if the product is used prior to disease onset. Becomes active in soil or on the plant foliage when the temperatures are above 45°F and is not effective when temperatures remain cold. Do not apply soil fumigants to treated areas.	Non-synthetic
Not classified; Botanical oil	Neem oil	Trilogy	1.0% solution	0	4	Not reviewed or no research available.	See label for specific volumes of water to use. Maximum labeled use of 2 gal/acre/application.	70051-2	Causes moderate eye irritation. Hazardous to fish and aquatic invertebrates. Toxic to bees exposed to direct treatment. Broad spectrum. Exercise care in timing applications during early morning/late evening to minimize the potential for leaf burn. Use care on plants with tender tissue. Check for leaf burn in small scale trials prior to use. Do not apply to sensitive plant species. Do not apply to wilted or otherwise stressed plants, or to newly transplanted materials or crops prior to root establishment. For optimal performance, do not mix with cold water (less than 45°F). Do not store below 40°F (4°C). Do not use or store near heat or open flame.	Non-synthetic

Botrytis cinerea (Botrytis Blight) / Blueberries: OMRI-Listed Fungicides for Use in the United States										
FRAC Code	Source: 2015 Organic Production and IPM Guide for Blueberries, Cornell University Cooperative Extension							Source: EPA Label		NOP Status
	Active Ingredient	Product Name	Product Rate/ Acre	PHI (Days)	REI (Days)	Efficacy	Comments	EPA Reg. No.	Comments	
Not classified; Inorganic salt	Potassium bicarbonate	EcoMate Amicarb O	2.5-5 lb/ 100 gal water	0	4	Not reviewed or no research available.		5905-541	Harmful if swallowed. Causes moderate eye irritation. Broad spectrum contact foliar fungicide. Prevent exposure to moisture during storage. Avoid contamination with other pesticides and fertilizers.	Synthetic
	Potassium bicarbonate	Milstop	2-5 lb	0	1	Not reviewed or no research available.		70870-1-68539	Harmful if swallowed. Causes moderate eye irritation. Broad spectrum contact foliar fungicide. Do not mix with other soluble pesticides or fertilizers. Not compatible with mild alkaline solutions. Acidification of solution will cause reduced product performance. Prevent exposure to moisture during storage. Avoid contamination with other pesticides and fertilizers.	
	Potassium silicate	Sil-Matrix	0.5-1% vol/vol solution	0	4	Not reviewed or no research available.	Apply 50-250 gallons spray per acre. Repeat applications no sooner than every 7 days.	82100-1	Causes moderate eye irritation. Avoid contact with glass. Remove promptly from glass surfaces. Store product above 40°F. Do not store in aluminum, fiberglass, copper, brass, zinc, or galvanized containers. Protect from excessive heat. Broad spectrum preventative fungicide.	Synthetic

Botrytis cinerea (Botrytis Blight) / Blueberries: OMRI-Listed Fungicides for Use in the United States										
FRAC Code	Source: 2015 Organic Production and IPM Guide for Blueberries, Cornell University Cooperative Extension							Source: EPA Label		NOP Status
	Active Ingredient	Product Name	Product Rate/ Acre	PHI (Days)	REI (Days)	Efficacy	Comments	EPA Reg. No.	Comments	
Not classified; Oxidizing agent	Hydrogen dioxide, Peroxyacetic acid	Oxidate 2.0	Initial/ Curative: 128 fl oz/ 100 gal water; 30-100 gal solution/ acre Preventative: 40-128 fl oz/ 100 gal water; 30-100 gal solution/ acre	0	Until dry	Not reviewed or no research available.	Apply 30-100 gallons spray solution per treatment acre. Apply first three treatments using curative rates at 5-day intervals. Reduce rate to 32 fl oz/100 gal water and maintain 5-day interval for preventative treatment.	70299-2	DANGER signal word. Causes irreversible eye damage. May be fatal if swallowed. Causes skin irritation or temporary discoloration of exposed skin. Highly toxic to bees and other beneficial insects. Toxic to fish. Toxic to birds who eat treated seed on soil surface. Strong oxidizing agent. Do not use in undiluted form. Never bring undiluted product in contact with other pesticides, cleaners or oxidative agents. May react with residues of metal-based fungicides or supplements. Allow at least 24 hrs. after application of metal-based products. Do not spray during conditions of intense heat, drought, or poor plant vigor (or vine canopy). Do not apply in conjunction with any other pesticides or fertilizers. Do not allow product to become overheated in storage. Do not store in a manner where cross-contamination with other pesticides or fertilizers could occur. Apply consecutive applications until control is achieved; then apply preventative treatments.	Synthetic
	Hydrogen peroxide, Peroxyacetic acid	Perpose Plus	Initial/ Curative: 1 fl oz/gal Weekly/ Preventative: 0.25-0.33 fl oz/gal	0	Until spray has dried	Not reviewed or no research available.	For initial or curative use, apply higher rate for 1-3 consecutive days. Then follow with weekly/preventative treatment. For weekly or preventative treatments, apply lower rate every five to seven days. At first sign of disease, use curative rate then resume weekly preventative treatment.	86729-1	DANGER signal word. Causes irreversible eye damage and skin burns. May be fatal if absorbed through the skin. Harmful if swallowed. Do not breathe vapor from concentrate. Toxic to birds, mammals, fish and aquatic life. At temperatures exceeding 156°F, decomposition releases oxygen. The oxygen released could initiate or promote combustion of other materials. Store away from combustibles. Broad spectrum algaecide and fungicide. Apply curative rates for 3 consecutive days (drenching the entire plant) followed by weekly preventative treatments.	Synthetic

Botrytis cinerea (Botrytis Blight) / Blueberries: Efficacy Trials

Botrytis cinerea (Botrytis Blight)/ Blueberries #1: Trial No. CER-2015-009

a. Design

<table>
<tr><td colspan="5">Botrytis cinerea (Botrytis Blight)/ Blueberries #1: Trial No. CER-2015-009: Design</td></tr>
<tr><td>Title:</td><td colspan="4">Fungicide Management of Blueberry Fruit Rots, 2015</td></tr>
<tr><td>Authors and affiliation:</td><td colspan="4">J.W. Pscheidt, J.P. Bassinette and L. A. Jones
Oregon State University
Corvallis, OR 97331-2903</td></tr>
<tr><td>Publication:</td><td colspan="4">PDMR 10:SMF027</td></tr>
<tr><td>Location:</td><td colspan="4">Corvallis, OR</td></tr>
<tr><td>Crop:</td><td colspan="4">Blueberries (‘Bluetta’)</td></tr>
<tr><td>Disease name:</td><td colspan="4">Botrytis blight</td></tr>
<tr><td>Pathogen:</td><td colspan="4">Botrytis cinerea</td></tr>
<tr><td>Test plot design:</td><td colspan="4">Randomized complete block design</td></tr>
<tr><td>Number of replicates:</td><td colspan="4">6</td></tr>
<tr><td>Application equipment:</td><td colspan="4">Hydraulic handgun sprayer (approximately 100 psi)</td></tr>
<tr><td>Spray volume:</td><td colspan="4">217 gal/acre</td></tr>
<tr><td>Number of applications:</td><td colspan="4">12 or 7</td></tr>
<tr><td rowspan="13">Chronology:</td><td>Application Dates</td><td>Application Interval</td><td>Application Dates</td><td>Application Interval</td></tr>
<tr><td>03/13/2015 (A)</td><td></td><td rowspan="2">03/13/2015 (A)</td><td rowspan="2"></td></tr>
<tr><td>03/20/2015 (B)</td><td>7 days</td></tr>
<tr><td>03/27/2015 (C)</td><td>7 days</td><td rowspan="2">03/27/2015 (C)</td><td rowspan="2">14 days</td></tr>
<tr><td>04/03/2015 (D)</td><td>7 days</td></tr>
<tr><td>04/10/2015 (E)</td><td>7 days</td><td rowspan="2">04/10/2015 (E)</td><td rowspan="2">14 days</td></tr>
<tr><td>04/17/2015 (F)</td><td>7 days</td></tr>
<tr><td>04/23/2015 (G)</td><td>6 days</td><td rowspan="2">04/23/2015 (G)</td><td rowspan="2">13 days</td></tr>
<tr><td>05/01/2015 (H)</td><td>8 days</td></tr>
<tr><td>05/08/2015 (I)</td><td>7 days</td><td rowspan="2">05/08/2015 (I)</td><td rowspan="2">15 days</td></tr>
<tr><td>05/15/2015 (J)</td><td>7 days</td></tr>
<tr><td>05/22/2015 (K)</td><td>7 days</td><td>05/22/2015 (K)</td><td>14 days</td></tr>
<tr><td>05/29/2015 (L)
(not applied)
06/05/2015 (M)</td><td>14 days</td><td>06/05/2015 (M)</td><td>14 days</td></tr>
<tr><td>Harvest date:</td><td colspan="4">06/15/2015</td></tr>
<tr><td>Pre-harvest disease assessment date:</td><td colspan="4">06/03/2015</td></tr>
<tr><td>Post-harvest disease assessment methodology:</td><td colspan="4">Harvested berries were placed within moist chambers and incubated at room temperature for 10 days. The number of berries with various rots were evaluated and removed each day.</td></tr>
</table>

b. Results

Botrytis cinerea (Botrytis Blight) / Blueberries #1: Trial No. CER-2015-009: Results							
Treatment	Time of Application	Rate/ Acre	g a.i./ ha	Active Ingredient	FRAC Code	Botrytis Blight (%) (Fruit)	
						Measured	Percent Control
Untreated control				Not Applicable		7.8 a	
Oso SC	A,C,E,G,K,M	5.6 fl oz	22	Polyoxin D zinc salt	19	2.2 bc	72
Kinetic		6 fl oz/100 gal		Sticker/spreader	NA		
Oso SC	All except L	5.6 fl oz	22	Polyoxin D zinc salt	19	1.0 bc	87
Kinetic		6 fl oz/100 gal		Sticker/spreader	NA		
Double Nickel LC	All except L	2 qt		*Bacillus amyloliquefaciens* str. D747	44	2.3 bc	71
Double Nickel LC	All except L	4 qt		*Bacillus amyloliquefaciens* str. D747	44	4.3 ab	45
Fortelis	A,C,E,G,K,M	16 fl oz		Penthiopyrad	7	0.2 c	97
Kinetic		6 fl oz/100 gal		Sticker/spreader	NA		
Treatment means followed by the same letter are not statistically different according to the Fisher's protected LSD test at P = 0.05. Analysis was based upon arcsine square root transformation.							

The date of first observation of Botrytis blight was not reported. Therefore, the treatments are assumed to be preventative.

No phytotoxicity was observed.

c. Discussion and Conclusions

Blueberries were grown in Oregon. The Botrytis blight pest pressure was 7.8% in the untreated control.

Two different Polyoxin D Zinc Salt 5SC Fungicide treatment programs were evaluated for control of Botrytis blight on blueberry fruit. For both treatment programs, Polyoxin D Zinc Salt 5SC Fungicide was applied preventatively at 5.6 fl oz/acre (22 g a.i./ha) with Kinetic, a sticker/spreader.

- One program included a total of 12 treatments typically applied at 6-day to 8-day intervals.
- The other program included only 7 applications applied at longer intervals, *i.e.*, 13-days to 15 days.

Superior (though not statistically significant) control was obtained with the longer Polyoxin D Zinc Salt 5SC Fungicide re-treatment interval.

- 12 applications typically 6-day to 8-day intervals provided 72% control.
- 7 applications at 13-day to 15-day intervals provided 87% control.

Both Polyoxin D Zinc Salt 5SC Fungicide treatment programs provided control of Botrytis blight of blueberries that was statistically:

- Superior to the untreated control; and
- Equivalent to the control provided by Double Nickel (*Bacillus amyloliquefaciens* str. D747) and by Fortelis (penthiopyrad) plus a sticker/spreader.

Botrytis cinerea (BUNCH ROT) / GRAPES

Botrytis cinerea (Bunch Rot) / Grapes: Disease Description

(Source: 2015 Organic Production and IPM Guide for Grapes, Cornell Univ. Cooperative Extension)

Botrytis is a fungus that causes a bunch rot of berries and also may blight blossoms, leaves, and shoots. The bunch rot phase of the disease can cause severe economic losses, particularly on tight-clustered hybrid and Vinifera varieties. Ripe berries are susceptible to direct attack and are particularly susceptible to infection through wounds such as those caused by insects, hail, or rain cracking. Once established, infections can spread rapidly throughout the cluster during the preharvest period, causing extensive loss in yield and quality. This disease can be distinguished from other causes of bunch rot by the characteristic masses of gray "fuzzy" spores produced by the Botrytis fungus on infected plant parts, especially during humid weather.

The fungus overwinters in debris on the vineyard floor or on the vine. Old cluster stems are a particularly important source of carry-over between seasons. Spores are produced throughout the growing season, although their numbers appear to be greatest near bloom and after veraison. Production of spores and subsequent infection are greatly favored by prolonged periods of wetness or very high humidity, particularly at moderate temperatures (60–75°F).

The Botrytis fungus is most capable of attacking injured or senescing tissues. Hence, infections usually occur as blossoms wither, as fruit ripens, or through wounds. Wounds caused by the grape berry moth are particularly common sites of infection. Under wet conditions, blossom parts can become infected between cap fall and bunch closing; such infections can lead to latent (dormant) infections of the young berries, which then become active as the berries begin to ripen. Although direct losses from these early infections appear to be modest, they often provide a starting point for sudden and significant disease spread within the clusters if wet weather occurs before harvest. Berries infected by powdery mildew between fruit set and bunch closing also can serve as starting points for a Botrytis epidemic. Hence, good control of powdery mildew during this period is an important component of a good Botrytis management program.

Botrytis cinerea (Bunch Rot) / Grapes: Disease Management

(Source: 2015 Organic Production and IPM Guide for Grapes, Cornell Univ. Cooperative Extension**)**

In organic production, Botrytis management is best accomplished through cultural practices. In fact, even for growers who use conventional fungicides, consistent control of Botrytis requires the conscientious use of cultural management practices. Any practice that improves air circulation and thereby reduces humidity within the canopy is of significant benefit. Such practices include site selection to avoid fog pockets and heavily wooded areas; management of canopy densities through pruning, shoot positioning, and selectively removing leaves in the cluster zone immediately after fruit have set; and avoiding excessive nitrogen fertilization. Loose clusters also significantly reduce Botrytis development, and the use of clones (*e.g.*, the 'Mariafeld' clones of cv. Pinot noir) or viticultural techniques that provide loose clusters can greatly aid control.

Botrytis cinerea (Bunch Rot) / Grapes: Disease Management Options (Source: 2015 Organic Production and IPM Guide for Grapes, Cornell Univ. Cooperative Extension)	
Scouting/thresholds	Damaging levels of Botrytis are due to extensive disease spread throughout a cluster and to neighboring clusters after a few berries first become diseased. Regularly scout for the presence of Botrytis starting shortly after veraison, and consider treatment to slow spread of the disease if it is detected.
Slightly susceptible varieties	Cabernet Franc, Cabernet Sauvignon, Cascade, Catawba, Cayuga White, Chambourcin, Chancellor, Concord, Corot noir, De Chaunac, Delaware, Dutchess, Einset Seedless, Foch, Fredonia, Frontenac, Frontenac gris, Himrod, Ives, La Crescent, Marquis, Melody, Niagara, Noiret, Rosette, Steuben, Traminette, Valvin Muscat, Vanessa, Ventura, and Vidal blanc.
Cultural management	• <u>Sanitation</u>. Remove old cluster stems from the canopy and drop to the ground during dormant pruning operations. Around bud break, cultivate beneath the vines to bury infected debris or cover with mulch. • <u>Fruit management</u>. Thin clusters to promote open cluster architecture on tight clustered varieties. Prevent grape berry moth damage. Protect against powdery mildew infections between fruit set and bunch closure. • <u>Canopy management</u>. Prune and train the vines to promote air circulation, reduce humidity, and speed drying of the clusters. On highly susceptible varieties or clones, thin or remove leaves immediately surrounding the cluster zone. This technique is most beneficial if practiced early in the fruiting period, soon after berries have set. • <u>Vineyard management</u>. Orient rows to improve air movement within the vineyard. Avoid sites prone to fog or heavily wooded areas.
Chemical treatment	Organically approved pesticides have provided little control under high disease pressure conditions, but some have been beneficial under more moderate conditions. The possible times for application are bloom, bunch closure, veraison, and pre-harvest, depending on the weather and current presence of disease. Wounds caused by grape berry moth are common sites of infection, as are powdery mildew infections occurring on fruit between fruit set and bunch closure. Good management of berry moth and powdery mildew will contribute to a good Botrytis management program.

Botrytis cinerea (Bunch Rot) / Grapes: OMRI Listed Fungicides for Use in the United States										
FRAC Code	Source: 2015 Organic Production and IPM Guide for Grapes, Cornell University Cooperative Extension							Source: EPA Label		NOP Status
	Active Ingredient	Product Name	Product Rate/ Acre	PHI (Days)	REI (Days)	Efficacy	Comments	EPA Reg. No.	Comments	
44	*Bacillus amyloliquefaciens* str. D747	Double Nickel 55	0.25-3 lb	0	4	Not reviewed or no research available.		70051-108	Causes moderate eye irritation. Dermal sensitizer. Broad-spectrum preventative fungicide. Do not use highly alkaline or highly acidic water to mix sprays. Use a buffering agent if necessary to maintain neutrality (pH 6 to 8) of water in the tank.	Non-synthetic
		Double Nickel LC	0.5-6 qt	0	4	Not reviewed or no research available.		70051-114	Harmful if absorbed through skin. Harmful if inhaled. Dermal sensitizer. Broad-spectrum preventative fungicide.	
	Bacillus subtilis str. QST 713	Optiva	14-24 oz	0	4	Inconsistent efficacy results.	Apply in sufficient water to provide full coverage.	62592-26	Causes moderate eye irritation. Dermal sensitizer. Broad spectrum preventative product.	Non-synthetic
		Serenade ASO	2-6 qt	0	4	Inconsistent efficacy results.		264-1152	Broad spectrum preventative fungicidal and bactericidal product.	
		Serenade MAX	1-3 lb	0	4	Inconsistent efficacy results.		69592-11	Dermal sensitizer. Broad spectrum preventative fungicidal and bactericidal product.	
		Serenade Optimum	14-20 oz	0	4	Inconsistent efficacy results.	Apply in sufficient water to provide full coverage.	264-1160		
P5	*Reynoutria sachalinensis*	Regalia Biofungicide	1-4 qt	0	4	Inconsistent efficacy results.	A preventative fungicide. Apply in 50 to 100 gal water per acre.	84059-3	Causes moderate eye irritation. Preventative rather than a curative application. Apply prior to disease infestation to protect the growing leaf tissue. Avoid freezing.	Non-synthetic
Not classified; Biological	*Streptomyces lydicus* WYEC 108	Actinovate AG	3-12 oz	0	1 or until solution has dried	Not effective.		73314-1	Avoid contact with skin, eyes, or clothing. Avoid breathing dust or spray mist. Mixer/loaders and applicators must wear a dust/mist filtering respirator meeting NIOSH standards of at least N-95, R-95, or P-95. Repeated exposure to high concentrations of microbial proteins can cause allergic sensitization. Keep from overheating or freezing. Optimum storage temperature is 40°F to 85°F. Contains live spores of a microbe. Best results will be obtained if the product is used prior to disease onset. Becomes active in soil or on the plant foliage when the temperatures are above 45°F and is not effective when temperatures remain cold. Do not apply soil fumigants to treated areas.	Non-synthetic

Botrytis cinerea (Bunch Rot) / Grapes: OMRI Listed Fungicides for Use in the United States										
FRAC Code	Source: 2015 Organic Production and IPM Guide for Grapes, Cornell University Cooperative Extension							Source: EPA Label		NOP Status
	Active Ingredient	Product Name	Product Rate/ Acre	PHI (Days)	REI (Days)	Efficacy	Comments	EPA Reg. No.	Comments	
Not classified: Botanical oil	Neem oil	Trilogy	0.5-1.0% solution	0	4	Not reviewed or no research available.	Do not use Trilogy after bloom on table grapes or following bunch closure on wine grapes. Provides significant control of powdery mildew, and for this reason treated vines will have less Botrytis. Has no direct effect on the Botrytis fungus nor will it control infections that develop through sites other than powdery mildew injuries. Use 25-100 gal/A. The maximum labeled rate is 2 gal of Trilogy/ acre/application.	70051-2	Causes moderate eye irritation. Hazardous to fish and aquatic invertebrates. Toxic to bees exposed to direct treatment. Broad spectrum. Exercise care in timing applications during early morning/late evening to minimize the potential for leaf burn. Use care on plants with tender tissue. Check for leaf burn in small scale trials prior to use. Do not apply to sensitive plant species. Do not apply to wilted or otherwise stressed plants, or to newly transplanted materials or crops prior to root establishment. For optimal performance, do not mix with cold water (less than 45°F). Do not store below 40°F (4°C). Do not use or store near heat or open flame. Growth stage use restrictions for grapes and stone fruit.	Non-synthetic

Botrytis cinerea (Bunch Rot) / Grapes: OMRI Listed Fungicides for Use in the United States										
FRAC Code	Source: 2015 Organic Production and IPM Guide for Grapes, Cornell University Cooperative Extension							Source: EPA Label		NOP Status
	Active Ingredient	Product Name	Product Rate/ Acre	PHI (Days)	REI (Days)	Efficacy	Comments	EPA Reg. No.	Comments	
Not classified; Inorganic salt	Potassium bicarbonate	EcoMate Amicarb O	2.5-5 lb/ 100 gal water	0	4	Not effective.		5905-541	Harmful if swallowed. Causes moderate eye irritation. Broad spectrum contact foliar fungicide. Prevent exposure to moisture during storage. Avoid contamination with other pesticides and fertilizers.	Synthetic
	Potassium bicarbonate	Milstop	2-5 lb	0	1	Not effective.	Provides significant control of powdery Mildew, and for this reason treated vines will have less Botrytis. Has no direct effect on the Botrytis fungus nor will it control infections that develop through sites other than powdery mildew injuries.	70870-1-68539	Harmful if swallowed. Causes moderate eye irritation. Broad spectrum contact foliar fungicide. Do not mix with other soluble pesticides or fertilizers. Not compatible with mild alkaline solutions. Acidification of solution will cause reduced product performance. Prevent exposure to moisture during storage. Avoid contamination with other pesticides and fertilizers.	
Not classified; Oxidizing agent	Hydrogen dioxide, Peroxyacetic acid	Oxidate 2.0	Initial/ Curative: 128 fl oz/ 100 gal water; 30-100 gal solution/ acre Preventative: 40-128 fl oz/ 100 gal water; 30-100 gal solution/ acre	0	Until dry	Not reviewed or no research available.		70299-2	DANGER signal word. Causes irreversible eye damage. May be fatal if swallowed. Causes skin irritation or temporary discoloration of exposed skin. Highly toxic to bees and other beneficial insects. Toxic to fish. Toxic to birds who eat treated seed on soil surface. Strong oxidizing agent. Do not use in undiluted form. Never bring undiluted product in contact with other pesticides, cleaners or oxidative agents. May react with residues of metal-based fungicides or supplements. Allow at least 24 hrs. after application of metal-based products. Do not spray during conditions of intense heat, drought, or poor plant vigor (or vine canopy). Do not apply in conjunction with any other pesticides or fertilizers. Do not allow product to become overheated in storage. Do not store in a manner where cross-contamination with other pesticides or fertilizers could occur. Apply consecutive applications until control is achieved; then apply preventative treatments.	Synthetic
	Hydrogen peroxide, Hydrogen dioxide	Perpose Plus	Initial/ Curative: 1 fl oz/gal Weekly/ Preventative: 0.25-0.33 fl oz/gal	0	Until spray has dried	Not reviewed or no research available.		86729-1	DANGER signal word. Causes irreversible eye damage and skin burns. May be fatal if absorbed through the skin. Harmful if swallowed. Do not breathe vapor from concentrate. Toxic to birds, mammals, fish and aquatic life. At temperatures exceeding 156°F, decomposition releases oxygen. The oxygen released could initiate or promote combustion of other materials. Store away from combustibles. Broad spectrum algaecide and fungicide. Apply curative rates for 3 consecutive days (drenching the entire plant) followed by weekly preventative treatments.	Synthetic

Botrytis cinerea (Bunch Rot) / Grapes: OMRI Listed Fungicides for Use in the United States										
FRAC Code	Source: 2015 Organic Production and IPM Guide for Grapes, Cornell University Cooperative Extension							Source: EPA Label		NOP Status
	Active Ingredient	Product Name	Product Rate/ Acre	PHI (Days)	REI (Days)	Efficacy	Comments	EPA Reg. No.	Comments	
Not classified; Petroleum oils	Paraffinic oil	Organic JMS Stylet Oil	1-2 gal/ 100 gal	Table grapes: 14 Other: 0	4	Not effective.	Provides significant control of powdery Mildew, and for this reason treated vines will have less Botrytis. Has no direct effect on the Botrytis fungus nor will it control infections that develop through sites other than powdery mildew injuries. Do not apply sulfur within 10 days of an oil application.	65564-1	Harmful if swallowed. Toxic to fish. Do not freeze. Do not spray wet foliage. Do not spray when freezing temperatures are anticipated within 48 hours of an oil application, above 90°F (32°C) or when plants are under heat or moisture stress. Do not apply to vegetables when the temperature is below 50°F (10°C). Do not apply micronized sulfur within 10 days of an oil application. Do not apply oil within 14 days of an application of wettable or dusting sulfur. Do not apply to oil sensitive varieties. See label for additional compatibility restrictions. Grapes: Do not use copper and oil when fruit is present. Do not apply micronized sulfur within 10 days of an oil application. Do not apply oil with 14 days of an application of wettable or dusting sulfur.	Synthetic
	Mineral oil	PureSpray Green	Dilute: 0.75 gal/ 100 gal water at 150-300 gal water Concentrate: 1-3 gal	0	4	Not reviewed or no research available.	Table grapes must not be sprayed within 2 weeks of harvest. Do not apply sulfur within 10 days of an oil application.	69526-9	Harmful if swallowed or absorbed through skin. Prolonged or repeated skin contact may cause allergic reaction in some individuals. Drift and runoff may be hazardous to aquatic organisms in water adjacent to treated areas. Use extreme care when using concentrate sprays as the potential for crop phytotoxicity is increased. Avoid excess heat. Do not spray during or immediately prior to hot or freezing weather (over 95°F or under 32°F), hot dry winds, rain or other unsuitable conditions. Do not overspray or double spray. Spray plants only when they are in vigorous condition and when their moisture condition is suitable. Before using, make certain spray tank is free of sulfur residues. Do not apply micronized sulfur within 10 days of an oil application. Do not apply oil within 14 days of an application of wettable or dusting sulfur. Do not apply to oil sensitive varieties. See label for additional compatibility restrictions regarding many conventional active ingredients. Grapes: Do not apply within 14 days of harvest. Do not tank mix oil and copper more than once/season. Do not use oil and copper together with fruit present.	Synthetic
		SuffOil-X	1-2 gal/ 100 gal water	0	4	Not reviewed or no research available.	Do not mix with sulfur products.	48813-1-68539	Harmful if absorbed through skin. Prolonged or frequently repeated skin contact may cause allergic reactions in some individuals. Do not use in combination with any product containing sulfur. Do not use with any product whose label recommends the use of no oils. Do not use in combination with NPK foliar fertilizer applications. Do not apply during periods of drought or when plants exhibit moisture stress.	
		TriTek	1-2 gal/ 100 gal water	0	4	Not reviewed or no research available.	Apply as needed.	48813-1		

Botrytis cinerea **(Bunch Rot) / Grapes: Efficacy Trials**

Botrytis cinerea (Bunch Rot) / Grapes #1: Trial No. CER-2013-002

a. Design

Botrytis cinerea (Bunch Rot) / Grapes #1: Trial No. CER-2013-002: Design				
Title:	Evaluation of Fungicide Programs for Management of Botrytis Bunch Rot of Grapes: 2013 Field Trial			
Authors and affiliation:	Trang T. Nguyen, Ian S. Bay, Ara A. Abramians, and W. Douglas Gubler University of California Cooperative Extension Department of Plant Pathology University of California, Davis, California, USA			
Publication:	PDMR 9:SMF-001			
Location:	Yountville, Napa Valley, CA			
Crop:	Grapes (Chardonnay)			
Disease name:	*Botrytis* Bunch Rot			
Pathogen:	*Botrytis cinerea*			
Test plot design:	Complete randomized block design, each with 2 adjacent vines			
Number of replicates:	4			
Application equipment:	Backpack sprayer			
Spray volume:	200 gallons water/acre (1871 L/ha)			
Number of applications:	4			
Chronology:	Application Dates	Growth Stage	Application Interval	Disease Assessment Date
	05/08/2013	Bloom		10/21/2013
	06/14/2013	Pre-close	37 days	
	08/01/2013	Veraison	48 days	
	09/26/2013	Pre-harvest	56 days	
Disease assessment methodology:	20 randomly selected clusters. *Botrytis* Bunch Rot incidence (portion of clusters in a plot with some living *Botrytis*). *Botrytis* Bunch Rot severity (estimated percentage of berries in a cluster that were infected).			

b. Results

Botrytis cinerea (Bunch Rot) / Grapes #1: Trial No. CER-2013-002: Results								
Treatment	Rate/ Acre	g a.i./ ha	Active Ingredient	FRAC Code	Severity (%)		Incidence(%)	
					Measured	Percent Control	Measured	Percent Control
Untreated control			NA		2.09 abc		30.00 a	
Tavano 5% SC	6.5 fl oz	25	Polyoxin D zinc salt	19	0.20 bcd	90.4	3.75 cde	87.5
Tavano 5% SC	13 fl oz	50	Polyoxin D zinc salt	19	0.04 d	98.1	3.75 cde	87.5
Serenade Optimum	16 oz		QST 713 strain of *Bacillus subtilis* (26.2%)	44	0.14 cd	93.3	3.75 cde	87.5
Dyneamic	0.25% (v/v)		Surfactant					
Timorex Gold	0.43 qt		Oil derived from tea tree, *Melaleuca alternifora* (23.8%)	NA	0.01 d	99.5	1.25 de	95.8
Timorex Gold	0.65 qt		Oil derived from tea tree, *Melaleuca alternifora* (23.8%)	NA	0.15 cd	92.8	8.75 bcde	70.8
Fontelis	200 g a.i./ha		Penthiopyrad	7	0.40 bcd	80.9	13.75 abcde	54.2
Luna Privilege	200 g a.i./ha		Fluopyram	7	0.03 d	99.0	2.50 de	91.7
Elevate	16 oz		Fenhexamid	17	0.01 d	99.5	1.25 de	95.8
Inspire	5.25 fl oz		Difenoconazole	3	0.01 d	99.5	1.25 de	95.8
Captan Gold	1.675 lb		Captan	M4	0.00 d	99.5	0.00 e	100
Treatment means followed by the same letter are not statistically different according to the Student's t-test at $\alpha = 0.05$. NA = Not assigned.								

The date of first observation of bunch rot was not reported. Therefore, the treatments are assumed to have been preventative.

No phytotoxicity was reported.

c. Discussion and Conclusions

Grapes were grown in California. The maximum Botrytis bunch rot incidence in the untreated control was 30.00%.

Polyoxin D Zinc Salt 5SC Fungicide (marketed in the US as TAVANO 5% SC) was applied preventatively to grapes. Four treatments were applied at 37-day to 56-day intervals. There was no statistically significant difference in the results for the two treatment programs. Treatments applied at:

- 6.5 fl oz/acre (25 g a.i./ha) provided mean 89.0% (range 87.5% to 90.4%) control; and
- 13 fl oz/acre (50 g a.i./ha) provided mean 92.8% (range 87.5% to 98.1%) control.

The two Polyoxin D Zinc Salt 5SC Fungicide treatment rates provided control of bunch rot of grapes that was statistically equivalent to both microbial (QST 713 strain of *Bacillus subtilis*), biochemical (oil derived from tea tree, *Melaleuca alternifora*), and conventional treatments (penthiopyrad, fluopyram, fenhexamid, difenoconazole, and captan).

No phytotoxicity was reported.

Botrytis cinerea (Bunch Rot) / Grapes #2: Trial No. CER-2013-021

a. Design

Botrytis cinerea (Bunch Rot) / Grapes #2: Trial No. CER-2013-021: Design				
Title:	Evaluation of Efficacy of TAVANO 5% SC at 18-21 Day Reapplication Intervals Compared to ELEVATE and PRISTINE			
Author and affiliation:	Brooks Bauer Two Bees Agricultural Research & Consulting 20592 Ayers Avenue, Escalon, CA, USA			
Publication:	Certis data. Not published. Permission received.			
Location:	Two Bees Agricultural Research Farm near Escalon, CA			
Crop:	Wine grape (Cabernet Sauvignon variety)			
Disease name:	Grape Bunch Rot			
Pathogen:	*Botrytis* sp.			
Test plot design:	ROCOBL Randomized Complete Block			
Number of replicates:	4			
Application equipment:	Mist blower			
Spray volume:	100 gallons water/acre (935 L/ha)			
Number of applications:	6			
Application dates and growth stages:	Application Dates	Application Interval	BBCH Growth Stage	Description
	04/24/2013		19	9 or more leaves unfolded
	05/13/2013	19 days	53	Inflorescence clearly visible
	06/03/2013	21 days	61	Beginning of flowering: 10% of flowerhoods fallen
	06/21/2013	18 days	64	40% of flowerhoods fallen
	07/10/2013	19 days	81	Beginning of ripening: Berries begin to develop variety-specific color. Veraison.
	07/29/2013	19 days	85	Softening of berries
Disease assessment date:	09/12/2013 (harvest)			

b. Results

Botrytis cinerea (Bunch Rot) / Grapes #2: Trial No. CER-2013-021: Results								
Treatment	Rate/ acre	g a.i./ ha	Active Ingredient	FRAC Code	Percent Incidence		Percent Severity	
					Measured	Percent Control	Measured	Percent Control
Untreated control					13.0		20.8	
Tavano 5% SC	6.5 fl oz	25	Polyoxin D zinc salt	19	2.0	84.6	3.8	81.7
Tavano 5% SC	13 fl oz	50	Polyoxin D zinc salt	19	1.0	92.3	7.5	63.9
Pristine	12 oz		Boscalid	7	4.0	25.0	9.1	56.3
			Pyraclostrobin	11				

Powdery mildew was first observed on May 29, 2013. Therefore, the treatments were preventative and curative.

No phytotoxicity was observed.

c. Discussion and Conclusions

Grapes were grown in California. Maximum bunch rot severity was 20.8%.

Polyoxin D Zinc Salt 5SC Fungicide treatments were applied preventatively and curatively. Six treatments were applied at 18-day to 21-day intervals. A positive dose-response was not observed.

- Treatments at 6.5 fl oz (25 g a.i./ha) provided mean 83.2% (range 81.7% to 84.6%) control.
- Treatments at 13 fl oz/acre (50 g a.i/ha) provided mean 78.1% (range 63.9% to 92.3%) control.

This was superior to the mean 40.7% (range 25.0 % to 56.3%) control provided by Pristine (boscalid plus pyraclostrobin.

No phytotoxicity was observed.

Botrytis cinerea (Bunch Rot) / Grapes #3: Trial No. CER-2014-045

a. Design

<table>
<tr><th colspan="6">Botrytis cinerea (Bunch Rot) / Grapes #3: Trial No. CER-2014-045: Design</th></tr>
<tr><td>Title:</td><td colspan="5">Evaluation of Fungicide Programs for Control of Botrytis Bunch Rot, 2014</td></tr>
<tr><td>Authors and affiliation:</td><td colspan="5">W. F. Wilcox and D. Combs
Department of Plant Pathology & P-MB
Cornell University
New York State Agricultural Experimental Station, USA</td></tr>
<tr><td>Publication:</td><td colspan="5">Not published. Permission received.</td></tr>
<tr><td>Location:</td><td colspan="5">Research farm near Geneva, NY, USA</td></tr>
<tr><td>Crop:</td><td colspan="5">Grape (hybrid ‘Vignoles’)</td></tr>
<tr><td>Disease name:</td><td colspan="5">Botrytis bunch rot</td></tr>
<tr><td>Pathogen:</td><td colspan="5">Botrytis cinerea</td></tr>
<tr><td>Test plot design:</td><td colspan="5">Randomized complete block</td></tr>
<tr><td>Number of replicates:</td><td colspan="5">4</td></tr>
<tr><td>Application equipment:</td><td colspan="5">hooded boom sprayer</td></tr>
<tr><td>Spray volume:</td><td colspan="5">At bloom: 50 gallons/acre (468 L/ha)
Post-bloom: 100 gallons/acre (935 L/ha)</td></tr>
<tr><td>Number of applications:</td><td colspan="5">4</td></tr>
<tr><td rowspan="5">Chronology:</td><td>Application Dates</td><td>Application Interval</td><td>Growth Stage</td><td>Hail Storm with Injury to Berries</td><td>Disease Assessment Dates</td></tr>
<tr><td>06/23/2014</td><td></td><td>Bloom</td><td rowspan="4">07/31/2014
(3 weeks before veraison)</td><td rowspan="4">10/1-2/2014</td></tr>
<tr><td>07/10/2014</td><td>17 days</td><td>Bunch closure</td></tr>
<tr><td>08/22/2014</td><td>43 days</td><td>Veraison</td></tr>
<tr><td>09/04/2014</td><td>13 days</td><td></td></tr>
</table>

b. Results

Botrytis cinerea (Bunch Rot) / Grapes #3: Trial No. CER-2014-045: Results								
Treatment	Rate/ acre	g a.i./ ha	Active Ingredient	FRAC Code	Cluster Incidence		Cluster Severity	
					Percent	Percent Control	Percent	Percent Control
Untreated control					76.3 a		31.6 a	
Tavano 5SC	6.5 fl oz	25	Polyoxin D zinc salt	19	60.0 a-f	21	14.9 b-e	53
Double Nickel LC	2.0 qt		*Bacillus amyloliquefaciens* strain D747	44	62.5 a-d	18	14.8 b-e	54
Protexio 3.34SC	19.2 fl oz		Fenpyrazamine	17	43.8 e-h	43	12.7 b-e	60
Switch 62.5 WG	14.0 oz		Cyprodinil	9	43.8 e-f	43	12.7 b-e	60
			Fludioxonil	12				
Pristine 38WG	23.0 oz		Boscalid	7	51.3 b-h	33	11.9 b-e	63
			Pyraclostrobin	11				
Elevate 50WG	1.0 lb		Fenhexamid	17	23.8 I	69	7.9 d-e	75
Teldor 500SC	15.7 fl oz		Fenhexamid	17	43.8 e-h	43	8.3 d-e	74
Botector	6.0 oz		*Aureobasidium pullulans* DSM 14940 and DSM 14941	NA	55.0 g-h	28	13.2 b-e	59
NA = Not assigned. Treatment means followed by the same letter are not statistically different (Student's *t*-test, P = 0.05).								

The date of first observation of Botrytis symptoms was not reported. However, the report notes that sporulating Botrytis infections were observed post-veraison. Therefore, the treatments were preventative and curative.

No phytotoxicity was reported.

c. Discussion and Conclusions

Grapes were grown in New York state. Maximum bunch rot incidence in the untreated controls was 76.3% Due to a severe hailstorm, multiple injuries to grape clusters occurred throughout the vineyard three weeks before veraison. Most injured berries eventually shriveled and fell from the vines, thereby reducing the berry compaction, although a small percentage of injured berries were retained and developed sporulating *Botrytis* infections post-veraison. This contributed to variability among the plots.

Grapes received a total of 4 fungicide treatments with Polyoxin D Zinc Salt 5SC Fungicide at 13-day to 43-day intervals (at bloom, bunch closure, veraison, and 13 days after veraison). Treatments applied preventatively and curatively at 6.5 fl oz/acre (25 g a.i./ha) provided mean 37% (range 21% to 53%) control.

- The 21% control of disease incidence provided by Polyoxin D Zinc Salt 5S Fungicide was statistically:
  - Equivalent to the untreated control and the control of bunch rot incidence provided by *Bacillus amyloliquefaciens* strain D747 (Double Nickel), fenpyrazamine, cyprodinil plus fludioxonil, boscalid plus pyraclostrobin, fenhexamid (Teldor 500 SC), and *Aureobasidium pullulans* DSM 14940 and DSM 14941 (Biotector).
  - Less than that of fenhexamid (Elevate 50WG) which provided 69% control.

- The 53% control of bunch rot severity provided by Polyoxin D Zinc Salt 5S Fungicide was statistically:
  - Superior to the untreated control; and
  - Equivalent to that provided by *Bacillus amyloliquefaciens* strain D747 (Double Nickel), fenpyrazamine, cyprodinil plus fludioxonil, boscalid plus pyraclostrobin, fenhexamid, and *Aureobasidium pullulans* DSM 14940 and DSM 14941.

No phytotoxicity was reported.

Botrytis cinerea (Bunch Rot) / Grapes #4: Trial No. CER-2015-115

a. Design

Botrytis cinerea (Bunch Rot) / Grapes #4: Trial No. CER-2015-115: Design				
Title:	Evaluation of Fungicide Programs for Control of Botrytis Bunch Rot, 2015			
Authors and affiliation:	W. F. Wilcox and D. Combs Dept. of Plant Pathology & P-MB Cornell University, NY State Agric. Expt. Sta. Geneva, NY 14456			
Publication:	Not published. Permission received.			
Location:	Near Geneva, NY			
Crop:	Grape (*Vitis* interspecific hybrid 'Vignoles') (15 year old vines)			
Disease name:	Botrytis bunch rot			
Pathogen:	Botrytis cinerea			
Test plot design:	Randomized control block			
Number of replicates:	4			
Application equipment:	Hooded boom sprayer (100 psi)			
Spray volume:	50 gal/acre at bloom. 100 gal/acre for all remaining sprays.			
Number of applications:	4			
Chronology:	Application Dates	Growth Stage	Application Interval	Disease Assessment Dates
	06/22/2015	Late bloom		09/16-21/2015
	07/07/2015	Bunch closing	15 days	
	08/17/2015	Veraison	41 days	
	08/31/2015	2+ wks pre-harvest	14 days	
Disease assessment methodology:	20 clusters were collected from the center of each plot. Incidence = percentage of clusters showing any infection.			

b. Results

Botrytis cinerea (Bunch Rot) / Grapes #4: Trial No. CER-2015-115: Results								
Treatment	Rate/ Acre	g a.i./ ha	Active Ingredient	FRAC Code	Severity (%)		Incidence (%)	
					Measured	Percent Control	Measured	Percent Control
Untreated control			Not Applicable		44 ab		96 a	
Oso	6.5 fl oz.	25	Polyoxin D zinc salt	19	12 d-f	88	50 gh	50
Double Nickel LC	1 qt		*Bacillus amyloliquefaciens* str. D747	44	23 de	77	86 a-d	14
Double Nickel LC	2 qt		*Bacillus amyloliquefaciens* str. D747	44	11 ef	89	48 h	53
Protexio 3.34SC	14.4 oz		Fenpyrazamine	17	7 ef	93	53 e-h	47
Elevate 50WG	1.0 lb		Fenhexamid	17	20 c-e	80	75 b-f	25
Luna Experience	8.0 oz		Fluopyram	7	15 d-f	85	58 e-h	42
			Tebuconazole	3				
Luna Tranquility	16.0 oz		Fluopyram	7	8 ef	92	48 f-h	52
			Pyrimethalin	9				
Switch 62.5WG	14.0 oz		Cyprodinil	9	13 d-f	87	63 d-h	37
			Fludioxonil	12				
Fracture	30.5		Banda de Lupinus albus doce (BLAD)	NC	7 ef	93	55 e-h	45
Treatment means followed by the same letter are not statistically different according to the Student's t-test at P = 0.05.								

The date of disease assessment was after the last treatment. Therefore, treatments are assumed to have been preventative.

No phytotoxicity was observed.

c. Discussion and Conclusions

Grapes were grown in New York.

Four applications were applied at late bloom, bunch closing, veraison, and more than 2 weeks pre-harvest.

Polyoxin D Zinc Salt 5SC Fungicide applied preventatively at 6.5 fl oz/ace (25 g ai/ha) provided mean 69% control of Botrytis bunch rot.

Incidence

Botrytis bunch rot incidence was 96% in the untreated control. Polyoxin D Zinc Salt 5SC Fungicide applied at 6.5 fl oz/ace (25 g ai/ha) provided 50% control of Botrytis bunch rot incidence. This was:

- Statistically superior to the control provided by:
    - *Bacillus amyloliquefaciens* str. D747 (Double Nickel) (1 qt/acre);
    - Fenhexamid; and
- Statistically equivalent to the control provided by:
    - *Bacillus amyloliquefaciens* str. D747 (Double Nickel) (2 qt/acre);
    - Fenpyrazamine;
    - Fluopyram plus tebuconazole
    - Fluopyram plus pyrimethalin;
    - Cyprodinil plus fludioxonil; and
    - Banda de Lupinus albus doce (BLAD).

Severity

Botrytis bunch rot severity was 44% in the untreated control. Polyoxin D Zinc Salt 5SC Fungicide applied at 6.5 fl oz/ace (25 g ai/ha) provided 88% control of Botrytis bunch rot severity. This was:

- Statistically equivalent to the control provided by:
    - *Bacillus amyloliquefaciens* str. D747 (Double Nickel);
    - Fenpyrazamine;
    - Fenhexamid;
    - Fluopyram plus tebuconazole;
    - Fluopyram plus pyrimethalin;
    - Cyprodinil plus fludioxonil; and
    - Banda de Lupinus albus doce (BLAD).

No phytotoxicity was observed.

Botrytis cinerea (Bunch Rot) / Grapes #5: Trial No. CER-2015-140

a. Design

Botrytis cinerea (Bunch Rot) / Grapes #5: Trial No. CER-2015-140: Design				
Title:	Evaluation of Fungicides for Control of Botrytis Bunch Rot and Powdery Mildew, 2015			
Authors and affiliation:	A. M. Schilder, J. M. Gillett, and R. W. Sysak Michigan State University East Lansing, MI			
Publication:	PDMR 10:SMF011			
Location:	Lawton, Michigan, USA			
Crop:	Grape (*Vitis* interspecific hybrid 'Aurore')			
Disease name:	Botrytis Bunch Rot			
Pathogen:	*Botrytis cinerea*			
Test plot design:	Randomized complete block			
Number of replicates:	4			
Application equipment:	Farmco research skid-mounted sprayer			
Spray volume:	06/09/2015: 50 gal/acre All later treatments: 75 gal/acre			
Number of applications:	4			
Chronology:	Application Dates	Growth Stage	Application Interval	Disease Assessment Dates
	06/09/2015	10-16 inch shoots		08/31/2015
	07/07/2015	Pre-bunch closure	29 days	
	08/04/2015	Veraison	28 days	
	08/24/2015	Pre-harvest	20 days	
Disease assessment methodology:	Disease incidence: Percent clusters exhibiting disease. Disease severity: Percent clusters blade with disease on diseased samples only.			

b. Results

Botrytis cinerea (Bunch Rot) / Grapes #5: Trial No. CER-2015-140: Results on Clusters								
Treatment	Rate/ Acre	g a.i./ ha	Active Ingredient	FRAC Code	Severity (%)		Incidence (%)	
					Measured	Percent Control	Measured	Percent Control
Untreated control			Not Applicable		5.73 a		25 a	
Oso 5%SC	6.5 fl oz	25	Polyoxin D zinc salt	19	1.88 bcd	67.2	14 b	44
Super Spread 90	0.125% (v/v)	NA	Surfactant	NA				
Protexio SC	14.4 fl oz		Fenpyrazamine	17	1.13 cde	80.3	6 def	76
Super Spread 90	0.125% (v/v)		Surfactant	NA				
Treatment means followed by the same letter are not statistically different according to Fisher's Protected LSD test at $P \leq 0.05$.								

The bunch rot assessment date was after the final treatment. Therefore, treatments are assumed to have been preventative.

c. Discussion and Conclusions

Grapes were grown in Michigan. Bunch rot incidence was 25%.

Polyoxin D Zinc Salt 5SC Fungicide applied preventatively at 6.5 fl oz/acre (25 g a.i./ha) with Super Spread 90 (surfactant) provided mean 56% (range 44% to 67.2%) control of Botrytis bunch rot on grapes. This was statistically:

- Superior to the untreated control;
- Equivalent to fenpyrazamine with surfactant for control of bunch rot severity; and
- Less control of bunch rot incidence than that provided by fenpyrazamine with surfactant.

Botrytis cinerea **(Bunch Rot) / Grapes: Grower Need**

Control of Botrytis bunch rot on grapes (Project Nos. B00052 and B00063) was identified as a grower need at the IR-4 2015 Biopesticide Workshop.

Botrytis cinerea (GRAY MOLD) / LETTUCE

Botrytis cinerea (Gray Mold) / Lettuce: Introduction

(Source: 2015 Organic Production and IPM Guide for Lettuce, Cornell University Cooperative Extension)

Time for concern: The fungus grows within a wide range of temperatures, but is favored by cool (65°F to 75°F), moist conditions, either in greenhouses or field locations. Plants are susceptible at all stages.

Key characteristics: Gray mold is especially common in the cool moist conditions of greenhouses or high tunnels. Symptoms of affected seedlings are similar to those of damping-off. The pathogen initially develops on damaged or dead tissue when wet, or tissue that is touching soil. It can then spread to adjacent healthy tissue. Initial symptoms are brownish to black water-soaked lesions that become a mushy rot. The pathogen can spread from lesions on the margins of outer leaves to the stem. Profuse gray-brown conidia (spores) develop and may be followed by black resting bodies (sclerotia). Affected plant parts rapidly turn soft and rot. The fungus can also grow up the stem and rot the inside of a head causing the plant to collapse before any outward symptoms are visible. Infection can spread through heads after harvest affecting marketability. The gray mold fungus is widespread, surviving on the dead or dying tissue of many plants. Consequently, management is largely dependent on selecting sites and planting dates which provide warmer and drier conditions.

Relative Risk: Gray mold is one of the three most important diseases of head lettuce, particularly in greenhouse or high tunnel lettuce. Because the fungus is ubiquitous, the risk of gray mold can be widespread dependent on favorable weather conditions.

Botrytis cinerea **(Gray Mold) / Lettuce: Management Options**
(Source: 2015 Organic Production and IPM Guide for Lettuce, Cornell University Cooperative Extension)

Management Option	Recommendation for Gray Mold
Scouting/thresholds	Scout plantings weekly. Thresholds for organic production have not been established.
Site selection	Select a well-drained field with good air flow that will help dry leaves and soil quickly.
Crop rotation	Rotation alone will not manage this ubiquitous fungus, although it may help reduce the pathogen population.
Resistant varieties	Resistant varieties are not known.
Seed	This fungus is not seed-borne.
Planting	Orient rows parallel to the prevailing winds and use wide row spacing to encourage quick drying of leaves and soil. Plant in fields where crop debris is well decomposed at planting time. Wounded transplants are more prone to gray mold development; transplant before seedlings are large and overly mature. Since Romaine is particularly susceptible, direct seeding is recommended over transplanting.
Weed control	Avoid wounding plants during early cultivation to prevent infection.
Cultural controls	Maintain low moisture and humidity levels in greenhouse and high tunnel production. Strict hygiene is essential in plant bed and greenhouse settings
Harvest	Trim off affected leaves. Keep harvested plants refrigerated between 32°F and 36°F.
Postharvest	Plow under debris after harvest. Avoid use of overhead irrigation to prevent extended periods of leaf wetness. If watering is necessary, irrigate early in the day when sun or wind are more likely to quickly dry leaves. Damage from frost, heat or other disease can predispose lettuce to infection by *Botrytis cinerea* as can physiological disorders such as tipburn.
Notes	Avoid use of overhead irrigation to prevent extended periods of leaf wetness. If watering is necessary, irrigate early in the day when sun or wind are more likely to quickly dry leaves. Damage from frost, heat or other disease can predispose lettuce to infection by *Botrytis cinerea* as can physiological disorders such as tipburn.

Botrytis cinerea (Gray Mold) / Lettuce: OMRI-Listed Fungicides for Use in the United States										
FRAC Code	Source: 2015 Organic Production and IPM Guide for Lettuce, Cornell Univ. Cooperative Extension							Source: EPA Label		NOP Status
	Active Ingredient	Product Name	Product Rate/ Acre	PHI (Days)	REI (Days)	Efficacy	Comments	EPA Reg. No.	Comments	
Not classified ; Biological	*Gliocladium catenulatum* str. J1446	Prestop Biofungicide	0.1-1.0% suspension soil treatment	0	0	Labeled product for use on lettuce, but efficacy not known.	Do not apply when above-ground harvestable food commodities are present.	64137-11	Harmful if swallowed. Applicators and other handlers must wear a NIOSH-approved respirator with any N, P, R or HE filter. Consists of live microbes. Store below 46°F (8°C) for up to 6 months. Immediately use the entire package's content after opening. Foliar spray prohibited on listed crops; use limited to soil treatments. Do not tank mix with any pesticides or concentrated fertilizers. Do not use most chemical pesticides within 1-4 days of application.	Non-synthetic
	Streptomyces griseoviridis	Mycostop Biofungicide	0.1% solution by weight	0	4	Labeled product for use on lettuce, but efficacy not known.	Only provides suppression of Botrytis. Apply to runoff. Labeled only for greenhouse use.	64137-5	Harmful if inhaled. Causes moderate eye irritation. Applicators and other handlers must wear a dust/mist filtering respirator. Consists of live microbes. Store below 46°F (8°C). Do not store open packets since product will lose its activity. Do not tank mix with any pesticides or with concentrated fertilizers. Suppression only.	Non-synthetic
	Streptomyces lydicus WYEC 108	Actinovate AG	3-12 oz	0	1 or until solution has dried	Labeled product for use on lettuce, but efficacy not known.	The label recommends use of a spreader sticker.	73314-1	Avoid contact with skin, eyes, or clothing. Avoid breathing dust or spray mist. Mixer/loaders and applicators must wear a dust/mist filtering respirator meeting NIOSH standards of at least N-95, R-95, or P-95. Repeated exposure to high concentrations of microbial proteins can cause allergic sensitization. Keep from overheating or freezing. Optimum storage temperature is 40°F to 85°F. Contains live spores of a microbe. Best results will be obtained if the product is used prior to disease onset. Becomes active in soil or on the plant foliage when the temperatures are above 45°F and is not effective when temperatures remain cold. Do not apply soil fumigants to treated areas.	Non-synthetic

Botrytis cinerea (Gray Mold) / Lettuce: OMRI-Listed Fungicides for Use in the United States										
FRAC Code	Source: 2015 Organic Production and IPM Guide for Lettuce, Cornell Univ. Cooperative Extension							Source: EPA Label		NOP Status
	Active Ingredient	Product Name	Product Rate/ Acre	PHI (Days)	REI (Days)	Efficacy	Comments	EPA Reg. No.	Comments	
Not classified; Botanical oil	Neem oil	Trilogy	0.5-1.0% solution	0	4	Labeled product for use on lettuce, but efficacy not known.	Use in 25-100 gal per acre. Apply no more than 2 gallons per acre per application.	70051-2	Causes moderate eye irritation. Hazardous to fish and aquatic invertebrates. Toxic to bees exposed to direct treatment. Broad spectrum. Exercise care in timing applications during early morning/late evening to minimize the potential for leaf burn. Use care on plants with tender tissue. Check for leaf burn in small scale trials prior to use. Do not apply to sensitive plant species. Do not apply to wilted or otherwise stressed plants, or to newly transplanted materials or crops prior to root establishment. For optimal performance, do not mix with cold water (less than 45°F). Do not store below 40°F (4°C). Do not use or store near heat or open flame.	Non-synthetic
Not classified; Inorganic salt	Potassium bicarbonate	EcoMate Amicarb O	2.5-5 lb/ 100 gal water	0	4	Labeled product for use on lettuce, but efficacy not known.		5905-541	Harmful if swallowed. Causes moderate eye irritation. Broad spectrum contact foliar fungicide. Prevent exposure to moisture during storage. Avoid contamination with other pesticides and fertilizers.	Synthetic
		Milstop	2-5 lb	0	1	Labeled product for use on lettuce, but efficacy not known.		70870-1-68539	Harmful if swallowed. Causes moderate eye irritation. Broad spectrum contact foliar fungicide. Do not mix with other soluble pesticides or fertilizers. Not compatible with mild alkaline solutions. Acidification of solution will cause reduced product performance. Prevent exposure to moisture during storage. Avoid contamination with other pesticides and fertilizers.	

Botrytis cinerea (Gray Mold) / Lettuce: OMRI-Listed Fungicides for Use in the United States										
FRAC Code	Source: 2015 Organic Production and IPM Guide for Lettuce, Cornell Univ. Cooperative Extension							Source: EPA Label		NOP Status
	Active Ingredient	Product Name	Product Rate/ Acre	PHI (Days)	REI (Days)	Efficacy	Comments	EPA Reg. No.	Comments	
Not classified ; Oxidizing agent	Hydrogen dioxide, Peroxyacetic acid	Oxidate 2.0	Initial/ Curative: 128 fl oz/ 100 gal water; 30-100 gal solution/ acre Preventative: 40-128 fl oz/ 100 gal water; 30-100 gal solution/ acre	0	Until dry	Labeled product for use on lettuce, but efficacy not known.	For curative sprays, use 128 fl oz/100 gal water. Apply 30-100 gallons of solution per treated acre. Apply consecutive applications until control is achieved and then follow directions for preventative treatment. For preventative sprays, apply 30-100 gallons of spray solution per treated acre. Begin when plants are small. Apply first three treatments using the curative rate at 5-day intervals. Reduce to preventative rate after completion of the third treatment and maintain 5-day interval spray cycle until harvest.	70299-2	DANGER signal word. Causes irreversible eye damage. May be fatal if swallowed. Causes skin irritation or temporary discoloration of exposed skin. Highly toxic to bees and other beneficial insects. Toxic to fish. Toxic to birds who eat treated seed on soil surface. Strong oxidizing agent. Do not use in undiluted form. Never bring undiluted product in contact with other pesticides, cleaners or oxidative agents. May react with residues of metal-based fungicides or supplements. Allow at least 24 hrs. after application of metal-based products. Do not spray during conditions of intense heat, drought, or poor plant vigor (or vine canopy). Do not apply in conjunction with any other pesticides or fertilizers. Do not allow product to become overheated in storage. Do not store in a manner where cross-contamination with other pesticides or fertilizers could occur. Apply consecutive applications until control is achieved; then apply preventative treatments.	Synthetic
	Hydrogen peroxide, Hydrogen dioxide	Perpose Plus	Initial/ Curative: 1 fl oz/gal Weekly/ Preventative: 0.25-0.33 fl oz/gal	0	Until spray has dried	Labeled product for use on lettuce, but efficacy not known.	For initial or curative use, apply higher rate for 1 to 3 consecutive days. Then follow with weekly/preventative treatment. For weekly or preventative treatments, apply lower rate every five to seven days. At first signs of disease, use curative rate then resume weekly preventative treatment.	86729-1	DANGER signal word. Causes irreversible eye damage and skin burns. May be fatal if absorbed through the skin. Harmful if swallowed. Do not breathe vapor from concentrate. Toxic to birds, mammals, fish and aquatic life. At temperatures exceeding 156°F, decomposition releases oxygen. The oxygen released could initiate or promote combustion of other materials. Store away from combustibles. Broad spectrum algaecide and fungicide. Apply curative rates for 3 consecutive days (drenching the entire plant) followed by weekly preventative treatments.	Synthetic

Botrytis cinerea **(Gray Mold) / Lettuce: Efficacy Trials**

Botrytis cinerea (Gray Mold) / Lettuce #1: CER-2011-014

a. Design

Botrytis cinerea (Gray Mold) / Lettuce #1: CER-2011-014: Design				
Title	Efficacy of CX-10440 for the Control of Botrytis (*Botrytis cinerea*) in Lettuce			
Research organization:	Pacific Ag Research			
Publication:	Certis data. Not published. Permission received.			
Location:	Guadalupe, CA			
Crop:	Lettuce (Cannery Row)			
Disease name:	Botrytis, Gray mold			
Pathogen:	*Botrytis cinerea*			
Test plot design:	Randomized complete block			
Number of replicates:	4			
Application equipment:	Botran boom (40 psi)			
Spray volume:	50 gal/acre			
Number of applications:	4			
Chronology:	Application Dates	Application Interval	Assessment Dates	Harvest Date
	07/08/2011		07/14/2011	08/12/2011
	07/18/2011	10 days	07/20/2011	
	07/28/2011	10 days	07/27/2011	
	08/08/2011	11 days	08/02/2011	
			08/09/2011	

b. Results

Botrytis cinerea (Gray Mold) / Lettuce #1: CER-2011-014: Disease Control Results								
Treatment	Rate/ Acre	g a.i./ ha	Active Ingredient	FRAC Code	Incidence (%) (8/9/2011)		AUDPC	
					Measured	Percent Control	Measured	Percent Control
Untreated control			Not Applicable		52.62 a		206.63 a	
CX-10440 [1]	3.75 fl oz	14	Polyoxin D zinc salt	19	32.23 b	38.75	144.63 b	30.00
CX-10440 [1]	7.5 fl oz	29	Polyoxin D zinc salt	19	26.05 b	50.49	120.50 bc	41.68

AUDPC = Area under the disease progression curve.
Treatment means followed by the same letter are not statistically different (P = 0.05, LSD).
1. CX-10440 is the Certis USA, L.L.C. code for Polyoxin D Zinc Salt 5SC Fungicide.

Botrytis cinerea (Gray Mold) / Lettuce #1: CER-2011-014: Yield Results								
Treatment	Rate/ Acre	g a.i./ ha	Active Ingredient	FRAC Code	Yield (Total No. Heads/ Plot)		Yield (Total Weight/ Plot)	
					Measured	Increase (%)	Measured	Increase (%)
Untreated control			Not Applicable		81.25 a		42.45 a	
CX-10440 [1]	3.75 fl oz	14	Polyoxin D zinc salt	19	89.75 a	4.6	45.65 a	7.5
CX-10440 [1]	7.5 fl oz	29	Polyoxin D zinc salt	19	86.75 a	6.8	45.05 a	6.1

AUDPC = Area under the disease progression curve.
Treatment means followed by the same letter are not statistically different (P = 0.05, LSD).
1. CX-10440 is the Certis USA, L.L.C. code for Polyoxin D Zinc Salt 5SC Fungicide.

Botrytis was first observed on July 27, 2011. Therefore, the treatments were preventative and curative.

No phytotoxicity was observed.

c. Discussion and Conclusions

Head lettuce was grown in California. Maximum gray mold incidence in the untreated control was 52.62%.

Polyoxin D Zinc Salt 5SC Fungicide treatments were applied preventatively and curatively. There was a positive dose response for gray mold incidence:

- Treatments at 3.75 fl oz/acre (14 g a.i./ha) provided mean 34.38% (range 30.00% to 38.75%) control.
- Treatments at 7.5 fl oz/acre (29 g a.i./ha) provided mean 46.09% (range 41.68% to 50.49%) control.

The two Polyoxin D zinc Salt 5SC Fungicide treatment rates provided control that were statistically:

- Superior to the untreated control; and
- Equivalent to each other.

Treatments with Polyoxin D Zinc Salt 5SC Fungicide provided non-statistically significant increased yields.

- At the low rate, the mean increased yield was 6.1% (range 4.6% to 7.5%).
- At the high rate, the mean increased yield was 6.5% (range 6.1% to 6.8%).

No phytotoxicity was observed.

Botrytis cinerea (TAN SPOT, GRAY MOLD, BOTRYTIS VINE ROT) / POTATOES

Botrytis cinerea (Tan Spot, Gray Mold, Botrytis Vine Rot) / Potatoes: Introduction

(Source: Luke Steere and William Kirk, Botrytis Blight, Michigan Potato Diseases, Michigan State University Extension Bulletin E-3205, February 2015)

The primary causal agent of Botrytis blight (gray mold and tan spot) of potatoes is *Botrytis cinerea.*

Botrytis blight or grey mold (tan spot) is a common disease in Michigan potato fields. The disease is often observed on stems and leaves but when inoculum levels are high, the disease can also be seen on tubers. The lesions on foliage are very similar to and can be confused with those caused by early blight *(Alternaria solani)* and late blight *(Phytophthora infestans)*. The pathogen is able to overwinter in the soil as sclerotia. Leaf and stem lesions lead to early plant death and decreased yield and tuber quality. Excessive fertilizer inputs and irrigation or precipitation may lead to a dense canopy with reduced air circulation, which can remain wet for extended periods and promote grey mold. The pathogen has a wide host range with reported incidence in more than 200 different hosts, some of which are used in rotation with potatoes. This wide host range causes a drastic increase in inoculum levels over time.

Botrytis cinerea (Tan Spot, Gray Mold, Botrytis Vine Rot) / Potatoes: Symptoms

(Source: Luke Steere and William Kirk, Botrytis Blight, Michigan Potato Diseases, Michigan State University Extension Bulletin E-3205, February 2015)

Grey mold is named for the grey conidia that appear on senescing plant tissue. The disease first appears as tan lesions (tan spot) at the leaf margin. Leaf lesions are often seen on dying tissue or plants that have been damaged. Infection and colonization of leaves often lead to petiole lesions, which constrict the vascular system in compound leaves thus leading to decreased transport of photosynthates. The mycelium spreads from the petiole to the main stem and causes stem lesions at sites of previous injury from fallen leaves or from insect damage, in particular, from corn stem borers. Girdling is the most common result of stem lesions, but under hot conditions complete stem rot may occur in the presence of secondary bacteria. Dry rot symptoms similar to those caused by *Fusarium* spp. may be seen on tubers in storage when inoculum levels are high.

Botrytis cinerea (Tan Spot, Gray Mold, Botrytis Vine Rot) / Potatoes: Disease Cycle

(Source: Luke Steere and William Kirk, Botrytis Blight, Michigan Potato Diseases, Michigan State University Extension Bulletin E-3205, February 2015)

The fungus overwinters as sclerotia or mycelium in plant debris. When conditions are favorable, the mycelium produces conidiophores and conidia. On potatoes, *Botrytis cinerea* can be seed-borne and develop from mycelium on the mother tuber. In Michigan with such a wide crop range, mycelium on plant debris in the upper layers of the soil may serve as inoculum sources of the pathogen. Conidia are readily airborne and may also be carried on the surface of splashing rain or irrigation water. Relative humidity around 90 percent is necessary for spore production. Spores landing on potato plants germinate and infect in the presence of free water from dew, rain, mists or irrigation. The optimum temperature for infection is between 65 and 75°F and can occur within five hours. However, temperatures above 82°F suppress growth and spore production, although at temperatures this high, secondary bacterial infections can enhance the development of other disease complexes. Infected flowers can spread infection to leaves and stems. In addition, direct contact with moist, infested soil or plant debris can promote infection.

***Botrytis cinerea* (Tan Spot, Gray Mold, Botrytis Vine Rot) / Potatoes: Management**
(Source: 2015 Organic Production and IPM Guide for Potatoes, Cornell University Cooperative Extension)

Management Option	Recommendation
Scouting/thresholds	Record the occurrence and severity of Botrytis vine rot if it will cause disease problems with the crop rotation. Thresholds have not been established for organic production.
Site selection	Avoid planting in fields with soil that drain poorly. Avoid areas where foliage remains wet from dew for long periods. Fields surrounded by trees that shade and slow air movement, or those remaining damp late into the morning are at high risk.
Resistant varieties	No resistant varieties are available.
Crop rotation, seed selection, post-harvest, and sanitation	These are not currently viable management options.
Notes	Nitrogen rates that result in excess vine growth aggravate this disease.

Botrytis cinerea (Tan Spot, Gray Mold, Botrytis Vine Rot) / Potatoes: OMRI Listed Fungicides for Use in the United States										
FRAC Code	Source: 2015 Organic Production and IPM Guide for Potatoes, Cornell University Cooperative Extension							Source: EPA Label		NOP Status
	Active Ingredient	Product Name	Product Rate/ Acre	PHI (Days)	REI (Days)	Efficacy	Comments	EPA Reg. No.	Comments	
44	*Bacillus amyloliquefaciens* str. D747	Double Nickel 55	0.25-3 lb	0	4	Not reviewed or no research available.		70051-108	Causes moderate eye irritation. Dermal sensitizer. Broad-spectrum preventative fungicide. Do not use highly alkaline or highly acidic water to mix sprays. Use a buffering agent if necessary to maintain neutrality (pH 6 to 8) of water in the tank.	Non-synthetic
		Double Nickel LC	0.5-6 qt	0	4	Not reviewed or no research available.		70051-114	Harmful if absorbed through skin. Harmful if inhaled. Dermal sensitizer. Broad-spectrum preventative fungicide.	
	Bacillus subtilis str. QST 713	Optiva	14-24 oz	0	4	Not reviewed or no research available.	Repeat on a 7-10 day interval or a needed.	62592-26	Causes moderate eye irritation. Dermal sensitizer. Broad spectrum preventative product.	Non-synthetic
		Serenade ASO	2-6 qt	0	4	Not reviewed or no research available.	Repeat on a 7-10 day interval or a needed.	264-1152	Broad spectrum preventative fungicidal and bactericidal product.	
		Serenade MAX	1-3 lb	0	4	Not reviewed or no research available.	Repeat on a 7-10 day interval or a needed.	69592-11	Dermal sensitizer. Broad spectrum preventative fungicidal and bactericidal product.	
		Serenade Optimum	14-20 oz	0	4	Not reviewed or no research available.		264-1160		
P5	*Reynoutria sachalinensis*	Regalia Biofungicide	1-4 qt	0	4	Not reviewed or no research available.	Apply every 5-7 days.	84059-3	Causes moderate eye irritation. Preventative rather than a curative application. Apply prior to disease infestation to protect the growing leaf tissue. Avoid freezing.	Non-synthetic

Botrytis cinerea (Tan Spot, Gray Mold, Botrytis Vine Rot) / Potatoes: OMRI Listed Fungicides for Use in the United States										
FRAC Code	Source: 2015 Organic Production and IPM Guide for Potatoes, Cornell University Cooperative Extension							Source: EPA Label		NOP Status
	Active Ingredient	Product Name	Product Rate/ Acre	PHI (Days)	REI (Days)	Efficacy	Comments	EPA Reg. No.	Comments	
Not classified; Biological	*Gliocladium catenulatum* str. J1446	Prestop Biofungicide	3.5 oz/5 gal water applied at 0.5 gal mix/100 sq ft.	0	0	Not reviewed or no research available.		64137-11	Harmful if swallowed. Applicators and other handlers must wear a NIOSH-approved respirator with any N, P, R or HE filter. Consists of live microbes. Store below 46°F (8°C) for up to 6 months. Immediately use the entire package's content after opening. Foliar spray prohibited on listed crops; use limited to soil treatments. Do not tank mix with any pesticides or concentrated fertilizers. Do not use most chemical pesticides within 1-4 days of application.	Non-synthetic
	Streptomyces lydicus WYEC 108	Actinovate AG	3-12 oz	0	1 or until solution has dried	Not reviewed or no research available.	Label recommends using a spreader sticker for foliar applications.	73314-1	Avoid contact with skin, eyes, or clothing. Avoid breathing dust or spray mist. Mixer/loaders and applicators must wear a dust/mist filtering respirator meeting NIOSH standards of at least N-95, R-95, or P-95. Repeated exposure to high concentrations of microbial proteins can cause allergic sensitization. Keep from overheating or freezing. Optimum storage temperature is 40°F to 85°F. Contains live spores of a microbe. Best results will be obtained if the product is used prior to disease onset. Becomes active in soil or on the plant foliage when the temperatures are above 45°F and is not effective when temperatures remain cold. Do not apply soil fumigants to treated areas.	Non-synthetic
Not classified: Botanical oil	Neem oil	Trilogy	0.5-1.0% solution in 25-100 gal of water/acre	0	4	Not reviewed or no research available.	Limited to a maximum of 2 gallons/acre/ application.	70051-2	Causes moderate eye irritation. Hazardous to fish and aquatic invertebrates. Toxic to bees exposed to direct treatment. Broad spectrum. Exercise care in timing applications during early morning/late evening to minimize the potential for leaf burn. Use care on plants with tender tissue. Check for leaf burn in small scale trials prior to use. Do not apply to sensitive plant species. Do not apply to wilted or otherwise stressed plants, or to newly transplanted materials or crops prior to root establishment. For optimal performance, do not mix with cold water (less than 45°F). Do not store below 40°F (4°C). Do not use or store near heat or open flame. Growth stage use restrictions for grapes and stone fruit.	Non-synthetic

Botrytis cinerea (Tan Spot, Gray Mold, Botrytis Vine Rot) / Potatoes: OMRI Listed Fungicides for Use in the United States										
FRAC Code	Source: 2015 Organic Production and IPM Guide for Potatoes, Cornell University Cooperative Extension							Source: EPA Label		NOP Status
	Active Ingredient	Product Name	Product Rate/ Acre	PHI (Days)	REI (Days)	Efficacy	Comments	EPA Reg. No.	Comments	
Not classified; Inorganic salt	Potassium bicarbonate	EcoMate Amicarb O	2.5-5 lb/ 100 gal water	0	4	Not reviewed or no research available.	Apply mixed solution at a minimum of 20 gal/ acre.	5905-541	Harmful if swallowed. Causes moderate eye irritation. Broad spectrum contact foliar fungicide. Prevent exposure to moisture during storage. Avoid contamination with other pesticides and fertilizers.	Synthetic
	Potassium bicarbonate	Milstop	2-5 lb	0	1	Not reviewed or no research available.		70870-1-68539	Harmful if swallowed. Causes moderate eye irritation. Broad spectrum contact foliar fungicide. Do not mix with other soluble pesticides or fertilizers. Not compatible with mild alkaline solutions. Acidification of solution will cause reduced product performance. Prevent exposure to moisture during storage. Avoid contamination with other pesticides and fertilizers.	Synthetic
Not classified; Oxidizing agent	Hydrogen peroxide, Hydrogen dioxide	Perpose Plus	Initial/ Curative: 1 fl oz/gal Weekly/ Preventative: 0.25-0.33 fl oz/gal	0	Until spray has dried	Not reviewed or no research available.	For initial or curative use, apply higher rate for 1 to 3 consecutive days. Then follow with weekly/preventative treatment. For weekly or preventative treatment, apply lower rate every five to seven days. At first signs of disease, use curative rate then resume weekly prevention.	86729-1	DANGER signal word. Causes irreversible eye damage and skin burns. May be fatal if absorbed through the skin. Harmful if swallowed. Do not breathe vapor from concentrate. Toxic to birds, mammals, fish and aquatic life. At temperatures exceeding 156°F, decomposition releases oxygen. The oxygen released could initiate or promote combustion of other materials. Store away from combustibles. Broad spectrum algaecide and fungicide. Apply curative rates for 3 consecutive days (drenching the entire plant) followed by weekly preventative treatments.	Synthetic

Botrytis cinerea **(Tan Spot, Gray Mold, Botrytis Vine Rot) / Potatoes: Efficacy Trials**

Botrytis cinerea (Tan Spot, Gray Mold, Botrytis Vine Rot) / Potatoes #1: Trial No. CER-2011-029

a. Trial Design

<table>
<tr><th colspan="5">Botrytis cinerea (Tan Spot, Gray Mold, Botrytis Vine Rot) / Potatoes #1: Trial No. CER-2011-029: Design</th></tr>
<tr><td>Title:</td><td colspan="4">Evaluation of Fungicide Programs for Potato Early Blight, Brown Spot and Tan Spot Control: 2011</td></tr>
<tr><td>Authors and affiliation:</td><td colspan="4">W. W. Kirk and R. L. Schafer
Department of Plant Pathology
Michigan State University
East Lansing, Michigan, USA</td></tr>
<tr><td>Publication:</td><td colspan="4">PDMR 6:V107</td></tr>
<tr><td>Location:</td><td colspan="4">East Lansing, Michigan, USA</td></tr>
<tr><td>Crop:</td><td colspan="4">Potato (variety ‘Russet Norkotah’)</td></tr>
<tr><td>Disease names:</td><td colspan="4">Tan spot, Botrytis blight, gray mold</td></tr>
<tr><td>Pathogen:</td><td colspan="4">Botrytis cinerea</td></tr>
<tr><td>Test plot design:</td><td colspan="4">Randomized complete block</td></tr>
<tr><td>Number of replicates:</td><td colspan="4">4</td></tr>
<tr><td>Application equipment:</td><td colspan="4">R&D spray boom</td></tr>
<tr><td>Spray solution volume:</td><td colspan="4">25 gal/acre (234 L/ha)</td></tr>
<tr><td>Number of applications:</td><td colspan="4">8</td></tr>
<tr><td>Application interval:</td><td colspan="4">7 days</td></tr>
<tr><td rowspan="2">Chronology:</td><td>Planting Date</td><td>Fungicide Application Dates</td><td>Disease Evaluation Date</td><td>Harvest Date</td></tr>
<tr><td>05/25/2011</td><td>07/05/2011 A
07/12/2011 B
07/19/2011 C
07/25/2011 D
08/01/2011 E
08/08/2011 F
08/16/2011 G
08/23/2011 H
08/30/2011 I</td><td>09/12/2011</td><td>10/22/2011</td></tr>
</table>

b. Results

Botrytis cinerea (Tan Spot, Gray Mold, Botrytis Vine Rot) / Potatoes #1: Trial No. CER-2011-029: Results

Treatment	Rate/ Acre	g a.i./ ha	Active Ingredient	FRAC Code	App. Code	Tan Spot		Yield (cwt/ acre)	Yield Increase (%)
						Incidence (%)	Control (%)		
Untreated Control						35.0 a		231 b	
CX-10440 5SC (Note 1)	3.8 fl oz	15	Polyoxin D zinc salt	19	ABCDEFGHI	8.8 def	74.9	292 ab	26.4
CX-10440 5SC (Note 1)	7.5 fl oz	29	Polyoxin D zinc salt	19	ABCDEFGHI	10.0 cde	71.4	247 b	6.9
Echo ZN 4.17SC	1.5 pt		Chlorothalonil	M5	ABCDEFGHI	7.5 efg	78.6	277 ab	19.9
Echo ZN 4.17SC	1.5 pt		Chlorothalonil	M5	ABCDEFGHI	7.5 efg	78.6	258 ab	11.7
Scala 60 SC	7 fl oz		Pyrimethalin	9	EG				
Tanos 50WG	6 oz		Famozadone	11	ABCDEFGHI	8.8 def	74.9	266 ab	15.2
Manzate 75WG	1.5 lb		Cymoxanil	27					
Echo ZN 4.17SC	2.12 pt		Chlorothalonil	M5	ACEI	8.8 def	74.9	317 a	37.2
Priaxor 4.17 SC	4 fl oz		Fluxapryoxad	7	BF				
			Pyraclostrobin	11					
Echo ZN 4.17SC	2 pt		Chlorothalonil	M5					
Dithane Rainshield 75DF	2 lb		Mancozeb	M3	GH				
Super Tin 80 WP	2.5 oz		Triphenyltin hydroxide	30					

Values followed by the same letter are not significantly different at p= 0.05 (Fishers LSD).

Note 1: The list of treatments includes "CX-10440 11.3 SC." This is a typographical error. The treatment should have been described as "CX-10440 5SC." The only liquid formulation of polyoxin D zinc salt is the 5.0% SC formulation. The Certis USA, L.L.C. research code for the formulation is CX-10440. This formulation is also known as Polyoxin D Zinc Salt 5SC Fungicide. (The 11.3% formulation is an older formulation and is the water dispersible granule formulation, *i.e.*, a dry formulation.)

The report does not note the date of first observation of tan spot symptoms. Therefore, the tan spot treatments are assumed to have been preventative.

No phytotoxicity was observed.

c. Discussion and Conclusions

Potatoes grown in Michigan were evaluated for control of *Botrytis cinerea* (tan spot). Maximum tan spot incidence in the untreated control was 35.0%.

Eight consecutive treatments of Polyoxin D Zinc Salt 5SC Fungicide were applied preventatively at 7-day intervals. A positive dose response was not observed.

- Treatments applied at 3.8 fl oz/acre (15 g a.i./acre) provided:
  - 74.9% control of tan spot incidence and 26.4% increased yield.
- Treatments applied at 7.5 fl oz/acre (29 g a.i./ha) provided:
  - 71.4% control of tan spot incidence and 6.9% increased yield.

The two Polyoxin D Zinc Salt 5SC Fungicide treatment rates provide control of tan spot incidence that were statistically:

- Superior to the untreated control; and
- Equivalent to each other and to treatment programs that included:
  - Chlorothalonil only;
  - Chlorothalonil plus pyrimethalin;
  - Famozadone plus cymoxanil; and
  - Chlorothalonil, fluxapryoxad, pyraclostrobin, mancozeb, and triphenyltin hydroxide.

The two Polyoxin D Zinc Salt 5SC Fungicide treatment rates provided mean 16.7% (range 6.9% to 26.4%) increased yields compared to the untreated control. The increases are not statistically significant but are probably commercially significant.

The yields for the following treatments provided similar increased yield that were not statistically significant:

- Chlorothalonil;
- Chlorothalonil plus pyrimethalin; and
- Famozadone plus cymoxalin

The following treatment program provided statistically significant increased yield:

- Chlorothalonil, fluxapryoxad, pyraclostrobin, mancozeb, plus triphenyltin hydroxide.

No phytotoxicity was observed.

Botrytis cinerea **(BOTRYTIS FRUIT ROT & CANE BOTRYTIS) / RASPBERRIES**

Botrytis cinerea **(Botrytis Fruit Rot & Cane Botrytis) / Raspberries: Introduction**
(Source: Pacific Northwest Plant Disease Management Handbook)

Botrytis cinerea is a fungus that causes blossom blight, preharvest rot, postharvest rot, and cane infections of raspberries. Crop losses can exceed 50% in years when rains persist through bloom and into harvest. On raspberry, it overwinters as sclerotia on canes and mycelia in dead leaves and mummified fruit. Sclerotia produce conidia in spring. A moist, humid environment is ideal for pathogen sporulation and spread. Spores are dispersed mainly by wind, but can also be moved by splashing rain or irrigation water. Spores require free water on plant surfaces to germinate and infect. Wet weather (such as rain, heavy dew, fog, or even irrigation) just before and during bloom is important for disease development. All flower parts except sepals are very susceptible. Initial infections of flowers are latent such that the fungus is dormant until fruit ripens. Fruit rot may be more prevalent in wet weather, in fields under overhead set irrigation systems, or where fruit overripens in the field for mechanical harvest. Conidia can infect mature or senescent leaves, resulting in floricane and sometimes primocane infections through petioles. Cane infections can also initiate through wounds.

Botrytis cinerea **(Botrytis Fruit Rot & Cane Botrytis) / Raspberries: Symptoms**
(Source: Pacific Northwest Plant Disease Management Handbook**)**

Rotted fruit, usually with tufts of gray fungus growing on all or part of the berry. In some years, only a few drupelets on a berry may become moldy. Infected berries rarely leak juice. Receptacles of picked fruit also may be colonized and become gray with fungal spores. Pale-brown lesions may appear on primocane leaves in mid- to late summer. A brown, shield-shape lesion may initially be seen around a cane node, which indicates infection via a colonized leaf petiole. This shield shape will be lost as the lesion expands.

Cane infections between nodes appear as tan-to brown-lesions and expand in both directions often encompassing more than one node. Cane lesions exhibit typical concentric "watermark" patterns from late summer through late winter. Sclerotia may be visible on canes as shiny, black, blister-like structures. Sclerotia appear on spent floricanes during early fall and later on primocanes in late fall and throughout the winter. Young damaged primocanes may be killed when lesions girdle the cane. Lesions on older primocanes usually do not kill the canes.

Botrytis cinerea **(Botrytis Fruit Rot & Cane Botrytis) / Raspberries: Cultural Control**
(Source: Pacific Northwest Plant Disease Management Handbook)

No single cultural practice provides adequate management of gray mold under highly conducive conditions. Integrate several tactics to manage this disease. The use of cultural tactics reduces reliance on fungicide applications and can help manage fungicide resistance.

- 'Munger', 'Chilliwack', 'Comox', 'Fairview', and 'Meeker' have shown moderate resistance to Botrytis fruit rot. 'Chilcotin', 'Nootka', and 'Willamette' have shown resistance to Botrytis cane infections.
- Create an open plant canopy: use a double top wire training system, prune, avoid excessive nitrogen fertilization, and control weeds. These practices improve air circulation, increase light penetration, and speed drying of plant surfaces after irrigation and rain.
- Avoid excessive nitrogen fertilization.
- Pick fruit in the coolest part of the day. Keep harvested fruit in shade while in the field, and then move to cold storage as soon as possible. Pick frequently so that berries do not become overripe.

- Control early-season primocanes.
- Adjust irrigation so plants do not stay wet for extended periods of time. Switch from overhead to drip/trickle irrigation.
- Remove fall fruit during tying time.

Botrytis cinerea **(Botrytis Fruit Rot & Cane Botrytis) / Raspberries: Chemical Control**
(Source: Pacific Northwest Plant Disease Management Handbook)

Spray first at 5% bloom and again 7 to 10 days later. Applications during the growing season, especially preharvest, aid control when wet weather is expected. Thorough coverage and canopy penetration are essential. Fungal strains can become tolerant to a fungicide when it is used exclusively in a spray schedule. To reduce the possibility of tolerance, alternate or tank-mix fungicides that have different modes of action. Minimize the use of any one group of fungicides to no more than twice a year.

Strains resistant to 5 different modes of action have been reported from Germany. Resistance to Group 2, 9 and 17 fungicides have been documented in northern Washington. Discontinuation of Group 2 fungicides for many years has resulted in increased sensitivity and allowed its limited reuse once again in this area.

Botrytis cinerea (Botrytis Fruit Rot) / Raspberries: OMRI Listed Fungicides for Use in the United States
(No efficacy data have been identified or evaluated.)

FRAC Code	Source: EPA Label								NOP Status
	Active Ingredient	Product Name	Label claim	Product Rate/ Acre	PHI (Days)	REI (Hours)	EPA Reg. No.	Comments	
44	*Bacillus amyloliquefaciens* str. D747	Double Nickel 55	Botrytis blight (*Botrytis cinerea*)	0.25-3 lb	0	4	70051-108	Causes moderate eye irritation. Dermal sensitizer. Broad-spectrum preventative fungicide. Do not use highly alkaline or highly acidic water to mix sprays. Use a buffering agent if necessary to maintain neutrality (pH 6 to 8) of water in the tank. Suppression only. Begin applications at or before pistillate bloom, repeating every 7-10 days. Apply before rainfall if possible, and tank mix or rotate with copper-based bactericide registered for such use to improve control.	Non-synthetic
P5	*Reynoutria sachalinensis*	Regalia Biofungicide	Botrytis blight (*Botrytis cinerea*)	1-4 qt	0	4	84059-3	Causes moderate eye irritation. Preventative rather than a curative application. Apply prior to disease infestation to protect the growing leaf tissue. Avoid freezing. Apply prior to disease infestation.	Non-synthetic
Not classified; Biological	*Aureobasidium pullulans* strains DSM 14940 and DSM 14941	Botector	Gray mold (*Botrytis cinerea*)	5-10 oz	0	4	86174-3	Harmful if swallowed or absorbed through the skin. Applicators and other handlers must wear a NIOSH-approved respirator. Repeated exposure to high concentrations of microbial proteins can cause allergic sensitization. Do not apply by ground within 25 feet of lakes; reservoirs; rivers; permanent streams, marshes or natural ponds; estuaries and commercial fish farm ponds. Do not cultivate within 10 feet of the aquatic areas to allow growth of a vegetative filter strip. Must be stored out of direct sunlight in a cool dry place. Do not freeze. From date of manufacture, product can be stored: 10 months at room temperature (47-68°F; 9-20°C) or 24 months at cold temperature (34-46°F; 1-8°C).	Non-synthetic
Not classified; Botanical oil	Neem oil	Trilogy	Botrytis	0.5-1.0% solution	0	4	70051-2	Causes moderate eye irritation. Hazardous to fish and aquatic invertebrates. Toxic to bees exposed to direct treatment. Broad spectrum. Exercise care in timing applications during early morning/late evening to minimize the potential for leaf burn. Use care on plants with tender tissue. Check for leaf burn in small scale trials prior to use. Do not apply to sensitive plant species. Do not apply to wilted or otherwise stressed plants, or to newly transplanted materials or crops prior to root establishment. For optimal performance, do not mix with cold water (less than 45°F). Do not store below 40°F (4°C). Do not use or store near heat or open flame.	Non-synthetic
M1	Copper octanoate	Cueva Fungicide Concentrate	Gray mold (*Botrytis cinerea*)	0.5-2.0 gal/ 100 gal	0	4	67702-2-70051	Harmful if swallowed or absorbed through skin. Toxic to fish and aquatic organisms. May cause some copper toxicity on some plant species. Store away from open fire or flame. Product may be damaged by freezing. Do not store product below 4°C. Do not mix with chelated or liquid fertilizers. Use caution when using product with other fungicides and insecticides. Apply at the start of flowering and continue every 7 to 10 days until harvest.	Synthetic

Botrytis cinerea (Botrytis Fruit Rot) / Raspberries: OMRI Listed Fungicides for Use in the United States **(No efficacy data have been identified or evaluated.)**									
FRAC Code	Source: EPA Label								NOP Status
	Active Ingredient	Product Name	Label claim	Product Rate/ Acre	PHI (Days)	REI (Hours)	EPA Reg. No.	Comments	
Not classified; Oxidizing agent	Hydrogen dioxide, Peroxyacetic acid	Oxidate	Botrytis	Initial/ Curative: 128 fl oz/ 100 gal water; 30-100 gal solution/ acre Preventative: 40-128 fl oz/ 100 gal water; 30-100 gal solution/ acre	0	Until dry	70299-2	DANGER signal word. Causes irreversible eye damage. May be fatal if swallowed. Causes skin irritation or temporary discoloration of exposed skin. Highly toxic to bees and other beneficial insects. Toxic to fish. Toxic to birds who eat treated seed on soil surface. Strong oxidizing agent. Do not use in undiluted form. Never bring undiluted product in contact with other pesticides, cleaners or oxidative agents. May react with residues of metal-based fungicides or supplements. Allow at least 24 hrs. after application of metal-based products. Do not spray during conditions of intense heat, drought, or poor plant vigor (or vine canopy). Do not apply in conjunction with any other pesticides or fertilizers. Do not allow product to become overheated in storage. Do not store in a manner where cross-contamination with other pesticides or fertilizers could occur. Apply consecutive applications until control is achieved; then apply preventative treatments.	Synthetic

Botrytis cinerea (Botrytis Fruit Rot) / Raspberries: Efficacy Trials

Botrytis cinerea (Botrytis fruit rot) / Red Raspberry #1: Trial No. IND-2015-RASP

a. Design

Botrytis sp. (Botrytis fruit rot) / Red Raspberry #1: Trial No. IND-2015-RASP: Design			
Title:	Washington Raspberry Commission 2015: Raspberry Research Reports		
Authors and affiliation:	Dr. Alan Schreiber, Dr. Tom Walters, and Andy Nagy Agricultural Development Group, Inc.		
Publication:	Permission received.		
Location:	Near Everson, Washington		
Crop:	Red raspberry		
Disease name:	Botrytis fruit rot		
Pathogen:	*Botrytis cinerea*		
Test plot design:	Randomized complete block		
Number of replicates:	4		
Application equipment:	Over the row sprayer		
Spray volume:	100 gal/acre		
Number of applications:	6		
Chronology:	Application Dates	Application Interval	Disease Assessment Dates
	05/19/2015 to 07/09/2015	10 days	07/10/2015 07/16/2015
Resistance history:	The test field had a history of resistance to fenhexamid, cyprodinil, and boscalid.		
Notes:	The 2015 growing season had record high temperatures and record low rainfall. Supplemental overhead irrigation was applied to promote disease development.		

b. Results

Botrytis sp. (Botrytis fruit rot) / Red Raspberry #1: Trial No. IND-2015-RASP: Results						
Treatment	Rate/ Acre	g a.i./ ha	Active Ingredient	FRAC Code	Incidence (%) (7/10/2015)	
					Measured	Percent Control
Untreated control			Not Applicable		19.0 ab	
Oso	12 fl oz	46	Polyoxin D zinc salt	19	9.3 cde	51
Omega	1.25 pt		Fluazinam	29	5.3 de	72
Merivon	5.5 fl oz		Fluxapyroxad	7	6.8 cde	64
			Pyraclostrobin	11		
Topsin M	1.5 lb		Thiophanate-methyl	1	8.0 cde	58
Captan	2.5 ld		Fludioxonil	12	10.0 b-e	47
Switch	14 oz		Cyprodinil	9	10.5 b-e	48
Proline	5 fl oz		Prothioconazole	3	10.5 b-e	45
Iprodione	1 pt		Iprodione	2	11.0 b-e	42
Protexio	0.5 lb		Fenpyrazamine	17	11.0 b-e	42
NeoBoost	3 lb		Sodium percarbonate	NC	11.8 b-e	38
			Tetraactetylethylenediamine	NC		
			Potassium silicate	NC		
Luna Tranquility	18 fl oz		Fluopyram	7	12.0 b-e	37
			Pyrimethalin	9		
Pristine	23 oz		Boscalid	7	13.0 b-e	32
			Pyraclostrobin	11		
Scala	18 fl oz		Pyrimethalin	9	14.5 bcd	24
Elevate	1.5 lb		Fenhexamid	17	28.5 a	-50
Treatment means followed by the same letter are not statistically different according to the LSD test at P = 0.05.						

The date of first observation of Botrytis fruit was not reported. Therefore, the treatments are assumed to have been preventative.

No phytotoxicity was reported.

c. Discussion and Conclusions

Red raspberries were grown in Washington. The maximum Botrytis fruit rot incidence of 19.0% was observed in the untreated control on July 10, 2015.

Polyoxin D Zinc Salt 5SC Fungicide applied preventatively at 12 fl oz/acre (46 g a.i./ha) provided 51% control of Botrytis fruit rot incidence of red raspberries. This was statistically superior to the untreated control and statistically equivalent to the control provided by:

- Fluazinam;
- Fluxapyroxad plus pyraclostrobin; and
- Thiophanate-methyl.

The control of Botrytis fruit rot incidence of red raspberries provided by the following active ingredients was less than that provided by Polyoxin D Zinc Salt 5SC Fungicide and as statistically equivalent to the untreated control:

- Fludioxonil;
- Cyprodinil;
- Prothioconazole;
- Iprodione;
- Fenpyrazamine;
- Sodium percarbonate plus tetraactetylethylenediamine plus potassium silicate;
- Fluopyram plus pyrimethalin;
- Boscalid plus pyraclostrobin; and
- Pyrimethalin.

Treatment with fenhexamid provided less control of Botrytis fruit rot incidence than did the untreated control.

No phytotoxicity was reported.

Botrytis cinerea **(Botrytis Fruit Rot) / Raspberries: Grower Need**
Control of Botrytis on raspberries (Project No. B00129) was identified as a grower need at the IR-4 2015 Biopesticide Workshop.

Botrytis cinerea (GRAY MOLD) / STRAWBERRIES

Botrytis cinerea (Gray Mold) / Strawberries: Introduction

[Sources: (1) Small Fruit IPM Disease Identification Sheet No. 1, Cornell University. (2) 2015 Organic Production and IPM Guide for Strawberries, Cornell University Cooperative Extension.]

Botrytis fruit rot, also called gray mold, is a major disease of strawberries throughout the world. The disease, caused by the fungus *Botrytis cinerea,* is responsible for fruit losses of 50 percent or more during cool, wet seasons. In addition to strawberries, Botrytis causes economic losses on many other crop plants. Gray mold can be difficult to control organically in strawberries if the weather does not cooperate.

Botrytis cinerea (Gray Mold) / Strawberries: Disease Cycle

(Source: Small Fruit IPM Disease Identification Sheet No. 1, Cornell University)

Botrytis cinerea may colonize and produce spores (conidia) on almost any plant debris. It overwinters in strawberry plantings on decayed foliage and fruit from the previous season. Increasing temperatures and moisture in the spring promotes fungal growth and production of conidia which are spread by wind and rain to the developing strawberry plants. Botrytis conidia are abundant throughout the growing season in most strawberry growing areas.

Disease development is favored by wet conditions accompanied by temperatures between 5°C (41°F) and 30°C (86°F). Conditions that impede drying of fruit wetted by rain or sprinkler irrigation will encourage Botrytis rot. Strawberries are susceptible to Botrytis during bloom and again as fruits ripen. During the blossom blight phase of the disease, the fungus colonizes senescing flower parts, turning the blossoms brown. Blossom infections establish the fungus within the plant and produce inoculum that can spread the fungus to other plants. Cool, wet weather and particularly frost injury favors blossom infections. The fungus can then move into developing fruit and remain quiescent until the fruits start to mature, at which time the rot becomes noticeable. Infections may be associated with senescent petals adhering to sepals at the stem end of green or ripe fruit. Infected senescent petals adhering to leaves may also result in a leaf blight. Abundant gray-brown, fluffy, fungal growth on infected tissue is responsible for the disease's name "gray mold". Fruit infections may be noticeable on green fruits. However, they are most apparent on ripe fruit where abundant sporulation may develop. Fruits touching the ground or in areas where poor air drainage does not allow for rapid drying are most likely to become rotted. When conditions are conducive to abundant blossom infection, the chance of a high level of fruit rot developing at harvest is increased.

Botrytis cinerea (Gray Mold) / Strawberries: Control

(Source: Small Fruit IPM Disease Identification Sheet No. 1, Cornell University)

Botrytis fruit rot can be controlled by a combination of cultural and chemical control measures. Proper weed control and spacings of 4½ feet between row centers, 5-7 inches between plants within the fruiting matted row, and a 15-18 inch width of the row encourages good air drainage and prevents moisture buildup on berries. Application of fertilizer to strawberries should be made after harvest or in the fall of the year. Spring fertilization of fruiting beds results in vigorously growing plants that are more susceptible to Botrytis. Sprinkler irrigation used early in the day so foliage and fruit will dry prior to night fall will reduce wetting periods favorable to Botrytis infection. Practices which promote good air drainage within the planting also favor maximum fungicide spray coverage. Spray programs for rot control should start at bloom and continue throughout the season. Since blossom infections greatly influence subsequent fruit rot, close attention to control at this time is necessary. When possible, sprayers that give the best coverage of all plant surfaces should be used. Sprays should also be applied to fruits as they near harvest, particularly during cool, wet periods. Research has shown that strawberry varieties differ in their susceptibility to Botrytis rot. See your local extension service for up to date control recommendations.

***Botrytis cinerea* (Gray Mold) /Strawberries: Grower Need**

Control of Botrytis on strawberry (Project No. B00129) was identified as an grower need at the 2015 IR-4 Biopesticide Workshop.

Botrytis cinerea (Gray Mold) / Strawberry: OMRI Listed Fungicides for Use in the United States										
FRAC Code	Source: 2015 Organic Production and IPM Guide for Strawberries, Cornell University Cooperative Extension							Source: EPA Label		NOP Status
	Active Ingredient	Product Name	Product Rate/ Acre	PHI (Days)	REI (Days)	Efficacy	Comments	EPA Reg. No.	Comments	
44	*Bacillus amyloliquefaciens* str. D747	Double Nickel 55	0.25-3 lb	0	4	Not reviewed or no research available.	Foliar application.	70051-108	Causes moderate eye irritation. Dermal sensitizer. Broad-spectrum preventative fungicide. Do not use highly alkaline or highly acidic water to mix sprays. Use a buffering agent if necessary to maintain neutrality (pH 6 to 8) of water in the tank. Suppression only. Begin applications at or before pistillate bloom, repeating every 7-10 days. Apply before rainfall if possible, and tank mix or rotate with copper-based bactericide registered for such use to improve control.	Non-synthetic
		Double Nickel LC	0.5-6 qt	0	4	Not reviewed or no research available.	Foliar application.	70051-114	Harmful if absorbed through skin. Harmful if inhaled. Dermal sensitizer. Broad-spectrum preventative fungicide.	
	Bacillus subtilis str. QST 713	Optiva	14-24 oz	0	4	Not effective.	Repeat on 7-10 day intervals.	62592-26	Causes moderate eye irritation. Dermal sensitizer. Broad spectrum preventative product.	Non-synthetic
		Serenade ASO	2-6 qt	0	4	Not effective.	Begin application at or before flowering; repeat every 7-10 days.	264-1152	Broad spectrum preventative fungicidal and bactericidal product.	
		Serenade MAX	1-3 lb	0	4	Not effective.	Begin application at or before flowering ; repeat every 7-10 days.	69592-11	Dermal sensitizer. Broad spectrum preventative fungicidal and bactericidal product.	
		Serenade Optimum	14-20 oz	0	4	Not effective.	Begin application at or before flowering ; repeat every 7-10 days.	264-1160		
P5	*Reynoutria sachalinensis*	Regalia Biofungicide	1-3 qt	0	4	Not reviewed or no research available.	Initiate at first sign of disease then every 7-14 days.	84059-3	Causes moderate eye irritation. Preventative rather than a curative application. Apply prior to disease infestation to protect the growing leaf tissue. Avoid freezing.	Non-synthetic

Botrytis cinerea (Gray Mold) / Strawberry: OMRI Listed Fungicides for Use in the United States										
FRAC Code	Source: 2015 Organic Production and IPM Guide for Strawberries, Cornell University Cooperative Extension							Source: EPA Label		NOP Status
	Active Ingredient	Product Name	Product Rate/ Acre	PHI (Days)	REI (Days)	Efficacy	Comments	EPA Reg. No.	Comments	
Not classified; Biological	*Gliocladium catenulatum* str. J1446	Prestop	3.5 oz/5 gal	0	0	Not reviewed or no research available.	Foliar spray. Apply at 0.5 gallon of mixed spray per 100 sq. ft. Apply only when above-ground harvestable food commodities are present.	64137-11	Harmful if swallowed. Applicators and other handlers must wear a NIOSH-approved respirator with any N, P, R or HE filter. Consists of live microbes. Store below 46°F (8°C) for up to 6 months. Immediately use the entire package's content after opening. Foliar spray prohibited on listed crops; use limited to soil treatments. Do not tank mix with any pesticides or concentrated fertilizers. Do not use most chemical pesticides within 1-4 days of application.	Non-synthetic
	Streptomyces lydicus WYEC 108	Actinovate AG	3-12 oz	0	1 or until solution has dried	Inconsistent efficacy results.	Foliar application. For best results apply with a spreader/sticker prior to onset of disease.	73314-1	Avoid contact with skin, eyes, or clothing. Avoid breathing dust or spray mist. Mixer/loaders and applicators must wear a dust/mist filtering respirator meeting NIOSH standards of at least N-95, R-95, or P-95. Repeated exposure to high concentrations of microbial proteins can cause allergic sensitization. Keep from overheating or freezing. Optimum storage temperature is 40°F to 85°F. Contains live spores of a microbe. Best results will be obtained if the product is used prior to disease onset. Becomes active in soil or on the plant foliage when the temperatures are above 45°F and is not effective when temperatures remain cold. Do not apply soil fumigants to treated areas.	Non-synthetic

Botrytis cinerea (Gray Mold) / Strawberry: OMRI Listed Fungicides for Use in the United States										
FRAC Code	Source: 2015 Organic Production and IPM Guide for Strawberries, Cornell University Cooperative Extension							Source: EPA Label		NOP Status
	Active Ingredient	Product Name	Product Rate/ Acre	PHI (Days)	REI (Days)	Efficacy	Comments	EPA Reg. No.	Comments	
Not classified; Botanical oil	Cinnamon oil	Cinnerate	13-30 fl oz/ 100 gal water	0	0	Not reviewed or no research available.	Apply 85-125 gal diluted spray/acre.	N/A. FIFRA §25(b) pesticide.	May cause eye and skin irritation. May cause dermal sensitization. Store upright at room temperature. Avoid exposure to extreme temperatures. Do not expose to light and keep away from any heat source. Do not mix with oxidizing, strong acidic or basic materials. Broad spectrum, contact foliar fungicide. All applications should be preceded by a phytotoxicity check to ensure that the material is safe for the particular plant variety.	Non-synthetic
	Neem oil	Trilogy	1.0% solution	0	4	Not reviewed or no research available.	Apply in 25-100 gal water/acre. Maximum labeled use of 2 gal/acre /application	70051-2	Causes moderate eye irritation. Hazardous to fish and aquatic invertebrates. Toxic to bees exposed to direct treatment. Broad spectrum. Exercise care in timing applications during early morning/late evening to minimize the potential for leaf burn. Use care on plants with tender tissue. Check for leaf burn in small scale trials prior to use. Do not apply to sensitive plant species. Do not apply to wilted or otherwise stressed plants, or to newly transplanted materials or crops prior to root establishment. For optimal performance, do not mix with cold water (less than 45°F). Do not store below 40°F (4°C). Do not use or store near heat or open flame. Growth stage use restrictions for grapes and stone fruit.	Non-synthetic
M1	Copper octanoate	Cueva Fungicide Concentrate	0.5-2.0 gal/ 100 gal	0	4	Not reviewed or no research available.	Product is applied as a dilute spray at 50-100 gallons per acre.	67702-2-70051	Harmful if swallowed or absorbed through skin. Toxic to fish and aquatic organisms. May cause some copper toxicity on some plant species. Store away from open fire or flame. Product may be damaged by freezing. Do not store product below 4°C. Do not mix with chelated or liquid fertilizers. Use caution when using product with other fungicides and insecticides.	Synthetic

Botrytis cinerea (Gray Mold) / Strawberry: OMRI Listed Fungicides for Use in the United States										
FRAC Code	Source: 2015 Organic Production and IPM Guide for Strawberries, Cornell University Cooperative Extension							Source: EPA Label		NOP Status
	Active Ingredient	Product Name	Product Rate/ Acre	PHI (Days)	REI (Days)	Efficacy	Comments	EPA Reg. No.	Comments	
Not classified; Inorganic salt	Potassium bicarbonate	EcoMate Amicarb O	2.5-5.0 lb/ 100 gal water	0	4	Not effective.		5905-541	Harmful if swallowed. Causes moderate eye irritation. Broad spectrum contact foliar fungicide. Prevent exposure to moisture during storage. Avoid contamination with other pesticides and fertilizers.	Synthetic
		Milstop	2-5 lb	0	1	Not effective.		70870-1-68539	Harmful if swallowed. Causes moderate eye irritation. Broad spectrum contact foliar fungicide. Do not mix with other soluble pesticides or fertilizers. Not compatible with mild alkaline solutions. Acidification of solution will cause reduced product performance. Prevent exposure to moisture during storage. Avoid contamination with other pesticides and fertilizers.	

Botrytis cinerea (Gray Mold) / Strawberry: OMRI Listed Fungicides for Use in the United States										
FRAC Code	Source: 2015 Organic Production and IPM Guide for Strawberries, Cornell University Cooperative Extension							Source: EPA Label		NOP Status
	Active Ingredient	Product Name	Product Rate/ Acre	PHI (Days)	REI (Days)	Efficacy	Comments	EPA Reg. No.	Comments	
Not classified; Oxidizing agent	Hydrogen dioxide, Peroxyacetic acid	Oxidate	Initial/ Curative: 128 fl oz/ 100 gal water; 30-100 gal solution/ acre Preventative: 40-128 fl oz/ 100 gal water; 30-100 gal solution/ acre	0	Until dry	Not reviewed or no research available.	Pre-plant dip. Foliar application, at planting and for existing plantings. See label for additional instructions.	70299-2	DANGER signal word. Causes irreversible eye damage. May be fatal if swallowed. Causes skin irritation or temporary discoloration of exposed skin. Highly toxic to bees and other beneficial insects. Toxic to fish. Toxic to birds who eat treated seed on soil surface. Strong oxidizing agent. Do not use in undiluted form. Never bring undiluted product in contact with other pesticides, cleaners or oxidative agents. May react with residues of metal-based fungicides or supplements. Allow at least 24 hrs. after application of metal-based products. Do not spray during conditions of intense heat, drought, or poor plant vigor (or vine canopy). Do not apply in conjunction with any other pesticides or fertilizers. Do not allow product to become overheated in storage. Do not store in a manner where cross-contamination with other pesticides or fertilizers could occur. Apply consecutive applications until control is achieved; then apply preventative treatments.	Synthetic
	Hydrogen peroxide, Hydrogen dioxide	Perpose Plus	Initial/ Curative: 1 fl oz/gal Weekly/ Preventative: 0.25-0.33 fl oz/gal	0	Until spray has dried	Not effective.	For initial or curative use, apply higher rate for 1 to 3 consecutive days. Then follow with weekly/ preventative treatment. For weekly or preventative treatments, apply lower ate every five to seven days. At first sign of disease, use curative rate then resume weekly preventative treatment.	86729-1	DANGER signal word. Causes irreversible eye damage and skin burns. May be fatal if absorbed through the skin. Harmful if swallowed. Do not breathe vapor from concentrate. Toxic to birds, mammals, fish and aquatic life. At temperatures exceeding 156°F, decomposition releases oxygen. The oxygen released could initiate or promote combustion of other materials. Store away from combustibles. Broad spectrum algaecide and fungicide. Apply curative rates for 3 consecutive days (drenching the entire plant) followed by weekly preventative treatments.	Synthetic

Botrytis cinerea (Gray Mold) / Strawberry: OMRI Listed Fungicides for Use in the United States										
FRAC Code	Source: 2015 Organic Production and IPM Guide for Strawberries, Cornell University Cooperative Extension							Source: EPA Label		NOP Status
	Active Ingredient	Product Name	Product Rate/ Acre	PHI (Days)	REI (Days)	Efficacy	Comments	EPA Reg. No.	Comments	
Not classified; Petroleum oils	Paraffinic oil	Organic JMS Stylet Oil	3 qt/ 100 gal water	0	4	Inconsistent efficacy results.	A high volume of water is needed for thorough coverage. Many common pesticides are phytotoxic when applied with or close to oil sprays (*e.g.*, sulfur). Check for label restrictions.	65564-1	Harmful if swallowed. Toxic to fish. Do not freeze. Do not spray wet foliage. Do not spray when freezing temperatures are anticipated within 48 hours of an oil application, above 90°F (32°C) or when plants are under heat or moisture stress. Do not apply to vegetables when the temperature is below 50°F (10°C). Do not apply micronized sulfur within 10 days of an oil application. Do not apply oil within 14 days of an application of wettable or dusting sulfur. Do not apply to oil sensitive varieties. See label for additional compatibility restrictions.	Synthetic
	Mineral oil	PureSpray Green	0.75-1.5 gals oil/100 gal water	0	4	Not reviewed or no research available.	Apply 100-200 gal water per acre. Spray no less than 400 PSI using ceramic nozzles.	69526-9	Harmful if swallowed or absorbed through skin. Prolonged or repeated skin contact may cause allergic reaction in some individuals. Drift and runoff may be hazardous to aquatic organisms in water adjacent to treated areas. Use extreme care when using concentrate sprays as the potential for crop phytotoxicity is increased. Avoid excess heat. Do not spray during or immediately prior to hot or freezing weather (over 95°F or under 32°F), hot dry winds, rain or other unsuitable conditions. Do not overspray or double spray. Spray plants only when they are in vigorous condition and when their moisture condition is suitable. Before using, make certain spray tank is free of sulfur residues. Do not apply micronized sulfur within 10 days of an oil application. Do not apply oil within 14 days of an application of wettable or dusting sulfur. Do not apply to oil sensitive varieties. See label for additional compatibility restrictions regarding many conventional active ingredients.	Synthetic

Botrytis cinerea (Gray Mold) / Strawberries: Efficacy Trials

Botrytis cinerea (Gray Mold) / Strawberries #1: Trial No. CER-2012-070

a. Design

Botrytis cinerea (Gray Mold) / Strawberries #1: Trial No. CER-2012-070: Design		
Title:	Efficacy of CX-10440 for Control of Powdery Mildew (*Sphacelotheca* sp.) and Botrytis (*Botrytis cinerea*) in Strawberry	
Research organization:	Pacific Ag Research	
Publication:	Certis data. Not published. Permission received.	
Location:	Gaudalupe, California, USA (south central California, near the Pacific Ocean)	
Crop:	Strawberry	
Disease name:	Botrytis	
Pathogen:	*Botrytis cinerea*	
Test plot design:	Not reported	
Number of replicates:	Not reported	
Application equipment:	Carbon dioxide backpack sprayer	
Application volume:	50 gal/acre (468 L/ha)	
Number of applications:	5	
Application interval:	7 to 8 days	
Chronology:	Applications Dates	Disease Assessment Dates
	05/08/2012 05/16/2012 05/24/2012 05/31/2012 06/08/2012	05/14/2012 05/23/2012 06/07/2012 06/14/2012 06/21/2012

b. Results

Botrytis cinerea (Gray Mold) / Strawberries #1: Trial No. CER-2012-070: Results						
Treatment	Rate/ acre	g a.i./ ha	Active Ingredient	FRAC Code	Area Under the Disease Progression Curve for Infected Fruit	
					Percent	Percent Control
Untreated control					155.42 a	
CX-10440 [1]	3.75 fl oz	14	Polyoxin D zinc salt	19	92.91 b	40.22
CX-10440 [1]	6.5 fl oz	25	Polyoxin D zinc salt	19	115.88 ab	25.44
Pristine	23 oz		Boscalid	7	119.00 ab	23.44
			Pyraclostrobin	11		
Treatment means followed by the same letter are not statistically different. 1. CX-10440 is the Certis USA, L.L.C. code for Polyoxin D Zinc Salt 5SC Fungicide.						

Botrytis symptoms were first observed on May 14, 2012. Therefore, the treatments were preventative and curative.

No phytotoxicity was observed.

c. Discussion and Conclusions

Strawberries were grown in California near the Pacific Ocean. Maximum gray mold incidence in the untreated control was 17.79%.

Treatments with Polyoxin D Zinc Salt 5SC Fungicide applied preventatively and curatively did not have a positive dose response.

- Treatment with 3.75 fl oz/acre (14 g a.i./ha) provided 40.22% control of gray mold. This was statistically superior to the untreated control.
- Treatment with 6.5 fl oz/acre (25 g a.i./ha) provided 25.44% control of gray mold. This was statistically equivalent to the untreated control.

Treatments with Polyoxin D Zinc Salt 5SC Fungicide provided control of gray mold of strawberries that was statistically:

- Superior to the untreated control when applied at 3.75 fl oz/acre;
- Equal to the untreated control when applied at 6.5 fl oz/acre; and
- Equal to the control provided by boscalid plus pyraclostrobin (Pristine) when Polyoxin D Zinc Salt 5SC Fungicide was applied at both 3.75 fl oz/acre and 6.5 fl oz/acre.

No phytotoxicity was observed.

Botrytis cinerea (Botrytis Fruit Rot) / Strawberries #2: Trial No. CER-2014-038

a. Design

Botrytis cinerea (Botrytis Fruit Rot) / Strawberries #2: Trial No. CER-2014-038: Design	
Title:	Evaluation of Biorational Products for Control of Botrytis Fruit Rot in Annual Strawberry, 2014-15
Author and affiliation:	L. Cordova, A. Zuniga, J. Mertely, and N.A. Peres University of Florida Golf Coast Research and Education Center
Publication:	PDMR 9:SMF020
Location:	Plant City, FL
Crop:	Strawberry (*Fragaria x ananassa* 'Radiance')
Disease name:	*Botrytis* Bunch Rot
Pathogen:	*Botrytis cinerea*
Test plot design:	Random complete block
Number of replicates:	Not specified
Application equipment:	CO_2 back-pack sprayer
Spray volume:	100 gal/acre (60 psi)
Number of applications:	14
Application interval:	7-day
Application dates:	11/14/2014 to 02/20/2015
Harvest dates:	Twice weekly; 12/9/2014 to 2/27/2015.
Disease assessment date:	Twice weekly; 12/9/2014 to 2/27/2015.
Disease assessment methodology:	Percentage of all fruit harvested
Yield assessment methodology:	Counting and weighing of marketable fruit. Culled and diseased fruits were also counted.

b. Results

Botrytis cinerea (Botrytis Fruit Rot) / Strawberries #2: Trial No. CER-2014-038: Results								
Treatment	Rate/ Acre	g a.i./ ha	Active Ingredient	FRAC Code	Season Incidence (%)		Yield (lb/acre)	
					Measured	Percent Control	Measured	Percent Increase
Untreated control			NA		28.3 abc	NA	17,570 bc	NA
OSO	6.5 fl oz	25	Polyoxin D zinc salt	19	20.6 bcdef	27.2	22,500 abc	28.1
Milstop	3.75 lb		Potassium bicarbonate	NA	18.5 cdef	34.6	17,390 bc	-1.0
Regalia	2 qt		*Reynoutria sachalinensis*	NA	25.7 abcd	9.2	18,780 bc	6.9
Serenade Opti	1 lb		*Bacillus subtilis* str. QST 713	44	26.9 abcd	4.9	21,012 abc	19.6
Double Nickel	1.5 qt		*Bacillus amyloliquefaciens* str. D747	44	27.2 abcd	3.9	19,347 bc	10.1
Serenade ASO	4 qt		Bacillus subtilis str. QST 713	44	30.0 ab	-6.0	17,530 bc	-0.2
Oxidate	4 qt		Hydrogen dioxide, Peroxyacetic acid	NA	31.5 ab	-11.3	16,782 bc	-4.5
Actinovate	6 oz		*Streptomyces lydicus* WYEC 108	NA	32.5 a	-14.8	18,560 bc	5.6
Treatment means followed by the same letter are not statistically different according to the Tukey-Kramer least squares means ($\alpha = 0.05$)								

The report notes that severe epidemics of Botrytis occurred during the trial (second half of January, 2014 and second half of February, 2014). Therefore, the treatments were preventative and curative.

No phytotoxicity was observed.

c. Discussion and Conclusions

Strawberries were grown in Florida. The maximum measured gray mold fruit rot incidence in the untreated control was 47.7%. For the season as a whole, the gray mold fruit rot mean incidence was 28.3%.

Polyoxin D Zinc Salt 5SC Fungicide treatments were applied preventatively and curatively. Fourteen treatments were applied at 7-day intervals. The treatments provided 27.2% season-long control of gray mold fruit rot. This was statistically:

- Equivalent to the untreated control and to the control provided by:
  - Potassium bicarbonate (Milstop);
  - *Reynoutria sachalinensis* (Regalia);
  - *Bacillus subtilis* (Serenade Opti and Serenade ASO);
  - *Bacillus amyloliquefaciens* str. D747 (Double Nickel); and
  - Hydrogen dioxide plus peroxyacetic acid (Oxidate);
- Superior to the control provided by *Streptomyces lydicus* (Actinovate).

The Polyoxin D Zinc Salt 5SC Fungicide treatments provided 28.1% increased yield. The Polyoxin D Zinc Salt 5SC Fungicide provided the largest yield increase of all the treatments

No phytotoxicity was observed.

Botrytis cinerea (Gray Mold) / Strawberries #3: Review Article (Adaskaveg *et al.*, 2013)
(Source: Jim Adaskaveg, Doug Gubler, and Themis Michailides, Fungicides, Bactericides, and Biologicals for Deciduous Tree Fruit, Nut, Strawberry, and Vine Crops 2013. University of California.)

Fungicide	Gray Mold Efficacy Rating	Active Ingredient	FRAC Code	Resistance Risk
Fontelis	++++	Thiram	7	High
Pristine	++++	Pyraclostrobin + boscalid	7 + 11	Medium
Switch	++++	Fludioxonil + cyprodinil	9 + 12	High
Elevate	++++ A	Fenhexamid	17	High
Protexio	++++ A	Fenpyrazamine	17	High
Captan	+++	Captan	M4	Very low
Quilt Xcel	++	Propiconazole + azoxystrobin	3 + 11	Medium
Abound	++	Azoxystrobin	11	Medium
Tavano	++	Polyoxin D zinc salt	19	Medium
Thiram	++	Thiram	M3	Low
Cinnacure	----	Cinnamaldehyde		Low
M-Pede	----	Potassium salts		Low
Rally	----	Myclobutanil	3	High
Procure	----	Triflumazole	3	High
Bumper/Tilt	----	Propiconazole	3	High
Ridomil Gold SL	----	Mefenoxam	4	High
Quintec	----	Quinoline	13	High
Copper	----	Copper	M1	Low
Sulfur	----	Sulfur	M2	Low

A. Nonpersistent resistant populations of *Botrytis cinerea* to fenhexamid occur with repeated use of FRAC Group 17 fungicides.

Rating:
++++ = Excellent and consistent
+++ = Good and reliable
++ = Moderate and variable
+ = Limited and/or erratic
---- = Ineffective

Foliar treatments with Polyoxin D Zinc Salt provided moderate and variable control of gray mold of strawberries.

All of the OMRI-listed products included in the review were determined to be ineffective in controlling gray mold of strawberries. The ineffective OMRI-listed products included:

- Cinnacure (Cinnamaldehyde);
- M-Pede (Potassium salts);
- Copper; and
- Sulfur.

***Botrytis cinerea* (Gray Mold) / Strawberries: Grower Need**
Control of gray mold on strawberries (Project No. B00129) was identified as a grower need at the IR-4 2015 Biopesticide Workshop.

Bremia lactucae (DOWNY MILDEW) / LETTUCE

Bremia lactucae (Downy Mildew) / Lettuce: Introduction

(Source: 2015 Organic Production and IPM Guide for Lettuce, Cornell University Cooperative Extension)

Time for Concern: Ideal conditions for disease development include night temperatures of 43 to 50°F and day temperatures of 55 to 70°F with 100% humidity or long periods of leaf wetness. As temperatures increase, the disease subsides.

Key Characteristics: Downy mildew first appears on leaves as light green lesions, turning yellow and chlorotic. Older lesions are tan and papery. White sporangia and spores emerge on the underside of leaves and provide an avenue for other pathogens to enter. Downy mildew overwinters in New York on decomposing residue of infected plants. Spores can be spread by winds.

Relative Risk: Downy mildew is sporadic but very destructive when present. Plants are susceptible at all stages of growth.

Bremia lactucae (Downy Mildew) / Lettuce: Management Options

(Source: 2015 Organic Production and IPM Guide for Lettuce, Cornell University Cooperative Extension)

Management Option	Recommendation for Downy Mildew
Scouting/thresholds	Thresholds for organic production have not been established.
Site selection	Select a well-drained field with good air flow that encourages leaves and soil to dry quickly, especially for early and late season plantings. Plant in fields where crop debris is well decomposed at planting time.
Crop rotation	Crop rotation is the first line of defense. Rotate away from lettuce for a minimum of 2 to 3 years.
Seed selection	This fungus is not seed-borne.
Resistant varieties	Breeding resistant varieties is a challenge since the fungus readily produces new races.
Planting	Orient rows parallel with the prevailing winds and use wide row spacing to promote quick drying of leaves and soil.
Cultural practices	Avoid overhead irrigation to prevent extended periods of leaf wetness. If watering is necessary, irrigate early in the day when sun or wind are likely to dry leaves rapidly.
Weed control	Control alternate hosts such as perennial sowthistle, annual sowthistle, and prickly lettuce. Control weeds to improve air flow and shorten leaf wetness periods throughout the field.
Post-harvest	Plow, rather than disk, to deeply bury diseased crop residue.

Bremia lactucae (Downy Mildew) / Lettuce: OMRI-Listed Fungicides for Use in the United States										
FRAC Code	Source: 2015 Organic Production and IPM Guide for Lettuce, Cornell Univ. Cooperative Extension							Source: EPA Label		NOP Status
	Active Ingredient	Product Name	Product Rate/ Acre	PHI (Days)	REI (Days)	Efficacy	Comments	EPA Reg. No.	Comments	
44	*Bacillus amyloliquefaciens* str. D747	Double Nickel 55	0.25-3 lb	0	4	Labeled product for use on lettuce, but efficacy not known.		70051-108	Causes moderate eye irritation. Dermal sensitizer. Broad-spectrum preventative fungicide. Do not use highly alkaline or highly acidic water to mix sprays. Use a buffering agent if necessary to maintain neutrality (pH 6 to 8) of water in the tank. Suppression only.	Non-synthetic
		Double Nickel LC	0.5-6 qt	0	4	Labeled product for use on lettuce, but efficacy not known.		70051-114	Harmful if absorbed through skin. Harmful if inhaled. Dermal sensitizer. Broad-spectrum preventative fungicide.	
	Bacillus subtilis QST 713	Serenade ASO	2-6 qt	0	4	Labeled product for use on lettuce, but efficacy not known.		264-1152	Broad spectrum preventative fungicidal and bactericidal product. For suppression only. Begin applications when conditions are conducive to disease development and repeat on 2- to 10-day intervals or as needed. For improved performance, use in a tank-mix or rotational program with other registered fungicides for downy mildew control.	Non-synthetic
		Serenade MAX	1-3 lb	0	4	Labeled product for use on lettuce, but efficacy not known.		69592-11	Dermal sensitizer. Broad spectrum preventative fungicidal and bactericidal product.	
	Bacillus subtilis var. *amyloliquefaciens* str. FZB24	Taegro ECO	2.6-5.2 oz	0	24	Labeled product for use on lettuce, but efficacy not known.		70125-5	WARNING signal word. Causes skin irritation. Causes moderate eye irritation. Consists of living microbes. Store at room temperature and use before the expiration date. Avoid temperatures exceeding 73°F (23°C). Do not freeze. For suppression only. Most effective in low to medium disease situation.	Non-synthetic
P5	*Reynoutria sachalinensis*	Regalia Biofungicide	0.5-4 qt	0	4	Labeled product for use on lettuce, but efficacy not known.	Apply in 50 to 100 gal water per acre.	84059-3	Causes moderate eye irritation. Preventative rather than a curative application. Apply prior to disease infestation to protect the growing leaf tissue. Avoid freezing. Apply prior to disease infestation. Lettuce: Do not apply to plants that are stressed due to cold weather, drought, excessive moisture, etc. Do not apply when extended cold or cold and cloudy conditions are expected.	Non-synthetic

Bremia lactucae (Downy Mildew) / Lettuce: OMRI-Listed Fungicides for Use in the United States										
FRAC Code	Source: 2015 Organic Production and IPM Guide for Lettuce, Cornell Univ. Cooperative Extension							Source: EPA Label		NOP Status
	Active Ingredient	Product Name	Product Rate/ Acre	PHI (Days)	REI (Days)	Efficacy	Comments	EPA Reg. No.	Comments	
Not classified; Biological	*Streptomyces lydicus* WYEC 108	Actinovate AG	3-12 oz	0	1 or until solution has dried	Labeled product for use on lettuce, but efficacy not known.	Has relatively little residual activity and must be reapplied frequently, even if it does not rain.	73314-1	Avoid contact with skin, eyes, or clothing. Avoid breathing dust or spray mist. Mixer/loaders and applicators must wear a dust/mist filtering respirator meeting NIOSH standards of at least N-95, R-95, or P-95. Repeated exposure to high concentrations of microbial proteins can cause allergic sensitization. Keep from overheating or freezing. Optimum storage temperature is 40°F to 85°F. Contains live spores of a microbe. Best results will be obtained if the product is used prior to disease onset. Becomes active in soil or on the plant foliage when the temperatures are above 45°F and is not effective when temperatures remain cold. Do not apply soil fumigants to treated areas.	Non-synthetic
Not classified; Botanical oil	Sesame oil	Organocide 3-in-1	1-2 gal/100 gal	0	0	Labeled product for use on lettuce, but efficacy not known.		N/A. FIFRA §25(b) pesticide.	Insecticide, miticide, and fungicide. If spraying on severely stressed or damaged plants, consider using a lower rate such as 1 oz. per gallon to avoid adding additional stress. For best results, spray in the early morning.	Non-synthetic
	Neem oil	Trilogy	0.5-1.0% solution	0	4	Labeled product for use on lettuce, but efficacy not known.	Use in 25-100 gal per acre. Apply no more than 2 gallons per acre per application.	70051-2	Causes moderate eye irritation. Hazardous to fish and aquatic invertebrates. Toxic to bees exposed to direct treatment. Broad spectrum. Exercise care in timing applications during early morning/late evening to minimize the potential for leaf burn. Use care on plants with tender tissue. Check for leaf burn in small scale trials prior to use. Do not apply to sensitive plant species. Do not apply to wilted or otherwise stressed plants, or to newly transplanted materials or crops prior to root establishment. For optimal performance, do not mix with cold water (less than 45°F). Do not store below 40°F (4°C). Do not use or store near heat or open flame.	Non-synthetic

Bremia lactucae (Downy Mildew) / Lettuce: OMRI-Listed Fungicides for Use in the United States										
FRAC Code	Source: 2015 Organic Production and IPM Guide for Lettuce, Cornell Univ. Cooperative Extension							Source: EPA Label		NOP Status
	Active Ingredient	Product Name	Product Rate/ Acre	PHI (Days)	REI (Days)	Efficacy	Comments	EPA Reg. No.	Comments	
M1	Basic copper sulfate	Basic Copper 53	1-3 lb	0	24	Labeled product for use on lettuce, but efficacy not known.	Copper will leave a visible residue on leaves.	45002-8	WARNING signal word. Causes substantial but temporary eye injury. Harmful if absorbed through skin or inhaled. Dermal sensitizer. Toxic to fish and aquatic organisms.	Synthetic
	Copper hydroxide	Nu-Cop 50 WP	1-2 lb	1	24	Labeled product for use on lettuce, but efficacy not known.		42002-7	DANGER signal word. Corrosive. Causes irreversible eye damage. Harmful if swallowed, absorbed through skin, or inhaled. Skin sensitizer. Toxic to fish and aquatic organisms. Product should not be applied in spray water having a pH of less than 6.5 as phytotoxicity may result. Effectiveness reduced at pH greater than 9.0.	Synthetic
	Copper hydroxide, Copper oxychloride	Badge X2	1.75-3.5 lbs	0	48	Labeled product for use on lettuce, but efficacy not known.		80289-12	WARNING signal word. May be fatal if swallowed. Causes substantial but temporary eye injury. Harmful if absorbed through skin. Harmful if inhaled. Toxic to fish and aquatic organisms. Product must not be applied in a spray solution having a pH of less than 6.5 as phytotoxicity may occur. Do not tank mix product with Aliette® fungicide for use on any registered crops or ornamentals unless appropriate precautions have been taken to buffer the spray solution because severe phytotoxicity may result. Lettuce: Slight injury may occur under adverse conditions.	Synthetic
	Copper octanoate	Cueva Fungicide Concentrate	0.5-2.0 gal/ 100 gal water	0	4	Labeled product for use on lettuce, but efficacy not known.	Note that mixed material is applied at 50-100 gallons of diluted spray per acre. Use low rate on copper-sensitive lettuce varieties.	67702-2-70051	Harmful if swallowed or absorbed through skin. Toxic to fish and aquatic organisms. May cause some copper toxicity on some plant species. Store away from open fire or flame. Product may be damaged by freezing. Do not store product below 4°C. Do not mix with chelated or liquid fertilizers. Use caution when using product with other fungicides and insecticides.	Synthetic

Bremia lactucae (Downy Mildew) / Lettuce: OMRI-Listed Fungicides for Use in the United States										
FRAC Code	Source: 2015 Organic Production and IPM Guide for Lettuce, Cornell Univ. Cooperative Extension							Source: EPA Label		NOP Status
	Active Ingredient	Product Name	Product Rate/ Acre	PHI (Days)	REI (Days)	Efficacy	Comments	EPA Reg. No.	Comments	
	Cupric hydroxide	Nu-Cop 50DF	1-2 lb	1	24	Labeled product for use on lettuce, but efficacy not known.	Copper will leave a visible residue on leaves.	45002-4	DANGER signal word. Corrosive. Causes irreversible eye damage. Harmful if swallowed or absorbed through skin. Dermal sensitizer. Toxic to fish and aquatic organisms. Effectiveness reduced at pH greater than 9.0. Product should not be applied in spray water having a pH of less than 6.5 as phytotoxicity may result. Leafy greens: Flecking and/or yellowing of leaves may occur. Injury may be severe enough to reduce crop value.	Synthetic
		Nu-Cop HB	0.5-1 lb	1	24	Labeled product for use on lettuce, but efficacy not known.		42750-132	DANGER signal word. Corrosive. Causes irreversible eye damage. Harmful if swallowed, absorbed through skin, or inhaled. Product should not be applied in spray water having a pH of less than 6.5 as phytotoxicity may result. Lettuce: Flecking and/or yellowing of leaves may occur. Injury may be severe enough to reduce crop value.	
	Cuprous oxide	Nordox 75 WG	0.66-1.25 lb	0	12	Labeled product for use on lettuce, but efficacy not known.		48142-4	Harmful if swallowed or absorbed through skin. Causes eye irritation. Do not apply in a spray solution with a pH of less than 6.5. Lettuce: Slight injury may occur under adverse weather conditions.	Synthetic
Not classified; Inorganic salt	Potassium bicarbonate	EcoMate Amicarb O	2.5-5 lb/100 gal water	0	4	Labeled product for use on lettuce, but efficacy not known.	Has relatively little residual activity and must be reapplied frequently, even if it does not rain.	5905-541	Harmful if swallowed. Causes moderate eye irritation. Broad spectrum contact foliar fungicide. Prevent exposure to moisture during storage. Avoid contamination with other pesticides and fertilizers.	Synthetic
		Milstop	2-5 lb	0	1	Labeled product for use on lettuce, but efficacy not known.		70870-1-68539	Harmful if swallowed. Causes moderate eye irritation. Broad spectrum contact foliar fungicide. Do not mix with other soluble pesticides or fertilizers. Not compatible with mild alkaline solutions. Acidification of solution will cause reduced product performance. Prevent exposure to moisture during storage. Avoid contamination with other pesticides and fertilizers.	

Bremia lactucae (Downy Mildew) / Lettuce: OMRI-Listed Fungicides for Use in the United States										
FRAC Code	Source: 2015 Organic Production and IPM Guide for Lettuce, Cornell Univ. Cooperative Extension							Source: EPA Label		NOP Status
	Active Ingredient	Product Name	Product Rate/ Acre	PHI (Days)	REI (Days)	Efficacy	Comments	EPA Reg. No.	Comments	
Not classified; Oxidizing agent	Hydrogen dioxide, Peroxyacetic acid	Oxidate 2.0	Initial/ Curative: 128 fl oz/ 100 gal water; 30-100 gal solution/ acre Preventative: 40-128 fl oz/ 100 gal water; 30-100 gal solution/ acre	0	Until dry	Labeled product for use on lettuce, but efficacy not known.	For curative sprays, use 128 fl oz/100 gal water. Apply 30-100 gallons of solution per treated acre. Apply consecutive applications until control is achieved and then follow directions for preventative treatment. For preventative sprays, begin when plants are small. Apply first three treatments using the curative rate at 5-day intervals. Reduce to preventative rate after completion of the third treatment and maintain 5-day interval spray cycle until harvest.	70299-2	DANGER signal word. Causes irreversible eye damage. May be fatal if swallowed. Causes skin irritation or temporary discoloration of exposed skin. Highly toxic to bees and other beneficial insects. Toxic to fish. Toxic to birds who eat treated seed on soil surface. Strong oxidizing agent. Do not use in undiluted form. Never bring undiluted product in contact with other pesticides, cleaners or oxidative agents. May react with residues of metal-based fungicides or supplements. Allow at least 24 hrs. after application of metal-based products. Do not spray during conditions of intense heat, drought, or poor plant vigor (or vine canopy). Do not apply in conjunction with any other pesticides or fertilizers. Do not allow product to become overheated in storage. Do not store in a manner where cross-contamination with other pesticides or fertilizers could occur. Apply consecutive applications until control is achieved; then apply preventative treatments.	Synthetic
	Hydrogen peroxide, Hydrogen dioxide	Perpose Plus	Initial/ Curative: 1 fl oz/gal Weekly/ Preventative: 0.25-0.33 fl oz/gal	0	Until spray has dried	Not effective in any known trials	Hydrogen peroxide effective on 0 of 1 trial. For initial or curative use, apply higher rate for 1 to 3 consecutive days. Then follow with weekly/preventative treatment. For weekly or preventative treatments, apply lower rate every five to seven days. At first sign of disease, use curative rate then resume weekly preventative treatment.	86729-1	DANGER signal word. Causes irreversible eye damage and skin burns. May be fatal if absorbed through the skin. Harmful if swallowed. Do not breathe vapor from concentrate. Toxic to birds, mammals, fish and aquatic life. At temperatures exceeding 156°F, decomposition releases oxygen. The oxygen released could initiate or promote combustion of other materials. Store away from combustibles. Broad spectrum algaecide and fungicide. Apply curative rates for 3 consecutive days (drenching the entire plant) followed by weekly preventative treatments.	Synthetic

Bremia lactucae (Downy Mildew) / Lettuce: Efficacy Trials

Bremia lactucae (Downy Mildew) / Lettuce #1: Trial No. CER-2011-046

a. Design

Bremia lactucae (Downy Mildew) / Lettuce #1: Trial No. CER-2011-046: Design			
Title:	Efficacy of CX-10440 and CX-10445 for the Control of Downy Mildew (*Bremia lactucae*) in Lettuce		
Research organization:	Pacific Ag Research		
Publication:	Certis data. Not published. Permission received.		
Location:	Guadalupe, CA		
Crop:	Lettuce (cultivar: Cannery Row)		
Disease name:	Downy mildew		
Pathogen:	*Bremia lactucae*		
Test plot design:	Random complete block		
Number of replicates:	4		
Application equipment:	Botran boom (40 psi)		
Spray volume:	20 gal/acre		
Number of applications:	4		
Chronology:	Application Dates	Application Interval	Harvest and Evaluation Dates
	05/16/2011		05/26/2011
	05/31/2011	15 days	06/02/2011
	06/13/2011	14 days	06/09/2011
	06/27/2011	14 days	06/15/2011
			06/22/2011
			06/28/2011
			07/06/2011
			07/09/2011

b. Results

Bremia lactucae (Downy Mildew) / Lettuce #1: Trial No. CER-2011-046: Results										
Treatment	Rate/ Acre	g a.i./ ha	Active Ingredient	FRAC Code	No. lesions on 10 Leaves/Replicate (7/6/2011)		No. Lesions per Infected Plant (7/6/2011)		Percent Incidence (7/6/2011)	
					Measured	Percent Control	Measured	Percent Control	Measured	Percent Control
Untreated control			Not Applicable		31.28 a		6.10 a		100.00 a	
CX-10440 [1]	3.75 fl oz	14	Polyoxin D zinc salt	19	14.63 b	52.3	3.50 c	42.6	100.00 a	0.0
CX-10440 [1]	7.5 fl oz	29	Polyoxin D zinc salt	19	19.45 b	37.8	4.30 bc	29.5	100.00 a	0.0
Treatment means followed by the same letter are not statistically different at P = 0.05. Mean descriptors are reported in transformed data units, and not de-transformed. 1. CX-10440 is the Certis USA, L.L.C. code for Polyoxin D Zinc Salt 5SC Fungicide.										

Downy mildew lesions were first observed on May 26, 2011. Therefore, the treatments were preventative and curative. Maximum downy mildew severity (number of lesions) occurred on July 6, 2011.

No phytotoxicity was reported.

c. Discussion and Conclusions

Lettuce was grown in California. Downy mildew pressure reached 100% incidence in all treatments. Polyoxin D zinc salt was applied preventatively and curatively.

Four treatments of Polyoxin D Zinc Salt 5SC Fungicide were applied preventatively and curatively at 14-day to 15-day intervals. They provided:

- Mean 47.5% (range 42.6% to 52.3%) control of downy mildew severity on lettuce when applied at 3.75 fl oz/acre (14 g a.i./ha);
- Mean 33.7% (range 29.6% to 37.8%) control of downy mildew severity on lettuce when applied at 7.5 fl oz/acre (29 g a.i./ha); and
- Statistically superior control of downy mildew severity at both application rates compared to the untreated control.

No phytotoxicity was reported.

Bremia lactucae (Downy Mildew) / Lettuce #2: Trial No. CER-2013-014

a. Design

Bremia Lactucae (Downy Mildew) / Lettuce #2: Trial No. CER-2013-014: Design			
Title:	Efficacy of Oso for Control of *Bremia lactucae* (Downy Mildew) in Lettuce		
Research organization:	Pacific Ag Research		
Publication:	Certis data. Not published. Permission received.		
Location:	Guadalupe, CA		
Crop:	Lettuce (cultivar Cannery Row)		
Disease name:	Downy mildew		
Pathogen:	*Bremia Lactucae*		
Test plot design:	Randomized complete block		
Number of replicates:	Not reported		
Application equipment:	CO_2 backpack sprayer (50 psi)		
Spray volume:	40 gal/acre and 50 gal/acre		
Number of applications:	8		
Chronology:	Application Dates	Application Interval	Evaluation Dates
	04/19/2013		04/24/2013
	04/26/2013	7 days	04/30/2013
	05/03/2013	7 days	05/08/2013
	05/10/2013	7 days	05/16/2013
	05/17/2013	7 days	05/22/2013
	05/24/2013	7 days	05/29/2013
	05/31/2013	7 days	06/05/2013
	06/07/2013	7 days	06/12/2013
			06/16/2013

b. Results

Bremia Lactucae (Downy Mildew) / Lettuce #2: Trial No. CER-2013-014: Results								
Treatment	Rate/ Acre	g a.i./ ha	Active Ingredient	FRAC Code	Incidence (Lesions/Head) (6/12/2013)		Severity (6/12/2013)	
					Measured	Percent Control	Measured	Percent Control
Untreated control			Not Applicable		12.58 a		13 a	
Oso	6.5 fl oz	25	Polyoxin D zinc salt	19	6.7 ab	46.7	6 b	54
Oso	13 fl oz	50	Polyoxin D zinc salt	19	5.73 ab	54.5	4 b	69
Potassium phosphite	2 qt/ 100 gal		Potassium phosphite	NC	3.15 b	74.9	2 b	85
Treatment means followed by the same letter are not statistically different using ANOVA mean comparison with Student-Newman-Keul's test and $\alpha = 0.05$.								

Downy mildew lesions were first observed on May 16, 2013. Therefore, the treatments were preventative and curative. Maximum downy mildew incidence and severity were observed on June 12, 2014.

No phytotoxicity was observed.

c. Discussion and Conclusions

Lettuce was grown in California. Downy mildew pressure was low and increased to 12.58% incidence at the last evaluation period.

Eight treatments of Polyoxin D Zinc Salt 5SC Fungicide were applied preventatively and curatively at 7-day intervals. They provided a positive dose response.

- Treatment at 6.5 fl oz/acre (25 g a.i./ha) provided mean 50% (range 46.7% to 54%) control of downy mildew on lettuce; and
- Treatment at 13 fl oz/acre (50 g a.i./ha) provided mean 62% (range 54.5% to 69%) control of downy mildew on lettuce.

The control of downy mildew severity by Polyoxin D Zinc Salt 5SC Fungicide was statistically:

- Superior to that provided by the untreated control; and
- Equivalent to that provided by potassium phosphite.

No phytotoxicity was observed.

Bremia Lactucae (Downy Mildew) / Lettuce #3: Trial No. CER-2013-032

a. Design

Bremia lactucae (Downy Mildew) / Lettuce #3: Trial No. CER-2013-032: Design			
Title	Lettuce Downy Mildew Fungicide Trial: 2013		
Author and affiliation:	Steven T. Koike University of California Cooperative Extension Monterey County, CA		
Publication:	Not published. Permission received.		
Location:	Near Salinas, California		
Crop:	Iceberg lettuce		
Disease name:	Downy mildew		
Pathogen:	*Bremia lactucae*		
Test plot design:	Randomized complete block		
Number of replicates:	4		
Application equipment:	CO_2 backpack sprayer (35 psi)		
Spray volume:	65 gal/acre		
Number of applications:	4		
Chronology:	Application Dates	Application Interval	Disease Assessment Date
	07/08/2013		08/07/2015
	07/18/2013	10 days	
	07/25/2013	7 days	
	07/31/2013	6 days	
Disease assessment methodology:	For each harvested plant, all lower leaves that were yellowed, senescent, necrotic, or otherwise damaged were removed. The remaining five lower leaves were used for evaluation. The number of downy mildew lesions was counted and recorded for each of those leaves.		

b. Results

Bremia lactucae (Downy Mildew) / Lettuce #3: Trial No. CER-2013-032: Results						
Treatment	Rate/ Acre	g a.i./ ha	Active Ingredient	FRAC Code	No. Lesions/Leaf	
					Measured	Percent Control
Untreated control			Not Applicable		4.26	
OSO	13 fl oz	50	Polyoxin D zinc salt	19	2.29	46.2
Syl-Tac	4 fl oz		NA; surfactant	NA		
Sonata	4 qt		*Bacillus pumilis* strain QST 2808	44	2.65	37.8
Syl-Tac	4 fl oz		NA; surfactant	NA		
Fosphite	64 fl oz		Mono- and dipotassium salts of phosphoric acid	NC	0.39	90.8
Syl-Tac	4 fl oz		NA; surfactant	NA		
Statistically comparisons were not included in the report.						

The single disease assessment date, August 7, 2013, was after the final application date. The report did not include any reference to any earlier observations of downy mildew lesions. Therefore, the treatments are assumed to be preventative.

No phytotoxicity was observed.

c. Discussion and Conclusions

Head lettuce was grown in California. After removing from harvested heads all lower leaves that were yellowed, senescent, necrotic, or otherwise damaged, the number of downy mildew lesions on the remaining five lower leaves were counted. An average of 4.26 lesions were counted in the untreated control.

Four Polyoxin D Zinc Salt 5SC Fungicide treatments were applied preventatively at 13 fl oz/acre (50 g a.i./ha) at 6-day to 10-day intervals with Syl-Tac, a surfactant.

Polyoxin D Zinc Salt 5SC Fungicide in combination with Syl-Tac provided 46.2% control of downy mildew on lettuce. This was:

- Greater control than that provided by Sonata plus Syl-Tac (37.8% control); and
- Lesser control than that provided by Fosphite plus Syl-Tac (90.8% control).

No phytotoxicity was observed.

Coleophoma empetri, *Colletotrichum* spp., *Phomopsis vaccinii*, and *Physalospora vaccinii* (FRUIT ROT COMPLEX) / CRANBERRIES

Coleophoma empetri, *Colletotrichum* spp., *Phomopsis vaccinii*, and *Physalospora vaccinii* (Fruit Rot Complex) / Cranberries: Causes of Cranberry Fruit Rot

(Source: Peter V. Oudemans, *et al.*, Cranberry Fruit Rot in the Northeast: A Complex Disease, Plant Disease, Vol. 82, No. 11, November 1998.)

Cranberry fruit rot is a generic term applied to any rot symptom affecting the berries. In practice, there are two types recognized, field rot and storage rot. Ten to 15 species of fungi have been implicated in both forms of the disease, and there is considerable overlap among the causal agents. For example, *Physalospora vaccinii* can be both an important field-rotting and storage rotting species. On the other hand, *Colletotrichum gloeosporioides* and *Allanto-phomopsis* spp. appear to be more specific to the field or storage rots, respectively. In addition, major differences exist in the frequencies of the pathogen species among the various cranberry growing areas. Field rot tends to be most severe in New Jersey and Massachusetts, while the disease pressure is much lower in Wisconsin and the western growing areas such as Oregon, Washington, and British Colombia.

It can be very difficult to identify the causal organism by rot symptom alone because symptoms caused by individual fungi are usually not distinct. Fungi from diseased tissue must be cultured soon after symptoms appear to ensure that the specific pathogens causing disease are isolated. Symptoms of fruit rot in the field begin to appear in early July, and the incidence increases throughout the season. The relative importance of field rot compared with storage rot depends largely on the end use of the crop. In the East, fruit destined for processing is frozen soon after harvest, and thus storage rot is of minor importance. Fruit used in the fresh market is harvested and then stored under refrigeration for as long as 3 months until sold, and storage rots can be vitally important.

The fungi responsible for these diseases represent a diverse group of Ascomycetes and Fungi Imperfecti whose taxonomy is relatively well described. Although Koch's postulates have been conducted on relatively few of these fungi, the species believed to be most important in fruit rot on commercial cranberry farms today have had pathogenicity confirmed. However, some important exceptions do exist. For example, *Phomopsis vaccinii* is commonly isolated from both diseased uprights and rotted fruit, but artificial inoculations have not been successful. A unique cause of cranberry fruit decay that resembles fruit rot is referred to as "sterile breakdown," and no biotic agents have been implicated in this disorder.

Several surveys have been conducted to determine the cause of cranberry fruit rot, and numerous fungal species are found associated with both sound and rotted fruit. It has not been fully determined which of the less common species are primary pathogens and which are secondary colonizers.

- Surveys conducted in New Jersey from 1926 to 1929 indicated that *Phyllosticta vaccinii* and sterile breakdown were the most common causes of fruit decay occurring around harvest time.
- Weidemann and Boone found *Phyllosticta vaccinii* to be a very prevalent species in New Jersey field-rotted fruit from 1975 to 1978.
- C. M. Stiles and P. V. Oudemans conducted a survey in New Jersey and found two species, *Physalospora vaccinii* and *Colletotrichum gloeosporioides,* to be the most commonly isolated fungi from decayed fruit from 1994 to 1995.
- In 1996, the frequency of *C. gloeosporioides* had declined markedly. Other species, such as *Coleophoma empetri*, *Phyllosticta vaccinii,* and *Phomopsis vaccinii,* were isolated at high frequencies from a limited number of locations.
- In Massachusetts, *Godronia cassandrae* (anamorph *Fusicoccum putrefaciens*)*, Colletotrichum gloeosporioides, Coleophoma empetri, Phyllosticta vaccinii,* and sterile breakdown were the most common causes of fruit decay from 1926 to 1933.

- Zuckerman reported and Caruso has since verified an increase in the prevalence of *Coleophoma empetri* compared with the earlier surveys in Massachusetts.
- Numerous other fungi are commonly isolated from cranberry leaves and fruit, but many of these species have uncertain pathogenicity.

The causes of change in frequency and importance of fruit-rotting species over time are not known. However, these changes do indicate that fungi currently considered unimportant could emerge as major factors affecting fruit quality in the future.

One remarkable feature of cranberry fruit rot is the lack of evidence for bacterial-related decays. Although bacteria are frequently isolated from leaf and fruit surfaces, there are few, if any, published accounts that implicate bacteria as cranberry pathogens. In fact, relatively few bacterial diseases have been reported from any Ericaceous plant. Kobayashi *et al.* reported a new blueberry leaf spot caused by *Pseudomonas andropogonis*, but tests with this bacteria indicated it was only weakly pathogenic to cranberry.

***Coleophoma empetri*, *Colletotrichum* spp., *Phomopsis vaccinii*, and *Physalospora vaccinii* (Fruit Rot Complex) / Cranberries: Life Cycles**
(Source: Peter V. Oudemans, *et al.*, Cranberry Fruit Rot in the Northeast: A Complex Disease, Plant Disease, Vol. 82, No. 11, November 1998.)

Cranberry fruit-rotting fungi appear to exist as indigenous populations in cranberry beds. As such, each species must overwinter within the bed. In commercial cranberry culture, the role of infected fruit as a source of inoculum is uncertain, but it is probably insignificant since the majority of fruit is removed from the beds prior to the formation of any type of fruiting structure. Furthermore, experiments testing the transmissibility of fruit rot in storage indicate that there is virtually no spread from infected to healthy fruit.

Of the fruit-rotting species that have been studied, there appear to be three general types of life cycles that differ with respect to the tissues where the fungi overwinter and the timing of fruit infection. These distinctions are made for the first time in this article and are useful because they illustrate some basic differences in the life histories of these fungi. These different life cycle types may be modified as research reveals more details of the fungal life histories. At this stage, the classifications serve to distinguish 12 fungal species into three general groups.

- <u>Life cycle type I.</u> These fungi overwinter in older tissues such as woody stems or persistent pedicels. Spore-bearing structures probably form on these woody tissues when the growing season begins. Infections leading to fruit rot begin during bloom and early fruit set, but the duration of spore dissemination is unknown. Species with this type of life cycle include *Colletotrichum gloeosporioides*, *Fusicoccum putrefaciens*, *Phomopsis vaccinii*, and possibly *Synchronoblastia crypta*. Of the species mentioned in this category, *Phomopsis vaccinii* and *Synchronoblastia crypta* also cause a vine disease known as upright dieback. Infections by these species are presumed to occur during vegetative bud break, although infection studies have been unsuccessful and Koch’s postulates have not been confirmed.

- <u>Life cycle type II.</u> These fungi survive in living leaves as latent infections or possibly as endophytes. In cranberry, leaves generally remain on the vines for 2 years. Sporulation occurs as leaves begin to senesce, usually in the summer 2 years after they were formed, but there are some exceptions. Infections leading to fruit rot probably begin during late bloom, but again, the duration of spore dissemination is unknown. The species reported in this category include *Coleophoma empetri*, *Phyllosticta elongata*, *Phyllosticta vaccinii*, and *Physalospora vaccinii*. One species, *Phyllosticta vaccinii,* can also be a leaf or flower blossom pathogen. The remaining species appear to have little effect on the host plant, and symptoms appear after the leaves begin to senesce or as the fruit ripens.

- Life cycle type III. These fungi also overwinter in living and dead leaves and stems. However, the majority of fruit infection occurs during harvest. When the beds are flooded, large numbers of spores can be found in the floodwater, and these spores can cause infections at wound sites inflicted on the fruit during harvest. Infections may also occur in dry-harvested fruit, but at very low frequencies. Species with this type of life cycle include *Strasseria geniculata, Allantophomopsis cytisporea,* and *Allantophomopsis lycopodina*. Black rot is a specific type of fruit rot with distinct symptoms commonly caused by these fungi.

Cranberry fruit rot, in general, seems to behave as a simple-interest disease. Disease increase from year to year usually occurs in a step-wise fashion in the absence of controls. However, there is very limited information on the frequency of infection cycles, the duration of latent periods, and timing of sporulation. We believe that most of the species mentioned above, with the exception of *Phyllosticta vaccinii,* complete a single infection cycle once every 1 to 3 years. Zuckerman hypothesized that infections occur through the receptive stigma. Although this has been substantiated for the cottonball pathogen, *Monilinia oxycocci*, it does not appear to be true for the other fruit-rotting species. Much of the evidence on the timing of infection comes from experiments investigating the effect of timing of fungicide applications. P. V. Oudemans and F. L. Caruso demonstrated under both New Jersey and Massachusetts conditions that protection of the developing fruit during late bloom and early fruit set is critical for effective disease control. Applications made following the bloom period are progressively less effective as time increases. Chemical control of the storage rots, especially the type III species, has been less successful, probably because of the lateness of infection.

***Coleophoma empetri*, *Colletotrichum* spp., *Phomopsis vaccinii*, and *Physalospora vaccinii* (Fruit Rot Complex) / Cranberries: Keeping Quality**
(Source: Peter V. Oudemans, *et al.*, Cranberry Fruit Rot in the Northeast: A Complex Disease, Plant Disease, Vol. 82, No. 11, November 1998.)

"Keeping quality" is essentially a measure of the shelf life of refrigerated fruit. Stevens defined keeping quality as the proportion of spoilage that develops in storage after a predefined period. The keeping quality is to a large degree related to the amount of fungal infection of the fruit. However, in some years, significant losses due to sterile breakdown (fruit softening without evidence of culturable fungi) occur. Historically, keeping quality was determined by the shipper, who had to sort fruit after storage and before sending it to market.

Stevens found that keeping quality varied tremendously from one year to the next, as well as among varieties. He initiated research aimed at predicting the keeping quality of cranberry fruit each season. Franklin and Cross made several improvements to Stevens' predictive scheme. Predictions for keeping quality, based on the method of Franklin and Cross, have been issued by the University of Massachusetts Cranberry Experiment Station since 1949. The predictions are generally on the conservative side and therefore are considered especially useful by growers of fresh fruit.

***Coleophoma empetri*, *Colletotrichum* spp., *Phomopsis vaccinii*, and *Physalospora vaccinii* (Fruit Rot Complex) / Cranberries: Integrated Disease Management**
(Source: Peter V. Oudemans, *et al.*, Cranberry Fruit Rot in the Northeast: A Complex Disease, Plant Disease, Vol. 82, No. 11, November 1998.)

Since cranberry fruit rot is caused by numerous fungal species, control methods vary according to the species of fungi present, the prevalent type of fruit rot (field or storage), and how the fruit will be marketed. Currently, controlling this group of plant pathogens is most reliably achieved through timely fungicide applications. However, other methods, including various cultural practices, can reduce the primary inoculum load, and biocontrol regimes now under development also show promise.

***Coleophoma empetri*, *Colletotrichum* spp., *Phomopsis vaccinii*, and *Physalospora vaccinii* (Fruit Rot Complex) / Cranberries: Cultural Control**
(Source: Peter V. Oudemans, *et al.*, Cranberry Fruit Rot in the Northeast: A Complex Disease, Plant Disease, Vol. 82, No. 11, November 1998.)

Several cultural practices are used that influence fruit rot incidence and severity. Application of late water is a practice that has been used in Massachusetts since the 1800s. The approach is to drain the winter floodwaters in early- to mid-March and then, 4 weeks later, re-flood and keep the beds flooded for 4 weeks. This treatment has been found to improve keeping quality of the crop, as well as to decrease the severity of some insect and weed problems. In addition, use of late water has been shown to reduce fruit rot incidence, thereby curtailing the need for fungicide applications for 2 years. Of eight pathogen species examined, two (*Physalospora vaccinii* and *Phyllosticta elongata*) increased and six (*Coleophoma empetri, Glomerella cingulata, Fusicoccum putrefaciens, Phomopsis vaccinii,* and *Phyllosticta vaccinii*) decreased in frequency in beds receiving late water. The mechanism by which applying late water affects fruit rot is unknown. However, one effect is to delay the onset of bloom by 10 to 14 days, resulting in a compression of the bloom period to about 20 days. Thus, avoidance of infections that lead to fruit rot may be a possible mechanism for disease reduction. Late water treatments have not been effective in managing fruit rot in New Jersey.

Sanding is a practice where 2 to 5 cm of washed, screened sand is distributed evenly across the bed during the winter season— usually when the beds are flooded. This is done either by using a sanding barge or by distributing the sand across the ice on frozen beds and allowing the sand to filter through the canopy during a thaw. The result of this practice is to improve vine vigor by burying runners and stimulating new root formation. It is suspected that this practice may reduce the amount of pathogen inoculum by burying the sources of inoculum. More work is needed to establish how the timing of sand applications can influence inoculum levels.

Drainage can have a significant effect on fruit rot incidence. First, poor drainage provides an ideal climate for fungal infection, resulting in an increase in rot levels. This has long been realized by Eastwood, who recommended that growers "raise the soil and bring it to the level of that part of the yard in which the cranberry does not rot."

Second, high soil moisture and poor drainage are also conducive to increased root rot (caused by *Phytophthora cinnamomi*) incidence. The reduction in vine density caused by this pathogen can result in elevated fruit rot levels, possibly due to an increase in reflected heat. Thus, even in the unique environment of the cranberry bed, efficient drainage is critical to production of healthy fruit.

During the harvest of cranberries, numerous leaves and debris are also recovered from the beds. This material is sometimes separated from the fruit immediately and sometimes after the fruit is taken to a receiving station. The leaves, stems, and weeds recovered in this manner are placed in trash piles. Removal of these trash piles can aid in the reduction of inoculum load during the growing season. It is not clear how serious a factor trash piles are, since most of the pathogens appear to be dispersed over relatively short distances. Many growers remove trash piles from around cranberry beds because cranberry leaves are known to be potential reservoirs of fungal inoculum.

Cultural practices that reduce vine overgrowth, increase air circulation in the cranberry canopy, and enhance solar penetration will provide less favorable environments for fruit rot development. Pruning is one option commonly used for removing heavy vine growth. Pruning is normally done in the fall following harvest or during early spring before the vines resume growth. Dry harvesters (as opposed to water harvesters that pick fruit in flooded beds) also prune the vines as they pick fruit from dry beds. In addition, managing nitrogen levels to provide only the minimum necessary for berry production will limit vine overgrowth. Davenport demonstrated that high levels of nitrogen would cause an increase in fruit rot levels. Practices that limit canopy overgrowth will also allow better penetration and coverage by fungicides and should promote more effective fruit rot control.

Many of the important fruit diseases of cranberry survive in stems and leaves. Cuttings from established beds are often used to plant new beds. Thus, the pathogens are commonly introduced with the vines used to establish a bed. Crowley suggested that some of the diseases and insects found in the Pacific Northwest were imported with vines from eastern sources. Introduction of *Phyllosticta vaccinii* to Wisconsin occurred recently and may have been avoided if planting stock were derived from tissue cultured plants. Other methods such as sterilization have not been sufficiently tested and are currently not an option.

Coleophoma empetri, *Colletotrichum* spp., *Phomopsis vaccinii*, and *Physalospora vaccinii* (Fruit Rot Complex) / Cranberries: OMRI Listed Fungicides for Use in the United States
(No efficacy data have been identified or evaluated.)

FRAC Code	Source: EPA Label								NOP Status
	Active Ingredient	Product Name	Label claim	Product Rate/ Acre	PHI (Days)	REI (Days)	EPA Reg. No.	Comments	
44	*Bacillus amyloliquefaciens* str. D747	Double Nickel 55	Anthracnose fruit rot *Colletotrichum acutatum*	0.25-3 lb	0	4	70051-108	Causes moderate eye irritation. Dermal sensitizer. Broad-spectrum preventative fungicide. Do not use highly alkaline or highly acidic water to mix sprays. Use a buffering agent if necessary to maintain neutrality (pH 6 to 8) of water in the tank. Suppression only. Begin applications at or before pistillate bloom, repeating every 7-10 days. Apply before rainfall if possible, and tank mix or rotate with copper-based bactericide registered for such use to improve control.	Non-synthetic
	Bacillus subtilis str. QST 713	Optiva	Anthracnose Fruit Rot *Colletotrichum gloeosporioides* *Colletotrichum acutatum*	14-24 oz	0	4	62592-26	Causes moderate eye irritation. Dermal sensitizer. Broad spectrum preventative product. Make application to non-flooded fields only. Suppression. Begin application prior to disease development and repeat on a 2- to 10-day interval or as needed. For improved performance, add a surfactant to the spray tank to improve coverage.	Non-synthetic
		Serenade ASO	Anthracnose Fruit Rot *Colletotrichum gloeosporiodes* *Colletotrichum acutatum*	2-6 qt	0	4	264-1152	Broad spectrum preventative fungicidal and bactericidal product. Make application to non-flooded fields only. Begin applications at the first sign of disease or when conditions become conducive for disease development. Repeat on 7- to 10-day intervals or as needed. Not for use in California.	
		Serenade MAX	Anthracnose Fruit Rot *Colletotnchum gloeosporiodes* *Colletotnchum acutatum* Phomopsis *Phomopsis vaccinii*	1-3 lb	0	4	69592-11	Dermal sensitizer. Broad spectrum preventative fungicidal and bactericidal product. Make application to non-flooded fields only. Begin applications at the first sign of disease or when conditions become conducive for disease development Repeat on 7 to 10 day intervals or as needed.	
		Serenade Optimum	Anthracnose Fruit Rot *Colletotrichum gloeosporiodes* *Colletotrichum acutatum*	14-20 oz	0	4	264-1160	Dermal sensitizer. Broad spectrum preventative fungicidal and bactericidal product. Make application to non-flooded fields only. Suppression. Begin application prior to disease development and repeat on a 2- to 10-day interval or as needed. For improved performance, add a surfactant to the spray tank to improve coverage.	
P5	*Reynoutria sachalinensis*	Regalia Biofungicide	Anthracnose Fruit Rot *Colletotrichum acutatum* Phomopsis Fruit Rot *Phomopsis* spp.	1-4 qt	0	4	84059-3	Causes moderate eye irritation. Preventative rather than a curative application. Apply prior to disease infestation to protect the growing leaf tissue. Avoid freezing. Apply prior to disease infestation.	Non-synthetic

Coleophoma empetri, *Colletotrichum* spp., *Phomopsis vaccinii*, and *Physalospora vaccinii* (Fruit Rot Complex) / Cranberries: OMRI Listed Fungicides for Use in the United States **(No efficacy data have been identified or evaluated.)**									
FRAC Code	Source: EPA Label								NOP Status
	Active Ingredient	Product Name	Label claim	Product Rate/ Acre	PHI (Days)	REI (Days)	EPA Reg. No.	Comments	
M1	Copper hydroxide	Nu-Cop 50 WP	Fruit rot	8 lb	1	24	42002-7	DANGER signal word. Corrosive. Causes irreversible eye damage. Harmful if swallowed, absorbed through skin, or inhaled. Skin sensitizer. Toxic to fish and aquatic organisms. Product should not be applied in spray water having a pH of less than 6.5 as phytotoxicity may result. Effectiveness reduced at pH greater than 9.0. Apply beginning in late bloom (late-July) followed by 2 additional applications made at 10 to 14 day intervals.	Synthetic
		Champ WG	Fruit rot	4.2 lb	0	48	55146-1	DANGER signal word. Corrosive. Causes irreversible eye damage. Harmful if inhaled. Skin sensitizer. Toxic to fish and aquatic organisms. Make first application in late bloom. One or 2 additional applications at 10 to 14 day intervals maybe required depending upon disease severity.	
	Copper hydroxide, Copper oxychloride	Badge X2	Fruit rot	3.5 lbs	0	48	80289-12	WARNING signal word. May be fatal if swallowed. Causes substantial but temporary eye injury. Harmful if absorbed through skin. Harmful if inhaled. Toxic to fish and aquatic organisms. Make first application in late bloom. One or 2 additional applications at 10 to 14 day intervals maybe required depending upon disease severity. Product must not be applied in a spray solution having a pH of less than 6.5 as phytotoxicity may occur. Do not tank mix product with Aliette® fungicide for use on any registered crops or ornamentals unless appropriate precautions have been taken to buffer the spray solution because severe phytotoxicity may result.	Synthetic
	Copper sulfate pentahydrate	CS 2005	Fruit rot	51.2 oz	0	48	66675-3	DANGER signal word. Corrosive. Causes irreversible eye damage and skin irritation. Harmful if swallowed, inhaled or absorbed through the skin. Dermal sensitizer. Toxic to fish and aquatic organisms. Do not mix with acidic compounds. Do not mix with pot ash. Store away from excessive heat. Product will freeze. Store and handle product in 316L stainless steel, fiberglass, PVC's, polypropylenes or plastic equipment. Keep away from galvanized pipe and any nylon storage handling equipment. Make application in late bloom. Apply one or two additional applications at 10 to 14 day intervals or as needed depending on disease severity.	Synthetic
	Cupric hydroxide	Nu-Cop HB	Fruit rot	4.2 lb	0	24	42750-132	DANGER signal word. Corrosive. Causes irreversible eye damage. Harmful if swallowed, absorbed through skin, or inhaled. One or two additional applications at 10 to 14 day intervals may be required, depending on disease pressure. Product should not be applied in spray water having a pH of less than 6.5 as phytotoxicity may result.	Synthetic
	Cuprous oxide	Nordox 75 WG	Fruit rot	5 lb	0	12	48142-4	Harmful if swallowed or absorbed through skin. Causes eye irritation. Do not apply in a spray solution with a pH of less than 6.5. Begin application in late bloom. Apply one or two additional applications at 10-14 day intervals maybe necessary.	Synthetic

Coleophoma empetri, *Colletotrichum* spp., *Phomopsis vaccinii*, and *Physalospora vaccinii* (Fruit Rot Complex) / Cranberries: OMRI Listed Fungicides for Use in the United States **(No efficacy data have been identified or evaluated.)**									
FRAC Code	Source: EPA Label								NOP Status
	Active Ingredient	Product Name	Label claim	Product Rate/ Acre	PHI (Days)	REI (Days)	EPA Reg. No.	Comments	
Not classified; Oxidizing agent	Hydrogen dioxide, Peroxyacetic acid	Oxidate	Cranberry fruit rot	Initial/ Curative: 128 fl oz/ 100 gal water; 30-100 gal solution/ acre Preventative: 40-128 fl oz/ 100 gal water; 30-100 gal solution/ acre	0	Until dry	70299-2	DANGER signal word. Causes irreversible eye damage. May be fatal if swallowed. Causes skin irritation or temporary discoloration of exposed skin. Highly toxic to bees and other beneficial insects. Toxic to fish. Toxic to birds who eat treated seed on soil surface. Strong oxidizing agent. Do not use in undiluted form. Never bring undiluted product in contact with other pesticides, cleaners or oxidative agents. May react with residues of metal-based fungicides or supplements. Allow at least 24 hrs. after application of metal-based products. Do not spray during conditions of intense heat, drought, or poor plant vigor (or vine canopy). Do not apply in conjunction with any other pesticides or fertilizers. Do not allow product to become overheated in storage. Do not store in a manner where cross-contamination with other pesticides or fertilizers could occur. Apply consecutive applications until control is achieved; then apply preventative treatments.	Synthetic

Coleophoma empetri, _Colletotrichum_ spp., _Phomopsis vaccinii_, and _Physalospora vaccinii_ (Fruit Rot Complex) / Cranberries: Efficacy Trials

Coleophoma empetri, _Colletotrichum_ spp., _Phomopsis vaccinii_, and _Physalospora vaccinii_ (Fruit Rot Complex) / Cranberries #1: Trial No. IND-2014-166

a. Design

Coleophoma empetri, *Colletotrichum* spp., *Phomopsis vaccinii*, and *Physalospora vaccinii* (Fruit Rot Complex) / Cranberries #1: Trial No. IND-2014-166: Design	
Title:	Evaluation of Fungicides for Control of Cranberry Fruit Rot in Wisconsin, 2014
Authors and affiliation:	P. McManus and R. S. Perry University of Wisconsin Madison, WI
Publication:	PDMR 9:SMF015
Location:	Near Tomah, WI
Crop:	Cranberry (Vaccinium macrocarpon 'Stevens')
Disease name:	Cranberry Fruit Rot Complex. Primary components: Ripe rot; Bitter rot; Viscid rot; and Blotch rot.
Pathogen:	Primary components: *Coleophoma empetri*; *Colletotrichum* spp.; *Phomopsis vaccinii*; and *Physalospora vaccinii*.
Test plot design:	Randomized compete block
Number of replicates:	5
Application equipment:	CO_2 backpack sprayer (30 psi)
Spray volume:	28.4 gallons/acre
Number of applications:	2
Application interval:	9 days
Application dates:	07/01/2014 (40% bloom) 07/10/2014 (early fruit set)
Disease assessment date(s):	09/25/2014
Disease assessment methodology:	Incidence of fruit rot (soft, discolored fruit) was determined in a 200-berry sample harvested from the center of each plot.

b. Results

Coleophoma empetri, *Colletotrichum* spp., *Phomopsis vaccinii*, and *Physalospora vaccinii* (Fruit Rot Complex) / Cranberries #1: Trial No. IND-2014-166: Results						
Treatment	Rate/ Acre	g a.i./ ha	Active Ingredient	FRAC Code	Fruit Rot Incidence (%)	
					Measured	Percent Control
Untreated control			Not Applicable		18.1 a	
Tavano 5SC	6.5 fl oz	25	Polyoxin D zinc salt	19	9.0 b	50
Regalia 5SC	2 pt		*Reynoutria sachalinensis*	P5	7.2 bc	63
Abound 2.08 SC	15.5 fl oz		Azoxystrobin	11	3.3 efg	82
Treatment means followed by the same letter are not statistically different according to Fisher's Protected LSD test at P = 0.0001.						

The date of first observation of cranberry fruit rot symptoms was not reported. Therefore, the applications as assumed to have been preventative.

No phytotoxicity was observed.

c. Discussion and Conclusions

Cranberries were grown in Wisconsin. Cranberry fruit rot incidence in the untreated control was 18.1%.

Two treatments Polyoxin D Zinc Salt 5SC Fungicide was applied preventatively at 6.5 fl oz/acre (25 g a.i./ha) at 9-day intervals. They provided 50% control of cranberry fruit rot. This was statistically:

- Superior to the untreated control;
- Equivalent to the control provided by Regalia 5SC (*Reynoutria sachalinensis*); and
- Less control than that provided by azoxystrobin.

No phytotoxicity was observed.

Coleophoma empetri, *Colletotrichum* spp., *Phomopsis vaccinii*, and *Physalospora vaccinii* (Fruit Rot Complex) / Cranberries #2: Trial No. CER-2015-104

a. Design

<table>
<tr><th colspan="6">Coleophoma empetri, Colletotrichum spp., Phomopsis vaccinii, and Physalospora vaccinii
(Fruit Rot Complex) / Cranberries #2: Trial No. CER-2015-104: Design</th></tr>
<tr><td>Title:</td><td colspan="5">Evaluation of Fungicides for Control of Cranberry Fruit Rot in Mature and Cranberry Beds in Wisconsin, 2015</td></tr>
<tr><td>Authors and affiliation:</td><td colspan="5">P. McManus and R.S. Perry
University of Wisconsin
Madison, WI</td></tr>
<tr><td>Publication:</td><td colspan="5">PDMR 10:SMF008</td></tr>
<tr><td rowspan="4">Location; Crop; Crop age</td><td colspan="5">Warrens; Cranberry ‘Crimson Queen’; 2 years</td></tr>
<tr><td colspan="5">Valley Junction; Cranberry ‘Stevens’; 2 years</td></tr>
<tr><td colspan="5">Plainfield; Cranberry ‘GHI’; 6 years</td></tr>
<tr><td colspan="5">Oakdale; Cranberry ‘Stevens’; 22 years</td></tr>
<tr><td>Disease name:</td><td colspan="5">Cranberry fruit rot complex</td></tr>
<tr><td>Pathogen:</td><td colspan="5">Ripe rot: Coleophoma empetri
Bitter rot: Colletotrichum spp.
Viscid rot: Phomopsis vaccinii
Early rot: Phyllosticta vaccinii
Blotch rot: Physalospora vaccinii</td></tr>
<tr><td>Test plot design:</td><td colspan="5">Randomized complete block</td></tr>
<tr><td>Number of replicates:</td><td colspan="5">5</td></tr>
<tr><td>Application equipment:</td><td colspan="5">CO_2 backpack sprayer (31 psi)</td></tr>
<tr><td>Spray volume:</td><td colspan="5">28.4 gal/acre</td></tr>
<tr><td>Number of applications:</td><td colspan="5">2</td></tr>
<tr><td rowspan="9">Chronology:</td><td>Site</td><td>App. Date</td><td>Growth Stage</td><td>App. Interval</td><td>Disease Assessment</td></tr>
<tr><td rowspan="2">Warrens</td><td>06/18/2015</td><td>50% bloom</td><td></td><td>09/10/2015</td></tr>
<tr><td>07/07/2015</td><td>20% fruit set</td><td>19 days</td><td></td></tr>
<tr><td rowspan="2">Valley Junction</td><td>06/23/2015</td><td>25% bloom</td><td></td><td>09/14/2015</td></tr>
<tr><td>07/07/2015</td><td>70% bloom</td><td>14 days</td><td></td></tr>
<tr><td rowspan="2">Plainfield</td><td>06/24/2015</td><td>50% bloom</td><td></td><td>09/17/2015</td></tr>
<tr><td>07/03/2015</td><td>20% fruit set</td><td>9 days</td><td></td></tr>
<tr><td rowspan="2">Oakdale</td><td>06/18/2015</td><td>50% bloom</td><td></td><td>09/18/2015</td></tr>
<tr><td>07/07/2015</td><td>20% fruit set</td><td>19 days</td><td></td></tr>
<tr><td>Disease assessment methodology:</td><td colspan="5">Soft, discolored fruit</td></tr>
</table>

b. Results (Warrens)

Coleophoma empetri, *et al.*, (Fruit Rot Complex) / Cranberries #2a: Trial No. CER-2015-104: Results: Warrens								
Treatment	Rate/ Acre	g a.i./ ha	Active Ingredient	FRAC Code	Fruit Rot Incidence (%)		Yield (Barrels/Acre)	
					Measured	Percent Control	Measured	Percent Increase
Untreated control			Not Applicable		23.6 a		216	
Oso 5SC	6.5 fl oz	25	Polyoxin D zinc salt	19	3.7 d	84.3	216	0
X77	0.25% (v/v)	NA	Non-ionic spreader	NA				
Oso 5SC	13 fl oz	50	Polyoxin D zinc salt	19	9.3 bc	60.6	212	-1.9
Bravo Weather Stik 6L	6.6 pt		Chlorothalonil	M5	3.6 d	84.7	226	4.6
Abound 2.08SC	15.5 fl oz		Azoxystrobin	11	3.3 d	86.0	211	-5.0
Regalia 5EC	2 pt		*Reynoutria sachalinensis*	P5	5.0 cd	78.8	200	-7.4
Double Nickel 99LC	6 qt		*Bacillus amyloliquefaciens* str. D747	44	10.3 b	56.4	240	11.1
Champ 37	5.3 pt		Copper hydroxide	M1	Not tested		Not tested	
Treatment means followed by the same letter are not statistically different according to the Fisher's Protected LSD test at P = 0.0001 for fruit rot; P = 0.6267 for yield.								

The diseases assessment date was after the last application treatment. Therefore, the treatments were assumed to be preventative.

No phytotoxicity was observed.

c. Discussion and Conclusions (Warrens)

Cranberries were grown in Warrens, Wisconsin. Cranberry fruit rot incidence in the untreated control was 23.6%.

Two treatments of Polyoxin D Zinc Salt 5SC Fungicide were applied preventatively at a 19-day interval. There was no positive dose response for control of cranberry fruit rot. Polyoxin D Zinc Salt 5SC Fungicide treatments applied at:

- 6.5 fl oz/acre (25 g a.i./ha) with a spreader provided 84.3% disease control.
- 13 fl oz/acre (50 g a.i./ha) without a spreader provided 60.6% disease control.

The 6.5 fl oz/acre (25 g a.i./ha) treatment with Polyoxin D Zinc Salt 5SC Fungicide plus a non-ionic spreader provided control of cranberry fruit rot that was statistically:

- Superior to:
  - The untreated control;
  - Treatment with 13 fl oz/acre Polyoxin D Zinc Salt 5SC Fungicide treatment without a spreader; and
  - treatment with *Bacillus amyloliquefaciens* str. D747 (Double Nickel 99LC); and
- Equivalent to separate treatments with chlorothalonil, azoxystrobin, and *Reynoutria sachalinensis* (Regalia).

The 13 fl oz/acre (50 g a.i./ha) treatment with Polyoxin D Zinc Salt 5SC Fungicide provided control of cranberry fruit rot that was statistically:

- Superior to the untreated control;
- Equivalent to the control provided by *Bacillus amyloliquefaciens* str. D747 (Double Nickel 99LC); and
- Less than that provided:
  - By polyoxin D Zinc Salt 5SC Fungicide applied at 6.5 fl oz /acre (25 g a.i./ha); and
  - Separately by chlorothalonil, azoxystrobin, and *Reynoutria sachalinensis* (Regalia).

Treatment of cranberries with Polyoxin D Zinc Salt 5SC Fungicide did not increase yields.

No phytotoxicity was observed.

d. Results (Valley Junction)

Coleophoma empetri, *et al.*, (Fruit Rot Complex) / Cranberries #2b: Trial No. CER-2015-104: Results: Valley Junction								
Treatment	Rate/ Acre	g a.i./ ha	Active Ingredient	FRAC Code	Fruit Rot Incidence (%)		Yield (Barrels/Acre)	
					Measured	Percent Control	Measured	Percent Increase
Untreated control			Not Applicable		45.0 a		169 ab	
Oso 5SC	6.5 fl oz	25	Polyoxin D zinc salt	19	4.4 c	90.2	228 ab	34.9
X77	0.25% (v/v)	NA	Non-ionic spreader	NA				
Oso 5SC	13 fl oz	50	Polyoxin D zinc salt	19	Not tested		Not tested	
Bravo Weather Stik 6L	6.6 pt		Chlorothalonil	M5	8.8 c	80.4	182 ab	7.7
Abound 2.08SC	15.5 fl oz		Azoxystrobin	11	2.9 c	93.6	262 a	55.0
Regalia 5EC	2 pt		*Reynoutria sachalinensis*	P5	9.5 c	78.9	173 ab	2.4
Double Nickel 99LC	6 qt		*Bacillus amyloliquefaciens* str. D747	44	33.8 b	24.9	217 ab	28.4
Champ 37	5.3 pt		Copper hydroxide	M1	Not tested		Not tested	
Treatment means followed by the same letter are not statistically different according to the Fisher's Protected LSD test at P = 0.0001 for fruit rot; P = 0.0187 for yield.								

The diseases assessment date was after the last application treatment. Therefore, the treatments were assumed to be preventative.

No phytotoxicity was observed.

e. Discussion and Conclusions (Valley Junction)

Cranberries were grown in Valley Junction, Wisconsin. Cranberry fruit rot incidence in the untreated control was 45.0%.

Two treatments of Polyoxin D Zinc Salt 5SC Fungicide were applied preventatively at a 14-day interval. The treatments were applied at 6.5 fl oz/acre (25 g a.i./ha) with a non-ionic spreader. They provided 90.2% control of cranberry fruit rot. This was statistically:

- Superior to the untreated control and the control provided by *Bacillus amyloliquefaciens* str. D747 (Double Nickel 99LC); and
- Equivalent to the control separately provided by chlorothalonil, azoxystrobin, and *Reynoutria sachalinensis* (Regalia).

The Polyoxin D Zinc Salt 5SC Fungicide treatments increased the cranberry yield by 34.9% compared to the untreated control. This increase was determined to not be statistically different than the yield in the untreated control.

No phytotoxicity was observed.

f. Results (Plainfield)

Coleophoma empetri, *et al.*, (Fruit Rot Complex) / Cranberries #2c: Trial No. CER-2015-104: Results: Plainfield								
Treatment	Rate/ Acre	g a.i./ ha	Active Ingredient	FRAC Code	Fruit Rot Incidence (%)		Yield (Barrels/Acre)	
					Measured	Percent Control	Measured	Percent Increase
Untreated control			Not Applicable		30.5 a		292 ab	
Oso 5SC	6.5 fl oz	25	Polyoxin D zinc salt	19	9.6 de	68.5	298 ab	2.1
X77	0.25% (v/v)	NA	Non-ionic spreader	NA				
Oso 5SC	13 fl oz	50	Polyoxin D zinc salt	19	11.0 d	63.9	285 ab	-2.4
Bravo Weather Stik 6L	6.6 pt		Chlorothalonil	M5	4.0 fg	86.9	330 a	13.0
Abound 2.08SC	15.5 fl oz		Azoxystrobin	11	4.2 fg	86.2	279 b	-4.5
Regalia 5EC	2 pt		*Reynoutria sachalinensis*	P5	7.1 ef	76.7	295 ab	1.0
Double Nickel 99LC	6 qt		*Bacillus amyloliquefaciens* str. D747	44	17.6 c	42.3	286 ab	-2.1
Champ 37	5.3 pt		Copper hydroxide	M1	26.3 b	13.8	262 b	-10.3
Treatment means followed by the same letter are not statistically different according to the Fisher's Protected LSD test at P = 0.0001 for fruit rot; P = 0.0061 for yield.								

The diseases assessment date was after the last application treatment. Therefore, the treatments were assumed to be preventative.

No phytotoxicity was observed.

g. Discussion and Conclusions (Plainfield)

Cranberries were grown in Plainfield, Wisconsin. Cranberry fruit rot incidence in the untreated control was 30.5%.

Two treatments of Polyoxin D Zinc Salt 5SC Fungicide were applied preventatively at a 9-day interval. Polyoxin D Zinc Salt 5SC Fungicide treatments applied at:

- 6.5 fl oz/acre (25 g a.i./ha) with a spreader provided 68.5% disease control.
- 13 fl oz/acre (50 g a.i./ha) without a spreader provided 63.9% disease control.

The 6.5 fl oz/acre (25 g a.i./ha) treatment with Polyoxin D Zinc Salt 5SC Fungicide provided control of cranberry fruit rot that was statistically:

- Superior to the untreated control and treatment separately with *Bacillus amyloliquefaciens* str. D747 (Double Nickel 99LC), copper hydroxide;
- Equivalent to treatment with 13 fl oz/acre Polyoxin D Zinc Salt 5SC Fungicide treatment without a spreader, and with *Reynoutria sachalinensis* (Regalia); and
- Less than the control provided separately by chlorothalonil and azoxystrobin.

The 13 fl oz/acre (50 g a.i./ha) treatment with Polyoxin D Zinc Salt 5SC Fungicide provided control of cranberry fruit rot that was statistically:

- Superior to the untreated control and to the control provided by *Bacillus amyloliquefaciens* str. D747 (Double Nickel 99LC) and by copper hydroxide;
- Less than the control provided by Polyoxin D Zinc Salt 5SC Fungicide applied at 6.5 fl oz /acre (25 g a.i./ha) and by chlorothalonil, by azoxystrobin, and by *Reynoutria sachalinensis* (Regalia).

There were no statistically significant increases in yield.

No phytotoxicity was observed.

h. Results (Oakdale)

<table>
<tr><td colspan="9">Coleophoma empetri, et al., (Fruit Rot Complex) / Cranberries #2d: Trial No. CER-2015-104: Results: Oakdale</td></tr>
<tr><td rowspan="2">Treatment</td><td rowspan="2">Rate/ Acre</td><td rowspan="2">g a.i./ ha</td><td rowspan="2">Active Ingredient</td><td rowspan="2">FRAC Code</td><td colspan="2">Fruit Rot Incidence (%)</td><td colspan="2">Yield (Barrels/Acre)</td></tr>
<tr><td>Measured</td><td>Percent Control</td><td>Measured</td><td>Percent Increase</td></tr>
<tr><td>Untreated control</td><td></td><td></td><td>Not Applicable</td><td></td><td>22.2 a</td><td></td><td>224 b</td><td></td></tr>
<tr><td>Oso 5SC</td><td>6.5 fl oz</td><td>25</td><td>Polyoxin D zinc salt</td><td>19</td><td rowspan="2">4.8 de</td><td rowspan="2">78.4</td><td rowspan="2">289 ab</td><td rowspan="2">29.0</td></tr>
<tr><td>X77</td><td>0.25% (v/v)</td><td>NA</td><td>Non-ionic spreader</td><td>NA</td></tr>
<tr><td>Oso 5SC</td><td>13 fl oz</td><td>50</td><td>Polyoxin D zinc salt</td><td>19</td><td>4.2 de</td><td>81.1</td><td>290 ab</td><td>29.5</td></tr>
<tr><td>Bravo Weather Stik 6L</td><td>6.6 pt</td><td></td><td>Chlorothalonil</td><td>M5</td><td>4.3 de</td><td>80.6</td><td>257 ab</td><td>14.7</td></tr>
<tr><td>Abound 2.08SC</td><td>15.5 fl oz</td><td></td><td>Azoxystrobin</td><td>11</td><td>2.2 e</td><td>90.0</td><td>277 ab</td><td>23.7</td></tr>
<tr><td>Regalia 5EC</td><td>2 pt</td><td></td><td>Reynoutria sachalinensis</td><td>P5</td><td>4.0 de</td><td>82.0</td><td>290 ab</td><td>29.5</td></tr>
<tr><td>Double Nickel 99LC</td><td>6 qt</td><td></td><td>Bacillus amyloliquefaciens str. D747</td><td>44</td><td>12.7 c</td><td>42.8</td><td>274 ab</td><td>22.3</td></tr>
<tr><td>Champ 37</td><td>5.3 pt</td><td></td><td>Copper hydroxide</td><td>M1</td><td>Not tested</td><td></td><td>Not tested</td><td></td></tr>
<tr><td colspan="9">Treatment means followed by the same letter are not statistically different according to the Fisher's Protected LSD test at P = 0.0001 for fruit rot; P = 0.0064 for yield.</td></tr>
</table>

The diseases assessment date was after the last application treatment. Therefore, the treatments were assumed to be preventative.

No phytotoxicity was observed.

i. Discussion and Conclusions (Oakdale)

Cranberries were grown in Oakdale, Wisconsin. Cranberry fruit rot incidence in the untreated control was 22.2%.

Two treatments of Polyoxin D Zinc Salt 5SC Fungicide were applied preventatively at a 19-day interval. Polyoxin D Zinc Salt 5SC Fungicide treatments applied at:

- 6.5 fl oz/acre (25 g a.i./ha) with a spreader provided 78.4% disease control and 29.0% increased yield; and
- 13 fl oz/acre (50 g a.i./ha) without a spreader provided 81.1% disease control and 29.5% increased yield.

The 6.5 fl oz/acre (25 g a.i./ha) treatment with Polyoxin D Zinc Salt 5SC Fungicide and a non-ionic spreader provided control of cranberry fruit rot that was statistically:

- Superior to the untreated control and to treatment with *Bacillus amyloliquefaciens* str. D747 (Double Nickel 99LC); and
- Equivalent to treatment with 13 fl oz/acre Polyoxin D Zinc Salt 5SC Fungicide treatment without a spreader and with separate treatments with chlorothalonil, azoxystrobin, and *Reynoutria sachalinensis* (Regalia).

The 13 fl oz/acre (50 g a.i./ha) treatment with Polyoxin D Zinc Salt 5SC Fungicide without a non-ionic surfactant provided control of cranberry fruit rot that was statistically:

- Superior to the untreated control and to the control provided by *Bacillus amyloliquefaciens* str. D747 (Double Nickel 99LC); and
- Equivalent to the control provided separately by chlorothalonil, azoxystrobin, and *Reynoutria sachalinensis* (Regalia).

Treatment of cranberries with Polyoxin D Zinc Salt 5SC Fungicide increased mean yields 29.3% (range 29.0% to 29.5%) compared to the untreated control. The increased yield from treatment with Polyoxin D Zinc Salt 5SC Fungicide was statistically equivalent to the increased yields from separate treatments with chlorothalonil, azoxystrobin, *Reynoutria sachalinensis* (Regalia), and *Bacillus amyloliquefaciens* str. D747 (Double Nickel).

No phytotoxicity was observed.

Colletotrichum acutatum (ANTHRACNOSE) / STRAWBERRIES

Colletotrichum acutatum (Anthracnose) / Strawberries: Introduction
(Source: 2015 Organic Production and IPM Guide for Strawberries, Cornell University Cooperative Extension)

One or more circular spots occur on the fruit. Spots originally are tan or light brown but become darker and sunken. Sunken spots are usually about one eighth to one quarter inch in diameter and may be covered with pink slimy spore masses during wet or very humid periods. The disease may occur on both green and ripe fruit, but is most common on ripe fruit following periods of warm, wet weather. In New York, anthracnose occurs only sporadically and is a more common problem on day-neutral varieties in the summer than it is on June-bearing varieties. However, the disease can be serious on June-bearing varieties if warm, wet weather conditions occur between fruit set and harvest. Anthracnose fruit rots can be difficult to control organically if the weather does not cooperate.

Colletotrichum acutatum (Anthracnose) / Strawberries: Management Options
(Source: 2015 Organic Production and IPM Guide for Strawberries, Cornell University Cooperative Extension)

Scouting/thresholds	None established.
Variety susceptibility	No known resistant varieties.
Cultural management	Provide good air circulation by controlling weeds and reducing planting density. Use of protected production structures, such as low tunnels, reduces anthracnose occurrence by limiting fruit wetness. The anthracnose fungus is spread throughout a planting by splashing raindrops or sprinkler irrigation. Straw mulch may reduce the rate of disease spread relative to bare ground (less rain splash).
Chemical treatment	See table below.

Colletotrichum acutatum (Anthracnose) / Strawberries: OMRI Listed Fungicides for Use in the United States										
FRAC Code	Source: 2015 Organic Production and IPM Guide for Strawberries, Cornell University Cooperative Extension							Source: EPA Label		NOP Status
	Active Ingredient	Product Name	Product Rate/ Acre	PHI (Days)	REI (Days)	Efficacy	Comments	EPA Reg. No.	Comments	
44	*Bacillus amyloliquefaciens* str. D747	Double Nickel 55	0.25-3 lb	0	4	Not reviewed or no research available.	Foliar application.	70051-108	Causes moderate eye irritation. Dermal sensitizer. Broad-spectrum preventative fungicide. Do not use highly alkaline or highly acidic water to mix sprays. Use a buffering agent if necessary to maintain neutrality (pH 6 to 8) of water in the tank.	Non-synthetic
		Double Nickel LC	0.5-6 qt	0	4	Not reviewed or no research available.	Foliar application.	70051-114	Harmful if absorbed through skin. Harmful if inhaled. Dermal sensitizer. Broad-spectrum preventative fungicide.	
	Bacillus subtilis str. QST 713	Serenade ASO	2-6 qt	0	4	Not reviewed or no research available.	Begin application at or before disease development then repeat every 7-10 days.	264-1152	Broad spectrum preventative fungicidal and bactericidal product.	Non-synthetic
		Serenade MAX	1-3 lb	0	4	Inconsistent efficacy results.	Apply on a 7-10 day schedule following disease onset.	69592-11	Dermal sensitizer. Broad spectrum preventative fungicidal and bactericidal product.	
		Serenade Optimum	14-20 oz	0	4	Not effective.	Begin applications at or before flowering. Repeat every 7-10 days.	264-1160		
P5	*Reynoutria sachalinensis*	Regalia Biofungicide	1-3 qt	0	4	Not reviewed or no research available.	Apply preventatively in 50-100 gal water/acre and repeat on a 7-10 day interval or as needed.	84059-3	Causes moderate eye irritation. Preventative rather than a curative application. Apply prior to disease infestation to protect the growing leaf tissue. Avoid freezing.	Non-synthetic
Not classified; Biological	*Streptomyces lydicus* WYEC 108	Actinovate AG	3-12 oz	0	1 or until solution has dried	Inconsistent efficacy results.	Foliar application. For best results, apply with a spreader/ sticker prior to onset of disease. Re-apply as needed.	73314-1	Avoid contact with skin, eyes, or clothing. Avoid breathing dust or spray mist. Mixer/loaders and applicators must wear a dust/mist filtering respirator meeting NIOSH standards of at least N-95, R-95, or P-95. Repeated exposure to high concentrations of microbial proteins can cause allergic sensitization. Keep from overheating or freezing. Optimum storage temperature is 40°F to 85°F. Contains live spores of a microbe. Best results will be obtained if the product is used prior to disease onset. Becomes active in soil or on the plant foliage when the temperatures are above 45°F and is not effective when temperatures remain cold. Do not apply soil fumigants to treated areas.	Non-synthetic

Colletotrichum acutatum (Anthracnose) / Strawberries: OMRI Listed Fungicides for Use in the United States										
FRAC Code	Source: 2015 Organic Production and IPM Guide for Strawberries, Cornell University Cooperative Extension							Source: EPA Label		NOP Status
	Active Ingredient	Product Name	Product Rate/ Acre	PHI (Days)	REI (Days)	Efficacy	Comments	EPA Reg. No.	Comments	
Not classified; Botanical oil	Neem oil	Trilogy	1.0% solution	0	4	Not reviewed or no research available.	Apply in 25-100 gal water/acre. Maximum labeled use of 2 gal/acre/application.	70051-2	Causes moderate eye irritation. Hazardous to fish and aquatic invertebrates. Toxic to bees exposed to direct treatment. Broad spectrum. Exercise care in timing applications during early morning/late evening to minimize the potential for leaf burn. Use care on plants with tender tissue. Check for leaf burn in small scale trials prior to use. Do not apply to sensitive plant species. Do not apply to wilted or otherwise stressed plants, or to newly transplanted materials or crops prior to root establishment. For optimal performance, do not mix with cold water (less than 45°F). Do not store below 40°F (4°C). Do not use or store near heat or open flame.	Non-synthetic
M1	Copper octanoate	Cueva Fungicide Concentrate	0.5-2.0 gal/100 gal water	0	4	Not reviewed or no research available.	Product is applied as a diluted spray at 50-100 gallons per acre.	67702-2-70051	Harmful if swallowed or absorbed through skin. Toxic to fish and aquatic organisms. May cause some copper toxicity on some plant species. Store away from open fire or flame. Product may be damaged by freezing. Do not store product below 4°C. Do not mix with chelated or liquid fertilizers. Use caution when using product with other fungicides and insecticides.	Synthetic
Not classified; Inorganic salt	Potassium bicarbonate	EcoMate Amicarb O	2.5-5 lb/ 100 gal water	0	4	Not effective.		5905-541	Harmful if swallowed. Causes moderate eye irritation. Broad spectrum contact foliar fungicide. Prevent exposure to moisture during storage. Avoid contamination with other pesticides and fertilizers.	Synthetic
		Milstop	2-5 lb	0	1	Not reviewed or no research available.	Do not mix with other pesticides or fertilizers. Not compatible with alkaline solutions.	70870-1-68539	Harmful if swallowed. Causes moderate eye irritation. Broad spectrum contact foliar fungicide. Do not mix with other soluble pesticides or fertilizers. Not compatible with mild alkaline solutions. Acidification of solution will cause reduced product performance. Prevent exposure to moisture during storage. Avoid contamination with other pesticides and fertilizers.	

Colletotrichum acutatum (Anthracnose) / Strawberries: OMRI Listed Fungicides for Use in the United States										
FRAC Code	Source: 2015 Organic Production and IPM Guide for Strawberries, Cornell University Cooperative Extension							Source: EPA Label		NOP Status
	Active Ingredient	Product Name	Product Rate/ Acre	PHI (Days)	REI (Days)	Efficacy	Comments	EPA Reg. No.	Comments	
Not classified; Oxidizing agent	Hydrogen peroxide, Peroxyacetic acid	Perpose Plus	Initial/ Curative: 1 fl oz/gal Weekly/ Preventative: 0.25-0.33 fl oz/gal	0	Until spray has dried	Inconsistent efficacy results.	For initial or curative use, apply higher rate for 1 to 3 consecutive days. Then follow with weekly/preventative treatment. For weekly of preventative treatments, apply lower rate every five to seven days. At first signs of disease, use curative rate then resume weekly preventative treatment.	86729-1	DANGER signal word. Causes irreversible eye damage and skin burns. May be fatal if absorbed through the skin. Harmful if swallowed. Do not breathe vapor from concentrate. Toxic to birds, mammals, fish and aquatic life. At temperatures exceeding 156°F, decomposition releases oxygen. The oxygen released could initiate or promote combustion of other materials. Store away from combustibles. Broad spectrum algaecide and fungicide. Apply curative rates for 3 consecutive days (drenching the entire plant) followed by weekly preventative treatments.	Synthetic

Colletotrichum orbiculare (ANTHRACNOSE) / CUCURBITS

Colletotrichum Orbiculare (Anthracnose) / Cucurbits: Introduction
(Source: J. Palenchar, D. Treadwell, *et al.*, Cucumber Anthracnose in Florida, University of Florida IFAS Extension, September 2012)

Cucumber (*Cucumis sativus* L.) is an important crop in Florida and in the U.S. Cucumbers are (1) grown for the fresh market (slicers) and pickling (processing cucumbers) (Mills, 2001), and (2) are grown in the field and in the greenhouse (Larson *et al.*, 2003). In 2007, Florida was the second largest producer of slicers in the U.S. and the fourth largest producer of processing cucumbers (USDA-NASS, 2008). In 2006, the value of slicers and processing cucumbers in Florida was $73.9 million and $24.2 million, respectively. Florida also had the highest yield per acre in the U.S. for both cucumber types (USDA-NASS, 2008).

Diseases, weeds, and insect pests can adversely affect the yield and quality of cucumbers. In Florida, one of the most common diseases on cucumber is anthracnose, caused by the fungus *Colletotrichum orbiculare* (syn. *C. lagenarium*). Anthracnose causes serious economic losses to several economically important vegetable crops worldwide. In addition to cucumber, anthracnose can affect cantaloupe, chayote, citron, gherkin, gourd, honeydew melon, muskmelon, watermelon, and many non-cucurbit species. Anthracnose is rare on pumpkin and squash (Wasilwa *et al.*, 1993). The objective of this publication is to describe the symptoms, causal organism, disease cycle, and management of cucumber anthracnose in Florida.

Colletotrichum Orbiculare (Anthracnose) / Cucurbits: Symptoms
(Source: J. Palenchar, D. Treadwell, *et al.*, Cucumber Anthracnose in Florida, University of Florida IFAS Extension, September 2012)

Anthracnose symptoms occur on all aboveground parts of cucumber plants. Lesions that appear on the cotyledons begin small and water-soaked. They are pale in color, chlorotic (yellow) or necrotic (brown), and are restricted. As the disease progresses, the lesions become larger, coalesce, and eventually the cotyledons dry up and die. Similar symptoms appear on the leaves. The petioles, fruit pedicel, and stem can also become infected resulting in vine defoliation, fruit decline, and plant death. Fruit can become infected as they begin to mature; fruit lesions appear sunken, circular, water-soaked, and dark in color. Often the pathogen produces spores, or conidia, on infected fruit giving lesions a wet, pink appearance. Symptoms on the fruit can develop without notice while still in the field and continue to progress after harvest, resulting in infected cucumber fruit in storage and/or transit.

Colletotrichum Orbiculare (Anthracnose) / Cucurbits: Causal Organism
(Source: J. Palenchar, D. Treadwell, *et al.*, Cucumber Anthracnose in Florida, University of Florida IFAS Extension, September 2012)

When plant tissue samples are submitted to a diagnostic laboratory to confirm cucumber anthracnose, pathogen identification is based on symptoms on the plant and the following description of *C. orbiculare* conidia. Conidia are the infective structures, or spores, of *C. orbiculare*. Conidia are formed in masses known as acervuli (singular acervulus), which appear as pink-colored, slimy masses on infected tissue (Zitter *et al.*, 1998). The acervulus is often surrounded by black, hairlike structures, known as setae that are only visible under a microscope. The conidia are oval, or pill-shaped, clear, and have no cross walls (Zitter *et al.*, 1998).

Many efforts have been made to distinguish *C. orbiculare* into different races based on host range. Race is a term used to describe a sub-category or group within a fungal species that is genetically and often geographically distinct. Originally, seven races were described that were differentiated based on their ability to infect different cucurbit types (Wasilwa *et al.*, 1993). Recently, two races have been defined based on multiple factors including DNA markers, vegetative compatibility groups, and virulence phenotype. Race 1 is highly virulent on cantaloupe, cucumber, and some watermelon varieties. Race 2 is moderately virulent on most cucumber varieties and highly virulent on most watermelon varieties (Wasilwa *et al.*, 1993).

Colletotrichum Orbiculare **(Anthracnose) / Cucurbits: Disease Cycle**
(Source: J. Palenchar, D. Treadwell, *et al.*, Cucumber Anthracnose in Florida, University of Florida IFAS Extension, September 2012)

The fungus *C. orbiculare* can survive between cucumber crops on seed, volunteer cucurbits, and weeds (such as cockleburs), and on infected crop residues. The spores can be moved by water, workers, and insects, such as *Pimelia* sp. (Tenebrionidae). Once spores land on susceptible plant parts, they can germinate and form infection structures on the plant known as appressoria. Temperatures of 72-80°F (22-27°C) and a relative humidity of 100% are the optimal conditions for infection to occur. Plant disease symptoms appear about 4 days after infection (Zitter *et al.*, 1998). Epidemics of anthracnose can reduce yield when they are severe and occur early in the season (Thompson and Jenkins, 1985). Temperatures less than 90°F (32°C) and rain will favor disease epidemics. Environmental conditions have a significant influence on the disease progression of anthracnose on cucumber. Anthracnose is less likely to infect cucumber when temperatures get above 86°F (30°C), even if rainfall occurs (Thompson and Jenkins, 1985).

Colletotrichum Orbiculare **(Anthracnose) / Cucurbits: Cultural Control**
(Source: J. Palenchar, D. Treadwell, *et al.*, Cucumber Anthracnose in Florida, University of Florida IFAS Extension, September 2012)

An integrated pest management strategy is necessary to effectively manage cucumber anthracnose in Florida. The use of resistant cultivars should be the first step in managing any plant disease and can greatly reduce yield losses due to anthracnose. Several seed companies offer cultivars with varying levels of resistance to this disease, which may be listed as anthracnose, *Colletotrichum orbiculare*, or ‘Co’ on the seed package, and/or catalogue. Some anthracnose resistant slicing cucumber cultivars include ‘Diamante’, ‘Stonewall’, and ‘Greensleeves’. Pickling cucumber types that have resistance to anthracnose include ‘Cross Country’, ‘Eclipse’, ‘Feisty’, ‘Fortune’, ‘Spunky’, and ‘Treasure’.

Numerous plant growth-promoting rhizobacteria have been shown to effectively reduce the severity of anthracnose when applied to cucumber seeds before or at planting. This reduction is due to the induction of systemic acquired resistance (SAR) in the cucumber (Raupach and Kloepper, 2000; Wei *et al.*, 1991). Systemic acquired resistance is a general resistance response that occurs throughout a plant after the plant experiences injury from a chemical or infection by a pathogen. Cucumber seedlings grown in compost have limited disease severity, which was attributed to SAR-associated gene expression in cucumber plants in greenhouse trials (Zhang *et al.*, 1996). Our recent studies suggest potential for anthracnose suppression by amending potting media with high rates of silicon.

Cultural pest management techniques play a very important role in the prevention and reduction in severity of anthracnose epidemics. Plants should always be started from clean seed (Zitter *et al.*, 1998), and it is desirable to get seed from production areas that are not known to have problems with anthracnose. Cucurbit volunteers and alternative hosts in and around the field and transplant houses should be destroyed. Immediately following the final harvest, deep plowing should be carried out to destroy all infected cucumber plants and debris in the field. Crop rotation with non-hosts for at least 1-year is another management technique that is effective in reducing the incidence of anthracnose (Zitter *et al.*, 1998).

It is very important to monitor or scout cucumber plants for signs of anthracnose, especially when plants are young. Protecting young plants from infection and managing early infections can prevent a build-up of inoculum in the field and can reduce losses (Thompson and Jenkins, 1985).

Colletotrichum Orbiculare (Anthracnose) / Cucurbits: OMRI-Listed Fungicides for Use in the United States **(No efficacy data have been identified or evaluated.)**								
FRAC Code	Source: EPA Label							NOP Status
	Active Ingredient	Product Name	Product Rate/Acre	PHI (Days)	REI (Days)	EPA Reg. No.	Comments	
44	*Bacillus pumilus* str. QST 2808	Sonata ASO	2-4 qt	0	4	264-1153	Harmful if inhaled. Mixers/loaders and applicators must wear a dust/mist filtering respirator meeting NIOSH standards of at least N-95, R-95, or P-95. Repeated exposure to high concentrations of microbial proteins can cause allergic sensitization. Maintain a spray solution pH between 4.5 and 8.5.	Non-synthetic
	Bacillus subtilis str. QST 713	Serenade MAX	1-3 lb	0	4	69592-11	Dermal sensitizer. Broad spectrum preventative fungicidal and bactericidal product.	Non-synthetic
P5	*Reynoutria sachalinensis*	Regalia Biofungicide	1-4 qt	0	4	84059-3	Causes moderate eye irritation. Preventative rather than a curative application. Apply prior to disease infestation to protect the growing leaf tissue. Avoid freezing.	Non-synthetic
Not classified; Biological	*Streptomyces lydicus* WYEC 108	Actinovate AG	3-12 oz	0	1 or until soluti on has dried	73314-1	Avoid contact with skin, eyes, or clothing. Avoid breathing dust or spray mist. Mixer/loaders and applicators must wear a dust/mist filtering respirator meeting NIOSH standards of at least N-95, R-95, or P-95. Repeated exposure to high concentrations of microbial proteins can cause allergic sensitization. Keep from overheating or freezing. Optimum storage temperature is 40°F to 85°F. Contains live spores of a microbe. Best results will be obtained if the product is used prior to disease onset. Becomes active in soil or on the plant foliage when the temperatures are above 45°F and is not effective when temperatures remain cold. Do not apply soil fumigants to treated areas.	Non-synthetic
Not classified; Botanical oil	Neem oil	Trilogy	0.5-1.0% solution	0	4	70051-2	Causes moderate eye irritation. Hazardous to fish and aquatic invertebrates. Toxic to bees exposed to direct treatment. Broad spectrum. Exercise care in timing applications during early morning/late evening to minimize the potential for leaf burn. Use care on plants with tender tissue. Check for leaf burn in small scale trials prior to use. Do not apply to sensitive plant species. Do not apply to wilted or otherwise stressed plants, or to newly transplanted materials or crops prior to root establishment. For optimal performance, do not mix with cold water (less than 45°F). Do not store below 40°F (4°C). Do not use or store near heat or open flame	Non-synthetic
M1	Copper hydroxide	Nu-Cop 50 WP	2-3 lb	0	24	42002-7	DANGER signal word. Corrosive. Causes irreversible eye damage. Harmful if swallowed, absorbed through skin, or inhaled. Skin sensitizer. Toxic to fish and aquatic organisms. Product should not be applied in spray water having a pH of less than 6.5 as phytotoxicity may result. Effectiveness reduced at pH greater than 9.0. Watermelon only.	Synthetic
		Nu-Cop HB	1.0 lb	1	24	42750-132	DANGER signal word. Corrosive. Causes irreversible eye damage. Harmful if swallowed, absorbed through skin, or inhaled. Product should not be applied in spray water having a pH of less than 6.5 as phytotoxicity may result. Discontinue use if injury occurs.	
	Copper sulfate pentahydrate	CS 2005	19.2-25.6 oz	0	48	66675-3	DANGER signal word. Corrosive. Causes irreversible eye damage and skin irritation. Harmful if swallowed, inhaled or absorbed through the skin. Dermal sensitizer. Toxic to fish and aquatic organisms. Do not mix with acidic compounds. Do not mix with pot ash. Store away from excessive heat. Product will freeze. Store and handle product in 316L stainless steel, fiberglass, PVC's, polypropylenes or plastic equipment. Keep away from galvanized pipe and any nylon storage handling equipment. Crop injury may occur from application at higher rates and shorter intervals.	Synthetic
	Cuprous oxide	Nordox 75 WG	1-1.25 lb	0	12	48142-4	Harmful if swallowed or absorbed through skin. Causes eye irritation. Do not apply in a spray solution with a pH of less than 6.5.	Synthetic

Colletotrichum Orbiculare (Anthracnose) / Cucurbits: OMRI-Listed Fungicides for Use in the United States
(No efficacy data have been identified or evaluated.)

FRAC Code	Source: EPA Label							NOP Status
	Active Ingredient	Product Name	Product Rate/Acre	PHI (Days)	REI (Days)	EPA Reg. No.	Comments	
Not classified; Inorganic salt	Potassium bicarbonate	EcoMate Amicarb O	2.5-5 lb/100 gal water	0	4	5905-541	Harmful if swallowed. Causes moderate eye irritation. Broad spectrum contact foliar fungicide. Prevent exposure to moisture during storage. Avoid contamination with other pesticides and fertilizers.	Synthetic
		Milstop	2-5 lb	0	1	70870-1-68539	Harmful if swallowed. Causes moderate eye irritation. Broad spectrum contact foliar fungicide. Do not mix with other soluble pesticides or fertilizers. Not compatible with mild alkaline solutions. Acidification of solution will cause reduced product performance. Prevent exposure to moisture during storage. Avoid contamination with other pesticides and fertilizers.	
Not classified; Oxidizing agent	Hydrogen dioxide, Peroxyacetic acid	Oxidate 2.0	0.5 - 1 gal/ 100 gal water (foliar application)	0	Until dry	70299-2	DANGER signal word. Causes irreversible eye damage. May be fatal if swallowed. Causes skin irritation or temporary discoloration of exposed skin. Highly toxic to bees and other beneficial insects. Toxic to fish. Toxic to birds who eat treated seed on soil surface. Strong oxidizing agent. Do not use in undiluted form. Never bring undiluted product in contact with other pesticides, cleaners or oxidative agents. May react with residues of metal-based fungicides or supplements. Allow at least 24 hrs. after application of metal-based products. Do not spray during conditions of intense heat, drought, or poor plant vigor (or vine canopy). Do not apply in conjunction with any other pesticides or fertilizers. Do not allow product to become overheated in storage. Do not store in a manner where cross-contamination with other pesticides or fertilizers could occur. Do not apply during intense heat, drought, or poor vine canopy. Apply consecutive applications until control is achieved; then apply preventative treatments.	Synthetic
	Hydrogen peroxide, Hydrogen dioxide	Perpose Plus	Initial/ Curative: 1 fl oz/gal Weekly/ Preventative: 0.25-0.33 fl oz/gal	0	Until spray has dried	86729-1	DANGER signal word. Causes irreversible eye damage and skin burns. May be fatal if absorbed through the skin. Harmful if swallowed. Do not breathe vapor from concentrate. Toxic to birds, mammals, fish and aquatic life. At temperatures exceeding 156°F, decomposition releases oxygen. The oxygen released could initiate or promote combustion of other materials. Store away from combustibles. Broad spectrum algaecide and fungicide. Apply curative rates for 3 consecutive days (drenching the entire plant) followed by weekly preventative treatments.	Synthetic

Colletotrichum Orbiculare **(Anthracnose) / Cucurbits: Efficacy Reports**

Colletotrichum orbiculare (Anthracnose) / Watermelon #1: Trial No. CER-2014-057

a. Design

Colletotrichum orbiculare (Anthracnose) / Watermelon #1: Trial No. CER-2014-057: Design			
Title:	Evaluation of Oso and Double Nickel LC in a Program to Control Downy Mildew and Other Foliar Diseases of Watermelon, Overton 2014		
Author and affiliation:	Dr. Karl Steddom Kilgore College and Texas A&M AgriLife Research		
Publication:	Not published. Permission received.		
Location:	Overton, TX		
Crop:	Watermelon (Var. Solitaire)		
Disease name:	Anthracnose		
Pathogen:	*Colletotrichum orbiculare*		
Test plot design:	Randomized complete block		
Number of replicates:	4		
Application equipment:	Small plot air blast sprayer		
Spray volume:	Not reported		
Number of applications:	7		
Chronology:	Application Dates	Application Interval	Harvest Dates
	15 days from planting		72 days from planting 82 days from planting
	23 days from planting	8 days	
	34 days from planting	11 days	
	40 days from planting	6 days	
	47 days from planting	7 days	
	54 days from planting	7 days	
	61 days from planting	7 days	
Disease assessment methodology:	Disease evaluations are based upon a 0-5 scale. 0 = No disease. 5 = More than 95% of the leaf area was damaged.		

b. Results

Colletotrichum orbiculare (Anthracnose) / Watermelon #1: Trial No. CER-2014-057: Results										
Treatment	Rate/ Acre	g a.i./ ha	Active Ingredient	FRAC Code	App Code	Anthracnose Rating (0-5 Scale)		Yield (Weight per acre)		Phyto-toxicity
						Measured	Percent Control	Measured	% Change	
Untreated control			Not Applicable			1.38 b		36,086 a		0.00 a
Oso	6.5 fl oz	25	Polyoxin D zinc salt	19	ABCDEFG	0.25 a	82	37,280 a	3.3	0.00 a
Capsil	12 fl oz/ 100 gal	NA	Surfactant	NA						
Chlorothalonil FH	2 pt		Chlorothalonil	M5	ABCDEF	0.19 a	86	41,133 a	14.0	1.44 b
Gavel	2 lb		Mancozeb	M3	G					
			Zoxamide	22						
Double Nickel LC	1 qt		*Bacillus amyloliquefaciens* str. D747	44	ACEG	0.17 a	88	38,656 a	6.7	0.00 a
Bravo	2 pt		Chlorothalonil	M5	BDF					
Treatment means followed by the same letter are not statistically different according to Turkey's HSD test at p = 0.05.										

The date of first observation of anthracnose symptoms was the date of the last treatment. Therefore, treatments were preventative and curative.

c. Discussion and Conclusions

Watermelons were grown in Texas. On a 0 to 5 scale (0 = no disease; 5 = more than 95% of the leaf area was damaged), the anthracnose rating was 1.38 in the untreated control.

Polyoxin D Zinc Salt 5SC Fungicide applied preventatively and curatively at 6.5 fl oz/acre (25 g a.i./ha) with a surfactant provided 82% control of anthracnose. This was statistically:

- Superior to the untreated control; and
- Equivalent to the treatment program that included chlorothalonil, mancozeb, and zoxamide and the treatment program that included *Bacillus amyloliquefaciens* str. D747 (Double Nickel) and chlorothalonil.

Yield was increased, though not statistically, by each of the treatments.

Treatment with Polyoxin D Zinc Salt 5SC Fungicide applied with a surfactant increased yield by 3.3% compared to the untreated controls. This yield increase and the yield increase resulting from the two other treatment programs were not statistically significant.

Phytotoxicity was observed in the commercial standard treatment that included chlorothalonil, mancozeb, and zoxamide. No phytotoxicity was observed in the untreated control or the other treatments.

No phytotoxicity was observed in the untreated control and from treatment with polyoxin D zinc salt plus surfactant, and with *Bacillus amyloliquefaciens* str. D747 (Double Nickel) and chlorothalonil.

Corynespora cassiicola **(TARGET SPOT) / TOMATOES**

Corynespora cassiicola **(Top Spot) / Tomato: Signs and Symptoms**
(Source: Ken Pernezny, Disease Management: Target Spot of Tomatoes, University of Florida, IFAS Extension)

On tomato leaves, target spot first appears as small, necrotic lesions with light-brown centers and dark margins. On tomato fruit, the first lesions first appear as brown, slightly sunken flecks. As lesions develop, large, pitted areas appear on fruit. Symptoms often begin deep within the tomato canopy.

Always inspect the interior of the tomato canopy for the “melting out” effect seen with target spot. This refers to the loss of foliage in the inside of the canopy which often operates to thin out the interior due to premature defoliation.

Pited fruit may appear to have been damaged by hail or other abiotic stress.

Corynespora cassiicola **(Top Spot) / Tomato: Disease Cycle and Epidemiology**
(Source: Ken Pernezny, Disease Management: Target Spot of Tomatoes, University of Florida, IFAS Extension)

Target spot is favored by moderate temperatures (70-80°F). *Corynespora cassiicola* has a wide host range, which includes cucumber, papaya and a number of ornamentals. Several common week species also serve as alternate hosts.

Corynespora cassiicola **(Top Spot) / Tomato: Cultural Controls**
(Source: Ken Pernezny, Disease Management: Target Spot of Tomatoes, University of Florida, IFAS Extension)

Destroy crop residues promptly.

Avoid over-fertilization, especially with nitrogen, as this leads to a lush growth habit, with more likelihood of significant “melting out”.

Be certain that fields are scouted thoroughly and that target spot is not misdiagnosed as bacterial spot, early blight, or other foliar diseases.

No known resistance to target spot is currently available in environmental cultivars.

Corynespora cassiicola **(Top Spot) / Tomato**: OMRI-Listed Fungicides for Use in the United States **(No efficacy data have been identified or evaluated.)**								
FRAC Code	Source: EPA Label							NOP Status
	Active Ingredient	Product Name	Product Rate/Acre	PHI (Days)	REI (Days)	EPA Reg. No.	Comments	
44	*Bacillus subtilis* str. QST 713	Serenade ASO	2-6 qt	0	4	264-1152	Broad spectrum preventative fungicidal and bactericidal product. Begin applications soon after emergence or transplant and when environmental conditions are conducive to disease development. Continue applications on 2- to 7-day intervals or as needed.	Non-synthetic
		Serenade MAX	1-3 lb	0	4	69592-11	Dermal sensitizer. Broad spectrum preventative fungicidal and bactericidal product. Begin applications soon after emergence or transplant and when environmental conditions are conducive to disease development. Continue applications on 2 to 7 day intervals or as needed.	
		Serenade Optimum	14-20 oz	0	4	264-1160		
P5	*Reynoutria sachalinensis*	Regalia Biofungicide	1-3 qt	0	4	84059-3	Causes moderate eye irritation. Preventative rather than a curative application. Apply prior to disease infestation to protect the growing leaf tissue. Avoid freezing. For ground applications, apply this product preventatively in 25–100 gallons of water per acre. Increase water volume as plant size increases. Repeat applications at 7–10-day intervals. Tank mix this product with other registered fungicides for improved disease control under heavy pressure.	Non-synthetic

Corynespora cassiicola (Target Spot) / Tomatoes: Efficacy Trials

Corynespora cassiicola (Target Spot) / Tomatoes #1: Trial No. CER-2014-095

a. Design

<table>
<tr><th colspan="5">Corynespora cassiicola (Target Spot) / Tomato #1: Trial No. CER-2014-095: Design</th></tr>
<tr><td>Title:</td><td colspan="4">Evaluation of Fungicides for the Management of Common Foliar Fungal Diseases of Tomato, Spring 2014</td></tr>
<tr><td>Authors and affiliation:</td><td colspan="4">G. E. Vallad, F. M. Aguiar, et al.
University of Florida, GDREC
Wimauma, FL 33598</td></tr>
<tr><td>Publication:</td><td colspan="4">PDMR 9:V072</td></tr>
<tr><td>Location:</td><td colspan="4">Balm, FL</td></tr>
<tr><td>Crop:</td><td colspan="4">Tomato</td></tr>
<tr><td>Pathogen and disease name:</td><td colspan="4">Alternaria tomatophila (Early blight)
Corynespora cassiicola (Target spot)</td></tr>
<tr><td>Test plot design:</td><td colspan="4">Randomized complete block</td></tr>
<tr><td>Number of replicates:</td><td colspan="4">4</td></tr>
<tr><td>Application equipment:</td><td colspan="4">High-volume tractor sprayer</td></tr>
<tr><td>Spray volume:</td><td colspan="4">60, 90, and 120 gal/acre (210 psi)</td></tr>
<tr><td>Number of applications:</td><td colspan="4">8</td></tr>
<tr><td rowspan="9">Chronology:</td><td>Application Dates</td><td>Application Interval</td><td>Disease Assessment Dates</td><td>Inoculation Date</td></tr>
<tr><td>03/20/2014</td><td></td><td>04/03/2014</td><td>03/24/2014</td></tr>
<tr><td>03/27/2014</td><td>7 days</td><td>04/11/2014</td><td></td></tr>
<tr><td>04/02/2014</td><td>6 days</td><td>04/24/2014</td><td></td></tr>
<tr><td>04/11/2014</td><td>9 days</td><td>05/08/2014</td><td></td></tr>
<tr><td>04/17/2014</td><td>6 days</td><td>05/29/2014</td><td></td></tr>
<tr><td>04/24/2014</td><td>7 days</td><td></td><td></td></tr>
<tr><td>05/01/2014</td><td>7 days</td><td></td><td></td></tr>
<tr><td>05/08/2014</td><td>7 days</td><td></td><td></td></tr>
<tr><td>Inoculants:</td><td colspan="4">10^5 spores/mL suspension:
Alternaria tomatophila (Early blight)
Corynespora cassiicola (Target spot)</td></tr>
<tr><td>Disease assessment methodology:</td><td colspan="4">The severity of foliar disease was assessed as the percentage of canopy affected. Gray leaf spot (Stemphylim solani) symptoms were observed throughout the trial and were included in the in all disease rating because it became a predominant disease along with Target Spot.
The Horsfall-Barratt scale was used for all ratings, but values were converted to mid-percentages prior to statistical analysis.</td></tr>
</table>

b. Results

Corynespora cassiicola (Target Spot) / Tomato #1: Trial No. CER-2014-095: Results								
Treatment	Rate/ Acre	g a.i./ ha	Active Ingredient	FRAC Code	Foliar Disease Severity (%) (5/8/2014)		AUDPC	
					Measured	Percent Control	Measured	Percent Control
Water treated control			Not Applicable		55.0 a		2055 a	
Oso	6.5 fl oz	25	Polyoxin D zinc salt	19	31.4 bc	42.9	1359 bc	33.9
Bravo Weatherstik	2 pt		Chlorothalonil	M5	37.5 ab	31.8	1451 b	29.4
Mettle	8 fl oz		Tetraconazole	3	31.4 bc	42.9	1352 bc	34.2
Equation	6.2 fl oz		Azoxystrobin	11	22.1 c	59.8	1070 bc	47.9
Quadris	6.2 fl oz		Azoxystrobin	11	37.5 ab	31.8	1240 bc	39.7
Priaxor	6 fl oz		Fluxapryoxad	7	37.5 ab	31.8	1328 bc	35.4
			Pyraclostrobin	11				
Endura	5 fl oz		Boscalid	7	26.6 bc	51.6	1045 bc	49.1
Quintec	6 fl oz		Quinoxyfen	13	26.3 bc	52.2	1006 c	51.0
Luna Tranquility	11 fl oz		Fluopyram	7	26.3 bc	52.2	1051 bc	48.9
			Pyrimethalin	9				
Fluopyram 500SC	6.8 fl oz		Fluopyram	7	37.5 ab	31.8	1388 bc	32.5
AUDPC = Area Under the Disease Progression Curve. Treatment means followed by the same letter are not statistically different according to Fisher's LSD test at α = 0.05.								

Target spot was first observed on April 3, 2014, *i.e.*, *before* the last 5 treatments. The treatments were therefore preventative and curative.

No phytotoxicity was observed.

c. Discussion and Conclusions

Tomatoes were grown in Florida. The tomatoes were inoculated with a 10^5 spores/mL suspension of *Alternaria tomatophila* (early blight) and *Corynespora cassiicola* (target spot) four days after the initial fungicide treatment. The maximum measured foliar disease severity was 55.0% on May 8, 2014.

Treatments of Polyoxin D Zinc Salt 5SC Fungicide were applied preventatively and curatively. Eight treatments were applied at 6-day to 9-day intervals. The mean foliar disease control for target spot (*Corynespora cassiicola*), early blight (*Alternaria tomatophila*), and gray leaf spot (*Stemphylium solani*) combined was 42.9%. Based upon the area under the disease progression curve, polyoxin D zinc salt provided 33.9% foliar disease control. The average was 38.4% foliar disease control. This was statistically:

- Superior to the water treated control.
- Equivalent to all other treatments comprised of 9 different conventional active ingredients and 6 different modes of action.

Corynespora cassiicola **(Target Spot) / Tomatoes: Grower Need**

Control of target spot on tomatoes (Project No. B00128) was identified as a grower need at the IR-4 2015 Biopesticide Workshop.

Didymella bryoniae (GUMMY STEM BLIGHT) / CUCURBITS

Didymella bryoniae (Gummy Stem Blight) / Cucurbits: Host Range

(Source: Newark, M., Paret, M.L., *et al.*, Management of Gummy Stem Blight (Black Rot) on Cucurbits in Florida, Univ. of Florida Extension, August 2014.)

Gummy stem blight (GSB) is a major disease of many cucurbits, including watermelon, cantaloupe, cucumber, pumpkin, squash, muskmelon, and other melons. The fungus, *Didymella bryoniae,* is the causal organism for this disease. Infection on watermelon and cantaloupe is commonly seen in Florida, and the disease can cause significant production losses when conditions are ideal for the spread of this fungal pathogen. The disease is also known as black rot due to its characteristic appearance on infected fruits.

Didymella bryoniae (Gummy Stem Blight) / Cucurbits: Symptoms

(Source: Newark, M., Paret, M.L., *et al.*, Management of Gummy Stem Blight (Black Rot) on Cucurbits in Florida, Univ. of Florida Extension, August 2014.)

Cucurbit plants can become infected with *Didymella bryoniae* at any growth stage of the plant, from seedling to mature vine with fruit. Infection signs and symptoms can be seen on all parts of the plant except for the roots. Yellowing of the leaf margins (chlorosis) is an early symptom on the plant, and light-brown to dark-brown spots (necrosis) can appear on the seed leaves (cotyledons). These symptoms are often visible before and after transplanting in the field. Prior to the occurrence of chlorosis or necrosis, the same tissue may appear water soaked. Wilting, followed by death of the transplants, can occur.

Lesions can also form on the stem that enlarge and girdle the main stem. Cracking is often visible on the stem, accompanied by gummy ooze. Cankers develop on the stem that can be red, brown, or black in color, and a red to amber gummy substance can exude from this region. Pycnidia swell and release tendrils of spores if the tissue is wetted in water. This is easily observed with the use of a hand lens or microscope. Large, brown lesions from severe infections can form on areas of the leaves that retain moisture for long periods of time, such as around veins or leaf margins. Vine wilting symptoms are usually not observed until later in the infection cycle, typically a period of three to four weeks after infection.

Fruit rot in watermelon is only a problem if the vines are severely infected with gummy stem blight. Lesions on fruits of cucumber, muskmelon, and watermelon are first oval to circular and greasy green in color. The lesions subsequently merge and become brownish-black in color. Hence, the disease is also known as black rot. These lesions appear depressed in the center. Internally, the rind becomes dark brown to black and cracked. Butternut squash fruit can be infected with the vines being healthy. A lesion, dark yellow to brown in color and crusty in appearance, occurs on large areas of the butternut squash.

Didymella bryoniae (Gummy Stem Blight) / Cucurbits: Causal Agent and Disease Spread

(Source: Newark, M., Paret, M.L., *et al.*, Management of Gummy Stem Blight (Black Rot) on Cucurbits in Florida, Univ. of Florida Extension, August 2014.)

Didymella bryoniae (anamorph is *Phoma cucurbitacearum)* is an ascomycete fungus that can survive on seeds, weeds (citron, balsam pear, and other volunteer cucurbits), and plant debris from previously infected cucurbits. The fungus produces two spore stages, a sexually produced spore (perithecia giving rise to ascospores) and an asexually produced spore (pycnidia giving rise to conidia). Perithecia and pycnidia can be found embedded in the same lesion. Ascospores serve as the primary inoculum and are readily spread from field to field by wind. Conidia are released in a gummy substance and are therefore more adapted for short-distance movement through splashing water, which leads to secondary spread of the disease. Dark pseudothecia may also form, especially on stems, but are rarely seen.

Moisture and temperature play an important role in germination, sporulation, colonization of conidia into the plant tissue, and symptom development. The optimum conditions for the infection process are temperatures ranging from 61°F–75°F and a moisture level of 85% relative humidity caused by consistent leaf wetness for 1–10 hours. Nighttime temperature and moisture conditions prevalent in Florida are ideal for GSB infection during much of the crop-growing season. After spore germination on a susceptible host tissue, symptoms can appear in 7–12 days. Wounding of host tissue by mechanical injury, feeding by aphids and striped cucumber beetles, and infections from other diseases, including powdery mildew (caused by *Sphaerotheca fuliginea*), may provide entry sites for the GSB pathogen. Harvest points on fruits can also be a point of entry for the pathogen, leading to post-harvest decay.

Didymella bryoniae **(Gummy Stem Blight) / Cucurbits: Disease Management**
(Source: Newark, M., Paret, M.L., *et al.*, Management of Gummy Stem Blight (Black Rot) on Cucurbits in Florida, Univ. of Florida Extension, August 2014.)

A sequence of management plans must be initiated to control gummy stem blight (GSB):

1. Seed: One source of GSB inoculum is the seed. Purchase seeds from reputable companies with a good history of GSB-free seed production. Seeds from healthy fruits are free of GSB. Remember: Seeds can be infested without expressing symptoms. Seed treatment is necessary if not previously treated, and disinfectants as solutions are more effective than dry-dust treatments. GSB-resistant varieties are not available in any cucurbits.

2. Transplants: GSB is common at the seedling stage and displays one or more of the characteristic symptoms (necrotic areas on the margin of the leaves, water-soaked regions on the stem, gummy ooze from the stem). Growers should regularly inspect transplant seedlings in the greenhouses. Whenever possible, avoid using healthy-looking seedlings from trays with infected plants.

3. Organic debris: Another source of primary inoculum is organic debris from previous cucurbit crops. As soon as a cucurbit crop is harvested (especially crops with GSB inoculum), the decaying debris from that crop should be disked and deep plowed into the soil if it is to be followed by a long-term crop rotation practice.

4. Volunteer plants: Wild citrons, balsam pear, or volunteer cucurbits are other sources of inoculum and should be eradicated before planting cucurbits.

5. Crop rotation: Fields should not be cultivated with cucurbits routinely, and rotation with a non-cucurbit crop is important. A two-year to three-year rotation with non-hosts is an effective way to reduce incidence of GSB.

6. Scouting: Routine scouting of the fields helps in timely application of fungicides that can prevent major crop losses.

7. Biological control and biopesticides: The effectiveness of bio-control agents currently available in the market is heavily dependent upon environmental conditions at the time of application and therefore has demonstrated minimal success against GSB.

8. Fungicide application: Apply fungicides in a preventative manner. If weather conditions are conducive for the occurrence and rapid spread of GSB, fungicide application should start during the early stages of plant growth. To prevent development of fungicide resistance, various chemistries should be alternated during the spray program.

9. Storage: GSB infection can also occur on the fruit. Avoid wounding fruits during harvest. Store fruits at 45°F–50°F to prevent post-harvest black rot.

Didymella bryoniae (Gummy Stem Blight) / Cucurbits: OMRI-Listed Fungicides for Use in the United States									
FRAC Code	Source: Newark, M., Paret, M.L., *et al.*, Management of Gummy Stem Blight (Black Rot) on Cucurbits in Florida, Univ. of Florida Extension, August 2014.			Source: EPA Label					
	Active Ingredient	Product Name	Comments	EPA Reg. No.	Product Rate/Acre	PHI (Days)	REI (Hrs)	Comments	NOP Status
44	*Bacillus subtilis* QST 713	Serenade ASO	Do not use product alone. Apply with registered fungicide.	264-1152	2-6 qt	0	4	Broad spectrum preventative fungicidal and bactericidal product.	Non-synthetic
		Serenade Max		69592-11	1-3 lb	0	4	Dermal sensitizer. Broad spectrum preventative fungicidal and bactericidal product.	
		Rhapsody ASO		246-1155	2-8 qt/ 100 gal	0	4	Harmful if inhaled. Broad spectrum, preventative product for the control or suppression of many important plant diseases.	
P5	*Reynoutria sachalinensis*	Regalia Biofungicide		84059-3	1% v/v in water	0	4	Causes moderate eye irritation. Preventative rather than a curative application. Apply prior to disease infestation to protect the growing leaf tissue. Avoid freezing.	Non-synthetic
Not classified; Oxidizing agent	Hydrogen dioxide	Oxidate 2.0		70299-2	0.5 - 1 gal/ 100 gal water	0	Until dry	DANGER signal word. Causes irreversible eye damage. May be fatal if swallowed. Causes skin irritation or temporary discoloration of exposed skin. Highly toxic to bees and other beneficial insects. Toxic to fish. Toxic to birds who eat treated seed on soil surface. Strong oxidizing agent. Do not use in undiluted form. Never bring undiluted product in contact with other pesticides, cleaners or oxidative agents. May react with residues of metal-based fungicides or supplements. Allow at least 24 hrs. after application of metal-based products. Do not spray during conditions of intense heat, drought, or poor plant vigor (or vine canopy). Do not apply in conjunction with any other pesticides or fertilizers. Do not allow product to become overheated in storage. Do not store in a manner where cross-contamination with other pesticides or fertilizers could occur. Do no apply during intense heat, drought, or pood canopy cover. Apply consecutive applications until control is achieved; then apply preventative treatments.	Synthetic

Didymella bryoniae **(Gummy Stem Blight) / Cucurbits: Efficacy Trials**

Didymella bryoniae (Gummy Stem Blight) / Cantaloupe #1: Trial No. IND-2012-125

a. Design

Didymella bryoniae (Gummy Stem Blight) / Cantaloupe #1: Trial No. IND-2012-125: Design	
Title:	Greenhouse Evaluation of Biopesticides for Control of Gummy Stem Blight
Authors and affiliation:	Anthony P. Keinath and Virginia B. DuBose Clemson University, Coastal Research and Education Center Charleston, South Carolina, USA
Publication:	Submitted for publication in Plant Health Progress
Location:	Charleston, South Carolina, USA (greenhouse)
Crop:	Cantaloupe
Disease name:	Gummy Stem Blight
Pathogen:	*Didymella bryoniae*
Test plot design:	Randomized complete block
Number of replicates:	4
Application equipment:	Foliar spray
Spray solution volume:	100 gal/acre (935 L/ha)
Number of applications:	1
Chronology:	
Day 1	Application. Phytotoxicity evaluation.
Day 2	Inoculation. Immediately put in a chamber with 100% humidity.
Day 3	Phytotoxicity evaluation.
Day 5	Evaluation of disease incidence and severity
Day 7	Phytotoxicity evaluation.
Inoculant:	Obtained from a commercial watermelon field in South Carolina. 10^6 spores/mL.
Application growth stage:	Seedlings with 2 true leaves.

b. Results

Didymella bryoniae (Gummy Stem Blight) / Cantaloupe #1: Trial No. IND-2012-125: Results									
Treatment	Rate/ acre	g a.i./ ha	Active Ingredient		Gummy Stem Blight on Field Grown Cantaloupe				Phyto-toxicity
			Common Name	Conc.	Incidence		Severity		
					Percent	Percent Control	Percent	Percent Control	
Water, Inoculated control	NA		None	NA	100.0 a	0	21.5 a	0	None
CX 10440	14 fl oz	54	Polyoxin D zinc salt	5%	23.3 d	76.7	0.7 cd	96.7	None
JMS Stylet Oil	6 qt		Paraffinic oil	97%	100.0 a	0	19.7 a	8.4	None
Organocide	2 gal		Edible fish oil	92%	100.0 a	0	6.1 b	71.6	Injury
			Sesame oil	5%					
Oxidate	1 gal		Hydrogen dioxide	27%	99.4 ab	0.6	14.0 a	34.9	None
			Peroxyacetic acid	2.0%					
Serenade ASO	6 qt		Bacillus subtilis QST713 strain	1.34%	85.9 bc	14.1	2.7 bc	87.4	None
Regalia	1 gal		*Reynoutria sachalinensis* root extract	5%	73.0 c	27.0	2.7 bc	87.4	None
Mazate Pro-Stick	2-3 lb (Note A)		Mancozeb 75 DG	75%	11.8 d	88.2	0.1 d	99.5	None
Amicarb 100	5 lb		Potassium bicarbonate	85%	NA	NA	NA	NA	Injury
Water, Non-inoculated control	NA		None	NA	0.0 e		0.0 d		None

Means within a column with the same letter do not differ based on t-tests of least-square means, P = 0.01.
NA = Not available due to phytotoxicity.
A. Mancozeb was applied at 3 lb/100 gal in trial one and at 2 lb/100 gal in trial 2. There were no differences between the two rates.

The cantaloupe plants were inoculated on Day 2, *i.e.*, one day after the single fungicide treatments. Therefore, the treatments were preventative.

c. Discussion and Conclusions

Cantaloupe seedlings were treated in a greenhouse. Gummy stem blight incidence was 100% in the inoculated water control.

A single application of Polyoxin D Zinc Salt 5SC Fungicide was applied preventatively to cantaloupe at 14 fl oz/acre (54 g a.i./ha). This provided mean 86.7% (range 76.7% to 96.7%) control of gummy stem blight. This was statistically:

1. Superior to the untreated control and to the control provided by paraffinic oil, edible fish oil plus sesame oil, hydrogen dioxide plus peroxyacetic acid, Bacillus *subtilis* QST713 strain (Serenade ASO) and *Reynoutria sachalinensis* root extract (Regalia), each of which are approved for use in organic crop production; and
2. Equivalent to the control provided by Mancozeb.

Two alternative treatments provided *no control* of gummy stem blight:

- Paraffinic oil (JMS Stylet Oil); and
- Edible fish oil plus sesame oil (Organocide).

JMS Stylet Oil is registered for gummy stem blight control on melons. Organocide is not registered for gummy stem blight control.

Use of polyoxin D zinc salt resulted in no phytotoxicity. Phytotoxicity was observed for two alternative treatments, *i.e.*:

- Edible fish oil plus sesame oil (Organocide); and
- Potassium bicarbonate (Amicarb 100).

Didymella bryoniae (Gummy Stem Blight) / Cucumber #1: Trial No. BCGGA-2015-02

a. Design

Didymella bryoniae (Gummy Stem Blight) / Cucumber #1: Trial No. BCGGA-2015-02: Design			
Title:	Polyoxin D for Greenhouse Cucumber Integrated Disease Management		
Authors and affiliation:	Janice F. Elmhirst, J. Hayes, *et al.* Elmhirst Diagnostics and Research Abbotsford, BC V4X 1T6, Canada		
Publication:	Canadian Journal Plant Pathology, Vol. 38: No. 1, 2016, p. 134-137.		
Location:	Greenhouse Kwantlen Polytechnic University, Langley BC V3A 8G6, Canada		
Crop:	Cucumber (*Cucumis sativus* L.) cv. 'Jawell' (mini-cucumber)		
Disease name:	Gummy stem blight		
Pathogen:	*Didymella bryoniae* (Funkel) Rehm (1881)		
Test plot design:	Randomized complete block		
Number of replicates:	4		
Application equipment:	CO_2 backpack sprayer (28 psi)		
Spray volume:	1000 L/ha		
Number of applications at 7-day intervals:	4 (0.3, 0.5, and 1.0 L/ha)		
Number of applications at 14-day intervals:	2 (1.0 and 1.5 L/ha)		
Chronology:	Application Dates	Inoculation Dates	Disease Assessment Dates
	06/01/2015 06/08/2015 06/15/2015 06/22/2015	06/02/2015 06/24/2015	06/04/2015 06/08/2015 06/15/2015 06/22/2015 06/29/2015 07/06/2015 07/13/2015
Statistical analysis:	A minimum of 2 different statistical tests were used.		

b. Results

Didymella bryoniae (Gummy Stem Blight) / Cucumber #1: Trial No. BCGGA-2015-02: Disease Severity Results										
Treatment	No. Apps & Interval	Rate/ Acre	Rate/ ha	g a.i./ ha	Active Ingredient	FRAC Code	Mean Incidence (AUDPC)		Mean Severity (AUDPC)	
							Measured	% Control	Measured	% Control
Water, inoculated control	4 at 7 days	NA	NA	NA	Not Applicable		540.6 ± 47.4 a (a)	NA	319.2 ± 95.3 a (a)	NA
Polyoxin D 5SC	4 at 7 days	4.1 fl oz	0.3 L	15	Polyoxin D zinc salt	19	454.9 ± 69.6 b (b)	15.9	138.2 ± 84.2 b (b)	56.7
Polyoxin D 5SC	4 at 7 days	6.8 fl oz	0.5 L	25	Polyoxin D zinc salt	19	431.2 ± 67.8 b (b)	20.2	100.4 ± 53.8 c (bc)	68.5
Polyoxin D 5SC	4 at 7 days	13.7 fl oz	1.0 L	50	Polyoxin D zinc salt	19	338.0 ± 62.1 c (cd)	37.5	49.4 ± 33.5 d (cd)	84.5
Polyoxin D 5SC	2 at 14 days	13.7 fl oz	1.0 L	50	Polyoxin D zinc salt	19	342.1 ± 62.1 c (cd)	36.7	48.8 ± 19.1 d (cd)	84.7
Polyoxin D 5SC	2 at 14 days	20.5 fl oz	1.5 L	75	Polyoxin D zinc salt	19	363.2 ± 65.4 c (c)	32.8	47.8 ± 30.2 d (cd)	85.0
Pristine WDG, followed by	1 at 14 days		1.3 kg		Boscalid	7	294.3 ± 41.9 d (d)	45.6	32.7 ± 17.6 d (d)	89.8
					Pyraclostrobin	11				
Nova 40W	1 at 14 days		340 g		Myclobutanil	3				
Incidence = Number of leaves with necrotic spots divided by the total number of expanded leaves per plant. Severity = Percentage of leaf necrotic area per plant. AUDPC = Area Under the Disease Progression Curve. Treatment means followed by the same letter are not statistically different according to Duncan's MRT or (Tukey's HSD) at P = 0.05.										

Didymella bryoniae (Gummy Stem Blight) / Cucumber #1: Trial No. BCGGA-2015-02: Crop Yield Results								
Treatment	No. Apps & Interval	Rate/ Acre	Rate/ ha	g a.i./ ha	Active Ingredient	FRAC Code	Marketable Fruit	
							Mean No.	Mean Wt.
Water, inoculated control	4 at 7 days	NA	NA	NA	Not Applicable		103.2 ± 20.5 b (b) [b] --	6321.2 ± 1387.4 b (b) [a] --
Polyoxin D 5SC	4 at 7 days	4.1 fl oz	0.3 L	15	Polyoxin D zinc salt	19	123.2 ± 3.0 a (a) [ab] +16.2%	7298.8 ± 442.5 ab (ab) [a] +13.4%
Polyoxin D 5SC	4 at 7 days	6.8 fl oz	0.5 L	25	Polyoxin D zinc salt	19	120.0 ± 14.4 ab (ab) [ab] +14.0%	7561.5 ± 1170.2 a (a) [a] +16.4%
Polyoxin D 5SC	4 at 7 days	13.7 fl oz	1.0 L	50	Polyoxin D zinc salt	19	129.2 ± 14.4 a (a) [ab] +20.1%	7950.2 ± 1195.6 a (a) [a] +20.5%
Polyoxin D 5SC	2 at 14 days	13.7 fl oz	1.0 L	50	Polyoxin D zinc salt	19	121.0 ± 20.0 ab (ab) [ab] +14.7%	7608.4 ± 1698.8 a (a) [a] +16.9%
Polyoxin D 5SC	2 at 14 days	20.5 fl oz	1.5 L	75	Polyoxin D zinc salt	19	132.0 ± 6.2 a (a) [a] +21.8%	8083.2 ± 461.9 a (a) [a] +21.9%
Pristine WDG, followed by	1 at 14 days		1.3 kg		Boscalid	7	131.0 ± 10.4 a (a) [ab] 21.2%	8098.5 ± 769.7 a (a) [a] +21.9%
					Pyraclostrobin	11		
Nova 40W	1 at 14 days		340 g		Myclobutanil	3		
Treatment means followed by the same letter are not statistically different according in LSD, or (Duncan's MRT), or [Tukey's HSD] at P = 0.05.								

The first inoculation date was one day after the first of four application dates. Therefore, the treatments are preventative and curative.

No phytotoxicity was observed.

c. Discussion and Conclusions

Disease Control
Four-week old mini-cucumber plants that were flowering and fruiting were treated foliarly. Four treatments were applied every 7 days, or a total of 2 treatments were applied every 14 days. The plants were inoculated with approximately 1.6 x 10^5 cfu/mL *Didymella bryoniae* (gummy stem blight) one day after the first treatment and again 29 days after the first treatments (2 days after the forth treatment at 7-day intervals). Pest pressure was high (79.4% diseased leaves per plant at the first assessment in the water control and as high as 90.8% diseased leaves per plant in the water control). The first treatments were preventative (one day before inoculation); later treatments were curative.

Polyoxin D Zinc Salt 5SC Fungicide provided greater than 84% control of severity of gummy stem blight (percentage of leaf necrotic area per plant) when applied:

1. Four times at 7-day intervals at 13.7 fl oz /acre (50 g a.i./ha); and
2. Two times at 14-day intervals at 13.7 fl oz /acre (50 g a.i./ha).

This control of gummy stem blight severity was statistically equivalent to that provided by Pristine WDG followed by Nova 40W.

Lower Polyoxin D Zinc Salt 5SC Fungicide application rates, *i.e.*, 4.1 fl oz/acre (15 g a.i/ha) and 6.8 fl oz/acre (25 g a.i./ha) provided lower control of gummy stem blight severity, *i.e.*, 56.7% and 68.5%, respectively. However, the 6.8 fl oz/acre (25 g a.i./ha) rate and higher rates provided statistically equivalent control of severity.

Increasing the application rate to 20.5 fl oz/acre (75 g a.i./ha) did not significantly increase the efficacy of Polyoxin D Zinc Salt 5SC Fungicide.

The statistical comparisons for gummy stem blight incidence were similar to those of gummy stem blight severity, though the magnitude of reductions in incidence were lower (15.9% to 32.8%). Polyoxin D Zinc Salt 5SC Fungicide reduced the incidence of gummy stem blight (number of leaves with necrotic spots divided by the total number of expanded leaves) compared to the water control. Treatment with 13.7 fl oz Polyoxin D Zinc Salt 5SC Fungicide/acre (50 g a.i./ha) provided the greatest percent incidence control (37.5% and 36.7%). This was statistically equivalent to the percent incidence control provided by Pristine WDG followed by Nova 40W.

Yield
Compared to the water control, all treatments with Polyoxin D Zinc Salt 5SC Fungicide resulted in an increased mean number of marketable fruit and an increased mean weight of marketable fruit. The increases were very similar to those observed for treatment with Pristine WDG followed by treatment with NOVA 40W.

Compared to the control, all treatments with Polyoxin D Zinc Salt 5SC fungicide resulted in an increased mean number of marketable fruit (14.0% to 21.8%) and an increased mean weight of marketable fruit (13.4% to 21.9%). The increases were statistically equivalent to those observed for treatment with Pristine WDG followed by treatment with NOVA 40W.

No phytotoxicity was observed.

d. Grower Need
This study was sponsored by the British Columbia Greenhouse Growers Association to address the need of British Columbian greenhouse growers for fungicides to control *Didymella bryoniae* (gummy stem blight) on greenhouse grown cucumbers.

Didymella bryoniae (Gummy Stem Blight) / Watermelon #1: Trial No. CER-2011-028

a. Design

Didymella bryoniae (Gummy Stem Blight)/ Watermelon #1: Trial No. CER-2011-028: Design				
Title:	Evaluation of Fungicide Programs that Include Chlorothalonil Against Gummy Stem Blight on Watermelon, 2011			
Authors and affiliation:	A. P. Keinath, V. B. DuBose, and J.A. Dufault Clemson University, Coastal Research and Education Center Charleston, South Carolina, USA			
Publication:	PDMR 6:V023			
Location:	Charleston, South Carolina, USA (field)			
Crop:	Watermelon			
Disease name:	Gummy stem blight			
Pathogen:	*Didymella bryoniae*			
Test plot design:	Randomized complete block			
Number of replicates:	4			
Application equipment:	Foliar spray			
Spray volume:	Not reported			
Inoculant:	10^6 spores/0.03 fl oz of two pyrostrobin- and boscalid-insensitive isolates of *Didymella bryoniae*			
Number of applications:	7			
Application interval:	7 to 12 days			
Chronology:	08/15/2011	Transplanted	10/03/2011	Disease severity rating
	09/01/2011	Application A	10/06/2011	Application E
	09/05/2011	Inoculated	10/11/2011	Disease severity rating
	09/08/2011	Application B	10/13/2011	Application F
	09/15/2011	Application C	10/18/2011	Disease severity rating
	09/19/2011	Disease severity rating	10/20/2011	Harvest
	09/22/2011	Inoculated	10/21/2011	Application G
	09/26/2011	Disease severity rating	10/24/2011	Disease severity rating
	09/27/2011	Application D	10/31/2011	Disease severity rating
			11/01/2011	Harvest

b. Results

Didymella bryoniae (Gummy Stem Blight) / Watermelon #1: Trial No. CER-2011-028 : Results											
Treatment	Rate/ acre	g a.i./ ha	Active Ingredient	FRAC Code	Gummy Stem Blight Disease Severity						Control (%)
					10/3	10/11	10/18	10/24	10/31	AUDPC	
Water control					6.5	37.5 a	92.0 a	96.8 a	99.9 a	1227 a	
CX-10440 [1]	7 fl oz	27	Polyoxin D zinc salt	19	5.3	23.1 b	60.3 b	85.1 a	96.9 ab	815 ab	33.6
CX-10440 [1]	14 fl oz	54	Polyoxin D zinc salt	19	3.1	8.3 c	30.0 c	60.3 b	86.7 bc	460 bc	62.5
Catamaran 5.27SC	5 pt		Chlorothalonil	M5	3.1	8.3 c	25.2 cd	44.9 bc	79.1 cd	385 cd	68.6
			Potassium phosphite	NA							
Bravo Weather Stik 6SC	2 pt		Chlorothalonil	M5	2.3	6.7 c	21.0 cde	42.0 bc	70.0 def	315 cde	74.3

AUDPC = Area Under the Disease Progress Curve.
Control (%) = [(AUDPC untreated control - AUDPC treated) x 100] / (AUDPC untreated control).
Means followed by the same letter(s) are not significantly different. (Statistical test and criteria are not specified.)
NA = Not assigned.
1. CX-10440 is the Certis USA, L.L.C. code for Polyoxin D Zinc Salt 5SC Fungicide.

The first inoculation date was 4 days after the first of 7 treatment dates. Therefore, the treatments were preventative and curative.

No phytotoxicity was reported.

c. Discussion and Conclusions

Watermelons were grown in South Carolina. Gummy stem blight severity was greater than 92.0% at the time of the last three applications and reached 99.9% by the last application on October 31, 2011.

Polyoxin D Zinc Salt 5SC Fungicide treatments were applied preventatively and curatively to watermelon. A total of 7 applications were applied at 7-day to 12-day intervals.

Polyoxin D Zinc Salt 5SC Fungicide treatments had a positive dose-response.

- Treatments at 7 fl oz/acre (27 g a.i./ha) provided 33.6% season-long control.
- Treatments at 14 fl oz/acre (54 g a.i./ha) provided 62.5% season-long control.

Polyoxin D Zinc Salt 5SC Fungicide applied at 14 fl oz/ace (54 g a.i./ha) provided season-long control that was statistically:

- Superior to the untreated control; and
- Equivalent to that provided by Polyoxin D Zinc Salt 5SC Fungicide applied at 7 fl oz/ace (27 g a.i./ha) and by chlorothalonil plus potassium phosphite and by chlorothalonil only.

No phytotoxicity was reported.

Didymella bryoniae (Gummy Stem Blight) / Watermelon #2: Trial No. CER-2012-051

a. Design

Didymella bryoniae (Gummy Stem Blight) / Watermelon #2: Trial No. CER-2012-051: Design				
Title:	Evaluation of Fungicide Sprays on Gummy Stem Blight of Watermelon in Georgia, 2012			
Authors and affiliation:	F. H. Sanders, Jr. and D. B. Langston, Jr. University of Georgia Coop. Ext. Service Dept. of Plant Pathology, Tifton, Georgia, USA			
Publication:	Submitted for publication in Plant Health Congress			
Location:	Tifton, Georgia, USA (field)			
Crop:	Watermelons			
Disease name:	Gummy stem blight			
Pathogen:	*Didymella bryoniae*			
Test plot design:	Randomized complete block			
Number of replicates:	5			
Application equipment:	Foliar spray			
Spray volume:	25 gal/acre (234 L/ha)			
Inoculant:	Inoculated (1 x 10 ^{3} suspension, units not specified)			
Number of applications:	7			
Chronology:	Inoculation Date	Transplant Date	Application Dates	Application Intervals
	5/31/2012	6/01/2012	6/19/2012	
			6/28/2012	9 days
			7/05/2012	7 days
			7/10/2012	5 days
			7/17/2012	7 days
			7/24/2012	7 days
			7/31/2012	7 days

b. Results

Didymella bryoniae (Gummy Stem Blight) / Watermelon #2: Trial No. CER-2012-051: Results									
Treatment	Rate/acre	g a.i./ha	Active Ingredient	FRAC Code	Gummy Stem Blight Percent Severity (Note A)			AUDPC (Note B)	Percent Control (Note C)
					7/17	7/24	7/31		
Untreated control					23.0 a	49.0 a	85.0 a	721.0 a	
CX-10440 [1]	6.5 fl oz	25	Polyoxin D zinc salt	19	11.0 b-e	35.0 bc	72.0 bcd	535.5 bc	25.7
CX-10440 [1]	13.0 fl oz	50	Polyoxin D zinc salt	19	6.0 d-g	34.0 c	69.0 cde	500.5 cd	30.6
Pristine 38 G	18.5 oz		Boscalid	7	2.60 j	20.0 ef	56.0 f	345.1 fg	52.1
			Pyraclostrobin	11					

A. 0 = 0% leaf area affected. 50 = 50% leaf area affected. 100 = 100% leaf area affected.
B. AUDPC = Area Under the Disease Progress Curve calculated from rating taken on July 17, July 24, and July 31.
C. Percent Control = [(AUDPC untreated control - AUDPC treated) x 100] / (AUDPC untreated control).
Means followed by the same letter(s) are not significantly different according to Fisher's protected LSD test at $P \leq 0.05$.
1. CX-10440 is the Certis USA, L.L.C. code for Polyoxin D Zinc Salt 5SC Fungicide.

No phytotoxicity was observed.

c. Discussion and Conclusions

Watermelons were grown in South Carolina. The crop was inoculated with *Didymella bryoniae* (gummy stem blight pathogen) 20 days before the first fungicide treatments were applied. The maximum gummy stem blight severity was 85%.

A total of 7 treatments of Polyoxin D Zinc Salt 5SC Fungicide were applied curatively to watermelon at 5-day to 9-day intervals. There was a small positive dose-response.

- Treatment at 6.5 fl oz/acre (25 g a.i./ha) provided 25.7% season-long control.
- Treatment at 13.0 fl oz/acre (25 g a.i./ha) provided 30.6% season-long control.

At both application rates, Polyoxin D Zinc Salt 5SC Fungicide provided control of gummy stem blight that was statistically:

- Superior to the untreated control; and
- Less than the control provided by boscalid plus pyraclostrobin.

No phytotoxicity was observed.

***Didymella bryoniae* (Gummy Stem Blight) / Cucurbits: Grower Need**

Pesticidal products with a zero-day PHI for use on greenhouse grown vegetables were identified as a grower need (Project No. B00024) at the 2015 IR-4 Biopesticide Workshop.

Erisyphe necator (POWDERY MILDEW) / GRAPES

Erisyphe necator (Powdery Mildew) / Grapes: Disease Description

(Source: 2015 Organic Production and IPM Guide for Grapes, Cornell Univ. Cooperative Extension)

Powdery mildew is a fungal disease that affects all green tissues. Diseased tissues appear to be covered with a white to grayish-white powder. Severe leaf infection can result in cupping and drying of leaves and premature leaf drop. Infected berries may fail to ripen properly; remain covered with a dusty mass of the fungus; turn dark brown; and/or shrivel and split, depending on the time and severity of infection. Fruit infection may promote growth of spoilage microorganisms and reduce wine quality on grapes intended for that use, even when symptoms are relatively mild.

The powdery mildew fungus overwinters on the bark of the vine as tiny black fruiting bodies ("cleistothecia"). Spores ("ascospores") contained in the cleistothecia are released during rains of approximately 1/10-inch or more, from bud break until shortly after bloom. They are wind-dispersed to young leaves and clusters, and can infect wet or dry tissue at temperatures of 50°F or higher. These primary mildew colonies produce masses of white, powdery secondary spores ("conidia"). Conidia are wind-dispersed throughout the vineyard. They do not require rain for release or infection, although humid conditions particularly favor disease development. New colonies that result from these secondary infections produce additional conidia, which can continue to spread the disease.

This repeating cycle of infection, spore production, spore dispersal, and re-infection continues throughout the season if susceptible tissue is present. The rate that is driven by temperature. Thus, at optimum temperatures in the mid-60s to mid-80s (°F), a new generation of the fungus can multiply every 5–7 days, resulting in an epidemic of powdery mildew unless it is managed efficiently. Disease development also is strongly favored by high humidity and cloudy weather. Therefore, management programs may need to be intensified (*e.g.*, shorter spray intervals, higher fungicide rates, more effective materials) during periods when such conditions occur. Conversely, the harmful impact of sunlight on the powdery mildew fungus can be exploited by pruning and training practices that promote good light exposure throughout the canopy, thereby utilizing this natural "fungicide" to help manage the disease.

Berries are highly susceptible to infection from the immediate prebloom stage until about two to three weeks after fruit set. Severe fruit damage observed later in the season almost always is the result of infections that occurred during this peak period of susceptibility. Berries of Concord become almost completely resistant to infection after this time (about 1/4-inch diameter fruit). Concord rachises remain susceptible until harvest, but the economic importance of mid- or late-summer rachis infections on processing fruit is questionable. On berries of Vinifera and certain hybrid varieties, infections can continue to occur until bunch closure or slightly thereafter. Such midsummer infection usually results in the development of sparse, inconspicuous infections that can be especially important as entry points for Botrytis and sour rot organisms that become apparent at harvest, or for spoilage microorganisms (*e.g.*, *Brettanomyces*) that reduce wine quality.

Leaf infections that occur beyond the fruit set period are much less serious on Concord and similar varieties than on Vinifera and susceptible hybrids. On low to moderately cropped Concord vines, such infections appear to have relatively little effect on yield and Brix levels. However, on more heavily cropped Concord vines they can suppress both Brix levels and yield, particularly in years with poor ripening conditions. Thus, on this variety, the need for fungicide sprays after fruit set should be heavily influenced by both crop size and weather factors. On Vinifera and highly susceptible hybrid varieties, continued suppression of foliar mildew is required throughout the summer to avoid poor ripening, premature defoliation, and reduced winter hardiness.

***Erisyphe necator* (Powdery Mildew) / Grapes: Disease Management**
(Source: 2015 Organic Production and IPM Guide for Grapes, Cornell Univ. Cooperative Extension)

Good management of leaf infections throughout the season significantly reduces disease pressure the following year by limiting the number of cleistothecia (fungal fruiting structures) that form, overwinter, and initiate infection in the spring. Limiting the level of overwintering inoculum has been shown to have a particularly positive impact on the control of cluster infections the following season.

To protect against powdery mildew infections of the fruit, management programs should be at their peak from just before bloom through fruit set, emphasizing the use of effective fungicides, full rates, appropriate spray intervals, and superior spray coverage (every row, proper speed, sufficient gallonage). The risk of berry infection is particularly high when days and nights remain warm during this period and/or weather is cloudy and wet, and spray programs may need to be especially "tight" under these circumstances. Protection of Concord berries is not required after fruit are 1/4-inch in diameter, although continued foliar protection may be beneficial under high-crop-load or poor-ripening conditions. For Vinifera and susceptible hybrids, it is important to maintain excellent protection of the clusters through the bunch closure period because powdery mildew infections at this time can promote the later development of bunch rots and/or wine spoilage.

Maintenance programs to protect foliage throughout the summer are necessary for attaining maximum fruit and vine quality on Vinifera and susceptible hybrid varieties. In years or locations where several weeks may elapse between harvest and frost, additional post-harvest protection of the foliage may benefit vines of highly susceptible Vinifera varieties, especially if disease is active in the vineyard and the weather is reasonably warm.

Erisyphe necator (Powdery Mildew) / Grapes: Management Options (Source: 2015 Organic Production and IPM Guide for Grapes, Cornell Univ. Cooperative Extension)	
Scouting/Thresholds	Scout foliage shortly before bloom and apply eradicative fungicide if disease is observed. Continue to scout foliage and young berries soon after fruit set and apply eradicative fungicide if disease is observed.
Slightly susceptible varieties	Canadice, Cayuga White, Corot noir, Ives, Melody, Noiret, Steuben, and Traminette.
Cultural management	• <u>Canopy management</u>. Prune and train the vines to maximize sunlight exposure, promote air circulation, reduce humidity, and speed drying of the leaves and clusters. • <u>Vineyard management</u>. Orient rows to maximize sunlight exposure and reduce humidity within the vineyard. Avoid sites prone to fog or heavily wooded areas. On highly susceptible varieties, thinning or removing leaves around clusters soon after fruit set will help to control this disease by exposing them to sunlight and, furthermore, will improve spray coverage of the fruit.
Chemical treatment	Unlike other fungal diseases of grapes, the powdery mildew fungus lives almost entirely on the *outside* of diseased tissues. Therefore, it is sensitive to topical applications of many products—oils, potassium salts (*e.g.*, Kaligreen, Milstop), hydrogen dioxide (Oxidate), etc.—that have no effect on other diseases, whose causal fungi live *within* diseased tissues, where they are protected from these materials. (This is also the likely reason that sulfur is so much more effective against powdery mildew than any other disease). With the exception of sulfur, these other materials have relatively little residual activity, and must be reapplied frequently, even if it does not rain. Sulfur washes off in rains and must be reapplied frequently in wet weather, but persists during dry periods.

Erisyphe necator (Powdery Mildew) / Grapes: OMRI-Listed Fungicides for Use in the United States										
FRAC Code	Source: 2015 Organic Production and IPM Guide for Grapes, Cornell University Cooperative Extension							Source: EPA Label		NOP Status
	Active Ingredient	Product Name	Product Rate/Acre	PHI (Days)	REI (Days)	Efficacy	Comments	EPA Reg. No.	Comments	
44	*Bacillus amyloliquefaciens* str. D747	Double Nickel 55	0.25-3 lb	0	4	Not reviewed or no research available		70051-108	Causes moderate eye irritation. Dermal sensitizer. Broad-spectrum preventative fungicide. Do not use highly alkaline or highly acidic water to mix sprays. Use a buffering agent if necessary to maintain neutrality (pH 6 to 8) of water in the tank. Start application when new shoots are ½ to 1½ inches long. Repeat at 3-5 inches, 8-10 inches, and then at 7-10 day intervals until disease conditions no longer exist.	Non-synthetic
		Double Nickel LC	0.5-6 qt	0	4	Not reviewed or no research available		70051-114	Harmful if absorbed through skin. Harmful if inhaled. Dermal sensitizer. Broad-spectrum preventative fungicide.	
	Bacillus subtilis str. QST 713	Optiva	14-24 oz	0	4	Not effective		62592-26	Causes moderate eye irritation. Dermal sensitizer. Broad spectrum preventative product.	Non-synthetic
		Serenade ASO	2-6 qt	0	4	Not effective	Has relatively little residual activity and must be reapplied frequently, even if it does not rain.	264-1152	Broad spectrum preventative fungicidal and bactericidal product.	
		Serenade MAX	1-3 lb	0	4			69592-11	Dermal sensitizer. Broad spectrum preventative fungicidal and bactericidal product.	
		Serenade Optimum	14-20 oz	0	4	Inconsistent efficacy results	Apply in sufficient water to provide full coverage.	264-1160		
P5	*Reynoutria sachalinensis*	Regalia Biofungicide	1-4 qt	0	4	Effective in some research studies	Apply in 50 to 100 gal water per acre.	84059-3	Causes moderate eye irritation. Preventative rather than a curative application. Apply prior to disease infestation to protect the growing leaf tissue. Avoid freezing.	Non-synthetic
Not classified; Biological	*Streptomyces lydicus* WYEC 108	Actinovate AG	3-12 oz	0	1 or until solution has dried	Inconsistent efficacy results	Has relatively little residual activity and must be reapplied frequently, even if it does not rain.	73314-1	Avoid contact with skin, eyes, or clothing. Avoid breathing dust or spray mist. Mixer/loaders and applicators must wear a dust/mist filtering respirator meeting NIOSH standards of at least N-95, R-95, or P-95. Repeated exposure to high concentrations of microbial proteins can cause allergic sensitization. Keep from overheating or freezing. Optimum storage temperature is 40°F to 85°F. Contains live spores of a microbe. Best results will be obtained if the product is used prior to disease onset. Becomes active in soil or on the plant foliage when the temperatures are above 45°F and is not effective when temperatures remain cold. Do not apply soil fumigants to treated areas.	Non-synthetic

Erisyphe necator (Powdery Mildew) / Grapes: OMRI-Listed Fungicides for Use in the United States										
FRAC Code	Source: 2015 Organic Production and IPM Guide for Grapes, Cornell University Cooperative Extension							Source: EPA Label		NOP Status
	Active Ingredient	Product Name	Product Rate/Acre	PHI (Days)	REI (Days)	Efficacy	Comments	EPA Reg. No.	Comments	
Not classified; Botanical oil	Cinnamon oil	Cinnerate	13-35 fl oz/100 gal water	0	0	Not reviewed or no research available	Apply 40-85 gallons diluted spray/A.	N/A. FIFRA §25(b) pesticide.	May cause eye and skin irritation. May cause dermal sensitization. Store upright at room temperature. Avoid exposure to extreme temperatures. Do not expose to light and keep away from any heat source. Do not mix with oxidizing, strong acidic or basic materials. Broad spectrum, contact foliar fungicide. All applications should be preceded by a phytotoxicity check to ensure that the material is safe for the particular plant variety.	Non-synthetic
	Cottonseed oil, corn oil, and garlic oil	Mildew Cure	1 gal/100 gal	0	0	Effective in some research studies	Conduct phytotoxicity test prior to application. Although all oil products have not been tested, each works in the same general way.	N/A. FIFRA §25(b) pesticide.	Avoid contract with skin, eyes, and clothing. Do not apply this product to seedlings or very young plants. Do not apply at less than 7-day intervals.	Non-synthetic
	Rosemary oil, clove oil, and thyme oil	Sporatec	1.0-3.0 pt in 100 gallons/ acre	0	0				May be harmful if swallowed. Avoid contact with eyes, skin, and clothing. Avoid breathing vapors or spray mist. May be toxic to bees. Minimum risk to fish and aquatic organisms. Do not apply on plants when the temperature is 90°F or above. Do not apply to wilted or otherwise stressed plants, or to newly transplanted materials prior to root establishment. Check for leaf and flower burn in small-scale trials before conducting large-scale application. For optimal performance, do not mix with cold water (less than 45°F). Do not use, pour, spill or store near heat or open flames.	Non-synthetic
	Sesame oil	Organocide 3-in-1	1-2 gal/ 100 gal	0	0				Insecticide, miticide, and fungicide. If spraying on severely stressed or damaged plants, consider using a lower rate such as 1 oz. per gallon to avoid adding additional stress. For best results, spray in the early morning.	Non-synthetic
	Neem oil	Trilogy	0.5-1.0% solution	0	4	Effective in some research studies	Do not use Trilogy after bloom on table grapes or following bunch closure on wine grapes. Use 25-100 gallons of water per acre and a maximum of 2 gal of Trilogy per acre per application. Although all oil products have not been tested, each works in the same general way.	70051-2	Causes moderate eye irritation. Hazardous to fish and aquatic invertebrates. Toxic to bees exposed to direct treatment. Broad spectrum. Exercise care in timing applications during early morning/late evening to minimize the potential for leaf burn. Use care on plants with tender tissue. Check for leaf burn in small scale trials prior to use. Do not apply to sensitive plant species. Do not apply to wilted or otherwise stressed plants, or to newly transplanted materials or crops prior to root establishment. For optimal performance, do not mix with cold water (less than 45°F). Do not store below 40°F (4°C). Do not use or store near heat or open flame. Growth stage use restrictions for grapes and stone fruit.	Non-synthetic

Erisyphe necator (Powdery Mildew) / Grapes: OMRI-Listed Fungicides for Use in the United States										
FRAC Code	Source: 2015 Organic Production and IPM Guide for Grapes, Cornell University Cooperative Extension							Source: EPA Label		NOP Status
	Active Ingredient	Product Name	Product Rate/Acre	PHI (Days)	REI (Days)	Efficacy	Comments	EPA Reg. No.	Comments	
Not classified; Organic acid	Citric acid	Nuke Em	Normal: 1 fl oz/31 fl oz water. Enhanced: 1.5 fl oz/30.5 fl oz water. Strong: 2 fl oz/32 fl oz water.	0	0	Not reviewed or no research available	Use the normal strength first. If needed, use the next stronger strength.	N/A. FIFRA §25(b) fungicide.	Do not spray on top of other insecticides. Do not mix with other insecticides. Store out of direct sunlight. Not for sale in Mississippi, Indiana or New Mexico. Makes a powdery mildew claim for all crops.	Non-synthetic
M1	Copper hydroxide	Nu-Cop 50 WP	2 lb	0	24	Effective in some research studies	Use with hydrated lime. May cause injury on sensitive varieties. Although all copper products have not been tested, each contains essentially the same active ingredient.	42002-7	DANGER signal word. Corrosive. Causes irreversible eye damage. Harmful if swallowed, absorbed through skin, or inhaled. Skin sensitizer. Toxic to fish and aquatic organisms. Product should not be applied in spray water having a pH of less than 6.5 as phytotoxicity may result. Effectiveness reduced at pH greater than 9.0. <u>Grapes</u>: Slight to severe foliage injury may occur on copper sensitive varieties.	Synthetic
		Champ WG	2-6 lb	0	48	Effective in some research studies	May cause injury on sensitive varieties. Although all copper products have not been tested, each contains essentially the same active ingredient.	55146-1	DANGER signal word. Corrosive. Causes irreversible eye damage. Harmful if inhaled. Skin sensitizer. Toxic to fish and aquatic organisms. <u>Grapes</u>: Slight to severe foliage injury may occur on copper sensitive varieties.	
	Copper hydroxide, Copper oxychloride	Badge X2	0.75-1.75 lbs	0	48	Effective in some research studies	May cause injury on sensitive varieties. Although all copper products have not been tested, each contains essentially the same active ingredient.	80289-12	WARNING signal word. May be fatal if swallowed. Causes substantial but temporary eye injury. Harmful if absorbed through skin. Harmful if inhaled. Toxic to fish and aquatic organisms Product must not be applied in a spray solution having a pH of less than 6.5 as phytotoxicity may occur. Do not tank mix product with Aliette® fungicide for use on any registered crops or ornamentals unless appropriate precautions have been taken to buffer the spray solution because severe phytotoxicity may result. <u>Grapes</u>: Foliage injury may occur on copper sensitive varieties.	Synthetic

Erisyphe necator (Powdery Mildew) / Grapes: OMRI-Listed Fungicides for Use in the United States										
FRAC Code	Source: 2015 Organic Production and IPM Guide for Grapes, Cornell University Cooperative Extension							Source: EPA Label		NOP Status
	Active Ingredient	Product Name	Product Rate/Acre	PHI (Days)	REI (Days)	Efficacy	Comments	EPA Reg. No.	Comments	
	Copper octanoate	Cueva Fungicide Concentrate	0.5-2.0 gal/100 gal water	0	4	Effective in some research studies	May cause injury on sensitive varieties. Although all copper products have not been tested, each contains essentially the same active ingredient.	67702-2-70051	Harmful if swallowed or absorbed through skin. Toxic to fish and aquatic organisms. May cause some copper toxicity on some plant species. Store away from open fire or flame. Product may be damaged by freezing. Do not store product below 4°C. Do not mix with chelated or liquid fertilizers. Use caution when using product with other fungicides and insecticides. Do not mix with lime. Certain Vinifera and French Hybrid varieties may be sensitive to copper sprays resulting in marginal leaf burn.	Synthetic
	Copper sulfate pentahydrate	CS 2005	19.2-32 oz	0	48	Effective in some research studies	May cause injury on sensitive varieties. Although all copper products have not been tested, each contains essentially the same active ingredient.	66675-3	DANGER signal word. Corrosive. Causes irreversible eye damage and skin irritation. Harmful if swallowed, inhaled or absorbed through the skin. Dermal sensitizer. Toxic to fish and aquatic organisms. Do not mix with acidic compounds. Do not mix with pot ash. Store away from excessive heat. Product will freeze. Store and handle product in 316L stainless steel, fiberglass, PVC's, polypropylenes or plastic equipment. Keep away from galvanized pipe and any nylon storage handling equipment. <u>Grapes</u>: Foliage injury may occur on copper sensitive varieties.	Synthetic
		Copper Sulfate Crystals	4-8 lb/ 100 gal water. Use 300 gal water/acre.	0	24	Effective in some research studies	Dormant application. Apply prior to bud swell in the spring before any green tissue is present. Thoroughly wet the dormant vine.	56576-1	DANGER signal word. Corrosive. Causes eye damage and skin irritation. Harmful if swallowed. Toxic to fish. Crop injury statements. <u>Grapes</u>: Bordeaux mixture will exhibit some phytotoxicity on most varieties.	
		Quimag Quimicos Aguila Copper Sulfate Crystals	4-8 lb/ 100 gallons of water	0	24	Not reviewed or no research available	Restricted use pesticide. Dormant application. Apply prior to bud swell in the spring before any green tissue is present. Thoroughly wet the dormant vine.	73385-3	DANGER signal word. Corrosive. Causes irreversible eye damage. May be fatal if swallowed. Causes skin irritation. Dermal sensitizer. Toxic to fish and aquatic invertebrates. Endangered species restriction. <u>Grapes</u>: Bordeaux mixture will exhibit some phytotoxicity on most varieties.	

Erisyphe necator (Powdery Mildew) / Grapes: OMRI-Listed Fungicides for Use in the United States										
FRAC Code	Source: 2015 Organic Production and IPM Guide for Grapes, Cornell University Cooperative Extension							Source: EPA Label		NOP Status
	Active Ingredient	Product Name	Product Rate/Acre	PHI (Days)	REI (Days)	Efficacy	Comments	EPA Reg. No.	Comments	
	Cupric hydroxide	Nu-Cop 50DF	2 lb	1	24	Effective in some research studies	May cause injury on sensitive varieties. Although all copper products have not been tested, each contains essentially the same active ingredient.	45002-4	DANGER signal word. Corrosive. Causes irreversible eye damage. Harmful if swallowed or absorbed through skin. Dermal sensitizer. Toxic to fish and aquatic organisms. Effectiveness reduced at pH greater than 9.0. Product should not be applied in spray water having a pH of less than 6.5 as phytotoxicity may result. Grapes: Foliage injury may occur on copper sensitive varieties.	Synthetic
		Nu-Cop HB	14-24 oz	1	24	Effective in some research studies	Either test for sensitivity or add 1 to 3 pounds of hydrated lime per pound of Nu-Cop HB. May cause injury on sensitive varieties. Although all copper products have not been tested, each contains essentially the same active ingredient.	42750-132	DANGER signal word. Corrosive. Causes irreversible eye damage. Harmful if swallowed, absorbed through skin, or inhaled. Product should not be applied in spray water having a pH of less than 6.5 as phytotoxicity may result. Grapes: Foliage injury may occur on copper sensitive varieties.	
	Cuprous oxide	Nordox 75 WG	1.25 lb	0	12	Effective in some research studies	May cause injury on sensitive varieties. Although all copper products have not been tested, each contains essentially the same active ingredient.	48142-4	Harmful if swallowed or absorbed through skin. Causes eye irritation. Do not apply in a spray solution with a pH of less than 6.5. Grapes: Foliage injury may occur on copper sensitive varieties.	Synthetic

Erisyphe necator (Powdery Mildew) / Grapes: OMRI-Listed Fungicides for Use in the United States										
FRAC Code	Source: 2015 Organic Production and IPM Guide for Grapes, Cornell University Cooperative Extension							Source: EPA Label		NOP Status
	Active Ingredient	Product Name	Product Rate/Acre	PHI (Days)	REI (Days)	Efficacy	Comments	EPA Reg. No.	Comments	
M2	Sulfur	Acoidal	2-10 lb	0	24	Effective in some research studies		62562-4	Harmful if swallowed, inhaled, or absorbed through skin. Toxic to fish and aquatic organisms. Sulfur dust suspended in air ignites easily. Keep away from heat, sparks, or flames. Do not smoke while applying this product. Sulfur may cause severe fruit and foliage injury to certain crops. Sulfur may burn foliage when temperature is high. Do not apply within 2 weeks of an oil spray treatment.	Synthetic
		Defend DF	2-10 lb	0	24	Effective in some research studies		62562-8		
		Kumulus DF	2-10 lb	0	24	Effective in some research studies		51306-352-66330	Harmful if swallowed. Avoid breathing spray mist. Avoid contact with eyes, skin, and clothing. Do not apply within 2 weeks of an oil spray treatment. Do not store above 104°F. Store away from heat, sparks, and open flame.	
		Micro Sulf	3-10 lb	0	24	Effective in some research studies		55146-75	Harmful if swallowed, inhaled, or absorbed through skin. Causes eye irritation. Risk of crop injury if temperature exceeds 90°F within 3 days following application. Do not use on any crop unless sulfur has been shown to be safe in your locality. Do not apply within 14 days of an oil spray. Keep away from heat, sparks, or flames. Do not smoke while applying this product.	
		Microthiol Disperss	3-10 lb	0	24	Effective in some research studies		70506-187	Harmful if swallowed, inhaled, or absorbed through skin. Risk of crop injury if temperature exceeds 90°F within 3 days following application. Do not use on any crop unless sulfur has been shown to be safe in your locality. Do not store near flammable materials. Do not store in a manner where cross-contamination with other pesticides, fertilizers, food or feed could occur. Restrictions regarding application time before and after an oil spray treatment.	
		Thiolux	2-5 lb	0	24	Effective in some research studies		34704-1079	Harmful if swallowed, inhaled, or absorbed through skin. Causes eye irritation. Sulfur may case severe fruit and foliage injury to certain crops. Risk of crop injury if temperature exceeds 90°F within 3 days following application. Do not apply within 14 days of an oil spray. Sulfur dust suspended in air easily ignites. Keep away from heat, sparks, or flames. Do not smoke while applying this product.	

*Erisyphe necator (*Powdery Mildew) / Grapes: OMRI-Listed Fungicides for Use in the United States										
FRAC Code	Source: 2015 Organic Production and IPM Guide for Grapes, Cornell University Cooperative Extension							Source: EPA Label		NOP Status
	Active Ingredient	Product Name	Product Rate/Acre	PHI (Days)	REI (Days)	Efficacy	Comments	EPA Reg. No.	Comments	
Not classified; Inorganic salt	Potassium bicarbonate	EcoMate Amicarb O	2.5-5 lb/100 gal water	0	4	Effective in some research studies	Has relatively little residual activity and must be reapplied frequently, even if it does not rain.	5905-541	Harmful if swallowed. Causes moderate eye irritation. Broad spectrum contact foliar fungicide. Prevent exposure to moisture during storage. Avoid contamination with other pesticides and fertilizers.	Synthetic
		Kaligreen	2.5-5 lb	1	4	Effective in some research studies		70231-1	Harmful if swallowed, absorbed through skin, or inhaled. Do not mix with highly acidic products as effectiveness may be compromised. Use of a buffering agent for acidification of a tank mixture may also decrease effectiveness. Crop injury may result due to certain environmental or growing conditions, manner of use or application.	
		Milstop	2-5 lb	0	1	Effective in some research studies		70870-1-68539	Harmful if swallowed. Causes moderate eye irritation. Broad spectrum contact foliar fungicide. Do not mix with other soluble pesticides or fertilizers. Not compatible with mild alkaline solutions. Acidification of solution will cause reduced product performance. Prevent exposure to moisture during storage. Avoid contamination with other pesticides and fertilizers.	
	Potassium silicate	Sil-Matrix	2-4 qt/100 gal	0	4	Not reviewed or no research available	Apply at 50-250 gallons finished spray/acre.	82100-1	Causes moderate eye irritation. Avoid contact with glass. Remove promptly from glass surfaces. Store product above 40°F. Do not store in aluminum, fiberglass, copper, brass, zinc, or galvanized containers. Protect from excessive heat. Broad spectrum preventative fungicide.	Synthetic

Erisyphe necator (Powdery Mildew) / Grapes: OMRI-Listed Fungicides for Use in the United States										
FRAC Code	Source: 2015 Organic Production and IPM Guide for Grapes, Cornell University Cooperative Extension							Source: EPA Label		NOP Status
	Active Ingredient	Product Name	Product Rate/Acre	PHI (Days)	REI (Days)	Efficacy	Comments	EPA Reg. No.	Comments	
Not classified; Oxidizing agent	Hydrogen dioxide, Peroxyacetic acid	Oxidate 2.0	Initial/ Curative: 128 fl oz/ 100 gal water; 30-100 gal solution/ acre Preventative: 40-128 fl oz/ 100 gal water; 30-100 gal solution/ acre	0	Until dry	Not reviewed or no research available	Apply 30-100 gallons spray solution per treated acre.	70299-2	DANGER signal word. Causes irreversible eye damage. May be fatal if swallowed. Causes skin irritation or temporary discoloration of exposed skin. Highly toxic to bees and other beneficial insects. Toxic to fish. Toxic to birds who eat treated seed on soil surface. Strong oxidizing agent. Do not use in undiluted form. Never bring undiluted product in contact with other pesticides, cleaners or oxidative agents. May react with residues of metal-based fungicides or supplements. Allow at least 24 hrs. after application of metal-based products. Do not spray during conditions of intense heat, drought, or poor plant vigor (or vine canopy). Do not apply in conjunction with any other pesticides or fertilizers. Do not allow product to become overheated in storage. Do not store in a manner where cross-contamination with other pesticides or fertilizers could occur. Apply consecutive applications until control is achieved; then apply preventative treatments.	Synthetic
	Hydrogen peroxide, Hydrogen dioxide	Perpose Plus	Initial/ Curative: 1 fl oz/gal Weekly/ Preventative: 0.25-0.33 fl oz/gal	0	Until spray has dried	Not reviewed or no research available		86729-1	DANGER signal word. Causes irreversible eye damage and skin burns. May be fatal if absorbed through the skin. Harmful if swallowed. Do not breathe vapor from concentrate. Toxic to birds, mammals, fish and aquatic life. At temperatures exceeding 156°F, decomposition releases oxygen. The oxygen released could initiate or promote combustion of other materials. Store away from combustibles. Broad spectrum algaecide and fungicide. Apply curative rates for 3 consecutive days (drenching the entire plant) followed by weekly preventative treatments.	Synthetic

Erisyphe necator (Powdery Mildew) / Grapes: OMRI-Listed Fungicides for Use in the United States										
FRAC Code	Source: 2015 Organic Production and IPM Guide for Grapes, Cornell University Cooperative Extension							Source: EPA Label		NOP Status
	Active Ingredient	Product Name	Product Rate/Acre	PHI (Days)	REI (Days)	Efficacy	Comments	EPA Reg. No.	Comments	
Not classified; Petroleum oils	Mineral oil	Glacial Spray Fluid	1-2 gal/ 100 gal	0	4	Effective in some research studies	Although all oil products have not been tested, each works in the same general way.	34704-849	Harmful is swallowed, absorbed through skin, or inhaled. Causes eye irritation. Prolonged or repeated skin contact may cause allergic reaction in some individuals. Potential skin sensitizer. Drift and runoff may be hazardous to aquatic organisms in water adjacent to treated areas. Do not apply in undiluted form. Sensitive foliage may be injured. Do not spray oil sensitive varieties. Crop injury prevention use restrictions. Do not make oil application within 2 weeks prior to or after an application of sulfur. Use restrictions regarding sulfur, captan, chlorothalonil, dimethoate, dicofol, and propargite. Grapes: Do not tank mix oil and copper more than once/season. Do not use oil and copper together with fruit present.	Synthetic
		PureSpray Green	Dilute: 0.75 gal/ 100 gal at 150-300 gal water/A Concentrate: 1-3 gal	Table grapes: 14 Others: 0	4	Effective in some research studies		69526-9	Harmful if swallowed or absorbed through skin. Aspiration pneumonia hazard. Dermal sensitizer. Avoid excess heat. Do not spray during or immediately prior to hot or freezing weather (over 95°F or under 32°F), hot dry winds, rain or other unsuitable conditions. Do not overspray or double spray. Spray plants only when they are in vigorous condition and when their moisture condition is suitable. Before using, make certain spray tank is free of sulfur residues. Do not apply micronized sulfur within 10 days of an oil application. Do not apply oil within 14 days of an application of wettable or dusting sulfur. See label for additional compatibility restrictions.	
		SuffOil-X	1-2 gal/ 100 gal water	0	4	Effective in some research studies	Do not mix with sulfur products. Although all oil products have not been tested, each works in the same general way.	48813-1-68539	Harmful if absorbed through skin. Prolonged or frequently repeated skin contact may cause allergic reactions in some individuals. Do not use in combination with any product containing sulfur. Do not use with any product whose label recommends the use of no oils. Do not use in combination with NPK foliar fertilizer applications. Do not apply during periods of drought or when plants exhibit moisture stress.	
		TriTek	1-2 gal/ 100 gal water	0	4	Effective in some research studies	Although all oil products have not been tested, each works in the same general way.	48813-1		

*Erisyphe necator (*Powdery Mildew) / Grapes: OMRI-Listed Fungicides for Use in the United States										
FRAC Code	Source: 2015 Organic Production and IPM Guide for Grapes, Cornell University Cooperative Extension							Source: EPA Label		NOP Status
	Active Ingredient	Product Name	Product Rate/Acre	PHI (Days)	REI (Days)	Efficacy	Comments	EPA Reg. No.	Comments	
	Paraffinic oil	Organic JMS Stylet Oil	1-2 gal/ 100 gal	Table grapes: 14 Others: 0	4	Effective in some research studies	Do not apply within 10 days of a sulfur application. Although all oil products have not been tested, each works in the same general way. JMS Stylet Oil and PureSpray Green have been the most effective in comparative field tests.	65564-1	Harmful if swallowed. Toxic to fish. Do not freeze. Do not spray wet foliage. Do not spray when freezing temperatures are anticipated within 48 hours of an oil application, above 90°F (32°C) or when plants are under heat or moisture stress. Do not apply to vegetables when the temperature is below 50°F (10°C). Do not apply micronized sulfur within 10 days of an oil application. Do not apply oil within 14 days of an application of wettable or dusting sulfur. Do not apply to oil sensitive varieties. See label for additional compatibility restrictions. Grapes: Do not use copper and oil when fruit is present. Do not apply micronized sulfur within 10 days of an oil application. Do not apply oil with 14 days of an application of wettable or dusting sulfur.	Synthetic

Erisyphe necator (Powdery Mildew) / Grape: Efficacy Trials

Erysiphe necator (Powdery Mildew)/ Grapes #1: Trial No. CER-2011-013

a. Design

Erysiphe necator (Powdery Mildew) / Grapes #1: Trial No. CER-2011-013: Design				
Title:	Evaluation of Efficacy of Experimental Compounds CX-10440 & CX-10445 Against Grape Powdery Mildew			
Authors and affiliation:	Brooks Bauer Two Bees Agricultural Research & Consulting			
Publication:	Certis data. Not published. Permission received.			
Location:	Escalon, California, USA (central California, inland)			
Crop:	Grape (variety: Carignane, a pinot noir wine grape)			
Disease name:	Powdery mildew			
Pathogen:	*Erysiphe necator*			
Test plot design:	Randomized complete block			
Number of replicates:	4			
Application equipment:	Mist blower			
Spray volume:	100 gallons/acre (935 L/ha)			
Number of applications:	8			
Chronology:	Application Dates	Application Interval	Date Disease First Observed	Disease Assessment Dates
	04/26/2011			05/10/2011
	05/06/2011	10 days		05/18/2011
	05/16/2011	10 days		05/25/2011
	05/26/2011	10 days	05/26/2011	06/01/2011
	06/06/2011	11 days		06/09/2011
	06/16/2011	10 days		06/16/2011
	06/27/2011	11 days		06/23/2011
	07/07/2011	10 days		07/06/2011
				07/13/2011

b. Results

Erysiphe necator (Powdery Mildew) / Grapes #1: Trial No. CER-2011-013: Results for Leaves								
Treatment	Rate/ Acre	g a.i./ ha	Active Ingredient	FRAC Code	Leaves (6/23/2011)			
					Incidence		Severity	
					Percent	Percent Control	Percent	Percent Control
Untreated Control					35.0 a		21.3 a	
CX-10440 [1]	3.75 fl oz	14	Polyoxin D zinc salt	19	5.5 b	84.3	6.0 b	71.8
CX-10440 [1]	7.5 fl oz	29	Polyoxin D zinc salt	19	7.5 b	78.6	3.8 b	82.2
CX-10445 (ENDORSE 11.3% WDG)	3.75 oz wt	65.4	Polyoxin D zinc salt	19	9.3 b	73.4	4.8 b	77.5
Treatment means followed by the same letter are not statistically different (Duncan's New MRT, *P* = 0.05). 1. CX-10440 is the Certis USA, L.L.C. code for Polyoxin D Zinc Salt 5SC Fungicide.								

Erysiphe necator (Powdery Mildew) / Grapes #1: Trial No. CER-2011-013: Results for Fruit								
Treatment	Rate/ Acre	g a.i./ ha	Active Ingredient	FRAC Code	Fruit (6/23/2011)			
					Incidence		Severity	
					Percent	Percent Control	Percent	Percent Control
Untreated Control					70.3 a		51.3 a	
CX-10440 [1]	3.75 fl oz	14	Polyoxin D zinc salt	19	18.0 b	74.4	8.8 b	82.8
CX-10440 [1]	7.5 fl oz	29	Polyoxin D zinc salt	19	15.5 b	77.5	20.5 b	60.0
CX-10445 (ENDORSE 11.3% WDG)	3.75 oz wt	65.4	Polyoxin D zinc salt	19	19.3 b	72.1	16.3 b	68.2
Treatment means followed by the same letter are not statistically different (Duncan's New MRT, *P* = 0.05). 1. CX-10440 is the Certis USA, L.L.C. code for Polyoxin D Zinc Salt 5SC Fungicide.								

Powdery mildew symptoms were first observed on the day of application 4 of 8. Therefore, the treatments were preventive and curative.

No phytotoxicity was observed.

c. Discussion and Conclusions

Grapes were grown in California. Maximum powdery mildew incidence was 70.3% on grape fruit and 35.0% on grape leaves.

A total of 8 treatments of Polyoxin D Zinc Salt 5SC Fungicide were applied preventatively and curatively at 10-day to 11-day intervals. Control of powdery mildew was similar for grape leaves and grape fruit based upon both powdery mildew incidence and powdery mildew severity. Treatments of Polyoxin D Zinc Salt 5SC Fungicide did not resulted in a positive dose response.

- Treatment at 3.75 fl oz/acre (14 g a.i./ha) provided mean 78.3% (range 71.8% to 84.3%) control of powdery mildew on grape leaves and fruit.
- Treatment at 7.5 fl oz/acre (29 g a.i./ha) provided mean 74.6% (range 60.0% to 82.2%) control of powdery mildew on grape leaves and fruit.

At both treatment rates, Polyoxin D Zinc Salt 5SC Fungicide provided control of powdery mildew of grape leaves and fruit that was statistically:

- Superior to the untreated control; and
- Equivalent to the older polyoxin D zinc salt WDG formulation.

It is noteworthy that in this trial the newer 5.0% suspension concentrate formulation of polyoxin D zinc salt achieved statistically equivalent control of powdery mildew on grapes *at 6.7-fold lower active ingredient application rate* than the older 11.3% water dispersible granular formulation of polyoxin D zinc salt.

No phytotoxicity was observed.

Erysiphe necator (Powdery Mildew) / Grapes #2: Trial No. CER-2012-069

a. Design

Erysiphe necator (Powdery Mildew) / Grapes #2: Trial No. CER-2012-069: Design			
Title:	Effect of CX-10440 on Wine Quality, Powdery Mildew, and Crop Response Applied on a Wine Grape Varietal		
Research organization:	Pacific Ag Research		
Publication:	Certis data. Not published. Permission received.		
Location:	Arroyo Grande, CA (southern California, near the Pacific Ocean)		
Crop:	Grape (pinot noir variety)		
Disease name:	Powdery mildew		
Pathogen:	*Erysiphe necator*		
Test plot design:	Not reported		
Number of replicates:	Replicated, but number of replicates is not reported.		
Application equipment:	Broadcast sprayer with spray boom		
Spray volume:	100 gallons/acre (935 L/ha)		
Number of applications:	8		
Chronology:	Application Dates	Application Interval	Powdery Mildew Assessment Date
	05/25/2012 A		08/01/2012
	06/04/2012 B	10 days	
	06/14/2014 C	10 days	
	06/25/2014 D	11 days	
	07/05/2012 E	10 days	
	07/16/2012 F	11 days	
	07/26/2012 G	10 days	
	08/06/2012 H	10 days	

b. Results

Erysiphe necator (Powdery Mildew) / Grapes #2: Trial No. CER-2012-069: Results									
Treatment	Rate/ Acre	g a.i./ ha	Active Ingredient	FRAC Code	App. Code	Incidence on Fruit (08/01/2012)		Wine Alcohol Content (%)	Wine Tritrat-able Acidity (g/ 100 mL)
						Percent	Percent Control		
Untreated Control						30.00 a	0.00	13.38 a	0.58 a
CX-10440 [1]	13 fl oz	50	Polyoxin D zinc salt	19	ABCD EFGH	1.00 b	96.67	11.76 b	0.54 b
CX-10440 [1]	13 fl oz	50	Polyoxin D zinc salt	19	AE	5.00 b	83.33	11.79 b	0.53 b
Rally 40W	4 oz		Myclobutanil	3	CG				
Pristine 38WG	8 oz		Boscalid	7	A	5.00 b	83.33	11.71 b	0.53 b
			Pyraclostrobin	11					
Rally 40W	5 oz		Myclobutanil	3	C				
Quintec 250SC	4 oz		Quinoxyfen	13	E				
Elite 45 DF	5 oz		Tetraconazole	3	G				
Treatment means followed by the same letter are not statistically different (ANOVA mean comparison with LSD test and α = 0.05). 1. CX-10440 is the Certis USA, L.L.C. code for Polyoxin D Zinc Salt 5SC Fungicide.									

Powdery mildew symptoms were first observed on August 1, 2012, *i.e.*, before the last of 8 applications. Therefore, the treatments were preventative and curative.

No phytotoxicity was observed.

c. Discussion and Conclusions

Wine grapes were grown in California. Powdery mildew incidence on grape fruit was 30% incidence.

A total of 8 treatments of Polyoxin D Zinc Salt 5SC Fungicide applied preventatively and curatively at 10-day to 11-day intervals. Treatments applied at 13 fl oz/acre (50 g a.i./ha) provided 96.67% control of powdery mildew on wine grapes. The control provided by Polyoxin D Zinc Salt 5SC Fungicide was statistically:

- Superior to the untreated control; and
- Equivalent to though numerically greater than the control provided by:
  - Polyoxin D Zinc Salt 5SC Fungicide applied alternately with myclobutanil; and
  - A treatment program that included boscalid, pyraclostrobin, myclobutanil, quinoxyfen, and tetraconazole.

No phytotoxicity was observed.

Treatment of the grapes with Polyoxin D Zinc Salt 5SC Fungicide had no material impact on the wine produced from the grapes. The statistical differences relative to untreated control were limited to:

- Decreased alcohol content; and
- Decreased titratable acidity.

Wine parameters for which there was no statistical difference between the untreated control and any of the treatments were:

- pH;
- Free SO_2;
- Total SO_2;
- Volatile acidity;
- Malic acid;
- Appearance;
- Color;
- Aroma;
- Acetic acid;
- Total acidity;
- Sweetness;
- Body;
- Flavor;
- Bitterness; and
- Quality.

Erysiphe necator (Powdery Mildew) / Grapes #3: Trial No. CER-2013-021

a. Design

Erysiphe necator (Powdery Mildew) / Grapes #3: Trial No. CER-2013-021: Design				
Title:	Evaluation of Efficacy of Tavano 5SC at 18-21-Day Reapplication Intervals Compared to Elevate (or [1] Pristine)			
Author and affiliation:	Brooks Bauer Two Bees Agricultural Research & Consulting 20592 Ayers Avenue Escalon, California, USA			
Publication:	Certis data. Not published. Permission received.			
Location:	Escalon, California, USA (central California, inland)			
Crop:	Grape (cabernet sauvignon)			
Disease name:	Powdery mildew			
Pathogen:	*Erysiphe necator*			
Test plot design:	Completely randomized block			
Number of replicates:	4			
Application equipment:	Mist blower			
Spray volume:	100 gallons/acre (935 L/ha)			
Number of applications:	5			
Chronology:	Application Dates	Application Intervals	Disease First Observed	Disease Assessments
	04/24/2013		05/13/2013	05/06/2013
	05/13/2013	19 days		05/13/2013
	06/03/2013	21 days		05/29/2013
	06/21/2013	18 days		06/04/2013
	07/10/2013	19 days		06/11/2013
	07/29/2013	19 days		06/21/2013
				07/01/2013
				07/09/2013
				07/22/2013
Application growth stages:	19, 53, 61, 64, 81, 85 (BBCH scale)			
1. Corrected title. The report title incorrectly states "&" Pristine.				

b. Results

Erysiphe necator (Powdery Mildew) / Grapes #3: Trial No. CER-2013-021: Results								
Treatment	Rate/ Acre	g a.i./ ha	Active Ingredient	FRAC Code	Fruit (7/22/2013)			
					Incidence		Severity	
					Percent	Percent Control	Percent	Percent Control
Untreated Control					100.0		99.8	
Tavano	6.5 fl oz	25	Polyoxin D zinc salt	19	62.0	38.0	49.5	50.4
Tavano	13 fl oz	50	Polyoxin D zinc salt	19	29.0	71.0	23.8	76.2
Pristine	12 oz		Boscalid	7	33.3	66.7	18.3	81.7
			Pyraclostrobin	11				

Powdery mildew incidence was first observed on May 29, 2013, *i.e.*, five days after the first of 8 treatments. Therefore, the treatments were preventative and curative.

No phytotoxicity was observed.

c. Discussion and Conclusions

Wine grapes were grown in California. Powdery mildew incidence and severity on grape fruit were 100% and 99.8%, respectively, in the untreated control.

A total of 5 treatments of Polyoxin D Zinc Salt 5SC Fungicide were applied preventatively and curatively at 18-day to 21-day intervals. There was a strong positive dose response.

- Treatment at 6.5 fl oz/acre (25 g a.i./ha) provided mean 44.2% (range 38.0% to 50.4%) control of powdery mildew on fruit.
- Treatment at 13 fl oz/acre (50 g a.i./ha) provided mean 73.6% (range 71.0% to 76.2%) control of powdery mildew on fruit.

Treatments with Polyoxin D Zinc Salt 5SC Fungicide:

- At both 6.5 fl oz/acre (25 g a.i./ha) and 13 fl oz/acre (50 g a.i./ha) provided control that was superior to the untreated control; and
- At 13 fl oz/acre (50 g a.i./ha) provided control of powdery mildew incidence and severity that was similar to the control provided by boscalid plus pyraclostrobin.

No phytotoxicity was observed.

Erysiphe necator (Powdery Mildew) / Grape #4: Trial No. CER-2015-019

a. Design

Erysiphe necator (Powdery Mildew) / Grape #4: Trial No. CER-2015-019: Design			
Title:	Certis Grape Mildew		
Author and affiliation:	Craig Collins, Collins Agricultural Consultants, Inc.		
Publication:	Certis data. Not published. Permission received.		
Location:	Oregon City, OR		
Crop:	Grape (Pinot noir)		
Disease name:	Powdery mildew		
Pathogen:	*Erysiphe necator*		
Test plot design:	Randomized complete block		
Number of replicates:	4		
Application equipment:	CO_2 backpack sprayer, 40 psi		
Spray volume:	55 gal/acre		
Number of applications:	6		
Chronology:	Application Dates	Application Interval	Assessment Dates
	06/11/2015		06/18/2015
	06/24/2015	13 days	06/29/2015
	07/08/2015	14 days	07/08/2015
	07/22/2015	14 days	07/15/2015
	08/06/2015	15 days	07/23/2015
	08/20/2015	14 days	08/03/2015
			08/12/2015
			08/26/2015

b. Results

Erysiphe necator (Powdery Mildew) / Grape #4: Trial No. CER-2015-019: Results									
Treatment	Rate/ Acre	g a.i./ ha	Active Ingredient	FRAC Code	Appn Code	Leaf Severity (%) (8/26/2015)		Bunch Severity (%) (8/26/2015)	
						Measured	Percent Control	Measured	Percent Control
Untreated control			Not Applicable			73.6 a		87.5 a	
OSO	6.5 fl oz	25	Polyoxin D zinc salt	19	ABCDEF	10.2 b	86.1	50.0 b	47.9
Sylguard 309	0.025%v/v		NA; silicone surfactant	NA	ABCDEF				
Rally WP	5.0 oz		Myclobutanil	3	ADF	5.4 bc	92.7	9.0 *	89.7
Vivando SC	10.3 fl oz		Metrafenone	U8	BE				
Pristine WG	12 oz		Pyraclostrobin	11	CF				
			Boscalid	7					
Sylguard 309	0.025% v/v		NA; silicone surfactant	NA	ABCDEF				
Serenade Optimum	16.0 oz		QST 713 strain of *Bacillus subtilis*	44	ADF	3.3 c	95.5	25.0 c	71.4
Vivando	10.3 fl oz		Metrafenone	U8	BE				
Pristine	12.0 oz		Pyraclostrobin	11	CF				
			Boscalid	7					
Sylguard 309	0.025% v/v		NA; silicone surfactant	NA	ABCDEF				
Regalia	64.0 fl oz		Extract of *Reynoutria sachalinensis*	P5	ADF	3.8 bc	94.8	20.0 c	77.1
Vivando	10.3 fl oz		Metrafenone	U8	BE				
Pristine	12.0 oz		Pyraclostrobin	11	CF				
			Boscalid	7					
Sylguard 309	0.025% v/v		NA; silicone surfactant	NA	ABCDEF				
Treatment means followed by the same letter are not statistically different according to the LSD test at P = 0.05. * Statistical comparison was not reported.									

Powdery mildew symptoms were first observed in the untreated control on June 18, 2015, *i.e.*, *before* the last five treatments. Therefore, the treatments were preventative and curative.

No phytotoxicity was observed.

c. Discussion and Conclusions

Wine grapes were grown in Oregon. Powdery mildew severity on bunches in the untreated control was 87.5%.

Six treatments of Polyoxin D Zinc Salt 5SC Fungicide plus Sylguard (a surfactant) were applied preventatively and curatively at 13-day to 15-day intervals. Polyoxin D Zinc Salt 5SC Fungicide was applied at 6.5 fl oz/acre (25 g a.i./acre).

Treatments with Polyoxin D Zinc Salt 5SC Fungicide plus Sylguard provided mean 67.0% (range 47.9% to 86.1%) control of powdery mildew.

The control of powdery mildew by Polyoxin D Zinc Salt 5SC Fungicide was statistically:

- Superior to the untreated control for both leaves and bunches;
- Equivalent to the two treatment programs for control of powdery mildew on leaves:
    - Myclobutanil, metrafenone, pyraclostrobin, and boscalid, plus silicone surfactant; and
    - Extract of *Reynoutria sachalinensis* (Regalia), metrafenone, pyraclostrobin, and boscalid, plus silicone surfactant; and
- Less control of powdery mildew on bunches compared to all three alternative treatment programs.

For all fungicide treatments and treatment programs, control of powdery mildew on grape leaves was superior to the control on grape bunches.

No phytotoxicity was observed.

Erysiphe necator (Powdery Mildew) / Grape #5: Trial No. CER-2015-140

a. Design

<table>
<tr><th colspan="5">Erysiphe necator (Powdery Mildew) / Grapes #4: Trial No. CER-2015-140: Design</th></tr>
<tr><td>Title:</td><td colspan="4">Evaluation of Fungicides for Control of Botrytis Bunch Rot and Powdery Mildew, 2015</td></tr>
<tr><td>Authors and affiliation:</td><td colspan="4">A. M. Schilder, J. M. Gillett, and R. W. Sysak
Michigan State University
East Lansing, MI</td></tr>
<tr><td>Publication:</td><td colspan="4">PDMR 10:20164</td></tr>
<tr><td>Location:</td><td colspan="4">Lawton, Michigan, USA</td></tr>
<tr><td>Crop:</td><td colspan="4">Grape (Vitis interspecific hybrid ‘Aurore’)</td></tr>
<tr><td>Disease name:</td><td colspan="4">Botrytis Bunch Rot</td></tr>
<tr><td>Pathogen:</td><td colspan="4">Botrytis cinerea</td></tr>
<tr><td>Test plot design:</td><td colspan="4">Randomized complete block</td></tr>
<tr><td>Number of replicates:</td><td colspan="4">4</td></tr>
<tr><td>Application equipment:</td><td colspan="4">Farmco research skid-mounted sprayer</td></tr>
<tr><td>Spray volume:</td><td colspan="4">06/09/2015: 50 gal/acre
All later treatments: 75 gal/acre</td></tr>
<tr><td>Number of applications:</td><td colspan="4">4</td></tr>
<tr><td rowspan="5">Chronology:</td><td>Application Dates</td><td>Growth Stage</td><td>Application Interval</td><td>Disease Assessment Dates</td></tr>
<tr><td>06/09/2015</td><td>10-16 inch shoots</td><td></td><td>08/31/2015</td></tr>
<tr><td>07/07/2015</td><td>Pre-bunch closure</td><td>29 days</td><td></td></tr>
<tr><td>08/04/2015</td><td>Veraison</td><td>28 days</td><td></td></tr>
<tr><td>08/24/2015</td><td>Pre-harvest</td><td>20 days</td><td></td></tr>
<tr><td>Disease assessment methodology:</td><td colspan="4">Disease incidence: Percent clusters or leaves exhibiting disease.
Disease severity: Percent cluster or leaf blade with disease on diseased samples only.</td></tr>
</table>

b. Results

Erysiphe necator (Powdery Mildew) / Grapes #5: Trial No. CER-2015-140: Results on Clusters								
Treatment	Rate/ Acre	g a.i./ ha	Active Ingredient	FRAC Code	Severity (%)		Incidence (%)	
					Measured	Percent Control	Measured	Percent Control
Untreated control			Not Applicable		5.73 a		25 a	
Oso 5%SC	6.5 fl oz	25	Polyoxin D zinc salt	19	1.88 bcd	67.2	14 b	44
Super Spread 90	0.125% (v/v)	NA	Surfactant	NA				
Protexio SC	14.4 fl oz		Fenpyrazamine	17	1.13 cde	80.3	6 def	76
Super Spread 90	0.125% (v/v)		Surfactant	NA				
Treatment means followed by the same letter are not statistically different according to Fisher's Protected LSD test at P ≤ 0.05.								

Erysiphe necator (Powdery Mildew) / Grapes #5: Trial No. CER-2015-140: Results on Leaves								
Treatment	Rate/ Acre	g a.i./ ha	Active Ingredient	FRAC Code	Severity (%)		Incidence (%)	
					Measured	Percent Control	Measured	Percent Control
Untreated control			Not Applicable		8.88 a		37 a	
Oso 5%SC	6.5 fl oz	25	Polyoxin D zinc salt	19	3.13 b	64.8	20 b	46
Super Spread 90	0.125% (v/v)	NA	Surfactant	NA				
Protexio SC	14.4 fl oz		Fenpyrazamine	17	2.38 bc	73.2	12 c	68
Super Spread 90	0.125% (v/v)		Surfactant	NA				
Treatment means followed by the same letter are not statistically different according to Fisher's Protected LSD test at P ≤ 0.05.								

The powdery mildew assessment date was after the final treatment. Therefore, treatments are assumed to have been preventative.

No phytotoxicity was observed.

c. Discussion and Conclusions

Grapes were grown in Michigan. Powdery mildew was evaluated in both leaves and clusters. Powdery mildew incidence on leaves was 37%.

Polyoxin D Zinc Salt 5SC Fungicide applied preventatively at 6.5 fl oz/acre (25 g a.i./ha) with Super Spread 90 (surfactant) at 20-day to 29-day intervals provided mean 56% (range 44% to 67.2%) control of powdery mildew on grapes. This was statistically:

- Superior to the untreated control;
- Equivalent to the control of powdery mildew severity on clusters and leaves provided by fenpyrazimine with surfactant; and
- Less control of powdery mildew incidence on clusters and leaves than provided by fenpyrazimine with surfactant.

No phytotoxicity was observed.

Erisyphe necator **(Powdery Mildew) / Grape: Grower Need**
Control of powdery mildew on grapes (Project No. B00130) was identified as a grower need at the IR-4 2015 Biopesticide Workshop.

Geastrumia polystigmatus, *Leptodontium elatus*, and *Peltaster fructicola* (SOOTY BLOTCH COMPLEX) / POME FRUITS

Geastrumia polystigmatus, etc. (Sooty Blotch Complex) / Pome Fruits: Introduction

(Source: Wayne F. Wilcox, Sooty Blotch and Flyspeck, Cornell Cooperative Extension Disease Identification Sheet No. D11, 1994)

Sooty blotch and fly speck are the two most common "summer diseases" of apples in the Northeast. They are also problems on pears. Although caused by two different organisms, the diseases often occur together since both are confined to the fruit surface and are favored by similar environmental and horticultural conditions. Disease incidence and severity can be highly variable among production regions, growing seasons, and even individual orchards. Economic losses result primarily from the diminished appearance and commercial quality of infected fruit.

Geastrumia polystigmatus, etc. (Sooty Blotch Complex) / Pome Fruits: Symptoms

(Source: Wayne F. Wilcox, Sooty Blotch and Flyspeck, Cornell Cooperative Extension Disease Identification Sheet No. D11, 1994)

Sooty blotch appears as dark olive green or sooty-colored fungus colonies on the surface of infected fruit. One to many nearly circular colonies may develop individually or large, unshaped colonies may spread out over the fruit. Symptoms can develop as soon as 3-4 weeks after petal fall, but are usually much more common and severe by late summer or early fall.

Symptoms of flyspeck are well-described by the disease name. Small, circular colonies of up to 50 or more tiny black dots (fungus fruiting bodies) form on the fruit surface. One to many individual colonies can form per fruit, but flyspeck symptoms are typically less pronounced than are those of sooty blotch (fruit on left with sooty blotch, fruit on right with flyspeck). The timing of symptom appearance is similar to that for sooty blotch.

Geastrumia polystigmatus, etc. (Sooty Blotch Complex) / Pome Fruits: Disease Cycle and Causal Organisms

(Source: Wayne F. Wilcox, Sooty Blotch and Flyspeck, Cornell Cooperative Extension Disease Identification Sheet No. D11, 1994)

Sooty *blotch.* Sooty blotch is caused by the fungus *Gloeodes pomigena.* The fungus overwinters as fruiting bodies (pycnidia) or in a vegetative state (mycelium) on infected twigs of apple trees and numerous woody plants in hedgerows and woodlots. These "reservoir hosts" include brambles (blackberries and raspberries), oaks, maples, ash, elm, grape, tulip tree, and many others common to eastern North America. Spores formed within the pycnidia or from sections of the mycelium are spread by rains during the late spring and early summer, and begin causing fruit infections about 2-3 weeks after petal fall.

Typical sooty blotch symptoms are caused by the dark mycelium of fungal colonies that develop on the surface of the fruit cuticle. Because of the superficial nature of this growth, it is extremely sensitive to the microclimate conditions (particularly relative humidity) immediately surrounding the fruit. Growth is optimum at 100% relative humidity, good at 95% relative humidity, fair at 92% relative humidity, and poor at 90% relative humidity. No growth occurs below 90% relative humidity. The effects of temperature vary somewhat among individual isolates, but optimum temperatures are generally about 64-80°F (18-27°C). Growth is very limited and slow during periods below 50°F (10°C) or above 86°F (30°C).

The period of time between the beginning of an infection and the appearance of symptoms depends on how often and for how long temperature and humidity conditions allow fungal growth. In the Northeast, this incubation period is often 3-4 weeks under relatively favorable conditions, but can be 2 months or longer otherwise. In warmer regions where the disease occurs regularly (*e.g.*, the Hudson Valley), it is common for infections to be initiated during the early cover spray period, stop development during a hot and dry mid-summer, then finish incubating and finally become apparent when conditions become more favorable towards the end of summer. Once fungal colonies do appear, mycelial fragments can be broken off by raindrops and spread to additional fruit, causing further disease if environmental conditions remain favorable. Thus, disease is generally most severe in years and orchards where conditions favor early disease development followed by extensive secondary spread.

Sooty blotch infections that are not apparent at harvest can sometimes finish their development during long periods of cold storage when relative humidities are near 100 percent.

***Geastrumia polystigmatus*, etc. (Sooty Blotch Complex) / Pome Fruits: Control**
(Source: Wayne F. Wilcox, Sooty Blotch and Flyspeck, Cornell Cooperative Extension Disease Identification Sheet No. D11, 1994)

Control of sooty blotch and flyspeck should integrate horticultural practices designed to reduce the chances of disease development together with fungicide sprays to protect against infection when necessary.

Because both diseases are so dependent on long periods of extreme humidity around the fruit, annual pruning to open tree canopies and to promote air circulation will minimize the periods favorable for sooty blotch and flyspeck development. Supplemental summer pruning in dense-canopied trees can provide significant additional benefits in some years. Proper fruit thinning is also important for reducing the development of high-humidity microclimates around clustered fruit. Like good pruning, thinning will furthermore improve the spray coverage for any fungicides that may be applied. Mowing of grass middles and good within-row weed control will provide additional help in reducing overall humidity levels within orchards during the summer.

The removal of hedgerows or surrounding woodlots is not always practical, but can substantially improve airflow and reduce humidities within the orchard. Destruction of the many woody reservoir hosts in these sites will also reduce some of the inoculum that initiates fruit infections. Because of their importance as an inoculum source, it is particularly important to eliminate brambles in hedgerows and within the orchard itself should they occur there.

The need for and timing of fungicide sprays to control these diseases is variable among orchards and years. In regions where they occur regularly, sprays should start around first cover and be repeated as necessary according to the prevailing weather conditions and material being used. Where the diseases occur more sporadically, fungicide programs should be initiated and continued on the basis of weather conditions, specific orchard factors, and previous experience. In general, fungicide programs will need to be most intense for orchards in low fog pockets, surrounded by woods, or with dense tree canopies. Minimizing these factors at the time of planting will help reduce the intensity of sooty blotch and flyspeck control programs required in subsequent years.

Geastrumia polystigmatus, *Leptodontium elatus*, and *Peltaster fructicola* (Sooty Blotch Complex) / Pome Fruits: OMRI-Listed Fungicides for Use in the United States **(No efficacy data have been identified or evaluated.)**								
FRAC Code	Source: EPA Label							
	Active Ingredient	Product Name	Product Rate/ Acre	PHI (Days)	REI (Days)	EPA Reg. No.	Comments	NOP Status
44	*Bacillus amyloliquefaciens* str. D747	Double Nickel 55	0.25-3 lb	0	4	70051-108	Causes moderate eye irritation. Dermal sensitizer. Broad-spectrum preventative fungicide. Do not use highly alkaline or highly acidic water to mix sprays. Use a buffering agent if necessary to maintain neutrality (pH 6 to 8) of water in the tank. Suppression only. Make first application at popcorn stage and repeat every 7 days. Begin applications before bloom when environmental conditions favor disease development, repeating at 7 to 14 day intervals or as needed. Control may be enhanced by addition of a surfactant to improve spray coverage. Not for use in California.	Non-synthetic
P5	*Reynoutria sachalinensis*	Regalia Biofungicide	1-4 qt	0	4	84059-3	Causes moderate eye irritation. Preventative rather than a curative application. Apply prior to disease infestation to protect the growing leaf tissue. Avoid freezing. Apply prior to disease infestation.	Non-synthetic

Geastrumia polystigmatus, etc. (Sooty Blotch Complex) / Pome Fruits: Efficacy Trials

Geastrumia polystigmatus, etc. (Sooty Blotch Complex) / Apple #1: Trial No. CER-2012-025

a. Design

Geastrumia polystigmatus, etc. (Sooty Blotch Complex) / Apples #1: Trial No. CER-2012-025: Design				
Title:	Evaluation of Experimental and Registered Cover Spray Fungicide Combinations for Disease Control on Fuji Apple, 2012			
Authors and affiliation:	K.S. Yoder, A.E. Cochran, *et al.* Virginia Tech Agricultural Research and Extension Center Winchester, VA			
Publication:	PDMR 7:PF034			
Location:	Winchester, VA			
Crop:	Apple (Fuji)			
Disease name:	Sooty Blotch Complex			
Pathogens:	*Geastrumia polystigmatus* *Leptodontium elatus* *Peltaster fructicola*			
Test plot design:	Random complete block			
Number of replicates:	4			
Application equipment:	Airblast			
Spray volume:	100 gal/acre			
Number of applications:	9			
Chronology:	Application Dates	Growth Stage	Application Interval	Harvest Date
	04/13/2012	Bloom-petal fall		10/04/2012
	04/25/2012		12 days	
	05/09/2012		14 days	
	05/24/2012		15 days	
	06/06/2012		13 days	
	06/20/2012		14 days	
	07/18/2012		28 days	
	08/02/2012		15 days	
	08/22/2012		20 days	

b. Results

Geastrumia polystigmatus, etc. (Sooty Blotch Complex) / Apples #1: Trial No. CER-2012-025: Results								
Treatment	Rate/ Acre	g a.i./ ha	Active Ingredient	FRAC Code	Percent Fruit Infected		Percent Fruit Area Infected	
					Measured	Percent Control	Measured	Percent Control
Untreated control			Not Applicable		94 i		12.3 h	
CX-10440 [1]	6.5 fl oz	25	Polyoxin D zinc salt	19	30 de	68	1.2 de	90
CX-10440 [1]	13 fl oz	50	Polyoxin D zinc salt	19	56 g	40	3.5 fg	72
Optiva	1.0 lb		*Bacillus subtilis* str. QST 713	44	60 gh	36	2.9 f	76
Mettle 125ME	5 fl oz		Tetraconazole	3	74 h	21	4.4 g	64
Evito 480SC	6 fl oz		Fluoxastrobin	11	31 ef	67	1.6 e	87
Captan 80WDG	30 oz		Captan	M4	7 bc	93	0.4 bc	97
Treatment means followed by the same letter are not statistically different according to the Waller-Duncan K-ratio t-test (p = 0.05). 1. CX-10440 is the Certis USA, L.L.C. code for Polyoxin D Zinc Salt 5SC Fungicide.								

The report notes:
- The 250-wetting hour threshold was reached on May 25, 2012; and
- Sooty blotch incidence was first observed on June 13, 2012.

Therefore, the treatments were preventative and curative.

No phytotoxicity was reported.

c. Discussion and Conclusions

Apples were grown in Virginia near the border with Pennsylvania. Sooty blotch complex infected 94% of the fruit in the untreated control.

Nine treatments of Polyoxin D Zinc Salt 5SC Fungicide were applied at 12-day to 28 day intervals. The treatments did not provide a positive dose-response.
- Treatment at 6.5 fl oz/acre (25 g a.i./ha) provided mean 79% (range 68% to 90%) control.
- Treatment at 13 fl oz/acre (50 g a.i./ha) provided mean 56% (range 40% to 72%) control.

Polyoxin D Zinc Salt 5SC Fungicide applied at both 6.5 fl oz/acre and 13 fl oz/acre provided control of sooty blotch complex of apples that was statistically superior to that provided by the untreated control.

Polyoxin D Zinc Salt 5SC Fungicide applied at 6.5 fl oz/acre (25 g a.i./ha) provided control of sooty blotch complex that was statistically:
- Superior to the control provided separately by *Bacillus subtilis* str. QST 713 (Optiva) and tetraconazole;
- Equivalent to the control provided by fluoxastrobin; and
- Less than the control provided by captan.

No phytotoxicity was reported.

***Geastrumia polystigmatus*, etc. (Sooty Blotch Complex) / Pome Fruits: Grower Need**

Control of foliar diseases on apples (Project No. B00092) was identified as a grower need at the IR-4 2015 Biopesticide Workshop.

Golovinomyces cichoracearum (POWDERY MILDEW) / LETTUCE

Golovinomyces cichoracearum (Powdery Mildew) / Lettuce: Introduction
(Source: Beth Scheckelhoff, Powdery Mildew on Greenhouse Grown Lettuce, E-Gro Alert, November 2015, Ohio State)

Many growers struggle with controlling powdery mildew on greenhouse-grown lettuce crops, especially during the fall and winter months. Symptoms of powdery mildew include patches of white powdery growth on the upper and lower leaves and stems. Disease severity depends upon lettuce type and variety, age and overall condition of the plant, as well as microclimate conditions. Older leaves and mature plants are usually affected first and become chlorotic and deformed, limiting plant growth and marketable yield. Severely affected tissues may turn necrotic and die.

Powdery mildews are fairly host-specific, although plants in the same family can be susceptible to the same mildew species. The fungus *Golovinomyces cichoracearum* (formerly *Erysiphe cichoracearum*) causes powdery mildew on lettuce. Strains of *Golovinomyces cichoracearum* have infected over 150 crop species, including other greenhouse crops in the Asteraceae such as *Achillea*, *Dahlia*, *Cosmos*, *Dendranthema*, *Leucanthemum*, *Zinnia*, and *Gerbera*, among others.

The greenhouse environment provides ideal conditions for development of powdery mildew on lettuce, especially when the foliage canopy is dense and air flow restricted. Mildew spores are spread via the air current and will germinate at a broad temperature range from 41-86°F(5-30°C) with an optimum at 64-77°F (18-25°C). Optimum relative humidity levels for germination are 95-98%, though germination can occur when the relative humidity is at 50%, enabling the disease to develop in both humid and dry environments. Interestingly, free water on plant surfaces prevents spore germination and infection.

Golovinomyces cichoracearum (Powdery Mildew) / Lettuce: Cultural Controls
(Source: Beth Scheckelhoff, Powdery Mildew on Greenhouse Grown Lettuce, E-Gro Alert, November 2015, Ohio State)

- Select varieties that are less susceptible to the pathogen. Studies have shown leaf and butterhead types show more resistance to powdery mildew than romaine and crisphead lettuces. Check seed company and University trial results for varieties and cultivars that show resistance, though performance may vary depending on your specific greenhouse conditions and cultural practices.
- Monitor and scout for disease presence regularly, especially in sections of the greenhouse that have reduced air flow, dense plant canopies, or standing water. Examine both the upper and lower side of leaves. Powdery mildew forming on the underside of leaves can go undetected and move quickly through the greenhouse before it is noticed.
- Harvest mature plants in a timely manner to prevent overgrowth and the formation of dense canopies where powdery mildew can thrive.
- Properly vent the greenhouse to keep humidity levels low, by using fans and ventilation tubing to increase air movement within the plant canopy.

Golovinomyces cichoracearum (Powdery Mildew) / Lettuce: OMRI-Listed Fungicides for Use in the United States **(No efficacy data have been identified or evaluated.)**								
FRAC Code	Source: EPA Label							NOP Status
	Active Ingredient	Product Name	Product Rate/Acre	PHI (Days)	REI (Days)	EPA Reg. No.	Comments	
44	*Bacillus amyloliquefaciens* str. D747	Double Nickel 55	0.25-3 lb	0	4	70051-108	Causes moderate eye irritation. Dermal sensitizer. Broad-spectrum preventative fungicide. Do not use highly alkaline or highly acidic water to mix sprays. Use a buffering agent if necessary to maintain neutrality (pH 6 to 8) of water in the tank. Suppression only.	Non-synthetic
		Double Nickel LC	0.5-6 qt	0	4	70051-114	Harmful if absorbed through skin. Harmful if inhaled. Dermal sensitizer. Broad-spectrum preventative fungicide.	
	Bacillus subtilis str. QST 713	Serenade ASO	2-6 qt	0	4	264-1152	Broad spectrum preventative fungicidal and bactericidal product. For suppression only. Begin applications when conditions are conducive to disease development and repeat on 2- to 10- day intervals or as needed. For improved performance, use in a tank-mix or rotational program with other registered fungicides for powdery mildew control.	Non-synthetic
		Serenade MAX	1-3 lb	0	4	69592-11	Dermal sensitizer. Broad spectrum preventative fungicidal and bactericidal product. For suppression only. Begin applications when conditions are conducive to disease development and repeat on 2- to 10- day intervals or as needed. For improved performance, use in a tank-mix or rotational program with other registered fungicides for powdery mildew control.	
P5	*Reynoutria sachalinensis*	Regalia Biofungicide	1-4 qt in 50 to 100 gal water/acre.	0	4	84059-3	Causes moderate eye irritation. Preventative rather than a curative application. Apply prior to disease infestation to protect the growing leaf tissue. Avoid freezing. Repeat applications at 7–14-day intervals.	Non-synthetic
Not classified; Biological	*Streptomyces lydicus* WYEC 108	Actinovate AG	3-12 oz	0	1 or until solution has dried	73314-1	Avoid contact with skin, eyes, or clothing. Avoid breathing dust or spray mist. Mixer/loaders and applicators must wear a dust/mist filtering respirator meeting NIOSH standards of at least N-95, R-95, or P-95. Repeated exposure to high concentrations of microbial proteins can cause allergic sensitization. Keep from overheating or freezing. Optimum storage temperature is 40°F to 85°F. Contains live spores of a microbe. Best results will be obtained if the product is used prior to disease onset. Becomes active in soil or on the plant foliage when the temperatures are above 45°F and is not effective when temperatures remain cold. Do not apply soil fumigants to treated areas.	Non-synthetic

Golovinomyces cichoracearum (Powdery Mildew) / Lettuce: OMRI-Listed Fungicides for Use in the United States **(No efficacy data have been identified or evaluated.)**								
FRAC Code	Source: EPA Label							NOP Status
	Active Ingredient	Product Name	Product Rate/Acre	PHI (Days)	REI (Days)	EPA Reg. No.	Comments	
Not classified; Botanical oil	Cinnamon oil	Cinnerate	13-30 fl oz/100 gal water in 85-100 gal/acre	0	0	NA. FIFRA §25(b) pesticide.	May cause eye and skin irritation. May cause dermal sensitization. Store upright at room temperature. Avoid exposure to extreme temperatures. Do not expose to light and keep away from any heat source. Do not mix with oxidizing, strong acidic or basic materials. Broad spectrum, contact foliar fungicide. All applications should be preceded by a phytotoxicity check to ensure that the material is safe for the particular plant variety.	Non-synthetic
	Cottonseed oil, corn oil, and garlic oil	Mildew Cure	1.5 oz/gal water	0	0	NA. FIFRA §25(b) pesticide.	Avoid contract with skin, eyes, and clothing. Do not apply this product to seedlings or very young plants. Do not apply at less than 7-day intervals.	Non-synthetic
	Neem oil	Trilogy	0.5-1.0% solution	0	4	70051-2	Causes moderate eye irritation. Hazardous to fish and aquatic invertebrates. Toxic to bees exposed to direct treatment. Broad spectrum. Exercise care in timing applications during early morning/late evening to minimize the potential for leaf burn. Use care on plants with tender tissue. Check for leaf burn in small scale trials prior to use. Do not apply to sensitive plant species. Do not apply to wilted or otherwise stressed plants, or to newly transplanted materials or crops prior to root establishment. For optimal performance, do not mix with cold water (less than 45°F). Do not store below 40°F (4°C). Do not use or store near heat or open flame.	Non-synthetic
	Rosemary oil, clove oil, and thyme oil	Sporatec	1.5-3 pt in 100 gallons/ acre	0	0	NA. FIFRA §25(b) pesticide.	May be harmful if swallowed. Avoid contact with eyes, skin, and clothing. Avoid breathing vapors or spray mist. May be toxic to bees. Minimum risk to fish and aquatic organisms. Do not apply on plants when the temperature is 90°F or above. Do not apply to wilted or otherwise stressed plants, or to newly transplanted materials prior to root establishment. Check for leaf and flower burn in small-scale trials before conducting large-scale application. For optimal performance, do not mix with cold water (less than 45°F). Do not use, pour, spill or store near heat or open flames.	Non-synthetic
	Sesame oil	Organocide 3-in-1	1-2 gal/100 gal	0	0	NA. FIFRA §25(b) pesticide.	Insecticide, miticide, and fungicide. If spraying on severely stressed or damaged plants, consider using a lower rate such as 1 oz. per gallon to avoid adding additional stress. For best results, spray in the early morning.	Non-synthetic
Not classified; Organic acid	Citric acid	Nuke Em	Normal: 1 fl oz/31 fl oz water. Enhanced: 1.5 fl oz/30.5 fl oz water. Strong: 2 fl oz/32 fl oz water.	0	0	N/A. FIFRA §25(b) fungicide.	Do not spray on top of other insecticides. Do not mix with other insecticides. Store out of direct sunlight. Not for sale in Mississippi, Indiana or New Mexico. Makes a powdery mildew claim for all crops.	Non-synthetic

Golovinomyces cichoracearum (Powdery Mildew) / Lettuce: OMRI-Listed Fungicides for Use in the United States

(No efficacy data have been identified or evaluated.)

FRAC Code	Source: EPA Label							NOP Status
	Active Ingredient	Product Name	Product Rate/Acre	PHI (Days)	REI (Days)	EPA Reg. No.	Comments	
M1	Copper octanoate	Cueva Fungicide Concentrate	0.5-2.0 gal/100 gal water	0	4	67702-2-70051	Harmful if swallowed or absorbed through skin. Toxic to fish and aquatic organisms. May cause some copper toxicity on some plant species. Store away from open fire or flame. Product may be damaged by freezing. Do not store product below 4°C. Do not mix with chelated or liquid fertilizers. Use caution when using product with other fungicides and insecticides. For powdery mildew, plants that are very susceptible should be sprayed twice a week during the first 2 weeks after emergence and weekly thereafter. Use Precaution: Use lower rate on copper sensitive varieties of lettuce. Do not apply more than 2670 gallons of diluted spray per acre per year. Do not reapply within 5 days.	Synthetic
M2	Sulfur	Acoidal	5-10 lb	0	24	62562-4	Harmful if swallowed, inhaled, or absorbed through skin. Toxic to fish and aquatic organisms. Sulfur dust suspended in air ignites easily. Keep away from heat, sparks, or flames. Do not smoke while applying this product. Sulfur may cause severe fruit and foliage injury to certain crops. Sulfur may burn foliage when temperature is high. Do not apply within 2 weeks of an oil spray treatment. Apply at early leaf stage and repeat every 14 days or as needed. Thorough coverage is required.	Synthetic
		Defend DF	5-10 lb	0	24	62562-8		
		Kumulus DF	5-9 lb	0	24	51306-352-66330	Harmful if swallowed. Avoid breathing spray mist. Avoid contact with eyes, skin, and clothing. Do not apply within 2 weeks of an oil spray treatment. Do not store above 104°F. Store away from heat, sparks, and open flame. Apply at early leaf stage and repeat every 14 days or as needed.	
		Micro Sulf	3-10 lb	0	24	55146-75	Harmful if swallowed, inhaled, or absorbed through skin. Causes eye irritation. Risk of crop injury if temperature exceeds 90°F within 3 days following application. Do not use on any crop unless sulfur has been shown to be safe in your locality. Do not apply within 14 days of an oil spray. Keep away from heat, sparks, or flames. Do not smoke while applying this product. Apply at early leaf stage and repeat every 14 days or as needed.	
		Microthiol Disperss	5-10 lb	0	24	70506-187	Harmful if swallowed, inhaled, or absorbed through skin. Risk of crop injury if temperature exceeds 90°F within 3 days following application. Do not use on any crop unless sulfur has been shown to be safe in your locality. Do not store near flammable materials. Do not store in a manner where cross-contamination with other pesticides, fertilizers, food or feed could occur. Restrictions regarding application time before and after an oil spray treatment. Apply at early leaf stage and repeat every 14 days or as needed.	
		Thiolux	5-6 lb	0	24	34704-1079	Harmful if swallowed, inhaled, or absorbed through skin. Causes eye irritation. Sulfur may case severe fruit and foliage injury to certain crops. Risk of crop injury if temperature exceeds 90°F within 3 days following application. Do not apply within 14 days of an oil spray. Sulfur dust suspended in air easily ignites. Keep away from heat, sparks, or flames. Do not smoke while applying this product. Apply at early leaf stage and repeat every 14 days or as needed.	

Golovinomyces cichoracearum (Powdery Mildew) / Lettuce: OMRI-Listed Fungicides for Use in the United States **(No efficacy data have been identified or evaluated.)**								
FRAC Code	Source: EPA Label							NOP Status
	Active Ingredient	Product Name	Product Rate/Acre	PHI (Days)	REI (Days)	EPA Reg. No.	Comments	
Not classified; Inorganic salt	Potassium bicarbonate	EcoMate Amicarb O	2.5-5.0 lb/100 gal water	0	4	5905-541	Harmful if swallowed. Causes moderate eye irritation. Broad spectrum contact foliar fungicide. Prevent exposure to moisture during storage. Avoid contamination with other pesticides and fertilizers.	Synthetic
		Kaligreen	2.5-3 lb	1	4	70231-1	Harmful if swallowed, absorbed through skin, or inhaled. Do not mix with highly acidic products as effectiveness may be compromised. Use of a buffering agent for acidification of a tank mixture may also decrease effectiveness. Crop injury may result due to certain environmental or growing conditions, manner of use or application.	
		Milstop	2-5 lb	0	1	70870-1-68539	Harmful if swallowed. Causes moderate eye irritation. Broad spectrum contact foliar fungicide. Do not mix with other soluble pesticides or fertilizers. Not compatible with mild alkaline solutions. Acidification of solution will cause reduced product performance. Prevent exposure to moisture during storage. Avoid contamination with other pesticides and fertilizers.	
	Potassium silicate	Sil-Matrix	2-4 qt/100 gal	0	4	82100-1	Causes moderate eye irritation. Avoid contact with glass. Remove promptly from glass surfaces. Store product above 40°F. Do not store in aluminum, fiberglass, copper, brass, zinc, or galvanized containers. Protect from excessive heat. Broad spectrum preventative fungicide.	Synthetic
Not classified: Organic salt	Potassium salt of fatty acids	M-Pede	1.5-2% v/v	0	12	10163-324	WARNING signal word. Causes substantial but temporary eye injury and skin irritation. May be hazardous to aquatic invertebrates. Do not use with sulfur or within 3 days of a sulfur application. Apply M-Pede solutions to wet (minimize run-off) to decrease the potential for injury on foliage, fruit and flowers of sensitive plants. Avoid application to new transplants and unrooted cuttings.	Synthetic

Golovinomyces cichoracearum (Powdery Mildew) / Lettuce: OMRI-Listed Fungicides for Use in the United States **(No efficacy data have been identified or evaluated.)**								
FRAC Code	Source: EPA Label							NOP Status
	Active Ingredient	Product Name	Product Rate/Acre	PHI (Days)	REI (Days)	EPA Reg. No.	Comments	
Not classified; Oxidizing agent	Hydrogen dioxide, Peroxyacetic acid	Oxidate 2.0	Initial/Curative: 128 fl oz/ 100 gal water; 30-100 gal solution/acre Preventative: 40-128 fl oz/ 100 gal water; 30-100 gal solution/acre	0	Until dry	70299-2	DANGER signal word. Causes irreversible eye damage. May be fatal if swallowed. Causes skin irritation or temporary discoloration of exposed skin. Highly toxic to bees and other beneficial insects. Toxic to fish. Toxic to birds who eat treated seed on soil surface. Strong oxidizing agent. Do not use in undiluted form. Never bring undiluted product in contact with other pesticides, cleaners or oxidative agents. May react with residues of metal-based fungicides or supplements. Allow at least 24 hrs. after application of metal-based products. Do not spray during conditions of intense heat, drought, or poor plant vigor (or vine canopy). Do not apply in conjunction with any other pesticides or fertilizers. Do not allow product to become overheated in storage. Do not store in a manner where cross-contamination with other pesticides or fertilizers could occur. Apply consecutive applications until control is achieved; then apply preventative treatments.	Synthetic
	Hydrogen peroxide, Hydrogen dioxide	Perpose Plus	Initial/Curative: 1 fl oz/gal Weekly/Preventative: 0.25-0.33 fl oz/gal	0	Until spray has dried	86729-1	DANGER signal word. Causes irreversible eye damage and skin burns. May be fatal if absorbed through the skin. Harmful if swallowed. Do not breathe vapor from concentrate. Toxic to birds, mammals, fish and aquatic life. At temperatures exceeding 156°F, decomposition releases oxygen. The oxygen released could initiate or promote combustion of other materials. Store away from combustibles. Broad spectrum algaecide and fungicide. Apply curative rates for 3 consecutive days (drenching the entire plant) followed by weekly preventative treatments.	Synthetic

Golovinomyces cichoracearum (Powdery Mildew) / Lettuce: OMRI-Listed Fungicides for Use in the United States **(No efficacy data have been identified or evaluated.)**								
FRAC Code	Source: EPA Label							NOP Status
	Active Ingredient	Product Name	Product Rate/Acre	PHI (Days)	REI (Days)	EPA Reg. No.	Comments	
Not classified; Petroleum oils	Mineral oil	PureSpray Green	Dilute: 0.75 gal/100 gal at 150-300 gal water/A Concentrate: 1-3 gal	0	4	69526-9	Harmful if swallowed or absorbed through skin. Prolonged or repeated skin contact may cause allergic reaction in some individuals. Drift and runoff may be hazardous to aquatic organisms in water adjacent to treated areas. Use extreme care when using concentrate sprays as the potential for crop phytotoxicity is increased. Avoid excess heat. Do not spray during or immediately prior to hot or freezing weather (over 95°F or under 32°F), hot dry winds, rain or other unsuitable conditions. Do not overspray or double spray. Spray plants only when they are in vigorous condition and when their moisture condition is suitable. Before using, make certain spray tank is free of sulfur residues. Do not apply micronized sulfur within 10 days of an oil application. Do not apply oil within 14 days of an application of wettable or dusting sulfur. Do not apply to oil sensitive varieties. See label for additional compatibility restrictions regarding many conventional active ingredients.	Synthetic
		SuffOil-X	1-2 gal/100 gal water	0	4	48813-1-68539	Harmful if absorbed through skin. Prolonged or frequently repeated skin contact may cause allergic reactions in some individuals. Do not use in combination with any product containing sulfur. Do not use with any product whose label recommends the use of no oils. Do not use in combination with NPK foliar fertilizer applications. Do not apply during periods of drought or when plants exhibit moisture stress.	
	Paraffinic oil	Organic JMS Stylet Oil	3-6 qt/ 100 gal	0	4	65564-1	Harmful if swallowed. Toxic to fish. Do not freeze. Do not spray wet foliage. Do not spray when freezing temperatures are anticipated within 48 hours of an oil application, above 90°F (32°C) or when plants are under heat or moisture stress. Do not apply to vegetables when the temperature is below 50°F (10°C). Do not apply micronized sulfur within 10 days of an oil application. Do not apply oil within 14 days of an application of wettable or dusting sulfur. Do not apply to oil sensitive varieties. See label for additional compatibility restrictions.	Synthetic

Golovinomyces cichoracearum **(Powdery Mildew) / Lettuce: Efficacy Trials**

Golovinomyces cichoracearum (Powdery Mildew) / Lettuce #1: Trial No. CER-2012-074

a. Design

Golovinomyces cichoracearum (Powdery Mildew) / Lettuce #1: Trial No. CER-2012-074: Design			
Title:	Evaluation of Fungicides for Management of Downy and Powdery Mildew on Lettuce, 2013		
Authors and affiliation:	M. E. Matheron and M. Porchas Yuma Agricultural Center University of Arizona Yuma, AZ		
Publication:	PDMR 8:V199		
Location:	Yuma, Arizona		
Crop:	Lettuce ‘Winterhaven’		
Disease name:	Powdery mildew		
Pathogen:	*Golovinomyces cichoracearum*		
Test plot design:	Randomized complete block		
Number of replicates:	5		
Application equipment:	Tractor mounted spray boom (100 psi)		
Spray volume:	50 gal/acre		
Number of applications:	4		
Chronology:	Application Dates	Application Interval	Disease Assessment Dates
	01/23/2012		03/01/2012
	01/31/2012	8 days	
	02/07/2012	8 days	
	02/18/2012	11 days	

b. Results

Golovinomyces cichoracearum (Powdery Mildew) / Lettuce #1: Trial No. CER-2012-074: Results						
Treatment	Rate/ Acre	g a.i./ ha	Active Ingredient	FRAC Code	Severity Rating (0 to 5 Scale)	
					Measured	Percent Control
Untreated control			Not Applicable		3.9	
CX-10440 [A]	3.75 fl oz	14	Polyoxin D zinc salt	19	1.2	69
CX-10440 [A]	6.5 fl oz	25	Polyoxin D zinc salt	19	1.2	69
Microthiol Disperss	10.0 lb		Sulfur	M2	0	100
Quadris	15.4 fl oz		Azoxystrobin	11	1.3	67
Fracture	24.4 fl oz		Banda de Lupinus albus doce (BLAD)	NC	2.1	46

Rating scale:
0 = No powdery mildew present.
1 = Powdery mildew present on bottom leaves of plant.
2 = Powdery mildew present on bottom leaves and lower wrapper leaves.
3 = Powdery mildew present on bottom leaves and all wrapper leaves.
4 = Powdery mildew present on bottom leaves, wrapper leaves, and cap leaf.
5 = Powdery mildew present on entire head.
A. CX-10440 is the Certis USA, L.L.C. code for Polyoxin D Zinc Salt 5SC Fungicide.

Powdery mildew was first observed on February 7, 2015, *i.e.*, *before* the final treatment. Therefore, the treatments were preventative and curative.

No phytotoxicity was observed.

c. Discussion and Conclusions

Lettuce was grown in Arizona. The powdery mildew pressure in the untreated control was 3.9 on a 0 to 5 scale for which:

- A rating of 3 indicated that powdery mildew was present on bottom leaves, wrapper leaves, and cap leaf, and
- A rating of 4 indicated that powdery mildew was also present on cap leaves.

Four treatments of Polyoxin D Zinc Salt 5SC Fungicide were applied preventatively and curatively at 8-day to 11-day intervals. The Polyoxin D Zinc Salt 5SC Fungicide treatments did not provide a positive dose response.

- Treatments at 3.75 fl oz/acre provided 69% control of downy mildew.
- Treatments at 6.5 fl oz/acre also provided 69% control of downy mildew.

The Polyoxin D Zinc Salt 5SC Fungicide treatments provide control of powdery mildew on lettuce that was:

- Superior to the untreated control;
- Superior to the 46% control provided by Banda de Lupinus albus doce (BLAD) (Fracture);
- Superior to but probably statistically equivalent to the 67% control provided by azoxystrobin; and
- Less than the 100% control provided by sulfur.

No phytotoxicity was observed.

Leviellula taurica (POWDERY MILDEW) / TOMATOES

Leviellula taurica (Powdery Mildew) / Tomatoes: Introduction

(Source: University of California Pest Management Guidelines, Powdery Mildew on Field-Grown Tomatoes, September 11, 2015.)

Leaves on infected tomato plants develop irregular, bright yellow blotches. Severely affected leaves die but seldom drop. Spots of dead tissue, sometimes surrounded by a yellow halo, eventually appear in the blotches. Abundant white sporulation may be observed on upper or lower leaf surfaces. There are no lesions on stems or fruit. As the disease progresses, leaves die, resulting in sunburn damage on fruit, reduced soluble solids, and weakened plants.

Powdery mildew occurs in most tomato-growing areas of California. The fungus infects weeds and crops in the solanaceous family. Spores are carried by wind to tomato plants. The disease usually is most severe late in the season. High relative humidity favors disease development. Mild temperatures favor infection while higher temperatures hasten the death of infected leaves. Plants stressed by other problems appear to be more susceptible to powdery mildew.

Leviellula taurica (Powdery Mildew) / Tomatoes: Disease Management

(Source: University of California Pest Management Guidelines, Powdery Mildew on Field-Grown Tomatoes, September 11, 2015.)

There are no immune tomato varieties in California, though varieties vary in susceptibility.

When conditions are conducive to disease development and sporulation is abundant, fungicide applications may be necessary to control powdery mildew. *Bacillus pumilus* (Sonata) and some sulfur sprays may be acceptable for use on organically certified produce.

A weather-based, forecasting model is available online. The model attempts to predict the occurrence of powdery mildew based on temperature, relative humidity, and leaf wetness. However, since 2007, the disease has been more severe and faster developing such that disease severity and fungicide timings have not been well predicted by the model in recent years.

Fungicides may not be needed on early-season crops harvested in July or August. In the Central Valley, disease outbreaks generally start in July or August and mainly affect plants that are at full-bloom or a later stage. Multiple, early applications of sulfur dust are the most effective option. Once the disease becomes severe, control is difficult. Apply fungicides if needed preventatively or during the early infection period. When disease pressure is high, repeat fungicide applications at 7-day intervals to control the disease. Stop treatments within two weeks of harvest.

Leviellula taurica (Powdery Mildew) / Tomatoes: OMRI-Listed Fungicides for Use in the United States

Please see *Odium neolycopersici* (POWDERY MILDEW) / TOMATOES (GH).

Leviellula taurica (Powdery Mildew) / Tomatoes: Efficacy Trials

Leviellula taurica (Powdery Mildew) / Tomatoes #1: Trial No. CER-2012-016

a. Design

Leviellula taurica (Powdery Mildew) / Tomatoes #1: Trial No. CER-2012-016: Design			
Title:	Evaluation of Fungicides for Control of Powdery Mildew (*Leviellula taurica*) on Tomato, 2012		
Author and affiliation:	Brenna Aegerter University of California Cooperative Extension San Joaquin County		
Publication:	Not published. Permission received.		
Location:	Collegeville, CA		
Crop:	Tomato cv Bobcat (a fresh market variety)		
Disease name:	Powdery mildew		
Pathogen:	*Leviellula taurica*		
Test plot design:	Randomized complete block		
Number of replicates:	4		
Application equipment:	CO_2 backpack sprayer (34 psi)		
Spray volume:	Not reported		
Number of applications:	3		
Application interval:	9 days and 14 days		
Chronology:	Application Dates	Application Interval	Disease Assessment Date
	08/27/2012		09/18/2012
	09/10/2012	14 days	09/26/2012
	09/19/2012	9 days	10/02/2012
Disease assessment methodology:	Percentage of foliage that was affected by powdery mildew using a 10-point pre-transformed rating scale		

b. Results

Leviellula taurica (Powdery Mildew) / Tomatoes #1: Trial No. CER-2012-016: Results								
Treatment	Rate/ Acre	g a.i./ ha	Active Ingredient	FRAC Code	Severity on Oldest Leaves (%) (9/26/2012)		Fruit Biomass (Tons/Acre)	
					Measured	Percent Control	Measured	Difference
Untreated control			Not Applicable		93.5 a		27.5	
CX-10440 [1]	13 fl oz	50	Polyoxin D zinc salt	19	49.3 cd	47.3	31.5	14.5%
Microthiol	20 lb		Sulfur	M2	28.0 de	70.1	25.7	-6.5%
Sonata	4 qt		*Bacillus pumilis* strain QST 2808	44	71.0 ab	24.1	28.8	4.7%

Treatment means followed by the same letter are not statistically different according to the Fisher's protected least significant difference test.
1. CX-10440 is the Certis USA, L.L.C. code for Polyoxin D Zinc Salt 5SC Fungicide.

The report notes:

- "At the time of the initial application, powdery mildew was present in the field; however symptoms were not yet apparent in the test area."
- "Powdery mildew developed in the field beginning in late August and progressed quite rapidly to a high level of disease. There was a high spore load in the air from an adjacent older tomato field. In non-treated areas, the older foliage became completely necrotic while the intermediate foliage was covered with necrotic spots and/or sporulating lesions and the new foliage showed early sporulation or yellow spotting."

Therefore, the treatments were curative.

No phytotoxicity was observed.

c. Discussion and Conclusions

Tomatoes were field-grown in California. The powdery mildew (*Leviellula taurica*) severity on oldest leaves was 93.5% in the untreated control on September 26, 2012.

Three treatments with Polyoxin D Zinc Salt 5SC Fungicide applied curatively at 13 oz/acre (50 g a.i./ha) at 9-day to 14-day intervals provided control of powdery mildew (*Leviellula taurica*) on tomato that was statistically:

- Superior to the untreated control and to the control provided by *Bacillus pumilis* strain QST 2808 (Sonata); and
- Less than the control provide by sulfur.

Three treatments with Polyoxin D Zinc Salt 5SC Fungicide applied at 13 oz/acre (50 g a.i./ha) provided:

- 14.5% increase in fruit biomass; and
- Greater yield than the untreated control, sulfur, and *Bacillus pumilis* strain QST 2808 (Sonata).

No phytotoxicity was observed.

Leviellula taurica **(Powdery Mildew) / Tomatoes: Grower Need**

Zero-day PHI products for use on greenhouse vegetables (Project No. B00024) was identified as a grower need at the IR-4 2015 Biopesticide Workshop.

Monilinia fructicola and *Monilinia laxa* (BROWN ROT) / STONE FRUITS

Monilinia spp. (Brown Rot) / Stone Fruits: Introduction

(Source: D. F. Richie, Brown Rots of Stone Fruits, The American Phytopathological Society. Updated 2005.)

Disease:	Brown rot of stone fruits
Pathogen:	*Monilinia fructicola*, *Monilinia laxa*, and *Monilinia fructigena*
Hosts:	Stone fruits (peach, nectarine, cherry, plum), almond, and occasionally some pome fruits (apple and pear)

Worldwide, brown rot is the most important disease risk for stone fruits in warm, humid climates. It is the primary disease for which fungicides are applied to stone fruits.

The brown rot fungi cause a blight of blossoms and twigs and a soft decay of fruits of peaches, cherries, and plums. Thus, there are two distinct phases of this disease:

1. Blossom and Twig Blight

This phase of the disease occurs in early spring when the trees are blooming, although twig blight also can occur during the fruit rot phase. The anthers and pistil of the flower are infected initially. The fungus then invades the floral tube, the ovary, peduncle, and usually the twig to which the peduncle is attached. Infected blossoms wilt, turn brown, and usually cling to the twig. Extension of the infection into the peduncle and twig results in a necrotic area in the woody tissue termed a "canker". Sometimes succulent twigs and shoots become infected directly when there are extended periods of both moisture and warm temperatures (20 to 28ºC, 68 to 82ºF).

Under moist or humid conditions, ash-gray-brown colored sporodochia (tufts of conidiophores) bearing conidia (asexual spores) form on the surface of diseased blossoms and twigs. The presence of conidia is a diagnostic sign that separates brown rot from other fungal and bacterial diseases of stone fruits. A gummy substance usually exudes from the cankers, causing the blighted flowers to adhere to the twig.

2. Fruit Rot

Fruit susceptibility to brown rot increases during the 2 to 3 week period prior to harvest. Increased susceptibility is associated with an increase in sugar content as the fruits ripen. Initially, tan-brown, circular spots are visible on the fruit. Under humid conditions, ash-gray-brown masses of conidia develop on these lesions. There can be thousands of conidia on a lesion, each potentially capable of initiating a new infection. If environmental conditions are wet and warm during fruit ripening, the entire crop can literally be destroyed"overnight."

Diseased fruit that do not fall to the ground dehydrate and become shriveled "mummies" that cling to the branch. Sometimes the fungal infection extends from the fruit into the twig and branch. Although not common, brown rot also can occur on ripe apples and pears.

Monilinia spp. (Brown Rot) / Stone Fruits: Pathogen Biology

(Source: D. F. Richie, Brown Rots of Stone Fruits, The American Phytopathological Society. Updated 2005.)

Monilinia fructicola, Monilinia laxa, and *Monilinia fructigena*

The first published description of a brown rot fungus on decaying fruit was in 1796. Different species of brown rot fungi were later discovered. The fruit-rotting fungi were placed in the genus *Sclerotinia* in the late 1800s and were transferred to the new genus *Monilinia* in 1928. Of the three closely related fungal species causing brown rot:

- *Monilinia fructicola* is the species most commonly found in North America, Australia, New Zealand, Japan, Brazil and other South American countries.
- *Monilinia laxa* is found in all major fruit producing countries where brown rot occurs. *Monilinia laxa* is relatively widespread in California and also occurs in the midwestern and northeastern states, but has not been found in the southeastern states. This species is especially common in Europe, South Africa, and Chile. The disease it causes is frequently called "European brown rot."
- *Monilinia fructigena* occurs on both stone and pome fruits in Europe, but does not cause the extensive crop loss caused by *Monilinia laxa* and *Monilinia fructicola*. The mycelial growth characteristics of the three *Monilinia* species vary when they are grown on 2% potato-dextrose agar (PDA) medium. Isolates of *Monilinia fructicola* can have different fruit rotting and sporulation capabilities.

Asexual Reproduction
Conidia (asexual spores) are produced on tufts of conidiophores called sporodochia. The conidia are hyaline (colorless), lemon-shaped, and produced in a moniloid manner (resembling a string of beads with constricted ends). Under ideal conditions, conidia germinate within 3 to 5 hours. Extensive mycelial growth can occur within 24 hours.

Sexual Reproduction
Brown rot fungi are ascomycetes. They produce ascospores (sexual spores**)** in tubular sacs termed asci that are produced on the upper surface of a cup- or disc-shaped structure, known as an apothecium. Apothecia can be 5-20 mm (up to nearly an inch) in diameter and are borne on mummified fruit that have fallen to the ground. Although commonly described in textbooks, apothecia are rarely observed in most areas.

Epidemiology
The opening blossoms are the first emerging susceptible tissue in the spring. Sources of blossom blight inoculum are mummies, infected peduncles, and cankers. Conidia from these sources are disseminated by splashing or wind-blown rain.

Infrequently, apothecia develop from mummies on the orchard floor or beneath secondary hosts such as wild plums and other *Prunus* spp. surrounding the orchard. Ascospores are released during rainfall and are carried by wind to the blossoms.

Blossom infection is highly dependent on wetness duration and temperature. For blossom infection to occur at 10ºC (50º F), 18 hours of wetting are necessary. At 24ºC (77º F) only 5 hours are necessary. The time required for symptoms of blossom blight to develop may be only a few days to 1 or 2 weeks depending on the temperature. Blighted blossoms often are obscured as new flushes of leaf growth occur. Thus, the first evidence that infection has occurred may be yellow and wilting leaves on branches or twigs. It takes very few blighted blossoms to cause severe fruit rot if environmental conditions are optimal as fruit ripen.

As fruit ripen and the sugar content increases, they become increasingly susceptible to infection. In contrast, green, immature fruit are less prone to infection unless they are injured. Inoculum sources for fruit infection include blighted blossoms, cankers, mummies from the previous year, and diseased fruit in the tree or on the orchard floor from thinning practices. The amount of inoculum is very important in determining the severity of brown rot. Warm, wet or humid weather during the 2 to 3 week period prior to harvest increases disease severity because it increases both the level of inoculum and the amount of infection. If wet weather extends into the harvest period, fruit loss can be severe. Insects, such as June beetles, which are attracted to overripe fruit, can increase disease severity not only by carrying the fungal conidia but also by creating wounds as they feed. Wet, warm conditions also increase overwintering inoculum available for blossom infections the following spring.

Monilinia spp. (Brown Rot) / Stone Fruits: Disease Management
(Source: D. F. Richie, Brown Rots of Stone Fruits, The American Phytopathological Society. Updated 2005.)

Orchard Location
Orchard location is important. Trees planted in orchards having poor air movement, and thus slow drying conditions, are more likely to have blossom blight and brown rot. Successful management of blossom blight and brown rot involves a combination of sanitary practices to reduce the amount of initial inoculum and the judicious use of fungicides. When compared to the results of good sanitation and cultural practices, biological control has had minimal success in the orchard. Biological control has shown better potential for prevention of post-harvest fruit decay.

Sanitation practices
The removal of diseased fruit mummies and blighted twigs from the trees and removal of fruit and mummies from the orchard floor following the final harvest can substantially reduce sources for overwintering inoculum. The orchard floor can be kept clean of vegetation, or the area can be raked or lightly cultivated to bury mummies and prevent the development of apothecia. However, care must be used not to cultivate too deeply to avoid damaging tree roots. If practical, wild Prunus spp. adjacent to the orchard should be removed.

Fungicides
Blossom blight occurrence is very much dictated by the weather conditions. In areas where blossom infection occurs, 1 to 3 fungicide sprays beginning just as the blossoms open control blossom blight.

For brown rot control, 2 to 3 fungicide sprays are usually applied during the 2 to 3 week period leading up to harvest. When combined with good cultural practices, currently registered fungicides are highly effective. In addition, insect control, especially for insects that directly damage fruit, is important during this period.

Disease Risk Analysis and Decision Support Systems
In an effort to more judiciously use fungicides to manage this disease, risk analysis and support systems for decision-making have been developed. These link temperature and moisture conditions, inoculum potential, potential for latent infections and tree growth stages such as bloom and fruit ripening. Such risk analysis systems may provide a risk predication for anticipated disease severity and aid in making decisions as to the need for fungicide sprays.

Post-Harvest Control
Practices used during harvest can significantly impact the amount of fruit decay following harvest. Picking and handling fruit carefully to avoid injuries, cooling fruit promptly after harvest by hydro-cooling or forced air cooling, using clean containers to hold the fruit, and timely harvesting of ripening fruit all help reduce post-harvest brown rot problems. Fungicides are commonly used to reduce post-harvest fruit decay, but there has been considerable research on alternative control methods.

Significance
Worldwide, brown rot poses the greatest disease risk for crop loss where stone fruits are grown in warm, wet climates. The disease has been studied for almost 200 years in Europe, for more than a 100 years in North America, and in other parts of the world as the fruit industries developed. Until the discovery and development of highly effective fungicides during the last quarter to half-century, significant losses from brown rot could be expected when fruit ripening coincided with periods of rainfall.

The use of fungicides, however, has not been without its problems. When highly effective and specific fungicides were used, brown rot fungi became resistant to them. The brown rot fungi have been used to study resistance to fungicides, serving as a model for development of strategies for managing or delaying the occurrence of fungicide resistance in plant pathogenic fungi.

Monilinia fructicola and *M. laxa* (Brown Rot) / Stone Fruit: OMRI-Listed Fungicides for Use in the United States
(No efficacy data have been identified or evaluated.)

Source: EPA Label

FRAC Code	Active Ingredient	Product Name	PHI (Days)	REI (Days)	EPA Reg. No.	Comments	Brown Rot Blossom Blight/Twig Blight	Brown Rot Fruit Rot	NOP Status
44	*Bacillus amyloliquefaciens* str. D747	Double Nickel 55	0	4	70051-108	Causes moderate eye irritation. Dermal sensitizer. Broad-spectrum preventative fungicide. Do not use highly alkaline or highly acidic water to mix sprays. Use a buffering agent if necessary to maintain neutrality (pH 6 to 8) of water in the tank. Suppression only; for improved control mix or rotate with chemical fungicide approved for such use.	All stone fruit/Brown rot blossom blight (*Monilinia laxa*). Start applying at early bloom stage and repeat every 7 days through petal fall.	All stone fruit/Brown rot (*Monilinia fructicola*) Suppression only. For improved control mix or rotate with chemical fungicide approved for such use. Pre-harvest applications in sufficient water to cover fruit or other harvested plant parts may improve control of postharvest infections.	Non-synthetic
	Bacillus pumilus str. QST 2808	Sonata ASO	0	4	264-1153	Harmful if inhaled. Mixers/loaders and applicators must wear a dust/mist filtering respirator meeting NIOSH standards of at least N-95, R-95, or P-95. Repeated exposure to high concentrations of microbial proteins can cause allergic sensitization. Maintain a spray solution pH between 4.5 and 8.5.	All stone fruit/Brown rot blossom blight (*Monilinia fructicola*): Begin application at early bloom and repeat at through petal fall at 7- to 14- day intervals as needed.	NA	Non-synthetic
	Bacillus subtilis str. QST 713	Optiva	0	4	62592-26	Causes moderate eye irritation. Dermal sensitizer. Broad spectrum preventative product. For suppression, begin application when plants are 4 to 6 inches high. Repeat applications on a 5- to 7-day interval or as needed. For improved performance, use in a tank mix or rotational program with other registered fungicides. Use shorter spray intervals under conditions conducive to rapid disease development.	All stone fruit/Brown rot blossom blight (*Monilinia fructicola*): Apply 14-24 lb/acre. Begin application at early bloom and repeat through petal fall on a 7-day interval or as needed.	All stone fruit/Fruit Brown Rot (*Monilinia fructicola*): Apply 14-24 lb/acre. Suppression. Begin application prior to disease development when environmental conditions and plant stage are conducive to rapid disease development and repeat on a 7- to 10-day interval or as needed.	Non-synthetic
		Serenade ASO	0	4	264-1152	Broad spectrum preventative fungicidal and bactericidal product. For suppression, begin applications when plants are 4 to 6 inches high. Repeat applications on 5- to 7-day intervals or as needed. For improved performance, use in a tank-mix or rotational program with other registered fungicides. Use the stated shorter spray intervals under conditions conducive to rapid disease development.	All stone fruit/Brown rot blossom blight (*Monilinia laxa*): 2-6 qt/acre. Begin applications at early bloom and repeat through petal fall on 7-day intervals or as needed.	NA	
		Serenade MAX	0	4	69592-11	Dermal sensitizer. Broad spectrum preventative fungicidal and bactericidal product. For suppression begin applications when plants are 4 to 6 inches high. Repeat applications on 5 to 7 day intervals or as needed. For improved performance use in a tank mix or rotational program with other registered fungicides. Use shorter spray intervals under conditions conducive to rapid disease development.	All stone fruit/ Brown Rot blossom blight (*Monilinia laxa*): 1-3 lb/acre. Begin applications at early bloom and repeat through petal fall on 7 day intervals or as needed.	All stone fruit/ Fruit Brown Rot Monilinia fruticola: 1-3 lb/acre. For suppression begin applications prior to disease development when environmental conditions and plant stage are conducive to rapid disease development Repeat on 7 to 10 day intervals or as needed.	
P5	*Reynoutria sachalinensis*	Regalia Biofungicide	0	4	84059-3	Causes moderate eye irritation. Preventative rather than a curative application. Apply prior to disease infestation to protect the growing leaf tissue. Avoid freezing. Repeat of 7-10 day intervals. Tank mix with other registered fungicides for improved disease control under heavy pressure.	All stone fruit/ Brown rot blossom blight (*Monilinia laxa*): 1-4 qt/acre. Begin application of this product in 50–100 gallons of water per acre at early bloom, and repeat through petal fall on a 7-day interval or as needed.	All stone fruit/ Brown Rot Fruit Rot (*Monilinia fruticola*): 1-4 qt/acre. Begin application prior to disease development when environmental conditions and plant stage are conducive to rapid disease development, and repeat on a 7–10-day interval or as needed. Use in a tank mix or rotational program when disease conditions are severe.	Non-synthetic

Monilinia fructicola and *M. laxa* (Brown Rot) / Stone Fruit: OMRI-Listed Fungicides for Use in the United States (No efficacy data have been identified or evaluated.)									
FRAC Code	Source: EPA Label								NOP Status
	Active Ingredient	Product Name	PHI (Days)	REI (Days)	EPA Reg. No.	Comments	Brown Rot Blossom Blight/Twig Blight	Brown Rot Fruit Rot	
M1	Basic copper sulfate	Basic Copper 53	NA	24	45002-8	WARNING signal word. Causes substantial but temporary eye injury. Harmful if absorbed through skin or inhaled. Dermal sensitizer. Toxic to fish and aquatic organisms. Begin making before disease appears. Repeat at 7 to 10 day intervals as needed. Cherries: Do not apply non-dormant sprays to sweet cherries or the English Morelo variety as severe crop injury may result.	Apricots/Brown rot blossom blight: Apply 14-20 lb/acre. For suppression in buds, apply lower rate through swelling buds and popcorn stage. Do not spray trees in leaf. When bud blight is a problem, apply the maximum rate after most leaves have fallen, usually in November or December, but ahead of fall rains. Spray may injure tender foliage. Cherries (sour only, excluding Great Lakes region)/ Brown rot blossom blight: Apply 12-16 lb/acre. For suppression, apply in red bud, popcorn, and late bloom stages. Cherries (sour only, Great Lakes region)/ Brown rot blossom blight: For suppression, use 3 lb/ acre or 1 lb/100 gal spray. Begin sprays at bud burst stage and apply at weekly intervals to late May. Later sprays may be phytotoxic causing some leaf defoliation. Peaches, nectarines/Brown rot blossom and twig blight: For suppression, apply 16-25 lb/acre as a dilute spray of 400-500 gallons/acre (4-5 lb per 100 gal). Apply before bud swell and again at full pink bud to popcorn stage before leaves emerge. Plums, prunes / Brown rot blossom and twig blight: For suppression, mix 4-5 lb per 100 gallons water for dilute spray or use 16-25 lb/acre. Apply in early bud and full bloom stages.	NA	Synthetic

Monilinia fructicola and *M. laxa* (Brown Rot) / Stone Fruit: OMRI-Listed Fungicides for Use in the United States (No efficacy data have been identified or evaluated.)									
FRAC Code	Source: EPA Label								NOP Status
	Active Ingredient	Product Name	PHI (Days)	REI (Days)	EPA Reg. No.	Comments	Brown Rot Blossom Blight/Twig Blight	Brown Rot Fruit Rot	
	Copper hydroxide	Nu-Cop 50 WP	NA	24	42002-7	DANGER signal word. Corrosive. Causes irreversible eye damage. Harmful if swallowed, absorbed through skin, or inhaled. Skin sensitizer. Toxic to fish and aquatic organisms. Product should not be applied in spray water having a pH of less than 6.5 as phytotoxicity may result. Effectiveness reduced at pH greater than 9.0. Apply at 7-10 day intervals. Use more frequent application when disease pressure is high.	Apricot: Brown rot blossom blight: Apply at popcorn to full bloom using 8-12 lb/acre. Use higher rate when conditions favor disease. Do not apply after bloom as crop injury may result. Cherries/Brown rot blossom blight: Apply 2-3 lb per 100 gal water as a full cover spray. Apply at popcorn and full bloom. Plum, prune/Brown rot blossom blight: Apply 8-12 lb per acre as a full cover application at pink, red, or early white bud stage. Use the higher rate when disease pressure is heavy or conditions favor disease development. Peaches, nectarines/ Brown rot blossom blight: Apply 8-12 lb per acre as a full cover application at pink, bud.	NA	Synthetic
		Champ WG	NA	48	55146-1	DANGER signal word. Corrosive. Causes irreversible eye damage. Harmful if inhaled. Skin sensitizer. Toxic to fish and aquatic organisms. Begin when disease first threatens and repeat at 7 to 10 day intervals depending on disease severity.	Apricot, cherry, plum, prune/Brown rot blossom blight: 8-16 lb/acre. Min 7-day interval. Apply before foliage buds begin to swell. For early bloom (popcorn) application, apply 6-8 lb/acre. Apply before full bloom. To avoid plant injury, do not use after full bloom. Peach, nectarine/ Brown rot blossom blight: 3.0 lb/acre. Min. 7-day interval. Apply as a full cover spray at pink bud. 3-week PHI. Use only specified rates. Spotting of leaves and defoliation may occur from use in cover sprays.	NA	
	Copper hydroxide, Copper oxychloride	Badge X2	NA	48	80289-12	WARNING signal word. May be fatal if swallowed. Causes substantial but temporary eye injury. Harmful if absorbed through skin. Harmful if inhaled. Toxic to fish and aquatic organisms. Begin when disease first threatens and repeat at 3 to 10 day intervals depending on disease severity. Product must not be applied in a spray solution having a pH of less than 6.5 as phytotoxicity may occur. Do not tank mix product with Aliette® fungicide for use on any registered crops or ornamentals unless appropriate precautions have been taken to buffer the spray solution because severe phytotoxicity may result. Cherries: Do not apply to sweet cherry or the English Morello variety as severe injury will result. Moderate to severe injury such as leaf spotting and defoliation may occur from post-bloom applications. Stone Fruits: Do not apply after full bloom or injury may occur.	Peach, nectarine/Brown rot blossom blight: 3.5-5.25 lb/acre. Min 5-day interval. Full cover spray at pink bud. Use the higher rates when conditions favor disease development.	NA	Synthetic

Monilinia fructicola and *M. laxa* (Brown Rot) / Stone Fruit: OMRI-Listed Fungicides for Use in the United States
(No efficacy data have been identified or evaluated.)

FRAC Code	Active Ingredient	Product Name	PHI (Days)	REI (Days)	EPA Reg. No.	Comments	Brown Rot Blossom Blight/Twig Blight	Brown Rot Fruit Rot	NOP Status
	Source: EPA Label								
	Copper octanoate	Cueva Fungicide Concentrate	NA	4	67702-2-70051	Harmful if swallowed or absorbed through skin. Toxic to fish and aquatic organisms. May cause some copper toxicity on some plant species. Store away from open fire or flame. Product may be damaged by freezing. Do not store product below 4°C. Do not mix with chelated or liquid fertilizers. Use caution when using product with other fungicides and insecticides. Do not reapply within 3 days.	Apricots, cherries, peaches, nectarines, plums/ Brown rot blossom blight: Full crop group: 0.5-2.0 gal/100 gal water. Apply full cover spray at delayed dormant (bud swell), popcorn, full bloom and petal fall stages. During wet weather, additional bloom sprays may be necessary.	NA	Synthetic
	Copper sulfate pentahydrate	CS 2005	NA	48	66675-3	DANGER signal word. Corrosive. Causes irreversible eye damage and skin irritation. Harmful if swallowed, inhaled or absorbed through the skin. Dermal sensitizer. Toxic to fish and aquatic organisms. Do not mix with acidic compounds. Do not mix with pot ash. Store away from excessive heat. Product will freeze. Store and handle product in 316L stainless steel, fiberglass, PVC's, polypropylenes or plastic equipment. Keep away from galvanized pipe and any nylon storage handling equipment. Begin applications when disease first threatens and repeat at 5 to 10 day intervals or as needed depending on disease severity. Use the higher rates when conditions favor disease. Cherries: Do not apply to sweet cherry or the English Morello variety as severe injury will result. Moderate to severe injury such as leaf spotting and defoliation may occur from post bloom applications. Stone fruits: Do not apply after full bloom or injury may occur.	Apricot, cherry, plum, prune/ Brown rot blossom blight: 60-90 oz/acre. Apply during early bloom. Do not apply after full bloom or injury may occur. Use the higher rates when rainfall is heavy and disease pressure is high.	NA	Synthetic
	Cupric hydroxide	Nu-Cop 50DF	NA	24	45002-4	DANGER signal word. Corrosive. Causes irreversible eye damage. Harmful if swallowed or absorbed through skin. Dermal sensitizer. Toxic to fish and aquatic organisms. Effectiveness reduced at pH greater than 9.0. Begin when disease first threatens and repeat at 7 to 10 day intervals or as needed depending on disease severity. Use higher rate for severe disease. Product should not be applied in spray water having a pH of less than 6.5 as phytotoxicity may result. Cherries: To avoid injury, do not apply after full bloom.	Apricot/Brown rot blossom blight: 8-12 lb/acre. Apply at popcorn to full bloom and use higher rate when conditions favor disease. Applications after full bloom will result in crop injury. Cherry/Brown rot blossom blight: 8-12 lb/acre. Apply a full cover spray at popcorn stage and second application at full bloom. to avoid crop injury, do not use after full bloom. Peaches, nectarines/ Brown rot blossom blight: 8-12 lb/acre. Apply as a full cover spray at pink bud. Spotting on leaves and defoliation may occur from use in cover sprays. Prunes, plums/Brown rot blossom blight: 8-12 lb/acre. Apply full cover application at pink, red, or early white bud stage. Use the higher rate when disease pressure is heavy or conditions favor disease development.	NA	Synthetic

Monilinia fructicola and *M. laxa* (Brown Rot) / Stone Fruit: OMRI-Listed Fungicides for Use in the United States
(No efficacy data have been identified or evaluated.)

FRAC Code	Active Ingredient	Product Name	PHI (Days)	REI (Days)	EPA Reg. No.	Comments	Brown Rot Blossom Blight/Twig Blight	Brown Rot Fruit Rot	NOP Status
	Source: EPA Label								
		Nu-Cop HB	NA	24	42750-132	DANGER signal word. Corrosive. Causes irreversible eye damage. Harmful if swallowed, absorbed through skin, or inhaled. Begin when disease first threatens and repeat at 7-10 day intervals or as needed depending on disease severity. Use higher rate for severe disease. Product should not be applied in spray water having a pH of less than 6.5 as phytotoxicity may result. Apricots: To avoid crop injury, do not apply after full bloom.	Apricot/Brown rot blossom blight: 3 lb/acre; 5-day interval. Apply at popcorn to full bloom as a full cover spray. To avoid spray injury, do not apply after full bloom. Cherry/Brown rot blossom blight: 2.0-3.0 lb/acre. Min. 5-day interval. Peaches, nectarines/Brown rot blossom blight: 4.0-6.0 lb/acre. Min 7-day interval. 8-12 lb/acre. Apply as a full cover spray at pink bud. Do not use rates above those recommended. Plums, prunes/Brown rot blossom blight: 2.0-3.0 lb/acre. Min 5-day interval. Apply full cover application at pink, red, or early white bud stage. Use the higher rate when disease pressure is heavy or conditions favor disease development.	NA	Synthetic
	Cuprous oxide	Nordox 75 WG	NA	12	48142-4	Harmful if swallowed or absorbed through skin. Causes eye irritation. Apply prior to the appearance of disease and repeat at 7-10 day intervals. Do not apply in a spray solution with a pH of less than 6.5. Apricots: Slight leaf injury may occur.	Apricot/Brown rot blossom blight: 5-13 lb/acre. Apply through popcorn stage. Do not apply after bloom. Cherries/Brown rot blossom blight: 5-13 lb/acre. Apply a popcorn and full bloom. Peaches, nectarine/Brown rot blossom blight: 5-13 lb/acre. Apply before bud swell in the full pink bud stage. Plums, prunes/Brown rot blossom blight: 8-13 lb/acre. Apply at early green bud to full popcorn stages.	NA	Synthetic

Monilinia fructicola and *M. laxa* (Brown Rot) / Stone Fruit: OMRI-Listed Fungicides for Use in the United States
(No efficacy data have been identified or evaluated.)

FRAC Code	Source: EPA Label								NOP Status
	Active Ingredient	Product Name	PHI (Days)	REI (Days)	EPA Reg. No.	Comments	Brown Rot Blossom Blight/Twig Blight	Brown Rot Fruit Rot	
M2	Calcium polysulfide	Rex Lime Sulfur Solution	2	48	71096-6	DANGER signal word. Corrosive. Causes irreversible eye damage. Causes skin burns. Harmful if swallowed or if absorbed through skin. Toxic to fish. Do not mix with acids or phosphate fertilizer products. Deadly and potentially extremely flammable hydrogen sulfide gas may be emitted. Do not store near fertilizers. Crop injury statements.	Cherries (sweet & tart)/Brown rot blossom blight: Apply 1½ to 2 gallons of product per 100 gallons of water. Begin at white bud (popcorn) and repeat every 10 to 14 days through bloom if rains continue. Peaches, nectarines/Brown rot blossom blight: Apply 1½ to 2 gallons of product per 100 gallons of water. Begin at pre-bloom and repeat every 10 to 14 days through bloom if rains continue. Plums, prunes/Brown rot blossom blight: Apply 1½ to 2 gallons of product per 100 gallons of water. Begin at white bud and repeat every 10 to 14 days through bloom if rains continue.	Cherries (sweet & tart)/ Brown rot fruit rot: Apply ½ gallon of product per 100 gallons of water. Apply 3 to 5 sprays at weekly intervals up to 2 days before harvest. Peaches, nectarines/Brown rot fruit rot: Apply ½ gallon of product per 100 gallons of water. Apply 3 to 5 sprays at weekly intervals up to 2 days before harvest. Plums, prunes/Brown rot fruit rot: Apply ½ gallon of product per 100 gallons of water. Apply 3 to 5 sprays at weekly intervals up to 2 days before harvest.	Synthetic
	Calcium polysulfide	Lime Sulfur Ultra	2	48	71096-11	DANGER signal word. Corrosive. Causes irreversible eye damage. Causes skin burns. Harmful if swallowed or if absorbed through skin. Toxic to fish. Do not mix with acids or phosphate fertilizer products. Deadly and potentially extremely flammable hydrogen sulfide gas may be emitted.	Cherries (sweet and sour)/Brown rot blossom blight: Apply ¾ to 1¼ gallons of product per 100 gallons of water. Begin at white bud (popcorn) and repeat every 10 to 14 days through bloom if rains continue. Peaches, nectarines/Brown rot blossom blight: Apply ¾ to 1¼ gallons of product per 100 gallons of water. Begin at pre-bloom and repeat every 10 to 14 days through bloom if rains continue. Plums, prunes/Brown rot blossom blight: Apply ¾ to 1¼ gallons of product per 100 gallons of water. Begin at white bud and repeat every 10 to 14 days through bloom if rains continue.	Cherries (sweet and sour)/ Brown rot fruit rot: Apply ½ gallon of product per 100 gallons of water. Apply 3 to 5 sprays at weekly intervals up to 2 days before harvest. Peaches, nectarines/Brown rot fruit rot: Apply ½ gallon of product per 100 gallons of water. Apply 3 to 5 sprays at weekly intervals up to 2 days before harvest. Plums, prunes/Brown rot fruit rot: Apply ½ gallon of product per 100 gallons of water. Apply 3 to 5 sprays at weekly intervals up to 2 days before harvest.	Synthetic

Monilinia fructicola and *M. laxa* (Brown Rot) / Stone Fruit: OMRI-Listed Fungicides for Use in the United States
(No efficacy data have been identified or evaluated.)

FRAC Code	Active Ingredient	Product Name	PHI (Days)	REI (Days)	EPA Reg. No.	Comments	Brown Rot Blossom Blight/Twig Blight	Brown Rot Fruit Rot	NOP Status
	Source: EPA Label								
	Sulfur	Acoidal	0	24	62562-4	Harmful if swallowed, inhaled, or absorbed through skin. Toxic to fish and aquatic organisms. Sulfur dust suspended in air ignites easily. Keep away from heat, sparks, or flames. Do not smoke while applying this product. Sulfur may cause severe fruit and foliage injury to certain crops. Sulfur may burn foliage when temperature is high. Do not apply within 2 weeks of an oil spray treatment.	Cherries, peaches, nectarines/ Brown rot blossom and twig blight: Apply 10-30 lb/acre. Apply at early bloom or early petal fall. Repeat as necessary, usually 10-14 days or after a period of wet weather.	NA	Synthetic
		Defend DF	0	24	62562-8	Harmful if swallowed, inhaled, or absorbed through skin. Toxic to fish and aquatic organisms. Sulfur dust suspended in air ignites easily. Keep away from heat, sparks, or flames. Do not smoke while applying this product. Sulfur may cause severe fruit and foliage injury to certain crops. Sulfur may burn foliage when temperature is high. Do not apply within 2 weeks of an oil spray treatment.	Cherries, peaches, nectarines, plums, prunes/ Brown rot blossom and twig blight: Apply 10-30 lb/acre. Apply at early bloom or early petal fall. Repeat as necessary, usually 10-14 days or after a period of wet weather.	NA	Synthetic
		Kumulus DF	0	24	51306-352-66330	Harmful if swallowed. Avoid breathing spray mist. Avoid contact with eyes, skin, and clothing. Do not apply within 2 weeks of an oil spray treatment. Do not store above 104°F. Store away from heat, sparks, and open flame.	Cherries, plums, prunes/ Brown rot blossom blight: Apply 10-30 lb/acre. Apply at early bloom or early petal fall. Repeat as necessary, usually 10-14 days or after a period of wet weather.	Cherries, plums, prunes/Brown rot fruit rot: Apply 10-30 lb/acre. Apply when fruit starts to ripen.	Synthetic
		Micro Sulf	0	24	55146-75	Harmful if swallowed, inhaled, or absorbed through skin. Causes eye irritation. Risk of crop injury if temperature exceeds 90°F within 3 days following application. Do not use on any crop unless sulfur has been shown to be safe in your locality. Do not apply within 14 days of an oil spray. Keep away from heat, sparks, or flames. Do not smoke while applying this product.	Cherries, nectarines, peaches, plums, prunes/ Brown rot blossom blight: Apply 10-30 lb/acre. Apply 10-30 lb/acre. Apply at early bloom or early petal fall. Repeat as necessary, usually 10-14 days or after a period of wet weather.	Cherries, nectarines, peaches, plums, prunes/Brown rot fruit rot: Apply 10-30 lb/acre. Apply when fruit starts to ripen.	Synthetic
		Microthiol Disperss	0	24	70506-187	Harmful if swallowed, inhaled, or absorbed through skin. Risk of crop injury if temperature exceeds 90°F within 3 days following application. Do not use on any crop unless sulfur has been shown to be safe in your locality. Do not store near flammable materials. Do not store in a manner where cross-contamination with other pesticides, fertilizers, food or feed could occur. Restrictions regarding application time before and after an oil spray treatment.	Cherries, nectarines, peaches, plums, prunes/ Brown rot blossom blight. Apply 10-20 lb/acre. Repeat applications at 7- to 10-day intervals or as needed.	Cherries, nectarines, peaches, plums, prunes/Brown rot fruit rot: Apply 10-20 lb/acre. Apply when fruit starts to ripen. Do not apply to apricots.	Synthetic
		Thiolux	0	24	34704-1079	Harmful if swallowed, inhaled, or absorbed through skin. Causes eye irritation. Sulfur may case severe fruit and foliage injury to certain crops. Risk of crop injury if temperature exceeds 90°F within 3 days following application. Do not apply within 14 days of an oil spray. Sulfur dust suspended in air easily ignites. Keep away from heat, sparks, or flames. Do not smoke while applying this product.	Cherries, nectarines, peaches, plums, prunes/ Brown rot blossom blight. Apply 10-20 lb/acre. Apply at early bloom or early petal fall and repeat as necessary, usually 10-14 days or after a period of wet weather.	Cherries, nectarines, peaches, plums, prunes/Brown rot fruit rot: Apply 10-20 lb/acre. Spray when fruit starts to ripen.	Synthetic

Monilinia fructicola and *M. laxa* (Brown Rot) / Stone Fruit: OMRI-Listed Fungicides for Use in the United States
(No efficacy data have been identified or evaluated.)

FRAC Code	Source: EPA Label								NOP Status
	Active Ingredient	Product Name	PHI (Days)	REI (Days)	EPA Reg. No.	Comments	Brown Rot Blossom Blight/Twig Blight	Brown Rot Fruit Rot	
Not classified; Inorganic salt	Potassium bicarbonate	EcoMate Amicarb O	0	4	5905-541	Harmful if swallowed. Causes moderate eye irritation. Broad spectrum contact foliar fungicide. Prevent exposure to moisture during storage. Avoid contamination with other pesticides and fertilizers.	Apricots/*Monilinia* (brown rot, blossom blight): 2.5-5.0 lb/100 gal water. Cherry/*Monilinia* (blossom rot, brown rot, seedling, twig, shoot leaf blight: 2.5-5.0 lb/100 gal water. Nectarine/*Monilinia* (twig blight, brown rot): 2.5-5.0 lb/100 gal water. Peaches/*Monilinia* (blossom and twig blight, brown rot): 2.5-5.0 lb/100 gal water. Prunes, plums: *Monilinia* (blossom blight, twig blight, brown rot): 2.5-5.0 lb/100 gal water.	Apricots/*Monilinia* (brown rot, blossom blight): 2.5-5.0 lb/100 gal water. Cherry/*Monilinia* (blossom rot, brown rot, seedling, twig, shoot leaf blight: 2.5-5.0 lb/100 gal water. Nectarine/*Monilinia* (twig blight, brown rot): 2.5-5.0 lb/100 gal water. Peaches/*Monilinia* (blossom and twig blight, brown rot): 2.5-5.0 lb/100 gal water. Prunes, plums: *Monilinia* (blossom blight, twig blight, brown rot): 2.5-5.0 lb/100 gal water.	Synthetic

Monilinia fructicola and *Monilinia laxa* (Brown Rot) / Stone Fruit: Efficacy Trials

Monilinia spp. (Brown Rot Blossom Blight) / Cherry #1: Trial No. CER-2015-035

a. Design

Monilinia fructicola (Brown Rot Blossom Blight) / Cherry #1: Trial No. CER-2015-035: Design					
Title:	Comparison of Fungicides for Management of Cherry Diseases, 2015				
Authors and affiliation:	J. W. Pscheidt, John P. Bassinette, and L. A. Jones Oregon State University Corvallis, OR 97331-2903				
Publication:	PDMR 10:STF009				
Location:	Corvallis, OR				
Crop:	Sweet cherry ('Bing')				
Disease name:	Brown rot blossom blight				
Pathogen:	*Monilinia* spp.				
Test plot design:	Randomized complete block				
Number of replicates:	Not reported				
Application equipment:	Hydraulic handgun sprayer (100 psi)				
Spray volume:	164 gal/acre				
Number of applications:	7 (all pre-harvest)				
Chronology:	Application Dates	Growth Stage	Application Intervals	Brown Rot Blossom Blight Assessment Dates	Harvest Date
	03/26/2015	Popcorn		04/14/2015	06/10/2015
	04/02/2015	Full bloom	7 days		
	04/15/2015	Petal fall	13 days		
	04/29/2015	Fruit set	14 days		
	05/12/2015		13 days		
	05/26/2015		14 days		
	06/09/2015	Pre-harvest	14 days		
Post-harvest evaluations:	Fruit that appeared to be healthy was harvested. Cherries were placed on wire racks within moist chambers and incubated at 70°C to 80°C for 20 days. During the 20-day observation period, cherries with disease symptoms were counted and removed daily.				

b. Results

Monilinia fructicola (Brown Rot Blossom Blight) / Cherry #1: Trial No. CER-2015-035: Results								
Treatment	Rate/ Acre	g a.i./ ha	Active Ingredient	FRAC Code	Brown Rot Blossom Blight (%)		Post-Harvest Brown Rot Fruit Rot (%)	
					Measured	Percent Control	Measured	Percent Control
Untreated control			Not Applicable		14.3 a		6.0	
Oso 5%SC	6.5 fl oz	25	Polyoxin D zinc salt	19	0.5 b	96.5	1.3	78.3
Induce	32 fl oz/ 100 gal		Wetter/sticker	NA				
Treatment means followed by the same letter are not statistically different according to Fisher's protected LDS (P = 0.05).								

Symptoms of brown rot blossom blight assessment were first observed on April 6, 2015 at the start of petal fall. This was 3 days before the last treatment. Therefore, the treatments were preventative and curative.

No phytotoxicity was observed.

c. Discussion and Conclusions

Bing cherries were grown in Oregon. Brown rot blossom blight disease pressure was 14.3% in the untreated control.

Seven treatments of Polyoxin D Zinc Salt 5SC Fungicide were applied at 7-day to 14-day intervals. This first treatments was applied at popcorn stage and the last treatment was applied pre-harvest. Polyoxin D Zinc Salt 5SC Fungicide treatments were applied preventatively and curatively at 6.5 fl oz/acre (25 g a.i./ha) with a wetter/sticker.

- Five hundred blossoms from the lower portion of the trees were arbitrarily selected for evaluations for brown rot blossom blight.
- Fruit that appeared to be healthy was harvested for evaluation of post-harvest control of brown rot fruit rot. The cherries were placed in wire racks in a moist chamber at 70-80°F for 20 days. Cherries were examined daily for disease symptoms. Diseased cherries were noted and removed.

The Polyoxin D Zinc Salt 5SC Fungicide treatments provided:

- 96.5% control of brown rot blossom blight. This was statistically superior to the untreated control.
- 78.3% post-harvest control of brown rot fruit rot.

No phytotoxicity was observed.

Monilinia laxa (Brown Rot Blossom Blight) / French Prune #1: Trial No. CER-2013-121

a. Design

Monilinia fructicola (Brown Rot Blossom Blight) / French Prune #1: Trial No. CER-2013-121: Design	
Title:	Epidemiology and Management of Brown Rot and Rust of Prune - Development and an Integrated Program with New Fungicides and Optimal Timing
Author and affiliation:	J. E. Adaskaveg University of California, Riverside
Publication:	University of California Agricultural and Natural Resources Repository. 07 CPB 6
Location:	Laboratory; Riverside, CA
Crop:	French prune
Disease name:	Brown rot blossom blight
Pathogen:	*Monilinia laxa*
Test plot design:	Not applicable
Number of replicates:	3
Application equipment:	Hand sprayer
Spray volume:	Not reported
Number of applications:	1
Application interval:	Not applicable
Application dates:	Not reported
Inoculation and disease assessment schedule:	Blossoms were collected at popcorn stage and allowed to open in the laboratory. • For evaluation of post-infection activity, blossoms were first inoculated with conidia of *Monilinia laxa* (20,000 conidia/mL) and treated after 24 hours using a hand sprayer. • For evaluation of pre-infection activity, blossoms were first treated and inoculated after 4 hours.

b. Results

Monilinia laxa (Brown Rot Blossom Blight) / French Prune #1: Trial No. CER-2013-121: Results								
Treatment	Rate/ Acre	g a.i./ ha	Active Ingredient	FRAC Code	Incidence (%) Post-Infection Activity; Curative Treatment		Incidence (%) Pre-Infection Activity; Preventative Treatment	
					Measured	Percent Control	Measured	Percent Control
Untreated control			Not Applicable		65.1 a		63.8 a	
CX-10440 [1]	6 fl oz	23	Polyoxin D zinc salt	19	9.2 bc	85.9	1.7 cd	97.3
Fracture	24 fl oz		Banda de Lupinus albus doce (BLAD)	NC	10.8 b	83.4	27.8 b	56.4
Pristine 38WG	14.5 oz		Boscalid	7	0.0 d	100	6.3 c	90.1
			Pyraclostrobin	11				
Treatment means followed by the same letter are not statistically different based upon an analysis of variance and LSD mean separation of P > 0.05. 1. CX-10440 is the Certis USA, L.L.C. code for Polyoxin D Zinc Salt 5SC Fungicide.								

No phytotoxicity was reported.

c. Discussion and Conclusions

French Prunes were grown in California. Samples were collected at popcorn stage and taken to a laboratory. For evaluation of brown rot blossom blight, blossoms were:

- Inoculated with conidia of *Monilinia laxa* (20,000 conidia/mL) and treated with fungicide treatments 24 hours later (curative treatment); or
- Treated with fungicides and inoculated with conidia of *Monilinia laxa* 4 hours later (preventative treatment).

Pest pressure was high for both the post-infection activity group and the pre-infection activity group. Disease incidence was greater than 63%.

Polyoxin D Zinc Salt 5SC Fungicide applied as a single curative treatment at 6 fl oz/acre (23 g a.i./ha) provided 85.9% control of brown rot blossom blight. This was statistically:

- Superior to the untreated control;
- Equivalent to the control provided by Banda de Lupinus albus doce (BLAD) (Fracture); and
- Less than the control provided by boscalid plus pyraclostrobin.

Polyoxin D Zinc Salt 5SC Fungicide applied as a single preventative treatment at 6 fl oz/acre (23 g a.i./ha) provided 97.3% control of brown rot blossom blight. This was statistically:

- Superior to the untreated control and to the control provided by Banda de Lupinus albus doce (BLAD) (Fracture); and
- Equivalent to the control provided by boscalid plus pyraclostrobin.

No phytotoxicity was reported.

Monilinia fructicola (Fruit Brown Rot) / Nectarine #1 and Peach #1: Trial No. CER-2013-119

a. Design

Monilinia fructicola (Fruit Brown Rot) / Nectarine #1 and Peach #1: Trial No. CER-2013-119: Design	
Title:	Management of Brown Rot, Powdery Mildew, and Peach Leaf Curl Diseases of Peach in California Annual Report - 2013 Prepared for the California Cling Peach Advisory Board
Author and affiliation:	J. E. Adaskaveg University of California, Riverside
Publication:	Internet
Location:	Kearney Ag Center 9240 S Riverbend Avenue, Parlier, CA 93648
Crop:	Summer Fire Nectarine Ryan Sun Peach
Disease name:	Fruit brown rot
Pathogen:	*Monilinia fructicola*
Test plot design:	Randomized completed block
Number of replicates:	4
Application equipment:	Air-blast sprayer
Spray volume:	100 gal/acre
Number of applications:	1
• Summer Fire Nectarine	06/20/2013
• Ryan Sun Peach	08/07/2013
Inoculation of harvested fruit:	*Monilinia fructicola* (20,000 spores/mL)
Incubation of harvested fruit:	5-7days at 20°C

b. Results

Monilinia fructicola (Fruit Brown Rot) / Nectarine #1 and Peach #1: Trial No. CER-2013-119: Results								
Treatment	Rate/ Acre	g a.i./ ha	Active Ingredient	FRAC Code	Post-Harvest Incidence (%) on Summer Fire Nectarine		Post-Harvest Incidence (%) on Ryan Sun Peach	
					Measured	Percent Control	Measured	Percent Control
Untreated control			Not Applicable		85.3 a		67.9 a	
CX-10440 [1]	3.5 fl oz	13	Polyoxin D zinc salt	19	70.3 b	18	46.9 bc	13
CX-10440 [1]	13 fl oz	50	Polyoxin D zinc salt	19	68.3 b	20	54.7 ab	19
Treatment means followed by the same letter are not statistically different according to analysis of variance and LSD mean separation procedures at P > 0.05. 1. CX-10440 is the Certis USA, L.L.C. code for Polyoxin D Zinc Salt 5SC Fungicide.								

No phytotoxicity was reported.

c. Discussion and Conclusions: Nectarines

Nectarines were grown in California. Pre-harvest applications were evaluated for post-harvest control of brown rot (*Monilinia fructicola*). Fruit brown rot incidence in nectarines inoculated post-harvest and stored for 5-7 days at 20°C was 85.3%.

A single treatment with Polyoxin D Zinc Salt 5SC Fungicide provide a slight positive dose response.

- Pre-harvest treatment with 3.5 fl oz/acre (13 g a.i./ha) provided 18% post-harvest control.
- Pre-harvest treatment with 13 fl oz/acre (50 g a.i./ha) provided 20% post-harvest control.

At both treatment rates, the post-harvest control of fruit brown rot provided by pre-harvest treatment with Polyoxin D Zinc Salt 5SC Fungicide was statistically superior to the untreated control.

No phytotoxicity was reported.

d. Discussion and Conclusions: Peaches

Peaches were grown in California. Pre-harvest applications were evaluated for post-harvest control of brown rot (*Monilinia fructicola*). Fruit brown rot incidence in peaches inoculated post-harvest and stored for 5-7 days at 20°C was 67.9%.

A single treatment with Polyoxin D Zinc Salt 5SC Fungicide provide a positive dose response.

- Treatment with 3.5 fl oz/acre (13 g a.i./ha) provided 13% control of fruit brown rot on peaches.
- Treatment with 13 fl oz/acre (50 g a.i./ha) provided 19% control of fruit brown rot on peaches.

At both treatment rates, the post-harvest control of fruit brown rot provided by pre-harvest treatment with Polyoxin D Zinc Salt 5SC Fungicide was statistically superior to the untreated control.

No phytotoxicity was reported.

***Monilinia fructicola* and *Monilinia laxa* (Brown Rot) / Stone Fruit: Grower Need**

[Sources: (1) J.E. Adaskaveg, Annual Report - 2013, Prepared for the Prune Board of California. (2) Bruce A. Watt, Brown Rot of Stone Fruits, The University of Maine Pest Management Fact Sheet #5090, 2013. (3) Wayne F. Wilcox, Brown Rot of Stone Fruits, Cornell Cooperative Extension Disease Identification Sheet No. 10. 1993. (4) Brown Rot *Monilinia fructicola*. West Virginia University Extension Service. Not dated.]

California

Brown rot, caused by *Monilinia* species is the most important blossom and pre-harvest disease of prune in California. In many growing areas of the state, *Monilinia laxa* is the primary pathogen on blossoms, whereas *Monilinia fructicola* is the main pathogen on fruit. Still, both species can be found causing blossom blight and fruit rot depending on the geographical production areas in California.

Maine

Brown rot is the most serious disease of stone fruits in Maine. It is caused by the fungus *Monilinia fructicola*. Affected fruits include peaches, plums, cherries, apricots, and other *Prunus* species. The disease is highly destructive and can ruin half or more of the fruit before harvest with the remaining fruit subject to post-harvest infection. Additional losses are caused by blighting of flowers and twigs.

New York

Brown rot is the most consistently destructive disease of stone fruits in the Northeast. When left uncontrolled, this disease can cause nearly complete crop loss in wet years.

West Virginia

Brown rot is one of the most important diseases of stone fruits in the mid-Atlantic region. Field losses of sweet and sour cherries can be extensive if conditions favorable for disease development occur during the blossom period, following shuck fall, or during the pre-harvest and harvest period.

Control of Monilinia brown rot blossom blight and fruit brown rot on stone fruit (Project No. B00054) was identified as a grower need at the IR-4 2015 Biopesticide Workshop.

Monilinia oxycocci (COTTONBALL) / CRANBERRIES

Monilinia oxycocci (Cottonball) / Cranberries: Organic Cranberry Production

(Source: Eric Zeldin, Overview of Organic Cranberry Production, University of Wisconsin-Madison)

The production of fruit without the use of manufactured fertilizers or chemical pesticides was once considered virtually impossible for cranberries in the modern era. However, there are now many organic cranberry growers spread across the continent, including over 30 acres each in Oregon and Massachusetts, over 100 acres in Wisconsin and perhaps 400 acres in Quebec. A small amount of organic cranberries is also produced in Maine. Organic cranberry products include fresh and frozen berries, juice and juice concentrate, sauce, sweetened-dried cranberries and cranberry powders. Organic products return a higher price than conventional, the amount depending on the product. The market for organic cranberries has been growing, but production and price can be obstacles to successful organic operations.

The major problems facing organic cranberry growers include weeds, insect pests, fruit rot and other fruit quality issues; but most significant is a 50% or more reduction in yield compared to conventional production.

There are a number of organic-certified products available to control insect pests. These have been effective to varying degrees. Frequent applications are often required.

Cranberry, which is already perceived as a healthy part of the diet, is a good candidate for further expansion in the health-conscious organic market if these production obstacles can be overcome.

Monilinia oxycocci (Cottonball) / Cranberries: Economic Importance

(Source: Patricia McManus, Strategic Use of Fungicides for Cottonball Control, University of Wisconsin-Madison)

Cottonball disease, caused by the fungus *Monilinia oxycocci,* is an economically important disease in many Wisconsin cranberry marshes. Many aspects of the biology and ecology of cottonball are not understood, and consequently, reliable cultural and nonchemical means of control (*e.g.*, resistant cultivars, biocontrols) have not been developed. Thus, control of cottonball has been, and continues to be, dependent on fungicides, particularly those in the sterol demethylation inhibitor (DMI) group. Fungicides are not the final word for cottonball control, however. More sustainable control methods are needed and are being investigated, but their implementation is many years away.

Monilinia oxycocci (Cottonball) / Cranberries: Cottonball Disease Cycle

(Source: Patricia McManus, Strategic Use of Fungicides for Cottonball Control, University of Wisconsin-Madison)

The cottonball fungus, *Monilinia oxycocci,* overwinters in sclerotia which are the hard, mummified remains of previous seasons' infected fruit. In the spring, small mushroom-like structures called apothecia grow from some of the sclerotia. Ascospores are ejected from the apothecia, starting at about budbreak and continuing until just before bloom. Maximal ascospore release occurs over a 10- to 14-day period when the majority of shoots are ½ to 1¼ inches long and very susceptible to infection. Infection probably requires water and moderate temperatures, although this has not been determined experimentally. The exact sites on the elongating uprights where the fungus penetrates are not known. Infection results in "tip blight" symptoms: crooked over shoot tips, tan discoloration of leaves, and blasted blossom buds starting about a week before bloom.

Just before bloom, the fungus produces spores (conidia) on infected floral and vegetative uprights. Conidia are carried to flowers by wind (the role of insects is unknown) and presumably infect by germinating on the stigma and growing down the style to the developing ovary, analogous to the pattern of pollen germination and growth. As the fruit matures, the fungus fills the seed cavity and eventually grows into the fleshy tissue. By harvest, sclerotia develop in 25-50% of the infected fruit. Berries that do not have sclerotia by harvest time decompose by the following spring.

Monilinia oxycocci **(Cottonball) / Cranberries: No OMRI-Listed Fungicides for Use in the United States in the United States**

Based upon Kaken's review of OMRI listed fungicides, there appears to no OMRI-listed fungicide that is EPA registered for use to control *Monilinia oxycocci* (cottonball) on cranberries.

Monilinia oxycocci **(Cottonball) / Cranberries: Efficacy Trials**

Monilinia oxycocci (Cottonball) / Cranberries #1: Trial No. IND-2014-165

a. Design

Monilinia oxycocci (Cottonball) / Cranberries #1: Trial No. IND-2014-165: Design		
Title:	Evaluation of Fungicides for Control of Cranberry Cottonball in Wisconsin, 2014	
Authors and affiliation:	P. McManus and R.S. Perry University of Wisconsin Madison, WI	
Publication:	PDMR 9:SMF014	
Location:	Near City Point, WI	Near Warrens, WI
Crop:	Cranberry (cultivar Stevens)	Cranberry (cultivar McFarlin)
Disease name:	Cottonball	
Pathogen:	*Monilinia oxycocci*	
Test plot design:	Randomized compete block	
Number of replicates:	5	
Application equipment:	CO_2 backpack sprayer (30 psi)	
Spray volume:	28.4 gal/acre	
Number of applications:	2	
Application interval:	14 days	14 days
Application dates:	06/23/2014 (10% bloom) 07/07/2014 (50% bloom)	06/24/2014 (4% bloom) 07/08/2014 (49% bloom)
Disease assessment date(s):	09/23/2014	09/23/2014

b. Results

Monilinia oxycocci (Cottonball) / Cranberries #1: Trial No. IND-2014-165: Results								
Treatment	Rate/ Acre	g a.i./ ha	Active Ingredient	FRAC Code	% Cottonball Incidence City Point, WI		% Cottonball Incidence Warrens, WI	
					Measured	Percent Control	Measured	Percent Control
Untreated control			Not Applicable		32 a		21 a	
Tavano 5SC	6.5 fl oz	25	Polyoxin D zinc salt	19	27 b	16	13 b	38
Regalia 5EC	2 pt		*Reynoutria sachalinensis*	P5	30 ab	6	9 c	57
Abound 2.08 SC	15.5 fl oz		Azoxystrobin	11	13 c	59	5 d	76
Treatment means followed by the same letter are not statistically different according to Fisher's LSD test at P = 0.0001.								

The date of first observation of cottonball symptoms was not reported. Therefore, the treatments are assumed to have been preventative.

No phytotoxicity was observed.

c. <u>Discussion and Conclusions: City Point, WI</u>

Cranberries were grown near City Point, WI. The cranberry cottonball incidence was 32%.

Two treatments of Polyoxin D Zinc Salt 5SC Fungicide were applied preventatively with a 14-day interval. Polyoxin D Zinc Salt 5SC Fungicide provided 16% control of cranberry cottonball. This was statistically:

- Superior to the untreated control and to the control provided by *Reynoutria sachalinensis* (Regalia); and
- Less than the control provided by azoxystrobin.

No phytotoxicity was observed.

d. <u>Discussion and Conclusions: Warrens, WI</u>

Cranberries were grown near Warrens, WI. The cranberry cottonball incidence was 21%.

Two treatments of Polyoxin D Zinc Salt 5SC Fungicide were applied preventatively with a 14-day interval. Polyoxin D Zinc Salt 5SC Fungicide provided 38% control of cranberry cottonball. This was statistically:

- Superior to the untreated control; and
- Less than the control provided by *Reynoutria sachalinensis* (Regalia) and by azoxystrobin.

No phytotoxicity was observed.

Monilinia oxycocci (Cottonball) / Cranberries #2: Trial No. IND-2015-208

a. Design

Monilinia oxycocci (Cottonball) / Cranberries #2: Trial No. IND-2015-208: Design					
Title:	Evaluation of Fungicides for Control of Cranberry Cottonball in Wisconsin, 2015				
Authors and affiliation:	P. McManus and R.S. Perry University of Wisconsin Madison, WI 53706				
Publication:	PDMR 10:SMF007				
Location:	Warrens, WI				
Crop:	Cranberry (Pilgrim)				
Disease name:	Cottonball				
Pathogen:	*Monilinia oxycocci*				
Test plot design:	Randomized complete block				
Number of replicates:	5				
Application equipment:	CO_2 backpack sprayer (31 psi)				
Spray volume:	28.4 gal/A				
Number of applications:	2				
Chronology:	Application Dates	Growth Stage	Application Interval	Assessment Dates	Harvest Date
	06/29/2015	22% bloom		07/09/2015	09/09/2015
	07/08/2015	50% bloom	9 days	07/17/2015	

b. Results

Monilinia oxycocci (Cottonball) / Cranberries #2: Trial No. IND-2015-208: Results								
Treatment	Rate/ Acre	g a.i./ ha	Active Ingredient	FRAC Code	% Cottonball Incidence		Yield	
					Measured	Percent Control	Measured	Percent Increase
Untreated control			Not Applicable		16.6 a		168 b	
Oso 5SC	6.5 fl oz	25	Polyoxin D zinc salt	19	7.5 b	54.8	197 a	17.3
X77	0.25% (v/v)	NA	Non-ionic spreader	NA				
Oso 5SC	6.5 fl oz		Polyoxin D zinc salt	19	5.3 b	68.1	205 a	22.0
Abound 2.08SC	15.5 fl oz		Azoxystrobin	11	5.7 b	65.7	199 a	18.5
Regalia 5EC	2 pt		*Reynoutria sachalinensis*	P5	4.1 b	75.3	194 a	15.5
Tilt 41.8EC	6 fl oz		Propiconazole	3	2.2 b	86.7	200 a	19.0
Treatment means followed by the same letter are not statistically different according to Fisher's Protected LSD test at P = 0.0001.								

The first disease assessment date was after the last treatment date. Therefore, both treatments are assumed to be preventative.

No phytotoxicity was observed.

c. Discussion and Conclusions

Cranberries were grown Wisconsin. Cranberry cottonball incidence was 16.6%.

Two treatments were applied with a 9-day interval. Treatments of Polyoxin D Zinc Salt 5SC Fungicide were applied preventatively at 6.5 fl oz/acre with and without X77, a non-ionic spreader.

- Polyoxin D Zinc Salt 5SC Fungicide treatments applied with the non-ionic spreader provided 54.8% control of cranberry cottonball and 17.3% increase in yield.
- Polyoxin D Zinc Salt 5SC Fungicide treatments applied without the non-ionic spreader provided 68.1% control of cranberry cottonball and 22.0% increase in yield.

Based upon this one trial, the inclusion of the non-ionic spreader decreased both the cranberry cottonball control and the cranberry yield. However, the differences were not statistically significant.

The Polyoxin D Zinc Salt 5SC Fungicide treatments with and without the spreader provided cranberry cottonball control that was statistically:

- Superior to the untreated control; and
- Equivalent to the control provided by azoxystrobin, by *Reynoutria sachalinensis* (Regalia), and by propiconazole.

No phytotoxicity was observed.

Monilinia vaccinii-corymbosi (MUMMYBERRY) / BLUEBERRIES

Monilinia vaccinii-corymbosi (Mummyberry) / Blueberries: Introduction

[Sources: (1) 2015 Organic Production and IPM Guide for Blueberries, Cornell University Cooperative Extension. (2) Wayne F. Wilcox, Mummberry Disease, Cornell Cooperative Extension, Disease Identification Sheet No. 3, 1991.]

Mummyberry is perhaps the most common disease of blueberries in North America. Its severity varies greatly from year to year depending on weather conditions. Crop losses can be significant in years with rainy springs. Mummyberry does not occur on all blueberry farms in New York, but it is likely to become an increasingly important problem as acreage planted to blueberries in the state expands.

Upon infection, young leaves (and in some cases new shoots) will wilt, turn violet/brown, and die (similar in appearance to frost injury). The blighted tissues resulting from infection remain fairly soft compared to blighted shoots resulting from spring frost damage. Grayish masses of conidia (spores) can sometimes be observed along the midrib of the blighted leaves. These conidia are the means by which the mummy berry fungus subsequently infects the fruit.

Mummy berry disease is not present in all blueberry plantings. However, management measures are usually necessary in those plantings where the disease has occurred previously. In these plantings, fungicide sprays may provide some additional benefit when applied between bud break and bloom. If not brought under control when first observed, the disease can become unmanageable in subsequent years as inoculum accumulates.

Monilinia vaccinii-corymbosi (Mummyberry) / Blueberries: Symptoms

(Source: Wayne F. Wilcox, Mummberry Disease, Cornell Cooperative Extension, Disease Identification Sheet No. 3, 1991.)

Mummyberry has two distinct phases:

1. Shoot blight; and
2. Hard rot of the fruit.

Symptoms of <u>shoot blight</u> become evident a few weeks after bud break but often are inconspicuous and easy to overlook. New leaves or shoots that become infected wilt and die quickly, turning dark brown. Under wet or humid conditions, blighted tissues may be covered by a light gray or cream-colored powdery mold.

Infections in <u>fruit</u> do not become apparent until healthy berries start to ripen and turn blue. At that time, infected berries ("mummy berries") shrivel, become whitish pink or salmon in color, and fall to the ground. When such berries are cut open with a knife, it will be evident that all or part of the fruit has been replaced by the mummyberry fungus. Infected berries that fall to the ground become pumpkin-shaped as they continue to shrivel and finally turn dark brown.

Monilinia vaccinii-corymbosi (Mummyberry) / Blueberries: Causal Organism and Disease Cycle

(Source: Wayne F. Wilcox, Mummberry Disease, Cornell Cooperative Extension, Disease Identification Sheet No. 3, 1991.)

Mummyberry disease is caused by the fungus *Monilinia vaccinii corymbosi,* which infects only cultivated blueberries and a few closely related wild blueberry species. Mummyberry is usually introduced from infected nearby plantings or from wild blueberries in adjacent woods. Once established in a planting, the mummyberry fungus overwinters in the mummified fruits that fall to the ground at harvest time. Under moist conditions in the early spring, the fungus forms small mushroom-like fruiting bodies from the mummies that have remained on the soil surface. These fruiting bodies, called apothecia, continue to develop when conditions are favorable. Activity is very slow at 50°F (10°C) or lower. Activity at 61°F (16°C) is optimal and eventually forms sacs of spores, called asci.

Asci begin to discharge their infective ascospores about the time green tissue first emerges from the buds of the blueberry plants. Ascospores are discharged for about 4 to 5 weeks, usually reaching a peak about 2 weeks after bud break. These spores are distributed by wind currents during dry periods of the day, and those that land on emerging leaves can germinate and infect if the leaves become wet from rain or dew. For infection to occur, leaves must remain wet for about 6 to 12 hours at the optimal temperature of 59°F (15°C) and somewhat longer at lower temperatures.

Once new leaves and shoots become infected, the fungus produces powdery, cream-colored spores called conidia on these infected tissues. Conidia are distributed to open flowers of the blueberry plant by wind or insects, which are attracted to sugars exuded by the blighted leaves and shoots. The conidia germinate, presumably during wet periods, and the fungus grows into the ovaries of the flowers, causing the seeds to abort. As infected berries develop, they become filled with growth of the fungus, turn pink, and drop to the ground, thus completing the disease cycle.

Monilinia vaccinii-corymbosi **(Mummyberry) / Blueberries: Control**
Berries mummify only when flowers are infected by conidia, which themselves develop only as a result of shoot and leaf infections by ascospores. Therefore, the key to control of mummyberry disease is to prevent these shoot blight infections by interfering with the production of ascospores and applying appropriate fungicides when needed.

Cultivation of the ground beneath infected bushes before bud break will greatly inhibit the production of the mushroom-like apothecia, the source of infective ascospores. Relatively few apothecia are formed from mummies buried ½ inch (1.25 cm) beneath the surface, and none are formed from mummies buried 1 inch (2.5 cm) or deeper. Such cultivation may provide acceptable control in years when there are relatively few overwintered mummy berries because of little fruit infection the previous season or when spring weather is only marginally favorable for disease development.

Fungicidal control also may be necessary in springs when weather is favorable for development of shoot blight and may be particularly important if there was no cultivation or if significant levels of fruit infection occurred the year before. The number and timing of sprays should be based on the likelihood of disease as determined by weather conditions (temperature and wetness) and the relative quantity of overwintering mummy berries remaining on the soil surface. If the chance of heavy infection is great, fungicidal protection may be needed from bud break until bloom. However, if there seems to be less likelihood of disease, a single spray 1 to 2 weeks after bud break (the period of greatest ascospore production) may suffice. Some fungicides can be used to protect flowers from infection by conidia, but these sprays will not be necessary if shoot blight infections are controlled.

Monilinia vaccinii-corymbosi (Mummyberry) / Blueberries: OMRI-Listed Fungicides for Use in the United States
(No efficacy data have been identified or evaluated.)

FRAC Code	Source: EPA Label							NOP Status
	Active Ingredient	Product Name	Product Rate/Acre	PHI (Days)	REI (Days)	EPA Reg. No.	Comments	
44	*Bacillus amyloliquefaciens* str. D747	Double Nickel 55	0.25-3 lb	0	4	70051-108	Causes moderate eye irritation. Dermal sensitizer. Broad-spectrum preventative fungicide. Do not use highly alkaline or highly acidic water to mix sprays. Use a buffering agent if necessary to maintain neutrality (pH 6 to 8) of water in the tank. Suppression only. For improved control mix or rotate with chemical fungicide approved for such use.	Non-synthetic
	Bacillus pumilus str. QST 2808	Sonata ASO	2-4 qt	0	4	264-1153	Harmful if inhaled. Mixers/loaders and applicators must wear a dust/mist filtering respirator meeting NIOSH standards of at least N-95, R-95, or P-95. Repeated exposure to high concentrations of microbial proteins can cause allergic sensitization. Maintain a spray solution pH between 4.5 and 8.5. Suppression only.	Non-synthetic
	Bacillus subtilis str. QST 713	Optiva	14-24 oz	0	4	62592-26	Causes moderate eye irritation. Dermal sensitizer. Broad spectrum preventative product. For suppression, begin application when plants are 4 to 6 inches high. Repeat applications on a 5- to 7-day interval or as needed. For improved performance, use in a tank mix or rotational program with other registered fungicides. Use shorter spray intervals under conditions conducive to rapid disease development. For suppression, begin application at the bud break stage of development and repeat on a 7- to 10-day interval or as needed. For improved performance, use in a tank mix or rotational program with other registered fungicides for mummy berry control.	Non-synthetic
		Serenade ASO	2-6 qt	0	4	264-1152	Broad spectrum preventative fungicidal and bactericidal product. For suppression, begin applications when plants are 4 to 6 inches high. Repeat applications on 5- to 7-day intervals or as needed. For improved performance, use in a tank-mix or rotational program with other registered fungicides. Use the stated shorter spray intervals under conditions conducive to rapid disease development. For control, begin applications at the bud break stage of development and repeat on 7- to 10-day intervals or as needed.	
		Serenade MAX	1-3 lb	0	4	69592-11	Dermal sensitizer. Broad spectrum preventative fungicidal and bactericidal product. For suppression begin applications when plants are 4 to 6 inches high. Repeat applications on 5 to 7 day intervals or as needed. For improved performance use in a tank mix or rotational program with other registered fungicides. Use shorter spray intervals under conditions conducive to rapid disease development. For control begin applications at the bud break stage of development and repeat on 7 to 10 day intervals or as needed.	
P5	*Reynoutria sachalinensis*	Regalia Biofungicide	1-4 qt in 25-100 gal water/acre	0	4	84059-3	Causes moderate eye irritation. Preventative rather than a curative application. Apply prior to disease infestation to protect the growing leaf tissue. Avoid freezing. Repeat of 7-10 day intervals. Tank mix with other registered fungicides for improved disease control under heavy pressure. Initiate application at bud break stage of development. Apply preventatively and repeat on a 7–10-day interval or as needed. For best performance, tank mix with other registered fungicides for mummy berry control.	Non-synthetic
Not classified; Botanical oils	Clove oil, Rosemary oil, Peppermint oil	BacStop	6-12 oz/ 100 gal water	0	0	NA. FIFRA §25(b) pesticide.	Causes temporary eye and skin irritation. Wear protective eye wear and chemical resistant gloves. Store at temperatures between 41°F and 85°F (5°C and 30°C).	Non-synthetic
Not classified; Inorganic salt	Potassium bicarbonate	EcoMate Amicarb O	2.5-5 lb/ 100 gal water	0	4	5905-541	Harmful if swallowed. Causes moderate eye irritation. Broad spectrum contact foliar fungicide. Prevent exposure to moisture during storage. Avoid contamination with other pesticides and fertilizers.	Synthetic

Monilinia vaccinii-corymbosi (Mummyberry) / Blueberries: Efficacy Trials

Monilinia vaccinii-corymbosi (Mummyberry) / Blueberries #1: Trial No. CER-2015-008

a. Design

Monilinia vaccinii-corymbosi (Mummyberry) / Blueberries #1: Trial No. CER-2015-008: Design				
Title:	Evaluation of Various Fungicides for Management of Mummy Berry, 2015			
Authors and affiliation:	J. W. Pscheidt, J. P. Bassinette, and S. Eckert Oregon State University Corvallis, OR			
Publication:	PDMR 10:SMF026			
Location:	Corvallis, OR			
Crop:	Blueberry (‘Berkeley’)			
Disease name:	Mummy berry			
Pathogen:	*Monilinia vaccinii-corymbosi*			
Test plot design:	Randomized complete block			
Number of replicates:	Not reported			
Application equipment:	Hydraulic handgun sprayer (100 psi)			
Spray volume:	290 gal/acre			
Number of applications:	9			
Chronology:	Application Dates	Growth Stage	App. Code	Application Interval
	03/09/2015	Floral bud break	A	
	03/16/2015	Vegetative bud break	B	7 days
	03/20/2015	Pre-bloom	C	4 days
	03/27/2015	First flowers open	D	4 days
	04/03/2015	Early bloom	E	7 days
	04/10/2015	Full bloom	F	7 days
	04/17/2015	Some petal fall	G	7 days
	04/23/2015	Late bloom	H	6 days
	05/01/2015	End of bloom	I	8 days

b. Results

Monilinia vaccinii-corymbosi (Mummyberry) / Blueberries #1: Trial No. CER-2015-008: Results							
Treatment	Rate/ Acre	g a.i./ ha	Active Ingredient	FRAC Code	App. Code	Incidence (%) (Fruit)	
						Measured	Percent Control
Untreated control			Not Applicable			34.8 ab	
Oso 5SC	5.6 fl oz	21.6	Polyoxin D zinc salt	19	ABCDEFGHI	27.4 abcd	21.3
Induce	6 fl oz/gal	NA	Wetter/sticker	NA	ABCDEFGHI		
Double Nickel LC	2 qt		*Bacillus amyloliquefaciens* strain D747	44	ABCDEFGHI	35.0 ab	-0.6
Serenade Opti	20 oz		*Bacillus subtilis*	44	ABCDEFGHI	31.7 abc	8.9
Quash 50 WDG	2.5 oz		Metconazole	3	A	21.3 cd	38.8
Proline 480 SC	5.7 fl oz		Prothioconazole	3	C		
Pristine WDG	18.5 oz		Boscalid	7	E		
			Pyraclostrobin	11			
Omega 500 F	20 fl oz		Fluazinam	29	G, I		
Treatment means followed by the same letter are not statistically different according to Fisher's protected LSD test (P = 0.05).							

On March 16, 2015, Apothecia started to emerge and open. On April 11, 2015, *i.e.*, *before* the last 3 treatments, mummyberry symptoms were first observed on both flower clusters and shoots. Therefore, the treatments were preventative and curative.

No phytotoxicity was observed.

c. Discussion and Conclusions

Blueberries were grown in Oregon. Mummyberry incidence was 34.8% in the untreated control.

Nine Polyoxin D Zinc Salt 5SC Fungicide treatments were applied at 4-day to 8-day intervals.

Polyoxin D Zinc Salt 5SC Fungicide applied preventatively and curatively at 5.6 fl oz/acre (21.6 g ai/acre) with Induce (a wetter/sticker) provided 21.3% control of mummy berry incidence on blueberries. This was:

- Numerically (but not statistically) superior to the untreated control and the control provided by *Bacillus amyloliquefaciens* strain D747 (Double Nickel LC) and by *Bacillus subtilis* (Serenade Opti).
- Statistically equivalent to the control provided by a 4-product program that included metconazole, prothioconazole, boscalid, pyraclostrobin, and fluazinam.

No phytotoxicity was observed.

Monilinia vaccinii-corymbosi (Mummyberry) / Blueberries #2: Trial No. CER-2015-143

a. Design

Monilinia vaccinii-corymbosi (Mummyberry) / Blueberries #2: Trial No. CER-2015-143: Design					
Title:	Evaluating Fungicides for Control of Mummy Berry and Post-Harvest Anthracnose Fruit Rot in Blueberries, 2015				
Authors and affiliations:	A. M. C. Schindler, J. M. Gillett, and R. W. Sysak Department of Plant, Soil and Microbial Sciences Michigan State University East Lansing, MI				
Publication:	PDMR 10:SMF009				
Location:	Covert, MI				
Crop:	Blueberry (*Vaccinium corymbosum* 'Rancocas')				
Disease name:	Mummy berry				
Pathogen:	Monilinia *vaccinii-corymbosi*				
Test plot design:	Randomized complete block				
Number of replicates:	4				
Application equipment:	Hand-held Smith Contractor Sprayer (29 psi)				
Spray volume:	40 gal/acre through June 9, 2015. 50 gal/acre thereafter.				
Number of applications:	5				
Chronology:	Application Dates	Growth Stage	Application Interval	Disease Assessment Dates	Harvest Date
	05/01/2015	Early green tip		05/21/2015	07/13/2015
	05/12/2015	Late green tip	11 days	05/29/2015	
	05/19/2015	Pink bud/ early bloom	7 days	06/03/2015	
	06/02/2015	Bloom/ early petal fall	14 days	07/14/2015	
	06/09/2015	Petal fall	7 days		

b. Results

Monilinia vaccinii-corymbosi (Mummyberry) / Blueberries #2: Trial No. CER-2015-143: Results								
Treatment	Rate/ Acre	g a.i./ ha	Active Ingredient	FRAC Code	No. Shoot Strikes/ Bush		No. Mummies/ Bush	
					Measured	Percent Control	Measured	Percent Control
Untreated control			Not Applicable		45.9 a		46.5 a	
Oso 5%SC	6.5 fl oz	25	Polyoxin D zinc salt	19	5.1 c	89	3.0 c	94
LI 700	0.125%		Adjuvant	NA				
Quash	2.5 oz		Metconazole	3	1.4 de	97	0.8 de	98
LI 700	0.125%		Adjuvant	NA				
Indar 2F	6 fl oz		Fenbuconazole	3	0.0 e	100	0.0 e	100
Treatment means followed by the same letter are not statistically different according to Fisher's Protected LSD test at $P \leq 0.05$.								

The date of first observation of mummyberry symptoms was not reported. Therefore, the treatments are assumed to be preventative.

No phytotoxicity was observed.

c. Discussion and Conclusions

Blueberries were grown in Michigan. The mummy berry disease pressure was reported as "moderate". Mean 45.9 shoot strikes per bush and mean 46.5 mummies per bush were observed in the untreated control.

Five applications of Polyoxin D Zinc Salt 5SC Fungicide applied preventatively at 6.5 fl oz/acre (25 g a.i./ha) with an adjuvant at 7-14 day intervals provided mean 92% (range 89% to 94%) control of mummy berry. This was statistically superior to the untreated control.

Statistically superior control was provided by:

- Metconazole plus adjuvant; and
- Fenbuconazole.

No phytotoxicity was observed.

Monilinia vaccinii-corymbosi **(Mummyberry) / Blueberries: Grower Need**
Control of mummyberry on blueberries (Project Nos. B00062, B00053 and B00083) was identified as an organic grower need at the IR-4 2015 Biopesticide Workshop.

Odium neolycopersici **(POWDERY MILDEW) / TOMATOES (GH)**

Odium neolycopersici **(Powdery Mildew) / Tomatoes (GH): Introduction**

(Source: Sharon M. Douglas, Powdery Mildew in the Greenhouse, Connecticut Agricultural Extension Station, New Haven, CT, January, 2001)

Powdery mildew is probably one of the most common and widely distributed diseases of plants in greenhouse production. This disease is responsible for significant economic losses in many greenhouse vegetable (*e.g.*, tomatoes, cucumbers) crops. With tomato, infections can significantly reduce fruit production. In the greenhouse, powdery mildew tends to be more problematic in the spring and fall when day-night temperatures favor high relative humidity, but it can develop at any time during any production cycle. An understanding of the disease cycle, organisms involved, and factors that favor disease development will contribute to successful management of this disease.

Odium neolycopersici **(Powdery Mildew) / Tomatoes (GH): Symptoms**

(Source: Sharon M. Douglas, Powdery Mildew in the Greenhouse, Connecticut Agricultural Extension Station, New Haven, CT, January, 2001)

Powdery mildews are easily recognized by the white, powdery growth of the fungus on infected portions of the plant host. The powdery appearance results from the superficial growth of the fungus as threadlike strands (hyphae) over the plant surface and the production of chains of spores (conidia). Colonies vary in appearance from fluffy and white to sparse and gray. Powdery mildew fungi usually attack young developing shoots, foliage, stems, and flowers. They can also colonize mature tissues. Symptoms often first appear on the upper leaf surface but can also develop on lower leaf surfaces. Early symptoms vary and can appear as irregular chlorotic or purple areas or as necrotic lesions, all of which are followed by the typical white, powdery appearance. Other symptoms include atypical scab-like lesions, witches'-brooms, twisting and distortion of newly emerging shoots, premature leaf coloration and drop, slowed or stunted growth, and leaf rolling. In rare but extreme situations, heavy infections cause plant death. Although diagnosis of powdery mildew is not difficult, symptoms often escape early detection if plants are not periodically monitored since symptoms can first develop on lower or middle leaves. This helps explain reports of sudden "explosions" of disease when the percentage of infected leaves increases from 10% to 70% in one week.

Odium neolycopersici **(Powdery Mildew) / Tomatoes (GH): Causal Organisms and Disease Development**

(Source: Sharon M. Douglas, Powdery Mildew in the Greenhouse, Connecticut Agricultural Extension Station, New Haven, CT, January, 2001)

Although the symptoms of disease are similar, the fungi responsible for powdery mildew fall into a number of different genera. The genera of primary importance to greenhouse production include *Erysiphe, Leveillula, Microsphaera, Sphaerotheca,* and *Oidium.* These fungi are all obligate parasites that require living hosts in order to complete their life cycles, so they readily infect healthy, vigorous plants. It is important to know the identity of the fungus in order to determine the potential for spread to other crops that might be present in the greenhouse.

Development of powdery mildew in the greenhouse is influenced by many environmental factors including temperature, relative humidity, light level, and air circulation. Unfortunately, greenhouses usually provide optimum levels for all of these conditions. Optimum conditions include moderate temperatures (68-86°F), high humidities (>95% relative humidity), and fairly low light intensities or shade. However, these requirements vary with the specific powdery mildew fungus. There is an inverse relationship between temperature and relative humidity which influences both the production and spread of powdery mildew conidia. As temperatures fall at night, relative humidity increases.

High relative humidity stimulates conidia to germinate and also encourages the production of chains of conidia in existing infections. In the morning after sunrise, the temperatures warm and relative humidity levels fall. These conditions help to dry the chains of conidia. Since conidia function as the primary means for new infections in the greenhouse, air movement and circulation in the house are very important for development and spread of disease. Dry, "powdery" conidia are easily dislodged and disseminated by air movement from grower activities in the house as well as by opening and closing doors.

Odium neolycopersici **(Powdery Mildew) / Tomatoes (GH): Strategies for Disease Management** (Source: Sharon M. Douglas, Powdery Mildew in the Greenhouse, Connecticut Agricultural Extension Station, New Haven, CT, January, 2001)

Although chemical control continues to be a key component of management of powdery mildew in the greenhouse, other strategies complement and enhance control efforts.

1. Culture and Pathogen Identification
   - Maintain adequate plant spacing to reduce relative humidity levels in the plant canopy. This also helps to obtain good coverage with fungicide sprays.
   - Maintain relative humidity levels below approximately 93% by properly timed venting and heating.
   - Identify the particular powdery mildew fungus in order to anticipate the potential for spread to other plants in the house.
   - Syringing or applying water directly to leaves of some greenhouse crops discourages germination of conidia and helps to wash conidia off leaf surfaces. This procedure works for some crops provided other types of foliar diseases favored by leaf wetness are not common problems for that crop.

2. Monitoring and Sanitation
   - Carefully examine and inspect new cuttings, seedlings, and plugs upon arrival. Never use diseased plant material.
   - Scout for disease on a regular schedule to identify outbreaks before they become widespread. This typically involves examining one out of 30 plants each week. It is helpful to concentrate on the middle and lower leaves since infections often start in these leaves. Once disease is detected, examine one out of 10 plants every week. Continue with this schedule until plants are free of disease for at least three weeks. Thereafter, resume weekly scouting of one plant out of 30.
   - All diseased tissues should be removed as soon as they are detected and immediately placed in a plastic bag to avoid carrying infected material through the house.
   - All production areas should be thoroughly cleaned and plant debris removed between crops and production cycles. This includes removing all weeds in and around the greenhouse.

3. Resistance
   - Genetic resistance is very effective for powdery mildew control.

4. Chemical

   Control with chemicals is targeted at eradication of existing infections and protection of healthy tissues. Once disease is detected, the first sprays should be aimed at eradication. These are usually followed by sprays for protection. The efficacy of specific compounds can vary significantly with the particular powdery mildew fungus and host, so knowledge of the host-pathogen combination is helpful. Attention to spray delivery and coverage is also very important.
   - Eradication sprays should be applied as soon as symptoms are first observed since early control is critical!!!

- Monitor and rotate the types of compounds used to avoid development of fungicide resistance in the powdery mildew population. The diversity of products currently registered and effective for greenhouse use makes fungicide resistance management much easier than in the past. Since pesticide registrations vary with state, check with the appropriate agency and consult the label before applying any pesticide.

Powdery Mildew (pathogen not specified) / Tomatoes: OMRI-Listed Fungicides for Use in the United States (Greenhouse and Field) (No efficacy data have been identified or evaluated.)								
(Source: EPA Label)								NOP Status
FRAC Code	Active Ingredient	Product Name	Product Rate/Acre	PHI (Days)	REI (Days)	EPA Reg. No.	Comments	
44	*Bacillus amyloliquefaciens* str. D747	Double Nickel 55	0.25-3 lb	0	4	70051-108	Causes moderate eye irritation. Dermal sensitizer. Broad-spectrum preventative fungicide. Do not use highly alkaline or highly acidic water to mix sprays. Use a buffering agent if necessary to maintain neutrality (pH 6 to 8) of water in the tank. Suppression only.	Non-synthetic
	Bacillus pumilus str. QST 2808	Sonata ASO	2-4 qt	0	4	264-1153	Harmful if inhaled. Mixers/loaders and applicators must wear a dust/mist filtering respirator meeting NIOSH standards of at least N-95, R-95, or P-95. Repeated exposure to high concentrations of microbial proteins can cause allergic sensitization. Maintain a spray solution pH between 4.5 and 8.5. NOT REGISTERED FOR POWDERY MILDEW CONTROL IN CALIFORNIA.	Non-synthetic
	Bacillus subtilis var. *amyloliquefaciens* str. FZB24	Taegro ECO	2.6-5.2 oz	0	4	70127-5-100	WARNING signal word. Causes skin irritation. Causes moderate eye irritation. Consists of living microbes. Store at room temperature and use before the expiration date. Avoid temperatures exceeding 73°F (23°C). Do not freeze. For suppression only. Most effective in low to medium disease situation. Start applications prior to disease or at disease establishment.	Non-synthetic
P5	*Reynoutria sachalinensis*	Regalia Biofungicide	0.5-1 qt	0	4	84059-3	Causes moderate eye irritation. Preventative rather than a curative application. Apply prior to disease infestation to protect the growing leaf tissue. Avoid freezing. Apply prior to disease infestation.	Non-synthetic
Not classified; Biological	*Streptomyces lydicus* WYEC 108	Actinovate AG	3-12 oz	0	1 or until solution has dried	73314-1	Avoid contact with skin, eyes, or clothing. Avoid breathing dust or spray mist. Mixer/loaders and applicators must wear a dust/mist filtering respirator meeting NIOSH standards of at least N-95, R-95, or P-95. Repeated exposure to high concentrations of microbial proteins can cause allergic sensitization. Keep from overheating or freezing. Optimum storage temperature is 40°F to 85°F. Contains live spores of a microbe. Best results will be obtained if the product is used prior to disease onset. Becomes active in soil or on the plant foliage when the temperatures are above 45°F and is not effective when temperatures remain cold. Do not apply soil fumigants to treated areas.	Non-synthetic
Not classified; Botanical oil	Cinnamon oil	Cinnerate	13-30 fl oz/ 85-210 gal water	0	0	N/A	May cause eye and skin irritation. May cause dermal sensitization. Store upright at room temperature. Avoid exposure to extreme temperatures. Do not expose to light and keep away from any heat source. Do not mix with oxidizing, strong acidic or basic materials. Broad spectrum, contact foliar fungicide. All applications should be preceded by a phytotoxicity check to ensure that the material is safe for the particular plant variety.	Non-synthetic
	Neem oil	Trilogy	0.5-1.0% solution/ 25-100 gal water	0	4	70051-2	Causes moderate eye irritation. Hazardous to fish and aquatic invertebrates. Toxic to bees exposed to direct treatment. Broad spectrum. Exercise care in timing applications during early morning/late evening to minimize the potential for leaf burn. Use care on plants with tender tissue. Check for leaf burn in small scale trials prior to use. Do not apply to sensitive plant species. Do not apply to wilted or otherwise stressed plants, or to newly transplanted materials or crops prior to root establishment. For optimal performance, do not mix with cold water (less than 45°F). Do not store below 40°F (4°C). Do not use or store near heat or open flame.	Non-synthetic
	Sesame oil	Organocide 3-in-1	1-2 oz/gal water	0	NA	N/A. FIFRA §25(b) pesticide.	Insecticide, miticide, and fungicide. If spraying on severely stressed or damaged plants, consider using a lower rate such as 1 oz. per gallon to avoid adding additional stress. For best results, spray in the early morning.	Non-synthetic

Powdery Mildew (pathogen not specified) / Tomatoes: OMRI-Listed Fungicides for Use in the United States (Greenhouse and Field) (No efficacy data have been identified or evaluated.)								
(Source: EPA Label)								NOP Status
FRAC Code	Active Ingredient	Product Name	Product Rate/Acre	PHI (Days)	REI (Days)	EPA Reg. No.	Comments	
M2	Sulfur	Acoidal	10-20 lb	0	24	62562-4	Harmful if swallowed, inhaled, or absorbed through skin. Toxic to fish and aquatic organisms. Sulfur dust suspended in air ignites easily. Keep away from heat, sparks, or flames. Do not smoke while applying this product. Sulfur may cause severe fruit and foliage injury to certain crops. Sulfur may burn foliage when temperature is high. Do not apply within 2 weeks of an oil spray treatment.	Synthetic
		Defend	10-20 lb	0	24	62562-8		
		Micro Sulf	5-10 lb	0	24	55146-75	Harmful if swallowed, inhaled, or absorbed through skin. Causes eye irritation. Risk of crop injury if temperature exceeds 90°F within 3 days following application. Do not use on any crop unless sulfur has been shown to be safe in your locality. Do not apply within 14 days of an oil spray. Keep away from heat, sparks, or flames. Do not smoke while applying this product.	
		Microthiol Disperss	10-20 lb	0	24	70506-187	Harmful if swallowed, inhaled, or absorbed through skin. Risk of crop injury if temperature exceeds 90°F within 3 days following application. Do not use on any crop unless sulfur has been shown to be safe in your locality. Do not store near flammable materials. Do not store in a manner where cross-contamination with other pesticides, fertilizers, food or feed could occur. Restrictions regarding application time before and after an oil spray treatment.	
		Thiolux	3-10 lb	0	24	34704-1079	Harmful if swallowed, inhaled, or absorbed through skin. Causes eye irritation. Sulfur may case severe fruit and foliage injury to certain crops. Risk of crop injury if temperature exceeds 90°F within 3 days following application. Do not apply within 14 days of an oil spray. Sulfur dust suspended in air easily ignites. Keep away from heat, sparks, or flames. Do not smoke while applying this product.	
Not classified; Inorganic salt	Potassium bicarbonate	Kaligreen	2.5-3.0 lb	1	4	70231-1	Harmful if swallowed, absorbed through skin, or inhaled. Do not mix with highly acidic products as effectiveness may be compromised. Use of a buffering agent for acidification of a tank mixture may also decrease effectiveness. Crop injury may result due to certain environmental or growing conditions, manner of use or application.	Synthetic
		Milstop	2-5 lb	0	1	70870-1-68539	Harmful if swallowed. Causes moderate eye irritation. Broad spectrum contact foliar fungicide. Do not mix with other soluble pesticides or fertilizers. Not compatible with mild alkaline solutions. Acidification of solution will cause reduced product performance. Prevent exposure to moisture during storage. Avoid contamination with other pesticides and fertilizers.	
	Potassium silicate	Sil-Matrix	0.25-1% solution	0	4	82100-1	Causes moderate eye irritation. Avoid contact with glass. Remove promptly from glass surfaces. Store product above 40°F. Do not store in aluminum, fiberglass, copper, brass, zinc, or galvanized containers. Protect from excessive heat. Broad spectrum preventative fungicide.	Synthetic
Not classified; Organic salt	Potassium salts of fatty acids	M-Pede	1-2% vol/vol	0	12	10163-324	WARNING signal word. Causes substantial but temporary eye injury and skin irritation. May be hazardous to aquatic invertebrates. Do not use with sulfur or within 3 days of a sulfur application. Apply M-Pede solutions to wet (minimize run-off) to decrease the potential for injury on foliage, fruit and flowers of sensitive plants. Avoid application to new transplants and unrooted cuttings.	Synthetic

Powdery Mildew (pathogen not specified) / Tomatoes: OMRI-Listed Fungicides for Use in the United States (Greenhouse and Field) **(No efficacy data have been identified or evaluated.)**								
(Source: EPA Label)								NOP Status
FRAC Code	Active Ingredient	Product Name	Product Rate/Acre	PHI (Days)	REI (Days)	EPA Reg. No.	Comments	
Not classified; Oxidizing agent	Hydrogen dioxide, Peroxyacetic acid	Oxidate 2.0	0.33 - 1.0 gal/ 100 gal water	0	Until spray has dried	70299-2	DANGER signal word. Causes irreversible eye damage. May be fatal if swallowed. Causes skin irritation or temporary discoloration of exposed skin. Highly toxic to bees and other beneficial insects. Toxic to fish. Toxic to birds who eat treated seed on soil surface. Strong oxidizing agent. Do not use in undiluted form. Never bring undiluted product in contact with other pesticides, cleaners or oxidative agents. May react with residues of metal-based fungicides or supplements. Allow at least 24 hrs. after application of metal-based products. Do not spray during conditions of intense heat, drought, or poor plant vigor (or vine canopy). Do not apply in conjunction with any other pesticides or fertilizers. Do not allow product to become overheated in storage. Do not store in a manner where cross-contamination with other pesticides or fertilizers could occur. Apply consecutive applications until control is achieved; then apply preventative treatments.	Synthetic
	Hydrogen peroxide, Hydrogen dioxide	Perpose Plus	Initial/ Curative: 1 fl oz/gal. Weekly/ Preventative: 0.25-0.33 fl oz/gal.	0	Until spray has dried	86729-1	DANGER signal word. Causes irreversible eye damage and skin burns. May be fatal if absorbed through the skin. Harmful if swallowed. Do not breathe vapor from concentrate. Toxic to birds, mammals, fish and aquatic life. At temperatures exceeding 156°F, decomposition releases oxygen. The oxygen released could initiate or promote combustion of other materials. Store away from combustibles. Broad spectrum algaecide and fungicide. Apply curative rates for 3 consecutive days (drenching the entire plant) followed by weekly preventative treatments.	Synthetic

Powdery Mildew (pathogen not specified) / Tomatoes: OMRI-Listed Fungicides for Use in the United States (Greenhouse and Field) **(No efficacy data have been identified or evaluated.)**								
(Source: EPA Label)								NOP Status
FRAC Code	Active Ingredient	Product Name	Product Rate/Acre	PHI (Days)	REI (Days)	EPA Reg. No.	Comments	
Not classified; Petroleum oils	Paraffinic oil	Organic JMS Stylet Oil	3-6 qt/100 gal water	0	4	65564-1	Harmful if swallowed. Toxic to fish. Do not freeze. Do not spray wet foliage. Do not spray when freezing temperatures are anticipated within 48 hours of an oil application, above 90°F (32°C) or when plants are under heat or moisture stress. Do not apply to vegetables when the temperature is below 50°F (10°C). Do not apply micronized sulfur within 10 days of an oil application. Do not apply oil within 14 days of an application of wettable or dusting sulfur. Do not apply to oil sensitive varieties. See label for additional compatibility restrictions. <u>Grapes</u>: Do not use copper and oil when fruit is present. Do not apply micronized sulfur within 10 days of an oil application. Do not apply oil with 14 days of an application of wettable or dusting sulfur.	
	Mineral oil	PureSpray Green	0.75-1.5 gals/ 100 gal at 100-200 gal water	0	4	69526-9	Harmful if swallowed or absorbed through skin. Prolonged or repeated skin contact may cause allergic reaction in some individuals. Drift and runoff may be hazardous to aquatic organisms in water adjacent to treated areas. Use extreme care when using concentrate sprays as the potential for crop phytotoxicity is increased. Avoid excess heat. Do not spray during or immediately prior to hot or freezing weather (over 95°F or under 32°F), hot dry winds, rain or other unsuitable conditions. Do not overspray or double spray. Spray plants only when they are in vigorous condition and when their moisture condition is suitable. Before using, make certain spray tank is free of sulfur residues. Do not apply micronized sulfur within 10 days of an oil application. Do not apply oil within 14 days of an application of wettable or dusting sulfur. Do not apply to oil sensitive varieties. See label for additional compatibility restrictions regarding many conventional active ingredients.	Synthetic
		SuffOil-X	1-2 gal/100 gal water	0	4	48813-1-68539	Harmful if absorbed through skin. Prolonged or frequently repeated skin contact may cause allergic reactions in some individuals. Do not use in combination with any product containing sulfur. Do not use with any product whose label recommends the use of no oils. Do not use in combination with NPK foliar fertilizer applications. Do not apply during periods of drought or when plants exhibit moisture stress.	
		Tritek	1-2 gal/100 gal water	0	4	48813-1		

Odium neolycopersici (Powdery Mildew) / Tomatoes (GH): Efficacy Trials

Odium neolycopersici (Powdery Mildew) / Tomatoes #1: Trial No. BCGGA-2015-03

a. Design

Odium neolycopersici (Powdery Mildew) / Tomatoes (GH) #1: Trial No. BCGGA-2015-03: Design				
Title:	Efficacy and Crop Tolerance of Polyoxin D Zinc 5SC Fungicide for Control of Powdery Mildew of Greenhouse Tomato in British Columbia, 2015			
Authors and affiliation:	J. F. Elmhirst, J. Hayes, *et al.* Elmhirst Diagnostics & Research Abbotsford, BC V4X 1T6 Canada			
Publication:	Canadian Journal of Plant Pathology DOI: 10.1080/07060661.2016.1163815			
Location:	Greenhouse Elmhirst Diagnostics & Research Abbotsford, BC V4X 1T6 Canada			
Crop:	Beefsteak-type Tomato (*Solanum lycopersicum* L.) cv. 'Torero'			
Disease name:	Powdery mildew			
Pathogen:	*Odium neolycopersici* L. Kiss a.k.a. *Pseudoidium neolycopersici* (I. Kiss) L. Kiss (2012)			
Test plot design:	Randomized complete block			
Number of replicates:	4			
Application equipment:	CO_2 backpack sprayer (40 psi)			
Spray volume:	1000 L/ha (first 3 applications) 2000 L/ha (final 2 applications due to the larger plant size)			
Number of applications:	5			
Application interval:	7 days			
Number of applications at 7-day intervals:	3 (0.3, 0.5, and 1.0 L/ha)			
Number of applications at 14-day intervals:	2 (1.0 and 1.5 L/ha)			
Chronology:	Application Dates at 7-Day Intervals	Application Dates at 14-Day Intervals	Inoculation Dates	Disease Assessment Dates
	05/06/2015	05/06/2015	05/07/2015	05/20/2015
	05/13/2015	05/20/2015	05/17/2015	05/27/2015
	05/20/2015	06/03/2015		06/03/2015
	05/27/2015			06/10/2015
	06/03/2015			06/17/2015
				06/24/2015
				07/01/2015

b. Results

Odium neolycopersici L. Kiss (Powdery Mildew) / Tomatoes (GH) #1: Trial No. BCGGA-2015-03: Efficacy Results										
Treatment	No. Apps & Interval	Rate/ Acre	Rate/ ha	g a.i./ ha	Active Ingredient	FRAC Code	Mean Incidence (AUDPC)		Mean Severity (AUDPC)	
							Measured	% Control	Measured	% Control
Water, inoculated control	4 at 7 days	NA	NA	NA	Not Applicable		1549.7 ± 181.6 a (a)	NA	5588.0 ± 4986.0 a (a)	NA
Polyoxin D 5SC	4 at 7 days	4.1 fl oz	0.3 L	15	Polyoxin D zinc salt	19	357.3 ± 197.3 b (bc)	76.9	409.6 ± 258.7 b (b)	92.7
Polyoxin D 5SC	4 at 7 days	6.8 fl oz	0.5 L	25	Polyoxin D zinc salt	19	311.0 ± 68.1 bc (bc)	79.9	338.4 ± 94.6 b (b)	93.9
Polyoxin D 5SC	4 at 7 days	13.7 fl oz	1.0 L	50	Polyoxin D zinc salt	19	249.5 ± 168.9 bc (bc)	83.9	193.9 ± 145.1 b (b)	96.5
Polyoxin D 5SC	2 at 14 days	13.7 fl oz	1.0 L	50	Polyoxin D zinc salt	19	424.4 ± 223.4 b (b)	72.6	430.5 ± 291.0 b (b)	92.3
Polyoxin D 5SC	2 at 14 days	20.5 fl oz	1.5 L	75	Polyoxin D zinc salt	19	437.6 ± 311.0 b (b)	71.8	343.9 ± 261.3 b (b)	93.9
Pristine WDG (Apps A and C)	2 at 14 days		1.3 kg		Boscolid	7	120.6 ± 94.0 c (c)	92.2	80.2 ± 80.2 b (b)	98.6
					Pyraclostrobin	11				
Nova 40W (App B)	1 at 14 days		340 g		Myclobutanil	3				

AUDPC = Area Under the Disease Progression Curve.

Disease incidence was assessed by counting (a) the percentage of trifoliated leaves with at least on powdery mildew colony out of the total number of leaves per plant and (b) the number of individual powdery mildew colonies (lesions) on the lower 8 leaves of each plant.

Disease severity (percentage of leaf necrotic area per plant) was rated visually on the Horsfall-Barrett (H-B) scale.
0 = No disease. 1 = 0.3% leaf area affected. 2 = 3-6% leaf area affected. 3 = 6-12% leaf area affected.
4 = 12-25% leaf area affected. 5 = 25-50% leaf area affected. 6 = 50-75% leaf area affected. 7 = 75-88% leaf area affected.
8 = 88-94% leaf area affected. 9 = 94-97% leaf area affected. 10 = 97-10% leaf area affected. 11 = 100% leaf area affected.
Severity scores were transformed to percentages following the standard grade formula of Redman, King and Brown (1982).

Treatment means followed by the same letter are not statistically different according to Duncan's MRT or (Tukey's HSD) at P = 0.05.

Inoculation was 24 hours after the first application. Therefore, the first treatment was preventative and the following treatments were curative.

No phytotoxicity was observed.

Odium neolycopersici L. Kiss (Powdery Mildew) / Tomatoes #1: Trial No. BCGGA-2015-03: Crop Yield Results										
Treatment	No. Apps & Interval	Rate/ Acre	Rate/ ha	g a.i./ ha	Active Ingredient	FRAC Code	Fruit Yield/Plot			
							Mean Number	Percent Increase	Mean Weight	Percent Increas e
Water, inoculated control	4 at 7 days	NA	NA	NA	Not Applicable		12.0 ± 2.2 a		1511.1 ± 282.9 a	
Polyoxin D 5SC	4 at 7 days	4.1 fl oz	0.3 L	15	Polyoxin D zinc salt	19	13.0 ± 2.2 a	8.3	1480.5 ± 105.4 a	-1.4
Polyoxin D 5SC	4 at 7 days	6.8 fl oz	0.5 L	25	Polyoxin D zinc salt	19	14.5 ± 3.9 a	20.8	1540.2 ± 571.7 a	1.9
Polyoxin D 5SC	4 at 7 days	13.7 fl oz	1.0 L	50	Polyoxin D zinc salt	19	14.5 ± 5.0 a	17.2	1697.9 ± 378.7 a	12.4
Polyoxin D 5SC	2 at 14 days	13.7 fl oz	1.0 L	50	Polyoxin D zinc salt	19	12.0 ± 2.9 a	0.0	1320.8 ± 170.8 a	-12.6
Polyoxin D 5SC	2 at 14 days	20.5 fl oz	1.5 L	75	Polyoxin D zinc salt	19	16.0 ± 6.5 a	33.3	1589.1 ± 288.8 a	5.2
Pristine WDG (Apps A and C)	2 at 14 days		1.3 kg		Boscalid	7	10.5 ± 2.1 a	-12.5	1216.9 ± 43.5 a	-19.5
					Pyraclostrobin	11				
Nova 40W (App B)	1 at 14 days		340 g		Myclobutanil	3				
Treatment means followed by the same letter are not statistically different in Duncan's MRT at P = 0.05.										

No phytotoxicity was observed.

c. Discussion and Conclusions

Greenhouse grown tomatoes were treated preventatively and curatively. Maximum powdery mildew incidence was 62.5%.

Five Polyoxin D Zinc Salt 5SC Fungicide treatment designs were used.

- Three treatment designs included 4 treatments at 7-day intervals. The associated application rates were 4.1 fl oz/acre (15 g a.i./ha), 6.8 fl oz/acre (25 g a.i./ha), and 13.7 fl oz/acre (50 g ai./ha).
- Two treatment designs included 2 treatments at 14-day intervals. The associated application rates were 13.7 (50 g a.i./ha) and 20.5 fl oz/acre (75 g a.i/ha).

The tomato plants were inoculated 1 day after the initial fungicide treatment and re-inoculated 10 days later. Therefore, first treatments were preventative, and the latter treatments were curative.

Polyoxin D Zinc Salt 5SC Fungicide treatments provided 92.3% to 93.9% control of powdery mildew severity. This was statistically:

- Superior to the untreated control; and
- Equivalent to the powdery mildew control provided by a treatment program that included boscalid, pyraclostrobin, and myclobutanil.

Polyoxin D Zinc Salt 5SC Fungicide treatments provided 71.8% to 83.9% control of powdery mildew incidence.

- All Polyoxin D Zinc Salt 5SC Fungicide treatments provided control of powdery mildew incidence that were superior to the untreated control.
- The Polyoxin D Zinc Salt 5SC Fungicide treatments with 7-day retreatment intervals provided control of powdery mildew incidence that were statistically equivalent to the control provided by a treatment program that included boscalid, pyraclostrobin, and myclobutanil.

No statistically significant differences in yield were observed. No phytotoxicity was observed.

Odium neolycopersici **(Powdery Mildew) / Tomatoes (GH): Canadian Greenhouse Grower Need**
This study was sponsored by the British Columbia Greenhouse Growers Association to address the need of British Columbian growers for fungicides to control powdery mildew on greenhouse grown tomatoes. *Odium neolycopersici* was the selected pathogen species because it is the predominant tomato powdery mildew pathogen species in British Columbia.

Odium neolycopersici **(Powdery Mildew) / Tomatoes (GH): US Greenhouse Grower Need**
Zero-day PHI products for use on greenhouse vegetables (Project No. B00024) was identified as a grower need at the IR-4 2015 Biopesticide Workshop.

Phytophthora infestans (LATE BLIGHT) / POTATOES

Phytophthora infestans (Late Blight) / Potatoes: Time for Concern

(Source: 2015 Organic Production and IPM Guide for Potatoes, Cornell University Cooperative Extension)

Throughout the growing season and in storage. High moisture and moderate temperatures (60-80°F) favor late blight development. Disease will stall in hot weather.

Phytophthora infestans (Late Blight) / Potatoes: Key Characteristics

(Source: 2015 Organic Production and IPM Guide for Potatoes, Cornell University Cooperative Extension)

This fungus causes lesions on leaves and stems that appear as small flecks within three to five days after infection. The infected tissue is initially water-soaked but becomes brown or black in a few days. Lesions are often surrounded by a halo of light green tissue. Under high humidity, sporulation is visible as a delicate, white mold surrounding the lesion. Rain may wash spores down the stems and infect tubers. Infected tubers develop a shallow reddish-brown corky dry rot. Bacterial soft rot often follows. Late blight overwinters on infected, stored tubers or tubers left in the field.

Phytophthora infestans (Late Blight) / Potatoes: Relative Risk

(Source: 2015 Organic Production and IPM Guide for Potatoes, Cornell University Cooperative Extension)

This disease is occurring with increasing regularity and can be totally devastating when present. In very wet cool weather, infections can spread quickly, leading to 50% or greater reductions in yield even with copper sprays, and complete yield loss if no control measures are taken. Hot weather slows disease progress.

Phytophthora infestans **(Late Blight) / Potatoes: Management Options**
(Source: 2015 Organic Production and IPM Guide for Potatoes, Cornell University Cooperative Extension)

Management Option	Recommendation for Late Blight
Scouting thresholds	Scout fields weekly for late blight symptoms. A forecasting system for late blight is available for some New York locations through the Network for Environment and Weather Awareness Potato late blight forecast. The forecasting system has two parts: • Early season prediction of first appearance of late blight (Blitecast); and • Subsequent recommended spray intervals (Simcast). Late blight is first expected to appear 1-2 weeks after 18 Blitecast Severity Values (SV) have accumulated, starting with the emergence of green tissue from the source of late blight inoculum. The source of inoculum could be plants growing from infected tubers in a cull pile, volunteers growing from infected tubers that survived the winter, or infected seed tubers. Start scouting soon after 18 SV have accumulated if a late blight forecast is available for your area, or when potatoes are 4-6" high. Conventional farmers begin applying fungicides at this point and maintain coverage until harvest, adjusting spray intervals to reflect weather conditions as described below. If late blight is found early in the season, it may not be possible to control it adequately using approved copper products, and the field may need to be disked under. Track where late blight has been found in NY and monitor potential sources of late blight spores from off your farm at usablight.org. If late blight is found in your county or adjacent counties and you choose to use copper, apply an approved copper fungicide immediately even if late blight has not been found in your field. The fungicide must be present before infection occurs to have a chance of successful control. Coverage should be excellent throughout the canopy. Once fungicide applications have started, use the Simcast Forecast to help determine spray intervals. Be aware that copper can build up in the soil. If present, harvest the crop early before it becomes contaminated. Harvest new potatoes and sell early, if possible.
Site selection	Avoid fields that cannot be effectively sprayed. Fields surrounded by trees that shade and slow air movement, or those remaining damp late into the morning are at higher risk for infection.
Crop rotation	Do not plant potatoes near a field where late blight occurred the previous year and there is a potential for volunteer plants growing from unharvested tubers.
Resistant varieties	Potato varieties differ slightly in their susceptibility, but commercial varieties do not have useful levels of resistance. Late variety Elba has foliar resistance but not tuber resistance. Choose early maturing varieties that will allow early harvest.

Management Option	Recommendation for Late Blight
Seed selection/treatment	Infected seed potatoes serve as an important source of inoculum. Plant phytosanitary certified seed. Know your seed grower. Even state phytosanitary certified seed may have a low percentage of late blight. Obtain plant health certification from state certifying agency indicating if late blight was present in the field. Phytosanitary certified seed must have no more than 1% late blight tuber rot.
Planting	Plant on proper row spacing to ensure adequate air flow around leaves and leaf drying.
Hilling	Proper hilling practices reduce the exposure of tubers to spores.
Vine killing	Proper vine-killing practices reduce the exposure of tubers to spores. If a field has significant infection, destroy foliage by mowing or flaming to prevent infection of other fields including tomatoes.
Harvest	Foliage and vines should be completely dead and dry before harvest to avoid inoculating tubers. Providing at least 2-3 weeks post-vinekill prior to harvesting will improve skin set and allow many blight infected tubers to develop visual symptoms that can be graded out prior to storage or marketing.
Postharvest	Cool tubers as quickly as possible to 50 degrees and maintain good air circulation. Maintain proper storage temperature depending on variety grown. Monitor storage potatoes for infection.
Sanitation	Eliminate cull piles and volunteers before plants emerge in the spring. Infected shoots from these plants can provide initial inoculum for field infection.
Notes	High nitrogen rates can lead to excessive foliage that will prevent adequate airflow and thus slow foliage drying.

Phytophthora infestans **(Late Blight) / Potatoes: OMRI-Listed Fungicides for Use in the United States for Foliar Treatments**										
FRAC Code	Source: 2015 Organic Production and IPM Guide for Potatoes, Cornell University Cooperative Extension							Source: EPA Label		NOP Status
	Active Ingredient	Product Name	Product Rate/Acre	PHI (Days)	REI (Days)	Efficacy	Comments	EPA Reg. No.	Comments	
44	*Bacillus amyloliquefaciens* str. D747	Double Nickel 55	0.25-3 lb	0	4	Not reviewed or no research available.	Suppression only.	70051-108	Causes moderate eye irritation. Dermal sensitizer. Broad-spectrum preventative fungicide. Do not use highly alkaline or highly acidic water to mix sprays. Use a buffering agent if necessary to maintain neutrality (pH 6 to 8) of water in the tank. Suppression only.	Non-synthetic
		Double Nickel LC	0.5-6 qt	0	4	Not reviewed or no research available.	Suppression only.	70051-114	Harmful if absorbed through skin. Harmful if inhaled. Dermal sensitizer. Broad-spectrum preventative fungicide.	
	Bacillus subtilis str. QST 713	Optiva	14-24 oz	0	4	Not reviewed or no research available.	Suppression. Repeat on a 5-7 day interval or as needed.	62592-26	Causes moderate eye irritation. Dermal sensitizer. Broad spectrum preventative product.	Non-synthetic
		Serenade ASO	2-6 qt	0	4	Not reviewed or no research available.	For suppression, begin applications soon after emergence when the conditions are conducive to disease development. Repeat on 5 to 7 day interval as needed.	264-1152	Broad spectrum preventative fungicidal and bactericidal product.	
		Serenade MAX	1-3 lb	0	4	Not reviewed or no research available.		69592-11	Dermal sensitizer. Broad spectrum preventative fungicidal and bactericidal product.	
P5	*Reynoutria sachalinensis*	Regalia Biofungicide	1-4 qt	0	4	Not reviewed or no research available.		84059-3	Causes moderate eye irritation. Preventative use only. Avoid freezing.	Non-synthetic
Not classified; Bio-surfactant	Rhamnolipid biosurfactant	Zonix	0.5-0.8 oz/gal	0	4	Not reviewed or no research available.	Contact biofungicide that controls disease upon contact with zoospores. Thorough coverage is necessary.	72431-1	DANGER signal word. Corrosive. Causes irreversible eye damage. Store out of direct sunlight and away from heat sources. Keep from overheating or freezing. Do not use for the control or prevention of late blight (*Phytophthora* spp.) when ambient temperatures are over 80°F. At above 80°F, that organism moves out of the zoospore stage and the product will not be efficacious.	Non-synthetic

Phytophthora infestans **(Late Blight) / Potatoes: OMRI-Listed Fungicides for Use in the United States for Foliar Treatments**										
FRAC Code	Source: 2015 Organic Production and IPM Guide for Potatoes, Cornell University Cooperative Extension							Source: EPA Label		NOP Status
	Active Ingredient	Product Name	Product Rate/Acre	PHI (Days)	REI (Days)	Efficacy	Comments	EPA Reg. No.	Comments	
M1	Basic copper sulfate	Basic Copper 53	2-4 lb	0	24	Copper products effective in 3/3 trials. Must be applied thoroughly and often. Suppression under ideal conditions. Not effective under heavy pressure.		45002-8	WARNING signal word. Causes substantial but temporary eye injury. Harmful if absorbed through skin or inhaled. Dermal sensitizer. Toxic to fish and aquatic organisms.	Synthetic
	Copper hydroxide	Nu-Cop 50 WP	Light infestation: 1-1.5 lb Heavy infestation: 3-4 lb	1	24	Copper products effective in 3/3 trials. Must be applied thoroughly and often. Suppression under ideal conditions. Not effective under heavy pressure.	Apply every 7-10 days when plants are 6 inches high.	42002-7	DANGER signal word. Corrosive. Causes irreversible eye damage. Harmful if swallowed, absorbed through skin, or inhaled. Skin sensitizer. Toxic to fish and aquatic organisms. Product should not be applied in spray water having a pH of less than 6.5 as phytotoxicity may result. Effectiveness reduced at pH greater than 9.0.	Synthetic
		Champ WG	1-4 lb	0	48	Copper products effective in 3/3 trials. Must be applied thoroughly and often. Suppression under ideal conditions. Not effective under heavy pressure.	Apply 1-1.5 lb where disease is light and up to 3 to 4 lb/acre where disease is more severe. May provide suppression of Colorado Potato Beetle.	55146-1	DANGER signal word. Corrosive. Causes irreversible eye damage. Harmful if inhaled. Skin sensitizer. Toxic to fish and aquatic organisms.	Synthetic
	Copper octanoate	Cueva Fungicide Concentrate	2.0 gal/ 100 gal water	0	4	Copper products effective in 3/3 trials. Must be applied thoroughly and often. Suppression under ideal conditions. Not effective under heavy pressure.	Apply in 50 to 100 gallons of water.	67702-2-70051	Harmful if swallowed or absorbed through skin. Toxic to fish and aquatic organisms. May cause some copper toxicity on some plant species. Store away from open fire or flame. Product may be damaged by freezing. Do not store product below 4°C. Do not mix with chelated or liquid fertilizers. Use caution when using product with other fungicides and insecticides.	Synthetic
	Copper oxychloride, Copper hydroxide	Badge X2	0.75-1.75 lbs	0	48	Copper products effective in 3/3 trials. Must be applied thoroughly and often. Suppression under ideal conditions. Not effective under heavy pressure.		80289-12	WARNING signal word. May be fatal if swallowed. Causes substantial but temporary eye injury. Harmful if absorbed through skin. Harmful if inhaled. Toxic to fish and aquatic organisms. Product must not be applied in a spray solution having a pH of less than 6.5 as phytotoxicity may occur. Do not tank mix product with Aliette® fungicide for use on any registered crops or ornamentals unless appropriate precautions have been taken to buffer the spray solution because severe phytotoxicity may result.	Synthetic

Phytophthora infestans (Late Blight) / Potatoes: OMRI-Listed Fungicides for Use in the United States for Foliar Treatments										
FRAC Code	Source: 2015 Organic Production and IPM Guide for Potatoes, Cornell University Cooperative Extension							Source: EPA Label		NOP Status
	Active Ingredient	Product Name	Product Rate/Acre	PHI (Days)	REI (Days)	Efficacy	Comments	EPA Reg. No.	Comments	
	Copper sulfate pentahydrate	Copper Sulfate Crystals	10 lb	0	24	Copper products effective in 3/3 trials. Must be applied thoroughly and often. Suppression under ideal conditions. Not effective under heavy pressure.		56576-1	DANGER signal word. Corrosive. Causes eye damage and skin irritation. Harmful if swallowed. Toxic to fish. Crop injury statements. <u>Grapes</u>: Bordeaux mixture will exhibit some phytotoxicity on most varieties.	Synthetic
		CS 2005	19.2-32 oz	0	48	Copper products effective in 3/3 trials. Must be applied thoroughly and often. Suppression under ideal conditions. Not effective under heavy pressure.		66675-3	DANGER signal word. Corrosive. Causes irreversible eye damage and skin irritation. Harmful if swallowed, inhaled or absorbed through the skin. Dermal sensitizer. Toxic to fish and aquatic organisms. Do not mix with acidic compounds. Do not mix with pot ash. Crop injury statements. Store away from excessive heat. Product will freeze. Store and handle product in 316L stainless steel, fiberglass, PVC's, polypropylenes or plastic equipment. Keep away from galvanized pipe and any nylon storage handling equipment.	Synthetic
		Quimag Quimicos Aguila Copper Sulfate Crystal	10	0	48	Copper products effective in 3/3 trials. Must be applied thoroughly and often. Suppression under ideal conditions. Not effective under heavy pressure.	Use alone through harvest to suppress late blight.	73385-3	DANGER signal word. Corrosive. Causes irreversible eye damage. May be fatal if swallowed. Causes skin irritation. Dermal sensitizer. Toxic to fish and aquatic invertebrates. Endangered species restriction. <u>Grapes</u>: Bordeaux mixture will exhibit some phytotoxicity on most varieties.	Synthetic
	Cupric hydroxide	Nu-Cop HB	0.5-2 lb	0	24	Copper products effective in 3/3 trials. Must be applied thoroughly and often. Suppression under ideal conditions. Not effective under heavy pressure.		42750-132	DANGER signal word. Corrosive. Causes irreversible eye damage. Harmful if swallowed, absorbed through skin, or inhaled. Product should not be applied in spray water having a pH of less than 6.5 as phytotoxicity may result.	Synthetic
	Cuprous oxide	Nordox 75 WG	1.25-2.5 lb	0	12	Copper products effective in 3/3 trials. Must be applied thoroughly and often. Suppression under ideal conditions. Not effective under heavy pressure.		48142-4	Harmful if swallowed or absorbed through skin. Causes eye irritation. Do not apply in a spray solution with a pH of less than 6.5.	Synthetic

Phytophthora infestans **(Late Blight) / Potatoes: OMRI-Listed Fungicides for Use in the United States for Foliar Treatments**										
FRAC Code	Source: 2015 Organic Production and IPM Guide for Potatoes, Cornell University Cooperative Extension							Source: EPA Label		NOP Status
	Active Ingredient	Product Name	Product Rate/Acre	PHI (Days)	REI (Days)	Efficacy	Comments	EPA Reg. No.	Comments	
Not classified; Oxidizing agent	Hydrogen dioxide, Peroxyacetic acid	Oxidate 2.0	Initial/ Curative: 128 fl oz/ 100 gal water; 30-100 gal solution/ acre Preventative: 40-128 fl oz/ 100 gal water; 30-100 gal solution/ acre	0	Until dry	Not effective in any known trials.	Hydrogen peroxide products effective in 0-3 trials.	70299-2	DANGER signal word. Causes irreversible eye damage. May be fatal if swallowed. Causes skin irritation or temporary discoloration of exposed skin. Highly toxic to bees and other beneficial insects. Toxic to fish. Toxic to birds who eat treated seed on soil surface. Strong oxidizing agent. Do not use in undiluted form. Never bring undiluted product in contact with other pesticides, cleaners or oxidative agents. May react with residues of metal-based fungicides or supplements. Allow at least 24 hrs. after application of metal-based products. Do not spray during conditions of intense heat, drought, or poor plant vigor (or vine canopy). Do not apply in conjunction with any other pesticides or fertilizers. Do not allow product to become overheated in storage. Do not store in a manner where cross-contamination with other pesticides or fertilizers could occur. Apply consecutive applications until control is achieved; then apply preventative treatments.	Synthetic
	Hydrogen peroxide, Hydrogen dioxide	Perpose Plus	Initial/ Curative: 1 fl oz/gal Weekly/ Preventa-tive: 0.25-0.33 fl oz/gal	0	Until spray has dried	Not effective in any known trials.	Hydrogen peroxide products effective in 0-3 trials.	86729-1	DANGER signal word. Causes irreversible eye damage and skin burns. May be fatal if absorbed through the skin. Harmful if swallowed. Do not breathe vapor from concentrate. Toxic to birds, mammals, fish and aquatic life. At temperatures exceeding 156°F, decomposition releases oxygen. The oxygen released could initiate or promote combustion of other materials. Store away from combustibles. Broad spectrum algaecide and fungicide. Apply curative rates for 3 consecutive days (drenching the entire plant) followed by weekly preventative treatments.	Synthetic

Phytophthora infestans **(Late Blight) / Potatoes: Efficacy Trials**

Phytophthora infestans (Late Blight) / Potatoes #1: Trial No. CER-2012-027

a. Design

Phytophthora infestans (Late Blight) / Potatoes #1: Trial No. CER-2012-027: Design						
Title:	Evaluation of Fungicides for Control of Potato Late Blight, 2012					
Authors and affiliation:	X.S. Qu, M.W. Peck, and B.J. Christ Department of Plant Pathology The Pennsylvania State University University Park, PA 16802					
Publication:	PDMR 7:V094					
Location:	Rock Springs, Centre County, Pennsylvania					
Crop:	Potato cv. 'Atlantic'					
Disease name:	Late blight					
Pathogen:	*Phytophthora infestans*					
Test plot design:	Randomized complete block					
Number of replicates:	4					
Inoculation:	3 isolates of *Phytophthora infestans* genotype US23 2.19×10^5 sporangia/mL					
Application equipment:	Tractor-mounted, N_2 pressurizes side boom sprayer					
Spray volume:	30 and 45 gal/acre					
Number of applications:	5					
Chronology:	Inoculation Date	Application Dates	Application Interval	Disease Assessment Dates	Vine Kill Dates	Harvest Date
	08/17/2012	08/15/2012		08/18/2012	09/20/2012	10/16/2012
		08/22/2012	7 days	08/24/2012	09/24/2012	
		08/29/2012	7 days	08/30/2012		
		09/05/2012	7 days	09/06/2012		
		09/12/2012	7 days	09/14/2012		
Disease assessment methodology:	Visual assessment for percentage of diseased foliage caused by late blight.					

b. Results

Phytophthora infestans (Late Blight) / Potatoes #1: Trial No. CER-2012-027: Results								
Treatment	Rate/ Acre	g a.i./ ha	Active Ingredient	FRAC Code	AUDPC		Yield (cwt/Acre)	
					Measured	Percent Control	Measured	Percent Increase
Untreated control			Not Applicable		1612 a		144 f	
CX-10440 [1]	6.5 oz	25	Polyoxin D zinc salt	19	1545 ab	4.2	167 ef	16.0
CX-10440 [1]	13 oz	50	Polyoxin D zinc salt	19	1449 b	10.1	164 f	13.9
Bravo Weather Stik 6SC	1.5 pt		Chlorothalonil	M5	437 de	72.9	257 a-d	78.5
Cabrio Plus	2.0 lb		Pyraclostrobin	11	445 de	72.4	232 cd	61.1
			Metiram	M2				
Treatment means followed by the same letter are not statistically different according to Fisher's protected least significant difference test at $P = 0.05$. AUDPC = Area under the disease progression curve. cwt/acre = Hundred weight per acre for tubers with diameter greater than 1.875 inches. 1. CX-10440 is the Certis USA, L.L.C. code for Polyoxin D Zinc Salt 5SC Fungicide.								

Late blight infection was observed in the field in the middle of August, 2012. Therefore, the treatments were preventative and curative.

No phytotoxicity was reported.

c. Discussion and Conclusions

Potatoes were grown in Pennsylvania. Two days after the first treatment, the trial was inoculated with 3 isolates of *Phytophthora infestans* genotype US23 at 2.19 x 10^5 sporangia/mL to promote a uniform spread of the late blight pathogen to all treatment plots. Late blight symptoms were soon observed. The area under the diseases progression curve in the untreated control was 1612.

Five treatments of Polyoxin D Zinc Salt 5SC Fungicide were applied preventatively and curatively at 7-day intervals.

- Polyoxin D Zinc Salt 5SC Fungicide applied at 6.5 oz/acre (25 g a.i./ha) provided 4.2% control of late blight in potatoes. This was numerically but not statistically superior to the untreated control. Yield was increased by 16.0%.
- Polyoxin D Zinc Salt 5SC Fungicide applied at 13 oz/acre (50 g a.i./ha) provided 10.1% control of late blight in potatoes. This was statistically superior to the untreated control. Yield was increased by 13.9%.
- Chlorothanonil and pyraclostrobin plus mitiram each provided superior control and increased yields.

No phytotoxicity was reported.

***Phytophthora infestans* (Late Blight) / Potatoes: Grower Need**

Control of late blight on potatoes (Project No. B00009) was identified as a grower need at the IR-4 2015 Biopesticide Workshop.

Phytophthora infestans (LATE BLIGHT) / TOMATO

Phytophthora infestans (Late Blight) / Tomato: Introduction

(Source: Late Blight: A Serious Disease of Potatoes and Tomatoes, Cornell University Cooperative Extension Fact Sheet)

Late blight is a plant disease that mainly attacks potatoes and tomatoes, although it can sometimes be found on other crops, weeds and ornamentals in the same botanical family (Solanaceae). Other plants that late blight may infect include petunia, nightshades, and tomatillos. Late blight was a factor in the Irish potato famine in the 1850's.

Late blight is caused by an oomycete pathogen. This organism is well known for its ability to produce millions of spores from infected plants under the wet weather conditions that favor the disease. Early in the season, the disease can be introduced into a field or garden on infected seed potatoes, from volunteer plants growing from diseased potatoes that were not harvested last season, from infected potatoes in cull piles, compost piles, or infected tomato transplants brought into the area.

Spores produced on infected potatoes and tomatoes can travel through the air, land on infected plants, and if the weather is sufficiently wet, cause new infections. Spores can also be washed through the soil to infect potato tubers, which may rot before harvest, or later in storage.

Because the oomycete that causes late blight produces so many spores, and the spores can travel long distances through the air, it is very important that everyone who grows potatoes or tomatoes is able to identify late blight and know how to control it, to avoid being a source of spores that infect potatoes and tomatoes in neighboring gardens and commercial fields. This disease is capable of wiping out not only your entire potato and tomato crop but also commercial fields very quickly under wet conditions. Farmers who grow potatoes or tomatoes are at serious risk of losing their entire income from these crops.

Phytophthora infestans (Late Blight) / Tomato: Symptoms

(Source: Late Blight: A Serious Disease of Potatoes and Tomatoes, Cornell University Cooperative Extension Fact Sheet)

On tomato fruit, late blight causes a firm, dark, greasy looking lesion from which the pathogen spore producing structures emerge under humid conditions.

Phytophthora infestans (Late Blight) / Tomato: Cultural Controls

(Source: Late Blight: A Serious Disease of Potatoes and Tomatoes, Cornell University Cooperative Extension Fact Sheet)

- <u>Avoid sources of inoculum</u>: The most effective management strategy for late blight is to avoid sources of early season inoculum (spores). Late blight can only survive on living tissue, so potato tubers or tomatoes (transplants or imported fruit) are the only source of early season inoculum. Certified seed is not a guarantee that late blight will not be present, however.
- <u>Resistant varieties</u>: Planting resistant varieties will slow down (but not prevent) the development of late blight.
- <u>Scouting</u>: During the growing season, check your potatoes and tomatoes for symptoms of late blight twice each week. Check more often during periods of wet weather. If you find any late blight in your garden, intensify your fungicide applications (by increasing application frequency or rates) within the guidelines listed on the label. If late blight becomes severe, destroy diseased plants by thoroughly tilling them under, or by cutting them off and immediately burying or bagging them to avoid producing large numbers of spores that could put nearby farmers and gardeners at risk.

Phytophthora infestans (Late Blight) / Tomatoes: OMRI-Listed Fungicides for Use in the United States
(No efficacy data have been identified or evaluated.)

FRAC Code	Active Ingredient	Product Name	Product Rate/Acre	PHI (Days)	REI (Days)	EPA Reg. No.	Comments	NOP Status
	Source: EPA Label							
44	*Bacillus amyloliquefaciens* str. D747	Double Nickel 55	0.25-3 lb	0	4	70051-108	Causes moderate eye irritation. Dermal sensitizer. Broad-spectrum preventative fungicide. Do not use highly alkaline or highly acidic water to mix sprays. Use a buffering agent if necessary to maintain neutrality (pH 6 to 8) of water in the tank. Suppression only.	Non-synthetic
		Double Nickel LC	0.5-6 qt	0	4	70051-114	Harmful if absorbed through skin. Harmful if inhaled. Dermal sensitizer. Broad-spectrum preventative fungicide. Suppression only.	
	Bacillus pumilus str. QST 2808	Sonata ASO	2-4 qt	0	4	264-1153	Harmful if inhaled. Mixers/loaders and applicators must wear a dust/mist filtering respirator meeting NIOSH standards of at least N-95, R-95, or P-95. Repeated exposure to high concentrations of microbial proteins can cause allergic sensitization. Maintain a spray solution pH between 4.5 and 8.5. Suppression only.	Non-synthetic
	Bacillus subtilis str. QST 713	Optiva	14-24 oz	0	4	62592-26	Causes moderate eye irritation. Dermal sensitizer. Broad spectrum preventative product. Suppression only. Repeat on a 5-7 day interval or as needed.	Non-synthetic
		Serenade ASO	2-6 qt	0	4	264-1152	Broad spectrum preventative fungicidal and bactericidal product. Suppression only. Begin applications when plants are 4 to 6 inches high. Repeat on 5 to 7 day interval as needed.	
		Serenade MAX	1-3 lb	0	4	69592-11	Dermal sensitizer. Broad spectrum preventative fungicidal and bactericidal product. Suppression only. Begin applications when plants are 4 to 6 inches high. Repeat on 5 to 7 day interval as needed.	
	Bacillus subtilis var. *amyloliquefaciens* str. FZB24	Taegro ECO	2.6-5.2 oz	0	4	70127-5-100	WARNING signal word. Causes skin irritation. Causes moderate eye irritation. Consists of living microbes. Store at room temperature and use before the expiration date. Avoid temperatures exceeding 73°F (23°C). Do not freeze. For suppression only. Most effective in low to medium disease situation. Start applications prior to disease or at disease establishment.	Non-synthetic
P5	*Reynoutria sachalinensis*	Regalia Biofungicide	1-3 qt	0	4	84059-3	Causes moderate eye irritation. Preventative use only. Avoid freezing. Reapply at 7-10 day intervals.	Non-synthetic
Not classified; Bio-surfactant	Rhamnolipid biosurfactant	Zonix	0.5-0.8 oz/gal	0	4	72431-1	DANGER signal word. Corrosive. Causes irreversible eye damage. Store out of direct sunlight and away from heat sources. Keep from overheating or freezing. Do not use for the control or prevention of late blight (*Phytophthora* spp.) when ambient temperatures are over 80°F. At above 80°F, that organism moves out of the zoospore stage and the product will not be efficacious.	Non-synthetic
Not classified; Botanical oil	Neem oil	Trilogy	0.5%-1.0% solution	0	4	70051-2	Causes moderate eye irritation. Hazardous to fish and aquatic invertebrates. Toxic to bees exposed to direct treatment. Broad spectrum. Exercise care in timing applications during early morning/late evening to minimize the potential for leaf burn. Use care on plants with tender tissue. Check for leaf burn in small scale trials prior to use. Do not apply to sensitive plant species. Do not apply to wilted or otherwise stressed plants, or to newly transplanted materials or crops prior to root establishment. For optimal performance, do not mix with cold water (less than 45°F). Do not store below 40°F (4°C). Do not use or store near heat or open flame.	Non-synthetic
M1	Basic copper sulfate	Basic Copper 53	2-4 lb	0	24	45002-8	WARNING signal word. Causes substantial but temporary eye injury. Harmful if absorbed through skin or inhaled. Dermal sensitizer. Toxic to fish and aquatic organisms.	Synthetic
	Copper hydroxide	Nu-Cop 50 WP	2-3 lb	1	24	42002-7	DANGER signal word. Corrosive. Causes irreversible eye damage. Harmful if swallowed, absorbed through skin, or inhaled. Skin sensitizer. Toxic to fish and aquatic organisms. Product should not be applied in spray water having a pH of less than 6.5 as phytotoxicity may result. Effectiveness reduced at pH greater than 9.0. Reapply at 3 to 10 day intervals.	Synthetic
		Champ WG	1.06 lb	0	48	55146-1	DANGER signal word. Corrosive. Causes irreversible eye damage. Harmful if inhaled. Skin sensitizer. Toxic to fish and aquatic organisms.	Synthetic

Phytophthora infestans (Late Blight) / Tomatoes: OMRI-Listed Fungicides for Use in the United States
(No efficacy data have been identified or evaluated.)

FRAC Code	Source: EPA Label							NOP Status
	Active Ingredient	Product Name	Product Rate/Acre	PHI (Days)	REI (Days)	EPA Reg. No.	Comments	
	Copper octanoate	Cueva Fungicide Concentrate	2.0 gal/ 100 gal water	0	4	67702-2-70051	Harmful if swallowed or absorbed through skin. Toxic to fish and aquatic organisms. May cause some copper toxicity on some plant species. Store away from open fire or flame. Product may be damaged by freezing. Do not store product below 4°C. Do not mix with chelated or liquid fertilizers. Use caution when using product with other fungicides and insecticides. Do not reapply within 3 days.	Synthetic
	Copper oxychloride, Copper hydroxide	Badge X2	0.75-1.75 lbs	0	48	80289-12	WARNING signal word. May be fatal if swallowed. Causes substantial but temporary eye injury. Harmful if absorbed through skin. Harmful if inhaled. Toxic to fish and aquatic organisms. Product must not be applied in a spray solution having a pH of less than 6.5 as phytotoxicity may occur. Do not tank mix product with Aliette® fungicide for use on any registered crops or ornamentals unless appropriate precautions have been taken to buffer the spray solution because severe phytotoxicity may result.	Synthetic
	Copper sulfate pentahydrate	CS 2005	19.2-32 oz	0	48	66675-3	DANGER signal word. Corrosive. Causes irreversible eye damage and skin irritation. Harmful if swallowed, inhaled or absorbed through the skin. Dermal sensitizer. Toxic to fish and aquatic organisms. Do not mix with acidic compounds. Do not mix with pot ash. Crop injury statements. Store away from excessive heat. Product will freeze. Store and handle product in 316L stainless steel, fiberglass, PVC's, polypropylenes or plastic equipment. Keep away from galvanized pipe and any nylon storage handling equipment. Reapply at 5-10 day intervals.	Synthetic
	Cupric hydroxide	Nu-Cop HB	1.0 lb	0	24	42750-132	DANGER signal word. Corrosive. Causes irreversible eye damage. Harmful if swallowed, absorbed through skin, or inhaled. Product should not be applied in spray water having a pH of less than 6.5 as phytotoxicity may result. Repeat at 3-10 day intervals.	Synthetic
	Cuprous oxide	Nordox 75 WG	1.25-2.5 lb	0	12	48142-4	Harmful if swallowed or absorbed through skin. Causes eye irritation. Do not apply in a spray solution with a pH of less than 6.5. Reapply at 7-10 day intervals.	Synthetic
Not classified; Oxidizing agent	Hydrogen dioxide, Peroxyacetic acid	Oxidate 2.0	0.33-1 gal/ 100 gal water	0	Until dry	70299-2	DANGER signal word. Causes irreversible eye damage. May be fatal if swallowed. Causes skin irritation or temporary discoloration of exposed skin. Highly toxic to bees and other beneficial insects. Toxic to fish. Toxic to birds who eat treated seed on soil surface. Strong oxidizing agent. Do not use in undiluted form. Never bring undiluted product in contact with other pesticides, cleaners or oxidative agents. May react with residues of metal-based fungicides or supplements. Allow at least 24 hrs. after application of metal-based products. Do not spray during conditions of intense heat, drought, or poor plant vigor (or vine canopy). Do not apply in conjunction with any other pesticides or fertilizers. Do not allow product to become overheated in storage. Do not store in a manner where cross-contamination with other pesticides or fertilizers could occur. Apply consecutive applications until control is achieved; then apply preventative treatments.	Synthetic
	Hydrogen peroxide, Hydrogen dioxide	Perpose Plus	Initial/ Curative: 1 fl oz/gal Weekly/ Preventative: 0.25-0.33 fl oz/gal	0	Until spray has dried	86729-1	DANGER signal word. Causes irreversible eye damage and skin burns. May be fatal if absorbed through the skin. Harmful if swallowed. Do not breathe vapor from concentrate. Toxic to birds, mammals, fish and aquatic life. At temperatures exceeding 156°F, decomposition releases oxygen. The oxygen released could initiate or promote combustion of other materials. Store away from combustibles. Broad spectrum algaecide and fungicide. Apply curative rates for 3 consecutive days (drenching the entire plant) followed by weekly preventative treatments.	Synthetic

Phytophthora infestans **(Late Blight) / Tomato: Efficacy Trials**

Phytophthora infestans (Late Blight) / Tomato #1: Trial No. CER-2011-027

a. Design

Phytophthora infestans (Late Blight) / Tomato #1: Trial No. CER-2011-027: Design					
Title:	Evaluation of Compounds for Management of Late Blight in Tomatoes, Spring 2011				
Authors and affiliation:	P. D. Roberts, R. S. Donahoo, and R. E. Sytsma University of Florida/IFAS Immokalee, FL				
Publication:	Not published. Permission received.				
Location:	Southwest Florida Research and Education Center Immokalee, FL				
Crop:	Tomato 'Sanibel'				
Disease name:	Late blight				
Pathogen:	*Phytophthora infestans*				
Test plot design:	Randomized complete block				
Number of replicates:	4				
Application equipment:	Double drop boom spray				
Spray volume:	60 gal/acre				
Number of applications:	2 or 4				
Chronology:	Application No.	Application Dates	Application Interval		Disease Assessment Dates
			Alternative	CX-10440	
	1	03/14/2011			03/30/2011
	2	03/21/2011	7 days		04/04/2011
	3	03/29/2011	8 days	15 days	04/11/2011
	4	04/04/2011	6 days		04/14/2011

b. Results

Phytophthora infestans (Late Blight) / Tomato #1: Trial No. CER-2011-027: Results									
Treatment	Rate/ Acre	g a.i./ ha	Active Ingredient	FRAC Code	App. No.	No. Lesions/Plot (4/14/2011)		AUDPC	
						Measured	Percent Control	Measured	Percent Control
Untreated control			Not Applicable			546.0 ab		3101.0 ab	
CX-10440 [1]	3.75 fl oz	14	Polyoxin D zinc salt	19	1,3	600.0 a	-9.9	3680.3 a	-18.7
CX-10440 [1]	7.5 fl oz	29	Polyoxin D zinc salt	19	1,3	217.0 cd	60.3	977.3 cd	68.5
Champ DP	1.5 lb		Copper hydroxide	M1	1,2,3,4	42.0 d	92.3	130.3 d	95.8
Oxidate	128 fl oz/ 100 gal		Hydrogen dioxide, Peroxyacetic acid	NA	1,2,3,4	354.0 bc	35.2	1980.5 bc	36.2

Treatment means followed by the same letter are not statistically different according to ANOVA using SAS and mean tested by LSD. P > 0.0001.
AUDPC = Area under the disease progression curve.
1. CX-10440 is the Certis USA, L.L.C. code for Polyoxin D Zinc Salt 5SC Fungicide.

Late blight was first observed in the untreated control on March 30, 2011. The last Polyoxin D Zinc Salt 5SC Fungicide treatment was applied one day earlier. Therefore the Polyoxin D Zinc Salt 5SC Fungicide treatments are assumed to have been preventative.

No phytotoxicity was reported.

c. Discussion and Conclusions

Tomatoes were grown in Florida. A maximum of 546 late blight lesions/plot were observed in the untreated control. There were 15 tomato plants per plot.

Two treatments with Polyoxin D Zinc Salt 5SC Fungicide were applied preventatively at a 15-day interval.

Control of late blight by Polyoxin D Zinc Salt 5SC Fungicide had a strong positive dose response.

- At 3.75 fl oz/acre (14 g a.i./ha), no control was observed.
- At 7.5 fl oz/acre (29 g a.i./ha), Polyoxin D Zinc Salt 5SC Fungicide provided mean 64.3% (range 60.3% to 68.5%) control of late blight on tomatoes. This was:
    - Statistically superior to the untreated control;
    - Numerically superior (but not statistically superior) to the control provided by hydrogen dioxide plus peroxyacetic acid; and
    - Statistically less than the control provided by four treatments with copper hydroxide applied more frequently, *i.e.*, at 6-day to 8-day intervals.

No phytotoxicity was reported.

Phytophthora infestans **(Late Blight) / Tomato: Grower Need**

Control of late blight on organic tomatoes (Project No. B00112) was identified as a grower need at the IR-4 2015 Biopesticide Workshop.

***Podosphaera aphanis* (POWDERY MILDEW) / CANEBERRIES**
[Sources: Pacific Northwest Plant Disease Management Handbook. Blackberry (*Rubus* spp.) - Powdery Mildew. Raspberry (*Rubus* spp.) - Powdery Mildew.]

***Podosphaera aphanis* (Powdery Mildew) / Caneberries: Cause**

<u>Blackberries</u>
Podosphaera aphanis var. *aphanis* (formerly *Sphaerotheca macularis*), a fungus. Powdery mildew causes fruit loss in some Pacific Northwest plantings each year. 'Boysenberry' is very susceptible while 'Loganberry' is less susceptible; however, most blackberries and their hybrids are generally not affected by this disease.

<u>Raspberries</u>
Podosphaera aphanis (formerly *Sphaerotheca macularis*), a fungus. Powdery mildew is occasionally a serious disease on foliage, new canes, and fruit of red raspberry in the Pacific Northwest. It also can infect 'Loganberry' leaves. The fungus overwinters as mycelium in dormant buds of stunted cane tips or as chasmothecia. Optimum conditions for spore germination and infection are 65°F to 80°F with relative humidity of 97% to 99%. In May, leaves develop lesions that produce fungal spores that are blown to healthy foliage. In June small, secondary-infection lesions appear on vegetative tissue and developing fruit.

Powdery mildew also attacks 'Munger' black raspberry, 'Himalaya', and some other blackberries. The 'Puyallup' red raspberry is very susceptible, so powdery mildew may be a limiting factor with that cultivar. 'Canby', 'Fairview', 'Haida', 'Skeena', 'Wakefield', and 'Washington' are sometimes infected. 'Amity', 'Cascade Bounty', 'Chilcotin', 'Heritage, 'Rudi, 'Sumner', and 'Willamette' are resistant. The powdery mildew of raspberry does not infect strawberry and that of strawberry does not infect raspberry despite the similar name.

***Podosphaera aphanis* (Powdery Mildew) / Caneberries: Symptoms**

<u>Blackberries</u>
Whitish gray, powdery growth on foliage and fruit. Severe mildew retards, dwarfs, and distorts plant parts and makes fruit unsalable. Young fruits fail to size properly, wither, and die.

<u>Raspberries</u>
A whitish-gray powdery coat covers foliage, young growing tips of canes, and fruit. The first lesions on infected leaves are light green blotches on the upper surface. Severe mildew retards, dwarfs, and distorts plant parts. Infected fruit may become covered with a white, mealy mat of fungus. Severely infected berries fail to size properly and wither and die.

***Podosphaera aphanis* (Powdery Mildew) / Caneberries: Cultural Control**

<u>Blackberries</u>
- Do not plant close to wooded areas that might shade the field.
- Remove wild blackberries from around the field.
- Plant more-resistant cultivars.
- Remove any infected primocanes that occur late in the season.
- Create an open plant canopy to improve air circulation and increase light penetration.

<u>Raspberries</u>
- Do not plant close to wooded areas that might shade the field.
- Plant more-resistant cultivars.
- Remove any infected primocanes that occur late in the season.
- Create an open plant canopy to improve air circulation and increase light penetration.

Podosphaera aphanis **(Powdery Mildew) / Caneberries: OMRI-Listed Fungicides for Use in the United States (All products listed below are registered for use on blackberries and raspberries.)**									
FRAC Code	Sources: Pacific Northwest Plant Disease Management Handbook. Blackberry (*Rubus* spp.) - Powdery Mildew. Raspberry (*Rubus* spp.) - Powdery Mildew.						Source: EPA Label		NOP Status
	Active Ingredient	Product Name	Product Rate/ Acre	PHI (Days)	REI (Hr)	Comments	EPA Reg. No.	Comments	
44	*Bacillus pumilis* strain QST 2808	Sonata ASO	2-4 qt	0	4		264-1153	Harmful if inhaled. Broad spectrum, preventative product for the control or suppression of many important plant diseases. Maintain a spray solution pH of 4.5 to 8.5.	Non-synthetic
P5	*Reynoutria sachalinensis*	Regalia	1-4 quart	0	4	Use on 7-day intervals	84059-3	Causes moderate eye irritation. Preventative use only. Avoid freezing.	Non-synthetic
Not classified; Botanical oil	Neem oil	Trilogy	1% spray volume, not to exceed 2.5 gal/A.	0	4		70051-2	Causes moderate eye irritation. Hazardous to fish and aquatic invertebrates. Toxic to bees exposed to direct treatment. Broad spectrum. Exercise care in timing applications during early morning/late evening to minimize the potential for leaf burn. Use care on plants with tender tissue. Check for leaf burn in small scale trials prior to use. Do not apply to sensitive plant species. Do not apply to wilted or otherwise stressed plants, or to newly transplanted materials or crops prior to root establishment. For optimal performance, do not mix with cold water (less than 45°F). Do not store below 40°F (4°C). Do not use or store near heat or open flame.	Non-synthetic
M2	Sulfur	Cosavet-DF	6-12 lb	0	24	Good efficacy. Do not use within 2 weeks of an oil spray.	70905-1	Harmful if swallowed, inhaled, or absorbed through skin. Causes moderate eye irritation. Sulfur dust suspended in air ignites easily. Keep away from heat, sparks, or flames. Do not smoke while applying this product. Sulfur may cause severe fruit and foliage injury on certain crops. Sulfur may burn foliage when temperature is high. Do not apply if temperatures during or within 3 days after application are expected to exceed 90°F.	Synthetic
		Kumulus DF	6-15 lb	0	24		51306-352-66330	Harmful if swallowed. Avoid breathing spray mist. Avoid contact with eyes, skin, and clothing. Do not apply within 2 weeks of an oil spray treatment. Do not store above 104°F. Store away from heat, sparks, and open flame.	
		Microthiol Disperss	6-15 lb	0	24		70506-187	Harmful if swallowed, inhaled, or absorbed through skin. Risk of crop injury if temperature exceeds 90°F within 3 days following application. Do not use on any crop unless sulfur has been shown to be safe in your locality. Do not store near flammable materials. Do not store in a manner where cross-contamination with other pesticides, fertilizers, food or feed could occur. Restrictions regarding application time before and after an oil spray treatment.	
		Safer Garden Fungicide (RTU)	Not specified	1	0		42697-17	Apply each week starting at first bloom color. Continue to spray at 10-14 day intervals until fruit set, then repeat as needed or following rain.	

Podosphaera aphanis **(Powdery Mildew) / Caneberries: OMRI-Listed Fungicides for Use in the United States (All products listed below are registered for use on blackberries and raspberries.)**									
FRAC Code	Sources: Pacific Northwest Plant Disease Management Handbook. Blackberry (*Rubus* spp.) - Powdery Mildew. Raspberry (*Rubus* spp.) - Powdery Mildew.						Source: EPA Label		NOP Status
	Active Ingredient	Product Name	Product Rate/ Acre	PHI (Days)	REI (Hr)	Comments	EPA Reg. No.	Comments	
Not classified: Inorganic salt	Potassium bicarbonate	Kalgreen	2.5-3.0 lb	1	4	Might be used to supplement a normal program when powdery mildew is first observed. Do not mix with acidifying agents. Easily washed off leaves so thorough and frequent coverage is essential.	70231-1	Harmful if swallowed, absorbed through skin, or inhaled.	Synthetic
Not classified: Organic salt	Potassium salts of fatty acids	M-Pede	1-2 gal/ 100 gal water	0	12	Do not use within 3 days of sulfur sprays. Do not mix with hard water.	10163-324	WARNING signal word. Causes substantial but temporary eye injury and skin irritation. May be hazardous to aquatic invertebrates. Do not use with sulfur or within 3 days of a sulfur application. Apply M-Pede solutions to wet (minimize run-off) to decrease the potential for injury on foliage, fruit and flowers of sensitive plants. Avoid application to new transplants and unrooted cuttings.	Synthetic
Not classified; Petroleum oils	Paraffinic oil	JSM Stylet Oil at 3 to 6 qt/100 gal water	3-6 qt/ 100 gal water	0	4	Necrotic foliage may results if applied within 10 days of any sulfur application. Do not tank-mix with copper-based products when fruit is present. Do not use during freezing temperature, above 90°F, or when plants are under heat or moisture stress. Do not use when foliage is wet because good coverage is essential.	65564-1	Harmful if swallowed. Toxic to fish. Do not freeze. Do not spray wet foliage. Do not spray when freezing temperatures are anticipated within 48 hours of an oil application, above 90°F (32°C) or when plants are under heat or moisture stress. Do not apply micronized sulfur within 10 days of an oil application. Do not apply oil within 14 days of an application of wettable or dusting sulfur. See label for additional compatibility restrictions.	Synthetic
	Petroleum oil	SuffOil-X	1-2 gal/ 100 gal water	0	4		48813-1-68539	Harmful if absorbed through skin. Prolonged or frequently repeated skin contact may cause allergic reactions in some individuals. Do not use in combination with any product containing sulfur. Do not use with any product whose label recommends the use of no oils. Do not use in combination with NPK foliar fertilizer applications. Do not apply during periods of drought or when plants exhibit moisture stress.	Synthetic

Podosphaera aphanis **(Powdery Mildew) / Caneberries: Efficacy Trials**

Podosphaera aphanis (Powdery Mildew) / Blackberries #1: Trial No. CER-2012-060

a. Design

Podosphaera aphanis (Powdery Mildew) / Blackberries #1: Trial No. CER-2012-060: Design				
Title:	Disease Control in Blackberry with CX-10440 Experimental Fungicide			
Author and affiliation:	Dave Anderson Western Biological Consulting Hubbard, OR			
Publication:	Certis data. Not published. Permission received.			
Location:	Near Salem, OR			
Crop:	Marion blackberries			
Disease name:	Powdery mildew			
Pathogen:	*Podosphaera aphanis*			
Test plot design:	Randomized complete block			
Number of replicates:	4			
Application equipment:	CO_2 backpack sprayer			
Application volume:	50 gallons/acre (486 L/ha)			
Number of applications:	3			
Chronology:	Application Date	Growth Stage	Application Interval	Field Evaluation of Ripe Fruit
	05/31/2012	10% bloom		07/13/2012
	06/13/2012	Mixed bloom and small berry	14 days	
	06/25/2012	Fruit developing; some color change observed	12 days	

b. Results

Podosphaera aphanis (Powdery Mildew) / Blackberries #1: Trial No. CER-2012-060: Results						
Treatment	Rate/ Acre	g a.i./ ha	Active Ingredient	FRAC Code	Potential berries (mildew infected fruit) remaining as undeveloped flowers on canes at time of harvest	
					Mean Percent	Percent Control
Untreated Control					60.0 ± 4.1 a	
CX-10440 [1]	3.75 fl oz	12.5	Polyoxin D zinc salt	19	35.0 ± 4.1 b	42
CX-10440 [1]	6.5 fl oz	25	Polyoxin D zinc salt	19	25.0 ± 4.1 b	58
Pristine	23 oz wt		Boscalid	7	7.5 ± 2.1 c	88
			Pyraclostrobin	11		
Means bearing the same letter do not differ significantly (P > 0.05; ANOVA *t*-test.) 1. CX-10440 is the Certis USA, L.L.C. code for Polyoxin D Zinc Salt 5SC Fungicide.						

The report notes that no obvious powdery mildew was observed on leaves or developing fruit a the time of the last treatment. Therefore, the treatments were preventative.

No phytotoxicity was observed.

c. Discussion and Conclusions

Marion blackberries were grown in Oregon. Powdery mildew incidence in the untreated control was 60.0%.

Three treatments of Polyoxin D Zinc Salt 5SC Fungicide were applied preventatively at 12-day to 14-day intervals. There was a positive dose response.

- Treatment at 3.75 fl oz/acre (12.5 g a.i./ha) provided 42% control.
- Treatment at 6.5 fl oz/acre (25 g a.i./ha) provided 58% control.

Polyoxin D Zinc Salt 5SC Fungicide treatments at both application rates provided control of powdery mildew that was statistically:

- Superior to the untreated control; and
- Less than the control provided by boscalid plus pyraclostrobin.

Podosphaera aphanis (POWDERY MILDEW) / STRAWBERRIES

Podosphaera aphanis (Powdery Mildew) Strawberries: Taxonomy

(Source: Surendra Dara, New Name of Strawberry Powdery Mildew Pathogen, Strawberries and Vegetables eNewsletter, February 18, 2011.)

The pathogen that causes powdery mildew of strawberries, previously known as *Sphaerotheca macularis*, is now referred to as *Podosphaera aphanis*.

Podosphaera aphanis (Powdery Mildew) / Strawberries: Pathogen and Symptoms

(Source: N.A. Peres and J.C. Mertely, Powdery Mildew of Strawberries, University of Florida Cooperative Extension Service Document PP-2018, May 2013)

Powdery mildew, *Podosphaera aphanis* (syn. *Sphaerotheca macularis*), occurs in most areas of the world where strawberries are grown. *Podosphaera aphanis* infects leaves, flowers, and fruit. Early foliar infections are characterized by small white patches of fungus growing on the lower leaf surface. On susceptible cultivars, dense mycelial growth and numerous chains of conidia (spores) give these patches a powdery appearance. Under favorable conditions, the patches expand and coalesce until the entire lower surface of the leaf is covered. In some strawberry cultivars, relatively little mycelium is produced, making it difficult to see the white patches. Instead, irregular yellow or reddish-brown spots develop on colonized areas on the lower leaf surface and eventually break through to the upper surface. The edges of heavily infected leaves curl upward. At times, dark round structures (cleistothecia) are produced in the mycelia on the undersides of leaves. Cleistothecia are initially white but turn black as they mature. The fungus also infects flowers, which may produce aborted or malformed fruit. In addition, *Podosphaera aphanis* colonizes older fruit, producing a fuzzy mycelial growth on the seeds. Both types of infection may reduce fruit quality and marketable yields.

Podosphaera aphanis (Powdery Mildew) / Strawberries: Disease Development and Spread

(Source: N.A. Peres and J.C. Mertely, Powdery Mildew of Strawberries, University of Florida Cooperative Extension Service Document PP-2018, May 2013)

Podosphaera aphanis is an obligate parasite that only infects living tissue of wild or cultivated strawberry. The fungus readily infects living, green leaves in the nursery. Thus, infected transplants are normally the primary source of inoculum for fruiting fields in Florida. When conditions are favorable, conidia produced on infected plants are wind dispersed. Powdery mildew development and spread are favored by moderate to high humidity and temperatures between 60°F and 80°F. Rain, dew, and overhead irrigation inhibit the fungus. Because dry conditions and high humidity are common in greenhouses and plastic tunnels, powdery mildew is typically more severe in protected culture. In open fields in Central Florida, the disease is typically most severe in November and December, usually subsides in January and early February, and may reappear in late February and March.

Podosphaera aphanis (Powdery Mildew) / Strawberries: Control

(Source: N.A. Peres and J.C. Mertely, Powdery Mildew of Strawberries, University of Florida Cooperative Extension Service Document PP-2018, May 2013)

Using powdery mildew-free transplants is a good method to control the disease, but even disease-free fields can become infected by conidia blown in from neighboring fields. Cultivars differ in their resistance to powdery mildew. However, the two most popular cultivars, ‘Strawberry Festival’ and ‘Florida Radiance’, are susceptible to the disease. Fields with susceptible cultivars should be surveyed regularly for powdery mildew, especially early in the season. Fungicides should be applied preventively or at the first sign of disease to control powdery mildew on susceptible cultivars. This is especially important when using protectant fungicides, such as elemental sulfur. Synthetic systemic fungicides have some limited curative action. Usually, controlling foliar infection helps to prevent fruit infection.

Podosphaera aphanis (Powdery Mildew) /Strawberries: Management Options (Source: 2015 Organic Production and IPM Guide for Strawberries, Cornell University Cooperative Extension)	
Scouting/Thresholds	None established.
Variety susceptibility	No known resistance varieties. If possible, avoid varieties commonly infected in New York which includes: ‘Earliglow’, ‘Darselects’, ‘Evangeline’, “Annapolis”, and to a lesser extent, ‘Raritan’.
Cultural management	Manage weeds and regulate planting density to promote good air circulation. Avoid excess nitrogen and sites with poor drainage.
Chemical treatment	See table below.

Podosphaera aphanis (Powdery Mildew) /Strawberries: OMRI-Listed Fungicides for Use in the United States										
FRAC Code	Source: 2015 Organic Production and IPM Guide for Strawberries, Cornell University Cooperative Extension							Source: EPA Label		NOP Status
	Active Ingredient	Product Name	Product Rate/ Acre	PHI (Days)	REI (Days)	Efficacy	Comments	EPA Reg. No.	Comments	
44	*Bacillus amyloliquefaciens* str. D747	Double Nickel 55	0.25-3 lb	0	4	Not reviewed or no research available	Foliar application.	70051-108	Causes moderate eye irritation. Dermal sensitizer. Broad-spectrum preventative fungicide. Do not use highly alkaline or highly acidic water to mix sprays. Use a buffering agent if necessary to maintain neutrality (pH 6 to 8) of water in the tank. Suppression only. Start applications just before flowering and repeat every 7-10 days as needed through harvest.	Non-synthetic
		Double Nickel LC	0.5-6 qt	0	4			70051-114	Harmful if absorbed through skin. Harmful if inhaled. Dermal sensitizer. Broad-spectrum preventative fungicide.	
Not classified; Biological	*Streptomyces lydicus* WYEC 108	Actinovate AG	3-12 oz	0	1 or until solution has dried	Not effective	Foliar application. For best results apply with a spreader/sticker prior to onset of disease. Re-apply at 7-14 day intervals depending upon disease pressure and environmental conditions.	73314-1	Avoid contact with skin, eyes, or clothing. Avoid breathing dust or spray mist. Mixer/loaders and applicators must wear a dust/mist filtering respirator meeting NIOSH standards of at least N-95, R-95, or P-95. Repeated exposure to high concentrations of microbial proteins can cause allergic sensitization. Keep from overheating or freezing. Optimum storage temperature is 40°F to 85°F. Contains live spores of a microbe. Best results will be obtained if the product is used prior to disease onset. Becomes active in soil or on the plant foliage when the temperatures are above 45°F and is not effective when temperatures remain cold. Do not apply soil fumigants to treated areas.	Non-synthetic

Podosphaera aphanis (Powdery Mildew) /Strawberries: OMRI-Listed Fungicides for Use in the United States										
FRAC Code	Source: 2015 Organic Production and IPM Guide for Strawberries, Cornell University Cooperative Extension							Source: EPA Label		NOP Status
	Active Ingredient	Product Name	Product Rate/ Acre	PHI (Days)	REI (Days)	Efficacy	Comments	EPA Reg. No.	Comments	
Not classified; Botanical oil	Cinnamon oil	Cinnerate	13-30 fl oz/ 100 gal water	0	0	Not reviewed or no research available	Apply 85-125 gal diluted spray/A.	N/A. FIFRA §25(b) pesticide.	May cause eye and skin irritation. May cause dermal sensitization. Store upright at room temperature. Avoid exposure to extreme temperatures. Do not expose to light and keep away from any heat source. Do not mix with oxidizing, strong acidic or basic materials. Broad spectrum, contact foliar fungicide. All applications should be preceded by a phytotoxicity check to ensure that the material is safe for the particular plant variety.	Non-synthetic
	Cottonseed oil, corn oil, and garlic oil	Mildew Cure	1 gal/100 gal water	0	0	Not reviewed or no research available	Apply 85-125 gal diluted spray/A.	N/A. FIFRA §25(b) pesticide.	Avoid contract with skin, eyes, and clothing. Do not apply this product to seedlings or very young plants. Do not apply at less than 7-day intervals.	Non-synthetic
	Neem oil	Trilogy	1.0% solution	0	4	Not reviewed or no research available	Apply in 25-100 gallons water/A. Maximum labeled use of 2 gal/acre/application.	70051-2	Causes moderate eye irritation. Hazardous to fish and aquatic invertebrates. Toxic to bees exposed to direct treatment. Broad spectrum. Exercise care in timing applications during early morning/late evening to minimize the potential for leaf burn. Use care on plants with tender tissue. Check for leaf burn in small scale trials prior to use. Do not apply to sensitive plant species. Do not apply to wilted or otherwise stressed plants, or to newly transplanted materials or crops prior to root establishment. For optimal performance, do not mix with cold water (less than 45°F). Do not store below 40°F (4°C). Do not use or store near heat or open flame. Growth stage use restrictions for grapes and stone fruit.	Non-synthetic
	Sesame oil	Organicide 3-in-1	1-2 gal/ 100 gal water	0	0	Not reviewed or no research available		N/A. FIFRA §25(b) pesticide.	Insecticide, miticide, and fungicide. If spraying on severely stressed or damaged plants, consider using a lower rate such as 1 oz. per gallon to avoid adding additional stress. For best results, spray in the early morning.	Non-synthetic
	Soybean oil	Golden Pest Spray	0.5-1% solution	0	4	Not reviewed or no research available		57538-11	Spray only when temperature is above 40°F and there is no danger of freezing. Avoid spraying when temperatures are excessive and avoid spraying when plants are suffering from lack of moisture. Sensitive foliage is susceptible to injury.	Non-synthetic
M1	Copper octanoate	Cueva Fungicide Concentrate	0.5-2.0 gal/100 gal	0	4	Not reviewed or no research available	Product is applied as a dilute spray at 50-100 gallons per acre.	67702-2-70051	Harmful if swallowed or absorbed through skin. Toxic to fish and aquatic organisms. May cause some copper toxicity on some plant species. Store away from open fire or flame. Product may be damaged by freezing. Do not store product below 4°C. Do not mix with chelated or liquid fertilizers. Use caution when using product with other fungicides and insecticides.	Synthetic

Podosphaera aphanis (Powdery Mildew) /Strawberries: OMRI-Listed Fungicides for Use in the United States										
FRAC Code	Source: 2015 Organic Production and IPM Guide for Strawberries, Cornell University Cooperative Extension							Source: EPA Label		NOP Status
	Active Ingredient	Product Name	Product Rate/ Acre	PHI (Days)	REI (Days)	Efficacy	Comments	EPA Reg. No.	Comments	
M2	Sulfur	Acoidal	5-10 lb	0	24	Effective in some research studies	Begin applications when disease first appears. Repeat as necessary. Do not use on sulfur sensitive varieties.	62562-4	Harmful if swallowed, inhaled, or absorbed through skin. Toxic to fish and aquatic organisms. Sulfur dust suspended in air ignites easily. Keep away from heat, sparks, or flames. Do not smoke while applying this product. Sulfur may cause severe fruit and foliage injury to certain crops. Sulfur may burn foliage when temperature is high. Do not apply within 2 weeks of an oil spray treatment.	Synthetic
		Defend	5-10 lb	0	24			62562-8		
		Kumulus DF	5-10 lb	0	24			51306-352-66330	Harmful if swallowed. Avoid breathing spray mist. Avoid contact with eyes, skin, and clothing. Do not apply within 2 weeks of an oil spray treatment. Do not store above 104°F. Store away from heat, sparks, and open flame.	
		Micro Sulf	5-10 lb	0	24	Effective in some research studies	Some varieties may be sensitive to sulfur.	55146-75	Harmful if swallowed, inhaled, or absorbed through skin. Causes eye irritation. Risk of crop injury if temperature exceeds 90°F within 3 days following application. Do not use on any crop unless sulfur has been shown to be safe in your locality. Do not apply within 14 days of an oil spray. Keep away from heat, sparks, or flames. Do not smoke while applying this product.	
		Microthiol Disperss	5-10 lb	0	24	Effective in some research studies	Not recommended within 2 weeks of an oil application nor if temperatures are expected to exceed 90 degrees within 3 days following application.	70506-187	Harmful if swallowed, inhaled, or absorbed through skin. Risk of crop injury if temperature exceeds 90°F within 3 days following application. Do not use on any crop unless sulfur has been shown to be safe in your locality. Do not store near flammable materials. Do not store in a manner where cross-contamination with other pesticides, fertilizers, food or feed could occur. Restrictions regarding application time before and after an oil spray treatment.	
		Thiolux	5-10 lb	0	24			34704-1079	Harmful if swallowed, inhaled, or absorbed through skin. Causes eye irritation. Sulfur may case severe fruit and foliage injury to certain crops. Risk of crop injury if temperature exceeds 90°F within 3 days following application. Do not apply within 14 days of an oil spray. Sulfur dust suspended in air easily ignites. Keep away from heat, sparks, or flames. Do not smoke while applying this product. Strawberries are susceptible to foliage burn with sulfur under ceratin climatic conditions. Do not apply if temperatures during or within 3 days after application are expected to exceed 90°F.	

Podosphaera aphanis (Powdery Mildew) /Strawberries: OMRI-Listed Fungicides for Use in the United States										
FRAC Code	Source: 2015 Organic Production and IPM Guide for Strawberries, Cornell University Cooperative Extension							Source: EPA Label		NOP Status
	Active Ingredient	Product Name	Product Rate/ Acre	PHI (Days)	REI (Days)	Efficacy	Comments	EPA Reg. No.	Comments	
Not classified; Inorganic salt	Potassium bicarbonate	Kaligreen	2.5-3.0 lb	1	4	Not effective	Do not mix with highly acidic products or nutrients.	70231-1	Harmful if swallowed, absorbed through skin, or inhaled. Do not mix with highly acidic products as effectiveness may be compromised. Use of a buffering agent for acidification of a tank mixture may also decrease effectiveness. Crop injury may result due to certain environmental or growing conditions, manner of use or application.	Synthetic
		Milstop	2-5 lb	0	1	Not effective	Do not mix with other pesticides or fertilizers. Not compatible with alkaline solutions.	70870-1-68539	Harmful if swallowed. Causes moderate eye irritation. Broad spectrum contact foliar fungicide. Do not mix with other soluble pesticides or fertilizers. Not compatible with mild alkaline solutions. Acidification of solution will cause reduced product performance. Prevent exposure to moisture during storage. Avoid contamination with other pesticides and fertilizers.	
	Potassium silicate	Sil-Matrix	0.5-1% solution	0	4	Not reviewed or no research available	Apply at 50-250 gal/A finished spray.	82100-1	Causes moderate eye irritation. Avoid contact with glass. Remove promptly from glass surfaces. Store product above 40°F. Do not store in aluminum, fiberglass, copper, brass, zinc, or galvanized containers. Protect from excessive heat. Broad spectrum preventative fungicide.	Synthetic
Not classified; Organic salt	Potassium salts of fatty acids	M-Pede	1-2% vol/vol	0	12	Not reviewed or no research available	Curative control.	10163-324	WARNING signal word. Causes substantial but temporary eye injury and skin irritation. May be hazardous to aquatic invertebrates. Do not use with sulfur or within 3 days of a sulfur application. Apply M-Pede solutions to wet (minimize run-off) to decrease the potential for injury on foliage, fruit and flowers of sensitive plants. Avoid application to new transplants and unrooted cuttings.	Synthetic

Podosphaera aphanis (Powdery Mildew) /Strawberries: OMRI-Listed Fungicides for Use in the United States										
FRAC Code	Source: 2015 Organic Production and IPM Guide for Strawberries, Cornell University Cooperative Extension							Source: EPA Label		NOP Status
	Active Ingredient	Product Name	Product Rate/ Acre	PHI (Days)	REI (Days)	Efficacy	Comments	EPA Reg. No.	Comments	
Not classified; Oxidizing agent	Hydrogen dioxide, Peroxyacetic acid	Oxidate 2.0	Initial/ Curative: 128 fl oz/ 100 gal water; 30-100 gal solution/ acre Preventative: 40-128 fl oz/ 100 gal water; 30-100 gal solution/ acre	0	Until spray has dried	Not reviewed or no research available	Pre-plant dip. At planting foliar application and foliar and crown disease control for existing plantings.	70299-2	DANGER signal word. Causes irreversible eye damage. May be fatal if swallowed. Causes skin irritation or temporary discoloration of exposed skin. Highly toxic to bees and other beneficial insects. Toxic to fish. Toxic to birds who eat treated seed on soil surface. Strong oxidizing agent. Do not use in undiluted form. Never bring undiluted product in contact with other pesticides, cleaners or oxidative agents. May react with residues of metal-based fungicides or supplements. Allow at least 24 hrs. after application of metal-based products. Do not spray during conditions of intense heat, drought, or poor plant vigor (or vine canopy). Do not apply in conjunction with any other pesticides or fertilizers. Do not allow product to become overheated in storage. Do not store in a manner where cross-contamination with other pesticides or fertilizers could occur. Apply consecutive applications until control is achieved; then apply preventative treatments.	Synthetic
	Hydrogen peroxide, Hydrogen dioxide	Perpose Plus	Initial/ Curative: 1 fl oz/gal. Weekly/ Preventative: 0.25-0.33 fl oz/gal.	0	Until spray has dried	Not effective	For initial or curative use, apply higher rate for 1 to 3 consecutive days. Then follow with weekly/preventative treatment. For weekly or preventative treatments, apply lower rate every five to seven days. At first sign of disease, use curative rate then resume weekly preventative treatment.	86729-1	DANGER signal word. Causes irreversible eye damage and skin burns. May be fatal if absorbed through the skin. Harmful if swallowed. Do not breathe vapor from concentrate. Toxic to birds, mammals, fish and aquatic life. At temperatures exceeding 156°F, decomposition releases oxygen. The oxygen released could initiate or promote combustion of other materials. Store away from combustibles. Broad spectrum algaecide and fungicide. Apply curative rates for 3 consecutive days (drenching the entire plant) followed by weekly preventative treatments.	Synthetic

Podosphaera aphanis (Powdery Mildew) /Strawberries: OMRI-Listed Fungicides for Use in the United States										
FRAC Code	Source: 2015 Organic Production and IPM Guide for Strawberries, Cornell University Cooperative Extension							Source: EPA Label		NOP Status
	Active Ingredient	Product Name	Product Rate/ Acre	PHI (Days)	REI (Days)	Efficacy	Comments	EPA Reg. No.	Comments	
Not classified; Petroleum oils	Mineral oil	Glacial Spray Fluid	0.75 gal/100 gal	0	4	Not reviewed or no research available	See label for specific application volumes and equipment.	34704-849	Harmful is swallowed, absorbed through skin, or inhaled. Causes eye irritation. Prolonged or repeated skin contact may cause allergic reaction in some individuals. Potential skin sensitizer. Drift and runoff may be hazardous to aquatic organisms in water adjacent to treated areas. Do not apply in undiluted form. Sensitive foliage may be injured. Do not spray oil sensitive varieties. Crop injury prevention use restrictions. Do not make oil application within 2 weeks prior to or after an application of sulfur. Use restrictions regarding sulfur, captan, chlorothalonil, dimethoate, dicofol, and propargite.	Synthetic
		PureSpray Green	0.75-1.5 gals/ 100 gal at 100-200 gal water	0	4	Not reviewed or no research available	Spray at no less than 400 PSI using ceramic nozzles.	69526-9	Harmful if swallowed or absorbed through skin. Prolonged or repeated skin contact may cause allergic reaction in some individuals. Drift and runoff may be hazardous to aquatic organisms in water adjacent to treated areas. Use extreme care when using concentrate sprays as the potential for crop phytotoxicity is increased. Avoid excess heat. Do not spray during or immediately prior to hot or freezing weather (over 95°F or under 32°F), hot dry winds, rain or other unsuitable conditions. Do not overspray or double spray. Spray plants only when they are in vigorous condition and when their moisture condition is suitable. Before using, make certain spray tank is free of sulfur residues. Do not apply micronized sulfur within 10 days of an oil application. Do not apply oil within 14 days of an application of wettable or dusting sulfur. Do not apply to oil sensitive varieties. See label for additional compatibility restrictions regarding many conventional active ingredients.	
		SuffOil-X	1-2 gal/ 100 gal water	0	4	Not reviewed or no research available	Do not mix with sulfur products.	48813-1-68539	Harmful if absorbed through skin. Prolonged or frequently repeated skin contact may cause allergic reactions in some individuals. Do not use in combination with any product containing sulfur. Do not use with any product whose label recommends the use of no oils. Do not use in combination with NPK foliar fertilizer applications. Do not apply during periods of drought or when plants exhibit moisture stress.	
		Tritek	1-2 gal/ 100 gal water	0	4	Not reviewed or no research available	Apply as needed.	48813-1		

Podosphaera aphanis (Powdery Mildew) /Strawberries: OMRI-Listed Fungicides for Use in the United States										
FRAC Code	Source: 2015 Organic Production and IPM Guide for Strawberries, Cornell University Cooperative Extension							Source: EPA Label		NOP Status
	Active Ingredient	Product Name	Product Rate/ Acre	PHI (Days)	REI (Days)	Efficacy	Comments	EPA Reg. No.	Comments	
	Paraffinic oil	Organic JMS Stylet Oil	3 qt/100 gal water	0	4	Inconsistent research results	A high volume of water is needed for thorough coverage. Many common pesticides are phytotoxic when applied with or close to oil sprays (*e.g.* sulfur). Check label for restrictions.	65564-1	Harmful if swallowed. Toxic to fish. Do not freeze. Do not spray wet foliage. Do not spray when freezing temperatures are anticipated within 48 hours of an oil application, above 90°F (32°C) or when plants are under heat or moisture stress. Do not apply to vegetables when the temperature is below 50°F (10°C). Do not apply micronized sulfur within 10 days of an oil application. Do not apply oil within 14 days of an application of wettable or dusting sulfur. Do not apply to oil sensitive varieties. See label for additional compatibility restrictions.	Synthetic

Podosphaera aphanis (Powdery Mildew) / Strawberries: Efficacy Trials

Podosphaera aphanis (Powdery Mildew)/ Strawberries #1: Trial No. CER-2012-070

a. Design

Podosphaera aphanis (Powdery Mildew) / Strawberries #1: Trial No. CER-2012-070: Design		
Title:	Efficacy of CX-10440 for Control of Powdery Mildew (*Sphacelotheca* sp.) and Botrytis (*Botrytis cinerea*) in Strawberry	
Research organization:	Pacific Ag Research	
Publication:	Certis data. Not published. Permission received.	
Location:	Gaudalupe, California, USA (south central California, near the Pacific Ocean)	
Crop:	Strawberry	
Disease name:	Powdery Mildew	
Pathogen:	*Sphacelotheca* sp. Updated taxonomy: *Podosphaera* sp.	
Test plot design:	Not reported	
Number of replicates:	Not reported	
Application equipment:	Carbon dioxide backpack sprayer	
Application volume:	50 gal/acre (468 L/ha)	
Number of applications:	5	
Application interval:	7 to 8 days	
Chronology:	Application Dates	Disease Assessment Dates
	05/08/2012 05/16/2012 05/24/2012 05/31/2012 06/08/2012	05/15/2012 05/23/2012 06/07/2012 06/14/2012 06/21/2012

b. Results

Podosphaera aphanis (Powdery Mildew) / Strawberries #1: Trial No. CER-2012-070: Results						
Treatment	Rate/ Acre	g a.i./ ha	Active Ingredient	FRAC Code	AUDPC	Percent Control
Untreated Control					2537.56 a	0.00 c
CX-10440 [1]	3.75 fl oz	14	Polyoxin D zinc salt	19	1873.34 b	26.31 b
CX-10440 [1]	6.5 fl oz	25	Polyoxin D zinc salt	19	1935.14 b	23.75 b
Pristine	23 oz wt		Boscalid	7	1570.21 c	38.10 a
			Pyraclostrobin	11		

AUDPC = Area Under the Disease Progression Curve.
Treatment means followed by the same letter are not statistically different (ANOVA mean comparison with LSD test and α = 0.05).
1. CX-10440 is the Certis USA, L.L.C. code for Polyoxin D Zinc Salt 5SC Fungicide.

Powdery mildew was observed on May 15, 2012, *i.e.*, 1 day before the second of five treatments. Therefore, the treatments were preventative and curative.

No phytotoxicity was observed.

c. Discussion and Conclusions

Strawberries were grown in southern California. Powdery mildew incidence reached 100% in the untreated control.

Five treatments of Polyoxin D Zinc Salt 5SC Fungicide were applied preventatively and curatively at 7-day to 8-day intervals. The powdery mildew control did not have a positive dose response.

- Treatment at 3.75 fl oz/acre (14 g a.i/ha) provided 26.31% control.
- Treatment at 6.5 fl oz/acre (25 g a.i/ha) provided 23.75% control.

For the two Polyoxin D Zinc Salt 5SC Fungicide treatment rates, powdery mildew control was statistically:

- Superior to the untreated control;
- Equal to each other; and
- Less that than the control provided by boscalid plus pyraclostrobin.

No phytotoxicity was observed.

Podosphaera aphanis (Powdery Mildew) / Strawberries #2: Trial No. CER-2013-008

a. Design

Podosphaera aphanis (Powdery Mildew) / Strawberries #2: Trial No. CER-2013-008: Design				
Title:	Evaluation of Tavano 5% SC in Strawberry Production Against Powdery Mildew and Botrytis			
Author and affiliation:	David Holden Holden Research and Consulting			
Publication:	Certis data. Not published. Permission received.			
Location:	Ventura, California, USA (Southern California, near the Pacific Ocean)			
Crop:	Strawberry (variety 'San Andreas')			
Disease name:	Powdery mildew			
Pathogen:	*Sphaerotheca* sp. Updated taxonomy: *Podosphaera* sp.			
Test plot design:	Randomized complete block			
Number of replicates:	4			
Application equipment:	Foliar spray			
Application volume:	200 liters/ha			
Number of applications:	7			
Chronology:	Application Dates	Application Intervals	Disease Assessment Dates	
	03/25/2013 A		03/19/2013	06/07/2013
	04/10/2013 B	16 days	03/27/2013	06/13/2013
	04/22/2013 C	12 days	04/02/2013	06/20/2013
	06/04/2013 D	43 days	04/11/2013	06/26/2013
	06/11/2013 E	7 days	04/17/2013	07/02/2013
	06/17/2013 F	6 days	04/23/2013	07/09/2013
	06/24/2013 G	7 days	04/29/2013	

b. Results

Podosphaera aphanis (Powdery Mildew) / Strawberries #2: Trial No. CER-2013-008: Results								
Treatment	Rate/ Acre	g a.i./ ha	Active Ingredient	FRAC Code	Incidence (6/20/2013)		Severity (6/20/2013)	
					Percent	Percent Control	Percent	Percent Control
Untreated Control					70		8.0	
CX-10440 [1]	6.5 fl oz	25	Polyoxin D zinc salt	19	5	93	0.5	94
CX-10440 [1]	13 fl oz	50	Polyoxin D zinc salt	19	15	79	1.5	81
Pristine	23 oz wt		Boscalid	7	10	86	0.8	90
			Pyraclostrobin	11				
1. CX-10440 is the Certis USA, L.L.C. code for Polyoxin D Zinc Salt 5SC Fungicide.								

Powdery mildew incidence was first observed on March 27, 2013, *i.e.*, two days after the first treatment was applied and before the last 6 treatments were applied. Therefore, the treatments were applied preventatively and curatively.

No phytotoxicity was reported.

c. Discussion and Conclusions

Strawberries were grown in California. Maximum powdery mildew incidence in the untreated control was 70%.

Seven treatments of Polyoxin D Zinc Salt 5SC Fungicide were applied preventatively and curatively at 6-day to 43-day intervals. Six-day and 7-day intervals were used for the last three treatments.

Polyoxin D Zinc Salt 5SC Fungicide treatments did not have a positive dose response.

- Treatment at 6.5 fl oz/acre (25 g a.i./ha) provided mean 93.5% (range 93% to 94%) control of powdery mildew.
- Treatment at 13 fl oz/acre (50 g a.i./ha) provided mean 80% (range 79% to 81%) control of powdery mildew.

The powdery mildew control provided by the two Polyoxin D Zinc Salt 5SC Fungicide treatment rates was:

- Significantly greater than the untreated control; and
- Numerically greater than the control provided by boscalid plus pyraclostrobin.

No phytotoxicity was reported.

Podosphaera clandestina (POWDERY MILDEW) / CHERRIES

Podosphaera clandestina (Powdery Mildew) / Cherries: Introduction
(Source: Melissa Hansen, Controlling Mildew on Organic Cherries, Good Fruit Grower, February 15th, 2010.)

Powdery mildew is a tough disease to control for Pacific Northwest cherry growers, but it's even tougher for organic growers who have limited fungicides to use. With so few organic tools available, an integrated approach is needed. Understanding the life cycle of cherry powdery mildew, components of your orchard, and what strategies and timing are effective are needed when putting together an integrated program. It's key to know when a primary infection is going on. Overwintering cleistothecia survive on the bark, crevices, leaves, and debris on the orchard floor, and wait for free moisture in the spring to release ascospores and initiate primary infection. Close observation is needed to see the small yellow patches on the upper leaf surface or delicate webbing on the underside that indicate primary infection. After the ascospores are released, white mildew colonies are formed on the underside of leaves near the center of the trunk or close to main scaffold limbs. These primary mildew colonies then produce chains of spores called conidia, giving the powdery appearance and spreading the infection throughout the orchard. A powdery mildew model has been developed for Northwest cherries by Washington State University and is part of WSU's Decision Aid System (http://das.wsu.edu) that can help growers predict critical disease periods and time cover sprays. If you can find mildew in your orchard around petal fall, then you know it's going to ramp up as the season goes on.

Podosphaera clandestina (Powdery Mildew) / Cherries: Orchard Components
(Source: Melissa Hansen, Controlling Mildew on Organic Cherries, Good Fruit Grower, February 15th, 2010.)

Tree structure, orchard location, varietal sensitivity, irrigation, and frost management all play roles in the development of powdery mildew.

Some tree structures, like the compact Spanish bush, may be more likely to encourage powdery mildew than the central or steep leader systems.

Orchard location sloping or flat land can also impact airflow and humidity. Early irrigation can also play a role. While we have no control over rain events, are we creating our own problem from spring frost irrigations? By delaying irrigation in the first few weeks, you could save one or two mildew sprays later on.

Additionally, cherry varieties can make a difference when it comes to mildew. Oregon growers with Regina cherries have had few mildew problems, while growers have found varieties like Bing, Rainier, Skeena, and Lapins to be more susceptible. Sweetheart cherries are particularly susceptible. Timing of harvest can influence disease severity. Late varieties have more time to develop secondary infections than early season cultivars.

Podosphaera clandestina (Powdery Mildew) / Cherry: Control Strategies
(Source: Melissa Hansen, Controlling Mildew on Organic Cherries, Good Fruit Grower, February 15th, 2010.)

An integrated approach to mildew uses a variety of strategies:

- <u>Cultural</u>: Are you keeping trees open and removing root suckers, which can be a source of mildew? Is your cover crop low or high?
- <u>Data logging</u>: Do you track temperatures and degree-days from a nearby weather station? Do you use WSU's computer mildew model to make management decisions?
- <u>Monitoring</u>: Are you actively looking for signs of mildew in the orchard?

- Management: How much time do you have for the cherry orchard? Do you have enough equipment to apply fungicides in a timely manner? Are you following your consultant's recommendations?
- Chemical controls: Are you willing to use chemicals, if needed?
- Fertilization: Are your trees vigorously growing? Putting on 100 to 200 pounds of nitrogen per acre to achieve tonnage will encourage vigorous tree growth, which may in turn encourages disease.
- Rain covers: Use of rain covers will increase humidity within the orchard and provide conducive conditions for mildew.

Podosphaera clandestina **(Powdery Mildew) / Cherries: Biggest Problem**
(Source: Melissa Hansen, Controlling Mildew on Organic Cherries, Good Fruit Grower, February 15th, 2010.)

Late varieties, such as Sweetheart, grown under dense canopies, seem to have the biggest problems with mildew. Even in orchards with good management, with growers doing all the right things, the late varieties are barely holding on. Early sites can usually get by without major mildew problems, but mid-season locations, especially those with susceptible varieties and dense tree structures, often "just get by" in terms of acceptable levels of damage from disease. Trees on dwarfing rootstocks, like Gisela 6, usually have acceptable levels of disease because growers are getting good coverage with their sprays. Spray coverage tends to be much poorer in big, tall, dense trees. This past year, if you had small fruit and mildew, with the poor market, your crop just didn't get picked.

Podosphaera clandestina (Powdery Mildew) / Cherries: OMRI-Listed Fungicides for Use in the United States
(No efficacy data have been identified or evaluated.)

FRAC Code	Source: EPA Label							NOP Status
	Active Ingredient	Product Name	Product Rate/ Acre	PHI (Days)	REI (Days)	EPA Reg. No.	Comments	
44	*Bacillus amyloliquefaciens* str. D747	Double Nickel 55	0.25-3 lb	0	4	70051-108	Causes moderate eye irritation. Dermal sensitizer. Broad-spectrum preventative fungicide. Do not use highly alkaline or highly acidic water to mix sprays. Use a buffering agent if necessary to maintain neutrality (pH 6 to 8) of water in the tank. Suppression only. Make first application at popcorn stage and repeat every 7 days.	Non-synthetic
	Bacillus pumilus str. QST 2808	Sonata ASO	2-4 qt	0	4	264-1153	Harmful if inhaled. Mixers/loaders and applicators must wear a dust/mist filtering respirator meeting NIOSH standards of at least N-95, R-95, or P-95. Repeated exposure to high concentrations of microbial proteins can cause allergic sensitization. Maintain a spray solution pH between 4.5 and 8.5. Begin application at popcorn stage and repeat at 7- to 14-day intervals as needed.	Non-synthetic
P5	*Reynoutria sachalinensis*	Regalia	1-4 qt	0	4	84059-3	Causes moderate eye irritation. Preventative rather than a curative application. Apply prior to disease infestation to protect the growing leaf tissue. Avoid freezing. Apply prior to disease infestation.	Non-synthetic
Not classified; Biological	*Streptomyces lydicus* WYEC 108	Actinovate AG	3-12 oz	0	1 or until solution has dried	73314-1	Avoid contact with skin, eyes, or clothing. Avoid breathing dust or spray mist. Mixer/loaders and applicators must wear a dust/mist filtering respirator meeting NIOSH standards of at least N-95, R-95, or P-95. Repeated exposure to high concentrations of microbial proteins can cause allergic sensitization. Keep from overheating or freezing. Optimum storage temperature is 40°F to 85°F. Contains live spores of a microbe. Best results will be obtained if the product is used prior to disease onset. Becomes active in soil or on the plant foliage when the temperatures are above 45°F and is not effective when temperatures remain cold. Do not apply soil fumigants to treated areas. For best results apply with a spreader/sticker prior to onset of disease. Re-apply every 7-14 days.	Non-synthetic
Not classified; Botanical oil	Cinnamon oil	Cinnerate	13-25 fl oz/ 100 gal water	0	0	N/A. FIFRA §25(b) pesticide.	May cause eye and skin irritation. May cause dermal sensitization. Store upright at room temperature. Avoid exposure to extreme temperatures. Do not expose to light and keep away from any heat source. Do not mix with oxidizing, strong acidic or basic materials. Broad spectrum, contact foliar fungicide. All applications should be preceded by a phytotoxicity check to ensure that the material is safe for the particular plant variety.	Non-synthetic
	Neem oil	Trilogy	1.0% solution	0	4	70051-2	Causes moderate eye irritation. Hazardous to fish and aquatic invertebrates. Toxic to bees exposed to direct treatment. Broad spectrum. Exercise care in timing applications during early morning/late evening to minimize the potential for leaf burn. Use care on plants with tender tissue. Check for leaf burn in small scale trials prior to use. Do not apply to sensitive plant species. Do not apply to wilted or otherwise stressed plants, or to newly transplanted materials or crops prior to root establishment. For optimal performance, do not mix with cold water (less than 45°F). Do not store below 40°F (4°C). Do not use or store near heat or open flame. Apply in 25-100 gallons water/A. Maximum labeled use of 2 gal/acre/application. Do not use after pit hardening.	Non-synthetic
	Sesame oil	Organicide 3-in-1	Cover leaf tops and bottoms	0	0	N/A. FIFRA §25(b) pesticide.	Insecticide, miticide, and fungicide. If spraying on severely stressed or damaged plants, consider using a lower rate such as 1 oz. per gallon to avoid adding additional stress. For best results, spray in the early morning.	Non-synthetic

Podosphaera clandestina (Powdery Mildew) / Cherries: OMRI-Listed Fungicides for Use in the United States **(No efficacy data have been identified or evaluated.)**								
FRAC Code	Source: EPA Label							NOP Status
	Active Ingredient	Product Name	Product Rate/ Acre	PHI (Days)	REI (Days)	EPA Reg. No.	Comments	
M2	Sulfur	Kumulus DF	10-30 lb	0	24	51306-352-66330	Harmful if swallowed. Avoid breathing spray mist. Avoid contact with eyes, skin, and clothing. Do not apply within 2 weeks of an oil spray treatment. Do not store above 104°F. Store away from heat, sparks, and open flame. Apply at bloom and early petal fall. Repeat as necessary, usually 10-14 days or after wet weather.	Synthetic
		Micro Sulf	10-30 lb	0	24	55146-75	Harmful if swallowed, inhaled, or absorbed through skin. Causes eye irritation. Risk of crop injury if temperature exceeds 90°F within 3 days following application. Do not use on any crop unless sulfur has been shown to be safe in your locality. Do not apply within 14 days of an oil spray. Keep away from heat, sparks, or flames. Do not smoke while applying this product. Apply at bloom or early petal fall. Repeat as necessary, usually 10-14 days or after wet weather.	
		Microthiol Disperss	10-20 lb	0	24	70506-187	Harmful if swallowed, inhaled, or absorbed through skin. Risk of crop injury if temperature exceeds 90°F within 3 days following application. Do not use on any crop unless sulfur has been shown to be safe in your locality. Do not store near flammable materials. Do not store in a manner where cross-contamination with other pesticides, fertilizers, food or feed could occur. Restrictions regarding application time before and after an oil spray treatment. Repeat applications at 7- to 10-day intervals.	
		Thiolux	5-10 lb	0	24	34704-1079	Harmful if swallowed, inhaled, or absorbed through skin. Causes eye irritation. Sulfur may case severe fruit and foliage injury to certain crops. Risk of crop injury if temperature exceeds 90°F within 3 days following application. Do not apply within 14 days of an oil spray. Sulfur dust suspended in air easily ignites. Keep away from heat, sparks, or flames. Do not smoke while applying this product.	
Not classified; Inorganic salt	Potassium bicarbonate	Kaligreen	2.5-3.0 lb	1	4	70231-1	Harmful if swallowed, absorbed through skin, or inhaled. Do not mix with highly acidic products as effectiveness may be compromised. Use of a buffering agent for acidification of a tank mixture may also decrease effectiveness. Crop injury may result due to certain environmental or growing conditions, manner of use or application.	Synthetic
	Potassium silicate	Sil-Matrix	0.25-1% solution	0	4	82100-1	Causes moderate eye irritation. Avoid contact with glass. Remove promptly from glass surfaces. Store product above 40°F. Do not store in aluminum, fiberglass, copper, brass, zinc, or galvanized containers. Protect from excessive heat. Broad spectrum preventative fungicide. Do not apply more than 10 qt/acre/application.	Synthetic
Not classified; Organic salt	Potassium salts of fatty acids	M-Pede	1-2% vol/vol; 100 gal solution/ acre	0	12	10163-324	WARNING signal word. Causes substantial but temporary eye injury and skin irritation. May be hazardous to aquatic invertebrates. Do not use with sulfur or within 3 days of a sulfur application. Apply M-Pede solutions to wet (minimize run-off) to decrease the potential for injury on foliage, fruit and flowers of sensitive plants. Do not apply to cherries after fruit formation.	Synthetic

Podosphaera clandestina (Powdery Mildew) / Cherries: OMRI-Listed Fungicides for Use in the United States **(No efficacy data have been identified or evaluated.)**								
FRAC Code	Source: EPA Label							NOP Status
	Active Ingredient	Product Name	Product Rate/ Acre	PHI (Days)	REI (Days)	EPA Reg. No.	Comments	
Not classified; Oxidizing agent	Hydrogen dioxide, Peroxyacetic acid	Oxidate 2.0	128 fl oz/100 gal; 30-100 gal solution/acre.	0	Until spray has dried	70299-2	DANGER signal word. Causes irreversible eye damage. May be fatal if swallowed. Causes skin irritation or temporary discoloration of exposed skin. Highly toxic to bees and other beneficial insects. Toxic to fish. Toxic to birds who eat treated seed on soil surface. Strong oxidizing agent. Do not use in undiluted form. Never bring undiluted product in contact with other pesticides, cleaners or oxidative agents. May react with residues of metal-based fungicides or supplements. Allow at least 24 hrs. after application of metal-based products. Do not spray during conditions of intense heat, drought, or poor plant vigor (or vine canopy). Do not apply in conjunction with any other pesticides or fertilizers. Do not allow product to become overheated in storage. Do not store in a manner where cross-contamination with other pesticides or fertilizers could occur. Apply pre-bloom. Maybe applied curatively (Three daily treatments. Then treatment at 5-7 day intervals.) Apply consecutive applications until control is achieved; then apply preventative treatments.	Synthetic
	Hydrogen peroxide, Hydrogen dioxide	Perpose Plus	Initial/ Curative: 1 fl oz/gal. Weekly/ Preventative: 0.25-0.33 fl oz/gal.	0	Until spray has dried	86729-1	DANGER signal word. Causes irreversible eye damage and skin burns. May be fatal if absorbed through the skin. Harmful if swallowed. Do not breathe vapor from concentrate. Toxic to birds, mammals, fish and aquatic life. At temperatures exceeding 156°F, decomposition releases oxygen. The oxygen released could initiate or promote combustion of other materials. Store away from combustibles. Broad spectrum algaecide and fungicide. Apply curative rates for 3 consecutive days (drenching the entire plant) followed by weekly preventative treatments.	Synthetic

Podosphaera clandestina (Powdery Mildew) / Cherries: OMRI-Listed Fungicides for Use in the United States **(No efficacy data have been identified or evaluated.)**								
FRAC Code	Source: EPA Label							NOP Status
	Active Ingredient	Product Name	Product Rate/ Acre	PHI (Days)	REI (Days)	EPA Reg. No.	Comments	
Not classified; Petroleum oils	Mineral oil	PureSpray Green	Dilute Spray: 1-2 gal per 100 gal of water at 200-600 gal of water/acre. Concentrate Spray: 6-8 gal per acre in a minimum of 20 gal of water per acre.	0	4	69526-9	Harmful if swallowed or absorbed through skin. Prolonged or repeated skin contact may cause allergic reaction in some individuals. Drift and runoff may be hazardous to aquatic organisms in water adjacent to treated areas. Use extreme care when using concentrate sprays as the potential for crop phytotoxicity is increased. Avoid excess heat. Do not spray during or immediately prior to hot or freezing weather (over 95°F or under 32°F), hot dry winds, rain or other unsuitable conditions. Do not overspray or double spray. Spray plants only when they are in vigorous condition and when their moisture condition is suitable. Before using, make certain spray tank is free of sulfur residues. Do not apply micronized sulfur within 10 days of an oil application. Do not apply oil within 14 days of an application of wettable or dusting sulfur. Do not apply to oil sensitive varieties. See label for additional compatibility restrictions regarding many conventional active ingredients.	Synthetic
	Paraffinic oil	Organic JMS Stylet Oil	1-2 gal/ 100 gal water	0	4	65564-1	Harmful if swallowed. Toxic to fish. Do not freeze. Do not spray wet foliage. Do not spray when freezing temperatures are anticipated within 48 hours of an oil application, above 90°F (32°C) or when plants are under heat or moisture stress. Do not apply to vegetables when the temperature is below 50°F (10°C). Do not apply micronized sulfur within 10 days of an oil application. Do not apply oil within 14 days of an application of wettable or dusting sulfur. Do not apply to oil sensitive varieties. See label for additional compatibility restrictions.	Synthetic

Podosphaera clandestina **(Powdery Mildew) / Cherries: Efficacy Trials**

Podosphaera clandestina (Powdery Mildew) / Cherries #1: Trial No. CER-2015-032

a. Design

Podosphaera clandestina (Powdery Mildew) / Cherries #1: Trial No. CER-2015-032: Design			
Title:	Efficacy of Oso 5%SC Fungicide Against Cherry Powdery Mildew in Washington		
Author and affiliation:	Ron Britt Ron Britt & Associates		
Publication:	Certis data. Not published. Permission received.		
Location:	Granger, Washington		
Crop:	Sweet cherry (Early Robin)		
Disease name:	Powdery mildew		
Pathogen:	*Podosphaera clandestina*		
Test plot design:	Randomized complete block		
Number of replicates:	4		
Application equipment:	Rears airblast sprayer (110 psi)		
Spray volume:	200 gal/acre		
Number of applications:	4		
Chronology:	Application Dates	Application Interval	Mildew Assessment Dates
	04/25/2015		05/15/2015
	05/09/2015	14 days	05/29/2015
	05/23/2015	14 days	06/18/2015
	06/07/2015	15 days	06/25/2015
Disease assessment methodology:	Ten shoots were randomly selected in each replicate. The top five true leaves, minus the immature leaves at the apical tip of each shoot were evaluated for the presence of mildew and the percentage of leaf covered with mildew was recorded. Fifty leaves per replicate were inspected for the percentage of leaf covered with powdery mildew. There was no fruit to evaluate due to the climatic conditions at the trial site.		

b. Results

Podosphaera clandestina (Powdery Mildew) / Cherries #1: Trial No. CER-2015-032: Results									
Treatment	Rate/ Acre	g a.i./ ha	Active Ingredient	FRAC Code	App Code	Total % Infected (06/25/2015)		Ave. % Leaves Infected (06/25/2015)	
						Measured	Percent Control	Measured	Percent Control
Untreated control			Not Applicable			602.8 a		15.588 a	
Oso 5%	6.5 fl oz	25	Polyoxin D zinc salt	19	ABCD	228.8 b	62.0	6.555 b	57.9
R-56	32 fl oz/ 100 gal	NA	Spreader/ sticker	NA	ABCD				
Procure 480SC	16 fl oz		Triflumazole	3	AC	180.3 b	70.0	5.182 b	66.8
Pristine	14.5 oz		Boscalid	7	BD				
			Pyraclostrobin	11					
Procure 480SC	16 fl oz		Triflumazole	3	AC	255.8 b	57.6	6.238 b	60.0
Oso 5%	6.5 fl oz		Polyoxin D zinc salt	19	BD				
R-56	32 fl oz/ 100 gal		Adjuvant	NA	BD				
Total percent infected = Sum of all the leave surface percentages infected added together. Treatment means followed by the same letter are not statistically different according to the Bartlett's X test (P = 0.312 for total % infected; P = 0.296 for average % leaves infected).									

Powdery mildew was first observed on May 15, 2015. Therefore, the treatments were preventative and curative.

No phytotoxicity was reported.

c. Discussion and Conclusions

Sweet cherries were grown in Washington. Maximum percent of leaves infected with powdery mildew in the untreated control was 89.0%.

Four fungicide treatments were applied preventatively and curatively at 14-day to 15-day intervals. Polyoxin D Zinc Salt 5SC Fungicide was applied at 6.5 fl oz/acre (25 g a.i./ha) with R-56 (a spreader/ sticker). The mean 60.0% (range 57.9% to 62.0%) control of powdery mildew on cherries was statistically:

- Superior to the untreated control; and
- Equivalent to two separate treatment programs that included:
  - Triflumazole, boscalid, and pyraclostrobin; and
  - Triflumazole, polyoxin D zinc salt, and R-56 (adjuvant).

No phytotoxicity was reported.

Podosphaera leucotricha (POWDERY MILDEW) / APPLES

Podosphaera leucotricha (Powdery Mildew) / Apples: Introduction

(Source: S.C. Marine, K.S. Yoder, and A. Baudoin. 2010. Powdery Mildew of Apple. *The Plant Health Instructor.* DOI:10.1094/PHII-2010-1021-01)
http://www.apsnet.org/edcenter/intropp/lessons/fungi/ascomycetes/Pages/ApplePowderyMildew.aspx

Disease: Powdery mildew of apple
Pathogen: *Podosphaera leucotricha* (Ell. and Ev.) Salm.
Hosts: Apples and flowering crabapples (*Malus* spp.) and pear (*Pyrus* spp.)

Powdery mildew of apple occurs in all apple-producing regions of the world. The disease causes economic damage by reducing tree vigor, flower bud production, and fruit quality.

Podosphaera leucotricha (Powdery Mildew) / Apples: Significance

(Source: S.C. Marine, K.S. Yoder, and A. Baudoin. 2010. Powdery Mildew of Apple. *The Plant Health Instructor.* DOI:10.1094/PHII-2010-1021-01)

Before the 1940's, mildew was considered a disease primarily of nursery stock and was of relatively minor importance to most commercial apple growers. Its rise to prominence within the apple disease spectrum can be partially attributed to the replacement of sulfur fungicides with organic fungicides, whose spectrum of activity focused more on apple scab and rust control. Initial efforts in breeding programs focused on "wet weather" disease resistance, but mildew infections do not require free moisture. The limited number of fungicide options available and the lack of satisfactory control helped ensure mildew's significance among other apple diseases.

Currently, powdery mildew is a persistent problem wherever apples are grown. Serious outbreaks can be a consequence of inadequate early-season spray programs, lax spray programs during dry spells, or development of resistance to some of the fungicides used. Powdery mildew's chronic effect on tree vigor and yield is detrimental to both the longevity and profitability of the orchard. Successful control of powdery mildew is dependent on grower education and a management strategy that incorporates resistant apple cultivars, cultural practices, and effective fungicide application.

Podosphaera leucotricha (Powdery Mildew) / Apples: Symptoms and Signs

(Source: S.C. Marine, K.S. Yoder, and A. Baudoin. 2010. Powdery Mildew of Apple. *The Plant Health Instructor.* DOI:10.1094/PHII-2010-1021-01)

Powdery mildew of apple produces symptoms on young shoots, leaves, blossoms, and fruit. In general, symptoms are most noticeable on the leaves and fruit.

<u>Apple shoots</u>. Overwintered infections in dormant flower and shoot buds provide inoculum for the following year. In spring when the terminal buds begin to grow, the fungus colonizes the young, green tissue as it emerges. These infected "flag shoots" have a silver-gray appearance and may exhibit defoliation, stunted growth, and die-back. In the following weeks, as the growing season progresses, the primary infections on the flag shoots produce inoculum, which causes secondary infections on leaves, blossoms, and fruit. Heavily infected trees become weakened and are more likely to be invaded by secondary pathogens. By midsummer, the mycelium darkens and numerous brown fruiting bodies (ascocarps) form.

Apple leaves and fruit. In contrast to primary infections, in which the leaf is colonized as it emerges from the bud, secondary infections occur when windborne spores land on young leaves as they unfurl and expand. Fungal colonies composed of mycelium and spores appear as white, felt-like patches. Secondary infections commonly appear first on the lower leaf surface, and may be detectable on the upper leaf surface as chlorotic spots. Leaves infected along the leaf margin may become curled, crinkled, or folded longitudinally. As the disease progresses, affected tissues develop the powdery, silver-gray appearance typical of powdery mildews. Infections on the blossom receptacle or of young fruit will cause netlike russetting and discoloration as the fruit matures. Fruit may also become distorted and/or dwarfed. Powdery mildew reduces both apple yield and quality.

Apple blossoms. Infected flower buds have a silver-gray appearance and open 5-8 days later than healthy ones, if at all. Petals are distorted and pale yellow or light green. Blossoms may become shriveled and fail to produce fruit. Secondary infections may occur on newly forming flower buds, which will remain dormant until the following spring. Since these buds will be diseased when they open, severe infection can eliminate the crop the following season.

Podosphaera leucotricha **(Powdery Mildew) / Apples: Pathogen Biology**
(Source: S.C. Marine, K.S. Yoder, and A. Baudoin. 2010. Powdery Mildew of Apple. *The Plant Health Instructor.* DOI:10.1094/PHII-2010-1021-01)

Podosphaera leucotricha is an ascomycete fungus in the Erysiphaceae family and is found in all apple-producing regions. (Other powdery mildew species have occasionally been recorded on Malus species, but appear to be of no economic significance.) During the growing season, this fungal obligate parasite continuously produces asexual spores (conidia) on specialized short stalks called conidiophores. Conidia are hyaline (clear, without color), measure 20-38 μm × 12 μm, and contain distinct fibrosin bodies. Fibrosin bodies are refractive inclusion bodies that exhibit varied shapes including rods and cones, and that can aid in the recognition of this group of powdery mildews.
Conidia are wind-dispersed and do not require free moisture to germinate. If they land on susceptible tissue, they initiate infection and produce colonies of mycelium. Infected lateral and terminal apple buds serve as overwintering sites and provide the earliest source of inoculum the following spring. However, extremely low winter temperatures will negatively impact the survival of *Podosphaera leucotricha* as infected buds are more vulnerable to winter kill.

Podosphaera leucotricha also produces sexual spores (ascospores) in sac-like asci enclosed in fruiting bodies (ascocarps). Each ascocarp contains a single ascus with eight ascospores, each of which is elliptical and measures 22-36 μm x 12-15 μm. Ascocarps are recognized as distinct black dots on the surface of a mycelial mat. Ascocarps are densely grouped together, measure 75-96 μm in diameter, and have apical and basal appendages. Ascocarps form late in the growing season and serve as overwintering structures, but don't play any known role in initiating new epidemics, as the ascospores fail to germinate readily. In the past, the ascocarps of *Podosphaera leucotricha* were called cleistothecia (reflecting the closed nature and lack of a preformed opening), perithecia (reflecting the arrangement of the asci of many powdery mildew fungi in a layer [hymenium]), and most recently, chasmothecia. All three terms can be found in the literature. Since cleistothecia in other groups of ascomycetes lack a hymenium (*i.e.*, the asci are randomly scattered throughout the enclosed structure), the term *chasmothecia* has been recently introduced to distinguish powdery mildew ascocarps from other cleistothecia. The word is derived from the vertical chasm that is formed during ascospore discharge.

***Podosphaera leucotricha* (Powdery Mildew) / Apple: Disease Cycle and Epidemiology**
(Source: S.C. Marine, K.S. Yoder, and A. Baudoin. 2010. Powdery Mildew of Apple. *The Plant Health Instructor.* DOI:10.1094/PHII-2010-1021-01)

Disease Cycle. *Podosphaera leucotricha* overwinters as mycelium in dormant flower and shoot buds infected the previous year. In spring, the infected buds break dormancy and the fungus resumes growth, colonizing the developing shoots and young leaf tissue. From these primary infections, asexual conidia are produced on conidiophores and dispersed by wind. Conidia will germinate at high relative humidity (greater than 70%, which is commonly available in the microclimate of the lower leaf surface) at temperatures between 10°C and 25°C. In contrast to most foliar fungal pathogens, leaf wetting is a deterrent to infection. The youngest leaves are the most susceptible, but become increasingly resistant as they mature.

Powdery mildew colonies generally appear first on the lower leaf surface as white felt-like patches. Conidia germinate to form hyphal outgrowths, which traverse the leaf surface, swell and then flatten to form appressoria. These structures release enzymes, which allow fungal infection pegs to penetrate the plant's epidermal cells and then enlarge to form haustoria. Haustoria are specialized organs formed inside living plant cells, which absorb nutrients and anchor the fungus. As the powdery mildew colony expands or as secondary infections lead to new colony formation, the infection process (hyphal outgrowth > appressorium > infection peg > haustorium) is repeated until susceptible tissue is no longer available. Late-season growth may result in a sudden increase in powdery mildew activity. In addition to contributing toward a rapid inoculum buildup, secondary disease cycles are also responsible for infecting lateral and terminal buds that will carry the fungus through the winter.

Primary infections in flower buds can produce conidia as early as tight-cluster, the stage of apple development when flower cluster leaves start to separate but flower buds remain aggregated. Infected buds usually open later than healthy ones, ensuring the presence of susceptible tissue (expanding and unfurling leaves, open blossoms, and immature fruit) for the fungus to colonize.
Secondary infection of the blossom receptacle occurs from 3 weeks before bloom to 3 weeks after bloom. Infected receptacles may shrivel and fail to produce fruit or may mature to produce fruit that is discolored, russetted, dwarfed, and/or distorted.

In late summer and early fall, overwintering structures (ascocarps) are formed within the mycelial mat on leaves and shoots. However, the sexual spores (ascospores) contained in these ascocarps are seldom viable, and no role in survival and infection has been established.

Powdery mildew is a chronic recurrent problem. High disease levels at the end of a season may:
(I) Increase the percentage of infected buds, leading to high levels of primary inoculum the next spring; and/or
(ii) Inhibit flower bud formation, reducing or eliminating the fruit crop the following season.
Therefore, management of the disease must focus on reducing the primary inoculum and protecting the trees from secondary inoculum.

Podosphaera leucotricha **(Powdery Mildew) / Apples: Disease Management**
(Source: S.C. Marine, K.S. Yoder, and A. Baudoin. 2010. Powdery Mildew of Apple. *The Plant Health Instructor.* DOI:10.1094/PHII-2010-1021-01)

Cultivar Selection. The use of less susceptible apple cultivars is perhaps the most effective means of preventing powdery mildew. Apple cultivars are available that demonstrate natural resistance to powdery mildew and need control only under high disease pressure. These include Jonafree, Prima, and Enterprise, but they are not widely grown. Planting cultivars that have some level of resistance to several common apple diseases (apple scab, powdery mildew, fireblight, and cedar apple rust) can reduce the number of fungicide treatments and the total cost of the spray program in a given growing season. Cultivar selection is influenced more by commercial appeal, fruit qualities, marketability, and pollination characteristics than by disease resistance. As a result, growers typically interplant cultivars of different susceptibilities in an orchard. Cultivars such as Golden Delicious, Idared, and Granny Smith are widely grown, but are moderately to highly susceptible to powdery mildew and may require chemical disease management. Charts of apple cultivars and their susceptibility to powdery mildew are available to aid growers in cultivar selection.

Cultural Practices. Primary infections can be controlled by removal of the primary inoculum sources (*i.e.*, flower and shoot buds infected the previous year). Growers should note any whitened terminal shoots and prune them out during winter or early spring. Unfortunately, this is hard to accomplish effectively. Removal of inoculum by pruning, especially in large commercial orchards, would be labor-intensive and may interfere with tree-structure training. Complete removal of this type of inoculum is just not economically feasible. The best candidates to use this control practice are small young orchards with low numbers of primary infections per tree.

Chemical Control. Secondary infections and fruit infections can be controlled by foliar fungicide applications. In commercial orchards, fungicides are almost always used to control powdery mildew, as well as other apple diseases. Fungicides are usually applied at 7-day to 10-day intervals from the tight-cluster stage until terminal shoot growth ends (about midsummer). This ensures that fungicide application coincides with rapid leaf development and the post-bloom period, and that the new growth does not remain unprotected for long. For highly susceptible cultivars, this could mean as many as 18 sprays.

Sulfur can provide effective control. Horticultural oils, waxes, and biological compounds produced by *Bacillus* strains are also available, but their effectiveness is somewhat inconsistent.

Failure to include pre-bloom sprays is one of the most common mistakes growers make in powdery mildew management. When *Podosphaera leucotricha* resumes growth in spring, large numbers of conidia are produced in uncontrolled secondary cycles. These asexual spores infect healthy flower and shoot buds, which serve as the primary inoculum source next year. Control is difficult to achieve during the growing season if it has been neglected early on. Growers may be tempted to relax spray programs during dry conditions when other apple diseases cannot develop, but powdery mildew thrives in dry weather and protection needs to be maintained.

Studies have also found that control is more enhanced by shortening the spray interval than by increasing the fungicide rate. However, this is mostly done in severe disease situations, as labor and fuel cost may become prohibitive if 3-day to 4-day intervals are used. Chemical control programs must be developed with pesticide compatibility, phytotoxicity, and registration restrictions in mind.

Podosphaera leucotricha (Powdery Mildew) / Pome Fruits: OMRI-Listed Fungicides for Use in the United States **(No efficacy data have been identified or evaluated.)**								
FRAC Code	Source: EPA Label							NOP Status
	Active Ingredient	Product Name	Product Rate/ Acre	PHI (Days)	REI (Days)	EPA Reg. No.	Comments	
44	*Bacillus amyloliquefaciens* str. D747	Double Nickel 55	0.25-3 lb	0	4	70051-108	Causes moderate eye irritation. Dermal sensitizer. Broad-spectrum preventative fungicide. Do not use highly alkaline or highly acidic water to mix sprays. Use a buffering agent if necessary to maintain neutrality (pH 6 to 8) of water in the tank. Suppression only. All pome fruit: Make first application at or before tight cluster if conditions favor disease development. Repeat at 7-10 day intervals through the second cover spray or longer on susceptible varieties or if environmental conditions favor rapid disease development.	Non-synthetic
	Bacillus pumilus str. QST 2808	Sonata ASO	2-4 qt	0	4	264-1153	Harmful if inhaled. Mixers/loaders and applicators must wear a dust/mist filtering respirator meeting NIOSH standards of at least N-95, R-95, or P-95. Repeated exposure to high concentrations of microbial proteins can cause allergic sensitization. Maintain a spray solution pH between 4.5 and 8.5. Begin application at tight cluster, or sooner, if conditions are conducive to disease development.	Non-synthetic
Not classified; Biological	*Streptomyces lydicus* WYEC 108	Actinovate AG	3-12 oz	0	1 or until solution has dried	73314-1	Avoid contact with skin, eyes, or clothing. Avoid breathing dust or spray mist. Mixer/loaders and applicators must wear a dust/mist filtering respirator meeting NIOSH standards of at least N-95, R-95, or P-95. Repeated exposure to high concentrations of microbial proteins can cause allergic sensitization. Keep from overheating or freezing. Optimum storage temperature is 40°F to 85°F. Contains live spores of a microbe. Best results will be obtained if the product is used prior to disease onset. Becomes active in soil or on the plant foliage when the temperatures are above 45°F and is not effective when temperatures remain cold. Do not apply soil fumigants to treated areas. For best results apply with a spreader/sticker prior to onset of disease. All pome fruit: Re-apply every 7-14 days. For best result, use with a spreader-sticker.	Non-synthetic
Not classified; Botanical oil	Cinnamon oil	Cinnerate	13-25 fl oz/ 100 gal water	0	0	N/A. FIFRA §25(b) pesticide.	May cause eye and skin irritation. May cause dermal sensitization. Store upright at room temperature. Avoid exposure to extreme temperatures. Do not expose to light and keep away from any heat source. Do not mix with oxidizing, strong acidic or basic materials. Broad spectrum, contact foliar fungicide. All applications should be preceded by a phytotoxicity check to ensure that the material is safe for the particular plant variety. Apples, pears: Apply 85-125 gal diluted spray/A. All applications should be preceded by a phytotoxicity check to ensure that the material is safe for the particular plant variety.	Non-synthetic
	Neem oil	Trilogy	1.0% solution	0	4	70051-2	Causes moderate eye irritation. Hazardous to fish and aquatic invertebrates. Toxic to bees exposed to direct treatment. Broad spectrum. Exercise care in timing applications during early morning/late evening to minimize the potential for leaf burn. Use care on plants with tender tissue. Check for leaf burn in small scale trials prior to use. Do not apply to sensitive plant species. Do not apply to wilted or otherwise stressed plants, or to newly transplanted materials or crops prior to root establishment. For optimal performance, do not mix with cold water (less than 45°F). Do not store below 40°F (4°C). Do not use or store near heat or open flame. All pome fruit: Apply in 25-100 gallons water/A. Maximum labeled use of 2 gal/acre/application.	Non-synthetic
	Sesame oil	Organocide 1-in-3	1-2 oz/gal water	0	0	N/A. FIFRA §25(b) pesticide.	Insecticide, miticide, and fungicide. If spraying on severely stressed or damaged plants, consider using a lower rate such as 1 oz. per gallon to avoid adding additional stress. For best results, spray in the early morning.	Non-synthetic

Podosphaera leucotricha (Powdery Mildew) / Pome Fruits: OMRI-Listed Fungicides for Use in the United States
(No efficacy data have been identified or evaluated.)

FRAC Code	Source: EPA Label							NOP Status
	Active Ingredient	Product Name	Product Rate/ Acre	PHI (Days)	REI (Days)	EPA Reg. No.	Comments	
M2	Sulfur	Kumulus DF	10-20 lb	0	24	51306-352-66330	Harmful if swallowed. Avoid breathing spray mist. Avoid contact with eyes, skin, and clothing. Do not apply within 2 weeks of an oil spray treatment. Do not store above 104°F. Store away from heat, sparks, and open flame. Apples, pears: Do not apply to D'anjou pears or sensitive apple varieties (*i.e.*, Ontario or Cox orange). Apply pre-bloom and petal fall. Apply with cover sprays throughout the season at 10-14 day intervals or after wet weather.	Synthetic
		Micro Sulf	10-20 lb	0	24	55146-75	Harmful if swallowed, inhaled, or absorbed through skin. Causes eye irritation. Risk of crop injury if temperature exceeds 90°F within 3 days following application. Do not use on any crop unless sulfur has been shown to be safe in your locality. Do not apply within 14 days of an oil spray. Keep away from heat, sparks, or flames. Do not smoke while applying this product. Apples, pears: Apply at pre-bloom and petal fall with cover sprays throughout the season. Do no apply to D'anjou pears during growing season. Repeat as necessary, usually 10-14 days or after wet weather.	
		Microthiol Disperss	10-20 lb	0	24	70506-187	Harmful if swallowed, inhaled, or absorbed through skin. Risk of crop injury if temperature exceeds 90°F within 3 days following application. Do not use on any crop unless sulfur has been shown to be safe in your locality. Do not store near flammable materials. Do not store in a manner where cross-contamination with other pesticides, fertilizers, food or feed could occur. Restrictions regarding application time before and after an oil spray treatment. Repeat applications at 7- to 10-day intervals. Apples, pears: Apply at pre-bloom and petal fall. Apply with cover sprays throughout the season. Do no apply to D'anjou pears or sensitive apple varieties (*i.e.*, Ontario or Cox orange).	
		Thiolux	10-20 lb	0	24	34704-1079	Harmful if swallowed, inhaled, or absorbed through skin. Causes eye irritation. Sulfur may case severe fruit and foliage injury to certain crops. Risk of crop injury if temperature exceeds 90°F within 3 days following application. Do not apply within 14 days of an oil spray. Sulfur dust suspended in air easily ignites. Keep away from heat, sparks, or flames. Do not smoke while applying this product. Apples, pears, quince: Apply with cover sprays throughout the season. Do not apply to D'anjou pears. Apples and pears are susceptible to foliage burn with sulfur under ceratin climatic conditions. Do not apply if temperatures during or within 3 days after application are expected to exceed 90°F.	

Podosphaera leucotricha (Powdery Mildew) / Pome Fruits: OMRI-Listed Fungicides for Use in the United States
(No efficacy data have been identified or evaluated.)

FRAC Code	Source: EPA Label							NOP Status
	Active Ingredient	Product Name	Product Rate/ Acre	PHI (Days)	REI (Days)	EPA Reg. No.	Comments	
Not classified; Inorganic salt	Potassium bicarbonate	Kaligreen	2.5-3.0 lb	1	4	70231-1	Harmful if swallowed, absorbed through skin, or inhaled. Do not mix with highly acidic products as effectiveness may be compromised. Use of a buffering agent for acidification of a tank mixture may also decrease effectiveness. Crop injury may result due to certain environmental or growing conditions, manner of use or application. All pome fruits: Use higher rate when disease pressure increases or a severe infection has occurred. Use in an Integrated Pest Management rotation program at 7-10 day intervals with other effective fungicides for resistance management. Begin application at the first sign of disease. Repeat applications as new growth or infection occurs or as favorable disease conditions continue.	Synthetic
	Potassium silicate	Sil-Matrix	0.25-1% solution	0	4	82100-1	Causes moderate eye irritation. Avoid contact with glass. Remove promptly from glass surfaces. Store product above 40°F. Do not store in aluminum, fiberglass, copper, brass, zinc, or galvanized containers. Protect from excessive heat. Broad spectrum preventative fungicide. Apple, crabapple, pear, quince: Do not apply more than 10 qt/acre/application.	Synthetic
Not classified; Organic salt	Potassium salts of fatty acids	M-Pede	1-2% vol/vol; 100 gal solution/ acre	0	12	10163-324	WARNING signal word. Causes substantial but temporary eye injury and skin irritation. May be hazardous to aquatic invertebrates. Do not use with sulfur or within 3 days of a sulfur application. All pome fruit: Apply M-Pede solutions to wet (minimize run-off) to decrease the potential for injury on foliage, fruit and flowers of sensitive plants.	Synthetic
Not classified; Oxidizing agent	Hydrogen dioxide, Peroxyacetic acid	Oxidate 2.0	Initial/ Curative: 128 fl oz/ 100 gal water; 30-100 gal solution/ acre Preventative: 40-128 fl oz/ 100 gal water; 30-100 gal solution/ acre	0	Until spray has dried	70299-2	DANGER signal word. Causes irreversible eye damage. May be fatal if swallowed. Causes skin irritation or temporary discoloration of exposed skin. Highly toxic to bees and other beneficial insects. Toxic to fish. Toxic to birds who eat treated seed on soil surface. Strong oxidizing agent. Do not use in undiluted form. Never bring undiluted product in contact with other pesticides, cleaners or oxidative agents. May react with residues of metal-based fungicides or supplements. Allow at least 24 hrs. after application of metal-based products. Do not spray during conditions of intense heat, drought, or poor plant vigor (or vine canopy). Do not apply in conjunction with any other pesticides or fertilizers. Do not allow product to become overheated in storage. Do not store in a manner where cross-contamination with other pesticides or fertilizers could occur. Apples ,Pears, Loquats , Mayhaws, and Quince: Begin application before disease appears. Apply first three treatments using the curative rate at 5-day intervals. Reduce rate to 32 fl. oz. per 100 gallons of water after the completion of third treatment and maintain 5-day interval spray cycle until harvest.	Synthetic
	Hydrogen peroxide, Hydrogen dioxide	Perpose Plus	Initial/ Curative: 1 fl oz/gal. Weekly/ Preventative: 0.25-0.33 fl oz/gal.	0	Until spray has dried	86729-1	DANGER signal word. Causes irreversible eye damage and skin burns. May be fatal if absorbed through the skin. Harmful if swallowed. Do not breathe vapor from concentrate. Toxic to birds, mammals, fish and aquatic life. At temperatures exceeding 156°F, decomposition releases oxygen. The oxygen released could initiate or promote combustion of other materials. Store away from combustibles. Broad spectrum algaecide and fungicide. All pome fruit: For initial or curative use, apply higher rate for 1 to 3 consecutive days. Then follow with weekly/preventative treatment. For weekly or preventative treatments, apply lower rate every five to seven days. At first sign of disease, use curative rate then resume weekly preventative treatment. Apply curative rates for 3 consecutive days (drenching the entire plant) followed by weekly preventative treatments.	Synthetic

Podosphaera leucotricha (Powdery Mildew) / Pome Fruits: OMRI-Listed Fungicides for Use in the United States
(No efficacy data have been identified or evaluated.)

FRAC Code	Source: EPA Label							NOP Status
	Active Ingredient	Product Name	Product Rate/ Acre	PHI (Days)	REI (Days)	EPA Reg. No.	Comments	
Not classified; Petroleum oils	Mineral oil	PureSpray Green	Dilute Spray: Use 1-2 gal per 100 gal of water at 200-600 gal of water/acre. Concentrate Spray: 6-8 gal per acre in a minimum of 20 gal of water per acre.	0	4	69526-9	Harmful if swallowed or absorbed through skin. Prolonged or repeated skin contact may cause allergic reaction in some individuals. Drift and runoff may be hazardous to aquatic organisms in water adjacent to treated areas. Use extreme care when using concentrate sprays as the potential for crop phytotoxicity is increased. Avoid excess heat. Do not spray during or immediately prior to hot or freezing weather (over 95°F or under 32°F), hot dry winds, rain or other unsuitable conditions. Do not overspray or double spray. Spray plants only when they are in vigorous condition and when their moisture condition is suitable. Before using, make certain spray tank is free of sulfur residues. Do not apply micronized sulfur within 10 days of an oil application. Do not apply oil within 14 days of an application of wettable or dusting sulfur. Do not apply to oil sensitive varieties. See label for additional compatibility restrictions regarding many conventional active ingredients. <u>Apples</u>: Apply at tight cluster and continue every 10-14 days through second cover spray. Use higher rate and/or shorter spray interval when disease conditions are severe. <u>Pears</u>: Apply at bud burst and continue every 10-14 days. Use the higher rates and/or shorter spray interval when disease conditions are severe. Not approved for use in California.	Synthetic
		SuffOil-X	1-2 gal/ 100 gal water/A	0	4	48813-1-68539	Harmful if absorbed through skin. Prolonged or frequently repeated skin contact may cause allergic reactions in some individuals. Do not use in combination with any product containing sulfur. Do not use with any product whose label recommends the use of no oils. Do not use in combination with NPK foliar fertilizer applications. Do not apply during periods of drought or when plants exhibit moisture stress.	
		Tritek	1-2 gal/ 100 gal water/A	0	4	48813-1		
	Paraffinic oil	Organic JMS Stylet Oil	1-2 gal/ 100 gal water	0	4	65564-1	Harmful if swallowed. Toxic to fish. Do not freeze. Do not spray wet foliage. Do not spray when freezing temperatures are anticipated within 48 hours of an oil application, above 90°F (32°C) or when plants are under heat or moisture stress. Do not apply to vegetables when the temperature is below 50°F (10°C). Do not apply micronized sulfur within 10 days of an oil application. Do not apply oil within 14 days of an application of wettable or dusting sulfur. Do not apply to oil sensitive varieties. See label for additional compatibility restrictions. <u>Apples, pears</u>: Apply at tight cluster and continue every 10-14 days through second cover spray. Use higher rate and/or shorter interval when disease conditions are severe. Do not apply micronized sulfur within 10 days of an oil application. Do not apply oil within 14 days of an application of wettable or dusting sulfur. See label for additional compatibility restrictions.	Synthetic

Podosphaera leucotricha / **Apples: Efficacy Trials**

Three trials are summarized below that include evaluation of Polyoxin D Zinc Salt 5SC Fungicide for the control of powdery mildew (*Podosphaera leucotricha*) on apples.

Podosphaera leucotricha / Apples #1: Trial No. CER-2012-020

a. Design

Podosphaera leucotricha (Powdery Mildew) / Apples #1: Trial No. CER-2012-020: Design			
Title:	Evaluation of Efficacy of Experimental Compound CX-10440 Against Powdery Mildew of Apple		
Authors and affiliation:	S. D. Cockfield and N. H. Stephens Northwest Contract Research		
Publication:	Certis data. Not published. Permission received.		
Location:	Block 1FR, Arrow Ranch, Bridgeport, WA, USA		
Crop:	Apple (variety 'Honeycrisp')		
Disease names:	Powdery mildew		
Pathogen:	*Podosphaera leucotricha*		
Test plot design:	Randomized complete block		
Number of replicates:	4		
Application equipment:	Backpack mist blower		
Spray volume:	100 gallons/acre (935 L/ha)		
Number of applications:	5		
Application intervals:	6 to 14 days		
Chronology:	Applications	Disease Assessments	Disease First Observed
	04/21/2012 04/27/2012 05/11/2012 05/25/2012 06/08/2012	05/21/2012 05/24/2012 05/31/2012 06/08/2012 06/14/2012	05/21/2012

b. <u>Results</u>

Podosphaera leucotricha (Powdery Mildew) / Apples #1: Trial No. CER-2012-020: Results								
Treatment	Rate/ Acre	g a.i./ ha	Active Ingredient	FRAC Code	Incidence (June 8)		Severity (June 8)	
					Percent	Percent Control	Percent	Percent Control
Untreated Control					35.5 a		8.5 a	
CX-10440 [1]	6.5 fl oz	25	Polyoxin D zinc salt	19	21.3 b	40.0	3.7 bc	56
CX-10440 [1]	13.0 fl oz	50	Polyoxin D zinc salt	19	20.3 b	42.8	3.9 bc	54
Cueva	1% v/v		Copper octanoate	M1	26.8 ab	24.5	5.8 ab	32
Flint	2.5 oz wt		Trifloxystrobin	11	8.5 c	76.1	1.5 c	82
Procure	12 fl oz		Triflumazole	3				
Treatment means followed by the same letter are not statistically different (Waller-Duncan *k*-ratio *t*-test). 1. CX-10440 is the Certis USA, L.L.C. code for Polyoxin D Zinc Salt 5SC Fungicide.								

Powdery mildew infections were first observed after the third application and before the forth application. Therefore, the first three applications were preventative, and the later two applications were curative.

No phytotoxicity was observed.

c. <u>Discussion and Conclusions</u>

Apple trees were grown in Washington. Powdery mildew incidence was 35.5% in the untreated control.

Five fungicide treatments were applied at preventatively and curatively 6-day to 14-day intervals.

Polyoxin D Zinc Salt 5SC Fungicide provided control of powdery mildew that did not have a positive dose response.

- Treatment at 6.5 fl oz/acre)(25 g a.i./ha) provided mean 48% (range 40.0% to 56%) control.
- Treatment at 13.0 fl oz/acre (50 g a.i./ha) provided mean 48% (range 42.8% to 54%) control.

Polyoxin D Zinc Salt 5SC Fungicide provided control of powdery mildew that was:

- Statistically superior to the untreated control;
- Numerically superior (but not statistically superior) to the control provided by copper octanoate;
- Superior to that of copper octanoate for which the results were not statistically different than untreated controls (24.5% control of powdery mildew incidence and 32% control of powdery mildew severity; and
- Statistically less than the control of powdery mildew severity provided by trifloxystrobin, plus triflumazole.

No phytotoxicity was observed.

Podosphaera leucotricha (Powdery Mildew) / Apples #2: Trial No. CER-2015-012

a. Design

<table>
<tr><th colspan="5">Podosphaera leucotricha (Powdery Mildew) / Apples #2: Trial No. CER-2015-012: Design</th></tr>
<tr><td>Title:</td><td colspan="4">Evaluation of Efficacy of OSO 5%SC Fungicide Against Powdery Mildew in Apple</td></tr>
<tr><td>Authors and affiliation:</td><td colspan="4">S. D. Cockfield and N. H. Stephens
Northwest Contract Research, LLC
Brewster, WA</td></tr>
<tr><td>Publication:</td><td colspan="4">Certis data. Not published. Permission received.</td></tr>
<tr><td>Location:</td><td colspan="4">Quincy, WA</td></tr>
<tr><td>Crop:</td><td colspan="4">Apple (‘Honeycrisp’)</td></tr>
<tr><td>Disease name:</td><td colspan="4">Powdery mildew</td></tr>
<tr><td>Pathogen:</td><td colspan="4">Podosphaera leucotricha</td></tr>
<tr><td>Test plot design:</td><td colspan="4">Randomized complete block</td></tr>
<tr><td>Number of replicates:</td><td colspan="4">4</td></tr>
<tr><td>Application equipment:</td><td colspan="4">Backpack mist blower (Stihl SR420)</td></tr>
<tr><td>Spray volume:</td><td colspan="4">100 gal/acre to each tree</td></tr>
<tr><td>Number of applications:</td><td colspan="4">5</td></tr>
<tr><td rowspan="6">Chronology:</td><td>Application Dates</td><td>Growth Stage</td><td>Application Interval</td><td>Disease Assessment Dates</td></tr>
<tr><td>4/03/2015</td><td>Tight cluster-pink</td><td></td><td rowspan="5">Leaves: First appearance of disease (4/21/2015) and at approximately 14 day intervals.
Fruit: 8/11/2015.</td></tr>
<tr><td>4/30/2015</td><td>Petal fall</td><td>27 days</td></tr>
<tr><td>5/14/2015</td><td></td><td>15 days</td></tr>
<tr><td>5/22/2015</td><td></td><td>8 days</td></tr>
<tr><td>6/02/2015</td><td></td><td>11 days</td></tr>
<tr><td>Disease assessment methodology:</td><td colspan="4">Incidence = Number of infections/tree
Severity = Percentage of leaf area infected
= (Portion of leaves infected) x (Percentage of area infected)
Fruit injury = Number of fruit with powdery mildew russet per plot and percent or fruit surface covered with russet</td></tr>
</table>

b. Results

Podosphaera leucotricha (Powdery Mildew) / Apples #2: Trial No. CER-2015-012: Results: Leaves								
Treatment	Rate/ Acre	g a.i./ ha	Active Ingredient	FRAC Code	Severity (%) (6/8/2015)		Incidence (%) (6/8/2015)	
					Measured	Percent Control	Measured	Percent Control
Untreated control			Not Applicable		25.0 a		61.3 a	
OSO 5%SC	6.5 fl oz	25	Polyoxin D zinc salt	19	17.5 b	30.0	52.5 a	14.4
R-56	4 fl oz		Spreader-sticker	NA				
Treatment means followed by the same letter are not statistically different according to Duncan's New MRT test at P = 0.05.								

Podosphaera leucotricha (Powdery Mildew) / Apples #2: Trial No. CER-2015-012: Results: Fruit						
Treatment	Rate/ Acre	g a.i./ ha	Active Ingredient	FRAC Code	Russet (%) (8/11/2015)	
					Measured	Percent Control
Untreated control			Not Applicable		23.83	
OSO 5%SC	6.5 fl oz	25	Polyoxin D zinc salt	19	5.20	78.2
R-56	4 fl oz		Spreader-sticker	NA		
Treatment means followed by the same letter are not statistically different according to Duncan's New MRT test at P = 0.05.						

Powdery mildew infection was first observed in the untreated control on April 7, 2015, *i.e.*, ***before*** the last 4 treatments. Therefore, the treatments were preventative and curative.

No phytotoxicity was observed.

c. Discussion and Conclusions

Apples were grown in Washington. The maximum observed powdery mildew pressure was 61.3% incidence in leaves.

Five applications of Polyoxin D Zinc Salt 5SC Fungicide were applied preventatively and curatively at 6.5 fl oz/ace (25 g polyoxin D zinc salt/ha) with R-56, a spreader-sticker, at 8-day to 27-day intervals. Treatment provided:

- Better control of powdery mildew on fruit than on leaves;
- 78.2% control of powdery mildew russeting of fruit;
- Mean 22.2% (range 14.4% to 30.0 %) control of powdery mildew on leaves only; and
- Mean 50.2% control of powdery mildew on fruit and leaves, combined.

No phytotoxicity was observed.

Podosphaera leucotricha (Powdery Mildew) / Apples #3: Trial No. CER-2015-034

a. Design

Podosphaera leucotricha (Powdery Mildew) / Apples #3: Trial No. CER-2015-034: Design			
Title:	Efficacy of Oso 5%SC Fungicide Against Powdery Mildew in Apples		
Author and affiliation:	Ron Britt Ron Britt & Associates		
Publication:	Certis data. Not published. Permission received.		
Location:	Granger, WA		
Crop:	Apple, Granny Smith		
Disease name:	Powdery mildew		
Pathogen:	*Podosphaera leucotricha*		
Test plot design:	Randomized complete block		
Number of replicates:	4		
Application equipment:	Rears airblast sprayer (110 psi)		
Spray volume:	200 gal/acre		
Number of applications:	6		
Chronology:	Application Dates	Application Interval	Disease Assessment Dates
	03/28/2015		05/14/2015
	04/16/2015	19 days	06/18/2015
	05/01/2015	15 days	
	05/16/2015	15 days	
	05/29/2015	13 days	
	06/13/2015	14 days	
Disease assessment methodology:	50 leaves per replicate were evaluated for the percent leaf covered with powdery mildew. Ten shoots were randomly selected in each replicate. The top five true leaves, minus the immature leaves at the apical tip of each shoot, were evaluated for the presence of powdery mildew and the percentage of the leaf surface covered with powdery mildew.		

b. Results

Podosphaera leucotricha (Powdery Mildew) / Apples #3: Trial No. CER-2015-034: Results								
Treatment	Rate/ Acre	g a.i./ ha	Active Ingredient	FRAC Code	Severity (06/18/2015)		Percent Incidence (06/18/2015)	
					Measured	Percent Control	Measured	Percent Control
Untreated control			Not Applicable		164.5 a		30.8 a	
OSO	6.5 fl oz	25	Polyoxin D zinc salt	19	76.8 b	53.3	22.3 b	27.6
R-56 or SB 56	Not reported		Spreader/sticker	NA				
Treatment means followed by the same letter are not statistically different according to Bartlett's X2 test at P = 0.263								

Powdery mildew symptoms were first observed on May 14, 2015, *i.e.*, before the last 3 treatments were applied. Therefore, the treatments were preventative and curative.

No phytotoxicity was reported.

c. Discussion and Conclusions

Apples were grown in Washington state. The powdery mildew incidence in the untreated control was 30.8%.

Six treatments of Polyoxin D Zinc Salt 5SC Fungicide were applied preventatively and curatively at 6.5 fl oz/acre (25 g a.i./ha) at 13-day to 19-day intervals with a sticker/spreader (R-56 or SB 56). The treatments provided mean 40.5% (range 27.6% to 53.3%) control of powdery mildew on apples. This was statistically superior to the untreated control.

No phytotoxicity was reported.

Podosphaera leucotricha **(Powdery Mildew) / Apples: Grower Needs**
Control of foliar diseases on apples (Project No. B00092) was identified as a grower need at the IR-4 2015 Biopesticide Workshop.

Podosphaera xanthii (POWDERY MILDEW) / CUCURBITS

Podosphaera xanthii (Powdery Mildew) / Cucurbits: Introduction

(Source: M. T. McGrath, Powdery Mildew of Cucurbits, Fact Sheet, Vegetable MD Online, Cornell University, June 2011.)

Powdery mildew is a common disease of cucurbits under field and greenhouse conditions in most areas of the world. Although all cucurbits are susceptible, symptoms are less common on cucumber and melon because many commercial cultivars have resistance. This disease can be a major production problem. Quantity of yield is reduced due to a decrease in the size or number of fruit or a decrease in the length of the harvest period. Premature senescence of infected leaves can result in reduced market quality because fruit become sunburnt or ripen prematurely or incompletely. Such fruit have poor storability (winter squash), low soluble solids with consequent poor flavor (melon), poor rind color (pumpkin), and shriveled, discolored handles (pumpkin). Stress from disease can lead to imperfections on fruit rind such as speckling, raised indentations, and oedema. In addition, powdery mildew infection predisposes plants to other diseases, in particular, gummy stem blight.

Podosphaera xanthii (previously known as *Sphaerotheca fuligines* and *S. fusca*) and *Erysiphe cichoracearum* are the two most commonly recorded fungi causing cucurbit powdery mildew. *Erysiphe cichoracearum* was considered to be the primary causal organism throughout most of the world before 1958. Today, *Podosphaera xanthii* is found more commonly worldwide. A shift in the predominance of these two fungi may have occurred or the causal organism may have been misidentified. *Podosphaera xanthii* is a more aggressive pathogen than *Erysiphe cichoracearum*. *Erysiphe cichoracearum* may have a lower temperature optimum since this species is found mainly during cooler spring and early summer periods, and *Podosphaera xanthii* appears to progress most rapidly during the warmer months. The conidia (spores produced asexually) of *Erysiphe cichoracearum* and *Podosphaera xanthii* are difficult to distinguish and cleistothecia, which are sexual fruiting bodies (structures containing spores produced through sexual reproduction), have been observed less commonly. Consequently, these fungi have been confused. The name of the fungus frequently has been reported without valid confirmation. Criteria for differentiating these fungi using the conidial stage were not identified until the 1960s. The main criterion used is presence of fibrosin bodies in conidia of *Podosphaera xanthii*. Based on these criteria, *Podosphaera xanthii* was found to be the predominant fungus, rather than *Erysiphe cichoracearum* as previously claimed, in several countries. During recent surveys, *Erysiphe cichoracearum* was found rarely and only at the start of disease development in New York and other eastern states.

Podosphaera xanthii (Powdery Mildew) / Cucurbits: Symptoms and Signs

(Source: M. T. McGrath, Powdery Mildew of Cucurbits, Fact Sheet, Vegetable MD Online, Cornell University, June 2011.)

White, powdery fungal growth develops on both leaf surfaces, petioles, and stems. This growth is primarily asexual spores called conidia. It usually develops first on crown leaves, on shaded lower leaves, and on leaf undersurfaces. Yellow spots may form on upper leaf surfaces opposite powdery mildew colonies. Older plants are affected first. Infected leaves usually wither and die. Plants may senesce prematurely. Fruit infection occurs rarely on watermelon and cucumber. Cleistothecia are dark brown, small (diameter of about 0.003 inches) structures that are barely discernable without a hand lens. They develop late in the growing season. The sexual spores within these structures are protected from adverse conditions.

Podosphaera xanthii **(Powdery Mildew) / Cucurbits: Disease Cycle**
(Source: M. T. McGrath, Powdery Mildew of Cucurbits, Fact Sheet, Vegetable MD Online, Cornell University, June 2011.)

Sources of initial inoculum for powdery mildew developing in New York have not been determined. The primary initial inoculum is believed to be airborne conidia dispersed over long distances from southern states, where cucurbit crops are grown earlier in the year. Conidia remain viable for 7-8 days based on results from laboratory studies. The causal fungi are obligate parasites and therefore cannot survive in the absence of living host plants, except as cleistothecia. Possible local sources of initial inoculum include conidia from greenhouse-grown cucurbits, cleistothecia, and alternate hosts. Cleistothecia have been reported rarely in the United States; however, even when present they can be overlooked. They have been found every year in New York that they were looked for since 1989. Both mating types required for sexual reproduction have been found throughout the United States, including New York. Although *Podosphaera xanthii* and *Erysiphe cichoracearum* are described as having broad host ranges, strains of these fungi have been shown to be host-specific. The role of non-cucurbit hosts as sources of inoculum has not been investigated. Verbena, a common ornamental plant, could be an important source of inoculum, especially for cucurbits grown as a crop or transplants in the same greenhouse as verbena.

Powdery mildew develops quickly under favorable conditions because the length of time between infection and symptom appearance is usually only 3 to 7 days and a large number of conidia can be produced in a short time. Favorable conditions include dense plant growth and low light intensity. High relative humidity is favorable for infection and conidial survival. However, infection can take place as low as 50% relative humidity. Dryness is favorable for colonization, sporulation, and dispersal. Rain and free moisture on the plant surface are unfavorable. However, disease development occurs in the presence or absence of dew. Mean temperature of 68-80°F is favorable; infection can occur at 50-90°F. Powdery mildew development is arrested when daytime temperatures are at least 100°F. Plants in the field often do not become affected until after fruit initiation. Susceptibility of leaves is greatest 16 to 23 days after unfolding. Pathogenically distinct races of *Podosphaera xanthii* have been differentiated on muskmelon. Races 1 and 2 have most common in the eastern United States recently.

Podosphaera xanthii **(Powdery Mildew) / Cucurbits: Disease Management Options**
(Source: 2015 Organic Production and IPM Guide for Cucumbers and Squash, Cornell Univ. Cooperative Extension)

Management Option	Recommendation for Powdery Mildew
Scouting/thresholds	When first fruit start to enlarge, begin scouting weekly by examining both the upper and lower leaf surfaces of 5 old, crown leaves in at least 10 locations throughout the field. It is critical that treatments begin as soon as powdery mildew is found on at least 1 of the 50 leaves.
Indicator crop	A spring planting of summer squash will become infected before a main season crop and thus can be used as an indicator of when powdery mildew is present in an area and it is time to begin scouting winter squash.
Resistant varieties	Plant resistant varieties whenever possible. Cucumber varieties have a very high level of resistance.
Crop rotation	The exact source of primary inoculum for powdery mildew in New York is not known. It has long been suspected that airborne conidia originating in southern states where cucurbit crops are grown earlier in the year could be the primary source.
Fungicide Use	A seven-day interval is recommended. It is important to begin early when disease is just starting. To obtain adequate control, fungicide is needed on the undersides of leaves.
Site selection, & sanitation	Do not plant sequential plantings next to each other.

Podosphaera xanthii **(Powdery Mildew) / Cucurbits: Cultural and Biological Controls**
(Source: M. T. McGrath, Powdery Mildew of Cucurbits, Fact Sheet, Vegetable MD Online, Cornell University, June 2011.)

Genetic resistance is used extensively in cucumber and melon and has been incorporated into most other cucurbit crops. Most resistant squash and pumpkin varieties in the United States contain one or two copies of the same major resistance gene from a wild cucurbit. Genetics of resistance is different in cucumber and melon. Recently, a decline in the degree of suppression achievable with resistant varieties has been detected indicating adaptation in *Podosphaera xanthii*. Successive cucurbit plantings should be physically separated or at least planted up-wind of older plantings because older plants can serve as a source of conidia. Fungicides containing antagonistic fungi for biological control have been developed.

Podosphaera xanthii **(Powdery Mildew) / Cucurbits: Chemical Control**
(Source: M. T. McGrath, Powdery Mildew of Cucurbits, Fact Sheet, Vegetable MD Online, Cornell University, June 2011.)

Fungicides should be applied every 7-10 days beginning early in disease development following detection through an IPM scouting program. Inspect plants weekly beginning in July and after fruit initiation (when plants become more susceptible). Examine upper and under surfaces of five older leaves at each of 10 sites or until symptoms are found. Initiate a weekly spray program when symptoms are found. A spring planting of summer squash will become infected first; therefore, when available, it can be used as an indicator of when to begin scouting vine crops and later plantings of summer squash.

For a preventive schedule, applications should begin when plants start to run and/or to produce fruit. To obtain adequate control, fungicide is needed on the undersurface of leaves and on leaves low in the plant canopy because the fungus develops best on these surfaces. This can be best accomplished by using mobile materials (*i.e.*, quinoxyfen, boscalid, and triflumizole). Another approach is to improve efficacy of contact materials (*i.e.*, chlorothalonil, and copper) by maximizing spray coverage on undersurfaces of leaves. Air-assist sprayers are one of the most effective means for increasing coverage and deposits on all leaf surfaces. Coverage produced by traditional hydraulic boom sprayers can be increased by either decreasing nozzle spacing (10 inches is better than 20 inches), increasing volume (75 gpa has worked well), increasing pressure (at least 80 psi), or by changing to smaller nozzle tips that direct sprays at an angle to the canopy. Use water sensitive paper to check spray coverage.

Development of fungicide resistance and consequent control failure is always a concern with mobile fungicides due to their single site mode of action. Strains of the powdery mildew fungus resistant (insensitive) to such fungicides have been found throughout the United States, including New York. Reduced sensitivity to fungicides from several chemical groups have been detected in other areas of the world as well. Therefore, tactics should always be used to minimize the potential of resistant pathogen strains being selected:

- Apply mobile fungicides with contact fungicides;
- Apply them only when needed most to protect yield (which usually is at the start of disease development);
- Use highest labeled rates; and
- Alternate between mobile fungicides with different modes of action as indicated by their FRAC code when possible (triflumizole and myclobutanil have the same mode of action; they are in FRAC group 3);
- Maximize spray coverage; and
- Use nonchemical control practices.

At the start of powdery mildew epidemics, frequency of strains resistant to mobile fungicides usually has been sufficiently low that at least one application of these fungicides has suppressed powdery mildew. This situation could change in the future. The frequency of resistant strains can increase rapidly following treatment.

Several biopesticides approved for organic production are registered for this disease in the United States. These products contain natural ingredients such as botanical oils, bicarbonates, hydrogen dioxide, and lipopeptides. They are contact materials, thus good coverage is critical for effective control. Products evaluated in university trials have exhibited a range in efficacy with some being as effective as conventional contact fungicides.

Podosphaera xanthii (Powdery Mildew) / Cucurbits: OMRI-Listed Fungicides for Use in the United States for Use in the United States											
FRAC Code	Source: 2015 Organic Production and IPM Guide for Cucumbers and Squash, Cornell Univ. Cooperative Extension								Source: EPA Label		NOP Status
	Active Ingredient	Product Name	Crop	Product Rate/Acre	PHI (Days)	REI (Hrs)	Efficacy	Comments	EPA Reg. No.	Comments	
44	*Bacillus amyloliquefaciens* str. D747	Double Nickel 55	C, WS	0.25-3 lb	0	4	Not reviewed or no research available		70051-108	Causes moderate eye irritation. Dermal sensitizer. Broad-spectrum preventative fungicide. Do not use highly alkaline or highly acidic water to mix sprays. Use a buffering agent if necessary to maintain neutrality (pH 6 to 8) of water in the tank.	Non-synthetic
		Double Nickel LC	C, WS	0.5-6 qt	0	4	Not reviewed or no research available		70051-114	Harmful if absorbed through skin. Harmful if inhaled. Dermal sensitizer. Broad-spectrum preventative fungicide.	
	Bacillus subtilis str. QST 713	Serenade ASO	C, WS	2-6 qt	0	4	Not reviewed or no research available		264-1152	Broad spectrum preventative fungicidal and bactericidal product.	Non-synthetic
		Serenade MAX	C, WS	1-3 lb	0	4	Not reviewed or no research available		69592-11	Dermal sensitizer. Broad spectrum preventative fungicidal and bactericidal product.	
P5	*Reynoutria sachalinensis*	Regalia Biofungicide	C, WS	1-4 qt	0	4	Not reviewed or no research available		84059-3	Causes moderate eye irritation. Preventative use only. Avoid freezing.	Non-synthetic
Not classified; Biological	*Streptomyces lydicus* WYEC 108	Actinovate AG	C, WS	3-12 oz	0	1 or until solutio n has dried	Effective in less than half of recent university trials	*Streptomyces lydicus* effective in 1 of 15 cucurbit trials.	73314-1	Avoid contact with skin, eyes, or clothing. Avoid breathing dust or spray mist. Mixer/loaders and applicators must wear a dust/mist filtering respirator meeting NIOSH standards of at least N-95, R-95, or P-95. Repeated exposure to high concentrations of microbial proteins can cause allergic sensitization. Keep from overheating or freezing. Optimum storage temperature is 40°F to 85°F. Contains live spores of a microbe. Best results will be obtained if the product is used prior to disease onset. Becomes active in soil or on the plant foliage when the temperatures are above 45°F and is not effective when temperatures remain cold. Do not apply soil fumigants to treated areas.	Non-synthetic

Podosphaera xanthii (Powdery Mildew) / Cucurbits: OMRI-Listed Fungicides for Use in the United States for Use in the United States											
FRAC Code	Source: 2015 Organic Production and IPM Guide for Cucumbers and Squash, Cornell Univ. Cooperative Extension								Source: EPA Label		NOP Status
	Active Ingredient	Product Name	Crop	Product Rate/Acre	PHI (Days)	REI (Hrs)	Efficacy	Comments	EPA Reg. No.	Comments	
Not classified; Botanical oil	Cinnamon oil	Cinnerate	C, WS	13-30 fl oz/100 gal water	0	0	Not effective in any known trials.	Apply 40-85 gallons diluted spray/A.	N/A. FIFRA §25(b) pesticide.	May cause eye and skin irritation. May cause dermal sensitization. Store upright at room temperature. Avoid exposure to extreme temperatures. Do not expose to light and keep away from any heat source. Do not mix with oxidizing, strong acidic or basic materials. Broad spectrum, contact foliar fungicide. All applications should be preceded by a phytotoxicity check to ensure that the material is safe for the particular plant variety.	Non-synthetic
	Cottonseed oil, corn oil, and garlic oil	Mildew Cure GC-3	C, WS	1 gal/ 100 gal water	0	0	Effective in half or more of recent university trials	Effective in 1 of 1 trial on pumpkin.	N/A. FIFRA §25(b) pesticide.	Avoid contract with skin, eyes, and clothing. Do not apply this product to seedlings or very young plants. Do not apply at less than 7-day intervals.	Non-synthetic
	Sesame oil	Organocide 3-in-1	C, WS	1-2 gal/ 100 gal water	0	4	Effective in half or more of recent university trials	Effective in 2 of 2 trials.	NA. FIFRA §25(b) pesticide.	Insecticide, miticide, and fungicide. If spraying on severely stressed or damaged plants, consider using a lower rate such as 1 oz. per gallon to avoid adding additional stress. For best results, spray in the early morning.	Non-synthetic
	Neem oil	Trilogy	C, WS	0.5-1.0% in 25 to 100 gal	0	4	Effective in half or more recent university trials.	Effective in 4 of 6 trials. May reapply every 7-14 days. Label specifies a 2 gal/A maximum per application.	70051-2	Causes moderate eye irritation. Hazardous to fish and aquatic invertebrates. Toxic to bees exposed to direct treatment. Broad spectrum. Exercise care in timing applications during early morning/late evening to minimize the potential for leaf burn. Use care on plants with tender tissue. Check for leaf burn in small scale trials prior to use. Do not apply to sensitive plant species. Do not apply to wilted or otherwise stressed plants, or to newly transplanted materials or crops prior to root establishment. For optimal performance, do not mix with cold water (less than 45°F). Do not store below 40°F (4°C). Do not use or store near heat or open flame.	Non-synthetic
Not classified; Clay	Kaolin	Surround WP	C, WS	12.5-25 lb	0	4	Not reviewed or no research available		61842-18	Causes moderate eye irritation. Suppression only. Apply every 7-14 days as required to maintain coverage.	Non-synthetic
Not classified; Organic acid	Citric acid	Nuke Em	C, WS	1 fl oz/31 fl oz water to 2 fl oz/30 fl oz water	0	0	Not reviewed or no research av available		N/A. FIFRA §25(b) pesticide.	Do not spray on top of other insecticides. Do not mix with other insecticides. Store out of direct sunlight. Not for sale in Mississippi, Indiana or New Mexico. Makes a powdery mildew claim for all crops.	Non-synthetic

Podosphaera xanthii (Powdery Mildew) / Cucurbits: OMRI-Listed Fungicides for Use in the United States for Use in the United States											
FRAC Code	Source: 2015 Organic Production and IPM Guide for Cucumbers and Squash, Cornell Univ. Cooperative Extension								Source: EPA Label		NOP Status
	Active Ingredient	Product Name	Crop	Product Rate/Acre	PHI (Days)	REI (Hrs)	Efficacy	Comments	EPA Reg. No.	Comments	
M1	Basic copper sulfate	Basic Copper 53	C, WS	2 lb	0	24	Effective in less than half of recent university trials. Copper based products effective in 2 of 7 trials. Contact control only, mostly on upper leaf surface; fungus develops on both upper and lower leaf surface.		45002-8	WARNING signal word. Causes substantial but temporary eye injury. Harmful if absorbed through skin or inhaled. Dermal sensitizer. Toxic to fish and aquatic organisms.	Synthetic
	Copper hydroxide	Nu-Cop 50 WP	WS	1.5-3.0 lb	1	24		Winter squash only.	42002-7	DANGER signal word. Corrosive. Causes irreversible eye damage. Harmful if swallowed, absorbed through skin, or inhaled. Skin sensitizer. Toxic to fish and aquatic organisms. Product should not be applied in spray water having a pH of less than 6.5 as phytotoxicity may result. Effectiveness reduced at pH greater than 9.0. Cucurbits: Crop injury may occur form application at higher rates and shorter intervals.	Synthetic
		Champ WG	C, WS	1.5-2.0 lb	0	48			55146-1	DANGER signal word. Corrosive. Causes irreversible eye damage. Harmful if inhaled. Skin sensitizer. Toxic to fish and aquatic organisms.	
	Copper hydroxide, Copper oxychloride	Badge X2	C, WS	0.5-1.25 lbs	0	48			80289-12	WARNING signal word. May be fatal if swallowed. Causes substantial but temporary eye injury. Harmful if absorbed through skin. Harmful if inhaled. Toxic to fish and aquatic organisms. Product must not be applied in a spray solution having a pH of less than 6.5 as phytotoxicity may occur. Do not tank mix product with Aliette® fungicide for use on any registered crops or ornamentals unless appropriate precautions have been taken to buffer the spray solution because severe phytotoxicity may result. Cucurbits: Crop injury may occur from application at higher rates and shorter intervals.	Synthetic
	Copper octanoate	Cueva Fungicide Concen-trate	C, WS	0.5-2.0 gal/ 100 gal water	0	4		Mixed material is applied at 50-100 gallons of diluted spray per acre.	67702-2-70051	Harmful if swallowed or absorbed through skin. Toxic to fish and aquatic organisms. May cause some copper toxicity on some plant species. Store away from open fire or flame. Product may be damaged by freezing. Do not store product below 4°C. Do not mix with chelated or liquid fertilizers. Use caution when using product with other fungicides and insecticides. On plants that are very susceptible to powdery mildew, spray the plants every 5 days during the first 2 weeks after emergence and weekly thereafter. Do not apply more than 1750 gallons of diluted spray per acre per year. Do not reapply within 5 days.	Synthetic

Podosphaera xanthii (Powdery Mildew) / Cucurbits: OMRI-Listed Fungicides for Use in the United States for Use in the United States											
FRAC Code	Source: 2015 Organic Production and IPM Guide for Cucumbers and Squash, Cornell Univ. Cooperative Extension								Source: EPA Label		NOP Status
	Active Ingredient	Product Name	Crop	Product Rate/Acre	PHI (Days)	REI (Hrs)	Efficacy	Comments	EPA Reg. No.	Comments	
	Copper sulfate pentahydrate	CS 2005	C, WS	19.2-25.6 oz	0	48			66675-3	DANGER signal word. Corrosive. Causes irreversible eye damage and skin irritation. Harmful if swallowed, inhaled or absorbed through the skin. Dermal sensitizer. Toxic to fish and aquatic organisms. Do not mix with acidic compounds. Do not mix with pot ash. Store away from excessive heat. Product will freeze. Store and handle product in 316L stainless steel, fiberglass, PVC's, polypropylenes or plastic equipment. Keep away from galvanized pipe and any nylon storage handling equipment. <u>Cucurbits</u>: Crop injury may occur from application at higher rates and shorter intervals.	Synthetic
	Cupric hydroxide	Nu-Cop 50DF	WS	1.5-3.0 lb	1	24	Effective in less than half of recent university trials. Copper based products effective in 2 of 7 trials. Contact control only, mostly on upper leaf surface; fungus develops on both upper and lower leaf surface.	Winter squash only.	45002-4	DANGER signal word. Corrosive. Causes irreversible eye damage. Harmful if swallowed or absorbed through skin. Dermal sensitizer. Toxic to fish and aquatic organisms. Effectiveness reduced at pH greater than 9.0. Product should not be applied in spray water having a pH of less than 6.5 as phytotoxicity may result.	Synthetic
		Nu-Cop HB	WS	0.75 to 1.5 lb	1	24		Winter squash only.	42750-132	DANGER signal word. Corrosive. Causes irreversible eye damage. Harmful if swallowed, absorbed through skin, or inhaled. Product should not be applied in spray water having a pH of less than 6.5 as phytotoxicity may result. <u>Cucurbits</u>: Discontinue use if injury occurs.	Synthetic
		Nu-Cop 50 WP	WS	1.5-3.0 lb	1	24		Winter squash only.	45002-7	DANGER signal word. Corrosive. Causes irreversible eye damage. Harmful if swallowed, absorbed through skin, or inhaled. May cause crop injury on sensitive varieties. Do not apply in spray solution with pH less than 6.5 as phytotoxicity may result. Crop injury statements.	Synthetic
	Cuprous oxide	Nordox 75 WG	C, WS	1-1.25 lb	0	12			48142-4	Harmful if swallowed or absorbed through skin. Causes eye irritation. Do not apply in a spray solution with a pH of less than 6.5.	Synthetic

Podosphaera xanthii (Powdery Mildew) / Cucurbits: OMRI-Listed Fungicides for Use in the United States for Use in the United States											
FRAC Code	Source: 2015 Organic Production and IPM Guide for Cucumbers and Squash, Cornell Univ. Cooperative Extension								Source: EPA Label		NOP Status
	Active Ingredient	Product Name	Crop	Product Rate/Acre	PHI (Days)	REI (Hrs)	Efficacy	Comments	EPA Reg. No.	Comments	
M2	Sulfur	Acoidal	C, WS	Cucumber: 2-4 lb Squash: 5-10 lb	0	24	Effective in half or more of recent university trials	Sulfur products effective in 18 of 26 trials.	62562-4	Harmful if swallowed, inhaled, or absorbed through skin. Toxic to fish and aquatic organisms. Sulfur dust suspended in air ignites easily. Keep away from heat, sparks, or flames. Do not smoke while applying this product. Sulfur may cause severe fruit and foliage injury to certain crops. Sulfur may burn foliage when temperature is high. Do not apply within 2 weeks of an oil spray treatment.	Synthetic
		Defend DF	C, WS	Cucumber: 2-4 lb Squash: 5-10 lb	0	24	Effective in half or more of recent university trials		62562-8		
		Kumulus DF	C, WS	Cucumber: 2-6 lb Squash: 5-10 lb	0	24	Effective in half or more of recent university trials		51306-352-66330	Harmful if swallowed. Avoid breathing spray mist. Avoid contact with eyes, skin, and clothing. Do not apply within 2 weeks of an oil spray treatment. Do not store above 104°F. Store away from heat, sparks, and open flame. Treat when disease first appears and repeat as necessary. Sulfur can injure plants, especially when the temperature reached 95°F. Do not use on sulfur sensitive varieties.	
		Micro Sulf	C, WS	Cucumber: 2-4 lb Squash: 5-10 lb	0	24	Effective in half or more of recent university trials	Limit 2 lb/A if temps exceed 95°F. Do not use on sulfur-sensitive squash varieties. Sulfur products effective in 18 of 26 trials.	55146-75	Harmful if swallowed, inhaled, or absorbed through skin. Causes eye irritation. Risk of crop injury if temperature exceeds 90°F within 3 days following application. Do not use on any crop unless sulfur has been shown to be safe in your locality. Do not apply within 14 days of an oil spray. Keep away from heat, sparks, or flames. Do not smoke while applying this product.	
		Microthiol Disperss	C, WS	Cucumber: 2-4 lb Squash: 5-10 lb	0	24	Effective in half or more of recent university trials	Do not apply within 2 weeks of an oil application nor at temperatures above 90°F. Sulfur products effective in 18 of 26 trials.	70506-187	Harmful if swallowed, inhaled, or absorbed through skin. Risk of crop injury if temperature exceeds 90°F within 3 days following application. Do not use on any crop unless sulfur has been shown to be safe in your locality. Do not store near flammable materials. Do not store in a manner where cross-contamination with other pesticides, fertilizers, food or feed could occur. Restrictions regarding application time before and after an oil spray treatment.	
		Thiolux	C, SW	Cucumber: 2-6 lb Squash: 5-10 lb	0	24	Effective in half or more of recent university trials	Sulfur products effective in 18 of 26 trials.	34704-1079	Harmful if swallowed, inhaled, or absorbed through skin. Causes eye irritation. Sulfur may case severe fruit and foliage injury to certain crops. Risk of crop injury if temperature exceeds 90°F within 3 days following application. Do not apply within 14 days of an oil spray. Sulfur dust suspended in air easily ignites. Keep away from heat, sparks, or flames. Do not smoke while applying this product.	

Podosphaera xanthii (Powdery Mildew) / Cucurbits: OMRI-Listed Fungicides for Use in the United States for Use in the United States											
FRAC Code	Source: 2015 Organic Production and IPM Guide for Cucumbers and Squash, Cornell Univ. Cooperative Extension								Source: EPA Label		NOP Status
	Active Ingredient	Product Name	Crop	Product Rate/Acre	PHI (Days)	REI (Hrs)	Efficacy	Comments	EPA Reg. No.	Comments	
Not classified; Inorganic salts	Potassium bicarbonate	EcoMate Amicarb O	C, WS	2.5-5 lb/ 100 gal water	0	4	Not reviewed or no research available	Bicarbonate products effective in 0 of 5 trials on pumpkin.	5905-541	Harmful if swallowed. Causes moderate eye irritation. Broad spectrum contact foliar fungicide. Prevent exposure to moisture during storage. Avoid contamination with other pesticides and fertilizers.	Synthetic
		Kaligreen	C, WS	2.5-5 lb	1	4	Effective in less than half of recent university trials	Effective in 3 of 7 trials.	70231-1	Harmful if swallowed, absorbed through skin, or inhaled. Do not mix with highly acidic products as effectiveness may be compromised. Use of a buffering agent for acidification of a tank mixture may also decrease effectiveness. Crop injury may result due to certain environmental or growing conditions, manner of use or application.	
		Milstop	C, WS	2-5 lb	0	1	Effective in half or more of recent university trials	Effective in 2 of 2 trials.	70870-1-68539	Harmful if swallowed. Causes moderate eye irritation. Broad spectrum contact foliar fungicide. Do not mix with other soluble pesticides or fertilizers. Not compatible with mild alkaline solutions. Acidification of solution will cause reduced product performance. Prevent exposure to moisture during storage. Avoid contamination with other pesticides and fertilizers.	
	Potassium silicate	Sil-Matrix	C, WS	0.5-2% solution	0	4	Not reviewed or no research available	Apply at least 20 gallons of finished spray solution per acre.	82100-1	Causes moderate eye irritation. Avoid contact with glass. Remove promptly from glass surfaces. Store product above 40°F. Do not store in aluminum, fiberglass, copper, brass, zinc, or galvanized containers. Protect from excessive heat. Broad spectrum preventative fungicide.	Synthetic
Not classified: Organic salt	Potassium salts of fatty acids	M-Pede	C, WS	1.5-2.0% (v/v) solution	0	12	Not reviewed or no research available		10163-324	WARNING signal word. Causes substantial but temporary eye injury and skin irritation. May be hazardous to aquatic invertebrates. Do not use with sulfur or within 3 days of a sulfur application. Apply M-Pede solutions to wet (minimize run-off) to decrease the potential for injury on foliage, fruit and flowers of sensitive plants. Avoid application to new transplants and unrooted cuttings.	Synthetic

Podosphaera xanthii (Powdery Mildew) / Cucurbits: OMRI-Listed Fungicides for Use in the United States for Use in the United States											
FRAC Code	Source: 2015 Organic Production and IPM Guide for Cucumbers and Squash, Cornell Univ. Cooperative Extension								Source: EPA Label		NOP Status
	Active Ingredient	Product Name	Crop	Product Rate/Acre	PHI (Days)	REI (Hrs)	Efficacy	Comments	EPA Reg. No.	Comments	
Not classified; Oxidizing agent	Hydrogen dioxide, Peroxyacetic acid	Oxidate 2.0	C, WS	0.33 - 1 gal / 100 gal water	0	Until dry	Not reviewed or no research available	Do not spray during conditions of intense heat, drought, or poor vine canopy.	70299-2	DANGER signal word. Causes irreversible eye damage. May be fatal if swallowed. Causes skin irritation or temporary discoloration of exposed skin. Highly toxic to bees and other beneficial insects. Toxic to fish. Toxic to birds who eat treated seed on soil surface. Strong oxidizing agent. Do not use in undiluted form. Never bring undiluted product in contact with other pesticides, cleaners or oxidative agents. May react with residues of metal-based fungicides or supplements. Allow at least 24 hrs. after application of metal-based products. Do not spray during conditions of intense heat, drought, or poor plant vigor (or vine canopy). Do not apply in conjunction with any other pesticides or fertilizers. Do not allow product to become overheated in storage. Do not store in a manner where cross-contamination with other pesticides or fertilizers could occur. Do not apply during intense heat, drought, or poor vine canopy. Apply consecutive applications until control is achieved; then apply preventative treatments.	Synthetic
	Hydrogen peroxide, Hydrogen dioxide	Perpose Plus	C, WS	Initial/ Curative: 1 fl oz/gal Preventative: 0.25-0.33 fl oz/gal	0	Until spray has dried	Not effective in any known trials.	Hydrogen peroxide products effective in 0 of 5 trials. For initial or curative use, apply higher rate for 1 to 3 consecutive days. Then follow with weekly/preservative treatment. For weekly or preventative treatments, apply lower rate every 5-7 days. At first sign of disease, use curative rate then resume weekly preventative treatment.	86729-1	DANGER signal word. Causes irreversible eye damage and skin burns. May be fatal if absorbed through the skin. Harmful if swallowed. Do not breathe vapor from concentrate. Toxic to birds, mammals, fish and aquatic life. At temperatures exceeding 156°F, decomposition releases oxygen. The oxygen released could initiate or promote combustion of other materials. Store away from combustibles. Broad spectrum algaecide and fungicide. Apply curative rates for 3 consecutive days (drenching the entire plant) followed by weekly preventative treatments.	

Podosphaera xanthii (Powdery Mildew) / Cucurbits: OMRI-Listed Fungicides for Use in the United States for Use in the United States

FRAC Code	Source: 2015 Organic Production and IPM Guide for Cucumbers and Squash, Cornell Univ. Cooperative Extension								Source: EPA Label		NOP Status
	Active Ingredient	Product Name	Crop	Product Rate/Acre	PHI (Days)	REI (Hrs)	Efficacy	Comments	EPA Reg. No.	Comments	
Not classified; Petroleum oil	Paraffinic oil	Organic JMS Stylet Oil	C, WS	3-6 qt/ 100 gal water	0	4	Effective in half or more of recent university trials	Effective in 3 of 3 trials. Protectant. Use at least 200 psi spray pressure. See label for sulfur and other compatibility information.	65564-1	Harmful if swallowed. Toxic to fish. Do not freeze. Do not spray wet foliage. Do not spray when freezing temperatures are anticipated within 48 hours of an oil application, above 90°F (32°C) or when plants are under heat or moisture stress. Do not apply to vegetables when the temperature is below 50°F (10°C). Do not apply micronized sulfur within 10 days of an oil application. Do not apply oil within 14 days of an application of wettable or dusting sulfur. Do not apply to oil sensitive varieties. See label for additional compatibility restrictions.	Synthetic
	Mineral oil	PureSpray Green	C, WS	0.75 -1.5 gal/A in 50-100 gal water	0	4	Effective in half or more of recent university trials		69526-9	Harmful if swallowed or absorbed through skin. Prolonged or repeated skin contact may cause allergic reaction in some individuals. Drift and runoff may be hazardous to aquatic organisms in water adjacent to treated areas. Use extreme care when using concentrate sprays as the potential for crop phytotoxicity is increased. Avoid excess heat. Do not spray during or immediately prior to hot or freezing weather (over 95°F or under 32°F), hot dry winds, rain or other unsuitable conditions. Do not overspray or double spray. Spray plants only when they are in vigorous condition and when their moisture condition is suitable. Before using, make certain spray tank is free of sulfur residues. Do not apply micronized sulfur within 10 days of an oil application. Do not apply oil within 14 days of an application of wettable or dusting sulfur. Do not apply to oil sensitive varieties. See label for additional compatibility restrictions regarding many conventional active ingredients.	Synthetic
		SuffOil-X	C, WS	1-2 gal/ 100 gal water	0	4	Effective in half or more of recent university trials	Apply as needed.	48813-1-68539	Harmful if absorbed through skin. Prolonged or frequently repeated skin contact may cause allergic reactions in some individuals. Do not use in combination with any product containing sulfur. Do not use with any product whose label recommends the use of no oils. Do not use in combination with NPK foliar fertilizer applications. Do not apply during periods of drought or when plants exhibit moisture stress.	
		TriTek	C, WS	1-2 gal/ 100 gal water	0	4	Effective in half or more of recent university trials	Apply as needed.	48813-1		

C = Cucumber
WS = Winter Squash

Podosphaera xanthii **(Powdery Mildew) / Cucurbits: Reported Resistance**
(Source: M. T. McGrath, Powdery Mildew of Cucurbits, Fact Sheet, Vegetable MD Online, Cornell University, June 2011.)

Resistance by *Podosphaera xanthii* to treatment by registered fungicides, including benomyl, neem, stobilurins, triadimefon, has been reported in the scientific literature:

Aboellil, A. H., Trilogy, A Product of Neem (*Azadirachta indica*) Induces Resistance in Cucumber Against *Podosphaera xanthii*, Research Journal of Microbiology 2 (5): 402-414, 2007.

Ishii, H., Fraaije, B.A., et al., Occurrence and molecular Characterization of Stobilurin Resistance in Cucumber Powdery Mildew and Downy Mildew, Phytopathology, Vol. 91, No. 12, December 2001, pp 1166-1171.

Ishii, H., Miyamoto, T., *et al.*, Lack of Cross-Resistance to a Novel Succinate Dehydrogenase Inhibitor, Fluopyram, in Highly Boscalid-Resistance Isolates of *Corynespora cassiicola* and *Podosphaera xanthii*, Pest Management Science, Vol 67, Issue 4, pp 474-482, April 2011.

McGrath, M. T., Fungicide Resistance in Cucurbit Powdery Mildew: Experiences and Challenges, Plant Diseases, Vol 85, No. 3, pp. 236-245, 2001.

Perez-Garcia, A., Romero, D., *et al.*, The Powdery Mildew Fungus *Podosphaera fusca* (synonym *Podosphaera xanthii*), a Constant Threat to Cucurbits, Molecular Plant Pathology, Volume 10, Issue 2, pp 153-160, March 2009.

Podosphaera xanthii (Powdery Mildew) / Cucurbits: Efficacy Trials

Podosphaera xanthii (Powdery Mildew)/ Cucumber #1: Trial No. R-14-10-0

a. Design

Podosphaera xanthii (Powdery Mildew) / Cucumber #1: Trial No. R-14-10-0: Design				
Title:	Evaluation of VEGGIETURBO 5SC Against Powdery Mildew on Greenhouse-Grown Cucumbers			
Research organization:	Kaken Pharmaceutical Co., Ltd. Gunstock 301, Fajita-GHI, Shizuoka, Japan			
Publication:	Kaken data. Not published.			
Location:	Japan (greenhouse)			
Crop:	Cucumber			
Disease names:	Powdery mildew			
Pathogen:	*Podosphaera xanthii*			
Test plot design:	Randomized complete block			
Number of replicates:	4			
Application equipment:	Back-pack sprayer with a battery			
Spray volume:	1000 L/ha			
Inoculation:	Inoculant (concentration not specified) applied to upper leaves.			
Number of applications:	2			
Application interval:	7 days			
Chronology:	Disease First Observed	Applications	Inoculation	Disease Assessments
	09/02/2014	09/19/2014 09/26/2014	09/20/2014	10/03/2014

b. Results

Podosphaera xanthii (Powdery Mildew) / Cucumber #1: Trial No. R-14-10-0: Results								
Treatment	Rate/ Acre	g a.i./ ha	Active Ingredient	FRAC Code	October 3, 2014			
					Incidence		Severity	
					Percent	Percent Control	Percent	Percent Control
Untreated Control					80.0 a		40.7 a	
Veggieturbo 5SC	6.5 fl oz	25	Polyoxin D zinc salt	19	23.1 b	71.1	4.6 b	89
Veggieturbo 5SC	13 fl oz	50	Polyoxin D zinc salt	19	20.6 b	74.3	4.7 b	88
Pristine WG	1.3 kg/ha		Boscalid	7	16.9 b	78.9	4.4 b	89
			Pyraclostrobin	11				
NOVA	340 g/ha		Myclobutanil	3	17.5 b	78.1	5.0 b	88
Treatment means followed by the same letter are not statistically different (Tukey's honest significant difference test, $P = 0.05$).								

Powdery mildew incidence was observed 17 days before the first fungicide treatment. Therefore, the treatments were curative.

No phytotoxicity was observed.

c. Discussion and Conclusion

Cucumbers were grown in a greenhouse. The maximum powdery mildew incidence in the untreated control was 80.0%.

Two treatments of Polyoxin D Zinc Salt 5SC Fungicide were applied curatively with a 7-day interval. Treatments provided an extremely modest positive dose response.

- Treatment at 6.5 fl oz/acre (25 g a.i./ha) provided mean 80% (range 71.7% to 89%) control.
- Treatment at 13 fl oz/acre (50 g a.i./ha) provided mean 81% (74.3% to 88%) control.

The Polyoxin D zinc Salt 5SC Fungicide treatments provided control of powdery mildew that was statistically:

- Superior to the untreated control, and
- Equivalent to the control provided by boscalid plus pyraclostrobin and by myclobutanil.

No phytotoxicity was observed.

Podosphaera xanthii (Powdery Mildew) / Pumpkin #1: Trial No. CER-2015-145

a. Design

Podosphaera xanthii (Powdery Mildew) / Pumpkin #1: Trial No. CER-2015-145: Design				
Title:	2015, JOB Pumpkin, Powdery Mildew (and other disease) Trial			
Author and affiliation:	Mohammad Babadoost University of Illinois, Champaign-Urbana			
Publication:	Not published. Permission received.			
Location:	Univ. of Illinois Vegetable Research Farm, Champaign, Illinois			
Crop:	Pumpkin (cultivar Howden)			
Disease name:	Powdery mildew			
Pathogen:	*Podosphaera xanthii*			
Test plot design:	Not reported			
Number of replicates:	Not reported			
Application equipment:	Not reported			
Spray volume:	50 gal/acre			
Number of applications:	7			
Chronology:	Transplant Date	Application Dates	Application Interval	Disease Assessment Dates
	06/30/2015	07/30/2015		07/22/2015
		08/06/2015	6 days	07/31/2015
		08/12/2015	6 days	08/10/2015
		08/19/2015	7 days	08/20/2015
		08/27/2015	8 days	09/06/2015
		09/03/2015	8 days	09/14/2015
		09/10/2015	7 days	

b. Results

Podosphaera xanthii (Powdery Mildew) / Pumpkin #1: Trial No. CER-2015-145: Results									
Treatment	Rate/ Acre	g a.i./ ha	Active Ingredient	FRAC Code	App Code	Severity (9/14/2015) (%)			
						Vines		Leaves	
						Measured	Percent Control	Measured	Percent Control
Untreated control			Not Applicable			30		30	
Oso 5.0SC	6.5 fl oz	25	Polyoxin D zinc salt	19	A-G	10	67	10	67
Activator	0.125%		Non-ionic surfactant	NA	A-G				
Quintec 2.08SC	6 fl oz		Quinoxyfen	13	ACEG	1	97	1	97
Kocide 3000 4.1 DF	1.5 lb		Copper hydroxide	M1	A-G				
Procure 480SC	8 fl oz		Triflumazole	3	BDF				

Powdery mildew symptoms were first observed in the untreated control on August 10, 2015, *i.e.*, ***before*** the last 5 treatments. Therefore, the treatments were preventative and curative.

No phytotoxicity was reported.

c. Discussion and Conclusions

Pumpkins were grown in Illinois. Maximum measured powdery mildew severity for both vines and leaves was 30%.

Seven treatments of Polyoxin D Zinc Salt 5SC Fungicide applied preventatively and curatively at 6.5 fl oz/acre (25 g a.i./ha) with a non-ionic surfactant at 6-8 day intervals provided 67% control of powdery mildew on vines and leaves.

An industry standard, quinoxyfen plus copper hydroxide applied alternately with triflumazole plus copper hydroxide, provided 97% control of powdery mildew on vines and leaves.

No phytotoxicity was reported.

Podosphaera xanthii (Powdery Mildew) / Pumpkin #2: Trial No. CER-2015-149

a. Design

Podosphaera xanthii (Powdery Mildew) / Pumpkin #2: Trial No. CER-2015-149: Design				
Title:	Evaluation of Fungicide on Powdery Mildew (*Podospharea xanthii*) of Squash in Georgia, 2015			
Author and affiliation:	Bhabesh Dutta University of Georgia College of Agriculture and Environmental Sciences Tifton, Georgia			
Publication:	Not published. Permission received.			
Location:	Tifton, Georgia			
Crop:	Yellow squash “Destiny”			
Disease name:	Powdery mildew			
Pathogen:	*Podospharea xanthii*			
Test plot design:	Randomized complete block			
Number of replicates:	5			
Application equipment:	Tractor mounted sprayer (58 psi)			
Spray volume:	41.5 gal/acre			
Number of applications:	5			
Chronology:	Transplant Date	Application Dates	Application Interval	Disease Assessment Dates
	07/30/2015	06/06/2015	5 days	07/14/2015
		06/13/2015	5 days	07/21/2015
		06/20/2015	5 days	07/30/2015
		06/27/2015	5 days	
		07/04/2015	5 days	
Disease assessment methodology:	Foliage was rated on a scale of 0-100% for symptoms of powdery mildew. (Zero = No disease. 100 = Plant mortality.) Area under the disease progression curve was calculated for all treatments.			

b. Results

Podosphaera xanthii (Powdery Mildew) / Pumpkin #2: Trial No. CER: Results							
Treatment	Rate/ Acre	g a.i./ ha	Active Ingredient	FRAC Code	App. Timing	Final disease rating (%)	
						Measured	Percent Control
Untreated control			Not Applicable			72.5 a	
Oso	6.5 fl oz	25	Polyoxin D zinc salt	19	ABCDE	35.0 bc	51.7
Non-ionic surfactant			Not applicable	NA			
Torino	3.4 fl oz		Cyflufenamid	U6	ACE	25.0 c	65.5
Proline	5.7 fl oz		Prothioconazole	3	BD		
Disease rating scale: Zero = No disease. 100 = Plant mortality. Treatment means followed by the same letter are not statistically different.							

The first disease assessment date was after the last treatment date. Therefore, the treatments are assumed to be preventative.

No phytotoxicity was reported.

c. Discussion and Conclusions

Yellow squash was grown in Georgia. The final disease rating in the untreated control was 72.5% based upon a scale of 0 to 100% for symptoms of powdery mildew. (Zero = No disease. 100 = Plant mortality.)

Five treatments of Polyoxin D Zinc Salt 5SC Fungicide (Oso) were applied preventatively at 6.5 fl oz/acre (25 g a.i./ha) at 7-day intervals with a non-ionic surfactant provided 51.7% control of powdery mildew on yellow squash. This was statistically:

- Superior to the untreated control; and
- Equivalent to the control provided by cyflufenamid applied alternately with prothioconazole.

No phytotoxicity was reported.

Pseudoperonospora cubensis (DOWNY MILDEW) / CUCURBITS

Pseudoperonospora cubensis (Downy Mildew) / Cucumber: Introduction

(Source: 2015 Organic Production and IPM Guide for Cucumbers and Squash, Cornell University Cooperative Extension)

Time for concern: Mid-July to the end of the season. Refer to the North American Plant Disease Forecast Center for cucurbit downy mildew forecast.

Affected crop(s): All cucurbits.

Key characteristics: Upper surfaces of leaves show angular, pale green areas bounded by leaf veins that give the impression of mosaic. These areas turn into yellow, and later necrotic angular spots. Under wet and humid conditions, sporulation occurs on the lower leaf surface.

Pseudoperonospora cubensis (Downy Mildew) / Cucumber: Disease Management

(Source: 2015 Organic Production and IPM Guide for Cucumbers and Squash, Cornell University Cooperative Extension)

Management Option	Recommendations for Downy Mildew
Monitoring, scouting, and thresholds	Monitoring: In areas of the state prone to infection, this disease has the potential for rapid spread with short incubation periods, so growers should be aware of disease occurrence within the area and the neighboring states. Refer to county agent newsletters, and monitor the Downy Mildew National Forecast website. Windblown sporangia from infected cucurbits in other areas are the primary inoculum source, followed by secondary spore production within the field. Scouting: As the plants begin to run (vine types) or flower (bush types), choose five representative sites. At each site, inspect two older leaves on each of five plants, for a total of 50 leaves inspected per field. Record the number of infected plants. After the row closes (vine types) or fruit that have set begin to enlarge (bush types), substitute five plant areas. Examine ten leaves and five fruit per area. Calculate and record the percent of plants infected. Threshold: Symptoms found on one leaf per 50 leaves sampled. When the disease threshold is met, spray on a seven to ten day schedule. Use a higher rate or shorter interval under severe disease pressure.
Resistant varieties	Plant resistant varieties of cucumbers whenever possible. Some newly developed varieties have resistance to the pathogen strain that dominated before 2005 and also exhibit some suppression of the current strain. See North Carolina State' Cucurbit Breeding website for trial results including downy mildew ratings.
Site selection	If possible, select sites with good air movement that encourages leaf drying.
Cultural	Fresh market growers have had success controlling downy mildew by trellising cucumbers, although this is probably cost prohibitive for process cucumber growers.
Notes	Avoid overhead irrigation to prevent moist conditions that favor disease.

Pseudoperonospora cubensis (Downy Mildew) / Cucumber: OMRI-Listed Fungicides for Use in the United States											
FRAC Code	Source: 2015 Organic Production and IPM Guide for Cucumbers and Squash, Cornell Univ. Cooperative Extension								Source: EPA Label		NOP Status
	Active Ingredient	Product Name	Crop	Product Rate/A	PHI (Days)	REI (Hrs)	Efficacy	Comments	EPA Reg. No.	Comments	
44	*Bacillus amyloliquefaciens* str. D747	Double Nickel 55	C, WS	0.25-3 lb	0	4	Not reviewed or no research available.		70051-108	Causes moderate eye irritation. Dermal sensitizer. Broad-spectrum preventative fungicide. Do not use highly alkaline or highly acidic water to mix sprays. Use a buffering agent if necessary to maintain neutrality (pH 6 to 8) of water in the tank.	Non-synthetic
		Double Nickel LC	C, WS	0.5-6 qt	0	4	Not reviewed or no research available.		70051-114	Harmful if absorbed through skin. Harmful if inhaled. Dermal sensitizer. Broad-spectrum preventative fungicide.	
	Bacillus subtilis str. QST 713	Serenade ASO	C, WS	2-6 qt	0	4	Effective in half or more of recent university trials.	Effective in 1/1 trial.	264-1152	Broad spectrum preventative fungicidal and bactericidal product.	Non-synthetic
		Serenade MAX	C, WS	1-3 lb	0	4	Effective in half or more of recent university trials.	Effective in 1/1 trial.	69592-11	Dermal sensitizer. Broad spectrum preventative fungicidal and bactericidal product.	
P5	*Reynoutria sachalinensis*	Regalia Biofungicide	C, WS	1-4 qt	0	4	Not effective in any known trials.	Effective in 0/1 recent trial on cucumber.	84059-3	Causes moderate eye irritation. Preventative rather than a curative application. Apply prior to disease infestation to protect the growing leaf tissue. Avoid freezing.	Non-synthetic
Not classified; Biological	*Streptomyces lydicus* WYEC 108	Actinovate AG	C, WS	3-12 oz	0	1 or until solution has dried	Effective in less than half of the university trials.	*Streptomyces lydicus* effective in 1 of 15 cucurbit trials.	73314-1	Avoid contact with skin, eyes, or clothing. Avoid breathing dust or spray mist. Mixer/loaders and applicators must wear a dust/mist filtering respirator meeting NIOSH standards of at least N-95, R-95, or P-95. Repeated exposure to high concentrations of microbial proteins can cause allergic sensitization. Keep from overheating or freezing. Optimum storage temperature is 40°F to 85°F. Contains live spores of a microbe. Best results will be obtained if the product is used prior to disease onset. Becomes active in soil or on the plant foliage when the temperatures are above 45°F and is not effective when temperatures remain cold. Do not apply soil fumigants to treated areas.	Non-synthetic

Pseudoperonospora cubensis (Downy Mildew) / Cucumber: OMRI-Listed Fungicides for Use in the United States											
FRAC Code	Source: 2015 Organic Production and IPM Guide for Cucumbers and Squash, Cornell Univ. Cooperative Extension								Source: EPA Label		NOP Status
	Active Ingredient	Product Name	Crop	Product Rate/A	PHI (Days)	REI (Hrs)	Efficacy	Comments	EPA Reg. No.	Comments	
Not classified; Botanical oil	Sesame oil	Organocide 3-in-1	C, WS	1-2 gal/ 100 gal water	0	0	Not reviewed or no research available.	Effective in 2 of 2 trials.	NA. FIFRA §25(b) pesticide.	If spraying on severely stressed or damaged plants, consider using a lower rate such as 1 oz. per gallon to avoid adding additional stress. For best results, spray in the early morning.	Non-synthetic
	Neem oil	Trilogy	C, WS	0.5-1.0% in 25 -100 gal water	0	4	Effective in half or more of recent university trials. (Note the inconsistency with the Comments column.)	Neem oil effective in 0 of 1 trial on squash. Maximum labeled rate of 2 gal/acre/ application.	70051-2	Causes moderate eye irritation. Hazardous to fish and aquatic invertebrates. Toxic to bees exposed to direct treatment. Broad spectrum. Exercise care in timing applications during early morning/late evening to minimize the potential for leaf burn. Use care on plants with tender tissue. Check for leaf burn in small scale trials prior to use. Do not apply to sensitive plant species. Do not apply to wilted or otherwise stressed plants, or to newly transplanted materials or crops prior to root establishment. For optimal performance, do not mix with cold water (less than 45°F). Do not store below 40°F (4°C). Do not use or store near heat or open flame.	Non-synthetic

Pseudoperonospora cubensis (Downy Mildew) / Cucumber: OMRI-Listed Fungicides for Use in the United States											
FRAC Code	Source: 2015 Organic Production and IPM Guide for Cucumbers and Squash, Cornell Univ. Cooperative Extension								Source: EPA Label		NOP Status
	Active Ingredient	Product Name	Crop	Product Rate/A	PHI (Days)	REI (Hrs)	Efficacy	Comments	EPA Reg. No.	Comments	
M1	Basic copper sulfate	Basic Copper 53	C, WS	2 lb	0	24	Effective in half or more of recent university trials.		45002-8	WARNING signal word. Causes substantial but temporary eye injury. Harmful if absorbed through skin or inhaled. Dermal sensitizer. Toxic to fish and aquatic organisms.	Synthetic
	Copper hydroxide	Nu-Cop 50 WP	C	1.5-3.0 lb	1	24	Effective in half or more of recent university trials.	Cucumber only.	42002-7	DANGER signal word. Corrosive. Causes irreversible eye damage. Harmful if swallowed, absorbed through skin, or inhaled. Skin sensitizer. Toxic to fish and aquatic organisms. Product should not be applied in spray water having a pH of less than 6.5 as phytotoxicity may result. Effectiveness reduced at pH greater than 9.0. <u>Cucurbits</u>: Crop injury may occur form application at higher rates and shorter intervals.	
		Champ WG	C, WS	1.5-2.0 lb	0	48	Effective in half or more of recent university trials.		55146-1	DANGER signal word. Corrosive. Causes irreversible eye damage. Harmful if inhaled. Skin sensitizer. Toxic to fish and aquatic organisms.	
	Copper hydroxide, Copper oxychloride	Badge X2	C, WS	0.5-1.25 lbs	0	48	Effective in half or more of recent university trials.		80289-12	WARNING signal word. May be fatal if swallowed. Causes substantial but temporary eye injury. Harmful if absorbed through skin. Harmful if inhaled. Toxic to fish and aquatic organisms. Product must not be applied in a spray solution having a pH of less than 6.5 as phytotoxicity may occur. Do not tank mix product with Aliette® fungicide for use on any registered crops or ornamentals unless appropriate precautions have been taken to buffer the spray solution because severe phytotoxicity may result. <u>Cucurbits</u>: Crop injury may occur from application at higher rates and shorter intervals.	

Pseudoperonospora cubensis (Downy Mildew) / Cucumber: OMRI-Listed Fungicides for Use in the United States											
FRAC Code	Source: 2015 Organic Production and IPM Guide for Cucumbers and Squash, Cornell Univ. Cooperative Extension								Source: EPA Label		NOP Status
	Active Ingredient	Product Name	Crop	Product Rate/A	PHI (Days)	REI (Hrs)	Efficacy	Comments	EPA Reg. No.	Comments	
	Copper octanoate	Cueva Fungicide Concentrate	C, WS	0.5-2.0 gal/ 100 gal water	0	4	Effective in half or more of recent university trials.	Mixed material is applied at 50-100 gallons of diluted spray per acre.	67702-2-70051	Harmful if swallowed or absorbed through skin. Toxic to fish and aquatic organisms. May cause some copper toxicity on some plant species. Store away from open fire or flame. Product may be damaged by freezing. Do not store product below 4°C. Do not mix with chelated or liquid fertilizers. Use caution when using product with other fungicides and insecticides. Toxic to fish and aquatic organisms. On plants that are very susceptible to powdery mildew, spray the plants every 5 days during the first 2 weeks after emergence and weekly thereafter. Do not apply more than 1750 gallons of diluted spray per acre per year. Do not reapply within 5 days.	
	Copper sulfate pentahydrate	CS 2005	C, WS	19.2-25.6 oz	0	48	Effective in half or more of recent university trials.		66675-3	DANGER signal word. Corrosive. Causes irreversible eye damage and skin irritation. Harmful if swallowed, inhaled or absorbed through the skin. Dermal sensitizer. Toxic to fish and aquatic organisms. Do not mix with acidic compounds. Do not mix with pot ash. Store away from excessive heat. Product will freeze. Store and handle product in 316L stainless steel, fiberglass, PVC's, polypropylenes or plastic equipment. Keep away from galvanized pipe and any nylon storage handling equipment. Cucurbits: Crop injury may occur from application at higher rates and shorter intervals.	
	Cupric hydroxide	Nu-Cop 50DF	C	1.5-2.0 lb	1	24	Effective in half or more of recent university trials.	Cucumber only.	45002-4	DANGER signal word. Corrosive. Causes irreversible eye damage. Harmful if swallowed or absorbed through skin. Dermal sensitizer. Toxic to fish and aquatic organisms. Effectiveness reduced at pH greater than 9.0. Crop injury statements. Phytotoxicity may result at pH less than 6.5.	
		Nu-Cop 50 WP	Melons	1.5-3 lb	1	24	Effective in half or more of recent university trials.	See EPA label comments.	45002-7	DANGER signal word. Corrosive. Causes irreversible eye damage. Harmful if swallowed, absorbed through skin, or inhaled. Dermal sensitizer. Toxic to fish and aquatic organisms. Phytotoxicity may result at pH less than 6.5. Crop injury statements. Effectiveness reduced at pH greater than 9.0. Crop injury may occur from application at higher rates or shorter intervals. Cucurbit uses limited to cantaloupe, honeydew, muskmelon.	

Pseudoperonospora cubensis (Downy Mildew) / Cucumber: OMRI-Listed Fungicides for Use in the United States											
FRAC Code	Source: 2015 Organic Production and IPM Guide for Cucumbers and Squash, Cornell Univ. Cooperative Extension								Source: EPA Label		NOP Status
	Active Ingredient	Product Name	Crop	Product Rate/A	PHI (Days)	REI (Hrs)	Efficacy	Comments	EPA Reg. No.	Comments	
		Nu-Cop HB	C	1 lb	1	24	Effective in half or more of recent university trials.	Cucumber only.	42750-132	DANGER signal word. Corrosive. Causes irreversible eye damage. Harmful if swallowed, absorbed through skin, or inhaled. Dermal sensitizer. Product should not be applied in spray water having a pH of less than 6.5 as phytotoxicity may result. Cucurbits: Discontinue use if injury occurs.	
		Nu-Cop 50 WP	C	1.5-2.0 lb	1	24	Effective in half or more of recent university trials.	Cucumber only.	45002-7	DANGER signal word. Corrosive. Causes irreversible eye damage. Harmful if swallowed, absorbed through skin, or inhaled. May cause crop injury on sensitive varieties. Do not apply in spray solution with pH less than 6.5 as phytotoxicity may result.	
	Cuprous oxide	Nordox 75 WG	C, WS	1-1.25 lb	0	12	Effective in half or more of recent university trials.		48142-4	Harmful if swallowed or absorbed through skin. Causes eye irritation. Do not apply in a spray solution with a pH of less than 6.5.	
Not classified; Inorganic salts	Potassium bicarbonate	EcoMate Amicarb O	C, WS	2.5-5 lb/ 100 gal water	0	4	Not effective in any known trials.	Bicarbonate products effective in 0 of 1 trial on pumpkin.	5905-541	Harmful if swallowed. Causes moderate eye irritation. Broad spectrum contact foliar fungicide. Prevent exposure to moisture during storage. Avoid contamination with other pesticides and fertilizers.	Synthetic
		Milstop	C, WS	2-5 lb	0	1	Not effective in any known trials.	Bicarbonate products effective in 0 of 1 trial on pumpkin.	70870-1-68539	Harmful if swallowed. Causes moderate eye irritation. Broad spectrum contact foliar fungicide. Do not mix with other soluble pesticides or fertilizers. Not compatible with mild alkaline solutions. Acidification of solution will cause reduced product performance. Prevent exposure to moisture during storage. Avoid contamination with other pesticides and fertilizers.	

Pseudoperonospora cubensis (Downy Mildew) / Cucumber: OMRI-Listed Fungicides for Use in the United States											
FRAC Code	Source: 2015 Organic Production and IPM Guide for Cucumbers and Squash, Cornell Univ. Cooperative Extension								Source: EPA Label		NOP Status
	Active Ingredient	Product Name	Crop	Product Rate/A	PHI (Days)	REI (Hrs)	Efficacy	Comments	EPA Reg. No.	Comments	
Not classified; Oxidizing agent	Hydrogen dioxide, Peroxyacetic acid	Oxidate 2.0	C, WS	0.33 - 1 gal in 100 gal water	0	Until dry	Effective in half or more of recent university trials.	Do not spray during conditions of intense heat, drought, or poor vine canopy. Effective in 1 of 1 recent trial on cucumber.	70299-2	DANGER signal word. Causes irreversible eye damage. May be fatal if swallowed. Causes skin irritation or temporary discoloration of exposed skin. Highly toxic to bees and other beneficial insects. Toxic to fish. Toxic to birds who eat treated seed on soil surface. Strong oxidizing agent. Do not use in undiluted form. Never bring undiluted product in contact with other pesticides, cleaners or oxidative agents. May react with residues of metal-based fungicides or supplements. Allow at least 24 hrs. after application of metal-based products. Do not spray during conditions of intense heat, drought, or poor plant vigor (or vine canopy). Do not apply in conjunction with any other pesticides or fertilizers. Do not allow product to become overheated in storage. Do not store in a manner where cross-contamination with other pesticides or fertilizers could occur. Apply consecutive applications until control is achieved; then apply preventative treatments.	Synthetic
	Hydrogen peroxide, Hydrogen dioxide	Perpose Plus	C, WS	Initial/ Curative: 1 fl oz/gal Preventative: 0.25-0.33 fl oz/gal	0	Until spray has dried	Not effective in any known trials.	Hydrogen peroxide products effective in 0 of 5 trials. For initial or curative use, apply higher rate for 1 to 3 consecutive days. Then follow with weekly/preservative treatment. For weekly or preventative treatments, apply lower rate every 5-7 days. At first sign of disease, use curative rate then resume weekly preventative treatment.	86729-1	DANGER signal word. Causes irreversible eye damage and skin burns. May be fatal if absorbed through the skin. Harmful if swallowed. Do not breathe vapor from concentrate. Toxic to birds, mammals, fish and aquatic life. At temperatures exceeding 156°F, decomposition releases oxygen. The oxygen released could initiate or promote combustion of other materials. Store away from combustibles. Broad spectrum algaecide and fungicide. Apply curative rates for 3 consecutive days (drenching the entire plant) followed by weekly preventative treatments.	

C = Cucumber
WS = Winter squash

Pseudoperonospora cubensis **(Downy Mildew) / Cucumber: Efficacy Trials**

Pseudoperonospora cubensis (Downy Mildew) / Cucumber #1: Trial No. CER-2012-067

a. Design

Pseudoperonospora cubensis (Downy Mildew) / Cucumber #1: Trial No. CER-2012-067: Design			
Title:	Evaluation of Fungicide Programs for Management of Diseases of Cucumbers, 2012		
Authors and affiliation:	K. L. Everts and M. Newark University of Maryland and University of Delaware Georgetown, DE		
Publication:	Not published. Permission received.		
Location:	Salsbury, MD		
Crop:	Cucumber (*Cucumis sativus*)		
Disease name:	Downy mildew		
Pathogen:	*Pseudoperonospora cubensis*		
Test plot design:	Randomized complete block		
Number of replicates:	4		
Application equipment:	Backpack sprayer (first application) Tractor mounted sprayer (43 psi) (all other applications)		
Spray volume:	45 gal/acre		
Number of applications:	5		
Chronology:	Application Dates	Application Interval	Harvest Dates
	06/28/2012		07/09/2012
	07/03/2012	5 days	07/12/2012
	07/10/2012	7 days	07/17/2012
	07/16/2012	6 days	07/20/2012
	07/23/2012	7 days	07/24/2012
			07/27/2012
			07/31/2012

b. Results

Pseudoperonospora cubensis (Downy Mildew) / Cucumber #1: Trial No. CER-2012-067: Results								
Treatment	Rate/ Acre	g a.i./ ha	Active Ingredient	FRAC Code	Downy Mildew (%)		Total Yield	
					Measured	Percent Control	Measured	Percent Increase
Untreated control			Not Applicable		17.5 a		89 a	
CX-10440 [1]	6.5 fl oz	25	Polyoxin D zinc salt	19	7.0 b	57.1	122 a	37.1
CX-10440 [1]	13 fl oz	50	Polyoxin D zinc salt	19	11.0 b	37.1	105 a	18.0
Treatment means followed by the same letter are not statistically different according to the Fisher's Protected LSD test at $\alpha = 0.05$. 1. CX-10440 is the Certis USA, L.L.C. code for Polyoxin D Zinc Salt 5SC Fungicide.								

Downy mildew symptoms were first observed on July 25, 2012, *i.e.*, after the last treatments were applied. Therefore, the treatments were preventative.

No phytotoxicity was observed.

c. Discussion and Conclusions

Cucumbers were grown in Delaware. Downy mildew pressure was 17.5% in the untreated control.

Five treatments of Polyoxin D Zinc Salt 5SC Fungicide were applied preventatively at 5-day to 7-day intervals. Treatments did not provide a positive dose response.

- Treatment at 6.5 fl oz/acre (25 g a.i./ha) provided 57.1% control of downy mildew and 37.1% increase in yield
- Treatment at 13 fl oz/acre (50 g a.i./ha) provided 37.1% control of downy mildew and 18.0% increase in yield.
-

The Polyoxin D Zinc Salt 5SC Fungicide treatments provided:

- Control of downy mildew that was statistically superior to the untreated control; and
- Numerically (but not statistically significant) increased yield.

No phytotoxicity was observed.

Pseudoperonospora cubensis (Downy Mildew) / Pumpkin #1: Trial No. CER-2015-145

a. Design

Pseudoperonospora cubensis (Downy Mildew) / Pumpkin #1: Trial No. CER-2015-145: Design				
Title:	2015, JOB Pumpkin, Powdery Mildew (and other disease) Trial			
Author and affiliation:	Mohammad Babadoost University of Illinois, Champaign-Urbana			
Publication:	Not published. Permission received.			
Location:	Univ. of Illinois Vegetable Research Farm, Champaign, Illinois			
Crop:	Pumpkin (cultivar Howden)			
Disease name:	Powdery mildew			
Pathogen:	*Podosphaera xanthii*			
Test plot design:	Not reported			
Number of replicates:	Not reported			
Application equipment:	Not reported			
Spray volume:	50 gal/acre			
Number of applications:	7			
Chronology:	Transplant Date	Application Dates	Application Interval	Disease Assessment Dates
	06/30/2015	07/30/2015		09/06/2015
		08/06/2015	6 days	
		08/12/2015	6 days	
		08/19/2015	7 days	
		08/27/2015	8 days	
		09/03/2015	8 days	
		09/10/2015	7 days	

b. Results

Pseudoperonospora cubensis (Downy Mildew) / Pumpkin #1: Trial No. CER-2015-145: Results							
Treatment	Rate/ Acre	g a.i./ ha	Active Ingredient	FRAC Code	App Code	Mean Severity (%)	
						Measured	Percent Control
Untreated control			Not Applicable			20.75	
Oso 5.0SC	6.5 fl oz	25	Polyoxin D zinc salt	19	ABCDEFG	4.5	78
Activator	0.125%		Non-ionic surfactant	NA	ABCDEFG		
Quintec 2.08SC	6 fl oz		Quinoxyfen	13	ACEG	6.0	71
Kocide 3000 4.1 DF	1.5 lb		Copper hydroxide	M1	ABCDEFG		
Procure 480SC	8 fl oz		Triflumazole	3	BDF		

Downy mildew symptoms were observed in the untreated control on September 6, 2015, *i.e.*, before the last treatment. Therefore, the downy mildew treatments were preventative and curative.

No phytotoxicity was reported.

c. Discussion and Conclusions

Pumpkins were grown in Illinois. Maximum measured downy mildew severity was 20.75%.

Seven treatments of Polyoxin D Zinc Salt 5SC Fungicide applied preventatively and curatively at 6.5 fl oz/acre (25 g a.i./ha) with a non-ionic surfactant at 6-8 day intervals provided 78% control of downy mildew on pumpkins.

An industry standard, quinoxyfen plus copper hydroxide applied alternately with triflumazole plus copper hydroxide, provided only 71% control of downy mildew on pumpkins.

No phytotoxicity was reported.

***Pseudoperonospora cubensis* (Downy Mildew) / Cucumber: Grower Need**

The following grower needs were identified at the 2015 IR-4 Biopesticide Workshop:

- Downy mildew / Organic cucurbits (Project No. B00149);
- Downy mildew / Cucurbits (Project No. B00051);
- Downy mildew / Organic pumpkin, squash (Project No. B00127);
- Pesticidal products with a zero-day PHI for use on greenhouses grown vegetables (Project No. B00024).

Sclerotinium rolfsii **(SOUTHERN BLIGHT) / CUCURBITS**

Sclerotinium rolfsii **(Southern Blight) / Cucurbits: Introduction**

(Source: Jackie Mullen, Auburn University, AL. Southern Blight, Southern Stem Blight, White Mold. American Phytopathological Society.)

Southern blight, caused by the soilborne fungus *Sclerotium rolfsii* is a serious disease of a wide variety of plants, including field, vegetable, fruit, ornamental crops and also turf. *Sclerotinium rolfsii* usually infects the lower stem near the soil surface. With some plants, the roots may become infected. Tomato fruit and other fruit at or near the soil surface may become infected with *Sclerotinium rolfsii.* Soft, water-soaked, sunken, slightly yellowish lesions develop. These lesions quickly spread throughout most or all of the fruit, which will eventually collapse. Coarse white mycelium develops with sclerotia. On low growing plants such as strawberries, statice, and peanut, leaves touching the soil may be infected with *Sclerotinium rolfsii*. Necrotic leaf spots have been described on many plants. Usually the high humidity near the soil surface is an important factor in disease development.

Sclerotinium rolfsii **(Southern Blight) / Cucurbits: Epidemiology**

(Source: Jackie Mullen, Auburn University, AL. Southern Blight, Southern Stem Blight, White Mold. American Phytopathological Society.)

Southern blight is a problem in warm and wet tropical and subtropical areas. The pathogen survives as mycelium on dead organic material when living susceptible plants are not present. It also survives as sclerotia in soil. Research has shown that fungal infection is enhanced when dead organic materials are available around susceptible plants.

Temperature and moisture are very important factors in the spread and development of this pathogen. Hyphal growth occurs over a temperature range of 8-40ºC / 46-104º F, but optimal growth and sclerotia production occurs between 27-35ºC / 81-95ºF. In addition to temperature effects, hyphal growth and sclerotia germination require a water-saturated soil. High humidity also favors fungal development. At 27ºC / 81ºF on potato dextrose agar, the hyphal growth rate of *Sclerotinium rolfsii* has been observed to be 0.8-0.9 mm per hour. Sclerotia form after 5-7 days. Host penetration and infection will proceed optimally at 27-30ºC / 81-86ºF provided that moisture and high humidity are present.

Current season spread of *Sclerotinium rolfsii* within a planting occurs by mycelial growth from infected plants, plant debris, or sclerotia. Long distance spread occurs as a result of movement of infected plant material or infested soil. Studies have shown that sclerotia may pass through the digestive tract of cattle or sheep and still be viable.

Sclerotinium rolfsii survives adverse conditions as sclerotia or as mycelium in diseased plants or plant debris. Sclerotia formation is favored by temperature of 30ºC / 86ºF, ample moisture, soil pH below 7, and well-aerated, light soil. Sclerotia survive best when present at or near the soil surface in well-drained soil. Research has demonstrated that no sclerotia survived when buried 15 cm (6 in.) deep for 45 days. Mycelium does not usually survive below freezing temperatures, but sclerotia are known to survive in locations where below freezing temperatures have occurred.

***Sclerotinium rolfsii* (Southern Blight) / Cucurbits: Disease Management**
(Source: Jackie Mullen, Auburn University, AL. Southern Blight, Southern Stem Blight, White Mold. American Phytopathological Society.)

- Excluding the Pathogen from an Area. Only pathogen-free plants, cuttings or seeds should be purchased from a reputable dealer. In a greenhouse, all pots and planting equipment must be clean and pathogen-free, and planting media also must be pathogen-free. If field planting is involved, areas that do not have a history of *Sclerotinium rolfsii* should be selected. Even though southern blight is not common in areas with cold winters, the disease may be a problem during the growing season if infected transplants from greenhouses or warmer regions are planted.

- Plant Removal. Prompt removal of infected plants will help prevent the addition of abundant fungal inoculum to the soil. If infected plants are allowed to remain in an area, these plants will serve as a continuous source of inoculum. Plant removal is a practical measure in landscapes, gardens, nurseries, and greenhouses, but not in field situations.

- Soil Removal. Sclerotia are reported to survive in the soil for 3-4 years. In gardens or landscapes, some localized soil removal and replacement may help to control *Sclerotinium rolfsii*. The grower should take care not to increase the distribution of the fungal inoculum in an area when transporting soil. In nurseries and greenhouses, used potting media should not be saved for new plants. Plant debris and used media should be thoroughly cleaned out of production areas after each crop is removed. Recycled containers should be thoroughly cleaned so as to remove all old pot media.

- Soil Heat Treatment. In some large nurseries or greenhouses, it may be possible to treat beds or bulk soil with aerated steam. All areas must be brought to a temperature of 160-180°F for 30 minutes. Treated soil should be stored away from contaminated areas. Even after steam treatment, some sclerotia may survive and losses may occur.

- Cultural Practices. Cultural modifications for management of *Sclerotinium rolfsii* in the landscape include deep plowing, lime additions, aerification, and thatch removal. In some situations, deep plowing will provide disease control. At depths below 20-30 cm (8-12 in.), sclerotia do not survive longer than 45 days. Also, deep plowing removes sclerotia from contact with root tissues. Although deep plowing is effective the first time, it may not work in subsequent years because sclerotia are returned to the upper soil layer. Keeping the soil pH at 6.5 by the addition of lime will help to prevent rapid fungal growth. Aerification of the soil and removal of thatch or other plant debris will also aid in suppressing *Sclerotinium rolfsii* growth. In greenhouses, areas should be kept open with good plant spacing to help keep relative humidity low. Also, keeping the temperature below 25ºC / 77ºF and maintaining well-aerified plant media will discourage fungal growth. Nurseries must be designed to carry drainage water away from container areas.

- Crop Rotation. This practice is not used much with southern blight because of the unusually wide host range of *Sclerotinium rolfsii*. Corn is reported to be a non-host of this pathogen.

- Resistance and Transgenic Plant Resistance. Many common host plant species of *Sclerotinium rolfsii* do not contain cultivars or varieties that exhibit high levels of resistance to this fungus. Nevertheless, research in this area continues.

***Sclerotinium rolfsii* (Southern Blight) / Cucurbits: No OMRI-Listed Fungicide for Use in the United States**

To the best of Kaken's knowledge, there is no OMRI-listed fungicide that is EPA registered for use on any cucurbit for control or suppression of *Sclerotinium rolfsii* (southern blight).

Sclerotinium rolfsii **(Southern Blight) / Cucurbits: Efficacy** Trials

Sclerotinium rolfsii (Southern Blight) / Squash #1: Trial No. CER-2012-050

a. Design

<table>
<tr><th colspan="5">Sclerotinium rolfsii (Southern Blight) / Squash #1: Trial No. CER-2012-050: Design</th></tr>
<tr><td>Title:</td><td colspan="4">Evaluation of CX-10440 to Control Southern Blight in Squash</td></tr>
<tr><td>Affiliation:</td><td colspan="4">GLC Consulting
Quitman, GA</td></tr>
<tr><td>Publication:</td><td colspan="4">Certis data. Not published. Permission received.</td></tr>
<tr><td>Location:</td><td colspan="4">Quitman, GA</td></tr>
<tr><td>Crop:</td><td colspan="4">Crookneck Squash (Cucurbita pepo)(variety Dixie)</td></tr>
<tr><td>Disease name:</td><td colspan="4">Southern blight</td></tr>
<tr><td>Pathogen:</td><td colspan="4">Sclerotinium rolfsii</td></tr>
<tr><td>Test plot design:</td><td colspan="4">Randomized complete block</td></tr>
<tr><td>Number of replicates:</td><td colspan="4">4</td></tr>
<tr><td>Application equipment:</td><td colspan="4">Sprayer (60 psi)</td></tr>
<tr><td>Spray volume:</td><td colspan="4">50 gal/acre</td></tr>
<tr><td>Number of applications:</td><td colspan="4">9</td></tr>
<tr><td rowspan="10">Chronology:</td><td>Application Dates</td><td>Application Interval</td><td>Crop Assessment Dates</td><td>Yield Assessment Dates</td></tr>
<tr><td>08/08/2012</td><td></td><td></td><td>10/05/2012</td></tr>
<tr><td>08/15/2012</td><td>7 days</td><td>08/15/2012</td><td>10/13/2012</td></tr>
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<tr><td>09/19/2012</td><td>7 days</td><td></td><td></td></tr>
<tr><td>09/26/2012</td><td>7 days</td><td>09/26/2012</td><td></td></tr>
<tr><td>10/03/2012</td><td>7 days</td><td></td><td></td></tr>
</table>

b. Results

Sclerotinium rolfsii (Southern Blight) / Squash #1: Trial No. CER-2012-050: Plant Results									
Treatment	Rate/ Acre	g a.i./ ha	Active Ingredient	FRAC Code	App. Code	Plant Vigor (1-10 rating) (9/26/2012)		Plant Stand - Subjective/ Emergence (9/26/2012)	
						Measured	Percent Increase	Measured	Percent Increase
Untreated control			Not Applicable			2.0 c		4.5 b	
CX-10440 [1]	6.5 fl oz	25	Polyoxin D zinc salt	19	ABCD EFGHI	3.0 bc	50	7.5 b	67
CX-10440 [1]	13 fl oz	50	Polyoxin D zinc salt	19	ABCD EFGHI	3.5 b	75	8.5 b	89
Quadris	12 fl oz		Azoxystrobin	11	ACEG	7.8 a	290	15.0 a	233
Treatment means followed by the same letter are not statistically different (P = 0.05; LSD). Plant Stand - Subjective/Emergence results were expressed as a number with a maximum of 30. 1. CX-10440 is the Certis USA, L.L.C. code for Polyoxin D Zinc Salt 5SC Fungicide.									

Sclerotinium rolfsii (Southern Blight) / Squash #1: Trial No. CER-2012-050: Yield Results									
Treatment	Rate/ Acre	g a.i./ ha	Active Ingredient	FRAC Code	App. Code	Yield: No. Fruits (10/13/2012)		Yield: Lb/Plot (10/13/2012)	
						Measured	Percent Increase	Measured	Percent Increase
Untreated control			Not Applicable			13.0 c		1.565 c	
CX-10440 [1]	6.5 fl oz	25	Polyoxin D zinc salt	19	ABCD EFGHI	29.0 b	123	14.725 b	841
CX-10440 [1]	13 fl oz	50	Polyoxin D zinc salt	19	ABCD EFGHI	38.3 b	195	15.775 b	908
Quadris	12 fl oz		Azoxystrobin	11	ACEG	75.8 a	418	22.275 a	1323
Treatment means followed by the same letter are not statistically different (P = 0.05; LSD). 1. CX-10440 is the Certis USA, L.L.C. code for Polyoxin D Zinc Salt 5SC Fungicide.									

The date of first observation of southern blight was not reported. The treatments are assumed to have been preventative.

No phytotoxicity was observed.

c. Discussion and Conclusions

Crookneck squash were grown in Georgia. Pest pressure was severe based upon the very large impacts on crop yield.

Nine treatments of Polyoxin D Zinc Salt 5SC Fungicide were applied preventatively at 7-day intervals. There was a positive dose response.

- Treatment at 6.5 fl oz/acre (25 g a.i./ha) provided:
    - Mean 59% (range 50% to 67%) southern blight disease control based upon increased plant vigor and increased plant stand-subjective emergence;
    - Mean 482% (range 123% to 841%) increased yield; and
    - Crop health and yield that were statistically less than that provided by azoxystrobin.

- Treatment at 13 fl oz/acre (50 g a.i./ha) provided:
    - Mean 82% (range 75% to 89%) control based upon increased plant vigor and increased plant stand-subjective emergence;
    - Mean 552% (range 195% to 908%) increased yield; and
    - Crop health and yield that were statistically less than that provided by azoxystrobin.

At both application rates, Polyoxin D Zinc Salt 5SC Fungicide provided control of southern blight that was statistically:

- Superior to the untreated control; and
- Less than the control provided by azoxystrobin.

No phytotoxicity was observed.

Sclerotinium rolfsii **(Southern Blight) / Cucurbits: Grower Need**
Zero-day PHI products for use on greenhouse vegetables (Project No. B00024) was identified as a grower need at the IR-4 2015 Biopesticide Workshop.

Sphacelotheca **sp. (POWDERY MILDEW) / STRAWBERRIES**
(Source: N. A. Peres and J.C. Mertely, Powdery Mildew of Strawberries, University of Florida IFAS Extension)

Powdery mildew on strawberries is caused by *Podosphaera aphanis* which is also known as *Sphaerotheca macularis*. Please see *Podosphaera aphanis* (POWDERY MILDEW) / STRAWBERRIES.

Venturia inaequalis (SCAB) / POME FRUITS

Venturia inaequalis (Scab) / Pome Fruits: Economic Importance
(Source: Wayne F. Wilcox, Apple Scab Fact Sheet, Cornell University Agricultural Extension)

Apple scab is the most economically destructive disease of apples in the world. In the Northeast it is usually not possible to produce apples commercially without some program to control this disease.

Venturia inaequalis (Scab) / Pome Fruits: Symptoms
(Source: Wayne F. Wilcox, Apple Scab Fact Sheet, Cornell University Agricultural Extension)

Scab may occur on leaves, fruit, leaf and fruit stems, and green twigs. Infections of the leaves and fruit are most common and obvious. Early season infections usually occur on the underside of the blossom cluster leaves because these are the first tissue surfaces to emerge from buds in the spring. Once the cluster leaves have unfolded and terminal leaves begin to develop, infections become evident on the upper surface of the leaves. Individual infections appear as roughly circular, brown to dark olive-green spots (lesions), which often seem slightly fuzzy or velvety in texture. Lesions along the veins or margins often cause those regions of the leaves to distort or crinkle. Primary (ascospore) infections are usually limited to one or two distinct spots per leaf, whereas secondary (conidia) infections are often much more numerous. Secondary infections occasionally are so numerous that the entire surface of the leaf appears covered with scab, a condition commonly referred to as sheet scab.

Lesions on young fruit initially resemble those on leaves but turn dark brown to black and become corky or scablike with time. Cells near lesions on young fruit may be killed, causing these regions to become deformed or cracked as they fail to grow and expand along with the remainder of the apple. Primary (ascospore) infections are usually limited to one or two distinct spots per fruit, often near the blossom end because it is upturned during the early stages of fruit development. Secondary infections are frequently much more numerous and may be clumped or grown together, particularly if the fruit is directly beneath a concentrated source of secondary spores such as an infected leaf. Secondary infections that occur in late summer or early fall are often numerous and relatively small in size, a symptom referred to as pin-point scab. Infections that occur just before harvest may be symptomless at picking yet develop into storage scab lesions after harvest.

Venturia inaequalis (Scab) / Pome Fruits: Disease Cycle and Causal Organism
(Source: Wayne F. Wilcox, Apple Scab Fact Sheet, Cornell University Agricultural Extension)

Apple scab is caused by the fungus *Venturia inacqualis,* which also is capable of infecting crabapple, hawthorn, mountain ash, and firethorn. Different but closely related *Venturia* species cause scab on European and Japanese pear.

In the Northeast, the scab fungus overwinters in infected leaves that have fallen to the ground. During autumn, the fungus begins to form tiny fruiting bodies (pseudothecia) which are embedded in the leaves near the surface. Sacs (asci) filled with the primary or spring spores of the fungus (ascospores) start to develop within the pseudothecia by late winter or early spring. The ascospores continue to develop and become mature as spring progresses. A few spores are usually mature at the time of bud break (green tip), and maturity progresses slowly until about the tight cluster stage of blossom development. After this time, the percentage of mature spores begins to increase rapidly whenever temperatures are favorable for tree growth. Most ascospores have matured by the end of bloom.

Mature ascospores are discharged into the air during periods of rain. In daylight, discharge usually begins within 30 minutes after the start of the rain and is largely completed within 3 to 6 hours. When rainfall begins at night, discharge is often delayed until daybreak, although significant night discharge can occur under some conditions. The number of spores discharged during any one rain is determined by both the size of the potential ascospore "crop" for the season (how many leaves were infected the previous year) and the percentage of these spores that have matured since the last discharge. Ascospore discharge usually peaks in the time from pink through bloom, and nearly all ascospores have been discharged within 1 or 2 weeks after petal fall.

Ascospores are blown to nearby trees by wind currents, then germinate in a film of water on the surface of leaves and fruit. If surface wetness continues long enough at prevailing temperatures, growth from the germinated spore penetrates and infects these organs just beneath the outer cuticle. Typical lesions, each bearing tens of thousands of secondary or summer spores (conidia), appear about 9 to 17 days later depending on temperature, although long periods of low humidity can delay their development. Conidia are dispersed by splashing rain throughout the rest of the season and are capable of causing new (secondary) infections. Because numerous additional conidia are produced on each new lesion, repeated secondary infections have a snowball or epidemic effect on disease development.

Incidence of infection is affected by the age of leaves and fruit. Young tissues generally are most susceptible. Leaves are most susceptible 1 to 5 days after unfolding and become completely resistant from the time they finish expanding until shortly before leaf drop in the autumn. Fruit are highly susceptible until about 3 to 4 weeks after petal fall, but much longer wetting periods are required for infection to occur after this time. Precise requirements for infection of mature fruit are not known, but limited data indicate that wetting periods must last at least 48 hours for significant infection to occur immediately before harvest.

Venturia inaequalis **(Scab) / Pome Fruits: Control**
(Source: Wayne F. Wilcox, Apple Scab Fact Sheet, Cornell University Agricultural Extension)

On most apple varieties, fungicide sprays are required every year for control of scab. Fungicide programs can be minimized and made most efficient by designing them around weather conditions (infection periods), inoculum availability, cultivar susceptibility, and specific characteristics of the available fungicides.

Season-long control of apple scab is difficult if primary infections are allowed to develop. Even moderate numbers of primary lesions can produce an extremely large population of conidia, requiring an intensive fungicide program to protect fruit throughout the summer. Conversely, good control of primary infections allows use of fungicides to be reduced or omitted during the summer, once ascospores have been depleted and fruit become less susceptible.

Control of primary infections has traditionally begun at or shortly after green tip, when the first ascospores become mature. The percentage of spores that are mature at this time is low, and the actual number of mature spores may be insignificant during the early stages of bud development if very little leaf scab developed the previous year (that is, the seasonal ascospore "crop" is small). Various systems for determining when fungicide programs must begin in "clean" orchards have been developed; check with your adviser for their current status.

Apple scab fungicides control disease in different ways. Some are most effective as protectants, some when applied after an infection period, and some can suppress production of conidia from established lesions. Understanding these activities and knowing which fungicides exhibit them is important for maximizing the efficiency of a fungicide program. Such information is available through Cornell Cooperative Extension.

Standard apple cultivars vary widely in their susceptibility to scab, which will influence the intensity of the control program necessary for a particular variety. In the Northeast:

- Jersey Mac is extremely susceptible;
- McIntosh and its progeny (Cortland, Macoun, Empire) are highly susceptible;
- Rome, Red Delicious, R. 1. Greening, Crispin, 20-Ounce, and Northern Spy are moderately susceptible;
- Golden Delicious, IdaRed, Jonathan, and PaulaRed are moderately resistant;
- Cultivars that are immune to apple scab are available, including some with fruit quality that appears to be commercially acceptable (*e.g.*, Liberty, Florina, Goldrush); additional selections are being evaluated. Growers interested in minimal or "organic" pesticide programs should strongly consider planting such varieties.

Because the scab fungus has different races, these rankings are not necessarily applicable to other regions where different races may predominate.

Venturia inaequalis (Scab) / Pome Fruits: OMRI-Listed Fungicides for Use in the United States **(No efficacy data have been identified or evaluated.)**								
FRAC Code	Source: EPA Label							NOP Status
	Active Ingredient	Product Name	Product Rate/ Acre	PHI (Days)	REI (Days)	EPA Reg. No.	Comments	
44	*Bacillus amyloliquefaciens* str. D747	Double Nickel 55	0.25-3 lb	0	4	70051-108	Causes moderate eye irritation. Dermal sensitizer. Broad-spectrum preventative fungicide. Do not use highly alkaline or highly acidic water to mix sprays. Use a buffering agent if necessary to maintain neutrality (pH 6 to 8) of water in the tank. Suppression only.	Non-synthetic
		Double Nickel LC	0.5-6 qt	0	4	70051-114	Harmful if absorbed through skin. Harmful if inhaled. Dermal sensitizer. Broad-spectrum preventative fungicide. Suppression only.	
	Bacillus pumilus str. QST 2808	Sonata ASO	2-4 qt	0	4	264-1153	Harmful if inhaled. Mixers/loaders and applicators must wear a dust/mist filtering respirator meeting NIOSH standards of at least N-95, R-95, or P-95. Repeated exposure to high concentrations of microbial proteins can cause allergic sensitization. Maintain a spray solution pH between 4.5 and 8.5. Suppression only. Begin applications at green tip; repeat at 7-day to 15-day intervals.	Non-synthetic
	Bacillus subtilis str. QST 713	Serenade ASO	2-6 lb	0	4	264-1152	Broad spectrum preventative fungicidal and bactericidal product. Suppression only.	Non-synthetic
		Serenade MAX	1-3 lb	0	4	69592-11	Dermal sensitizer. Broad spectrum preventative fungicidal and bactericidal product. Suppression only.	
P5	*Reynoutria sachalinensis*	Regalia Bio-fungicide	1-4 qt	0	4	84059-3	Causes moderate eye irritation. Preventative rather than a curative application. Apply prior to disease infestation to protect the growing leaf tissue. Avoid freezing. Suppression only.	Non-synthetic
Not classified; Botanical oils	Clove oil, Rosemary oil, and Peppermint oil	BacStop	6-12 oz/ 100 gal water	0	NA	NA. FIFRA §25(b) pesticide.	Causes temporary eye and skin irritation. Wear protective eye wear and chemical resistant gloves. Store at temperatures between 41°F and 85°F (5°C and 30°C).	Non-synthetic
		EF400	64-96 fl oz/ 100 gal	0	NA	FIFRA §25(b) pesticide.	Causes temporary eye and skin irritation. Wear protective eye wear and chemical resistant gloves. Store at temperatures between 41°F and 85°F (5°C and 30°C).	
	Neem oil	Trilogy	1.0% in 25-100 gal water	0	4	70051-2	Causes moderate eye irritation. Hazardous to fish and aquatic invertebrates. Toxic to bees exposed to direct treatment. Broad spectrum. Exercise care in timing applications during early morning/late evening to minimize the potential for leaf burn. Use care on plants with tender tissue. Check for leaf burn in small scale trials prior to use. Do not apply to sensitive plant species. Do not apply to wilted or otherwise stressed plants, or to newly transplanted materials or crops prior to root establishment. For optimal performance, do not mix with cold water (less than 45°F). Do not store below 40°F (4°C). Do not use or store near heat or open flame. Growth stage use restrictions for grapes and stone fruit.	Non-synthetic

Venturia inaequalis (Scab) / Pome Fruits: OMRI-Listed Fungicides for Use in the United States
(No efficacy data have been identified or evaluated.)

FRAC Code	Source: EPA Label							NOP Status
	Active Ingredient	Product Name	Product Rate/ Acre	PHI (Days)	REI (Days)	EPA Reg. No.	Comments	
M2	Sulfur	Acoidal	10-30	0	24	62562-4	Harmful if swallowed, inhaled, or absorbed through skin. Toxic to fish and aquatic organisms. Sulfur dust suspended in air ignites easily. Keep away from heat, sparks, or flames. Do not smoke while applying this product. Sulfur may cause severe fruit and foliage injury to certain crops. Sulfur may burn foliage when temperature is high. Do not apply within 2 weeks of an oil spray treatment. Do not apply to D'Anjou pears. Do not apply to sensitive varieties of pears after petal fall.	Synthetic
		Cosavet-DF	10-20	0	24	70905-1	Harmful if swallowed, inhaled, or absorbed through skin. Causes moderate eye irritation. Sulfur dust suspended in air ignites easily. Keep away from heat, sparks, or flames. Do not smoke while applying this product. Sulfur may cause severe fruit and foliage injury on certain crops. Sulfur may burn foliage when temperature is high. Do not apply if temperatures during or within 3 days after application are expected to exceed 90°F. Do not apply to D'Anjou pears.	
		Defend DF	10-30	0	24	62562-8	Harmful if swallowed, inhaled, or absorbed through skin. Toxic to fish and aquatic organisms. Sulfur dust suspended in air ignites easily. Keep away from heat, sparks, or flames. Do not smoke while applying this product. Sulfur may cause severe fruit and foliage injury to certain crops. Sulfur may burn foliage when temperature is high. Do not apply within 2 weeks of an oil spray treatment. Do not apply to D'Anjou pears. Do not apply to sensitive varieties of pears after petal fall.	
		Kumulus DF	10-20	0	24	51306-352-66330	Harmful if swallowed. Avoid breathing spray mist. Avoid contact with eyes, skin, and clothing. Do not apply within 2 weeks of an oil spray treatment. Do not store above 104°F. Store away from heat, sparks, and open flame. Do not apply to D'Anjou pears. Do not apply to sensitive apple varieties.	
		Micro Sulf	10-20	0	24	55146-75	Harmful if swallowed, inhaled, or absorbed through skin. Causes eye irritation. Risk of crop injury if temperature exceeds 90°F within 3 days following application. Do not use on any crop unless sulfur has been shown to be safe in your locality. Do not apply within 14 days of an oil spray. Keep away from heat, sparks, or flames. Do not smoke while applying this product. Do not apply to D'Anjou pears during the growing season.	
		Microthiol Disperss	10-20	0	24	70506-187	Harmful if swallowed, inhaled, or absorbed through skin. Risk of crop injury if temperature exceeds 90°F within 3 days following application. Do not use on any crop unless sulfur has been shown to be safe in your locality. Do not store near flammable materials. Do not store in a manner where cross-contamination with other pesticides, fertilizers, food or feed could occur. Restrictions regarding application time before and after an oil spray treatment. Do not apply to D'Anjou pears. Do not apply to sensitive apple varieties.	
		Thiolux	10-20	0	24	34704-1079	Harmful if swallowed, inhaled, or absorbed through skin. Causes eye irritation. Sulfur may case severe fruit and foliage injury to certain crops. Risk of crop injury if temperature exceeds 90°F within 3 days following application. Do not apply within 14 days of an oil spray. Sulfur dust suspended in air easily ignites. Keep away from heat, sparks, or flames. Do not smoke while applying this product. Do not apply to D'Anjou pears.	
		Kumulus DF	10-20 lb	0	24	51306-352-66330	Harmful if swallowed. Avoid breathing spray mist. Avoid contact with eyes, skin, and clothing. Do not apply within 2 weeks of an oil spray treatment. Do not store above 104°F. Store away from heat, sparks, and open flame. Do not apply to D'anjou pears or sensitive apple varieties.	

Venturia inaequalis (Scab) / Pome Fruits: Efficacy Trials

Venturia inaequalis (Scab) / Apples #1: CER-2012-025

a. Design

Venturia inaequalis (Scab) / Apples #1: Trial No. CER-2012-025: Design				
Title:	Evaluation of Experimental and Registered Cover Spray Fungicide Combinations for Disease Control on Fuji Apple, 2012			
Authors and affiliation:	K.S. Yoder, A.E. Cochran, *et al.* Virginia Tech Agricultural Research and Extension Center Winchester, VA			
Publication:	PDMR 7:PF034			
Location:	Winchester, VA			
Crop:	Apple (Fuji)			
Disease name:	Scab			
Pathogen:	*Venturia inaequalis*			
Test plot design:	Random complete block			
Number of replicates:	4			
Application equipment:	Airblast			
Spray volume:	100 gal/acre			
Application type(s):	Curative			
Number of applications:	9			
Chronology:	Application Dates	Growth Stage	Application Interval	Harvest Date
	04/13/2012	Bloom-petal fall		10/04/2012
	04/25/2012		12 days	
	05/09/2012		14 days	
	05/24/2012		15 days	
	06/06/2012		13 days	
	06/20/2012		14 days	
	07/18/2012		28 days	
	08/02/2012		15 days	
	08/22/2012		20 days	

b. Results

Venturia inaequalis (Scab) / Apples #1: Trial No. CER-2012-025: Results: Leaves								
Treatment	Rate/ Acre	g a.i./ ha	Active Ingredient	FRAC Code	% Leaves		Lesions/Leaf	
					Measured	Percent Control	Measured	Percent Control
Untreated control			Not Applicable		47 h		2.7 de	
CX-10440 [1]	6.5 fl oz	25	Polyoxin D zinc salt	19	27 d-f	43	1.0 a-d	63
CX-10440 [1]	13 fl oz	50	Polyoxin D zinc salt	19	40 gh	15	2.4 de	11
Optiva	1.0 lb		*Bacillus subtilis* str. QST 713	44	38 gh	19	2.1 b-e	22
Mettle 125ME	5 fl oz		Tetraconazole	3	35 fg	26	3.0 e	-10
Evito 480SC	6 fl oz		Fluoxastrobin	11	40 gh	15	2.4 de	11
Captan 80WDG	30 oz		Captan	M4	22 c-e	53	0.6 a-c	78
Treatment means followed by the same letter are not statistically different according to the Waller-Duncan K-ratio t-test (p = 0.05). 1. CX-10440 is the Certis USA, L.L.C. code for Polyoxin D Zinc Salt 5SC Fungicide.								

Venturia inaequalis (Scab) / Apples #1: Trial No. CER-2012-025: Results: Fruit								
Treatment	Rate/ Acre	g a.i./ ha	Active Ingredient	FRAC Code	Fruit with Scab on Tree (%)		Fruit with Scab at Harvest (%)	
					Measured	Percent Control	Measured	Percent Control
Untreated control			Not Applicable		87 g		87 e	
CX-10440 [1]	6.5 fl oz	25	Polyoxin D zinc salt	19	32 d	63	34 c	61
CX-10440 [1]	13 fl oz	50	Polyoxin D zinc salt	19	61 ef	30	58 d	33
Optiva	1.0 lb		*Bacillus subtilis* str. QST 713	44	73 f	16	57 d	34
Mettle 125ME	5 fl oz		Tetraconazole	3	65 ef	25	58 d	33
Evito 480SC	6 fl oz		Fluoxastrobin	11	55 e	37	55 d	37
Captan 80WDG	30 oz		Captan	M4	9 c	90	11 b	87
Treatment means followed by the same letter are not statistically different according to the Waller-Duncan K-ratio t-test (p = 0.05). 1. CX-10440 is the Certis USA, L.L.C. code for Polyoxin D Zinc Salt 5SC Fungicide.								

Disease observations:

- 03/16/2012: Ascospores were first trapped.
- 03/19-20/2012: Early primary infections.
- 04/13/2012: Scab lesions appeared on trees not protected.
- 04/26/2012: Most of the ascospores had matured.
- 04/18-19/2012: Severe secondary (and primary) scab infections.
- 04/21-23/2012: Severe secondary (and primary) scab infections.
- 05/5-30/2015: Later secondary infection periods.

Scab lesions were already present in the test block when the treatments series began April 13, 2012. Therefore, the treatments were applied curatively.

No phytotoxicity was reported.

c. Discussion and Conclusions

Apples were grown in Virginia near the border with Pennsylvania. In the untreated control, 47% of leaves were infected with scab and 87% of fruit was infected with scab.

Seven treatments of Polyoxin D Zinc Salt 5SC Fungicide were applied curatively at 7-day to 10-day intervals. A positive dose-response was not observed.

- Treatment at 6.5 fl oz/acre (25 g a.i./ha) provided 94% control of powdery mildew.
- Treatment at 13 fl oz/acre (50 g a.i./ha) provided 80% control of powdery mildew.

Polyoxin D Zinc Salt 5SC Fungicide applied at 6.5 fl oz/acre (25 g a.i./ha) provided mean 53% (range 43% to 63%) control of scab on leaves and fruit. This was statistically:

- Superior to the untreated control and to *Bacillus subtilis* str. QST 713 (Optiva);
- Equivalent to the control provided by fluoxastrobin and tetraconazole; and
- Less than the control provided by captan.

Polyoxin D Zinc Salt 5SC Fungicide applied at 13 fl oz/acre (50 g a.i./ha) provided mean 22% (range 11% to 33%) control of scab on leaves and fruit. This was statistically:

- Superior to the untreated control;
- Equivalent to the control provided by *Bacillus subtilis* str. QST 713 (Optiva), fluoxastrobin, and tetraconazole; and
- Less than the control provided by captan.

No phytotoxicity was reported.

Venturia inaequalis **(Scab) / Pome Fruits: Grower Need**

Control of foliar diseases on apples (Project No. B00092) was identified as a grower need at the IR-4 2015 Biopesticide Workshop.

Zygophiala jamaicensis (FLY SPECK) / POME FRUITS

Zygophiala jamaicensis (Fly Speck) / Pome Fruits: Introduction

(Source: Wayne F. Wilcox, Sooty Blotch and Flyspeck, Cornell Cooperative Extension Disease Identification Sheet No. D11, 1994)

Fly speck and sooty blotch are the two most common "summer diseases" of apples in the Northeast. They are also problems on pears. Although caused by two different organisms, the diseases often occur together since both are confined to the fruit surface and are favored by similar environmental and horticultural conditions. Disease incidence and severity can be highly variable among production regions, growing seasons, and even individual orchards. Economic losses result primarily from the diminished appearance and commercial quality of infected fruit.

Zygophiala jamaicensis (Fly Speck) / Pome Fruits: Symptoms

(Source: Wayne F. Wilcox, Sooty Blotch and Flyspeck, Cornell Cooperative Extension Disease Identification Sheet No. D11, 1994)

Symptoms of flyspeck are well-described by the disease name. Small, circular colonies of up to 50 or more tiny black dots (fungus fruiting bodies) form on the fruit surface. One to many individual colonies can form per fruit. Symptoms can develop as soon as 3-4 weeks after petal fall, but are usually much more common and severe by late summer or early fall.

Zygophiala jamaicensis (Fly Speck) / Pome Fruits: Disease Cycle and Causal Organisms

(Source: Wayne F. Wilcox, Sooty Blotch and Flyspeck, Cornell Cooperative Extension Disease Identification Sheet No. D11, 1994)

Flyspeck is caused by the fungus *Zygophiala jamaicensis.* The disease cycle is very similar to that of sooty blotch. The fungus overwinters as fruiting bodies (pseudothecia) on the twigs of infected apple trees and many of the same woody reservoir hosts colonized by the sooty blotch fungus. Bramble canes, however, appear to be a particularly common source of the flyspeck fungus. Spores within the pseudothecia (ascospores) are released during rains for a 1-2 month period starting around bloom, and are carried moderate distances by wind currents. The spores germinate at a temperature of 61-83°F (16-28°C), and a fungus colony begins developing on the fruit surface. Conditions for fungal growth are similar to those required by the sooty blotch fungus, although humidity requirements are even more restrictive. Virtually no flyspeck growth occurs at relative humidities below 95 percent.

The incubation period can be several weeks to several months, depending on the microclimate surrounding the fruit. Typical flyspeck symptoms result from the production of numerous dot-like pseudothecia within the fungus colonies on the fruit. These pseudothecia are connected by fine fungal strands (mycelium), which also bear microscopic secondary fungus spores (conidia). Conidia are then dispersed by wind currents and are able to cause additional fruit infections throughout the remainder of the growing season whenever conditions are favorable.

Zygophiala jamaicensis (Fly Speck) / Pome Fruits: Control

(Source: Wayne F. Wilcox, Sooty Blotch and Flyspeck, Cornell Cooperative Extension Disease Identification Sheet No. D11, 1994)

Control of flyspeck should integrate horticultural practices designed to reduce the chances of disease development together with fungicide sprays to protect against infection when necessary.

Because fly speck is so dependent on long periods of extreme humidity around the fruit, annual pruning to open tree canopies and promote air circulation will minimize the periods favorable for their development. Supplemental summer pruning in dense-canopied trees can provide significant additional benefits in some years. Proper fruit thinning is also important for reducing the development of high-humidity microclimates around clustered fruit. Like good pruning, thinning will furthermore improve the spray coverage for any fungicides that may be applied. Mowing of grass middles and good within-row weed control will provide additional help in reducing overall humidity levels within orchards during the summer.

The removal of hedgerows or surrounding woodlots is not always practical, but can substantially improve airflow and reduce humidities within the orchard. Destruction of the many woody reservoir hosts in these sites will also reduce some of the inoculum that initiates fruit infections. Because of their importance as an inoculum source, it is particularly important to eliminate brambles in hedgerows and within the orchard itself should they occur there.

The need for and timing of fungicide sprays to control these diseases is variable among orchards and years. In regions where they occur regularly, sprays should start around first cover and be repeated as necessary according to the prevailing weather conditions and material being used. Where the diseases occur more sporadically, fungicide programs should be initiated and continued on the basis of weather conditions, specific orchard factors, and previous experience. In general, fungicide programs will need to be most intense for orchards in low fog pockets, surrounded by woods, or with dense tree canopies. Minimizing these factors at the time of planting will help reduce the intensity of flyspeck control programs required in subsequent years.

Zygophiala jamaicensis (Fly Speck) / Pome Fruits: OMRI-Listed Fungicides for Use in the United States
(No efficacy data have been identified or evaluated.)

FRAC Code	Source: EPA Label							NOP Status
	Active Ingredient	Product Name	Product Rate/ Acre	PHI (Days)	REI (Days)	EPA Reg. No.	Comments	
44	*Bacillus amyloliquefaciens* str. D747	Double Nickel 55	0.25-3 lb	0	4	70051-108	Causes moderate eye irritation. Dermal sensitizer. Broad-spectrum preventative fungicide. Do not use highly alkaline or highly acidic water to mix sprays. Use a buffering agent if necessary to maintain neutrality (pH 6 to 8) of water in the tank. Suppression only. Make first application at popcorn stage and repeat every 7 days. Begin applications before bloom when environmental conditions favor disease development, repeating at 7 to 14 day intervals or as needed. Control may be enhanced by addition of a surfactant to improve spray coverage. Not for use in California.	Non-synthetic
	Bacillus subtilis str. QST 713	Serenade ASO	2-6 qt	0	4	264-1152	Broad spectrum preventative fungicidal and bactericidal product. Begin applications pre-bloom when environmental conditions are conducive to disease development. Repeat applications at 7- to 14-day intervals or as needed. NOT FOR USE IN CALIFORNIA.	Non-synthetic
		Serenade MAX	1-3 lb	0	4	69592-11	Dermal sensitizer. Broad spectrum preventative fungicidal and bactericidal product. Begin applications pre bloom when environmental conditions are conducive to disease development Repeat applications at 7 to 14 day intervals or as needed.	
		Serenade Optimum	14-21 oz	0	4	264-1160	Dermal sensitizer. Broad spectrum preventative fungicidal and bactericidal product. Begin applications pre bloom when environmental conditions are conducive to disease development Repeat applications at 7 to 14 day intervals or as needed. NOT FOR USE IN CALIFORNIA.	
P5	*Reynoutria sachalinensis*	Regalia Biofungicide	1-4 qt	0	4	84059-3	Causes moderate eye irritation. Preventative rather than a curative application. Apply prior to disease infestation to protect the growing leaf tissue. Avoid freezing.	Non-synthetic
M1	Copper octanoate	Cueva Fungicide Concentrate	0.5-2.0 gal/ 100 gal water	0	4	67702-2-70051	Harmful if swallowed or absorbed through skin. Toxic to fish and aquatic organisms. May cause some copper toxicity on some plant species. Store away from open fire or flame. Product may be damaged by freezing. Do not store product below 4°C. Do not mix with chelated or liquid fertilizers. Use caution when using product with other fungicides and insecticides. May cause russeting of susceptible apple varieties. Do not exceed the 1.0 gallon of product/100 gallons water use rate. Do not exceed one application during the fall, late dormant period. Do not exceed one application between silver tip and green tip growth stages. Do not apply more than 10,670 gallons of diluted spray per acre per year. Do not reapply within 5 days.	Synthetic
M2	Calcium polysulfide	Rex Lime Sulfur Solution	½ gallon/ 100 gallons water	2	48	71096-6	DANGER signal word. Corrosive. Causes irreversible eye damage. Causes skin burns. Harmful if swallowed or if absorbed through skin. Toxic to fish. Do not mix with acids or phosphate fertilizer products. Deadly and potentially extremely flammable hydrogen sulfide gas may be emitted. Do not store near fertilizers. Crop injury statements. Apply at 10 to 14 day intervals through the growing season; 4 to 6 applications.	Synthetic
Not classified; Inorganic salt	Potassium bicarbonate	EcoMate Amicarb O	2.5-5.0 lb/100 gal water	0	4	5905-541	Harmful if swallowed. Causes moderate eye irritation. Broad spectrum contact foliar fungicide. Prevent exposure to moisture during storage. Avoid contamination with other pesticides and fertilizers.	Synthetic
		Milstop	2.5-5.0 lb/100 gal water			70870-1-68539	Harmful if swallowed. Causes moderate eye irritation. Broad spectrum contact foliar fungicide. Do not mix with other soluble pesticides or fertilizers. Not compatible with mild alkaline solutions. Acidification of solution will cause reduced product performance. Prevent exposure to moisture during storage. Avoid contamination with other pesticides and fertilizers. NOT FOR USE IN CALIFORNIA.	

Zygophiala jamaicensis **(Fly Speck) / Pome Fruits: Efficacy Trials**

Zygophiala jamaicensis (Fly Speck) / Apple #1: Trial No. CER-2012-025

a. Design

Zygophiala jamaicensis (Fly Speck) / Apples #1: Trial No. CER-2012-025: Design				
Title:	Evaluation of Experimental and Registered Cover Spray Fungicide Combinations for Disease Control on Fuji Apple, 2012			
Authors and affiliation:	K.S. Yoder, A.E. Cochran, *et al.* Virginia Tech Agricultural Research and Extension Center Winchester, VA			
Publication:	PDMR 7:PF034			
Location:	Winchester, VA			
Crop:	Apple (Fuji)			
Disease name:	Fly Speck			
Pathogen:	*Zygophiala jamaicensis*			
Test plot design:	Random complete block			
Number of replicates:	4			
Application equipment:	Airblast			
Spray volume:	100 gal/acre			
Number of applications:	9			
Chronology:	Application Dates	Growth Stage	Application Interval	Harvest Date
	04/13/2012	Bloom-petal fall		10/04/2012
	04/25/2012		12 days	
	05/09/2012		14 days	
	05/24/2012		15 days	
	06/06/2012		13 days	
	06/20/2012		14 days	
	07/18/2012		28 days	
	08/02/2012		15 days	
	08/22/2012		20 days	

b. Results

Zygophiala jamaicensis (Fly Speck) / Apples #1: Trial No. CER-2012-025: Results								
Treatment	Rate/ Acre	g a.i./ ha	Active Ingredient	FRAC Code	Percent Fruit Infected		Percent Surface Area Infected	
					Measured	Percent Control	Measured	Percent Control
Untreated control			Not Applicable		87 i		6.6 h	
CX-10440 [1]	6.5 fl oz	25	Polyoxin D zinc salt	19	7 c-f	92	0.4 c-e	94
CX-10440 [1]	13 fl oz	50	Polyoxin D zinc salt	19	31 h	64	1.6 g	76
Optiva	1.0 lb		*Bacillus subtilis* str. QST 713	44	21 f-h	76	1.3 fg	80
Mettle 125ME	5 fl oz		Tetraconazole	3	20 e-h	77	1.1 e-g	83
Evito 480SC	6 fl oz		Fluoxastrobin	11	3 a-d	97	0.2 a-d	97
Captan 80WDG	30 oz		Captan	M4	21 gh	76	1.2 fg	82
Treatment means followed by the same letter are not statistically different according to the Waller-Duncan K-ratio t-test (p = 0.05). 1. CX-10440 is the Certis USA, L.L.C. code for Polyoxin D Zinc Salt 5SC Fungicide.								

The 250-hour wetting threshold for the presence of flyspeck was reached by May 25, 2012. Therefore, the treatments were preventative and curative.

No phytotoxicity was reported.

c. Discussion and Conclusions

Apples were grown in Virginia near the border with Pennsylvania. In the untreated control, 87% of the fruit was infected with fly speck and 6.6% of the surface area of the apples was infected with fly speck.

Nine fungicide treatments were applied preventatively and curatively at 12-day to 28-day intervals. Polyoxin D Zinc Salt 5SC Fungicide treatments did not provided a positive dose response.

- Treatment at 6.5 fl oz/acre (25 g a.i./ha) provided mean 93% (range 92% to 94%) control of fly speck.
- Treatment at 13 fl oz/acre (50 g a.i./ha) provided mean 70% (range 64% to 76%) control of fly speck.

Polyoxin D Zinc Salt 5SC Fungicide applied at 6.5 fl oz/acre (25 g a.i./ha) provided control of fly speck that was statistically:

- Superior to the untreated control, Polyoxin D Zinc Salt 5SC Fungicide applied at 13 fl oz/acre (50 g a.i./ha), and captan; and
- Equivalent to *Bacillus subtilis* str. QST 713 (Optiva), tetraconazole, and fluoxastrobin.

Polyoxin D Zinc Salt 5SC Fungicide applied at 13 fl oz/acre (50 g a.i./ha) provided control of fly speck that was statistically:

- Superior to the untreated control;
- Equivalent to the control provided by *Bacillus subtilis* str. QST 713 (Optiva), tetraconazole, and captan; and
- Less than the control provided by Polyoxin D Zinc Salt 5SC Fungicide applied at 6.5 fl oz/acre (25 g a.i./ha) and by fluoxastrobin.

No phytotoxicity was reported.

Zygophiala jamaicensis **(Fly Speck) / Pome Fruits: Grower Need**

Control of foliar diseases on apples (Project No. B00092) was identified as a grower need at the IR-4 2015 Biopesticide Workshop.

POST-HARVEST USES

Kaken has an EPA registration and California registration for Polyoxin D Zinc Salt 5SC Post-Harvest Fungicide (EPA Reg. No. 68173-5). Confirmatory commercial scale efficacy trials are planned for the 2016 use season. Given the small number of active ingredients registered for post-harvest use, users are concerned about both observed pest resistance and possible future pest resistance. Polyoxin D Zinc Salt 5SC Post-Harvest Fungicide will be an important addition to the post-harvest market.

HOME AND GARDEN USES

Novel 0.5%SC Fungicide (EPA Registration No. 70051-116) containing 0.5% polyoxin D zinc salt is registered by Certis USA, L.L.C. All of the inert ingredients in this formulation are allowed in formulations for organic use. Kaken proposes approval by the National Organic Program for the use of polyoxin D zinc salt for use in the organic home and garden market.

LETTERS OF SUPPORT

Please see Attachment 5 for previously submitted letters of support. Kaken anticipates submission of additional letters of support in advance of a future public hearing.

PETITION JUSTIFICATION STATEMENT

Polyoxin D zinc salt and Polyoxin D Zinc Salt 5SC Fungicide offer an important new crop production tool for organic growers.

Almost Non-Synthetic

Polyoxin D is produced via a fermentation process that meets the National Organic Program's definition of a non-synthetic material. Polyoxin D is very water soluble and would be readily washed off the surface of treated crops by irrigation water or rain water with an associated reduction in efficacy. To reduce the water solubility, Kaken converts polyoxin D to polyoxin D zinc salt via a simple chemical reaction. This simple chemical reaction causes polyoxin D zinc salt to be a synthetic material as defined by the National Organic Program.

Kaken does not control the production of the zinc used in the conversion of polyoxin D to polyoxin zinc salt. Therefore, Kaken cannot confirm that the purchased zinc source is mined or recycled.

Kaken has quality control standards. Kaken has conducted analyses for potential metal impurities of toxicological concern, *e.g.*, lead, arsenic, and cadmium. The product specifications for all products containing polyoxin D zinc salt submitted to and approved by the US Environmental Protection Agency do *not* permit any metal of toxicological concern as a listed impurity.

Kaken accepts the National Organic Program's classification of polyoxin D zinc salt as a synthetic material.

Non-Toxic Mode of Action

The mode of action of polyoxin D zinc salt is well understood. Polyoxin D zinc salt has a non-toxic mode of action. Polyoxin D zinc salt does not kill the target fungal plant pathogens. Instead, it stops the growth of the fungal plant pathogen.

Uridine diphosphate-N-acetylglucosamine binds with fungal chitin synthetase in the normal biosynthesis of chitin in fungi. In susceptible fungi, polyoxin D competes with uridine diphosphate-N-acetylglucosamine for the chitin synthetase binding sites, resulting in insufficient chitin for normal cell wall growth and loss of pathogenicity.

Not an Antibiotic

Bacteria contain no chitin. The above mode of action of polyoxin D is consistent with the observed absence of activity of polyoxin D against bacteria.

Yeasts contain chitin. Nonetheless, there has been no observed activity of polyoxin D against pathogenic yeast. Based upon the above summarized data, possibly this results from naturally high levels of uridine diphosphate-N-acetylglucosamine in yeast that favor uridine diphosphate-N-acetylglucosamine rather than polyoxin D in the competition for chitin synthetase binding sites. Alternatively, the shape of the chitin synthetase binding site in yeast may be slightly different than in susceptible fungi, resulting in polyoxin D having low binding affinity for the chitin synthetase binding site in yeast.

Polyoxin D and polyoxin D zinc salt have never been marketed as an antibiotic for use in human or veterinary medicine. There are *no* clinical trials that demonstrate efficacy of polyoxin D or polyoxin D zinc salt as an antibiotic for use in human or veterinary medicine.

Unique Mode of Action and Resistance Management

Polyoxin D zinc salt has a unique mode of action. No other active ingredient registered for use in North America has the same mode of action. In over 40 years of commercial use, there have been no observations of the development of pest resistance to polyoxin D zinc salt. Therefore, polyoxin D zinc salt can play an important role in resistance management programs.

All growers are encouraged to vary the mode(s) of action of the products they use to minimize the development of pest resistance. This is more challenging for organic growers than for conventional growers because organic growers have fewer available modes of action. While organic growers may have a variety of available products, the number of available modes of action is a smaller number.

Adding polyoxin D zinc salt to the organic grower's "tool box" will delay the development of pest resistance to organic growers' favorite products. This is a benefit to all fungicides used by organic growers.

Low Application Rate and Low Environmental Exposure

For Polyoxin D Zinc Salt 5SC Fungicide, the maximum single application rate is 0.72 oz a.i./acre. This is equivalent to 0.045 lb a.i./acre. This is a low application rate. Therefore, there is low environmental exposure. By comparison, example active ingredient maximum application rates for OMRI-listed alternative products are generally much higher than the polyoxin D zinc salt maximum application date. Actinovate (*Streptomyces lidicus*) is an exception.

Relative Maximum Active Ingredient Single Application Rates						
Brand Name (EPA Reg. No.)	Active Ingredient	AI Conc. (%)	Use	Maximum Single Application Rate		Relative Maximum Active Ingredient Single Application Rate for the Specified Use
				Formulation	Active Ingredient (lb/acre)	
Actinovate AG (73314-1)	*Streptomyces lidicus*	0.0371	Powdery mildew/ Berries	12 oz/acre	0.00028	0.0066
Oso 5%SC (68173-4-70051)	Polyoxin D zinc salt	5.0	Powdery mildew/ Berries	13.0 fl oz/acre	0.042	1
Serenade Max (69592-11)	*Bacillus subtilis* str. QST 713	14.6	Botrytis/ Berries	3.0 lb/acre	0.438	10
Cinnerate [FIFRA §25(b)]	Cinnamon oil	60.0	Powdery mildew/ Berries	30 fl oz/ 100 gallons water x 125 gallons solution/acre	1.38	33
Basic Copper 53 (45002-8)	Basic copper sulfate	98.0	Downy mildew/ Lettuce	3 lb/acre	2.94	70
Kaligreen (70231-1)	Potassium bicarbonate	82.0	Powdery mildew/ Cucurbits	5 lb/acre	4.10	98
Kumulus DF (51306-352-66330)	Sulfur	80.0	Powdery mildew/ Melons	25 lb/acre	20.0	476
Oxidate 2.0 (70299-2)	Hydrogen dioxide, Peroxyacetic acid	29.1	Powdery mildew/ Berries	128 fl oz/100 gal water x 100 gal solution/acre (Assume formulation has the density of water.)	Approximately 35.7	Approximately 850

Rapid Environmental Degradation
Polyoxin D zinc salt degrades rapidly under normal environmental conditions.

The aqueous photolysis half-life of polyoxin D, under neutral (pH 7.0) sterile conditions, is 2.3 days. Within 16 days, more than 99% of the applied polyoxin D degrades to low toxicity metabolites.

For many growers, polyoxin D's half life is at the "sweet spot." It is:
- Long enough to do its job *without* needing to make another application; but
- Short enough that the product does *not* accumulate in the environment.

No Adverse Effects on Soil and Soil Fungi
When used according to the directions for use, Polyoxin D Zinc Salt 5SC Fungicide has:
- No adverse effects on nitrogen fixation in soil (measured as NO_3-N production); and
- No adverse effects on carbon transformation in soil (measured as O_2 consumption) 28 days after soils were treated at 1.31 mg/kg dry soil and 6.56 mg/kg dry soil.

A separate soil study was conducted specifically to address concerns of a member of the National Organic Standards Board regarding possible effects on soil fungi, especially beneficial soil fungi. Two field test sites were selected that had received no pesticide treatments and no fertilizer treatments during the preceding 3 years.
- The site near Yakima, Washington had sandy loam soil with 1.9% organic matter. The pH of the soil was 7.8 (slightly alkaline).
- The site near Madison, Wisconsin had silty clay loam soil with 3.8% organic matter. The pH of the soil was 5.4 (acidic).

The test sites were tilled, and the bare sole was treated with Polyoxin D Zinc Salt 5SC Fungicide at the maximum label rate. Each site had an untreated control.

Experiment 1. The soil samples were subjected to routine microbiological analysis using malt yeast extract agar which is selective for the growth of fungi. There was no statistically significant difference in the number of fungal colonies in the control vs treated soil samples for samples collected on Days 0, 1, 7,14, 21, and 28. Interestingly, treatment with the test substance resulted in a statistically significant *increase* in the number of viable soil fungi on Day 3 at both the Washington and Wisconsin sites. The reduction of viability of soil fungi that might be anticipated following exposure to most fungicides was *not* observed following exposure to the test substance. Instead, a brief and reversible statistically significant increase in soil fungal viability was observed. This is consistent with the non-toxic mode of action of polyoxin D zinc salt, *i.e.*, it reversibly stops the growth of susceptible fungi without killing the fungus. This experiment demonstrated that Polyoxin D Zinc D Salt 5SC Fungicide applied to bare soil at the maximum label rate did *not* adversely effect the viability of soil fungi.

Experiment 2. Polymerase chain reaction analysis was used to qualitatively confirm that the soil fungi observed in Experiment 1 included *beneficial* soil fungi. The intergenic spacer region gene which is unique to beneficial fungi was determined to be present in the fungi from both the control and treated soil samples in Experiment 1. Experiment 2 demonstrated that Polyoxin D Zinc Salt 5SC Fungicide applied to soil at the maximum label rate did *not* adversely effect *beneficial* soil fungi.

No Anticipated Accumulation of Zinc in the Soil
When used according to the directions for use, Polyoxin D Zinc Salt 5SC Fungicide provides zinc at a level that is consistent with application of zinc to soil as a micronutrient. No accumulation of zinc in soil is anticipated via the registered use of Polyoxin D Zinc Salt 5SC Fungicide. Instead, it is anticipated that treated crops will absorb the zinc from polyoxin D zinc salt as a needed micronutrient for incorporation into essential plant enzymes.

Practically Nontoxic to Honeybees

Based upon the results of the acute oral and acute contact toxicity studies in honeybees, Polyoxin D zinc salt is practically non-toxic to honeybees.

No Adverse Effects on Ladybird Beetles

To respond to a concerns expressed by a member of the National Organic Standards Board, Kaken conducted an acute exposure study and a chronic exposure study regarding toxicity to and development of ladybird beetles.

Acute Exposure Study

Total immersion of ladybird beetle adults and 3rd instar larvae in 150 mg a.i./L aqueous solutions of Polyoxin D Zinc Salt Technical for 5 seconds resulted in:

- *No* mortality three days after treatment of both the adults and third instar larvae.
- *No* adverse effects on development (emergence as adults) of third instar larvae.

No acute adverse effects were observed.

Chronic Exposure Study

The Polyoxin D Zinc Salt 5SC Fungicide applied at the maximum label rate (13.0 fl. oz./acre) a total of three times did *not* adversely affect:

- The number of ladybird beetle eggs that hatched;
- The development of ladybird beetle larvae and pupae; and
- The number of ladybird beetles that emerged as adults.

No chronic adverse effects were observed.

No Adverse Effects on Other Beneficial Insects and a Predatory Spider

As noted in the March 4, 2012 petition, polyoxin D zinc salt has been determined to have no adverse effects on the following beneficial insects and mite:

- Silkworm (Kinshu x Showa);
- Marmalade hoverfly;
- Green lacewing;
- *Aphelinus mali* (a parasitic wasp); and
- Wolf spider.

Low Risk to Fish and Aquatic Invertebrates

As discussed in the March 4, 2012 petition, Polyoxin D Zinc Salt Technical is moderately toxic to fish and aquatic invertebrates.

Data Requirement	LC_{50}	Toxicity Category [A]	MRID
Freshwater Fish 96-hr LC_{50}	5.06 ppm	Moderately toxic	432618-42
Freshwater Aquatic Invertebrate Toxicity	1.35 ppm	Moderately toxic	432618-43

A. EPA Science Review in Support of a Tolerance Exemption Petition for Polyoxin D Zinc Salt (August 18, 2008).

Risk is defined as the product of hazard and exposure.

Risk = Hazard x Exposure

“Moderately toxic” describes the hazard component of this equation.

Exposure to polyoxin D zinc salt is very low due to:

- Low application rates; and
- Rapid degradation under normal environmental conditions.

In its August 18, 2008 Science Review, EPA concludes that polyoxin D zinc salt has low risk to fish and aquatic invertebrates. EPA wrote:

> "However, based upon the application rate and the proposed use patterns, the aquatic estimated environmental concentrations do not exceed any levels of concern for any aquatic non-targets, including threatened and endangered species."

Practically Non-Toxic to Other Non-Target Organisms

As noted in the previous petition and follow-up correspondence, Polyoxin D Zinc Salt Technical has been determined to be practically non-toxic to birds, algae, and earthworms.

Mild Dermal Sensitizer

The dermal sensitization report for Polyoxin D Zinc Salt 5SC Fungicide states:

> "The test substance produced very faint to faint erythema in 15 of 20 Test animals, but no reaction in any Naive control animals after the challenge treatment. Therefore, Polyoxin D Zinc Salt SSC is a mild sensitizer in Guinea pigs."

The Polyoxin D Zinc Salt 5SC Fungicide label states:

> "Prolonged or frequently repeated skin contact may cause allergic reactions in some individuals."

Dermal sensitization results are Yes/No endpoints. There is no number associated with the results. Therefore, dermal sensitization results and are not used in *quantitative* risk assessments.

Especially Low Toxicity to Humans and Non-Target Mammals

With the exception of the dermal sensitization results, no significant acute, subchronic, mutagenic, immunotoxic, developmental, or chronic dietary toxicity hazards were identified for polyoxin D zinc salt and Polyoxin D Zinc Salt 5SC Fungicide.

Polyoxin D zinc salt and Polyoxin D Zinc Salt 5SC Fungicide have:

- Especially low mammalian toxicity;
- Low applications rates; and thus
- Especially low mammalian risk.

Polyoxin D zinc salt and Polyoxin D Zinc Salt 5SC Fungicide are reduced risk pesticides.

Based upon label statements, Polyoxin D Zinc Salt 5SC Fungicide has lower human risk than most of the OMRI-listed alternative products, including most of the non-synthetic alternative products.

The lower risk enables reduced personal protection equipment requirements. For example, no protective eye wear and no respiratory protection are required for Polyoxin D Zinc Salt 5SC Fungicide.

No Observed Phytotoxicity

In over 40 years of commercial use and in even more years of field trials, there have been *no* observations of phytotoxicity resulting from of any formulation of polyoxin D zinc salt. Similarly, there have been on observations of injury to non-target plants.

Reduced Risk Product for Integrated Pest Management and Resistance Management

Polyoxin D zinc salt has a unique, non-toxic mode of action. It is selective for sensitive plant-pathogenic fungi. Polyoxin D zinc salt is a reduced risk fungicide that is well suited for use in integrated pest management and resistance management programs.

Clear Label Claims

The labels for all agricultural use products containing polyoxin D zinc salt clearly match the crops to be treated with the specific pathogen/disease for that crop or group of crops. By contrast, the polyoxin D zinc salt product labels for commercial use do *not* have a list of diseases and a separate list of crops, requiring the user to evaluate the efficacy of the specific crop/disease combinations of interest.

Inert Ingredients

Polyoxin D Zinc Salt 5SC Fungicide was developed specifically for the organic agricultural market. All of the inert ingredients are acceptable for use in organic pesticide formulations.

Efficacy Trials

Polyoxin D zinc salt was first registered:

- For use in Japan over 40 years ago;
- For non-food use in the United States during 1997; and
- For food use during 2008.

Polyoxin D zinc salt has competed directly with conventional pesticides. Many efficacy trials for Polyoxin D Zinc Salt 5SC Fungicide include comparisons with conventional fungicides, OMRI-listed conventional fungicides, (*e.g.*, copper and sulfur), and OMRI-listed biological and biochemical fungicides.

All of the efficacy data summarized in this petition are for the same formulation, *i.e.*, Polyoxin D Zinc Salt 5SC Fungicide (a.k.a. Veggieturbo 5SC Suspension Concentrate Fungicide, Oso 5%SC, Tavano 5%SC, and CX-10440). For simplicity, summaries of efficacy data for older polyoxin D zinc salt formulations (2.5% wettable powder and 11.3% water dispersible granules) are *not* included in this petition.

Efficacy data have been summarized in this petition for disease/crop combinations that are economically important to organic growers. For most of the summarized efficacy trials:

- Disease was observed *during* the spray season for the trial; and
- The treatments are described as preventative and curative.

For six of the trials:

- Disease was observed *before* the first fungicide application was applied; and
- The treatments are described as curative.

Disease Common Name	Crop(s)	Preventative and Curative	Curative
Alternaria	Blueberries		
Anthracnose	Strawberries	✔	
Botrytis	Blueberries, Grapes, Potatoes	✔	
Cotton ball	Cranberry		
Cranberry fruit rot complex	Cranberries, watermelon		
Downy mildew	Cucurbits, Lettuce	✔	
Early blight	Potato, Raspberries, Strawberries, Potato	✔	
Fly speck	Apples	✔	
Gummy stem blight	Cucurbits	✔	✔
Late blight	Potatoes, Tomatoes	✔	
Monilinia brown rot	Stone fruit	✔	✔
Mummyberry	Blueberries	✔	
Powdery mildew	Apples, Cherries, Blackberries, Grapes, Strawberries, Cucurbits, Lettuce, Tomatoes	✔	✔
Scab	Apples		✔
Sooty blotch	Apples	✔	
Southern blight	Cucurbits		
Target spot	Tomatoes	✔	
White rust	Spinach		✔

Increased Yields

For some efficacy trials, noteworthy increases in crop yield were observed. Most notably, 482% to 552% increased yields were observed following treatment of squash with Polyoxin D Zinc D Salt 5SC Fungicide for control of southern blight (Trial No. CER-2012-050).

Post-Harvest Control from Pre-Harvest Treatments

Preharvest applications of Polyoxin D Zinc Salt 5SC Fungicide has demonstrated post-harvest control of:

- Alternaria on blueberries (Trial No. CER-2012-049); and
- Brown rot on stone fruits (Trial Nos. CER-2013-019 and CER-2015-035).

Responsive to Grower Needs

IR-4 conducts annual workshops during which grower needs are prioritized for research using limited IR-4 resources. The current (or pending) Polyoxin D Zinc Salt 5SC Fungicide label addresses the following grower needs prioritized during the September 2015 IR-4 Biopesticide Workshop.

Category	Use		IR-4 Project No.	Organic	Conventional	EPA Label	
	Disease	Crop				Registered	Pending
Organic	Downy mildew	Organic cucurbit	B00149	✔		✔	
	Downy mildew	Organic pumpkin, squash	B00127	✔		✔	
	Late blight	Organic tomato	B00112	✔		✔	
	Anthracnose, Alternaria	Blueberry	B00083	✔		✔	
	Mummy berry	Blueberry	B00083	✔			✔
	Mummy berry	Organic blueberry (bushberry)	B00053	✔			✔
Fruit	Powdery mildew	Grape	B00130		✔	✔	
	Botrytis	Strawberry, raspberry	B00129		✔	✔	
	Foliar disease	Apple	B00092		✔	✔	
	Botrytis bunch rot	Grapes	B00063		✔	✔	
	Mummy berry	Blueberry	B00062		✔		✔
	Brown rot blossom blight & fruit rot	Stone fruit	B00054		✔	✔	
	Botrytis bunch rot	Grape	B00052		✔	✔	
Vegetables	Botrytis	Greenhouse tomato	B00165		✔	✔	
	Target spot	Tomato	B00128		✔		✔
	Downy mildew	Cucurbit	B00051		✔	✔	
	Zero-day PHI products	Greenhouse vegetables	B00024		✔	✔	
	Late blight	Potato	B00009		✔	✔	
Other	Post-harvest	Export crops	B00013		✔	✔	

Kaken proposes that conventional grower needs are also organic grower needs, *i.e.*, insufficient *effective* options are currently available.

Efficacy trials were conducted during 2015 for which the reports are not yet available. Also, efficacy trials are planned for the 2016 use season that focus on grower needs for diseases for which Kaken currently has no efficacy data. Kaken is hopeful that additional diseases important to US organic growers can be added to the Polyoxin D Zinc Salt 5SC Fungicide EPA and California Department of Pesticide Regulation registered labels in the near future.

No Current OMRI-listed Alternatives

To the best of Kaken's knowledge, there are currently no OMRI-listed alternatives for the following uses that are included in this petition:

- *Monilinia oxycocci* (Cottonball) / Cranberries; and
- *Sclerotinium rolfsii* (Southern Blight) / Cucurbits.

Grower Convenience

Polyoxin D Zinc Salt 5SC Fungicide has greater than 1 year storage stability (shelf-life). Polyoxin D Zinc Salt 5SC Fungicide has no physical-chemical hazards and no unusual storage requirements.

In the United States, polyoxin D zinc salt has a zero-day pre-harvest interval (PHI), a 4-hour worker re-entry interval, minimal personal protective equipment (PPE) requirements, and a tolerance exemption for all crops.

International Considerations

All crops treated in the United States with polyoxin D zinc salt per the US EPA registered label may be exported to Mexico. There is no Mexican MRL for polyoxin D zinc salt residues.

An import MRL application for polyoxin D zinc salt is pending at Canada's Pest Management Regulatory Agency (PMRA). Canadian regulation of polyoxin D zinc salt residues similar to that in the United States has been proposed. Kaken anticipates receiving PMRA's decision regarding the import MRL application during August 2016.

An import MRL application for polyoxin D zinc salt residues is pending in New Zealand.

Kaken is actively supporting additional new authorizations for polyoxin D zinc salt in additional countries and regions.

Essential for Organic Production and Compatible with Organic Production Practices

Polyoxin D zinc salt is a new reduced risk product with demonstrated efficacy and a new unique, non-toxic mode of action. Polyoxin D zinc salt can be a strong benefit to organic growers.

- Polyoxin D zinc salt fills many needs identified by growers for the 2015 IR-4 Biopesticide Workshop.
- Polyoxin D zinc salt is compatible with organic production practices.
- Polyoxin D zinc salt can be a significant new addition to organic growers' integrated pest management programs and resistance management programs.
- Use of polyoxin D zinc salt will enable organic growers to reduce their use of current OMRI-listed products that are phytotoxic, toxic to humans, toxic to the soil, and toxic to non-target organisms.

Kaken respectfully requests the support of the National Organic Standards Board and the National Organic Program to amend 7 CFR §205.601 to add Polyoxin D Zinc Salt as a synthetic substance allowed for use in organic crop production, including post-harvest use.

Post-Harvest Use

Kaken has an EPA registration and California registration for Polyoxin D Zinc Salt 5SC Post-Harvest Fungicide (EPA Reg. No. 68173-5). Confirmatory efficacy trials are planned for the 2016 use season. Given the small number of active ingredients registered for post-harvest use, users are concerned about both observed pest resistance and possible future pest resistance. Polyoxin D Zinc Salt 5SC Post-Harvest Fungicide will be an important addition to the post-harvest market. Additional products for the control of post-harvest diseases on export crops (Project No. B00013) was identified as a grower need at the IR-4 2015 Biopesticide Workshop.

Home and Garden Use

Novel 0.5%SC Fungicide (EPA Registration No. 70051-116) containing 0.5% polyoxin D zinc salt is registered by Certis USA, L.L.C. All of the inert ingredients in this formulation are allowed in formulations for organic use. Kaken proposes approval by the National Organic Program for the use of polyoxin D zinc salt for use in the organic home and garden market.

APPENDIX 1: CALCULATION OF METRIC EQUIVALENTS

5% Suspension Concentrate Formulation Application Rates

Sample Calculation:

(3.5 fl oz 5SC/acre) x (1 US gal 5SC /128 fl oz 5SC) x (7.03 oz a.i.//gal 5SC) x (1 lb a.i./16 oz ai) x (1000 g a.i./2.2 lb ai) x (2.47103 acres/ ha) = 13 g a.i./ha

Conversion Table:

fl oz 5SC/acre	g a.i./ha
3.5	13
3.75	14
3.8	15
5.6	22
6.0	23
6.5	25
6.7	26
7.0	27
7.5	29
12	46
13	50
14	54

Sample calculation:

(3.75 fl oz 5SC/acre) x (1 US gal 5SC /128 fl oz 5SC) x (3.78531 liters 5SC/US gal 5SC) x (1000 ml 5SC/liter 5SC) x (2.47103 acres/ ha) = 274 ml 5SC/ha

Conversion table:

fl oz 5SC/acre	ml 5SC/ha
3.75	274
3.8	278
6.5	475
7.5	548
13	950

Inoculant Concentrations

Sample calculation:

$$(4.07 \times 10^{4} \text{ conidia/fl oz}) \times (0.033814 \text{ fl oz/mL}) = 1.38 \times 10^{3} \text{ conidia/mL}$$

Conversion table:

conidia/fl oz	conidia/mL
4.07×10^{4}	1.38×10^{3}
1.28×10^{5}	4.33×10^{3}

ATTACHMENTS

1. Previous Correspondence from Kaken in Response to the Technical Evaluation Report or Crops Subcommittee Recommendation
    a. 2013/01/23 Reply to the Technical Evaluation Report (Page 5 Revised)
    b. 2013/03/06 Kaken written comments for the public hearing
    c. 2013/03/19 Additional Kaken written comments for the public hearing
    d. 2013/03/22 Non-target organism study reports
        - Green Lacewing
        - Marmalade Hoverfly
        - Silkworm
        - Wolf Spider
    e. 2013/04/04 Earthworm study report summary

2. Current EPA Registered Labels for Products Proposed for Use in Organic Crop Production
    a. EPA Reg. No. 68713-1: Polyoxin D Zinc Salt Technical
    b. EPA Reg. No. 68173-4: Veggieturbo 5SC Suspension Concentrate Fungicide
    c. EPA Reg. No. 68173-5: Polyoxin D Zinc Salt 5SC Post-Harvest Fungicide
    d. EPA Reg. No. 70051-116: Novel 0.5%SC Fungicide

3. Pending EPA Label:
    a. EPA Reg. No. 68173-4: Veggieturbo 5SC Suspension Concentrate Fungicide

4. EPA Documents
    a. May 11, 2012 EPA Science Review
    b. September 12, 2012 final rule (amended tolerance exemption)

5. Letters of Support

1. Previous Correspondence from Kaken in Response to the Technical Evaluation Report or Crops Subcommittee Recommendation

1.a. 2013/01/23 Reply to the Technical Evaluation Report (Page 5 Revised)

Polyoxin D Zinc Salt: Reply to and Comments Regarding the National Organic Program Technical Evaluation Report Dated September 23, 2012

NON-CONFIDENTIAL

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TABLES

APPENDICES

1. PETITION BASICS

1.1. SYNTHETIC VS NON-SYNTHETIC

On January 25, 2012, Kaken Pharmaceutical Co., Ltd. (Kaken) submitted a petition to confirm that polyoxin D zinc salt is a non-synthetic material and may be used in organic crop production on growing crops and on harvested commodities.

On February 22, 2012, based upon the preliminary communications with NOP, Kaken was advised that polyoxin D appears to be natural, but due to the absence of information that polyoxin D zinc salt is naturally occurring, it appears that polyoxin D zinc salt is synthetic. NOP suggested that Kaken consider re-positioning polyoxin D zinc salt as a synthetic material.

Polyoxin D is produced via an aerobic fermentation process. Polyoxin D is converted to polyoxin D zinc salt using an aqueous process. No organic solvent impurities are present in Polyoxin D Zinc Salt Technical. Zinc is a mined mineral. Please see http://www.zinc.org/basics/zinc_production. Zinc is also recycled. Please see http://www.zinc.org/basics/zinc_recycling. Kaken is not the producer of the zinc source used in the production of polyoxin D zinc salt and does not know if the zinc is "virgin" zinc from a mine or recycled zinc.

On March 4, 2012, in response to comments from NOP, Kaken submitted an amended petition that requested amendment of 7 CFR §205.601 to add polyoxin D zinc salt as a **synthetic** substance allowed for use in organic crop production. **The March 4, 2012 amended petition is not acknowledged in the September 23, 2012 Technical Evaluation Report.** (See lines 135-159.)

1.2. PETITION UPDATE

Please note the following:

- The Technical Evaluation Report is dated September 23, 2012.
- Based upon the status report on the Internet (http://www.ams.usda.gov/AMSv1.0/getfile?dDocName=STELPRDC5098805), the Technical Evaluation Report was deemed sufficient on November 20, 2012.
- Kaken received a copy of the Technical Evaluation Report on December 6, 2012.

On October 2, 2012, Kaken submitted an update for the pending petition that included:

- The May 11, 2012 EPA science review of polyoxin D zinc salt of data submitted September 23, 2011 to support the petition for and expanded tolerance exemption.
- The September 12, 2012 published final rule that expanded the tolerance exemption for polyoxin D zinc salt from listed crops to all agricultural commodities, including crops treated post-harvest.
- The September 28, 2012 EPA stamped accepted label for VEGGIETURBO 5SC Suspension Concentrate Fungicide (EPA Reg. No. 68173-4) which includes directions for use on a large number of new uses. The VEGGIETURBO 5SC Suspension Concentrate Fungicide formulation was designed for the organic market and will be marketed in the United States by Certis USA under the brand names OSO 5%SC Fungicide and TAVANO 5%SC Fungicide.

The October 2, 2012 update to NOP is not acknowledged in the NOP Technical Evaluation Report.

Effective January 1, 2013, CDPR registered VEGGIETURBO 5SC Suspension Concentrate Fungicide. The uses on the CDPR stamped accepted label include all of the uses on the EPA stamped accepted label with the exception of artichokes, ginseng and sugar beets. This document provides updates that include the CDPR registration.

1.3. SUBJECT AND SCOPE OF THE PETITION

1.3.1. Limited to Polyoxin D Zinc Salt

The subject of the petition is polyoxin D zinc salt (technical grade; active ingredient in EPA Reg. No. 68173-1; CAS No. 146659-78-1) and its proposed use as a synthetic substance for use in organic crop production.

Kaken notes that most of the research data regarding polyoxin D zinc salt was conducted to support EPA and other registrations and is largely unpublished data. **Key EPA documents that summarize EPA's review of the registration data were included in the petition submitted to NOP and appear to have been generally overlooked.**

1.3.2. Excludes Other Polyoxins

The Technical Evaluation Report includes data for compounds other than polyoxin D zinc salt. It appears that a literature search for "polyoxin" was conducted that presumably listed citations for all polyoxins, including polyoxin A through polyoxin N. However, the Technical Evaluation Report does not differentiate polyoxin D and polyoxin D zinc salt from other polyoxins.

1.3.3. Excludes Polyoxin Complex

Polyoxin Complex and formulations containing Polyoxin Complex are registered in Asia, but not in the United States. Polyoxin Complex and its formulation, Polyoxin AL WP, contain Polyoxin A, Polyoxin B, Polyoxin L, and Polyoxin K. Polyoxin Complex contains no Polyoxin D and no Polyoxin D zinc salt.

2. CHARACTERIZATION OF PETITIONED SUBSTANCE

2.1. MODE OF ACTION

Polyoxin D zinc salt has a non-toxic mode of action. Polyoxin D zinc salt inhibits the chitin synthetase found in fungi. This prevents the growth of fungi without killing the fungi. As such, polyoxin D zinc salt is truly fungistatic rather than fungicidal.

Page 3 of the May 11, 2012 EPA science review states,

> *"This inhibition of chitin synthesis is limited to chitin in fungal cell walls. Polyoxin D and its zinc salt do not inhibit the synthesis of chitin in animals that contain chitin, such as for insects and crustaceans that contain chitin in their exoskeletons. Polyoxin D Zinc Salt does not affect mammals because mammalian cells have plasma membranes that do not contain chitin."*

Page 56129 of the September 12, 2012 Federal Register notice regarding polyoxin D zinc salt states,

> *"This biochemical active ingredient has a nontoxic mode of action, which acts against fungi by inhibiting chitin growth in the cell walls, thus precluding the development of fungal colonies. Its effects are considered fungi-exclusive in that it has no mode of action relative to mammals and passes through mammalian digestive systems."*

The Technical Evaluation Report incorrectly states that polyoxins are toxic to fungi.

Line	Technical Evaluation Report Text
110	Polyoxin D Zinc Salt is a toxin derived from *Streptomyces cacaoi* var. asoensis, a soil-borne microorganism.
178-179	Polyoxins are most toxic against the following pathogens: *Alternaria kikuchiana, Pellicularia sasaki*, *Cochliobolus miyabeanus*, *Pyricularia oryzae* and *Neurospora crassa* (Hall, 1979).
233	As a broad-spectrum antibiotic and fungicide, polyoxin D Zinc Salt is toxic to soil fungi.

2.2. NOT AN ANTIBIOTIC

2.2.1. Marketing Claims for Polyoxin D Zinc Salt

Commercially significant quantities of polyoxin D zinc salt are produced exclusively by Kaken Pharmaceutical Company, Ltd. (Kaken). Kaken's polyoxin D zinc salt is marketed in the United States and elsewhere in the world **exclusively as a plant protection product**. Kaken has never marketed Polyoxin D or Polyoxin D zinc salt for use in human or veterinary medicine.

Research size samples of polyoxin D have been available from Fisher Scientific and other chemical supply companies. These research quantity suppliers make (or made) no antibiotic claims for their polyoxin D product.

2.2.2. US Environmental Protection Agency's Position

Polyoxin D zinc salt was first registered for use in the United States during 1997.

The May 11, 2012 EPA review of polyoxin D zinc salt states on pages 3-4:

> *"Polyoxin D Zinc Salt is used exclusively on plants as an anti-fungal agent in the United States and elsewhere. Based upon maximum inhibitory concentration (MIC) evaluations, Polyoxin D Zinc Salt is not effective as an anti-bacterial agent. Polyoxin D Zinc Salt has never been used as an antibiotic in human or veterinary medicine. Polyoxin D Zinc Salt is not effective in inhibiting bacteria and yeast, but in the 14 fungal species tested, effectiveness of inhibition ranged from highly effective to ineffective."*

The May 11, 2012 EPA review of polyoxin D zinc salt further states on pages 4-5:

> *"The mode of action of Polyoxin D and its zinc salt is the inhibition of chitin synthesis in the cell walls of fungi, some of which are pathogenic to plants. Polyoxin D and its zinc salt do not inhibit the synthesis of chitin in animals that contain chitin, and it does not affect mammals because mammalian cells have plasma membranes that do*

not contain chitin. Polyoxin D Zinc Salt is used exclusively on plants as an anti-fungal agent in the United States and elsewhere. It is not effective as an antibacterial agent, and it has never been used as an antibiotic in human or veterinary medicine. The data reported on minimum inhibitory concentrations in numerous species of bacteria, yeast, and fungi demonstrated no effectiveness in inhibiting bacteria and yeast, but in the 14 fungal species tested, effectiveness of inhibition ranged from highly effective to ineffective."

"In tests on 14 bacterial species (10 aerobic, 3 anaerobic, and 1 acid-fast), there was no demonstrated inhibition of bacterial growth in agar at concentrations up to 400 µg/mL (MRID 48653308). The species tested included pathogenic, intestinal, and other general bacteria that exist widely in nature. As expected, because bacteria contain no chitin, polyoxin D appears to have no effect on bacterial growth."

A complete copy of the above referenced maximum inhibitory concentration (MIC) reports was included as Appendix 3 and 4 of the public version of the January 25, 2012 initial petition and the March 4, 2012 amended petition. For the convenience of the reader, the maximum inhibitory concentration data are included in this document as APPENDIX 1.

2.2.3. Does Not Fit the Regulatory (FFDCA) Definition of an Antibiotic

Neither "antibiotic" nor "antibiotic drug" are defined:

- In the Federal Insecticide Fungicide and Rodenticide Act (FIFRA);
- By the US Department of Agriculture; or
- By the National Organic Program.

The Federal Food Drug and Cosmetic Act (FFDCA) defines an "antibiotic drug." Section 201 of 21 U.S.C. 321 states:

"(jj) *The term "antibiotic drug" means any drug <u>(except drugs for use in animals other than humans)</u> composed wholly or partly of any kind of penicillin, streptomycin, chlortetracycline, chloramphenicol, bacitracin, or any other drug <u>intended for human use</u> containing any quantity of any chemical substance which is produced by a micro-organism and which has the capacity to inhibit or destroy micro-organisms in dilute solution (including a chemically synthesized equivalent of any such substance) or any derivative thereof."* [Emphasis added.]

The proposed allowed use of polyoxin D zinc salt in organic crop production under 7 CFR §205.601 is a proposed regulatory authorization. **It is appropriate that a regulatory definition of "antibiotic" is used when NOP makes a regulatory decision regarding products that can be used in organic crop production. A non-regulatory definition would be viewed as arbitrary and capricious.**

Using the above FFDCA definition of an antibiotic, polyoxin D zinc salt is NOT an antibiotic drug because Polyoxin D zinc salt:

- **Is not intended for human use, and**
- **Is not for use in animals other than humans.**

Using the above FFDCA definition of an antibiotic, products that are used both as pharmaceuticals and as crop protection products can be identified and evaluated for implications for antibiotic resistance and for human and veterinary medicine. No such evaluation is needed for Polyoxin D zinc salt.

2.2.4. Definition of Antibiotic Used in Published Literature

Gottlieb and Shaw (1970)

Paragraph 2 states:

> *"Despite the fact that the term antibiotic has been a common household word for at least 20 years, not even scientific investigators agree on its definition. We shall use the term for organic substances that are produced by microbes and are deleterious at low concentrations to the growth or metabolic activities of other organisms. The compound need inhibit only one organism in order to qualify for the definition. A compound would not be excluded if it were also produced by a higher organism or animal."*

Gottlieb and Shaw (1970) note that their definition of an antibiotic is not an agreed definition. They described the mode of action of polyoxins as inhibition of cell wall formation. However, Gottlieb and Shaw (1970) make no claim that polyoxins have efficacy against fungal pathogens of humans or other animals.

The arbitrary definition and use of "antibiotic" in the early literature to describe polyoxins was repeated in the subsequent literature and the Technical Evaluation Report.

2.2.5. Repetitive Use of Arbitrary Definition of Antibiotic Used by Gottlieb and Shaw (1970)

NOP Technical Evaluation Report Lines 173-175 state:

> *"Polyoxins have long been regarded as antibiotics in both their structure and function (Gottlieb and Shaw, 1970; Worthington, 1988; DeBono and Gordee, 1994; Knight, et al., 1997, Dreikhorn and Owen, 2000; Suhadolnik and Reichenbach, 2000; EPA, 2001; O'Neill, 2006)."*

NOP Technical Evaluation Report Lines 309-312 state:

> *"Polyoxin D has been shown to be effective as a drug to treat the human and animal pathogens Candida albicans and Cryptococcus neoformans (Becker, et al., 1983; Hilenski, et al., 1986). Polyoxin D also shows some efficacy in the reduction of the protozoan parasite Encephalitozoon cuniculi infecting immune-compromised AIDS patients (Sobottka, et al., 2002)."*

Kaken Comments:

> The cited literature in the above passages were reviewed, and the findings are summarized below in the order of the citations.

Worthington (1988)

Worthington (1988) is a review article. The brief section on polyoxins on pages 49-50 discusses the isolation, structure, biosynthesis, and use in crop protection. Worthington (1988) makes no claim that polyoxins have efficacy against fungal pathogens of humans or other animals.

DeBono and Gordee (1994)

DeBono and Gordee (1994) is also a review article and provides evidence against the use of polyoxin as an antibiotic. Page 472 states,

> *"Chitin synthetase inhibitors have been studied through chemical modification of the polyoxins and nikkomycins but are limited because of unfavorable pharmacokinetics."*

Page 487 states,

> *"Polyoxin analogues bearing hydrolytic groups has increased stability against fungal peptidases but were less active against intact C. albicans. Coupling polyoxin D to other amino acids enhanced peptide transport. These analogues act as prodrugs, releasing polyoxin D upon intracellular hydrolysis. Although uptake was increased, antifungal activity was diminished."*

Thus, efforts to utilize polyoxin D as a pharmaceutical failed.

DeBono and Gordee (1994) make no claim that polyoxins can be successfully used to treat fungal infections of humans or other animals.

Knight, *et al*. (1997)

Knight, *et al*. (1997) is a review article and includes only one sentence regarding polyoxins which is based upon a 1965 reference:

> *"Another group of antibiotics, the polyoxins, have been use to protect against fungal diseases of fruit trees and vegetables."*

Knight, *et al*. (1997) makes no claim that polyoxins have efficacy against fungal pathogens of humans or other animals.

Dreikhorn and Owen (2000)

Dreikhorn and Owen (2000) is an encyclopedia article on the economic losses due to fungal diseases of crops. This article does not discuss fungal infections of humans or other animals.

Suhadolnik and Reichenbach (2000)

Suhadolnik and Reichenbach (2000) is an encyclopedia entry. It makes no claim that polyoxins have efficacy against fungal pathogens of humans or other animals.

EPA (2001)

This references appears to be on lines 607-608, i.e.,

> *"_______. 2001. Consideration of Eligibility for Registration of the New Pesticide Active Ingredient Polyoxin D Zinc Salt Memorandum Decision. Washington: USGPO."*

Though not clear from the citation, the reference is for the Biopesticide Registration Action Document (BRAD) Memorandum for Polyoxin D Zinc Salt. The BRAD summarizes the data EPA used to support the registration of Polyoxin D Zinc Salt. It states on page 2,

> *"Polyoxin D (also known as polyoxorim), the active portion of the polyoxin D zinc salt compound, is an antibiotic and acts to inhibit the growth of phytopathogenic fungal cell wall chitin by competitively inhibiting chitin synthetase. Polyoxin D is produced via a fermentation process using Streptomyces cacaoi var. asoensis, which was isolated from a soil sample collected in Japan. Polyoxin D is very water soluble so it is formulated as the zinc salt to give longer residence time on plant surfaces. The compound is fungistatic and reportedly has no residual effects after the compound has degraded or washed off surfaces."*

In this reference, EPA makes no claim that polyoxins have efficacy against fungal pathogens of humans or other animals.

O'Neill (2006)

This reference is to the 2006 edition of the Merck Index. It describes polyoxins as:

> *"Agricultural antifungal antibiotic complex produced by Streptomyces cacaoi var asoensis and S. piomogenus."*

This reference makes no claim that polyoxins have efficacy against fungal pathogens of humans or other animals.

Becker, *et al*. (1983)

Becker, *et al*. (1983) never states "*Polyoxin D has been shown to be effective as a drug to treat the human and animal pathogens Candida albicans and Cryptococcus neoformans*."

The abstract states:

> *"We demonstrated that polyoxin D at millimolar concentrations causes marked morphological alterations of the human pathogens Candida albicans and Cryptococcus neoformans. C. albicans incubated in the presence of this drug grew in long chains that were severely swollen. Polyoxin D inhibited growth of C. neoformans and killed cells of both the yeast and hyphal phase of C. albacans. These observations give the first evidence that polyoxin antibiotics can kill zoopathogenic fungi."*

In addition, the closing statement of Becker, *et al*. (1983) is:

> *"Our results are the first evidence that polyoxin D can inhibit zoopathogenic yeasts and point out a need for further investigation of the possibility of using chitin synthetase inhibitors as antifungal drugs."*

Becker, *et al*. (1983) describes *in vitro* (outside a living organism) experiments only and makes no claims for *in vivo* (within a living organism) efficacy in humans or other animals.

Hilenski, *et al*. (1986)

The abstract states:

> *"Yeast and mycelia of the pathogen Candida albicans grown in the presence of polyoxin D, a competitive inhibitor of chitin synthetase, formed chains of swollen bulbous cells as observed by fluorescence microscopy. Wheat germ aggutinin (WGA) complexed to colloidal gold (Au) was used as a specific label at the ultrastructural level to visualize chitin in walls of control and polyoxin-treated cells. In control cells, Au-WGA labelling was preferentially localized in the innermost wall layers and was predominantly at bud scars and septa. After 4.5 hours in 4 mM-polyoxin D, budding of yeasts and lateral wall growth in mycellia continued, but primary septa failed to form and no Au-WGA labeling was detected in the walls. These results demonstrated that the morphological alterations caused by polyoxin D were due to the absence of chitin, a wall component important for formation of primary septa for maintenance of structural integrity during morphogenesis."*

The last sentence of Hilenski, *et al*. (1986) is:

> *"These results confirmed that although chitin is not necessary for wall formation, it is an essential component for normal morphogenesis, maintenance of structural integrity and formation of primary septa."*

Hilenski, *et al*. (1986) describes *in vitro* experiments only any and makes no claims for *in vivo* efficacy in humans or other animals.

Sobottka, *et al*. (2002)

Though the authors state,

> *"Microspodidia of the genus Encephalitozoon are emerging protozoal agents that mainly infect immunocompromized patients with AIDS,"*

the authors make no claim that Polyoxin D is an effective drug for the treatment of *Encephalitozoon* infections for AIDS patients or any other patients. Instead, the authors state in the first sentence of the discussion,

> *"We have demonstrated, for the first time, in vitro activity of the chitin synthesis inhibitors POLY-D and NIK-Z against Enc. cuniculi."*

The authors further state at the end of the discussion,

> *"Enc. cuniculi in our study suggests a potential for chitin synthetase inhibitors in the treatment of microsporal infections. This should be confirmed in vitro and in vivo with different isolates of the genus Encephalitozoon."*

Sobottka, *et al*. (2002) provides no data to support the suggestion in the September 23, 2012 technical evaluation report that polyoxin D is an effective drug for the treatment of *Encephalitozoon* infections in AIDS patients.

2.2.6. Use of "Antibiotic" in the September 23, 2012 Technical Evaluation Report

The September 23, 2012 Technical Evaluation Report repeatedly describes polyoxins as antibiotics based the literature.

Line	Technical Evaluation Report Text
29	Agricultural antifungal antibiotic complex
87	Other antibiotics
173	Polyoxins have long been regarded as antibiotics
176	Nucleoside antibiotics
202	similar to the production of other antibiotics
233	As a broad-spectrum antibiotic and fungicide, polyoxin D Zinc Salt
234	other antibiotics
262	Polyoxin D and other nucleoside antibiotics
291	Antibiotics released into the environment can lead to the selection of antibiotic resistant organisms

Similarly, the titles of some of the references incorrectly use "antibiotic" with reference to polyoxin. The references cited in the September 23, 2012 Technical Evaluation Report that include "antibiotic" in the title are summarized in the table below. These references casually refer to polyoxins as antibiotics, but they present no data to support their use of the term "antibiotic" as defined by the FFDCA.

Line(s)	References Cited in the Technical Evaluation Report That Include Antibiotic" in the Citation
420-421	Bono, K., J. Nagatsu, K. Kobinata, K. Saski and S. Suzuki. 1967. Studies on polyoxins, antifungal antibiotics. *Agricultural Biological Chemistry* 31: 190-199. (Abstract)
433-434	Cann, I.K.O, Y. Kobayashi, A. Onoda, M. Wakita, S. Hoshino. 1993. Effects of some ionophore antibiotics and polyoxins on the growth of anaerobic rumen fungi. *Journal of Applied Microbiology* 74: 127-133.
490-491	Gottlieb, D. and P.D. Shaw. 1970. Mechanism and action of antifungal antibiotics. *Annual Review of* 490 *Phytopathology* 8: 371-402.
561-562	Misato, T. 1977. The development of agricultural antibiotics, in J.R. Plimmer (ed.), *Pesticide Chemistry in the* 561 *20th Century–A Symposium*: 170-192. Washington, DC: ACS.
619-620	Worthington, P.A. 1988. Antibiotics with antifungal and antibacterial activity against plant diseases. 619 *Natural Product Reports* 1: 47-66.

2.2.7. Use of "Pharmaceutical" in the September 23, 2012 Technical Evaluation Report

Similarly, the September 23, 2012 Technical Evaluation Report incorrectly describes polyoxins as a "pharmaceutical" based upon the literature.

Line	Technical Evaluation Report Text
49	Antifungal pharmaceutical

2.2.8. Organic Food Production Act Provisions

The Organic Food Production Act Provisions are published in 7CFR §205. "Antibiotic" appears only three times in all of 7CFR §205:

- **§205.237(b)(7) Livestock feed.**
  "The producer of an organic operation must not provide feed or forage to which any antibiotic including ionophores has been added."

- **§205.238(c)(1) Livestock health care practice standard.**
  "The producer of an organic livestock operation must not sell, label, or represent as organic any animal or edible product derived from an animal treated with antibiotics, any substance that contains a synthetic substance not allowed under §205.603, or any substance that contains a nonsynthetic substance prohibited in §205.604."

- **§205.603(a)(8) Synthetic substances allowed for use in organic livestock production**
  "In accordance with restrictions specified in this section the following synthetic substances may be used in organic livestock production as disinfectants, sanitizer, and medical treatments as applicable. Electrolytes – without antibiotics."

Interestingly, all of the above provisions relate to livestock production. The requested authorization, however, is to use of polyoxin D zinc salt in organic crop production for which the requirements are specified in 7CFR §205.601. There are no prohibitions regarding antibiotics in organic crop production. This further supports the use of the FFDCA regulatory definition of "antibiotic," *i.e.*,

> *"any drug (except drugs for use in animals other than humans) composed wholly or partly of any kind of penicillin, streptomycin, chlortetracycline, chloramphenicol, bacitracin, or any other drug intended for human use containing any quantity of any chemical substance which is produced by a micro-organism and which has the capacity to inhibit or destroy micro-organisms in dilute solution (including a chemically synthesized equivalent of any such substance) or any derivative thereof."* [Emphasis added.]

Based upon the available information, Kaken believes that:

- **Polyoxin D zinc salt is not an antibiotic;**
- **A crop that has been treated with polyoxin D zinc salt is not a "feed or forage to which an antibiotic has been added" as used in 7CFR §205.237(b)(7); and**
- **The provisions of 7CFR §205 regarding antibiotics do not prohibit the requested authorization of the use of polyoxin D zinc salt in organic crop production under 7CFR §205.601.**

2.2.9. Chitin Content

Polyoxin D zinc salt inhibits chitin synthetase, and the effects of polyoxin D zinc salt on an organism are predictable based upon the chitin content of the organism. Polyoxin D zinc salt provides good efficacy in the control of the crop pathogen *Alternaria mali* which contains 30-40% chitin. However, polyoxin D zinc salt has very poor efficacy for the control of the human pathogen *Candida albicans* which contains only 2-3% chitin. Furthermore, polyoxin D zinc salt does not kill fungi. Instead, Polyoxin D zinc salt prevents the growth of fungi. Polyoxin D is fungistatic and not truly fungicidal. **Given these properties, polyoxin D zinc salt is *NOT* suitable for use as an antibiotic.** Please note that the above described efforts by DeBono and Gordee (1994) to demonstrate efficacy against *Candida albicans* failed.

3. MAMMALIAN TOXICITY

The September 12, 2012 Federal Register final rule states on pages 56129-56130 with regard to the expanded tolerance exemption for polyoxin D zinc salt:

> *"Its effects are considered fungi-exclusive in that it has no mode of action relative to mammals and passes through mammalian digestive systems. Polyoxin D zinc salt does not persist in the environment and has a well understood low toxicity profile."*

3.1. ACUTE TOXICITY OF POLYOXIN D ZINC SALT TECHNICAL

Kaken Comments:

Table 2 in the September 23, 2012 Technical Evaluation Report includes a combination of chronic data and oncogenicity data. The chronic data are for polyoxin D zinc salt technical, whereas the acute toxicology data are for the WP formulation (EPA Reg. No. 68173-2). This is not clear because the title of the table indicates that the data in the table are for polyoxin D zinc salt.

The acute toxicity data for Polyoxin D Zinc Salt Technical are summarized below in Table 1.

Table 1. Acute Toxicity of Polyoxin D Zinc Salt Technical (EPA Reg. No. 68173-1)		
Toxicology Study	Toxicity Endpoint	EPA Toxicity Category
Acute oral (rats)	Males: LD_{50} > 15,000 mg/kg bw Females: LD_{50} >10,000 to 15,000 mg/kg bw	Practically Non-toxic (IV)
Acute dermal (rats)	LD_{50} > 2000 mg/kg bw	Moderately Toxic (III)
Acute inhalation (rats)	Males: LD_{50} > 2.44 mg/L Females: LD_{50} > 2.17 mg/L	Practically Non-toxic (IV)
Primary eye irritation (rabbits)	Slight to moderate irritation (Draize)	Moderately Toxic (III)
Primary dermal irritation (rabbits)	Slight irritation (Draize)	Practically Non-toxic (IV)
Dermal sensitization (guinea pigs)	Mild sensitizer at 5% TGAI (GPMT)	Not applicable

Source: EPA Biopesticide Registration Action Document (BRAD) for Polyoxin D Zinc Salt, page 7, Table 2.

3.2. ACUTE TOXICITY OF THE POLYOXIN D ZINC SALT 5SC FORMULATION

VEGGIETURBO 5SC Suspension Concentrate Fungicide was designed for the organic market and is the most relevant of the three EPA registered polyoxin D zinc salt formulations. The acute toxicity of VEGGIETURBO 5SC Suspension Concentrate Fungicide is so low (Category IV by all routes of exposure) that the First Aid statement is an optional statement on the EPA stamped accepted label. The acute toxicity for the 5SC formulation of polyoxin D zinc salt is summarized below in Table 2.

Table 2. Acute Toxicity of VEGGIETURBO 5SC Suspension Concentrate Fungicide (EPA Reg. No. 68173- 3) Containing 5.0% Polyoxin D Zinc Salt (marketed as OSO 5%SC Fungicide and TAVANO 5%SC Fungicide)		
Toxicology Study	Toxicity Endpoint	EPA Toxicity Category
Acute oral (rats)	LD_{50} > 5000 mg/kg (females)	Practically Non-toxic (IV)
Acute dermal (rats)	$LD_{50} \geq$ 5050 mg/kg (males, females, and combined)	Practically Non-toxic (IV)
Acute inhalation (rats)	LC_{50} > 2.20 mg/L (males, females, and combined)	Practically Non-toxic (IV)
Primary eye irritation (rabbits)	One hour after test material installation, the maximum average score was 4. No irritation was observed in any eyes 24 hours after treatment.	Practically Non-toxic (IV)
Primary dermal irritation (rabbits)	At 72 hours, the primary irritation index was 0.3. Product is slightly irritating.	Practically Non-toxic (IV)
Dermal sensitization (guinea pigs)	The test substance produced very faint to faint erythema in 15 of 20 test animals, but no reaction in any naive control animals after the treatment.	Mild dermal sensitizer

Source: EPA September 7, 2012 review of VEGGIETURBO 5SC Suspension Concentrate Fungicide, page 6, Table 3.

3.3. MUTAGENICITY

NOP Technical Evaluation Report Lines 182-184 state:

"An increased number of cells with chromosomal aberrations were observed in one study, which could be considered a possible adverse health effect (CDPR, 2003). There has been no follow-up on the CDPR 2003 new active ingredient public report (Leahy, 2012)."

Kaken Comments:

Page 56130 of the September 12, 2012 Federal Register states,

"A. Mutagenicity

Two new mutagenicity studies were performed for polyoxin D zinc salt to support the expansion of the tolerance exemption. The mutagenicity studies as described herein, along with the mutagenicity studies submitted to support the previous tolerance exemption (73 FR 69561), confirm that polyoxin D zinc salt is not a mutagen and that consumption of food commodities that have been treated with this substance when used as a pesticide is safe and will not result in any harm to human health from dietary exposure.

1. A reverse gene mutation assay in bacteria Master Record Identification Number (MRID) 48653313) using the technical grade of polyoxin D zinc salt, dissolved in dimethyl sulfoxide (DMSO), with and without metabolic S9 activation, showed no mutagenic effects or evidence of cytotoxicity or insolubility even at the limiting dose of 5,000 ug/plate (See Ref.). Therefore, polyoxin D zinc salt is considered to be non-mutagenic under the conditions of this assay.

2. An in vitro mammalian chromosome aberration test (MRID 48653314) using the technical grade of polyoxin D zinc salt, dissolved in DMSO, with and without metabolic S9 activation, showed clastogenic potential in Chinese hamster lung cells (CHL/IU) with and without activation (See Ref.). In Experiment I, polyoxin D zinc salt was tested up to dose levels that caused >50% cell lethality without activation (260 mg/mL) and with activation (1,600 mg/mL). Without activation, the frequencies of the metaphases with structural chromosome aberrations (excluding gaps) were 14.5% and 7.5% at test article concentrations of 186 and 260 mg/mL, respectively. With activation, the frequency of metaphase cells with structural chromosome aberrations (excluding gaps) was 9.5% at a test article concentration of 1,600 g/mL. The frequency of polyploid metaphase cells showed no increases either without or with activation. In Experiment II, a 24-hour continuous treatment without activation resulted in a 8.0% frequency of metaphases with structural chromosome aberrations (excluding gaps) at the concentration of 133 mg/mL. There were no increases in the frequency of polyploid metaphases."

"Although the submitted in vitro mammalian chromosome aberration test showed clastogenic potential, the results were not reproducible at the dose levels reported in the experiment. In addition, the mutagenicity data submitted to support the previous tolerance exemption (73 FR 69562), which included three complimentary Tier I mutagenicity tests and a Tier II mammalian erythrocyte micronucleus in vivo test, showed no mutagenic effects, including no clastogenic potential (no chromosomal aberrations). Furthermore, the lack of systemic toxicity noted in the following developmental toxicity section (Unit III.B) and the fact that no effects were reported in the Tier III 2-generation reproduction study submitted for the previous tolerance exemption (73 FR 69562), indicate that polyoxin D zinc salt is not mutagenic or clastogenic. Therefore, based on the weight of evidence of the mutagenicity data submitted to support this expansion of the tolerance exemption and the previous tolerance exemption (73 FR 69561), the mutagenicity data and information are sufficient to confirm that polyoxin D zinc salt is not a mutagen, and that consumption of food commodities that have been treated with this substance when used as a pesticide is safe and will not result in any harm to human health from dietary exposure." [Emphasis added.]

3.4. DEVELOPMENTAL TOXICITY

Kaken Comments:

Page 56130 of the September 12, 2012 Federal Register states,

"B. Developmental Toxicity
A new developmental study (MRID 48653315) was performed for polyoxin D zinc salt to support the expansion of the tolerance exemption. No treatment related effects were observed in general appearance, body weight, adjusted for gravid uterine weight, weight gain, or food consumption in maternal rats at the doses tested (0, 100, 300, and 1,000 milligrams/kilograms bodyweight/day (mg/kg bw/day) (See Ref.). Necropsy observations showed that almost all rats (20/24) in the 1,000 mg/kg/day group highest dose tested (HDT) had thickening of the limiting ridge. Therefore, the lowest observed adverse effect level (LOAEL) for maternal toxicity of polyoxin D zinc salt in rats is 1,000 mg/kg bw/day based on gross lesions in the stomach (thickening of the limiting ridge). The no observed

adverse effect level (NOAEL) for maternal toxicity is 300 mg/kg bw/day based on no effects observed at this dose. Although an effect of gross lesions in the stomach was found in maternal rats at the limit dose tested (1,000 mg/kg bw/day), there were no reported systemic effects in maternal rats at this dose. The effect in the stomach lining was limited to a localized gastric irritation due to the route of entry (oral gavage) at the limit dose tested (1,000 mg/kg bw/day), which is typical of the nature of the test substance."

"For developmental toxicity, no treatment-related effects were observed on developmental parameters including gravid uterine weight, placental weight, mean numbers of corpora lutea and implantation sites, numbers of early and later resorptions (dead or resorbed embryos or fetuses), number of live fetuses per dam, implantation index, viability index, sex ratio, and male and female body weight. The incidence of external, visceral, and skeletal variations and anomalies were not affected by treatment of polyoxin D zinc salt."

"Based on no effects observed for developmental toxicity at any doses tested, the NOAEL for developmental toxicity is greater than 1,000 mg/kg bw/day HDT. The LOAEL was not identified for developmental toxicity, suggesting that the test animals could have tolerated a higher dose. Based on the developmental toxicity data submitted for this expansion to the tolerance exemption, and the Tier III 2-generation reproduction study submitted for the previous tolerance exemption (73 FR 69562), which showed <u>no reproductive effects at the limit dose tested</u>, there are sufficient data and information to confirm that <u>polyoxin D zinc salt is not a developmental toxicant</u>, and that consumption of food commodities that have been treated with this substance when used as a pesticide is safe and will not result in any harm to human health from dietary exposure." [Emphasis added.]

3.5. CHRONIC TOXICITY AND ONCOGENICITY

Page 9 of EPA's BRAD for polyoxin D zinc salt states:

"Results of the chronic toxicity/oncogenicity studies indicated Polyoxin D Zinc Salt Technical <u>did not produce significant toxic or oncogenic responses</u> after mice were fed polyoxin D zinc salt at 0, 0.04%, 0.4% and 4% dose levels, beginning when the mice were six weeks old, and continuing for 24 months (MRID 432618-38). Furthermore, no significant toxic or oncogenic responses in rats were found after daily administration of polyoxin D zinc salt at 0, 0.01%. 0.1% 1.0% and 5% dose levels beginning when the rats were seven weeks old and continuing for 24 months (MRID 432618-39)." [Emphasis added.]

3.6. HUMAN RISK ASSESSMENT

The September 12, 2012 published final rule for polyoxin D zinc salt states on page 56131 of the Federal Register:

> *"Dietary risks to humans are considered negligible based on the lack of dietary toxicological endpoints for polyoxin D zinc salt and its non-toxic mode of action as a fungi-specific chitin synthetase inhibitor that passes through mammalian digestive systems. <u>No significant acute, subchronic, mutagenic, immunotoxic, developmental, or chronic dietary toxicity hazards were identified</u> in the studies submitted to support this expansion of the tolerance exemption or the previous tolerance exemption (73 FR 69562). Based on polyoxin D zinc salt's lack of dietary toxicity hazards for mammals, no aggregate dietary exposure concerns are expected."* [Emphasis added.]

The September 12, 2012 published final rule for polyoxin D zinc salt further states on page 56131-56132 of the Federal Register:

> *"Relevant data and information submitted for the previous tolerance exemption (73 FR 69560) and for this expansion of the tolerance exemption indicate that polyoxin D zinc salt has negligible acute, subchronic, chronic, and developmental toxicity. Moreover, polyoxin D zinc salt is defined by its fungistatic non-toxic mode of action, and demonstrates no significant mammalian effect. Therefore, the Agency concludes that there is a <u>reasonable certainty that no harm will result to the U.S. population, including infants and children, from aggregate exposure to the residues of polyoxin D zinc salt</u>. This includes all anticipated dietary exposures and all other exposures for which there is reliable information. EPA has arrived at this conclusion because the data and information available on polyoxin D zinc salt do not demonstrate toxic potential to mammals. Thus, there are no threshold effects of concern and, as a result, an additional margin of safety is not necessary."* [Emphasis added.]

4. ENVIRONMENTAL EXPOSURE

4.1. SURFACE WATER EXPOSURE ASSESSMENT

NOP Technical Evaluation Report Lines 286–289 state:

> *"The EPA estimated that concentration from runoff of residues into surrounding aquatic habitats from a 10 acre drainage basin into a 6 foot deep 1 acre pond would be approximately 1.6 ppb per 1% residue runoff. Any effects from runoff residues in aquatic environments are expected to be mitigated if the label instructions are followed (EPA, 2001)."*

Kaken Comments:

> The September 12, 2012 published final rule for polyoxin D zinc salt states on page 56131 of the Federal Register:
>
> > *"2. Drinking water exposure. As stated in the previous tolerance exemption (73 FR 69562), there is a small potential for trace amounts of polyoxin D zinc salt to enter drinking water sources after a significant rainfall, via surface water runoff, and/or via incidental spray drift. The petitioner submitted a photodegradation in water study (MRID 48653305) to support this tolerance exemption. The results of the study show that polyoxin D zinc salt has a net photolytic half-life of 0.4 days in sterile natural water (See Ref.). Even if residues of polyoxin D zinc salt enter*

> *water sources, residues are expected to degrade and be so diluted as to be negligible. The data and information demonstrate a lack of aggregate dietary risk via drinking water and is sufficient to support this expansion of the tolerance exemption."*

4.2. RESIDUES ON FOLIAR SURFACES OF TREATED CROPS

NOP Technical Evaluation Report Lines 295-297 state:

> *"The EPA expects concentrations on foliar surfaces of treated crops to reach maximum residue levels of between 9 ppm and 62 ppm for most plant types. These levels are considered to pose minimal levels of risk to mammalian and avian wildlife based on present toxicological data (EPA, 2001)."*

Kaken Comments:

On November 9, 2011, Kaken submitted significant new data to support the expanded tolerance exemption petition. EPA used the additional data and the T-REX modeling software to estimate polyoxin D zinc salt residues on treated crops.

The September 12, 2012 published final rule for polyoxin D zinc salt states on page 56131 of the Federal Register:

> *"Based on the residue data submitted for this expansion of the tolerance exemption, and the T-Rex residue modeling data from the previous tolerance exemption (73 FR 69562), any residues found are far below any toxicological endpoints identified in this expansion of the tolerance exemption (developmental toxicity NOAEL greater than 1,000 mg/kg bw/day; maternal toxicity NOAEL of 300 mg/kg/day) or in the previous tolerance exemption (73 FR 69561). ... In summary, <u>the residue and toxicity data demonstrate a lack of aggregate dietary risk</u> that is sufficient to support this expansion of the tolerance exemption."* [Emphasis added.]

5. TOXICITY TO NON-TARGET ORGANISMS

5.1. EFFECTS ON FISH AND AQUATIC ORGANISMS

NOP Technical Evaluation Report Lines 194-195 state:

> *"Failure to follow the label instructions may result in death of fish and aquatic organisms (EPA, 2001, 2008)."*

Kaken Comments:

Page 14 of the 2001 EPA Biopesticide Registration Action Document (BRAD) Memorandum for Polyoxin D Zinc Salt states:

> *"Exposure to aquatic invertebrates and vertebrates could occur based on current label use directions. Results of submitted aquatic non-target studies indicated polyoxin D zinc salt is moderately toxic to rainbow trout and freshwater invertebrates. However, with the appropriate aquatic mitigating label language, the exposure and therefore risk to aquatic species is expected to be minimal."*

The September 12, 2012 published final rule for polyoxin D zinc salt states on page 56131 of the Federal Register:

> *"2. Drinking water exposure. As stated in the previous tolerance exemption (73 FR 69562), there is a small potential for trace amounts of polyoxin D zinc salt to enter drinking water sources after a significant rainfall, via surface water runoff, and/or via incidental spray drift. The petitioner submitted a photodegradation in water study (MRID 48653305) to support this tolerance exemption. The results of the study show that polyoxin D zinc salt has a net photolytic half-life of 0.4 days in sterile natural water (See Ref.). Even if residues of polyoxin D zinc salt enter water sources, residues are expected to degrade and be so diluted as to be negligible."* [Emphasis added.]

Given the negligible polyoxin D zinc salt residues in aquatic environments under real world use conditions, the risk to fish and aquatic invertebrates from the registered use of polyoxin D zinc salt is negligible. (Risk = Exposure x Hazard.)

5.2. EFFECTS ON BENEFICIAL FUNGI

Polyoxin D zinc salt has a non-toxic mode of action. Polyoxin D zinc salt does not kill fungi, but instead prevents the growth of fungi. Polyoxin D zinc salt is fungistatic, not truly fungicidal.

Polyoxin D zinc salt degrades rapidly under environmental conditions. The May 11, 2012 EPA science review regarding the expanded tolerance exemption for polyoxin D zinc salt states on page 12:

> *"The net photolytic half-lives of [^{14}C]Polyoxin D were calculated to be 0.4 days, 4 days, 2.4 days, and 1.6 days in sterile natural water, pH 5.0, pH 7.0, and pH 9.0 buffers, respectively."*

Please note that a half-life is the time during which a material degrades by 50%. Also, the rate of degradation is determined by the fastest route of degradation. In the presence of sunlight, polyoxin D zinc salt degrades by 50% in 0.4 days (9.6 hours).

Because polyoxin D zinc salt (1) does not kill fungi and (2) degrades rapidly under environmental conditions, no long term adverse effects on beneficial fungi resulting from the registered use of polyoxin D zinc salt are anticipated.

5.2.1. Benítez, *et al.* (1976)

NOP Technical Evaluation Report Lines 216-219 state:

> *"As a fungicide used to control soil-borne pathogens, polyoxin D Zinc Salt by definition kills soil fungi. As such, several studies looked at impacts on beneficial fungi introduced in organic farming systems. The effects were found to be mixed. Polyoxin D inhibits the germination of Trichoderma viride (Benítez, et al., 1976).*

Kaken Comments:

The abstract for Benítez, *et al.* (1976) states:

> *"When polyoxin D is added to a spore suspension of Trichoderma viride at a concentration from 50-100 µg/ml, it inhibits from 40-60% of germination. This percentage increases if dimethylsulfoxide (DMSO) is added."*

> *"Mycelium growing in the presence of polyoxin D becomes irregular and loses its rigidity, showing several bulges along the hypha. Under the electron microscope the features of the cell wall and cytoplasmic content are apparently normal. Nevertheless, after incubation with different lytic systems or with (^{14}C)glucose, it can be seen that polyoxin D partially inhibits the biosynthesis of β-(1-3)glucan and the biosynthesis of chitin to a greater extent attaining inhibition of 83% at 100 µg/ml of the antibiotic concentration."*
>
> *"Regenerating protoplasts are less affected by polyoxin D. They do regenerate slower but the percentage of regeneration is more than 80%. Aberrant tubes synthesized by the protoplasts are not affected, they manifest their ususal morphology and lack of chitin is confirmed in their composition."*

The experiment described by Benítez, *et al.* (1976) included DMSO in the dosing solution. Page 186 of Benítez, *et al.* (1976) states,

> *"Another possibility is that the DMSO itself inhibits the germination and that due to this substance there occurs the death of some spores. The results in Table 1, referring to the spores with DMSO only, support this view."*

Benítez, *et al.* (1976) describes a laboratory experiment in which DMSO was added to the doing solution. Polyoxin D is not registered to be applied in combination with DMSO, and it would be a violation of Federal law to do so.

Benítez, *et al.* (1976) is not relevant to the registered use of polyoxin D zinc salt.

5.2.2. Bixby-Brosi and Potter (2012)

NOP Technical Evaluation Report Lines 219-224 state:

> *"T. viride is closely related to T. harzianum, which is used in organic farming under the brand name Root Shield (OMRI, 2012). Gliocladium virens, Paecilomyces fumosoroseus and Streptomyces griseoviridis are other fungi used as biological control agents in organic agriculture. G. virens is marketed as SoilGard, P. fumosoroseus is the active ingredient in PFR-97 and S. griseoviridis is sold as Mycostop (OMRI, 2012). Polyoxin D was also found to reduce the efficacy of the virus used to control the black cutwork (Agrotis ipsilon) (Bixby-Brosi and Potter, 2012)."*

Kaken Comments:

Bixby-Brosi and Potter (2012) concludes that polyoxin D is compatible with *Agip*MNPV. The abstract for Bixby-Brosi and Potter (2012) includes:

> *"This study tested whether applying the virus [AgipMNPV] together with such a fungicide [polyoxin D] can synergize AgipMNPV activity against A. ipsolon in turfgrass."*
>
> *"RESULTS: The addition of chitin synthesis inhibitor failed to increase AgipMNPV infectivity to A. ipsolon in the field. Rather, delayed and slightly reduced mortality from viral infection was seen when larvae fed on fungicide/virus treated grasses as opposed to virus-only treatment. Choice tests revealed fungicide residues to be a mild feeding deterrent."*

> *"CONCLUSION: Because polyoxin-d does not inactivate Agip MNPV, the two substances are compatible. However, combination applications of polyoxin-d and Agip MNPV on turfgrass might interfere with the larval ingestion of a lethal virus dose, resulting in prolonged larval feeding in the field."* [Emphasis added.]

5.3. EFFECTS ON MELANINS AND EARTHWORMS

NOP Technical Evaluation Report Lines 233-237 state:

> *"Polyoxins and other antibiotics were found to increase melanins in Alternaria kikuchiana (Kohno, et al., 1983; Butler and Day, 1998). The ecological functions of melanins are still unknown, but they are believed to enhance the phytotoxic and pathogenic properties of plant pathogens (Butler and Day, 1998). Earthworms were shown to have a preference for melanized fungi (Marfenina and Ischenko, 1997; Butler and Day, 1998)."*

Kaken Comments:

> **It is useful to review the cited literature more carefully.** Please see below.

5.3.1. Kohno, *et al.* (1983)

Kohno, *et al.* (1983) describes experiments that used exclusively polyoxin B. Neither polyoxin D nor polyoxin D zinc salt were used in the study. The abstract states:

> *"Polyoxin-B-treated and untreated (control) hypae of Alternaria kikuchiana Tanka were first degraded with 2N NaOH, 1N H_2SO_4, and digestive enzymes, and then morphological alterations of the cell walls were investigated by cytochemical methods and electron microscopy. … This study suggest two possibilities i) cell walls, especially inner cell wall layers, of control and polyoxin-treated hyphae may have different structural constituents, and ii) melanin-like pigments in inner cell walls may be associated with the resistance of polyoxin-treated hyphae to lysis by digestive enzymes."*

Kohno, *et al.* (1983) is not relevant to the NOP petition for polyoxin D zinc salt.

5.3.2. Butler and Day (1998)

Butler and Day (1998) is a review article regarding fungal melanins that references Kohno, *et al.* (1983) without specifying that the findings of Kohno, *et al.* (1983) are limited to polyoxin B.

Butler and Day (1998) is not relevant to the NOP petition for polyoxin D zinc salt.

5.3.3. Marfenia and Ischenko (1997)

This article is in Greek but has an abstract in English. The abstract, in its entirety, states:

> *"Choice experiments have demonstrated that earthworms Eisenia fetida discriminate between microscopic fungi. Specifically, dark melanin-containing fungi, such as Cladosporium cladosporioides, are the most attractive for the worms. Aspergillus niger specific for polluted and man-disturbed soils is not attractive but rather repellent and toxic for the worms."*

Marfenia and Ischenko (1997) does not appear to have information that is useful in the evaluation of the effects of polyoxin D zinc salt on earthworms or otherwise relevant to the NOP petition for polyoxin D zinc salt.

5.4. EFFECTS ON WOOD DESTROYING FUNGI

NOP Technical Evaluation Report Lines 239-240 state:

"Beneficial soil organisms may be adversely affected by exposure to polyoxin D. Polyoxin D inhibited the basidiospore germination of wood-decaying fungi (Schmidt, 1987)."

Kaken Comments:

Schmidt (1987) evaluated polyoxin D for possible use as a wood preservative for use by the forest products industry. Page 629 of Schmidt (1987) states:

"It is apparent from the frequencies cited in Table I that the spores for a given decay fungus do not always respond uniformly to a given concentration of Polyoxin D; some small percentage is either more or less sensitive than the great majority (as noted by the increasing frequency of visicle-type germination as compared to hyphal-type germination of P. tenuis as polyoxin D concentration increased from 0.1 to 5 ppm."

These data are not encouraging for the potential development of polyoxin D zinc salt as an active ingredient for use in the wood preservative industry.

5.5. EFFECTS ON SOIL FUNGI

NOP Technical Evaluation Report Lines 240-249 state:

"The nematode-trapping fungus, Arthrobotrys oligospora, was less affected by exposure to polyoxin D compared with the plant pathogen Rhizoctonia solani, with mixed results. At lower concentrations A. oligospora showed abnormalities of growth that resulted in greater trapping at lower concentrations and inhibition of trapping at higher concentrations (Persson and Nordbring-Hertz, 1990). Alternative fungicides such as copper or sulfur may have similar or greater effects on soil ecology, but no studies that compared the impacts of polyoxin D Zinc Salt with commercial fungicides used in organic production were found in the literature. The closest comparison found by the reviewers is a study that examined the use of Nikkomycin Z, another chitin synthesis inhibitor. Nikkomycin Z was found to inhibit hyphal growth and cell wall structures of arbuscular-mycorrhizal fungi (Bago, et al., 1996)."

Kaken Comments:

The above paragraph does not provide any data that suggests that the use of polyoxin D zinc salt is incompatible with organic crop production.

Please note that polyoxin D zinc salt does not truly kill fungi. It is a fungal chitin inhibitor that stops the growth of fungi. Therefore, use of polyoxin D zinc salt according to the label is anticipated to have no long-term adverse impacts on beneficial soil fungi.

5.6. EFFECTS ON NON-TARGET INSECTS AND MITES

NOP Technical Evaluation Report Lines 261-268 state:

> *"There have been no reported incidents of toxicity to non-target species by any member of the polyoxin family after over 30 years of use (Copping and Duke, 2007). Polyoxin D and other nucleoside antibiotics may be toxic to non-target insects and mites with chitinous cell walls given its mode of action (Hollingworth, 1975). Polyoxin D was shown to inhibit chitin synthetase in cockroaches (Leighton, et al, 1981). It is possible that polyoxin D would have similar activity against other insects with chitinous exoskeletons, some of which are beneficial, such as Hippodamia convergens, commonly known as lady beetles (Miyamoto, et al., 1993). However, no adverse effects have been reported against organisms that lack chitinous cell walls (Kim and Hwang, 2007)."*

Kaken Comments:

EPA's May 11, 2012 science review of polyoxin D zinc salt states on page 3,

> *"[The mode of action of] Polyoxin D and its zinc salt is the inhibition of chitin synthesis in the cell walls of fungi, some of which are pathogenic to plants. This inhibition of chitin synthesis is limited to chitin in fungal cell walls. Polyoxin D and its zinc salt do not inhibit the synthesis of chitin in animals that contain chitin, such as for insects and crustaceans that contain chitin in their exoskeletons. Polyoxin D Zinc Salt does not affect mammals because mammalian cells have plasma membranes that do not contain chitin."*

Polyoxin D zinc salt has been determined to have low toxicity to beneficial insects. Please see Table 3 for a summary of the available data regarding the toxicity of polyoxin D zinc salt to beneficial insects.

Table 3. Toxicity of Polyoxin D Zinc Salt Technical (188 PsDu/mg potency) to Nontarget Insects and Wolf Spider

Organism	Study Design	Results	Ref.
Honey bee	10 bees/replicate, 2-5 weeks after emergence; 5 replicates. OECD Guideline 213; Feed additive dosing.	96-hr LD_{50} = 28.774 µg/bee. 8% mortality after 96 hours. Practically non-toxic. [A]	1
Silkworm (Kinshu x Showa)	20 larvae/replicate; 3 replicates; Mulberry leaves dipped into test solution; treated leaves fed daily.	LC_{50} > 2100 mg/L No adverse effects observed.	2
Marmalade hoverfly	5 larvae/replicate; 4 replicates. Soy leaves dipped in test solution and allowed to dry; fed treated leaves.	10-day LC_{50} > 2100 mg/L No adverse effects observed.	3
	5 adults/replicate; 4 replicates. Soy leaves dipped in test solution and allowed to dry; fed treated leaves.	10-day LC_{50} > 2100 mg/L No adverse effects observed.	
Green lacewing	5 larvae/replicate; 4 replicates. Dosed by dipping in test solution for 5 sec.	14-day LC_{50} > 2100 mg/L No deaths.	4
Wolf spider	20, each 3.5-4.0 mm body length. Dosed by dipping in test solution for 5 sec.	10-day LC_{50} > 2100 mg/L 5% mortality after 10 days.	5

A. http://www.epa.gov/oppefed1/ecorisk_ders/toera_analysis_eco.htm
1. Mori,m K. (2001). Acute Oral toxicity study on polyoxin D zinc salt in the honey bees *(Apis mellifera* L.). Japan Plant Protection Association.
2. Tsukidate, H. (2001). Effects of Polyoxin D Zinc Salt on Silkworm (*Bombyx mori*). Eco-Science Corporation.
3. Tsukidate, H. (2001). Effects of Polyoxin D Zinc Salt on Marmalade Hoverfly (*Epistrophe balteatus*). Eco-Science Corporation.
4. Tsukidate, H. (2001). Effects of Polyoxin D Zinc Salt on Japanese Green Lacewing (*Chrysoperla nipponensis*). Eco-Science Corporation.
5. Tsukidate, H. (2001). Effects of Polyoxin D Zinc Salt on Wolf Spider (*Pardosa laura*). Eco-Science Corporation.

5.7. EFFECTS OF APPLICATIONS TO PASTURE

NOP Technical Evaluation Report Lines 270-271 state:

"Polyoxin D may have a negative effect on the growth of anaerobic rumen fungi when applied to pasture (Cann, et al., 1993)."

Kaken Comments:

Polyoxin D zinc salt is not registered for use on pasture, and it would be a violation of Federal law to apply polyoxin D zinc salt to pastures.

5.8. NOP TECHNICAL EVALUATION REPORT TABLE 3

Kaken Comments:

Table 3 identifies the subject of the summarized studies as polyoxin D. However, all of the summarized data are for Polyoxin D Zinc Salt Technical. This is the test substance that EPA has required for many years.

6. RESISTANCE

6.1. AGRICULTURAL USE HISTORY

Polyoxin D zinc salt has been used as a plant protectant in Asia for over 40 years and in the United States for 15 years. In spite on the many years of use, there has been no evidence of resistance to polyoxin D zinc salt.

6.2. TECHNICAL EVALUATION REPORT'S USE OF PUBLISHED LITERATURE

6.2.1. Vincelli and Williams (2012)

NOP Technical Evaluation Report Lines 251-259 state:

> *"Plant pathogens can acquire resistance to fungicides if exposed to continuous selection by fungicides with a single mode of action (Dekker, 1976). Having additional fungicides with different mode of action to rotate for specific pathogens is a strategy for resistance management. Access to Polyoxin D Zinc Salt by organic farmers may help to impede selection for resistant pathogens, but lack of rotation may result in resistance to fungicides with the same mode of action. Strains of Alternaria alternata resistant to Polyoxin B have been isolated in orchards in Japan, where it has been used intensively as a fungicide for many years (Copping and Menn, 2000; Ishii, 2006). Because of their similar structure and mode of action, cross-resistance Extension service specialists report that polyoxin D used on turf is considered to have a moderate risk of resistance (Vincelli and Williams, 2012)."*

Kaken Comments:

Polyoxin Complex (containing Polyoxin B) was overused without resistance management practices when Polyoxin Complex was a new product during the 1970s.

By contrast, Polyoxin D zinc salt has been used for over 40 years as a crop protectant without a single observation of pest resistance.

Polyoxin D zinc salt is the only form of polyoxin that is registered for use as a fungicide in the United States. Polyoxin B is not and has never been registered for use in the United States. **Therefore, there is no need for concern regarding possible cross-resistance of polyoxin D zinc salt with polyoxin B.**

NOP Technical Evaluation Report Lines 291-293 state:

> *"Antibiotics released into the environment can lead to the selection of antibiotic resistant organisms, some of which may be plant or human pathogens. Polyoxin D Zinc Salt is a Group 19 fungicide and may result in the selection for resistance of other Group 19 fungicides (Kaken, 2008)."*

Kaken Comments:

The above "Kaken (2008)" reference is the EPA registered label for Polyoxin D Zinc Salt Technical (EPA Reg. No. 68173-1). The label notes that polyoxin D zinc salt has a Fungicide Resistance Action Committee (FRAC) Code of 19, *i.e.,* the target site of action is chitin synthetase. No other EPA registered active ingredient has the same mode of action, *i.e.*, the same FRAC Code. For more information on FRAC Codes, see http://www.frac.info/publication/anhang/FRAC-Code-List2011-final.pdf.

The inclusion of the FRAC code on the label assists growers in their design of integrated pest management (IPM) programs that use a variety of modes of action as part of a resistance management program. Polyoxin D zinc salt is an important part of resistance management because it offers a **unique mode of action.**

6.2.2. Sahadolnik and Reichenbach (2000)

NOP Technical Evaluation Report Lines 126-129 state:

"The plant pathogen Alternaria kikuchiana has developed resistance to various polyoxin fungicides. Manufacturers have three different approaches to overcome resistance: 1) transnucleosideation; 2) biosynthesis of polyoxin with the 5-fluorouracil moiety; and 3) decarboxylation of the 5-carboxyuracil polyoxins (Sahadolnik and Reichenbach, 2000)."

Kaken Comments:

The full citation in the Technical Evaluation Report for (Sahadolnik and Reichenbach, 2000) is:

"Suhadolnik, R.J. and N.L. Reichenbach. 2000. Nucleosides and nucleotides. Kirk-Othmer Encyclopedia of Chemical Technology 1-37."

While the abstract is available on-line, Wiley's web site for purchasing and downloading the full article continues to not function in spite of direct communication with technical service. Also, the full article is not available from NOP.

Surprisingly, the above reference is not available from the Library of Congress. The publisher, John Wiley & Sons, did not submit a copy as is required for all publications with a US copyright.

The following text was found in the Kirk-Othmer Encyclopedia of Chemical Technology, Fourth Edition, © 1992, in an chapter on Antibiotics in a subsection titled Nucleosides and Nucleotides, and a further subsection titled Peptidyl N-Nucleoside Antibiotics. Polyoxins and Neopolyoxins.

"The polyoxins [11113-80-7] (102-113) [Polyoxins A to M], and neopolyoxins (114-116) shown in Figure 2, are peptidylpyrimidine nucleoside antibiotics that have achieved use as agricultural fungicides. ... Compounds (102-116) inhibit sheath-blight disease of rice crops, ie, the pathogenic fungus Pellicularia philamentosa f. sasakii. The polyoxins, which are structurally similar to UDP-N-acetylglucosamine, inhibit chitin synthesis. Polyoxin D (104) is a competitive inhibitor of UDP-N-acetylglucosamine. Polyoxin-resistance mutants of A. kikuchiana have a decreased uptake of polyoxins. To overcome the resistance of these mutants, three approaches have been used: transnucleosidation, biosynthesis of polyoxin with the 5-fluorouracil moiety, and decarboxylation of the 5-carboxyuracil polyoxins."

No references are cited.

Based upon the information that was found, there is no support for the suggestion in the Technical Evaluation Report that the plant pathogen *Alternaria kikuchiana* **has developed resistance to polyoxin D zinc salt or to polyoxin D. Furthermore, the cited three approaches to overcoming resistance are not relevant to the agricultural use of polyoxin D zinc salt.**

7. USES OF POLYOXIN D ZINC SALT

7.1. REGISTERED NEW USES OF POLYOXIN D ZINC SALT

The tolerance exemption for polyoxin D zinc salt was recently expanded from a list of selected crops to all crops, including crops treated post-harvest. Page 56133 of the September 12, 2012 Federal Register states,

> *"An exemption from the requirement of a tolerance is established for the residues of polyoxin D zinc salt in or on all food commodities when applied as a fungicide and used in accordance with good agricultural practices."*

EPA confirmed via email that the above language includes post-harvest uses.

VEGGIETURBO 5SC Suspension Concentrate Fungicide (68173-4) was registered by EPA on September 27, 2012, and by CDPR effective January 1, 2013. A cumulative list of all registered used of polyoxin D zinc salt is provided in Table 4. It includes:

- Use on 19 crop groups (or crops) and 73 crop group (or crop) / disease combinations.
- California registration of 65 of the 73 EPA registered uses.
- Curative efficacy for 67 of the 73 EPA registered uses.

The recently registered new uses are noted by the blue background and were not considered in the September 23, 2012 Technical Evaluation Report.

Polyoxin D zinc has curative activity for many of its uses, and this feature has been included in Table 4. Mueller and Robertson of Iowa State University discuss preventative vs. curative activity in http://www.extension.iastate.edu/CropNews/2008/Preventative+or+curative+fungicides.htm.

They state,

> *"Preventative activity occurs when a fungicide is present on or in the plant before the pathogen arrives or begins to develop. The fungicide acts as a protective barrier and prevents infection from occurring. This is also referred to as a protective activity."*
>
> *"Curative or early-infection activity occurs when the active fungicide ingredient is present within plant tissue and stops early growth of the pathogen (colonization) in the plant tissues. This type of fungicide is usually most effective 24 to 72 hours after infection occurs, depending on the fungicide. Most fungicides that prevent early-infection also have preventative activity and thus are most effective when applied before infection occurs."*
>
> *"Therefore, it is important to remember that "curative" fungicides will NOT cure a plant from a disease. They are effective if applied prior to infection or in the first 72 hours after infection, but they are not effective against more advanced latent infections."*

Table 4. Cumulative List of Registered Polyoxin D Zinc Salt Uses, with Recently Registered Uses Highlighted

Crop	Disease (Pathogen)	Curative [1]	New Use
Almonds	Alternaria leaf spot (*Alternaria* spp.)	✔	
Artichoke †	Gray mold/Botrytis rot (*Botrytis cinerea*)		✔
	Powdery Mildew (*Leveillula taurica, Erysiphe cichoracearum*)	✔	✔
Berries and small fruits (see separate section for grapes and strawberries)	*Alternaria* leaf spot and fruit rot (*Alternaria* spp.)	✔	✔
	Anthracnose leaf & fruit rot * (*Colletotrichum* spp.)	✔	✔
	Gray mold/fruit rot/Botrytis blight (*Botrytis cinerea*)	✔	✔
	Powdery mildew (*Sphaerotheca macularis*, *Erysiphe* spp.)	✔	✔
Brassica (Cole) leafy vegetables	Alternaria leaf spot (*Alternaria* spp.)	✔	✔
	Anthracnose (*Colletotrichum* spp.)		✔
	Gray mold (*Botrytis cinerea*)	✔	✔
	White spot (*Cercosporella* spp.)	✔	✔
	Bottom rot (*Rhizoctonia solani*)		✔
	Sclerotinia rot (*Sclerotinia sclerotiorum)*		✔
Bulb vegetables	Alternaria blight and Purple blotch (*Alternaria* spp.)	✔	✔
	Botrytis leaf blight /Leaf spot/Neck rot (*Botrytis* spp.)	✔	✔
	Downy mildew * (*Peronospora* spp.)		✔
	Rust (*Puccinia alii* or *Puccinia porri*)	✔	✔
Carrots and Parsnips	Alternaria leaf blight (*Alternaria dauci*)	✔	✔
	Cercospora leaf blight (*Cercospora carotae*)	✔	✔
	Powdery mildew (*Erysiphe polygoni*)	✔	✔
	Rhizoctonia crown rot and leaf blight (*Rhizoctonia solani*)	✔	✔

Table 4. Cumulative List of Registered Polyoxin D Zinc Salt Uses, with Recently Registered Uses Highlighted

Crop	Disease (Pathogen)	Curative [1]	New Use
Citrus fruits	*Alternaria* brown spot (*Alternaria alternata*)	✔	✔
	Botrytis rot (*Botrytis cinerea*)	✔	✔
	Septoria spot (*Septoria citri*)		✔
Cucurbits (Cucumbers, melons, squash and others)	Anthracnose (*Colletotrichum orbiculare*)	✔	✔
	Early blight (*Alternaria* spp.)	✔	
	Gray mold (*Botrytis* spp.)	✔	
	Gummy stem blight (*Didymella bryoniae*)	✔	
	Leaf spot (*Corynespora cossicola*)	✔	
	Powdery mildew (*Spthaerotheca* spp.)	✔	
	Scab (Cladosporium)	✔	
	Southern blight (*Sclerotium rolfsii*)	✔	✔
Fruiting vegetables (Eggplant, pepper, pepinos, tomatillos and tomatoes)	Early blight (*Alternaria solani*)	✔	
	Anthracnose * (*Colletotrichum coccodes*)		
	Gray molds (*Botrytis* sp.)	✔	
	Late blight * (*Phytophthera infestans*)		✔
	Leaf mold (*Fulvia (Cladosporium) fulvum,* also known as *Passalora fulva*)	✔	✔
	Powdery mildew (*Leveillula taurica* and *Oidiopsis sipula*)	✔	
	Southern blight * (*Sclerotium rolfsii*)	✔	✔
	Verticillium wilt * (*Verticillium dahliae*)		✔

Table 4. Cumulative List of Registered Polyoxin D Zinc Salt Uses, with Recently Registered Uses Highlighted

Crop	Disease (Pathogen)	Curative [1]	New Use
Ginseng †	Alternaria blight (*Alternaria panax*)	✔	
	Botrytis blight (*Botrytis cinerea*)	✔	
	Cylindrocarpon root rot (*Cylinderocarpon destructans*)	✔	
	Rhizoctonia root and crown rot (*Rhizoctonia solani*	✔	
Grapes	Bunch rot or Gray mold (*Botrytis cinerea*)	✔	
	Powdery mildew (*Unicula necator*)	✔	
Leafy vegetables	Alternaria leaf spot (*Alternaria* spp.)	✔	✔
	Downy mildew * (*Bremia lactucae* and *Peronospora* spp.)		✔
	Powdery mildew (*Golovinomyces (Erysiphe) cichoracearum*)	✔	✔
	Botrytis damping off, Botrytis leaf blight, Botrytis rot (*Botrytis* spp.)	✔	✔
	Bottom rot (*Rhizoctonia solani*)		✔
	Lettuce drop (*Sclerotinia* spp.)		✔
Legume vegetables	Asian Soybean Rust (*Phakopsora pachyrhizi*)	✔	✔
	Gray mold (*Botrytis cinerea*)	✔	✔
	Powdery mildew (*Erysiphe pisi*)	✔	✔
	Stem rot / White mold (*Sclerotinia sclerotiorum*)	✔	✔
Pistachios	*Alternaria* spp.	✔	
	Botryosphaeria spp.	✔	

Table 4. Cumulative List of Registered Polyoxin D Zinc Salt Uses, with Recently Registered Uses Highlighted

Crop	Disease (Pathogen)	Curative [1]	New Use
Pome fruit	Alternaria blotch (*Alternaria mali*)	✔	
	Leaf blotch (*Diplocarpon mali*)	✔	
	Powdery mildew (*Podosphaera leucotrica* in apples) *Phyllactinia mali* in pears)	✔	
	Scab * (*Venturia* spp.)	✔	
Potatoes	Black scurf (*Rhizoctonia solani*)		✔
	Early blight (*Alternaria solani*)	✔	
	Late blight * (*Phytophthora infestans*)		✔
	White mold (*Sclerotinia sclerotiorum*)		✔
Stone fruits	Botrytis blossom blight (*Botrytis cinerea*)	✔	✔
	Powdery mildew (*Podosphaera* spp., *Sphaerotheca pannosa*)	✔	✔
Strawberries	Anthracnose (*Colletotrichum* spp.)	✔	
	Gray mold (*Botrytis cinerea*)	✔	
	Powdery mildew (*Sphaerotheca*)	✔	
Sugar beet †	Cercospora leaf spot (*Cercospora beticola*)	✔	✔
	Rhizoctonia crown and root rot (*Rhizoctonia solani*)	✔	✔

† Not registered for use in California.
* Suppression only.
1. Curative as defined by Mueller and Robertson in
http://www.extension.iastate.edu/CropNews/2008/Preventative+or+curative+fungicides.htm

Color code:

Blue = recently registered use. Not included in the Technical Evaluation Report.

Polyoxin D zinc salt is registered to control or suppress pathogens belonging to 46 different genera. Table 5 summarizes the crop pathogens for which polyoxin D zinc salt is registered and the associated crops that may be treated.

Table 5. Crop Pathogens Controlled or Suppressed by Polyoxin D Zinc Salt

Pathogen	Crops (EPA Reg. No. 68173-4, a.k.a. VEGGIETURBO, OSO, TAVANO)	Crops (EPA Reg. No. 68173-3, a.k.a. ENDORSE)
Agarius spp.		Turf grasses *
Alternaria spp., *Alternaria alternata*, *Alternaria dauci*, *Alternaria mali,* *Alternaria panax*, or *Alternaria solani*	Berries and small fruit Brassica (cole) leafy vegetables Bulb vegetables Carrots and parsnips Citrus fruits Cucurbit vegetables Fruiting vegetables Ginseng † Leafy vegetables Pome fruits Potatoes	Almonds Cucurbit vegetables † Fruiting vegetables † Ginseng † Pistachios Pome fruits † Potatoes † Ornamentals
Botrytis spp. or *Botrytis cinerea*	Artichokes † Berries and small fruit Brassica (cole) leafy vegetables Bulb vegetables Citrus fruits Cucurbit vegetables Fruiting vegetables Ginseng † Grapes Leafy vegetables Legume vegetables Stone fruits	Cucurbit vegetables † Fruiting vegetables † Ginseng † Grapes Strawberries † Ornamentals
Botryosphaeria sp.		Pistachios *
Bremia lactucae	Leafy vegetables *	
Cercospora beticola	Sugar beet †	
Cercospora carotae	Carrots and parsnips	
Cercosporella spp.	Brassica (cole) leafy vegetables	
Cladosporium sp.	Cucurbit vegetables	Cucurbit vegetables †
Colletotrichum spp., *Colletotrichum coccodes*, *Colletotrichum orbiculare, or* *Colletotrichum cereale*	Berries and small fruit * Brassica (cole) leafy vegetables Cucurbit vegetables Fruiting vegetables *	Fruiting vegetables † * Strawberries † Ornamentals Turf grasses ¤
Corynespora crassiicola	Cucurbit vegetables	Cucurbit vegetables †
Curvularia		Ornamentals

Table 5. Crop Pathogens Controlled or Suppressed by Polyoxin D Zinc Salt

Pathogen	Crops (EPA Reg. No. 68173-4, a.k.a. VEGGIETURBO, OSO, TAVANO)	Crops (EPA Reg. No. 68173-3, a.k.a. ENDORSE)
Cylindrocarpon destructans	Ginseng †	Ginseng †
Didymella bryoniae	Cucurbit vegetables	Cucurbit vegetables †
Diplocarpon mali	Pome fruits	Pome fruits †
Dreschlera poae		Turf grasses ¤
Erysiphe spp., *Erysiphe,* *Erysiphe cichoracearum,* *Erysiphe necator,* *Erysiphe pisi*, or *Erysiphe polygoni*	Artichokes † Berries and small fruit Carrots and parsnips Cucurbit vegetables Fruiting vegetables Grapes Legume vegetables	Ornamentals
Fulvia (Cladosporium) fulvum, also known as *Passalora fulva*	Fruiting vegetables	
Golovinomyces (Erysiphe) cichoracearum	Leafy vegetables	
Laetisaria fuciformis		Turf grasses ¤
Lepiota spp.		Turf grasses *
Leveillula or *Leveillula taurica*	Artichokes † Fruiting vegetables	Fruiting vegetables †
Marasmius spp.		Turf grasses
Microdochium nivale		Turf grasses ¤
Myrothecium		Ornamentals
Oidium sp.		Ornamentals
Oidiopsis or *Oidiopsis* sipula	Fruiting vegetables	Fruiting vegetables †
Peronospora spp.	Bulb vegetables * Leafy vegetables *	Ornamentals
Phakopsora pachyrhizi	Legume vegetables *	
Phyllactinia mali	Pome fruits	
Phytophthora infestans	Fruiting vegetables Potatoes *	
Podosphaera spp. or *Podosphaera leucotricha*	Pome fruits Stone fruits	Pome fruits †
Phoma cucurbitacearum	Cucurbit vegetables	
Puccinia alii or *Puccinia porri*	Bulb vegetables	
Phyllactinia mali		Pome fruits †
Pyricularia grisea		Turf grasses *

Table 5. Crop Pathogens Controlled or Suppressed by Polyoxin D Zinc Salt

Pathogen	Crops (EPA Reg. No. 68173-4, a.k.a. VEGGIETURBO, OSO, TAVANO)	Crops (EPA Reg. No. 68173-3, a.k.a. ENDORSE)
Rhizoctonia solani, *Rhizoctonia cerealis*, or *Rhizoctonia zeae*	Brassica (cole) leafy vegetables Carrots and parsnips Ginseng † Leafy vegetables Potatoes Sugar beet †	Ginseng † Ornamentals Turf grasses
Sclerotinia spp. or *Sclerotinia sclerotiorum*	Brassica (cole) leafy vegetables Leafy vegetables Legume vegetables Potatoes	
Sclerotium rolfsii	Cucurbit vegetables Fruiting vegetables *	
Septoria citri	Citrus fruits	
Sphaerotheca, *Sphaerotheca macularis*, or *Sphaerotheca pannosa*	Fruiting vegetables Stone fruits	Cucurbit vegetables † Strawberries †
Thielaviopsis		Ornamentals
Typhula incarnate or Typhula ishikariensis		Turf grasses ¤
Uncinula necator		Grapes *
Venturia spp. or *Venturia inequalis*	Pome fruits *	Pome fruits † * Ornamentals
Verticillium dahliae	Fruiting vegetables *	
Waitea circinata		Turf grasses ¤

† Not registered for use in California.
* Suppression only.
¤ Aids in control of diseases in turf grasses.

7.2. PLANS FOR FUTURE USES OF POLYOXIN D ZINC SALT

On September 12, 2012, EPA issued a tolerance exemption for all crops, including crops that are treated post-harvest. This significantly reduces the time and cost of development of new pre-harvest and post-harvest uses of polyoxin D zinc salt. Kaken and the US distributor of the 5SC formulation, Certis USA, anticipate developing polyoxin D zinc salt for many additional new uses.

8. OMRI LISTED ALTERNATIVES TO POLYOXIN D ZINC SALT

The Technical Evaluation Report provides a list (Table 3 on page 8) of OMRI listed alternative pesticides labeled for the proposed uses for polyoxin D zinc salt. Many branded products are listed, giving the appearance of a diversity of available alternatives. However, a different conclusion can be drawn from more detailed examination of the labels, active ingredients, and modes of action of these products (tabulated fully in APPENDIX 2).

All of the listed alternatives fall into only 4 known fungicide mode of action classes as currently defined by the Fungicide Resistance Action Committee (http://www.frac.info/):

- **FRAC Code 44**: Microbial disruptors of pathogen cell membranes (Serenade and similar products based on *Bacillus subtilis* or related bacteria).
- **FRAC Codes M1 and M2**: Copper and sulfur compounds having nonspecific (multi-site) contact activity (*e.g.* Badge, Champ, Nordox, NuCop, Cosavet, and many others).
- **FRAC Code P**: Plant extracts triggering innate host defenses against pathogens (*e.g.* Regalia, based on extract from giant knotweed, *Reynoutria sachalinensis*).

Several types of products do not appear on the FRAC List (as of December 2012) or are listed as "Not Classified", having unknown or as yet unclassified modes of action:

- *Bacillus pumilus* (Sonata) and *Bacillus amyloliquefaciens* (Double Nickel). The mode of action for these biofungicides is very similar to that of *Bacillus subtilis,* so these active ingredients would likely be classified under FRAC Code 44.
- Nonspecific chemical compounds which kill fungi and bacteria on contact, with little or no residual activity. These include paraffinic oils (*e.g.* JMS Stylet Oil), potassium bicarbonate (Kaligreen), hydrogen dioxide (OxiDate), and potassium salts of fatty acids (M-Pede).
- Microbial control agents that directly attack or out compete plant pathogenic fungi (*e.g.* Actinovate, Contans, and PreStop).

In addition to the risk of resistance posed by such a limited number of available modes of action, each of these groups has characteristics that limit their practical utility in organic production as reflected in label use instructions and summarized in APPENDIX 2. Most copper and sulfur fungicides carry a DANGER signal word and are known to pose a high risk of crop injury due to phytotoxicity. Contact materials such as oil, potassium bicarbonate, hydrogen dioxide, and fatty acid salts have very short residual activity, necessitating frequent reapplication which also carries a high risk of phytotoxicity. Microbial fungicides (including *Bacillus subtilis*) and plant defense inducers must be used preventatively, *i.e.,* before infection and development of symptoms, and typically must be used in combination or rotation with contact fungicides or other fungicides for best performance.

Polyoxin D zinc salt represents a new opportunity for organic growers to address these limitations. The unique and well-defined mode of action (inhibition of chitin synthesis, preventing further growth and proliferation of plant pathogenic fungi) provides curative activity against incipient fungal infections with little or no risk of cross resistance to other modes of action. Little or no phytotoxicity has been observed from applications of VEGGIETURBO 5SC Suspension Concentrate Fungicide (a.k.a. OSO 5%SC Fungicide and TAVANO 5% SC Fungicide), and the acute toxicity is so low (Category IV by all routes of exposure) that a First Aid label statement is optional.

OMRI listed products that are potential alternatives to end-use products containing polyoxin D zinc salt are summarized in APPENDIX 2 and are organized by mode of action as identified by the FRAC code. Please note that applicable uses of JMS Farms Organic JMS Stylet Oil and Dow's M-Pede Insecticide-Miticide-Fungicide are included. The color code for APPENDIX 2 is as follows:

Blue = Recently registered use. Not included in the Technical Evaluation Report.
Gray = Divider between crops or crop groups.
Green = Favorable comment or efficacy.
Yellow = Cautionary issue.
Red = Significant adverse issue (e.g., phytoxicity) or multiple issue types.

For simplicity, APPENDIX 2 is limited to food uses. Uses on turf and ornamentals have been excluded. Also, only primary registrations are included. Alternate brand names and supplemental distributor registration have been excluded. Also, only representative products containing sulfur as the active ingredient have been included.

9. EFFICACY, PHYTOTOXICITY, AND RUSSETING

9.1. COMPARATIVE STUDIES THAT INCLUDE POLYOXIN D ZINC SALT

9.1.1. Polyoxin D Zinc Salt vs. Copper

Compared to copper, polyoxin D zinc salt provides greatly superior protection of cucumber plants against resistant stains of powdery mildew and gray mold. Polyoxin D zinc salt and copper both provide good protective value of cucumber plants against Corynespora leaf spot. Please see Table 6.

Table 6. Comparative Efficacy of Polyoxin D Zinc Salt vs. Copper Treatment of Cucumbers for Powdery Mildew, Gray Mold, and Corynespora Leaf Spot

Crop	Disease [1] (Pathogen strain)	Treatment [2]	AI Conc.	Protective Value (0-100)	Phyto-toxicity
Cucumber	Powdery mildew (QoI resistant strain)	Polyoxin D zinc salt (ENDORSE WDG formulation)	50 µg/mL	85	No
		Copper hydroxide DF	200 µg/mL	4	No
		Untreated control	NA	0	NA
Cucumber	Powdery mildew (QoI resistant strain)	Polyoxin D zinc salt (ENDORSE WDG formulation)	50 µg/mL	43	No
		Copper hydroxide DF	200 µg/mL	0	No
		Copper sulfate WP	350 µg/mL	0	No
		Untreated control	NA	0	NA
Cucumber	Gray mold (Benzimidazole, Dicarboximide, Diethofencarb cross-resistant strain)	Polyoxin D zinc salt (ENDORSE WDG formulation)	50 µg/mL	100	No
		Copper hydroxide DF	200 µg/mL	1	No
		Copper sulfate WP	350 µg/mL	0	No
		Untreated control	NA	0	NA
Cucumber	*Corynespora* leaf spot (QoI resistant strain)	Polyoxin D zinc salt (ENDORSE WDG formulation)	50 µg/mL	94	No
		Copper hydroxide DF	950 µg/mL	92	No
		Untreated control	NA	0	NA

1. Pathogen inoculated 5-6 hours after fungicide application.
2. Eight plants/treatment. 40 mL spray solution/treatment.
Source: Unpublished Kaken data.

9.1.2. Polyoxin D Zinc Salt vs. Potassium Bicarbonate

Compared to potassium bicarbonate, polyoxin D zinc salt provides significantly greater protection of cucumber plants against resistant stains of powdery mildew and gray mold. Please see Table 7.

Table 7. Comparative Efficacy of Polyoxin D Zinc Salt vs. Potassium Bicarbonate for Treatment of Cucumbers for Powdery Mildew and Gray Mold

Crop	Disease [1] (Pathogen strain)	Treatment [2]	AI Conc.	Protective Value (0-100)	Phyto-toxicity
Cucumber	Powdery mildew (QoI resistant strain)	Polyoxin D zinc salt (ENDORSE WDG formulation)	50 µg/mL	85	No
		Potassium bicarbonate WP	950 µg/mL	42	No
		Untreated control	NA	0	NA
Cucumber	Gray mold (Benzimidazole, Dicarboximide, Diethofencarb cross-resistant strain)	Polyoxin D zinc salt (ENDORSE WDG formulation)	50 µg/mL	100	No
		Potassium bicarbonate WP	950 µg/mL	40	No
		Untreated control	NA	0	NA

1. Pathogen inoculated 5-6 hours after fungicide application.
2. Eight plants/treatment. 40 mL spray solution/treatment.
Source: Unpublished Kaken data.

9.1.3. Polyoxin D Zinc Salt vs. *Bacillus subtilis*

Compared to *Bacillus subtilis* (Serenade), polyoxin D zinc salt provides significantly greater protection of cucumber plants against resistant stains of powdery mildew and gray mold. Please see Table 8.

Table 8. Comparative Efficacy of Polyoxin D Zinc Salt vs. *Bacillus subtilis* for Treatment of Cucumbers for Powdery Mildew and Gray Mold

Crop	Disease [1] (Pathogen strain)	Treatment [2]	AI Conc.	Protective Value (0-100)	Phyto-toxicity
Cucumber	Powdery mildew (QoI resistant strain)	Polyoxin D zinc salt (VEGGIETURBO 5SC formulation)	50 µg/mL	100	No
		Bacillus subtilis WP	5 x 10^7 CFU/mL	68	No
		Untreated control	NA	0	NA
Cucumber	Powdery mildew (QoI resistant strain)	Polyoxin D zinc salt (ENDORSE WDG formulation)	50 µg/mL	100	No
			25 µg/mL	100	No
		Bacillus subtilis WP	5 x 10^7 CFU/mL	62	No
			3 x 10^7 CFU/mL	54	No
		Untreated control	NA	0	NA
Cucumber	Gray mold (Benzimidazole, Dicarboximide, Diethofencarb cross-resistant strain)	Polyoxin D zinc salt (ENDORSE WDG formulation)	50 µg/mL	84	No
		Bacillus subtilis WP	5 x 10^7 CFU/mL	37	No
		Untreated control	NA	0	NA

1. Pathogen inoculated 5-6 hours after fungicide application.
2. Eight plants/treatment. 40 mL spray solution/treatment.

Source: Unpublished Kaken data.

9.1.4. Almonds, Grapes, Pistachios and Strawberries

The University of California published an annual evaluation of efficacy of registered fungicides against economically important diseases of fruit and nut crops based upon university field trials. [Adaskaveg, J., *et al.* (2012)] This publication is available online at http://www.ipm.ucdavis.edu/PDF/PMG/fungicideefficacytiming.pdf and includes comparative efficacy data for polyoxin D zinc salt (as Ph-D) for:

- Almonds (page 23);
- Apples and pears (page 27);
- Grapes (page 34);
- Pistachios (page 43); and
- Strawberries (page 49).

Most of the alternative products are conventional pesticides. However, the data tables include a few pesticides that are allowed in organic crop production. Based upon University of California ratings, polyoxin D zinc salt provides **superior performance** on:

- Almonds relative to copper, copper + oil, lime sulfur, and PlantShield for control of Brown rot, Jacket rot, Shot hole, Scab, Rust, and Alternaria leaf spot;
- Grapes relative to copper for control of Botrytis;
- Pistachios relative to copper for control of Alternaria blight, Botrytis blossom and bloom shoot blight, and Botrytisphaeria panicle and shoot blight; and
- Strawberries relative to:
    - Copper, sulfur, and M-Pede for control of Gray mold and Anthracnose; and
    - Copper and M-Pede for control of Powdery mildew.

The key pages of Adaskaveg, J., *et al.* (2012) are provided as APPENDIX 3.

9.2. NO RUSSETING OF APPLES

Polyoxin D zinc salt does not cause russeting of applies. Russeting is a cosmetic effect and not a disease effect. Apples with noticeable russeting are not considered suitable for the fresh market.

A Grower's Guide to Organic Apples by Peck and Merwin (2009) reviews the organic disease control options in New York State. (http://nysipm.cornell.edu/organic_guide/apples.pdf) Pages 48 to 51 note that russeting of applies is caused by the use of:

- Bordeaux mixture (which contains copper);
- Fixed copper, e.g., (1) copper oxychloride with copper sulfate, (2) copper hydroxide, (3) complexed forms of basic copper sulfate, and (4) copper dust preparations;
- Hydrogen dioxide; and
- Liquid lime sulfur and other sulfur products.

10. IMPORTANCE OF POLYOXIN D ZINC SALT FOR ORGANIC CROP PRODUCTION

10.1. POLYOXIN D ZINC SALT USES WITH NO OMRI LISTED ALTERNATIVES

NOP Technical Evaluation Report Lines 362-368 state:

The only two crop-disease pairs for which there were no pesticidal alternatives approved for organic production are C. destructans root rot in ginseng and Diplocarpon mali leaf blotch in apples. Researchers showed that the biological control agent Gliocladium catenulatem applied as the OMRI Listed product Prestop controlled C. destructans in ginseng comparable to the chemical fungicide metalaxyl-M (Rahman and Punja, 2007). Prestop is not currently labeled for C. destructans on ginseng. Blotches caused by Alternaria mali and Diplocarpon mali are not identified as a serious problem in US organic apple production (Swezey, 2000; Craver, et al., 2008; Delate, et al., 2008; Peck and Merwin, 2009)."

Kaken Comments:

EPA and CDPR registered uses of polyoxin D zinc salt for which no OMRI listed alternatives were found are listed below in Table 9. The use with a blue background was recently registered and was not considered in the September 23, 2012 Technical Evaluation Report.

Table 9. Uses of Polyoxin D Zinc Salt with no OMRI Listed Alternatives

Crop	Disease (Pathogen)	Curative	New Use
Cucurbits (Cucumbers, melons, squash and others)	Southern blight (*Sclerotium rolfsii*)	✔	✔
Ginseng †	Cylindrocarpon root rot (*Cylinderocarpon destructans*)	✔	
Pome fruit	Leaf blotch (*Diplocarpon mali*)	✔	

† Not registered for use in California.
* Suppression only.
Color code:
Blue = Recently registered use. Not included in the Technical Evaluation Report.

10.1.1. Southern Blight (*Sclerotium rolfsii* infection) of Cucurbits

Kenny Sebolb of the University of Kentucky College of Agriculture states in Fruit Rots of Cucurbits (http://www.ca.uky.edu/agcollege/plantpathology/ext_files/PPFShtml/PPFS-VG-7.pdf):

"Southern blight can cause fruit decay of cucumber, muskmelon, pumpkin, and watermelon. The pathogen has an extremely wide host range that also includes other vegetable crops (e.g. pepper, tomato, carrots, and beans), tree fruits (e.g. apple), herbaceous ornamentals (e.g. ajuga and vinca), and tobacco. … The pathogen also attacks stems and crowns, resulting in sudden wilting of the foliage. … Sclerotia enable the fungus to survive adverse conditions and can persist in the upper layers of soil for many years."

Ray Cerkauskas of Agriculture and Agri-Food Canada states in http://www.lsuagcenter.com/MCMS/RelatedFiles/%7B82703B62-B66D-46C6-BD4F-BEA720B25740%7D/Southern+Blight.pdf:

> *"Young infected plants wilt suddenly and permanently. On older plants, symptoms first appear as a dark brown lesion on the stem near the soil surface. The lesion girdles the stem, causing leaf yellowing and wilting. ... The fungus affects many crops, including tomato, other solanaceous crops (potato, pepper, and eggplant), legumes, and cucurbits. The pathogen persists on crop residues and as dormant sclerotia."*

North Carolina State College of Agriculture and Life Sciences states in North Carolina Pest News (http://ipm.ncsu.edu/current_ipm/12PestNews/12News3/pestnews.pdf):

> *"Southern blight is a serious and frequent disease in the Piedmont and Coastal Plain regions of North Carolina. This disease is caused by the fungus Sclerotium rolfsii, which attacks many vegetable crops including tomato, bean, cantaloupe, carrot, pepper, potato, sweetpotato, watermelon, and several field crops such as peanut, soybean, and tobacco. This disease is easily recognized by the white fan-shaped growth of the fungus at the base of the plants. Over time, tiny round tan to brown sclerotia are formed on soil and infected plants. These sclerotia can survive in the soil for MANY years. Rotation is not very effective because this pathogen has more than 1,000 reported hosts. Corn and some other members of the grass family are not hosts and are safe to plant in problem areas. In gardens, planting on a raised bed filled with sterile soil is the best way to avoid contact with native soil that may contain the pathogen. The disease is more active in warm, wet weather and can be seen every year in North Carolina."*

Sclerotium rolfsii overwinters in soil and most control measures are directed at killing it in the soil before the crop is present (fumigation, solarization, soil-applied fungicides, and deep plowing to bury the sclerotia). These preventative measures are only partially effective. Growers often must follow up with systemic or protectant fungicides to prevent infection, and/or curative fungicides to limit the spread of the disease once infection has occurred. Conventional growers have access to a number of these fungicides, but no OMRI listed fungicides were found that are registered for treatment of Southern blight once the crop is present. Curative fungicides are no substitute for good preventative practices, but Polyoxin D zinc salt represents a backup currently lacking in the organic grower's toolbox for dealing with this difficult disease.

Conclusion: **Southern blight is a significant disease of cucurbits. It causes rapid crop loss if not quickly treated, and Southern blight can be very persistent. Polyoxin D zinc salt was recently registered for preventative and curative treatment of Southern blight. No alternative OMRI listed product that is registered for treatment of Southern blight was found. Polyoxin D zinc salt will be an important tool for organic growers for the prevention of Southern blight in cucurbits and fruiting vegetables.**

10.1.2. Cylindrocarpon Root Rot (*Cylinderocarpon destructans* Infection) of Ginseng

Matuo and Miyazawa stated in Scientific Name of Cylindrocarpon sp. Causing Root Rot in Ginseng, *Ann. Pytopath. Soc. Japan* 50: 649-652 (1984) (https://www.jstage.jst.go.jp/article/jjphytopath1918/50/5/50_5_649/_pdf):

> *"We reported first that root rot of ginseng is caused by Cylindrocarpon sp., and named the causal fungus as Cylindrocarpon panacis Matuo et Miyazawa. This disease is the most destructive to the ginseng root, and is perceived the decisive obstacle on the continuous cropping (replantation) of this crop."*

M. Rahman stated in a 2006 publication entitled *Epidemiology of cylindrocarpon root rot and rust root rot on American ginseng (Panax quinquefolius l.)* (http://summit.sfu.ca/item/2308):

> *"Cylindrocarpon root rot, caused by Cylindrocarpon destructans (Zins) Scholten, and rusty root, a disorder of unknown cause(s), are two factors that limit ginseng cultivation globally. Epidemiological and other information on these problems is lacking and no control measures are available."*

Conclusion: **Cylindrocarpon root rot is a significant disease of ginseng. Polyoxin D zinc salt is registered for preventative treatment of Cylindrocarpon root rot. No alternative OMRI listed product that is registered for treatment of Cylindrocarpon root rot was found. Polyoxin D zinc salt will be an important tool for organic growers for the prevention of Cylindrocarpon root rot in ginseng.**

10.1.3. Leaf Blotch (*Diplocarpon mali* infection) of Pome Fruit

Zhao et al. of the USDA Agricultural Research Service stated at http://www.ars.usda.gov/research/publications/publications.htm?seq_no_115=282209:

> *"Leaf blotch of apple caused by the fungus Diplocarpon mali is a significant production problem as the disease results in premature defoliation, leading to reduction in quantity and quality of apple fruit."*
>
> *"Diplocarpon mali, the causal agent of Marssonina leaf blotch of apple, causes severe defoliation during the growing season. Little information is available on the mode of infection and infection process."*

Lee *et al.* wrote in Biological Characterization of *Marssonina coronaria* Associated with Apple Blotch Disease, published in Mycobiology 39(3): 200-205 (2011) (http://synapse.koreamed.org/Synapse/Data/PDFData/0184MB/mb-39-200.pdf):

> *"Apple blotch is one of the most severe apple diseases known. The disease is widely-distributed, being reported in North America, Oceana, and Asia [1-3]. This disease is caused by the fungus Diplocarpon mali (Y. Harada & K. Sawamura [anamorph Marssonina coronaria (Ellis & J. J. Davis) J.J. Davis, syn. M. mali (Henn.) S. Ito]) [1]. The fungus primarily infects apple leaves, and conidia formed in acervuli causes infection of the leaves and fruits during the growing season. The apothecia produced on overwintered diseased leaves are sources of the inoculum. The disease first appears as dark green circular patches on the upper surface of the mature leaves in mid-summer. As the disease progresses, the leaf spots coalesce and black pinhead-like*

asexual fruiting bodies (acervuli) develop on the affected surfaces. Severe infections of leaves result in premature defoliation, reducing the quantity and quality of apples produced [4, 5].”

“The occurrence of apple blotch in Korea was first reported on 1988 and the first disease outbreak happened in 1993 [6]. In 2006, leave defoliation reached 87.7% in an experimental field in mid-September, with nearly all leaves being infected. The diseased has continued and remained serious to the present day.”

Conclusion: **Leaf blotch is a significant disease of apples in the United States and internationally. Polyoxin D zinc salt is registered for preventative and curative treatment of leaf blotch on pome fruit. No alternative OMRI listed products that is registered for any type of treatment of leaf blotch on pome fruit was found. Polyoxin D zinc salt will be an important tool for organic growers for the prevention and cure of leaf blotch on pome fruit.**

10.2. RESISTANCE MANAGEMENT

Uses of polyoxin D zinc salt with only one or two alternative modes of action for OMRI listed alternative products are summarized below in Table 10 and Table 11, respectively. The uses with blue background are recently registered uses that were not considered in the September 23, 2012 Technical Evaluation Report.

For uses with only one mode of action for OMRI listed products, there is a significant opportunity for the development of resistance to the one mode of action.

For uses with only two modes of action for OMRI listed products, there are opportunities for alternating modes of action. However, the all of the OMRI listed alternatives have limitations that are included in the “Product Label Notes” column.

Polyoxin D zinc salt can be an important risk management tool, especially for the uses listed in Tables 10 and 11.

Table 10. Uses with Only ONE Alternative Mode of Action for OMRI Listed Alternative Products

Registered Uses of Polyoxin D Zinc Salt				OMRI Approved Alternative Products				
Crop	Disease (Pathogen)	Curative [1]	New Use	FRAC Code	Active Ingredient	EPA Reg. No.	Brand Name (Registrant)	Product Label Notes
Artichoke †	Gray mold/Botrytis rot (*Botrytis cinerea*)		✔	44	*Bacillus subtilis* strain QST 713	264-1151	Serenade Max (Bayer)	Preventative use only. Tank mix with other registered fungicide for better performance.
Brassica (Cole) leafy vegetables	Gray mold (*Botrytis cinerea*)	✔	✔	None	*Streptomyces lydicus* WYEC 108	73314-1	Actinovate Soluble (Natural Industries)	Preventative use only. Live bacterium; must be applied after sterilant/fumigant has dissipated. Soil temperature must be ≥45°F. Label does not include specific crop/pathogen combinations. Label claims suppression/control, without identifying uses limited to suppression.
Brassica (Cole) leafy vegetables	White spot (*Cercosporella* spp.)	✔	✔	None	*Bacillus pumilus* strain QST 2808	264-1153	Sonata ASO (Bayer)	Preventative use only. Suppression only. Tank mix with other registered fungicide for better performance.
Citrus fruits	Botrytis rot (*Botrytis cinerea*)	✔	✔	None	*Streptomyces lydicus* WYEC 108	73314-1	Actinovate Soluble (Natural Industries)	Preventative use only. Live bacterium; must be applied after sterilant/fumigant has dissipated. Soil temperature must be ≥45°F. Label does not include specific crop/pathogen combinations. Label claims suppression/control, without identifying uses limited to suppression.
Citrus fruits	Septoria spot (*Septoria citri*)		✔	M1	Copper hydroxide	45002-4	Nu-Cop 50DF (Albaugh)	Phytotoxic in spray solution with pH <6.5. DANGER signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.
				M1	Copper hydroxide and Copper oxychloride	80289-12	Badge X2 (Isagro)	Phytotoxic in spray solution with pH <6.5. WARNING signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.
				M1	Cuprous oxide	48142-7	Nordox 30/30 WG (Nordox)	High rate may be phytotoxic under hot or dry conditions. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.
				M1	Copper oxychloride	45002-17	COC WP (Albaugh)	Toxic to fish and aquatic organisms. Runoff warning for poorly draining soils with shallow water tables. Potential runoff for several months or longer after application. Tank mix with lime to prevent copper injury.
Cucurbits (Cucumbers, melons, squash and others)	Leaf spot (*Corynespora cossicola*)	✔		None	Hydrogen dioxide	70299-2	OxiDate (BioSafe)	Highly toxic to bees and beneficial insects. Toxic to birds and fish. Preventative use only. Corrosive; strong oxidizing agent.
	Scab (Cladosporium)	✔		None	Gliocladium catenulatum strain J1446)	64137-11	Prestop Biofungicide Powder (Verdura Oy)	Apply pre-fruiting only. Cannot be tank mixed with any pesticides or concentrated fertilizers. Label does not make

Table 10. Uses with Only ONE Alternative Mode of Action for OMRI Listed Alternative Products

Registered Uses of Polyoxin D Zinc Salt				OMRI Approved Alternative Products				
Crop	Disease (Pathogen)	Curative [1]	New Use	FRAC Code	Active Ingredient	EPA Reg. No.	Brand Name (Registrant)	Product Label Notes
								specific crop/pathogen specific claims.
Fruiting vegetables (Eggplant, pepper, pepinos, tomatillos and tomatoes)	Leaf mold (*Fulvia (Cladosporium) fulvum,* also known as *Passalora fulva*)	✔	✔	M1	Copper hydroxide and Copper oxychloride	80289-12	Badge X2 (Isagro)	Phytotoxic in spray solution with pH <6.5. WARNING signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.
				M1	Copper octanoate	67702-2	Cueva Fungicide Concentrate (Neudorff)	Toxic to fish and aquatic organisms. Runoff warning for poorly draining soils with shallow water tables. Must re-apply after rain. For best results, spray before disease first appears.
				M1	Copper(I) oxide	26883-20	Chem Copp 50 (American Chemet)	WARNING signal word. Toxic to fish For use on tomatoes only.
				M1	Copper oxychloride	45002-17	COC WP (Albaugh)	Toxic to fish and aquatic organisms. Runoff warning for poorly draining soils with shallow water tables. Potential runoff for several months or longer after application. For use on tomatoes only.
	Southern blight * (*Sclerotium rolfsii*)	✔	✔	None	*Bacillus amyloliquefaciens* strain D747	70051-108	Double Nickel 55	Preventative use only. Suppression only. Not for use in California.
Leafy vegetables	Botrytis damping off, Botrytis leaf blight, Botrytis rot (*Botrytis* spp.)	✔	✔	None	*Streptomyces lydicus* WYEC 108	73314-1	Actinovate Soluble (Natural Industries)	Preventative use only. Live bacterium; must be applied after sterilant/fumigant has dissipated. Soil temperature must be ≥45°F. Label does not include specific crop/pathogen combinations. Label claims suppression/control, without identifying uses limited to suppression.

* Polyoxin D zinc salt is registered for suppression only.
† Polyoxin D zinc salt is not for use in California for this use.
1. Curative as defined by Mueller and Robertson in http://www.extension.iastate.edu/CropNews/2008/Preventative+or+curative+fungicides.htm

Color code:
Blue = Recently registered use. Not included in the Technical Evaluation Report.
Yellow = Cautionary issue.
Red = Significant adverse issue or multiple issue types.

Table 11. Uses with Only TWO Alternative Modes of Action for OMRI Listed Alternative Products

Registered Uses of Polyoxin D Zinc Salt				OMRI Approved Alternative Products				
Crop	Disease (Pathogen)	Curative [1]	New Use	FRAC Code	Active Ingredient	EPA Reg. No.	Brand Name (Registrant)	Product Label Notes
Carrots and Parsnips	Cercospora leaf blight (*Cercospora carotae*)	✔	✔	M1	Copper hydroxide	55146-1	Champ WG (NuFarm)	Phytotoxic in spray solution with pH <6.0. DANGER signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.
				M1	Copper hydroxide	45002-4	Nu-Cop 50DF (Albaugh)	Phytotoxic in spray solution with pH <6.5. DANGER signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.
				M1	Cuprous oxide	48142-4	Nordox 75 WG	High rate may be phytotoxic under hot or dry conditions. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product. May corrode aluminum irrigation pipes. Use limited to carrots only.
				M1	Copper(I) oxide	26883-20	Chem Copp 50 (American Chemet)	WARNING signal word. Toxic to fish.
				M1	Copper oxychloride	450025-17	COC WP (Albaugh)	Toxic to fish and aquatic invertebrates. Potential for runoff for several months or more after application. Runoff warning for poorly drained soils and soils with shallow water table.
				M1	Copper sulfate	45002-8	Basic Copper 53 (Albaugh)	WARNING signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.
				M1	Copper sulfate pentahydrate	66675-3	CS 2005	Phytotoxicity warning. DANGER signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.
				P	*Reynoutria sachalinensis*	84059-6	Regalia Maxx (Marrone)	Preventative use only.
Carrots and Parsnips	Rhizoctonia crown rot and leaf blight (*Rhizoctonia solani*)	✔	✔	P	*Ranatra sachalinensis*	84059-3	Regalia Concentrate (Marrone)	Preventative use only.
				None	*Bacillus amyloliquefaciens* strain D747	70051-108	Double Nickel 55	Preventative use only.
Cucurbits (Cucumbers, melons, squash and others)	Gray mold (*Botrytis* spp.)	✔		M1	Copper octanoate	67702-2	Cueva Fungicide Concentrate (Neudorff)	Toxic to fish and aquatic organisms. Runoff warning for poorly draining soils with shallow water tables. Must re-apply after rain. For best results, spray before disease first appears.
				None	*Streptomyces lydicus* WYEC 108	73314-1	Actinovate Soluble (Natural Industries)	Preventative use only. Live bacterium; must be applied after sterilant/fumigant has dissipated. Soil temperature must be ≥45°F. Label does not include specific crop/pathogen combinations. Label claims suppression/control, without identifying uses limited to suppression.

Table 11. Uses with Only TWO Alternative Modes of Action for OMRI Listed Alternative Products

Registered Uses of Polyoxin D Zinc Salt				OMRI Approved Alternative Products				
Crop	Disease (Pathogen)	Curative [1]	New Use	FRAC Code	Active Ingredient	EPA Reg. No.	Brand Name (Registrant)	Product Label Notes
Fruiting vegetables (Eggplant, pepper, pepinos, tomatillos and tomatoes)	Verticillium wilt * (*Verticillium dahliae*)		✔	44	*Bacillus subtilis* strain QST 713	264-1151	Serenade Max (Bayer)	Preventative use only. Suppression only. Tank mix with other registered fungicide for better performance.
				None	*Bacillus amyloliquefaciens* strain D747	70051-108	Double Nickel 55	Preventative use only. Suppression only.
Leafy vegetables	Alternaria leaf spot (*Alternaria* spp.)	✔	✔	M1	Copper hydroxide	55146-1	Champ WG (NuFarm)	Phytotoxic in spray solution with pH <6.0. DANGER signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.
				None	*Streptomyces lydicus* WYEC 108	73314-1	Actinovate Soluble (Natural Industries)	Preventative use only. Live bacterium; must be applied after sterilant/fumigant has dissipated. Soil temperature must be ≥45°F. Label does not include specific crop/pathogen combinations. Label claims suppression/control, without identifying uses limited to suppression.
Legume vegetables	Asian Soybean Rust (*Phakopsora pachyrhizi*)	✔	✔	44	*Bacillus subtilis* strain QST 713	264-1151	Serenade Max (Bayer)	Preventative use only. Tank mix with other registered fungicide for better performance.
				None	*Bacillus pumilus* strain QST 2808	264-1153	Sonata ASO (Bayer)	Preventative use only. Tank mix with other registered fungicide for better performance.
Pome fruit	Alternaria blotch (*Alternaria mali*)	✔		P	*Reynoutria sachalinensis*	84059-3	Regalia Concentrate (Marrone)	Preventative use only.
				None	*Streptomyces lydicus* WYEC 108	73314-1	Actinovate Soluble (Natural Industries)	Preventative use only. Live bacterium; must be applied after sterilant/fumigant has dissipated. Soil temperature must be ≥45°F. Label does not include specific crop/pathogen combinations. Label claims suppression/control, without identifying uses limited to suppression.
Potatoes	Black scurf (*Rhizoctonia solani*)		✔	P	*Ranatra sachalinensis*	84059-3	Regalia Concentrate (Marrone)	Preventative use only.
				44	*Bacillus subtilis* strain QST 713	264-1151	Serenade Max (Bayer)	Preventative use only. Tank mix with other registered fungicide for better performance.

† Polyoxin D zinc salt is not for use in California for this use.
Polyoxin D zinc salt is not registered for suppression only for any of the above uses.
1. Curative as defined by Mueller and Robertson in http://www.extension.iastate.edu/CropNews/2008/Preventative+or+curative+fungicides.htm

Color code:
Blue = Recently registered use. Not included in the Technical Evaluation Report.
Yellow = Cautionary issue.
Red = Significant adverse issue or multiple issue types.

10.3. PERFORMANCE BENEFITS

Polyoxin D zinc salt:

- Provides board spectrum efficacy.
  - Current EPA registrations include use on:
    - 46 different genuses of fungi;
    - 19 crop groups or crops; and
    - 73 crop group (or crop) / disease combinations.
  - California registrations include use on:
    - 16 crop groups (or crops); and
    - 65 crop group (or crop) / disease combinations.
- Provides generally superior efficacy.
  - Available comparative efficacy data generally demonstrate significantly superior efficacy of polyoxin D zinc salt relative to the OMRI listed alternatives.
  - All of the microbial OMRI listed alternatives are registered for disease prevention only, *i.e.*, the products must be applied before the infection is present. Generally, Polyoxin D zinc salt can also be applied as a curative treatment soon after infection has occurred.
- Is not phytotoxic.
  - Copper and sulfur products have significant phytotoxicity issues.
  - Paraffinic oil increases the phytotoxicity of other products.
- Does not cause russeting of apples.
  - Copper, sulfur, and hydrogen dioxide cause the russeting of apples which reduces the value of the crop.
- Is easy to use.
  - There is no pre-harvest interval.
  - The re-entry interval is the minimal interval, 4 hours.
  - There are no air or soil temperature restrictions on the time of application. The following products do have such restrictions:
    - Actinovate Soluble (*Streptomyces lydicus* WYEC 108);
    - Contains WG (*Coniothyrium minitans* strains CON/M/91-08);
    - Organic JMS Stylet Oil (Paraffinic oil); and
    - Sulfur products.
  - There are no limits on application time based upon growth stage.
    - Prestop (*Gliocladium catenlatum* strain J1446) can be applied pre-fruiting only.
  - No person protective equipment are required beyond the base minimum required under the Worker Protection Standard.
- Is stable and requires no special storage or handling. By contrast:
    - Sulfur has fire prevention labeling.
    - Contans WG (*Coniothyrium minitans* strains CON/M/91-08) must be stored at ≤39°F and out of sunlight.
- Is not corrosive to metals and application equipment.
  - Oxidate (hydrogen dioxide) is corrosive.

10.4. COMPATIBILITY WITH OTHER PRODUCTS USED IN ORGANIC CROP PRODUCTION

Polyoxin D zinc salt is compatible with the OMRI listed alternative products. Polyoxin D zinc salt is not an antibiotic and does not kill bacteria. Polyoxin D zinc salt will not kill beneficial soil bacteria, and it will not kill live bacterial that are used as active ingredients in alternative products, *i.e.*, *Streptomyces lydicus* WYEC 108 in Actinovate.
Contans contains as its active ingredient a live fungus, *Coniothyrium minitans* strains CON/M/91-08. Given the mode of action of polyoxin D zinc salt, it would be best to not tank mix polyoxin D zinc salt with Contans.

10.5. WORKER SAFETY

Polyoxin D zinc salt is a very low hazard product. It has:

- Low acute toxicity;
- Low chronic toxicity;
- Low developmental toxicity;
- Is not mutagenic; and
- Is not oncogenic.

The formulation designed for the organic market (VEGGIETURBO 5SC Suspension Concentrate, a.k.a. OSO 5%SC Fungicide and TAVANO 5%SC Fungicide) has such low acute toxicity by all routes of exposure that EPA does not require a First Aid statement on the label.

A Grower's Guide to Organic Apples by Peck and Merwin (2009) (http://nysipm.cornell.edu/organic_guide/apples.pdf) reviews the organic disease control options in New York State. Pages 48 to 51 note worker safety issues for OMRI listed alternative products:

- **Fixed Copper**, *i.e.*, (1) copper oxychloride with copper sulfate, (2) copper hydroxide, (3) complexed forms of basic copper sulfate, and (4) copper dust preparations.
  - *"Acute exposure to copper can cause burning to skin, eyes, and nasal passages, and induce vomiting in humans."*
  - *'Over times, humans can bioaccumulate copper, which may lead to numerous chronic health problems involving the brain, heart, blood, liver, kidneys, stomach, intestinal tract, and reproductive organs.*
- **Lime Sulfur, Liquid Lime Sulfur**
  - *"The active compound, hydrogen sulfide, gives lime sulfur an unpleasant rotten egg smell that remains in the orchard for over a week."*
  - *"It is considered a dermal respiratory, and eye irritant."*
- **Sulfur**
  - *"Sulfur is considered a dermal, respiratory, and eye irritant, but has minimal chronic toxicity when properly handled."*
  - *"Sulfur residues on leaves can become a serious eye irritant for workers involved in hand thinning, summer pruning, or harvesting I the residues are not diminished by rainfall before workers enter the orchard."*

10.6. ENVIRONMENTAL SAFETY

10.6.1. Aquatic organisms

Kaken submitted a large number of degradation studies to support the tolerance exemption on all crops. These data demonstrate that polyoxin D zinc salt residues degrade quickly in the environment.

EPA has determined that:

- Polyoxin D zinc salt is moderately toxic to rainbow trout and freshwater invertebrates in laboratory studies; and
- *"Polyoxin D zinc salt has a net photolytic half-life of 0.4 days [degrades by 50% in the presence of sunlight in 9.6 hours] in sterile natural water. Even if residues of polyoxin D zinc salt enter water sources, residues are expected to degrade and be so diluted as to be negligible."* (September 12, 2012 Federal Register, page 56131).

Given the negligible exposure of fish and aquatic invertebrates from registered use under environmental conditions, there is a large margin of safety for fish and aquatic invertebrates. No short-term or long-term adverse effects on fish or aquatic invertebrates are reasonably anticipated from the registered use of polyoxin.

By contrast, copper:

- Is toxic to fish and aquatic invertebrates;
- Has potential for runoff several months or more after application; and
- Does not degrade.

10.6.2. Birds and Non-Target Insects

Polyoxin D zinc salt has low toxicity to birds and non-target insects. By contrast,

- Copper can harm birds and honeybees [Ref: Peck and Merwin (2009)]; and
- Oxidate (hydrogen dioxide) is:
  - Toxic to birds; and
  - Highly toxic to bees and beneficial insects.

10.6.3. Earthworms and beneficial soil fungi

Kaken has not conducted any studies to evaluate the effects of polyoxin D zinc salt on earthworms. However, based upon the mode of action and low toxicity to non-target organisms, no adverse effects on earthworms are anticipated.

Polyoxin D zinc salt is registered for treatment of a few soil-borne fungal pathogens. Polyoxin D zinc salt does not kill fungi. Instead, it stops their growth. Also, polyoxin D zinc salt rapidly degrades in the environment. No long-term adverse effects on beneficial soil fungi are anticipated.

10.6.4. Groundwater

Because polyoxin D zinc salt has low use rates and degrades rapidly under environmental conditions, polyoxin D zinc salt will not contaminate ground water.

10.7. CONCLUSION

Polyoxin D is believed to be a non-synthetic material produced via a fermentation process. The conversion of polyoxin D to polyoxin D zinc salt is achieved via an aqueous process in which no organic solvents are introduced as impurities. Because polyoxin D is not known to occur in nature as the zinc salt, polyoxin D zinc salt is described as a synthetic material.

Kaken believes that polyoxin D zinc salt can play a very important role in organic crop production.

- Integrated Pest Management. Polyoxin D zinc salt has a non-toxic mode of action. It inhibits chitin synthesis in fungal cell walls. Polyoxin D zinc salt does not inhibit chitin synthesis in insects, and it has low toxicity to honeybees and other non-target insects. Polyoxin D zinc salt has low toxicity to mammals and birds. Though polyoxin D zinc salt is moderately toxic to fish and aquatic invertebrates in laboratory studies, real world environmental exposures of aquatic habitats from registered use of polyoxin D zinc salt are negligible. Consequently, the risk to fish and aquatic invertebrates from registered use of polyoxin D zinc salt is also negligible. The very specific mode of action and low risk to non-target organisms make polyoxin D zinc salt well suited to integrated pest management programs.

- Resistance Management. Resistance management is achieved by not repeatedly using products with the same mode of action. While organic growers have many fungicide products available for use, the number of different modes of action of the products is surprisingly limited. Polyoxin D zinc salt has a unique mode of action and can be easily incorporated into resistance management programs. Authorization to use polyoxin D in organic crop production will help extend the useful life of the fungicides that are currently available to organic growers.

- Broad Spectrum Efficacy Without Phytotoxicity. Polyoxin D zinc salt provides broad spectrum activity against fungal plant pathogens without phytotoxicity. It is currently registered for the treatment of 73 crop group (or crop) / pathogen combinations. Nearly all of these uses are also registered in California. An active product development program for new uses on growing crops and post-harvest uses is planned, so the list of registered uses will be expanding. Unlike alternative products containing copper, sulfur and hydrogen dioxide, polyoxin D zinc salt does not cause russeting of apples. Use of polyoxin D zinc salt will enable organic growers to produce a higher quality crop and a higher yield crop.

- Fills a Need. Polyoxin D zinc salt may be used to control or suppress significant diseases on crops for which the organic grower currently has either no OMRI listed alternative or very few OMRI listed alternatives. Also, when comparative efficacy data are available, the data demonstrate that polyoxin D zinc salt provides, at a minimum, comparable efficacy, and polyoxin D zinc salt generally provides superior efficacy. Many of the alternative products are registered for preventative use only, *i.e.*, applications must be made *before* there are any symptoms of disease. In addition to preventative treatments, polyoxin D zinc salt can be applied as a curative treatment soon after disease symptoms first appear.

- Ease of use. Polyoxin D zinc salt gives growers flexibility on time of use. It has no pre-harvest interval, and it has the minimum 4-hour reentry interval. It may be used throughout the growing season, and there are no temperature restrictions on time or use. Also, there are no special storage requirements. Due to the low acute toxicity of polyoxin D zinc salt, only minimal personal protective equipment are required (long sleeve shirt, long pants, shoes, socks, and chemical resistant gloves).

- Formulation Designed for the Organic Market. VEGGIETURBO 5SC Suspension Concentrate Fungicide was formulated for the organic market. This formulation is registered by EPA and California. Certis USA will be marketing the 5SC formulation in the United States as OSO 5%SC Fungicide and TAVANO 5%SC Fungicide. OMRI listings of the products will be requested shortly after a favorable decision from NOP is scheduled for publication in the Federal Register.

APPENDICES

APPENDIX 1. Maximum Inhibitory Concentration Data

Minimum Inhibitory Concentrations (MIC) of Polyoxins against Bacteria, Yeast and Fungi

Keiji Takahashi
The Third Laboratory, Research Laboratories,
Kaken Chemical Co., Ltd.
April 1972

1. Determination of MIC
   1) Bacteria
      Agar streak method using peptone-glucose agar was employed.
      Determination was made after incubation at 31 ℃ for 18-24 hr.
   2) Yeast
      Agar streak method using potato sucrose agar was employed.
      Determination was made after incubation at 26 ℃ for 48 hr.
   3) Fungi
      Agar streak method using potato sucrose agar was employed.
      Determination was made after incubation at 26 ℃ for 48-65 hr.
      (For Fusarium spp. , Hopkins agar was used instead of potato sucrose agar.)

2. Test substance
   Polyoxin D, E and F mixture (purity 80 % up as polyoxin D activity)

3. Results
   1) Bacteria

	MIC(μg/ml)
Bacillus subtilis PCI-219	>100
Staphylococcus aureus FDA-209P	>100
S. aureus HEATLEY	>100
Escherichia coli NIHJ	>100
Pseudomonas fluorescens NRRL-B-10	>100
Klebsiella pneumoniae PCI-602	>100
Mycobacterium phlei CCM-1889	>100
Micrococcus flavus	>100
Sarcina lutea	>100
Xanthomonas citri	>100
Erwinia aroideae	>100

   2) Yeast

	MIC(μg/ml)
Candida albicans IPCR	>100
C. steratoides	>100
Endomyces magnusii	>100
Saccharomyces sp.	>100

Minimum Inhibitory Concentration (MIC) of Polyoxins Against Bacteria, Yeast and Fungi

3) Fungi

	MIC(μ g/ml)
Aspergillus flavus	>100
A. fumigatus	>100
A. niger	>100
Penicillium citrinum	>100
P. crysogenum	> 10
Mucor recemosus (-)	> 10
Rhizopus oryzae IFO-4707	< 1.0
Giberella zeae	>100
Fusarium avenaceum f. sp. fabae	>200
F. maniliforme var. majus	< 50
F. oxysporum f. sp. cucumerinum	<200
F. oxysporum f. sp. lycopersici	> 25
F. oxysporum f. niveum	< 50
Chaetomium cochliodes	<100

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Minimum Inhibitory Concentration (MIC) of Polyoxin D Against Various Bacteria

ABSTRACT

Growth inhibitory concentration of Polyoxin D against pathogenic, intestinal and other general bacteria existing widely in nature was measured by the agar plate dilution method. From the results obtained, the level of MIC was found to be higher than 400 μg/mL and it was concluded that Polyoxin D was inactive to bacteria.

STUDY REPORT

Starting date: March 18, 2004
Finishing date: June 25, 2004

STUDY SITE

Mitsubishi Kagaku Bio-Chemical Laboratories, Inc.
Main Reference Laboratory in Tokyo
30-1, Shimura 3-chome, Itabashi-ku, Tokyo 174-8555, Japan

STUDY DIRECTOR

Intetsu Kobayashi, Ph.D.
General Manager
Clinical Microbiological Department

MATERIALS AND METHODS

1. Test Substance
   Name: Polyoxin D (Lot PDWS-001)
   Purity: 94.6% (HPLC)

2. Test Concentration in Agar Plate Medium
   In a range from 400 to 0.025 μg/mL (15 different levels prepared by 2 times sequential dilution)

3. Test Microbial Strains
   (1) Aerobic bacteria
   Staphylococcus aureus ATCC25923
   Enterococcus faecalis ATCC19433
   Streptococcus pneumonia ATCC49619
   Baccilus subtilis ATCC6633
   Escherichia coli ATCC25922
   Enterobacter aerogenes ATCC13048
   Serratia marcescens ATCC13880
   Salmonella chileraesuls serotype Enteritidis (*Salmonella enteritidis*) ATCC13076
   Vibrio parahaemolyticus ATCC17802
   Pseudomonas aeruginosa ATCC27853

   (2) Anaerobic bacteria
   Clostridium perfrigens IID520
   Lactobacillus acidophilus ATCC4356
   Bacteroides fragilis ATCC25285

   (3) Acid-Fast bacteria
   Mycobacterium avium ATCC25291

4. Inoculum Size
   Aerobic bacteria approx 10^6 CFU/mL of medium
   Anaerobic bacteria: approx 10^8 CFU/mL of medium
   Acid-fast bacterium: approx 10^6 CFU/mL of medium

5. Assay Media
   Agar plate media used for the drug sensitivity test was shown in Table 1.

6. Drug Sensitivity Test Method
   The test was carried out according to the Agar Plate Dilution Method described in the Standard Operation Procedure of the Japanese Society of Chemotherapy [1), 2)]. The culture conditions were shown in Table1.

Table-1 Test Bacteria, Assay Media and Culture Conditions

Test bacteria	Assay media	Culture conditions
S. aureus	Mueller Hinton Agar (MHA)	Aerobic culture at 35°C for 18 to 20 hr
E. faecalis	"	"
B. subtilis	"	"
E. coli	"	"
E. aerogenes	"	"
S. marcescens	"	"
S. enteritidis	"	"
V. parahaemolyticus	"	"
P. aeruginosa	"	"
S. pneumonia	MHA with addition of 5% horse blood	"
C. perfrigens	Brucella agar[a] with addition of 5% horse blood	Anaerobic culture at 35°C for 40 to 48hr
L. acidophilus	"	"
B. fragilis	"	"
M.avium	Middlebrock 7H10 Agar[b]	Aerobic culture at 35°C for 3 to 10hr

[a]Five (5) mg of hemin and 1 mg of vitamin K_1 were added in 1L of the assay medium.
[b]Five (5) g of glycerol and 100 mL of OADC enrich were added in 1L of the assay medium.

7. Determination of MIC
   After confirming the growth of each bacterial strain in a control medium prepared without addition of the test substance, the MIC was determined from the lowest concentration of test substance at which no bacterial growth in the assay medium was observed.

RESULTS

The results were shown in Table 2. The values of MIC of Polyoxin D against all the tested aerobic, anaerobic and acid-fast bacteria were higher than 400 μg /mL.

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Table-2 MIC of Polyoxin D Against Various Bacteria

Strain of test bacteria	MIC (μg/mL)
Staphylococcus aureus ATCC25923	>400
Enterococcus faecalis ATCC19433	>400
Streptococcus pneumonia ATCC49619	>400
Baccilus subtilis ATCC6633	>400
Escherichia coli ATCC25922	>400
Enterobacter aerogenes ATCC13048	>400
Serratia marcescens ATCC13880	>400
Salmonella enteritidis ATCC13076	>400
Vibrio parahaemolyticus ATCC17802	>400
Pseudomonas aeruginosa ATCC27853	>400
Clostridium perfrigens IID520	>400
Lactobacillus acidophilus ATCC4356	>400
Bacteroides fragilis ATCC25285	>400
Mycobacterium avium ATCC25291	>400

DISCUSSION

Polyoxin D is an antifungal agent and the primary site of action is inhibition of the cell wall chitin synthesis of plant-pathogenic fungi [3), 4), 5), 6) 7), 8)]. Since bacteria contain no chitin, this compound has been known to be inactive to any bacteria. The present test results indicate that the levels of MIC of Polyoxin D against the various tested bacteria are higher than 400 μg/mL and, in conclusion, no effect of this compound on bacterial growth is reconfirmed.

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APPENDIX 2. Registered Uses of Polyoxin D Zinc Salt and OMRI Listed Alternatives Grouped by Fungicide Resistance Action Committee (FRAC) Code and Active Ingredient										
Registered Uses of Polyoxin D Zinc Salt				OMRI Approved Alternative Products						
Crop	Disease (Pathogen)	Curative [4]	New Use	FRAC Code	Active Ingredient	EPA Reg. No.	Brand Name (Registrant)	Product Label Notes	Efficacy	
									Notes	Ref.
Almonds	Alternaria leaf spot (*Alternaria* spp.)	✔		P	*Reynoutria sachalinensis*	84059-3	Regalia Concentrate (Marrone)	Preventative use only.		
				P	*Reynoutria sachalinensis*	84059-6	Regalia Maxx (Marrone)	Preventative use only.		
				None	*Bacillus pumilus* QST 2808	264-1153	Sonata ASO (Bayer)	Preventative use only. Tank mix with other registered fungicide for better performance.		
				None	*Streptomyces lydicus* WYEC 108	73314-1	Actinovate SP (Natural Industries)	Label does not include specific crop/pathogen combinations. Label claims suppression/control, without identifying uses limited to suppression. For best results, apply before disease onset. Live bacterium; must be applied after sterilant/fumigant has dissipated.		
Artichoke †	Gray mold/Botrytis rot (*Botrytis cinerea*)		✔	44	*Bacillus subtilis* strain QST 713	264-1151	Serenade Max (Bayer)	Preventative use only. Tank mix with other registered fungicide for better performance.		
Artichoke †	Powdery Mildew (*Leveillula taurica, Erysiphe cichoracearum*)	✔	✔	M1	Copper octanoate	67702-2	Cueva Fungicide Concentrate (Neudorff)	Toxic to fish and aquatic organisms. Runoff warning for poorly draining soils with shallow water tables. Must re-apply after rain. For best results, spray before disease first appears.		
				P	*Ranatra sachalinensis*	84059-3	Regalia Concentrate (Marrone)	Preventative use only.		
				P	*Reynoutria sachalinensis*	84059-6	Regalia Maxx (Marrone)	Preventative use only.		
				44	*Bacillus subtilis* strain QST 713	264-1151	Serenade Max (Bayer)	Preventative use only. Tank mix with other registered fungicide for better performance.		
				None	*Bacillus pumilus* strain QST 2808	264-1153	Sonata ASO (Bayer)	Preventative use only. Tank mix with other registered fungicide for better performance.		
				None	Potassium salts of fatty acids	10163-324	M-Pede Insecticide-Miticide-Fungicide (Gowan)	Phytotoxicity warning. Preventative use only. WARNING signal word. May be hazardous to aquatic invertebrates. Some tank mixes prohibited.		

APPENDIX 2. Registered Uses of Polyoxin D Zinc Salt and OMRI Listed Alternatives Grouped by Fungicide Resistance Action Committee (FRAC) Code and Active Ingredient

Registered Uses of Polyoxin D Zinc Salt				OMRI Approved Alternative Products						
Crop	Disease (Pathogen)	Curative [4]	New Use	FRAC Code	Active Ingredient	EPA Reg. No.	Brand Name (Registrant)	Product Label Notes	Efficacy Notes	Efficacy Ref.
Berries and small fruits (see separate section for grapes and strawberries)	*Alternaria* leaf spot and fruit rot (*Alternaria* spp.)	✔	✔	P	*Ranatra sachalinensis*	84059-3	Regalia Concentrate (Marrone)	Preventative use only.		
				P	*Reynoutria sachalinensis*	84059-6	Regalia Maxx (Marrone)	Preventative use only.		
				44	*Bacillus subtilis* strain QST 713	264-1151	Serenade Max (Bayer)	Preventative use only. Tank mix with other registered fungicide for better performance.		
				None	*Bacillus pumilus* strain QST 2808	264-1153	Sonata ASO (Bayer)	Preventative use only. Tank mix with other registered fungicide for better performance.		
				None	*Streptomyces lydicus* WYEC 108	73314-1	Actinovate Soluble (Natural Industries)	Preventative use only. Live bacterium; must be applied after sterilant/fumigant has dissipated. Soil temperature must be ≥45°F. Label does not include specific crop/pathogen combinations. Label claims suppression/control, without identifying uses limited to suppression.		

APPENDIX 2. Registered Uses of Polyoxin D Zinc Salt and OMRI Listed Alternatives Grouped by Fungicide Resistance Action Committee (FRAC) Code and Active Ingredient

Registered Uses of Polyoxin D Zinc Salt				OMRI Approved Alternative Products						
Crop	Disease (Pathogen)	Curative [4]	New Use	FRAC Code	Active Ingredient	EPA Reg. No.	Brand Name (Registrant)	Product Label Notes	Efficacy Notes	Efficacy Ref.
Berries and small fruits (see separate section for grapes and strawberries)	Anthracnose leaf & fruit rot * (*Colletotrichum* spp.)	✔	✔	M1	Copper hydroxide	55146-1	Champ WG (NuFarm)	Phytotoxic in spray solution with pH <6.0. DANGER signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				M1	Copper hydroxide	45002-4	Nu-Cop 50DF (Albaugh)	Phytotoxic in spray solution with pH <6.5. DANGER signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				M1	Cuprous oxide	48142-4	NORDOX 75 WG	High rate may be phytotoxic under hot or dry conditions. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product. May corrode aluminum irrigation pipes. Use limited to caneberries.		
				M1	Copper oxychloride and Copper hydroxide	80289-12	Badge X2 (Isagro)	Phytotoxic in spray solution with pH <6.5. WARNING signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				M1	Copper sulfate pentahydrate	66675-3	CS 2005	Phytotoxicity warning. DANGER signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				P	*Ranatra sachalinensis*	84059-3	Regalia Concentrate (Marrone)	Preventative use only.		
				P	*Reynoutria sachalinensis*	84059-6	Regalia Maxx (Marrone)	Preventative use only.	Blueberries: Evidence of control and/or yield increase.	1
				44	*Bacillus subtilis* strain QST 713	264-1151	Serenade Max (Bayer)	Preventative use only. Tank mix with other registered fungicide for better performance.		
				None	*Bacillus amyloliquefaciens* strain D747	70051-108	Double Nickel 55	Preventative use only.		

APPENDIX 2. Registered Uses of Polyoxin D Zinc Salt and OMRI Listed Alternatives Grouped by Fungicide Resistance Action Committee (FRAC) Code and Active Ingredient

Registered Uses of Polyoxin D Zinc Salt				OMRI Approved Alternative Products						
Crop	Disease (Pathogen)	Curative [4]	New Use	FRAC Code	Active Ingredient	EPA Reg. No.	Brand Name (Registrant)	Product Label Notes	Efficacy Notes	Efficacy Ref.
				None	*Bacillus pumilus* strain QST 2808	264-1153	Sonata ASO (Bayer)	Preventative use only. Tank mix with other registered fungicide for better performance.		
				None	*Streptomyces lydicus* WYEC 108	73314-1	Actinovate Soluble (Natural Industries)	Preventative use only. Live bacterium; must be applied after sterilant/fumigant has dissipated. Soil temperature must be ≥45°F. Label does not include specific crop/pathogen combinations. Label claims suppression/control, without identifying uses limited to suppression.		
Berries and small fruits (see separate section for grapes and strawberries)	Gray mold/fruit rot/Botrytis blight (*Botrytis cinerea*)	✔	✔	P	*Ranatra sachalinensis*	84059-3	Regalia Concentrate (Marrone)	Preventative use only.		
				P	*Reynoutria sachalinensis*	84059-6	Regalia Maxx (Marrone)	Preventative use only.		
				44	*Bacillus subtilis* strain QST 713	264-1151	Serenade Max (Bayer)	Preventative use only. Tank mix with other registered fungicide for better performance.		
				None	*Bacillus amyloliquefaciens* strain D747	70051-108	Double Nickel 55	Preventative use only.		
				None	*Bacillus pumilus* strain QST 2808	264-1153	Sonata ASO (Bayer)	Preventative use only. Tank mix with other registered fungicide for better performance.		
				None	*Streptomyces lydicus* WYEC 108	73314-1	Actinovate Soluble (Natural Industries)	Preventative use only. Live bacterium; must be applied after sterilant/fumigant has dissipated. Soil temperature must be ≥45°F. Label does not include specific crop/pathogen combinations. Label claims suppression/control, without identifying uses limited to suppression.		

APPENDIX 2. Registered Uses of Polyoxin D Zinc Salt and OMRI Listed Alternatives Grouped by Fungicide Resistance Action Committee (FRAC) Code and Active Ingredient

Registered Uses of Polyoxin D Zinc Salt				OMRI Approved Alternative Products						
Crop	Disease (Pathogen)	Curative [4]	New Use	FRAC Code	Active Ingredient	EPA Reg. No.	Brand Name (Registrant)	Product Label Notes	Efficacy Notes	Efficacy Ref.
Berries and small fruits (see separate section for grapes and strawberries)	Powdery mildew (*Sphaerotheca macularis*, *Erysiphe* spp.)	✔	✔	M2	Sulfur (elemental)	70905-1	Cosavet DF (Sulphur Mills)	Sulfur may cause severe fruit and foliage injury to certain crops. Sulfur dust suspended in air ignites easily. Keep away from heat, sparks, or flames. Do not smoke while applying this product. Do not apply when shade temperatures exceed or are likely to exceed 90°F. REI = 24 hour.		
				M2	Sulfur (Elemental)	2935-407	Golden Micronized Sulfur	Sulfur may cause severe fruit and foliage injury to certain crops. Sulfur dust suspended in air ignites easily. Keep away from heat, sparks, or flames. Do not smoke while applying this product. Do not apply when shade temperatures exceed or are likely to exceed 90°F. REI = 24 hour.		
				NC	Paraffinic oil	65564-1	Organic JMS Stylet Oil (JMS)	Phytotoxicity warning; enhances phytotoxicity of other products. Contains petroleum distillates. Do not apply when temperature is <50°F or >90°F. Many tank mix prohibitions.		
				NC	Potassium bicarbonate	20231-1	Kaligreen (Otsuka)	Do not mix with highly acidic products. Acidification with a buffering agent may reduce efficacy. Min PHI for food crops is 1 day. Use limited to powdery mildew; curative.		
				P	*Ranatra sachalinensis*	84059-3	Regalia Concentrate (Marrone)	Preventative use only.		
				44	*Bacillus subtilis* strain QST 713	264-1151	Serenade Max (Bayer)	Preventative use only. Tank mix with other registered fungicide for better performance.		
				None	*Bacillus pumilus* strain QST 2808	264-1153	Sonata ASO (Bayer)	Preventative use only. Tank mix with other registered fungicide for better performance.		

APPENDIX 2. Registered Uses of Polyoxin D Zinc Salt and OMRI Listed Alternatives Grouped by Fungicide Resistance Action Committee (FRAC) Code and Active Ingredient

Registered Uses of Polyoxin D Zinc Salt				OMRI Approved Alternative Products						
Crop	Disease (Pathogen)	Curative [4]	New Use	FRAC Code	Active Ingredient	EPA Reg. No.	Brand Name (Registrant)	Product Label Notes	Efficacy Notes	Efficacy Ref.
Brassica (Cole) leafy vegetables	Alternaria leaf spot (*Alternaria* spp.)	✔	✔	M1	Copper hydroxide	55146-1	Champ WG (NuFarm)	Phytotoxic in spray solution with pH <6.0. DANGER signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				M1	Copper hydroxide	45002-4	Nu-Cop 50DF (Albaugh)	Crop appearance effects label warning. Phytotoxic in spray solution with pH <6.5. DANGER signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				M1	Copper hydroxide	45002-7	Blue Shield (Albaugh)	Crop appearance effects label warning. Phytotoxic in spray solution with pH <6.5. DANGER signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				M1	Copper octanoate	67702-2	Cueva Fungicide Concentrate (Neudorff)	Toxic to fish and aquatic organisms. Runoff warning for poorly draining soils with shallow water tables. Must re-apply after rain. For best results, spray before disease first appears.		
				M1	Copper(I) oxide	26883-20	Chem Copp 50 (American Chemet)	WARNING signal word. Toxic to fish.		
				M1	Copper oxychloride	45002-17	COC WP (Albaugh)	Leaf effects warning. Toxic to fish and aquatic organisms. Runoff warning for poorly draining soils with shallow water tables. Potential runoff for several months or longer after application.		
				M1	Copper sulfate	45002-8	Basic Copper 53 (Albaugh)	WARNING signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				M1	Copper sulfate pentahydrate	66675-3	CS 2005	Phytotoxicity warning. DANGER signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		

APPENDIX 2. Registered Uses of Polyoxin D Zinc Salt and OMRI Listed Alternatives Grouped by Fungicide Resistance Action Committee (FRAC) Code and Active Ingredient

Registered Uses of Polyoxin D Zinc Salt				OMRI Approved Alternative Products						
Crop	Disease (Pathogen)	Curative [4]	New Use	FRAC Code	Active Ingredient	EPA Reg. No.	Brand Name (Registrant)	Product Label Notes	Efficacy Notes	Efficacy Ref.
				P	*Ranatra sachalinensis*	84059-3	Regalia Concentrate (Marrone)	Preventative use only.		
				P	*Reynoutria sachalinensis*	84059-6	Regalia Maxx (Marrone)	Preventative use only. Tank mix with another fungicide under moderate to heavy disease pressure.		
				44	*Bacillus subtilis* strain QST 713	264-1155	Rapsody ASO (Bayer)	Preventative use only. Tank mix with other registered fungicide for better performance.		
				44	*Bacillus subtilis* strain QST 713	264-1151	Serenade Max (Bayer)	Preventative use only. Tank mix with other registered fungicide for better performance.		
				None	*Bacillus amyloliquefaciens* strain D747	70051-108	Double Nickel 55	Preventative use only.		
				None	*Bacillus pumilus* strain QST 2808	264-1153	Sonata ASO (Bayer)	Preventative use only. Suppression only. Tank mix with other registered fungicide for better performance.		
				None	*Streptomyces lydicus* WYEC 108	73314-1	Actinovate Soluble (Natural Industries)	Preventative use only. Live bacterium; must be applied after sterilant/fumigant has dissipated. Soil temperature must be ≥45°F. Label does not include specific crop/pathogen combinations. Label claims suppression/control, without identifying uses limited to suppression.		
Brassica (Cole) leafy vegetables	Anthracnose (*Colletotrichum* spp.)		✔	44	*Bacillus subtilis* strain QST 713	264-1151	Serenade Max (Bayer)	Preventative use only. Tank mix with other registered fungicide for better performance.		
				None	*Bacillus pumilus* strain QST 2808	264-1153	Sonata ASO (Bayer)	Preventative use only. Suppression only. Tank mix with other registered fungicide for better performance.		
				None	*Streptomyces lydicus* WYEC 108	73314-1	Actinovate Soluble (Natural Industries)	Preventative use only. Live bacterium; must be applied after sterilant/fumigant has dissipated. Soil temperature must be ≥45°F. Label does not include specific crop/pathogen combinations. Label claims suppression/control, without identifying uses limited to suppression.		
Brassica (Cole) leafy vegetables	Gray mold (*Botrytis cinerea*)	✔	✔	None	*Streptomyces lydicus* WYEC 108	73314-1	Actinovate Soluble (Natural Industries)	Preventative use only. Live bacterium; must be applied after sterilant/fumigant has dissipated. Soil temperature must be ≥45°F. Label does not include specific crop/pathogen combinations. Label claims suppression/control, without identifying uses limited to suppression.		
Brassica (Cole) leafy vegetables	White spot (*Cercosporella* spp.)	✔	✔	None	*Bacillus pumilus* strain QST 2808	264-1153	Sonata ASO (Bayer)	Preventative use only. Suppression only. Tank mix with other registered fungicide for better performance.		

APPENDIX 2. Registered Uses of Polyoxin D Zinc Salt and OMRI Listed Alternatives Grouped by Fungicide Resistance Action Committee (FRAC) Code and Active Ingredient

Registered Uses of Polyoxin D Zinc Salt				OMRI Approved Alternative Products						
Crop	Disease (Pathogen)	Curative [4]	New Use	FRAC Code	Active Ingredient	EPA Reg. No.	Brand Name (Registrant)	Product Label Notes	Efficacy Notes	Efficacy Ref.
Brassica (Cole) leafy vegetables	Bottom rot (*Rhizoctonia solani*)		✔	P	*Ranatra sachalinensis*	84059-3	Regalia Concentrate (Marrone)	Preventative use only. Suppression only.		
				44	*Bacillus subtilis* strain QST 713	264-1151	Serenade Max (Bayer)	Preventative use only. Tank mix with other registered fungicide for better performance.		
				None	*Bacillus amyloliquefaciens* strain D747	70051-108	Double Nickel 55	Preventative use only.		
Brassica (Cole) leafy vegetables	Sclerotinia rot (*Sclerotinia sclerotiorum)*		✔	44	*Bacillus subtilis* strain QST 713	264-1152	Serenade ASO = Serenade Soil (Bayer)	Tank mix with other registered fungicide for better performance.		
				None	*Bacillus pumilus* strain QST 2808	264-1153	Sonata ASO (Bayer)	Preventative use only. Suppression only. Tank mix with other registered fungicide for better performance.		
				None	*Coniothyrium minitans* strains CON/M/91-08	7244-1	Contans WG (Prophyta Biologischer Pflanzenschutz)	Registered uses are limited to *Sclerotinia sclerotiorum* and *Sclerotinia minor* only. Application limited to period when temperature is below 81°C for 7 days; soil temperature should be 50-81°F. Soil must remain moist after application. Must be applied after sterilant or fumigant has dissipated. Product must be store at ≤39°F and out of sunlight. [Live fungus active ingredient. Ref: EPA BRAD.]		

APPENDIX 2. Registered Uses of Polyoxin D Zinc Salt and OMRI Listed Alternatives Grouped by Fungicide Resistance Action Committee (FRAC) Code and Active Ingredient

Registered Uses of Polyoxin D Zinc Salt				OMRI Approved Alternative Products					
Crop	Disease (Pathogen)	Curative [4]	New Use	FRAC Code	Active Ingredient	EPA Reg. No.	Brand Name (Registrant)	Product Label Notes	Efficacy Notes	Efficacy Ref.
Bulb vegetables	Alternaria blight and Purple blotch (*Alternaria* spp.)	✔	✔	M1	Copper(I) oxide	26883-20	Chem Copp 50 (American Chemet)	WARNING signal word. Toxic to fish.		
				M1	Cuprous oxide	48142-4	Nordox 75 WG	High rate may be phytotoxic under hot or dry conditions. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product. May corrode aluminum irrigation pipes.		
				M1	Copper oxychloride	45002-17	COC WP (Albaugh)	Crop injury warning. Toxic to fish and aquatic organisms. Runoff warning for poorly draining soils with shallow water tables. Potential runoff for several months or longer after application. Use limited to lettuce, endive and escarole.		
				M1	Copper sulfate	45002-8	Basic Copper 53 (Albaugh)	WARNING signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				M1	Copper sulfate pentahydrate	66675-3	CS 2005	Phytotoxicity warning. DANGER signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				P	*Ranatra sachalinensis*	84059-3	Regalia Concentrate (Marrone)	Preventative use only.		
				P	*Reynoutria sachalinensis*	84059-6	Regalia Maxx (Marrone)	Preventative use only. Tank mix with another fungicide under moderate to heavy disease pressure.		
				44	*Bacillus subtilis* strain QST 713	264-1155	Rapsody ASO (Bayer)	Preventative use only. Tank mix with other registered fungicide for better performance.		
				44	*Bacillus subtilis* strain QST 713	264-1151	Serenade Max (Bayer)	Preventative use only. Tank mix with other registered fungicide for better performance.		
				None	*Bacillus amyloliquefaciens* strain D747	70051-108	Double Nickel 55	Preventative use only.		
				None	*Bacillus pumilus* strain QST 2808	264-1153	Sonata ASO (Bayer)	Preventative use only. Tank mix with other registered fungicide for better performance.		

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Registered Uses of Polyoxin D Zinc Salt				OMRI Approved Alternative Products						
Crop	Disease (Pathogen)	Curative [4]	New Use	FRAC Code	Active Ingredient	EPA Reg. No.	Brand Name (Registrant)	Product Label Notes	Efficacy	
									Notes	Ref.
				None	*Streptomyces lydicus* WYEC 108	73314-1	Actinovate Soluble (Natural Industries)	Preventative use only. Live bacterium; must be applied after sterilant/fumigant has dissipated. Soil temperature must be ≥45°F. Label does not include specific crop/pathogen combinations. Label claims suppression/control, without identifying uses limited to suppression.		
Bulb vegetables	Botrytis leaf blight /Leaf spot/Neck rot (*Botrytis* spp.)	✔	✔	M1	Copper octanoate	67702-2	Cueva Fungicide Concentrate (Neudorff)	Toxic to fish and aquatic organisms. Runoff warning for poorly draining soils with shallow water tables. Must re-apply after rain. For best results, spray before disease first appears.		
				M2	Sulfur (Elemental)	2935-407	Golden Micronized Sulfur (Wilbur-Ellis)	Sulfur may cause severe fruit and foliage injury to certain crops. Sulfur dust suspended in air ignites easily. Keep away from heat, sparks, or flames. Do not smoke while applying this product. Do not apply when shade temperatures exceed or are likely to exceed 90°F. REI = 24 hour.		
				P	*Ranatra sachalinensis*	84059-3	Regalia Concentrate (Marrone)	Preventative use only.		
				P	*Reynoutria sachalinensis*	84059-6	Regalia Maxx (Marrone)	Preventative use only. Tank mix with another fungicide under moderate to heavy disease pressure.		
				44	*Bacillus subtilis* strain QST 713	264-1155	Rapsody ASO (Bayer)	Preventative use only. Tank mix with other registered fungicide for better performance.		
				44	*Bacillus subtilis* strain QST 713	264-1151	Serenade Max (Bayer)	Preventative use only. Tank mix with other registered fungicide for better performance.		
				None	*Bacillus amyloliquefaciens* strain D747	70051-108	Double Nickel 55	Preventative use only.		
				None	*Bacillus pumilus* strain QST 2808	264-1153	Sonata ASO (Bayer)	Preventative use only. Tank mix with other registered fungicide for better performance.		
				None	*Streptomyces lydicus* WYEC 108	73314-1	Actinovate Soluble (Natural Industries)	Preventative use only. Live bacterium; must be applied after sterilant/fumigant has dissipated. Soil temperature must be ≥45°F. Label does not include specific crop/pathogen combinations. Label claims suppression/control, without identifying uses limited to suppression.		

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Registered Uses of Polyoxin D Zinc Salt				OMRI Approved Alternative Products						
Crop	Disease (Pathogen)	Curative [4]	New Use	FRAC Code	Active Ingredient	EPA Reg. No.	Brand Name (Registrant)	Product Label Notes	Efficacy Notes	Efficacy Ref.
Bulb vegetables	Downy mildew * (*Peronospora* spp.)		✔	M1	Copper hydroxide	55146-1	Champ WG (NuFarm)	Phytotoxic in spray solution with pH <6.0. DANGER signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				M1	Copper hydroxide	45002-4	Nu-Cop 50DF (Albaugh)	Phytotoxic in spray solution with pH <6.5. DANGER signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				M1	Copper octanoate	67702-2	Cueva Fungicide Concentrate (Neudorff)	Toxic to fish and aquatic organisms. Runoff warning for poorly draining soils with shallow water tables. Must re-apply after rain. For best results, spray before disease first appears.		
				M1	Copper(I) oxide	26883-20	Chem Copp 50 (American Chemet)	WARNING signal word. Toxic to fish.		
				M1	Cuprous oxide	48142-4	Nordox 75 WG	High rate may be phytotoxic under hot or dry conditions. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product. May corrode aluminum irrigation pipes.		
				M1	Copper oxychloride	45002-17	COC WP (Albaugh)	Crop injury warning. Toxic to fish and aquatic organisms. Runoff warning for poorly draining soils with shallow water tables. Potential runoff for several months or longer after application.		
				M1	Copper sulfate pentahydrate	66675-3	CS 2005	Phytotoxicity warning. DANGER signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				P	*Ranatra sachalinensis*	84059-3	Regalia Concentrate (Marrone)	Preventative use only.		
				P	*Reynoutria sachalinensis*	84059-6	Regalia Maxx (Marrone)	Preventative use only. Tank mix with another fungicide under moderate to heavy disease pressure.		
				44	*Bacillus subtilis* strain QST 713	264-1155	Rapsody ASO (Bayer)	Preventative use only. Tank mix with other registered fungicide for better performance.		

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Registered Uses of Polyoxin D Zinc Salt				OMRI Approved Alternative Products						
Crop	Disease (Pathogen)	Curative [4]	New Use	FRAC Code	Active Ingredient	EPA Reg. No.	Brand Name (Registrant)	Product Label Notes	Efficacy Notes	Efficacy Ref.
				44	*Bacillus subtilis* strain QST 713	264-1151	Serenade Max (Bayer)	Preventative use only. Tank mix with other registered fungicide for better performance.		
				None	*Bacillus amyloliquefaciens* strain D747	70051-108	Double Nickel 55	Preventative use only.		
				None	*Bacillus pumilus* strain QST 2808	264-1153	Sonata ASO (Bayer)	Preventative use only. Tank mix with other registered fungicide for better performance.		
				None	*Streptomyces lydicus* WYEC 108	73314-1	Actinovate Soluble (Natural Industries)	Preventative use only. Live bacterium; must be applied after sterilant/fumigant has dissipated. Soil temperature must be ≥45°F. Label does not include specific crop/pathogen combinations. Label claims suppression/control, without identifying uses limited to suppression.		
Bulb vegetables	Rust (*Puccinia alii* or *Puccinia porri*)	✔	✔	P	*Reynoutria sachalinensis*	84059-6	Regalia Maxx (Marrone)	Preventative use only. Tank mix with another fungicide under moderate to heavy disease pressure.		
				44	*Bacillus subtilis* strain QST 713	264-1155	Rapsody ASO (Bayer)	Preventative use only. Tank mix with other registered fungicide for better performance.		
				44	*Bacillus subtilis* strain QST 713	264-1151	Serenade Max (Bayer)	Preventative use only. Suppression only. Tank mix with other registered fungicide for better performance.		
				None	*Bacillus amyloliquefaciens* strain D747	70051-108	Double Nickel 55	Preventative use only.		
				None	*Bacillus pumilus* strain QST 2808	264-1153	Sonata ASO (Bayer)	Preventative use only. Suppression only. Tank mix with other registered fungicide for better performance.		

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Registered Uses of Polyoxin D Zinc Salt				OMRI Approved Alternative Products						
Crop	Disease (Pathogen)	Curative [4]	New Use	FRAC Code	Active Ingredient	EPA Reg. No.	Brand Name (Registrant)	Product Label Notes	Efficacy Notes	Efficacy Ref.
Carrots and Parsnips	Alternaria leaf blight (*Alternaria dauci*)	✔	✔	M1	Copper octanoate	67702-2	Cueva Fungicide Concentrate (Neudorff)	Toxic to fish and aquatic organisms. Runoff warning for poorly draining soils with shallow water tables. Must re-apply after rain. For best results, spray before disease first appears.		
				M1	Copper(I) oxide	26883-20	Chem Copp 50 (American Chemet)	WARNING signal word. Toxic to fish.		
				M1	Cuprous oxide	48142-4	Nordox 75 WG	High rate may be phytotoxic under hot or dry conditions. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product. May corrode aluminum irrigation pipes. Use limited to carrots only.		
				M1	Copper hydroxide	45002-7	Blue Shield (Albaugh)	Crop appearance effects label warning. Phytotoxic in spray solution with pH <6.5. DANGER signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				M1	Copper sulfate pentahydrate	66675-3	CS 2005	Phytotoxicity warning. DANGER signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				P	*Ranatra sachalinensis*	84059-3	Regalia Concentrate (Marrone)	Preventative use only. Suppression only.		
				P	*Reynoutria sachalinensis*	84059-6	Regalia Maxx (Marrone)	Preventative use only.		
				44	*Bacillus subtilis* strain QST 713	264-1155	Rapsody ASO (Bayer)	Preventative use only. Tank mix with other registered fungicide for better performance.		
				44	*Bacillus subtilis* strain QST 713	264-1151	Serenade Max (Bayer)	Preventative use only. Tank mix with other registered fungicide for better performance.		
				None	*Bacillus pumilus* strain QST 2808	264-1153	Sonata ASO (Bayer)	Preventative use only. Suppression only. Tank mix with other registered fungicide for better performance.		

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Registered Uses of Polyoxin D Zinc Salt				OMRI Approved Alternative Products						
Crop	Disease (Pathogen)	Curative [4]	New Use	FRAC Code	Active Ingredient	EPA Reg. No.	Brand Name (Registrant)	Product Label Notes	Efficacy	
									Notes	Ref.
				None	*Streptomyces lydicus* WYEC 108	73314-1	Actinovate Soluble (Natural Industries)	Preventative use only. Live bacterium; must be applied after sterilant/fumigant has dissipated. Soil temperature must be ≥45°F. Label does not include specific crop/pathogen combinations. Label claims suppression/control, without identifying uses limited to suppression.		

APPENDIX 2. Registered Uses of Polyoxin D Zinc Salt and OMRI Listed Alternatives Grouped by Fungicide Resistance Action Committee (FRAC) Code and Active Ingredient

Registered Uses of Polyoxin D Zinc Salt				OMRI Approved Alternative Products						
Crop	Disease (Pathogen)	Curative [4]	New Use	FRAC Code	Active Ingredient	EPA Reg. No.	Brand Name (Registrant)	Product Label Notes	Efficacy Notes	Efficacy Ref.
Carrots and Parsnips	Cercospora leaf blight (*Cercospora carotae*)	✔	✔	M1	Copper hydroxide	55146-1	Champ WG (NuFarm)	Phytotoxic in spray solution with pH <6.0. DANGER signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				M1	Copper hydroxide	45002-4	Nu-Cop 50DF (Albaugh)	Phytotoxic in spray solution with pH <6.5. DANGER signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				M1	Cuprous oxide	48142-4	Nordox 75 WG	High rate may be phytotoxic under hot or dry conditions. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product. May corrode aluminum irrigation pipes. Use limited to carrots only.		
				M1	Copper(I) oxide	26883-20	Chem Copp 50 (American Chemet)	WARNING signal word. Toxic to fish.		
				M1	Copper oxychloride	450025-17	COC WP (Albaugh)	Toxic to fish and aquatic invertebrates. Potential for runoff for several months or more after application. Runoff warning for poorly drained soils and soils with shallow water table.		
				M1	Copper sulfate	45002-8	Basic Copper 53 (Albaugh)	WARNING signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				M1	Copper sulfate pentahydrate	66675-3	CS 2005	Phytotoxicity warning. DANGER signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				P	*Reynoutria sachalinensis*	84059-6	Regalia Maxx (Marrone)	Preventative use only.		

APPENDIX 2. Registered Uses of Polyoxin D Zinc Salt and OMRI Listed Alternatives Grouped by Fungicide Resistance Action Committee (FRAC) Code and Active Ingredient

Registered Uses of Polyoxin D Zinc Salt				OMRI Approved Alternative Products						
Crop	Disease (Pathogen)	Curative [4]	New Use	FRAC Code	Active Ingredient	EPA Reg. No.	Brand Name (Registrant)	Product Label Notes	Efficacy	
									Notes	Ref.
Carrots and Parsnips	Powdery mildew (*Erysiphe polygoni*)	✔	✔	M2	Sulfur (elemental)	70905-1	Cosavet DF (Sulphur Mills)	Sulfur may cause severe fruit and foliage injury to certain crops. Sulfur dust suspended in air ignites easily. Keep away from heat, sparks, or flames. Do not smoke while applying this product. Do not apply when shade temperatures exceed or are likely to exceed 90°F. REI = 24 hour.		
				NC	Potassium bicarbonate	20231-1	Kaligreen (Otsuka)	Do not mix with highly acidic products. Acidification with a buffering agent may reduce efficacy. Min PHI for food crops is 1 day. Use limited to powdery mildew; curative.		
				P	*Ranatra sachalinensis*	84059-3	Regalia Concentrate (Marrone)	Preventative use only.		
				P	*Reynoutria sachalinensis*	84059-6	Regalia Maxx (Marrone)	Preventative use only.		
				44	*Bacillus subtilis* strain QST 713	264-1151	Serenade Max (Bayer)	Preventative use only. Tank mix with other registered fungicide for better performance.		
				None	*Bacillus amyloliquefaciens* strain D747	70051-108	Double Nickel 55	Preventative use only.		
				None	*Bacillus pumilus* strain QST 2808	264-1153	Sonata ASO (Bayer)	Preventative use only. Tank mix with other registered fungicide for better performance.		
				None	Potassium salts of fatty acids	10163-324	M-Pede Insecticide-Miticide-Fungicide (Gowan)	Phytotoxicity warning. Preventative use only. WARNING signal word. May be hazardous to aquatic invertebrates. Some tank mixes prohibited.		
				None	*Streptomyces lydicus* WYEC 108	73314-1	Actinovate Soluble (Natural Industries)	Preventative use only. Live bacterium; must be applied after sterilant/fumigant has dissipated. Soil temperature must be ≥45°F. Label does not include specific crop/pathogen combinations. Label claims suppression/control, without identifying uses limited to suppression.		
Carrots and Parsnips	Rhizoctonia crown rot and leaf blight (*Rhizoctonia solani*)	✔	✔	P	*Ranatra sachalinensis*	84059-3	Regalia Concentrate (Marrone)	Preventative use only.		
				None	*Bacillus amyloliquefaciens* strain D747	70051-108	Double Nickel 55	Preventative use only.		

APPENDIX 2. Registered Uses of Polyoxin D Zinc Salt and OMRI Listed Alternatives Grouped by Fungicide Resistance Action Committee (FRAC) Code and Active Ingredient

Registered Uses of Polyoxin D Zinc Salt				OMRI Approved Alternative Products						
Crop	Disease (Pathogen)	Curative [4]	New Use	FRAC Code	Active Ingredient	EPA Reg. No.	Brand Name (Registrant)	Product Label Notes	Efficacy Notes	Efficacy Ref.
Citrus fruits	*Alternaria* brown spot (*Alternaria alternata*)	✔	✔	M1	Copper hydroxide	55146-1	Champ WG (NuFarm)	Phytotoxic in spray solution with pH <6.0. DANGER signal word. Suppression only. Copper injury warning. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				M1	Copper hydroxide and Copper oxychloride	80289-12	Badge X2 (Isagro)	Phytotoxic in spray solution with pH <6.5. WARNING signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				M1	Copper sulfate	45002-8	Basic Copper 53 (Albaugh)	WARNING signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				P	*Ranatra sachalinensis*	84059-3	Regalia Concentrate (Marrone)	Preventative use only.		
				P	*Reynoutria sachalinensis*	84059-6	Regalia Maxx (Marrone)	Preventative use only. Tank mix with another fungicide under moderate to heavy disease pressure.		
				44	*Bacillus subtilis* strain QST 713	264-1151	Serenade Max (Bayer)	Preventative use only. Tank mix with other registered fungicide for better performance.		
				None	*Bacillus amyloliquefaciens* strain D747	70051-108	Double Nickel 55	Preventative use only.		
				None	*Bacillus pumilus* strain QST 2808	264-1153	Sonata ASO (Bayer)	Preventative use only. Tank mix with other registered fungicide for better performance.		
				None	*Streptomyces lydicus* WYEC 108	73314-1	Actinovate Soluble (Natural Industries)	Preventative use only. Live bacterium; must be applied after sterilant/fumigant has dissipated. Soil temperature must be ≥45°F. Label does not include specific crop/pathogen combinations. Label claims suppression/control, without identifying uses limited to suppression.		
Citrus fruits	Botrytis rot (*Botrytis cinerea*)	✔	✔	None	*Streptomyces lydicus* WYEC 108	73314-1	Actinovate Soluble (Natural Industries)	Preventative use only. Live bacterium; must be applied after sterilant/fumigant has dissipated. Soil temperature must be ≥45°F. Label does not include specific crop/pathogen combinations. Label claims suppression/control, without identifying uses limited to suppression.		

APPENDIX 2. Registered Uses of Polyoxin D Zinc Salt and OMRI Listed Alternatives Grouped by Fungicide Resistance Action Committee (FRAC) Code and Active Ingredient										
Registered Uses of Polyoxin D Zinc Salt				OMRI Approved Alternative Products						
Crop	Disease (Pathogen)	Curative [4]	New Use	FRAC Code	Active Ingredient	EPA Reg. No.	Brand Name (Registrant)	Product Label Notes	Efficacy	
									Notes	Ref.
Citrus fruits	Septoria spot (*Septoria citri*)		✔	M1	Copper hydroxide	45002-4	Nu-Cop 50DF (Albaugh)	Phytotoxic in spray solution with pH <6.5. DANGER signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				M1	Copper hydroxide and Copper oxychloride	80289-12	Badge X2 (Isagro)	Phytotoxic in spray solution with pH <6.5. WARNING signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				M1	Cuprous oxide	48142-7	Nordox 30/30 WG (Nordox)	High rate may be phytotoxic under hot or dry conditions. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				M1	Copper oxychloride	45002-17	COC WP (Albaugh)	Toxic to fish and aquatic organisms. Runoff warning for poorly draining soils with shallow water tables. Potential runoff for several months or longer after application. Tank mix with lime to prevent copper injury.		

APPENDIX 2. Registered Uses of Polyoxin D Zinc Salt and OMRI Listed Alternatives Grouped by Fungicide Resistance Action Committee (FRAC) Code and Active Ingredient

Registered Uses of Polyoxin D Zinc Salt				OMRI Approved Alternative Products						
Crop	Disease (Pathogen)	Curative [4]	New Use	FRAC Code	Active Ingredient	EPA Reg. No.	Brand Name (Registrant)	Product Label Notes	Efficacy Notes	Efficacy Ref.
Cucurbits (Cucumbers, melons, squash and others)	Anthracnose (*Colletotrichum orbiculare*)	✔	✔	M1	Copper hydroxide	55146-1	Champ WG (NuFarm)	Phytotoxic in spray solution with pH <6.0. DANGER signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				M1	Copper octanoate	67702-2	Cueva Fungicide Concentrate (Neudorff)	Toxic to fish and aquatic organisms. Runoff warning for poorly draining soils with shallow water tables. Must re-apply after rain. For best results, spray before disease first appears.		
				M1	Copper oxychloride	45002-17	COC WP (Albaugh)	Crop injury warning. Toxic to fish and aquatic organisms. Runoff warning for poorly draining soils with shallow water tables. Potential runoff for several months or longer after application.		
				M1	Copper sulfate	45002-8	Basic Copper 53 (Albaugh)	WARNING signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				M1	Copper sulfate pentahydrate	66675-3	CS 2005	Phytotoxicity warning. DANGER signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				P	*Ranatra sachalinensis*	84059-3	Regalia Concentrate (Marrone)	Preventative use only.		
				P	*Reynoutria sachalinensis*	84059-6	Regalia Maxx (Marrone)	Preventative use only. Tank mix with another fungicide under moderate to heavy disease pressure.		
				44	*Bacillus subtilis* strain QST 713	264-1155	Rapsody ASO (Bayer)	Preventative use only. Tank mix with other registered fungicide for better performance.		
				44	*Bacillus subtilis* strain QST 713	264-1151	Serenade Max (Bayer)	Preventative use only. Tank mix with other registered fungicide for better performance.		
				None	*Bacillus pumilus* strain QST 2808	264-1153	Sonata ASO (Bayer)	Preventative use only. Tank mix with other registered fungicide for better performance.		

APPENDIX 2. Registered Uses of Polyoxin D Zinc Salt and OMRI Listed Alternatives Grouped by Fungicide Resistance Action Committee (FRAC) Code and Active Ingredient

Registered Uses of Polyoxin D Zinc Salt				OMRI Approved Alternative Products						
Crop	Disease (Pathogen)	Curative [4]	New Use	FRAC Code	Active Ingredient	EPA Reg. No.	Brand Name (Registrant)	Product Label Notes	Efficacy Notes	Efficacy Ref.
				None	*Streptomyces lydicus* WYEC 108	73314-1	Actinovate Soluble	Preventative use only. Live bacterium; must be applied after sterilant/fumigant has dissipated. Soil temperature must be ≥45°F. Label does not include specific crop/pathogen combinations. Label claims suppression/control, without identifying uses limited to suppression.	Ineffective.	2

APPENDIX 2. Registered Uses of Polyoxin D Zinc Salt and OMRI Listed Alternatives Grouped by Fungicide Resistance Action Committee (FRAC) Code and Active Ingredient

Registered Uses of Polyoxin D Zinc Salt				OMRI Approved Alternative Products						
Crop	Disease (Pathogen)	Curative [4]	New Use	FRAC Code	Active Ingredient	EPA Reg. No.	Brand Name (Registrant)	Product Label Notes	Efficacy Notes	Efficacy Ref.
Cucurbits (Cucumbers, melons, squash and others)	Alternaria leaf blight (*Alternaria* spp.)	✔		M1	Copper hydroxide	55146-1	Champ WG (NuFarm)	Phytotoxic in spray solution with pH <6.0. DANGER signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				M1	Cupric hydroxide	45002-4	Nu Cop DF (Albaugh)	Phytotoxic in spray solution with pH <6.5. DANGER signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				M1	Copper hydroxide	45002-7	Blue Shield (Albaugh)	Crop appearance effects label warning. Phytotoxic in spray solution with pH <6.5. DANGER signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				M1	Copper hydroxide and Copper oxychloride	80289-12	Badge X2 (Isagro)	Phytotoxic in spray solution with pH <6.5. WARNING signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				M1	Copper octanoate	67702-2	Cueva Fungicide Concentrate (Neudorff)	Toxic to fish and aquatic organisms. Runoff warning for poorly draining soils with shallow water tables. Must re-apply after rain. For best results, spray before disease first appears.		
				M1	Copper(I) oxide	26883-20	Chem Copp 50 (American Chemet)	WARNING signal word. Toxic to fish.		
				M1	Cuprous oxide	48142-4	Nordox 75 WG (Nordox)	High rate may be phytotoxic under hot or dry conditions. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product. May corrode aluminum irrigation pipes.		
				M1	Copper oxychloride	45002-17	COC WP (Albaugh)	Crop injury warning. Toxic to fish and aquatic organisms. Runoff warning for poorly draining soils with shallow water tables. Potential runoff for several months or longer after application.		

APPENDIX 2. Registered Uses of Polyoxin D Zinc Salt and OMRI Listed Alternatives Grouped by Fungicide Resistance Action Committee (FRAC) Code and Active Ingredient										
Registered Uses of Polyoxin D Zinc Salt				OMRI Approved Alternative Products						
Crop	Disease (Pathogen)	Curative [4]	New Use	FRAC Code	Active Ingredient	EPA Reg. No.	Brand Name (Registrant)	Product Label Notes	Efficacy Notes	Efficacy Ref.
				M1	Copper sulfate	45002-8	Basic Copper 53 (Albaugh)	WARNING signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				NC	Paraffinic oil	65564-1	Organic JMS Stylet Oil (JMS)	Phytotoxicity warning; enhances phytotoxicity of other products. Contains petroleum distillates. Do not apply when temperature is <50°F or >90°F. Many tank mix prohibitions.		
				P	*Reynoutria sachalinensis*	84059-3	Regalia Concentrate (Marrone)	Preventative use only.		
				None	Hydrogen dioxide	70299-2	OxiDate (BioSafe)	Highly toxic to bees and beneficial insects. Toxic to birds and fish. Preventative use only. Corrosive; strong oxidizing agent.		
				None	Gliocladium catenulatum strain J1446)	64137-11	Prestop Biofungicide Powder (Verdura Oy)	Apply pre-fruiting only. Cannot be tank mixed with any pesticides or concentrated fertilizers. Label does not make specific crop/pathogen specific claims.		
				None	*Streptomyces lydicus* WYEC 108	73314-1	Actinovate Soluble (Natural Industries)	Preventative use only. Live bacterium; must be applied after sterilant/fumigant has dissipated. Soil temperature must be ≥45°F. Label does not include specific crop/pathogen combinations. Label claims suppression/control, without identifying uses limited to suppression.		
Cucurbits (Cucumbers, melons, squash and others)	Gray mold (*Botrytis* spp.)	✔		M1	Copper octanoate	67702-2	Cueva Fungicide Concentrate (Neudorff)	Toxic to fish and aquatic organisms. Runoff warning for poorly draining soils with shallow water tables. Must re-apply after rain. For best results, spray before disease first appears.		
				None	*Streptomyces lydicus* WYEC 108	73314-1	Actinovate Soluble (Natural Industries)	Preventative use only. Live bacterium; must be applied after sterilant/fumigant has dissipated. Soil temperature must be ≥45°F. Label does not include specific crop/pathogen combinations. Label claims suppression/control, without identifying uses limited to suppression.		

APPENDIX 2. Registered Uses of Polyoxin D Zinc Salt and OMRI Listed Alternatives Grouped by Fungicide Resistance Action Committee (FRAC) Code and Active Ingredient

Registered Uses of Polyoxin D Zinc Salt				OMRI Approved Alternative Products						
Crop	Disease (Pathogen)	Curative [4]	New Use	FRAC Code	Active Ingredient	EPA Reg. No.	Brand Name (Registrant)	Product Label Notes	Efficacy Notes	Efficacy Ref.
Cucurbits (Cucumbers, melons, squash and others)	Gummy stem blight (*Didymella bryoniae*)	✔		M1	Copper hydroxide	55146-1	Champ WG (NuFarm)	DANGER signal word. Phytotoxicity warning.		
				M1	Copper hydroxide and Copper oxychloride	80289-12	Badge X2 (Isagro)	Phytotoxic in spray solution with pH <6.5. WARNING signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				M1	Copper octanoate	67702-2	Cueva Fungicide Concentrate (Neudorff)	Toxic to fish and aquatic organisms. Runoff warning for poorly draining soils with shallow water tables. Must re-apply after rain. For best results, spray before disease first appears.		
				M1	Copper(I) oxide	26883-20	Chem Copp 50 (American Chemet)	WARNING signal word. Toxic to fish.		
				M1	Cuprous oxide	48142-4	Nordox 75 WG (Nordox)	High rate may be phytotoxic under hot or dry conditions. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product. May corrode aluminum irrigation pipes.		
				M1	Copper oxychloride	45002-17	COC WP (Albaugh)	Crop injury warning. Toxic to fish and aquatic organisms. Runoff warning for poorly draining soils with shallow water tables. Potential runoff for several months or longer after application.		
				M1	Copper sulfate	45002-8	Basic Copper 53 (Albaugh)	WARNING signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				NC	Paraffinic oil	65564-1	Organic JMS Stylet Oil (JMS)	Phytotoxicity warning; enhances phytotoxicity of other products. Contains petroleum distillates. Do not apply when temperature is <50°F or >90°F. Many tank mix prohibitions.		
				P	*Reynoutria sachalinensis*	84059-3	Regalia Concentrate (Marrone)	Preventative use only.		
				P	*Reynoutria sachalinensis*	84059-6	Regalia Maxx (Marrone)	Preventative use only. Tank mix with another fungicide under moderate to heavy disease pressure.		

APPENDIX 2. Registered Uses of Polyoxin D Zinc Salt and OMRI Listed Alternatives Grouped by Fungicide Resistance Action Committee (FRAC) Code and Active Ingredient

Registered Uses of Polyoxin D Zinc Salt				OMRI Approved Alternative Products						
Crop	Disease (Pathogen)	Curative [4]	New Use	FRAC Code	Active Ingredient	EPA Reg. No.	Brand Name (Registrant)	Product Label Notes	Efficacy Notes	Efficacy Ref.
				44	*Bacillus subtilis* strain QST 713	264-1151	Serenade Max (Bayer)	Preventative use only. Tank mix with other registered fungicide for better performance.	Ineffective.	2
				None	*Bacillus amyloliquefaciens* strain D747	70051-108	Double Nickel 55	Preventative use only.		
				None	*Bacillus pumilus* QST 2808	264-1153	Sonata ASO (Bayer)	Preventative use only. Tank mix with other registered fungicide for better performance.		
				None	Hydrogen dioxide	70299-2	OxiDate (BioSafe)	Highly toxic to bees and beneficial insects. Toxic to birds and fish. Preventative use only. Corrosive; strong oxidizing agent.		
Cucurbits (Cucumbers, melons, squash and others)	Leaf spot (*Corynespora cossicola*)	✔		None	Hydrogen dioxide	70299-2	OxiDate (BioSafe)	Highly toxic to bees and beneficial insects. Toxic to birds and fish. Preventative use only. Corrosive; strong oxidizing agent.		

APPENDIX 2. Registered Uses of Polyoxin D Zinc Salt and OMRI Listed Alternatives Grouped by Fungicide Resistance Action Committee (FRAC) Code and Active Ingredient

Registered Uses of Polyoxin D Zinc Salt				OMRI Approved Alternative Products						
Crop	Disease (Pathogen)	Curative [4]	New Use	FRAC Code	Active Ingredient	EPA Reg. No.	Brand Name (Registrant)	Product Label Notes	Efficacy	
									Notes	Ref.
Cucurbits (Cucumbers, melons, squash and others)	Powdery mildew (*Sphaerotheca* spp.)	✔		M1	Copper hydroxide	55146-1	Champ WG (NuFarm)	Phytotoxic in spray solution with pH <6.0. DANGER signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.	Effective (brand not specified).	2
				M1	Copper octanoate	67702-2	Cueva Fungicide Concentrate (Neudorff)	Toxic to fish and aquatic organisms. Runoff warning for poorly draining soils with shallow water tables. Must re-apply after rain. For best results, spray before disease first appears.		
				M2	Sulfur (elemental)	70905-1	Cosavet DF (Sulphur Mills)	Sulfur may cause severe fruit and foliage injury to certain crops. Sulfur dust suspended in air ignites easily. Keep away from heat, sparks, or flames. Do not smoke while applying this product. Do not apply when shade temperatures exceed or are likely to exceed 90°F. REI = 24 hour.		
				M2	Sulfur (elemental)	82571-3	CSC Dusting Sulfur (Martin)	Sulfur may cause severe fruit and foliage injury to certain crops. Sulfur dust suspended in air ignites easily. Keep away from heat, sparks, or flames. Do not smoke while applying this product. Do not apply when shade temperatures exceed or are likely to exceed 90°F. REI = 24 hour.	Effective (brand not specified).	2
				M2	Sulfur (elemental)	2935-407	Golden Micronized Sulfur (Wilbur-Ellis)	Sulfur may cause severe fruit and foliage injury to certain crops. Sulfur dust suspended in air ignites easily. Keep away from heat, sparks, or flames. Do not smoke while applying this product. Do not apply when shade temperatures exceed or are likely to exceed 90°F. REI = 24 hour.		
				NC	Potassium bicarbonate	20231-1	Kaligreen (Otsuka)	Do not mix with highly acidic products. Acidification with a buffering agent may reduce efficacy. Min PHI for food crops is 1 day. Use limited to powdery mildew; curative.		
				NC	Paraffinic oil	65564-1	Organic JMS Stylet Oil (JMS)	Phytotoxicity warning; enhances phytotoxicity of other products. Contains petroleum distillates. Do not apply when temperature is <50°F or >90°F. Many tank mix prohibitions.		
				P	*Reynoutria sachalinensis*	84059-3	Regalia Concentrate (Marrone)	Preventative use only.		

APPENDIX 2. Registered Uses of Polyoxin D Zinc Salt and OMRI Listed Alternatives Grouped by Fungicide Resistance Action Committee (FRAC) Code and Active Ingredient

Registered Uses of Polyoxin D Zinc Salt				OMRI Approved Alternative Products						
Crop	Disease (Pathogen)	Curative [4]	New Use	FRAC Code	Active Ingredient	EPA Reg. No.	Brand Name (Registrant)	Product Label Notes	Efficacy Notes	Efficacy Ref.
				P	*Reynoutria sachalinensis*	84059-6	Regalia Maxx (Marrone)	Preventative use only. Tank mix with another fungicide under moderate to heavy disease pressure.		
				44	*Bacillus subtilis* strain QST 713	264-1151	Serenade Max (Bayer)	Preventative use only. Tank mix with other registered fungicide for better performance.	Effective.	2
				None	*Bacillus amyloliquefaciens* strain D747	70051-108	Double Nickel 55	Preventative use only.		
				None	*Bacillus pumilus* QST 2808	264-1153	Sonata ASO (Bayer)	Preventative use only. Tank mix with other registered fungicide for better performance.	No obvious response to treatment in one or more published reports.	1
									Effective.	2
				None	Potassium salts of fatty acids	10163-324	M-Pede Insecticide-Miticide-Fungicide (Gowan)	Phytotoxicity warning. Preventative use only. WARNING signal word. May be hazardous to aquatic invertebrates. Some tank mixes prohibited.		
				None	*Streptomyces lydicus* WYEC 108	73314-1	Actinovate Soluble (Natural Industries)	Preventative use only. Live bacterium; must be applied after sterilant/fumigant has dissipated. Soil temperature must be ≥45°F. Label does not include specific crop/pathogen combinations. Label claims suppression/control, without identifying uses limited to suppression.	Evidence for disease control and/or yield increase.	1
Cucurbits (Cucumbers, melons, squash and others)	Scab (Cladosporium)	✔		None	Gliocladium catenulatum strain J1446)	64137-11	Prestop Biofungicide Powder (Verdura Oy)	Apply pre-fruiting only. Cannot be tank mixed with any pesticides or concentrated fertilizers. Label does not make specific crop/pathogen specific claims.		
Cucurbits (Cucumbers, melons, squash and others)	Southern blight (*Sclerotium rolfsii*)	✔	✔				NONE FOUND			

APPENDIX 2. Registered Uses of Polyoxin D Zinc Salt and OMRI Listed Alternatives Grouped by Fungicide Resistance Action Committee (FRAC) Code and Active Ingredient

Registered Uses of Polyoxin D Zinc Salt				OMRI Approved Alternative Products						
Crop	Disease (Pathogen)	Curative [4]	New Use	FRAC Code	Active Ingredient	EPA Reg. No.	Brand Name (Registrant)	Product Label Notes	Efficacy Notes	Efficacy Ref.
Fruiting vegetables (Eggplant, pepper, pepinos, tomatillos and tomatoes)	Early blight (*Alternaria solani*)	✔		M1	Cupric hydroxide	45002-4	Nu Cop DF (Albaugh)	Phytotoxic in spray solution with pH <6.5. DANGER signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				M1	Copper hydroxide	45002-7	Blue Shield (Albaugh)	Crop appearance effects label warning. Phytotoxic in spray solution with pH <6.5. DANGER signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				M1	Copper hydroxide	55146-1	Champ WG (NuFarm)	DANGER signal word.		
				M1	Copper hydroxide and Copper oxychloride	80289-12	Badge X2 (Isagro)	Phytotoxic in spray solution with pH <6.5. WARNING signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				M1	Copper octanoate	67702-2	Cueva Fungicide Concentrate (Neudorff)	Toxic to fish and aquatic organisms. Runoff warning for poorly draining soils with shallow water tables. Must re-apply after rain. For best results, spray before disease first appears.		
				M1	Copper(I) oxide	26883-20	Chem Copp 50 (American Chemet)	WARNING signal word. Toxic to fish.		
				M1	Cuprous oxide	48142-4	Nordox 75 WG (Nordox)	High rate may be phytotoxic under hot or dry conditions. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product. May corrode aluminum irrigation pipes.		
				M1	Copper oxychloride	45002-17	COC WP (Albaugh)	Toxic to fish and aquatic organisms. Runoff warning for poorly draining soils with shallow water tables. Potential runoff for several months or longer after application.		
				M1	Copper sulfate	45002-8	Basic Copper 53 (Albaugh)	WARNING signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		

APPENDIX 2. Registered Uses of Polyoxin D Zinc Salt and OMRI Listed Alternatives Grouped by Fungicide Resistance Action Committee (FRAC) Code and Active Ingredient

Registered Uses of Polyoxin D Zinc Salt				OMRI Approved Alternative Products						
Crop	Disease (Pathogen)	Curative [4]	New Use	FRAC Code	Active Ingredient	EPA Reg. No.	Brand Name (Registrant)	Product Label Notes	Efficacy	
									Notes	Ref.
				NC	Paraffinic oil	65564-1	Organic JMS Stylet Oil (JMS)	Phytotoxicity warning; enhances phytotoxicity of other products. Contains petroleum distillates. Do not apply when temperature is <50°F or >90°F. Many tank mix prohibitions.		
				P	*Reynoutria sachalinensis*	84059-3	Regalia Concentrate (Marrone)	Preventative use only.		
				P	*Reynoutria sachalinensis*	84059-6	Regalia Maxx (Marrone)	Preventative use only. Tank mix with another fungicide under heavy disease pressure.		
				44	*Bacillus subtilis* strain QST 713	264-1151	Serenade Max (Bayer)	Preventative use only. Suppression only. Tank mix with other registered fungicide for better performance.		
				None	*Bacillus pumilus* QST 2808	264-1153	Sonata ASO (Bayer)	Preventative use only. Suppression only. Tank mix with other registered fungicide for better performance.		
				None	Hydrogen dioxide	70299-2	OxiDate (BioSafe)	Highly toxic to bees and beneficial insects. Toxic to birds and fish. Preventative use only. Corrosive; strong oxidizing agent.		
				None	*Bacillus pumilus* QST 2808	264-1153	Sonata ASO (Bayer)	Preventative use only. Suppression only. Tank mix with other registered fungicide for better performance.		
				None	Gliocladium catenulatum strain J1446)	64137-11	Prestop Biofungicide Powder (Verdura Oy)	Apply pre-fruiting only. Cannot be tank mixed with any pesticides or concentrated fertilizers. Label does not make specific crop/pathogen specific claims.		
				None	*Streptomyces lydicus* WYEC 108	73314-1	Actinovate Soluble (Natural Industries)	Preventative use only. Live bacterium; must be applied after sterilant/fumigant has dissipated. Soil temperature must be ≥45°F. Label does not include specific crop/pathogen combinations. Label claims suppression/control, without identifying uses limited to suppression.		

APPENDIX 2. Registered Uses of Polyoxin D Zinc Salt and OMRI Listed Alternatives Grouped by Fungicide Resistance Action Committee (FRAC) Code and Active Ingredient

Registered Uses of Polyoxin D Zinc Salt				OMRI Approved Alternative Products						
Crop	Disease (Pathogen)	Curative [4]	New Use	FRAC Code	Active Ingredient	EPA Reg. No.	Brand Name (Registrant)	Product Label Notes	Efficacy Notes	Efficacy Ref.
Fruiting vegetables (Eggplant, pepper, pepinos, tomatillos and tomatoes)	Anthracnose * (*Colletotrichum coccodes*)			M1	Copper hydroxide and Copper oxychloride	80289-12	Badge X2 (Isagro)	Phytotoxic in spray solution with pH <6.5. WARNING signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				M1	Copper hydroxide	55146-1	Champ WG (NuFarm)	Phytotoxic in spray solution with pH <6.0. DANGER signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				M1	Cupric hydroxide	45002-4	Nu Cop DF (Albaugh)	Phytotoxic in spray solution with pH <6.5. DANGER signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				M1	Copper hydroxide	45002-7	Blue Shield (Albaugh)	Crop appearance effects label warning. Phytotoxic in spray solution with pH <6.5. DANGER signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				M1	Copper(I) oxide	26883-20	Chem Copp 50 (American Chemet)	WARNING signal word. Toxic to fish.		
				M1	Cuprous oxide	48142-4	Nordox 75 WG (Nordox)	High rate may be phytotoxic under hot or dry conditions. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product. May corrode aluminum irrigation pipes.		
				M1	Copper oxychloride	45002-17	COC WP (Albaugh)	Toxic to fish and aquatic organisms. Runoff warning for poorly draining soils with shallow water tables. Potential runoff for several months or longer after application. For use on tomatoes only.		

APPENDIX 2. Registered Uses of Polyoxin D Zinc Salt and OMRI Listed Alternatives Grouped by Fungicide Resistance Action Committee (FRAC) Code and Active Ingredient										
Registered Uses of Polyoxin D Zinc Salt				OMRI Approved Alternative Products						
Crop	Disease (Pathogen)	Curative [4]	New Use	FRAC Code	Active Ingredient	EPA Reg. No.	Brand Name (Registrant)	Product Label Notes	Efficacy	
									Notes	Ref.
				M1	Copper sulfate	45002-8	Basic Copper 53 (Albaugh)	WARNING signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				44	*Bacillus subtilis* strain QST 713	264-1151	Serenade Max (Bayer)	Preventative use only. Tank mix with other registered fungicide for better performance.		
				None	Hydrogen dioxide	70299-2	OxiDate (BioSafe)	Highly toxic to bees and beneficial insects. Toxic to birds and fish. Preventative use only. Corrosive; strong oxidizing agent.		
				None	*Streptomyces lydicus* WYEC 108	73314-1	Actinovate Soluble (Natural Industries)	Label does not include specific crop/pathogen combinations. Label claims suppression/ control, without identifying uses limited to suppression. For best results, apply before disease onset. Live bacterium; must be applied after sterilant/fumigant has dissipated.		

APPENDIX 2. Registered Uses of Polyoxin D Zinc Salt and OMRI Listed Alternatives Grouped by Fungicide Resistance Action Committee (FRAC) Code and Active Ingredient

Registered Uses of Polyoxin D Zinc Salt				OMRI Approved Alternative Products						
Crop	Disease (Pathogen)	Curative [4]	New Use	FRAC Code	Active Ingredient	EPA Reg. No.	Brand Name (Registrant)	Product Label Notes	Efficacy Notes	Efficacy Ref.
Fruiting vegetables (Eggplant, pepper, pepinos, tomatillos and tomatoes)	Gray molds (*Botrytis* sp.)	✔		M1	Copper octanoate	67702-2	Cueva Fungicide Concentrate (Neudorff)	Toxic to fish and aquatic organisms. Runoff warning for poorly draining soils with shallow water tables. Must re-apply after rain. For best results, spray before disease first appears.		
				P	*Reynoutria sachalinensis*	84059-3	Regalia Concentrate (Marrone)	Preventative use only.		
				P	*Reynoutria sachalinensis*	84059-6	Regalia Maxx (Marrone)	Preventative use only. Tank mix with another fungicide under heavy disease pressure.		
				44	*Bacillus subtilis* strain QST 713	264-1151	Serenade Max (Bayer)	Preventative use only. Tank mix with other registered fungicide for better performance.		
				None	*Streptomyces lydicus* WYEC 108	73314-1	Actinovate Soluble (Natural Industries)	Preventative use only. Live bacterium; must be applied after sterilant/fumigant has dissipated. Soil temperature must be ≥45°F. Label does not include specific crop/pathogen combinations. Label claims suppression/control, without identifying uses limited to suppression.		
				None	Hydrogen dioxide	70299-2	OxiDate (BioSafe)	Highly toxic to bees and beneficial insects. Toxic to birds and fish. Preventative use only. Corrosive; strong oxidizing agent.		
				None	*Bacillus pumilus* QST 2808	264-1153	Sonata ASO (Bayer)	Preventative use only. Tank mix with other registered fungicide for better performance.		
				None	*Streptomyces lydicus* WYEC 108	73314-1	Actinovate Soluble (Natural Industries)	Preventative use only. Live bacterium; must be applied after sterilant/fumigant has dissipated. Soil temperature must be ≥45°F. Label does not include specific crop/pathogen combinations. Label claims suppression/control, without identifying uses limited to suppression.		

APPENDIX 2. Registered Uses of Polyoxin D Zinc Salt and OMRI Listed Alternatives Grouped by Fungicide Resistance Action Committee (FRAC) Code and Active Ingredient

Registered Uses of Polyoxin D Zinc Salt				OMRI Approved Alternative Products						
Crop	Disease (Pathogen)	Curative [4]	New Use	FRAC Code	Active Ingredient	EPA Reg. No.	Brand Name (Registrant)	Product Label Notes	Efficacy Notes	Efficacy Ref.
Fruiting vegetables (Eggplant, pepper, pepinos, tomatillos and tomatoes)	Late blight * (*Phytophthera infestans*)		✔	M1	Cupric hydroxide	45002-4	Nu Cop DF (Albaugh)	Phytotoxic in spray solution with pH <6.5. DANGER signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				M1	Copper hydroxide	45002-7	Blue Shield (Albaugh)	Crop appearance effects label warning. Phytotoxic in spray solution with pH <6.5. DANGER signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				M1	Copper octanoate	67702-2	Cueva Fungicide Concentrate (Neudorff)	Toxic to fish and aquatic organisms. Runoff warning for poorly draining soils with shallow water tables. Must re-apply after rain. For best results, spray before disease first appears.		
				M1	Copper(I) oxide	26883-20	Chem Copp 50 (American Chemet)	WARNING signal word. Toxic to fish.		
				M1	Cuprous oxide	48142-4	Nordox 75 WG	High rate may be phytotoxic under hot or dry conditions. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product. May corrode aluminum irrigation pipes. For use on peppers and tomatoes only.		
				M1	Copper sulfate pentahydrate	66675-3	CS 2005	Phytotoxicity warning. DANGER signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				P	*Ranatra sachalinensis*	84059-3	Regalia Concentrate (Marrone)	Preventative use only. Must tank mix with copper fungicide.		
				P	*Reynoutria sachalinensis*	84059-6	Regalia Maxx (Marrone)	Suppression only. Tank mix with another fungicide.		
				44	*Bacillus subtilis* strain QST 713	264-1155	Rapsody ASO (Bayer)	Preventative use only. Suppression only. Tank mix with other registered fungicide for better performance.		

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Registered Uses of Polyoxin D Zinc Salt				OMRI Approved Alternative Products						
Crop	Disease (Pathogen)	Curative [4]	New Use	FRAC Code	Active Ingredient	EPA Reg. No.	Brand Name (Registrant)	Product Label Notes	Efficacy	
									Notes	Ref.
				44	*Bacillus subtilis* strain QST 713	264-1151	Serenade Max (Bayer)	Preventative use only. Suppression only. Tank mix with other registered fungicide for better performance.		
				None	*Bacillus amyloliquefaciens* strain D747	70051-108	Double Nickel 55	Preventative use only.		
				None	*Bacillus pumilus* strain QST 2808	264-1153	Sonata ASO (Bayer)	Preventative use only. Suppression only. Tank mix with other registered fungicide for better performance.		
				None	*Streptomyces lydicus* WYEC 108	73314-1	Actinovate Soluble (Natural Industries)	Preventative use only. Live bacterium; must be applied after sterilant/fumigant has dissipated. Soil temperature must be ≥45°F. Label does not include specific crop/pathogen combinations. Label claims suppression/control, without identifying uses limited to suppression.	Evidence for disease control or yield increase.	1
Fruiting vegetables (Eggplant, pepper, pepinos, tomatillos and tomatoes)	Leaf mold (*Fulvia (Cladosporium) fulvum,* also known as *Passalora fulva*)	✔	✔	M1	Copper hydroxide and Copper oxychloride	80289-12	Badge X2 (Isagro)	Phytotoxic in spray solution with pH <6.5. WARNING signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				M1	Copper octanoate	67702-2	Cueva Fungicide Concentrate (Neudorff)	Toxic to fish and aquatic organisms. Runoff warning for poorly draining soils with shallow water tables. Must re-apply after rain. For best results, spray before disease first appears.		
				M1	Copper(I) oxide	26883-20	Chem Copp 50 (American Chemet)	WARNING signal word. Toxic to fish For use on tomatoes only.		
				M1	Copper oxychloride	45002-17	COC WP (Albaugh)	Toxic to fish and aquatic organisms. Runoff warning for poorly draining soils with shallow water tables. Potential runoff for several months or longer after application. For use on tomatoes only.		

APPENDIX 2. Registered Uses of Polyoxin D Zinc Salt and OMRI Listed Alternatives Grouped by Fungicide Resistance Action Committee (FRAC) Code and Active Ingredient

Registered Uses of Polyoxin D Zinc Salt				OMRI Approved Alternative Products						
Crop	Disease (Pathogen)	Curative [4]	New Use	FRAC Code	Active Ingredient	EPA Reg. No.	Brand Name (Registrant)	Product Label Notes	Efficacy Notes	Efficacy Ref.
Fruiting vegetables (Eggplant, pepper, pepinos, tomatillos and tomatoes)	Powdery mildew (*Leveillula taurica* and *Oidiopsis sipula*)	✔		M2	Sulfur (elemental)	70905-1	Cosavet DF (Sulphur Mills)	Sulfur may cause severe fruit and foliage injury to certain crops. Sulfur dust suspended in air ignites easily. Keep away from heat, sparks, or flames. Do not smoke while applying this product. Do not apply when shade temperatures exceed or are likely to exceed 90°F. REI = 24 hour.		
				M2	Sulfur (elemental)	82571-3	CSC Dusting Sulfur (Martin)	Sulfur may cause severe fruit and foliage injury to certain crops. Sulfur dust suspended in air ignites easily. Keep away from heat, sparks, or flames. Do not smoke while applying this product. Do not apply when shade temperatures exceed or are likely to exceed 90°F. REI = 24 hour.		
				NC	Paraffinic oil	65564-1	Organic JMS Stylet Oil (JMS)	Phytotoxicity warning; enhances phytotoxicity of other products. Contains petroleum distillates. Do not apply when temperature is <50°F or >90°F. Many tank mix prohibitions.		
				NC	Potassium bicarbonate	20231-1	Kaligreen (Otsuka)	Do not mix with highly acidic products. Acidification with a buffering agent may reduce efficacy. Min PHI for food crops is 1 day. Use limited to powdery mildew; curative.		
				P	*Reynoutria sachalinensis*	84059-3	Regalia Concentrate (Marrone)	Preventative use only.	Effective on tomato.	2
				P	*Reynoutria sachalinensis*	84059-6	Regalia Maxx (Marrone)	Preventative use only.		
				None	*Streptomyces lydicus* WYEC 108	73314-1	Actinovate Soluble (Natural Industries)	Preventative use only. Live bacterium; must be applied after sterilant/fumigant has dissipated. Soil temperature must be ≥45°F. Label does not include specific crop/pathogen combinations. Label claims suppression/control, without identifying uses limited to suppression.		
				None	Potassium salts of fatty acids	10163-324	M-Pede Insecticide-Miticide-Fungicide (Gowan)	Phytotoxicity warning. Preventative use only. WARNING signal word. May be hazardous to aquatic invertebrates. Some tank mixes prohibited.		
				None	Hydrogen dioxide	70299-2	OxiDate (BioSafe)	Highly toxic to bees and beneficial insects. Toxic to birds and fish. Preventative use only. Corrosive; strong oxidizing agent.		
				None	*Bacillus amyloliquefaciens* strain D747	70051-108	Double Nickel 55	Preventative use only.		

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Registered Uses of Polyoxin D Zinc Salt				OMRI Approved Alternative Products						
Crop	Disease (Pathogen)	Curative [4]	New Use	FRAC Code	Active Ingredient	EPA Reg. No.	Brand Name (Registrant)	Product Label Notes	Efficacy Notes	Efficacy Ref.
				None	*Bacillus pumilus* QST 2808	264-1153	Sonata ASO (Bayer)	Preventative use only. Tank mix with other registered fungicide for better performance.		
				None	*Streptomyces lydicus* WYEC 108	73314-1	Actinovate Soluble (Natural Industries)	Preventative use only. Live bacterium; must be applied after sterilant/fumigant has dissipated. Soil temperature must be ≥45°F. Label does not include specific crop/pathogen combinations. Label claims suppression/control, without identifying uses limited to suppression.	Effective on tomato.	2
Fruiting vegetables (Eggplant, pepper, pepinos, tomatillos and tomatoes)	Southern blight * (*Sclerotium rolfsii*)	✔	✔	None	*Bacillus amyloliquefaciens* strain D747	70051-108	Double Nickel 55	Preventative use only. Suppression only. Not for use in California.		
Fruiting vegetables (Eggplant, pepper, pepinos, tomatillos and tomatoes)	Verticillium wilt * (*Verticillium dahliae*)		✔	44	*Bacillus subtilis* strain QST 713	264-1151	Serenade Max (Bayer)	Preventative use only. Suppression only. Tank mix with other registered fungicide for better performance.		
				None	*Bacillus amyloliquefaciens* strain D747	70051-108	Double Nickel 55	Preventative use only. Suppression only.		

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Registered Uses of Polyoxin D Zinc Salt				OMRI Approved Alternative Products						
Crop	Disease (Pathogen)	Curative [4]	New Use	FRAC Code	Active Ingredient	EPA Reg. No.	Brand Name (Registrant)	Product Label Notes	Efficacy	
									Notes	Ref.
Ginseng †	Alternaria blight (*Alternaria panax*)	✔		M1	Copper hydroxide	55146-1	Champ WG (NuFarm)	Phytotoxic in spray solution with pH <6.0. DANGER signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product. Must be tank mixed with iprodione.		
				M1	Cupric hydroxide	45002-4	Nu Cop DF (Albaugh)	Phytotoxic in spray solution with pH <6.5. DANGER signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product. Must be tank mixed with iprodione.		
				M1	Copper hydroxide	45002-7	Blue Shield (Albaugh)	Crop appearance effects label warning. Phytotoxic in spray solution with pH <6.5. DANGER signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				M1	Copper hydroxide and Copper oxychloride	80289-12	Badge X2 (Isagro)	Phytotoxic in spray solution with pH <6.5. WARNING signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				M1	Copper octanoate	67702-2	Cueva Fungicide Concentrate (Neudorff)	Toxic to fish and aquatic organisms. Runoff warning for poorly draining soils with shallow water tables. Must re-apply after rain. For best results, spray before disease first appears.		
				M1	Cuprous oxide	48142-4	Nordox 75 WG (Nordox)	High rate may be phytotoxic under hot or dry conditions. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product. May corrode aluminum irrigation pipes. Must be tank mixed with Rovral.		

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Registered Uses of Polyoxin D Zinc Salt				OMRI Approved Alternative Products						
Crop	Disease (Pathogen)	Curative [4]	New Use	FRAC Code	Active Ingredient	EPA Reg. No.	Brand Name (Registrant)	Product Label Notes	Efficacy Notes	Efficacy Ref.
				M1	Copper sulfate	45002-8	Basic Copper 53 (Albaugh)	WARNING signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				P	*Reynoutria sachalinensis*	84059-3	Regalia Concentrate (Marrone)	Preventative use only.		
				P	*Reynoutria sachalinensis*	84059-6	Regalia Maxx (Marrone)	Preventative use only.		
				None	Hydrogen dioxide	70299-2	OxiDate (BioSafe)	Highly toxic to bees and beneficial insects. Toxic to birds and fish. Preventative use only. Corrosive; strong oxidizing agent.		
				None	*Bacillus pumilus* QST 2808	264-1153	Sonata ASO (Bayer)	Preventative use only. Tank mix with other registered fungicide for better performance.		
Ginseng †	Botrytis blight (*Botrytis cinerea*)	✔		M1	Copper octanoate	67702-2	Cueva Fungicide Concentrate (Neudorff)	Toxic to fish and aquatic organisms. Runoff warning for poorly draining soils with shallow water tables. Must re-apply after rain. For best results, spray before disease first appears.		
				P	*Reynoutria sachalinensis*	84059-3	Regalia Concentrate (Marrone)	Preventative use only.		
				P	*Reynoutria sachalinensis*	84059-6	Regalia Maxx (Marrone)	Preventative use only.		
				None	*Bacillus amyloliquefaciens* strain D747	70051-108	Double Nickel 55	Preventative use only.		
Ginseng †	Cylindrocarpon root rot (*Cylinderocarpon destructans*)	✔					NONE FOUND			
Ginseng †	Rhizoctonia root and crown rot (*Rhizoctonia solani*	✔		P	*Reynoutria sachalinensis*	84059-3	Regalia Concentrate (Marrone)	Preventative use only.		
				None	*Bacillus amyloliquefaciens* strain D747	70051-108	Double Nickel 55	Preventative use only.		
				None	Hydrogen dioxide	70299-2	OxiDate (BioSafe)	Highly toxic to bees and beneficial insects. Toxic to birds and fish. Preventative use only. Corrosive; strong oxidizing agent.		
				None	Gliocladium catenulatum strain J1446)	64137-11	Prestop Biofungicide Powder (Verdura Oy)	Apply pre-fruiting only. Cannot be tank mixed with any pesticides or concentrated fertilizers. Label does not make specific crop/pathogen specific claims.		

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Registered Uses of Polyoxin D Zinc Salt				OMRI Approved Alternative Products						
Crop	Disease (Pathogen)	Curative [4]	New Use	FRAC Code	Active Ingredient	EPA Reg. No.	Brand Name (Registrant)	Product Label Notes	Efficacy	
									Notes	Ref.
Grapes	Bunch rot or Gray mold (*Botrytis cinerea*)	✔		M1	Copper octanoate	67702-2	Cueva Fungicide Concentrate (Neudorff)	Toxic to fish and aquatic organisms. Runoff warning for poorly draining soils with shallow water tables. Must re-apply after rain. For best results, spray before disease first appears. Do not mix with lime. Marginal leaf burn in some varieties.		
				M1	Copper octanoate	67702-1	Cueva Fungicide RTU (Neudorff)	Marginal leaf burn in some varieties. Toxic to fish and aquatic organisms. May contaminate water through runoff. Cannot be used with lime.		
				M1	Copper oxychloride + basic copper sulfate + sulfur	82571-5	CSC Copper Sulfur Dust (Martin)	WARNING signal word. Phytotoxicity warning.		
				NC	Paraffinic oil	65564-1	Organic JMS Stylet Oil (JMS)	Phytotoxicity warning; enhances phytotoxicity of other products. Contains petroleum distillates. Do not apply when temperature is <50°F or >90°F. Many tank mix prohibitions.		
				P	*Reynoutria sachalinensis*	84059-3	Regalia Concentrate (Marrone)	Preventative use only.		
				P	*Reynoutria sachalinensis*	84059-6	Regalia Maxx (Marrone)	Preventative use only. Tank mix with another fungicide under heavy disease pressure.		
				44	*Bacillus subtilis* strain QST 713	264-1151	Serenade Max (Bayer)	Preventative use only. Can form white deposits on fruits if applied after initiation of berry set. Tank mix with other registered fungicide for better performance.		
				None	*Bacillus amyloliquefaciens* strain D747	70051-108	Double Nickel 55	Preventative use only.		
				None	*Bacillus pumilus* QST 2808	264-1153	Sonata ASO (Bayer)	Preventative use only. Tank mix with other registered fungicide for better performance.		
				None	Hydrogen dioxide	70299-2	OxiDate (BioSafe)	Highly toxic to bees and beneficial insects. Toxic to birds and fish. Preventative use only. Corrosive; strong oxidizing agent.		
				None	*Streptomyces lydicus* WYEC 108	73314-1	Actinovate Soluble (Natural Industries)	Preventative use only. Live bacterium; must be applied after sterilant/fumigant has dissipated. Soil temperature must be ≥45°F. Label does not include specific crop/pathogen combinations. Label claims suppression/control, without identifying uses limited to suppression.		

APPENDIX 2. Registered Uses of Polyoxin D Zinc Salt and OMRI Listed Alternatives Grouped by Fungicide Resistance Action Committee (FRAC) Code and Active Ingredient

Registered Uses of Polyoxin D Zinc Salt				OMRI Approved Alternative Products						
Crop	Disease (Pathogen)	Curative [4]	New Use	FRAC Code	Active Ingredient	EPA Reg. No.	Brand Name (Registrant)	Product Label Notes	Efficacy Notes	Efficacy Ref.
Grapes	Powdery mildew (*Unicula necator*)	✔		M1	Copper hydroxide	55146-1	Champ WG (NuFarm)	Foliar injury to some varieties. Phytotoxic in spray solution with pH <6.0. DANGER signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				M1	Cupric hydroxide	45002-4	Nu Cop DF (Albaugh)	Phytotoxic in spray solution with pH <6.5. DANGER signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				M1	Copper hydroxide	45002-7	Blue Shield (Albaugh)	Crop appearance effects label warning. Phytotoxic in spray solution with pH <6.5. DANGER signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				M1	Copper hydroxide and Copper oxychloride	80289-12	Badge X2 (Isagro)	Phytotoxic in spray solution with pH <6.5. WARNING signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				M1	Copper octanoate	67702-2	Cueva Fungicide Concentrate (Neudorff)	Toxic to fish and aquatic organisms. Runoff warning for poorly draining soils with shallow water tables. Must re-apply after rain. For best results, spray before disease first appears. Marginal leaf burn in some varieties.		
				M1	Copper octanoate	67702-1	Cueva Fungicide RTU (Neudorff)	Marginal leaf burn in some varieties. Toxic to fish and aquatic organisms. May contaminate water through runoff. Cannot be used with lime.		
				M1	Cuprous oxide	26883-20	Chem Copp 50 (American Chemet)	WARNING signal word. Foliar injury on copper-sensitive varieties.		

APPENDIX 2. Registered Uses of Polyoxin D Zinc Salt and OMRI Listed Alternatives Grouped by Fungicide Resistance Action Committee (FRAC) Code and Active Ingredient

Registered Uses of Polyoxin D Zinc Salt				OMRI Approved Alternative Products						
Crop	Disease (Pathogen)	Curative [4]	New Use	FRAC Code	Active Ingredient	EPA Reg. No.	Brand Name (Registrant)	Product Label Notes	Efficacy Notes	Efficacy Ref.
				M1	Cuprous oxide	48142-4	Nordox 75 WG (Nordox)	High rate may be phytotoxic under hot or dry conditions. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product. May corrode aluminum irrigation pipes.		
				M1	Cuprous oxide	48142-7	Nordox 30/30 WG (Nordox)	Phytotoxic to some varieties. High rate may be phytotoxic under hot or dry conditions. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				M1	Copper oxychloride	45002-17	COC WP (Albaugh)	Foliar injury warning. Toxic to fish and aquatic organisms. Runoff warning for poorly draining soils with shallow water tables. Potential runoff for several months or longer after application.		
				M1, M2	Copper oxychloride + basic copper sulfate + sulfur	82571-5	CSC Copper Sulfur Dust (Martin)	WARNING signal word. Phytotoxicity warning.		
				M1	Copper sulfate	45002-8	Basic Copper 53 (Albaugh)	WARNING signal word. Foliage injury to some grape varieties. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				M1	Copper sulfate	56576-1	Copper Sulfate Crystals (Chem One)	DANGER signal word. Some phototoxicity to most grape varieties.		
				M1	Copper sulfate	73385-3	Quimag Quimicos Aguila Copper Sulfate Crystal - Crop (Fabrica de Sulfato El Aguila, S.A. de C.V.)	DANGER signal word. Some phototoxicity to most grape varieties.		
				M2	Sulfur (elemental)	70905-1	Cosavet DF (Sulphur Mills)	Sulfur may cause severe fruit and foliage injury to certain crops. Sulfur dust suspended in air ignites easily. Keep away from heat, sparks, or flames. Do not smoke while applying this product. Do not apply when shade temperatures exceed or are likely to exceed 90°F. REI = 24 hour.		
				M2	Sulfur (elemental)	82571-4	CSC 80% Thiosperse (Martin)	Phytotoxicity warning.		

APPENDIX 2. Registered Uses of Polyoxin D Zinc Salt and OMRI Listed Alternatives Grouped by Fungicide Resistance Action Committee (FRAC) Code and Active Ingredient

Registered Uses of Polyoxin D Zinc Salt				OMRI Approved Alternative Products						
Crop	Disease (Pathogen)	Curative [4]	New Use	FRAC Code	Active Ingredient	EPA Reg. No.	Brand Name (Registrant)	Product Label Notes	Efficacy Notes	Efficacy Ref.
				M2	Sulfur (elemental)	82571-3	CSC Dusting Sulfur (Martin)	Sulfur may cause severe fruit and foliage injury to certain crops. Sulfur dust suspended in air ignites easily. Keep away from heat, sparks, or flames. Do not smoke while applying this product. Do not apply when shade temperatures exceed or are likely to exceed 90°F. REI = 24 hour.		
				M2	Sulfur		Most OMRI Listed sulfur products	Phytotoxicity warning.		
				NC	Potassium bicarbonate	20231-1	Kaligreen (Otsuka)	Do not mix with highly acidic products. Acidification with a buffering agent may reduce efficacy. Min PHI for food crops is 1 day. Use limited to powdery mildew; curative.		
				NC	Paraffinic oil	65564-1	Organic JMS Stylet Oil (JMS)	Phytotoxicity warning; enhances phytotoxicity of other products. Contains petroleum distillates. Do not apply when temperature is <50°F or >90°F. Many tank mix prohibitions.		
				P	*Reynoutria sachalinensis*	84059-3	Regalia Concentrate (Marrone)	Preventative use only.		
				P	*Reynoutria sachalinensis*	84059-6	Regalia Maxx (Marrone)	Preventative use only. Tank mix with another fungicide under heavy disease pressure.		
				44	*Bacillus subtilis* strain QST 713	264-1151	Serenade Max (Bayer)	Preventative use only. Can form white deposits on fruits if applied after initiation of berry set. Tank mix with other registered fungicide for better performance.		
				None	*Bacillus amyloliquefaciens* strain D747	70051-108	Double Nickel 55	Preventative use only.		
				None	*Bacillus pumilus* QST 2808	264-1153	Sonata ASO (Bayer)	Preventative use only. Tank mix with other registered fungicide for better performance.		
				None	Hydrogen dioxide	70299-2	OxiDate (BioSafe)	Highly toxic to bees and beneficial insects. Toxic to birds and fish. Preventative use only. Corrosive; strong oxidizing agent.		
				None	*Streptomyces lydicus* WYEC 108	73314-1	Actinovate Soluble (Natural Industries)	Preventative use only. Live bacterium; must be applied after sterilant/fumigant has dissipated. Soil temperature must be ≥45°F. Label does not include specific crop/pathogen combinations. Label claims suppression/control, without identifying uses limited to suppression.		

APPENDIX 2. Registered Uses of Polyoxin D Zinc Salt and OMRI Listed Alternatives Grouped by Fungicide Resistance Action Committee (FRAC) Code and Active Ingredient

Registered Uses of Polyoxin D Zinc Salt				OMRI Approved Alternative Products						
Crop	Disease (Pathogen)	Curative [4]	New Use	FRAC Code	Active Ingredient	EPA Reg. No.	Brand Name (Registrant)	Product Label Notes	Efficacy Notes	Efficacy Ref.
Leafy vegetables	Alternaria leaf spot (*Alternaria* spp.)	✔	✔	M1	Copper hydroxide	55146-1	Champ WG (NuFarm)	Phytotoxic in spray solution with pH <6.0. DANGER signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				None	*Streptomyces lydicus* WYEC 108	73314-1	Actinovate Soluble (Natural Industries)	Preventative use only. Live bacterium; must be applied after sterilant/fumigant has dissipated. Soil temperature must be ≥45°F. Label does not include specific crop/pathogen combinations. Label claims suppression/control, without identifying uses limited to suppression.		

APPENDIX 2. Registered Uses of Polyoxin D Zinc Salt and OMRI Listed Alternatives Grouped by Fungicide Resistance Action Committee (FRAC) Code and Active Ingredient

Registered Uses of Polyoxin D Zinc Salt				OMRI Approved Alternative Products						
Crop	Disease (Pathogen)	Curative [4]	New Use	FRAC Code	Active Ingredient	EPA Reg. No.	Brand Name (Registrant)	Product Label Notes	Efficacy Notes	Efficacy Ref.
Leafy vegetables	Downy mildew * (*Bremia lactucae* and *Peronospora* spp.)		✔	M1	Copper hydroxide	55146-1	Champ WG (NuFarm)	Phytotoxic in spray solution with pH <6.0. DANGER signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				M1	Copper hydroxide	45002-4	Nu-Cop 50 DF (Albaugh)	Phytotoxic in spray solution with pH <6.5. DANGER signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				M1	Copper hydroxide	45002-7	Blue Shield (Albaugh)	Crop appearance effects label warning. Phytotoxic in spray solution with pH <6.5. DANGER signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				M1	Copper(I) oxide	26883-20	Chem Copp 50 (American Chemet)	WARNING signal word. Toxic to fish. Lettuce and spinach only.		
				M1	Cuprous oxide	48142-4	Nordox 75 WG	High rate may be phytotoxic under hot or dry conditions. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product. May corrode aluminum irrigation pipes. For use on lettuce and spinach only. Slight injury can occur under adverse weather conditions.		
				M1	Copper oxychloride	45002-17	COC WP (Albaugh)	Crop injury warning. Toxic to fish and aquatic organisms. Runoff warning for poorly draining soils with shallow water tables. Potential runoff for several months or longer after application. Use limited to lettuce, endive and escarole.		
				44	*Bacillus subtilis* strain QST 713	264-1155	Rapsody ASO (Bayer)	Preventative use only. Suppression only. Tank mix with other registered fungicide for better performance.		
				44	*Bacillus subtilis* strain QST 713	264-1151	Serenade Max (Bayer)	Preventative use only. Suppression only. Tank mix with other registered fungicide for better performance.		

APPENDIX 2. Registered Uses of Polyoxin D Zinc Salt and OMRI Listed Alternatives Grouped by Fungicide Resistance Action Committee (FRAC) Code and Active Ingredient

Registered Uses of Polyoxin D Zinc Salt				OMRI Approved Alternative Products						
Crop	Disease (Pathogen)	Curative [4]	New Use	FRAC Code	Active Ingredient	EPA Reg. No.	Brand Name (Registrant)	Product Label Notes	Efficacy	
									Notes	Ref.
				P	*Ranatra sachalinensis*	84059-3	Regalia Concentrate (Marrone)	Preventative use only.		
				P	*Reynoutria sachalinensis*	84059-6	Regalia Maxx (Marrone)	Preventative use only.		
				None	*Bacillus amyloliquefaciens* strain D747	70051-108	Double Nickel 55	Preventative use only.		
				None	*Bacillus pumilus* strain QST 2808	264-1153	Sonata ASO (Bayer)	Preventative use only. Suppression only. Tank mix with other registered fungicide for better performance.	Ineffective on collards.	2
				None	Hydrogen dioxide	70299-2	OxiDate (BioSafe)	Highly toxic to bees and beneficial insects. Toxic to birds and fish. Preventative use only. Corrosive; strong oxidizing agent.	Provided limited control on lettuce.	2
				None	*Streptomyces lydicus* WYEC 108	73314-1	Actinovate Soluble (Natural Industries)	Preventative use only. Live bacterium; must be applied after sterilant/fumigant has dissipated. Soil temperature must be ≥45°F. Label does not include specific crop/pathogen combinations. Label claims suppression/control, without identifying uses limited to suppression.	Provided limited control.	2

APPENDIX 2. Registered Uses of Polyoxin D Zinc Salt and OMRI Listed Alternatives Grouped by Fungicide Resistance Action Committee (FRAC) Code and Active Ingredient

Registered Uses of Polyoxin D Zinc Salt				OMRI Approved Alternative Products						
Crop	Disease (Pathogen)	Curative [4]	New Use	FRAC Code	Active Ingredient	EPA Reg. No.	Brand Name (Registrant)	Product Label Notes	Efficacy Notes	Efficacy Ref.
Leafy vegetables	Powdery mildew (*Golovinomyces (Erysiphe) cichoracearum*)	✔	✔	M1	Copper hydroxide	55146-1	Champ WG (NuFarm)	Phytotoxic in spray solution with pH <6.0. DANGER signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				M1	Copper hydroxide	45002-7	Blue Shield (Albaugh)	Crop appearance effects label warning. Phytotoxic in spray solution with pH <6.5. DANGER signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				M1	Copper octanoate	67702-2	Cueva Fungicide Concentrate (Neudorff)	Toxic to fish and aquatic organisms. Runoff warning for poorly draining soils with shallow water tables. Must re-apply after rain. For best results, spray before disease first appears. Limited to use on chard, spinach, lettuce, chicory, and endive only.		
				M1	Copper oxychloride	45002-17	COC WP (Albaugh)	Phytotoxicity warning. Toxic to fish and aquatic organisms. Runoff warning for poorly draining soils with shallow water tables. Potential runoff for several months or longer after application.		
				M2	Sulfur (elemental)	70905-1	Cosavet DF (Sulphur Mills)	Sulfur may cause severe fruit and foliage injury to certain crops. Sulfur dust suspended in air ignites easily. Keep away from heat, sparks, or flames. Do not smoke while applying this product. Do not apply when shade temperatures exceed or are likely to exceed 90°F. REI = 24 hour.		
				M2	Sulfur	2935-407	Golden Micronized Sulfur (Wilbur-Ellis)	Sulfur may cause severe fruit and foliage injury to certain crops. Sulfur dust suspended in air ignites easily. Keep away from heat, sparks, or flames. Do not smoke while applying this product. Do not apply when shade temperatures exceed or are likely to exceed 90°F. REI = 24 hour. For use on lettuce only.		
				NC	Paraffinic oil	65564-1	Organic JMS Stylet Oil (JMS)	Phytotoxicity warning; enhances phytotoxicity of other products. Contains petroleum distillates. Do not apply when temperature is <50°F or >90°F. Many tank mix prohibitions.		

APPENDIX 2. Registered Uses of Polyoxin D Zinc Salt and OMRI Listed Alternatives Grouped by Fungicide Resistance Action Committee (FRAC) Code and Active Ingredient

Registered Uses of Polyoxin D Zinc Salt				OMRI Approved Alternative Products						
Crop	Disease (Pathogen)	Curative [4]	New Use	FRAC Code	Active Ingredient	EPA Reg. No.	Brand Name (Registrant)	Product Label Notes	Efficacy Notes	Efficacy Ref.
				NC	Potassium bicarbonate	20231-1	Kaligreen (Otsuka)	Do not mix with highly acidic products. Acidification with a buffering agent may reduce efficacy. Min PHI for food crops is 1 day. Use limited to powdery mildew; curative.		
				44	*Bacillus subtilis* strain QST 713	264-1155	Rapsody ASO (Bayer)	Preventative use only. Suppression only. Tank mix with other registered fungicide for better performance.		
				44	*Bacillus subtilis* strain QST 713	264-1151	Serenade Max (Bayer)	Preventative use only. Suppression only. Tank mix with other registered fungicide for better performance.		
				P	*Ranatra sachalinensis*	84059-3	Regalia Concentrate (Marrone)	Preventative use only.		
				P	*Reynoutria sachalinensis*	84059-6	Regalia Maxx (Marrone)	Preventative use only.		
				None	*Bacillus amyloliquefaciens* strain D747	70051-108	Double Nickel 55	Preventative use only.		
				None	*Bacillus pumilus* strain QST 2808	264-1153	Sonata ASO (Bayer)	Preventative use only. Suppression only. Tank mix with other registered fungicide for better performance.	Evidence for disease control and/or yield increase.	1
				None	*Streptomyces lydicus* WYEC 108	73314-1	Actinovate Soluble (Natural Industries)	Preventative use only. Live bacterium; must be applied after sterilant/fumigant has dissipated. Soil temperature must be ≥45°F. Label does not include specific crop/pathogen combinations. Label claims suppression/control, without identifying uses limited to suppression.		
Leafy vegetables	Botrytis damping off, Botrytis leaf blight, Botrytis rot (*Botrytis* spp.)	✔	✔	None	*Streptomyces lydicus* WYEC 108	73314-1	Actinovate Soluble (Natural Industries)	Preventative use only. Live bacterium; must be applied after sterilant/fumigant has dissipated. Soil temperature must be ≥45°F. Label does not include specific crop/pathogen combinations. Label claims suppression/control, without identifying uses limited to suppression.		

APPENDIX 2. Registered Uses of Polyoxin D Zinc Salt and OMRI Listed Alternatives Grouped by Fungicide Resistance Action Committee (FRAC) Code and Active Ingredient

Registered Uses of Polyoxin D Zinc Salt				OMRI Approved Alternative Products						
Crop	Disease (Pathogen)	Curative [4]	New Use	FRAC Code	Active Ingredient	EPA Reg. No.	Brand Name (Registrant)	Product Label Notes	Efficacy Notes	Efficacy Ref.
Leafy vegetables	Bottom rot (*Rhizoctonia solani*)		✔	M1	Copper octanoate	67702-2	Cueva Fungicide Concentrate (Neudorff)	Toxic to fish and aquatic organisms. Runoff warning for poorly draining soils with shallow water tables. Must re-apply after rain. For best results, spray before disease first appears. Use limited to lettuce, chicory and endive only.		
				P	*Ranatra sachalinensis*	84059-3	Regalia Concentrate (Marrone)	Preventative use only. Suppression only.		
				44	*Bacillus subtilis* strain QST 713	264-1151	Serenade Max (Bayer)	Preventative use only. Tank mix with other registered fungicide for better performance.		
				None	*Bacillus amyloliquefaciens* strain D747	70051-108	Double Nickel 55	Preventative use only.		
Leafy vegetables	Lettuce drop (*Sclerotinia* spp.)		✔	P	*Ranatra sachalinensis*	84059-3	Regalia Concentrate (Marrone)	Preventative use only.		
				P	*Reynoutria sachalinensis*	84059-6	Regalia Maxx (Marrone)	Preventative use only.		
				44	*Bacillus subtilis* strain QST 713	264-1155	Rapsody ASO (Bayer)	Preventative use only. Tank mix with other registered fungicide for better performance.		
				44	*Bacillus subtilis* strain QST 713	264-1151	Serenade Max (Bayer)	Preventative use only. Tank mix with other registered fungicide for better performance.	Ineffective on lettuce.	2
				None	*Bacillus amyloliquefaciens* strain D747	70051-108	Double Nickel 55	Preventative use only.		
				None	*Bacillus pumilus* strain QST 2808	264-1153	Sonata ASO (Bayer)	Preventative use only. Tank mix with other registered fungicide for better performance.	Evidence for disease control is mixed with some reports showing positive results and others not on lettuce.	1
				None	*Coniothyrium minitans* strains CON/M/91-08	7244-1	Contans WG (Prophyta Biologischer Pflanzenschutz)	Registered uses are limited to *Sclerotinia sclerotiorum* and *Sclerotinia minor* only. Application limited to period when temperature is below 81°C for 7 days; soil temperature should be 50-81°F. Soil must remain moist after application. Must be applied after sterilant or fumigant has dissipated. Product must be store at ≤39°F and out of sunlight. [Live fungus active ingredient. Ref: EPA BRAD.]	Evidence of disease control and/or yield increase on lettuce.	1
									Effective against *S. sclerotiorm* on lettuce.	2
									Ineffective against *S. minor*.	2

APPENDIX 2. Registered Uses of Polyoxin D Zinc Salt and OMRI Listed Alternatives Grouped by Fungicide Resistance Action Committee (FRAC) Code and Active Ingredient

Registered Uses of Polyoxin D Zinc Salt				OMRI Approved Alternative Products						
Crop	Disease (Pathogen)	Curative [4]	New Use	FRAC Code	Active Ingredient	EPA Reg. No.	Brand Name (Registrant)	Product Label Notes	Efficacy Notes	Efficacy Ref.
Legume vegetables	Asian Soybean Rust (*Phakopsora pachyrhizi*)	✔	✔	44	*Bacillus subtilis* strain QST 713	264-1151	Serenade Max (Bayer)	Preventative use only. Tank mix with other registered fungicide for better performance.		
				None	*Bacillus pumilus* strain QST 2808	264-1153	Sonata ASO (Bayer)	Preventative use only. Tank mix with other registered fungicide for better performance.		
Legume vegetables	Gray mold (*Botrytis cinerea*)	✔	✔	P	*Ranatra sachalinensis*	84059-3	Regalia Concentrate (Marrone)	Preventative use only.		
				P	*Reynoutria sachalinensis*	84059-6	Regalia Maxx (Marrone)	Preventative use only. Tank mix with another fungicide for improved performance.		
				44	*Bacillus subtilis* strain QST 713	264-1151	Serenade Max (Bayer)	Preventative use only. Tank mix with other registered fungicide for better performance.		
				None	*Bacillus amyloliquefaciens* strain D747	70051-108	Double Nickel 55	Preventative use only. Suppression only.		

APPENDIX 2. Registered Uses of Polyoxin D Zinc Salt and OMRI Listed Alternatives Grouped by Fungicide Resistance Action Committee (FRAC) Code and Active Ingredient

Registered Uses of Polyoxin D Zinc Salt				OMRI Approved Alternative Products						
Crop	Disease (Pathogen)	Curative [4]	New Use	FRAC Code	Active Ingredient	EPA Reg. No.	Brand Name (Registrant)	Product Label Notes	Efficacy Notes	Efficacy Ref.
Legume vegetables	Powdery mildew (*Erysiphe pisi*)	✔	✔	M1	Copper sulfate pentahydrate	66675-3	CS 2005	Phytotoxicity warning. DANGER signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				M2	Sulfur (elemental)	70905-1	Cosavet DF (Sulphur Mills)	Sulfur may cause severe fruit and foliage injury to certain crops. Sulfur dust suspended in air ignites easily. Keep away from heat, sparks, or flames. Do not smoke while applying this product. Do not apply when shade temperatures exceed or are likely to exceed 90°F. REI = 24 hour.		
				M2	Sulfur (elemental)	2935-407	Golden Micronized Sulfur (Wilbur-Ellis)	Sulfur may cause severe fruit and foliage injury to certain crops. Sulfur dust suspended in air ignites easily. Keep away from heat, sparks, or flames. Do not smoke while applying this product. Do not apply when shade temperatures exceed or are likely to exceed 90°F. REI = 24 hour.		
				NC	Potassium bicarbonate	20231-1	Kaligreen (Otsuka)	Do not mix with highly acidic products. Acidification with a buffering agent may reduce efficacy. Min PHI for food crops is 1 day. Use limited to powdery mildew; curative.		
				P	*Ranatra sachalinensis*	84059-3	Regalia Concentrate (Marrone)	Preventative use only.		
				P	*Reynoutria sachalinensis*	84059-6	Regalia Maxx (Marrone)	Preventative use only. Tank mix with another fungicide for improved performance.		
				44	*Bacillus subtilis* strain QST 713	264-1151	Serenade Max (Bayer)	Preventative use only. Tank mix with other registered fungicide for better performance.		
				None	*Bacillus amyloliquefaciens* strain D747	70051-108	Double Nickel 55	Preventative use only.		
				None	*Bacillus pumilus* strain QST 2808	264-1153	Sonata ASO (Bayer)	Preventative use only. Tank mix with other registered fungicide for better performance.		
				None	*Streptomyces lydicus* WYEC 108	73314-1	Actinovate Soluble (Natural Industries)	Preventative use only. Live bacterium; must be applied after sterilant/fumigant has dissipated. Soil temperature must be ≥45°F. Label does not include specific crop/pathogen combinations. Label claims suppression/control, without identifying uses limited to suppression.		

APPENDIX 2. Registered Uses of Polyoxin D Zinc Salt and OMRI Listed Alternatives Grouped by Fungicide Resistance Action Committee (FRAC) Code and Active Ingredient										
Registered Uses of Polyoxin D Zinc Salt				OMRI Approved Alternative Products						
Crop	Disease (Pathogen)	Curative [4]	New Use	FRAC Code	Active Ingredient	EPA Reg. No.	Brand Name (Registrant)	Product Label Notes	Efficacy	
									Notes	Ref.
Legume vegetables	Stem rot / White mold (*Sclerotinia sclerotiorum*)	✔	✔	M1	Copper octanoate	67702-2	Cueva Fungicide Concentrate (Neudorff)	Toxic to fish and aquatic organisms. Runoff warning for poorly draining soils with shallow water tables. Must re-apply after rain. For best results, spray before disease first appears.		
				M2	Sulfur	2935-407	Golden Micronized Sulfur (Wilbur-Ellis)	Sulfur may cause severe fruit and foliage injury to certain crops. Sulfur dust suspended in air ignites easily. Keep away from heat, sparks, or flames. Do not smoke while applying this product. Do not apply when shade temperatures exceed or are likely to exceed 90°F. REI = 24 hour.		
				P	*Ranatra sachalinensis*	84059-3	Regalia Concentrate (Marrone)	Preventative use only.		
				P	*Reynoutria sachalinensis*	84059-6	Regalia Maxx (Marrone)	Preventative use only. Tank mix with another fungicide for improved performance.		
				44	*Bacillus subtilis* strain QST 713	264-1151	Serenade Max (Bayer)	Preventative use only. Tank mix with other registered fungicide for better performance.		
				44	*Bacillus subtilis* strain QST 713	264-1152	Serenade ASO (Bayer)	Tank mix with other registered fungicide for better performance.		
				None	*Bacillus amyloliquefaciens* strain D747	70051-108	Double Nickel 55	Preventative use only.		
				None	*Bacillus pumilus* strain QST 2808	264-1153	Sonata ASO (Bayer)	Preventative use only. Tank mix with other registered fungicide for better performance.	No obvious response to treatment in one ore more published reports in lima beans.	1
				None	*Streptomyces lydicus* WYEC 108	73314-1	Actinovate Soluble (Natural Industries)	Preventative use only. Live bacterium; must be applied after sterilant/fumigant has dissipated. Soil temperature must be ≥45°F. Label does not include specific crop/pathogen combinations. Label claims suppression/control, without identifying uses limited to suppression.		

APPENDIX 2. Registered Uses of Polyoxin D Zinc Salt and OMRI Listed Alternatives Grouped by Fungicide Resistance Action Committee (FRAC) Code and Active Ingredient

Registered Uses of Polyoxin D Zinc Salt				OMRI Approved Alternative Products						
Crop	Disease (Pathogen)	Curative [4]	New Use	FRAC Code	Active Ingredient	EPA Reg. No.	Brand Name (Registrant)	Product Label Notes	Efficacy	
									Notes	Ref.
Pistachios	Alternaria late blight (*Alternaria spp.*)	✔		M1	Cupric hydroxide	45002-4	Nu Cop DF (Albaugh)	Phytotoxic in spray solution with pH <6.5. DANGER signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				M1	Copper hydroxide	45002-7	Blue Shield (Albaugh)	Crop appearance effects label warning. Phytotoxic in spray solution with pH <6.5. DANGER signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				M1	Copper hydroxide and Copper oxychloride	80289-12	Badge X2 (Isagro)	Phytotoxic in spray solution with pH <6.5. WARNING signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				M1	Cuprous oxide	48142-4	Nordox 75 WG (Nordox)	High rate may be phytotoxic under hot or dry conditions. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product. May corrode aluminum irrigation pipes.		
				M1	Cuprous oxide	48142-7	Nordox 30/30 WG (Nordox)	High rate may be phytotoxic under hot or dry conditions. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				M1	Copper oxychloride	45002-17	COC WP (Albaugh)	Toxic to fish and aquatic organisms. Runoff warning for poorly draining soils with shallow water tables. Potential runoff for several months or longer after application.		
				M1	Copper sulfate	45002-8	Basic Copper 53 (Albaugh)	WARNING signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		

APPENDIX 2. Registered Uses of Polyoxin D Zinc Salt and OMRI Listed Alternatives Grouped by Fungicide Resistance Action Committee (FRAC) Code and Active Ingredient

Registered Uses of Polyoxin D Zinc Salt				OMRI Approved Alternative Products						
Crop	Disease (Pathogen)	Curative [4]	New Use	FRAC Code	Active Ingredient	EPA Reg. No.	Brand Name (Registrant)	Product Label Notes	Efficacy	
									Notes	Ref.
				P	*Reynoutria sachalinensis*	84059-3	Regalia Concentrate (Marrone)	Preventative use only.		
				P	*Reynoutria sachalinensis*	84059-6	Regalia Maxx (Marrone)	Preventative use only.		
				None	*Bacillus pumilus* QST 2808	264-1153	Sonata ASO (Bayer)	Preventative use only. Tank mix with other registered fungicide for better performance.		

APPENDIX 2. Registered Uses of Polyoxin D Zinc Salt and OMRI Listed Alternatives Grouped by Fungicide Resistance Action Committee (FRAC) Code and Active Ingredient

Registered Uses of Polyoxin D Zinc Salt				OMRI Approved Alternative Products						
Crop	Disease (Pathogen)	Curative [4]	New Use	FRAC Code	Active Ingredient	EPA Reg. No.	Brand Name (Registrant)	Product Label Notes	Efficacy Notes	Efficacy Ref.
Pistachios	*Botryosphaeria pinicle and shoot blight* (*Botryosphaeria* spp.)	✔		M1	Cupric hydroxide	45002-4	Nu Cop DF (Albaugh)	Phytotoxic in spray solution with pH <6.5. DANGER signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				M1	Copper hydroxide	45002-7	Blue Shield (Albaugh)	Crop appearance effects label warning. Phytotoxic in spray solution with pH <6.5. DANGER signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				M1	Copper hydroxide and Copper oxychloride	80289-12	Badge X2 (Isagro)	Phytotoxic in spray solution with pH <6.5. WARNING signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				M1	Cuprous oxide	48142-4	Nordox 75 WG (Nordox)	High rate may be phytotoxic under hot or dry conditions. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product. May corrode aluminum irrigation pipes.		
				M1	Cuprous oxide	48142-7	Nordox 30/30 WG (Nordox)	High rate may be phytotoxic under hot or dry conditions. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				M1	Copper oxychloride	45002-17	COC WP (Albaugh)	Toxic to fish and aquatic organisms. Runoff warning for poorly draining soils with shallow water tables. Potential runoff for several months or longer after application.		
				M1	Copper sulfate	45002-8	Basic Copper 53 (Albaugh)	WARNING signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		

APPENDIX 2. Registered Uses of Polyoxin D Zinc Salt and OMRI Listed Alternatives Grouped by Fungicide Resistance Action Committee (FRAC) Code and Active Ingredient

Registered Uses of Polyoxin D Zinc Salt				OMRI Approved Alternative Products						
Crop	Disease (Pathogen)	Curative [4]	New Use	FRAC Code	Active Ingredient	EPA Reg. No.	Brand Name (Registrant)	Product Label Notes	Efficacy Notes	Efficacy Ref.
				P	*Reynoutria sachalinensis*	84059-3	Regalia Concentrate (Marrone)	Preventative use only.		
				P	*Reynoutria sachalinensis*	84059-6	Regalia Maxx (Marrone)	Preventative use only.		
				None	*Bacillus pumilus* QST 2808	264-1153	Sonata ASO (Bayer)	Preventative use only. Tank mix with other registered fungicide for better performance.		
Pome fruit	Alternaria blotch (*Alternaria mali*)	✔		P	*Reynoutria sachalinensis*	84059-3	Regalia Concentrate (Marrone)	Preventative use only.		
				None	*Streptomyces lydicus* WYEC 108	73314-1	Actinovate Soluble (Natural Industries)	Preventative use only. Live bacterium; must be applied after sterilant/fumigant has dissipated. Soil temperature must be ≥45°F. Label does not include specific crop/pathogen combinations. Label claims suppression/control, without identifying uses limited to suppression.		
Pome fruit	Leaf blotch (*Diplocarpon mali*)	✔					NONE FOUND			

APPENDIX 2. Registered Uses of Polyoxin D Zinc Salt and OMRI Listed Alternatives Grouped by Fungicide Resistance Action Committee (FRAC) Code and Active Ingredient

Registered Uses of Polyoxin D Zinc Salt				OMRI Approved Alternative Products						
Crop	Disease (Pathogen)	Curative [4]	New Use	FRAC Code	Active Ingredient	EPA Reg. No.	Brand Name (Registrant)	Product Label Notes	Efficacy Notes	Efficacy Ref.
Pome fruit	Powdery mildew (*Podosphaera leucotrica* in apples) *Phyllactinia mali* in pears)	✔		M2	Sulfur (elemental)	70905-1	Cosavet DF (Sulfur Mills)	Sulfur may cause severe fruit and foliage injury to certain crops. Sulfur dust suspended in air ignites easily. Keep away from heat, sparks, or flames. Do not smoke while applying this product. Do not apply when shade temperatures exceed or are likely to exceed 90°F. REI = 24 hour.		
				M2	Sulfur (elemental)	2935-407	Golden Micronized Sulfur (Wilbur-Ellis)	Sulfur may cause severe fruit and foliage injury to certain crops. Sulfur dust suspended in air ignites easily. Keep away from heat, sparks, or flames. Do not smoke while applying this product. Do not apply when shade temperatures exceed or are likely to exceed 90°F. REI = 24 hour. For use on apples only.		
				NC	Paraffinic oil	65564-1	Organic JMS Stylet Oil (JMS)	Phytotoxicity warning; enhances phytotoxicity of other products. Contains petroleum distillates. Do not apply when temperature is <50°F or >90°F. Many tank mix prohibitions.		
				NC	Potassium bicarbonate	20231-1	Kaligreen (Otsuka)	Do not mix with highly acidic products. Acidification with a buffering agent may reduce efficacy. Min PHI for food crops is 1 day. Use limited to powdery mildew; curative.		
				P	*Reynoutria sachalinensis*	84059-3	Regalia Concentrate (Marrone)	Preventative use only.		
				P	*Reynoutria sachalinensis*	84059-6	Regalia Maxx (Marrone)	Preventative use only.		
				44	*Bacillus subtilis* strain QST 713	264-1151	Serenade Max (Bayer)	Preventative use only. Tank mix with other registered fungicide for better performance.	Relatively ineffective in NY climatic conditions.	3
				None	*Bacillus amyloliquefaciens* strain D747	70051-108	Double Nickel 55	Preventative use only.		
				None	*Bacillus pumilus* QST 2808	264-1153	Sonata ASO (Bayer)	Preventative use only. Tank mix with other registered fungicide for better performance.		
				None	*Streptomyces lydicus* WYEC 108	73314-1	Actinovate Soluble (Natural Industries)	Preventative use only. Live bacterium; must be applied after sterilant/fumigant has dissipated. Soil temperature must be ≥45°F. Label does not include specific crop/pathogen combinations. Label claims suppression/control, without identifying uses limited to suppression.		

APPENDIX 2. Registered Uses of Polyoxin D Zinc Salt and OMRI Listed Alternatives Grouped by Fungicide Resistance Action Committee (FRAC) Code and Active Ingredient

Registered Uses of Polyoxin D Zinc Salt				OMRI Approved Alternative Products						
Crop	Disease (Pathogen)	Curative [4]	New Use	FRAC Code	Active Ingredient	EPA Reg. No.	Brand Name (Registrant)	Product Label Notes	Efficacy Notes	Efficacy Ref.
Pome fruit	Scab * (*Venturia* spp.)	✔		M1	Copper hydroxide	45002-4	Blue Shield DF (Albaugh)	Phytotoxic in spray solution with pH <6.5. DANGER signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				M1	Copper hydroxide	45002-7	Blue Shield (Albaugh)	Crop appearance effects label warning. Phytotoxic in spray solution with pH <6.5. DANGER signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				M1	Copper octanoate	67702-2	Cueva Fungicide Concentrate (Neudorff)	Russeting warning. Toxic to fish and aquatic organisms. Runoff warning for poorly draining soils with shallow water tables. Must re-apply after rain. For best results, spray before disease first appears.		
				M1	Copper(I) oxide	26883-20	Chem Copp 50 (American Chemet)	WARNING signal word. Toxic to fish For use on apples only. Dormant use and bud break only.		
				M1	Cuprous oxide	48142-4	Nordox 75 WG (Nordox)	High rate may be phytotoxic under hot or dry conditions. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product. May corrode aluminum irrigation pipes. For use on apples only.		
				M1	Copper oxychloride	45002-17	COC WP (Albaugh)	Toxic to fish and aquatic organisms. Runoff warning for poorly draining soils with shallow water tables. Potential runoff for several months or longer after application.		
				P	*Reynoutria sachalinensis*	84059-3	Regalia Concentrate (Marrone)	Preventative use only. Suppression only.		
				P	*Reynoutria sachalinensis*	84059-6	Regalia Maxx (Marrone)	Preventative use only.		
				None	*Bacillus amyloliquefaciens* strain D747	70051-108	Double Nickel 55	Preventative use only. Suppression only.		
				None	*Bacillus pumilus* QST 2808	264-1153	Sonata ASO (Bayer)	Preventative use only. Suppression only. Tank mix with other registered fungicide for better performance.		

APPENDIX 2. Registered Uses of Polyoxin D Zinc Salt and OMRI Listed Alternatives Grouped by Fungicide Resistance Action Committee (FRAC) Code and Active Ingredient

Registered Uses of Polyoxin D Zinc Salt				OMRI Approved Alternative Products					Efficacy	
Crop	Disease (Pathogen)	Curative [4]	New Use	FRAC Code	Active Ingredient	EPA Reg. No.	Brand Name (Registrant)	Product Label Notes	Notes	Ref.
				None	Gliocladium catenulatum strain J1446)	64137-11	Prestop Biofungicide Powder (Verdura Oy)	Apply pre-fruiting only. Cannot be tank mixed with any pesticides or concentrated fertilizers. Label does not make specific crop/pathogen specific claims.		
				None	Hydrogen dioxide	70299-2	OxiDate (BioSafe)	Highly toxic to bees and beneficial insects. Toxic to birds and fish. Preventative use only. Corrosive; strong oxidizing agent.		
Potatoes	Black scurf (*Rhizoctonia solani*)		✔	P	*Ranatra sachalinensis*	84059-3	Regalia Concentrate (Marrone)	Preventative use only.		
				44	*Bacillus subtilis* strain QST 713	264-1151	Serenade Max (Bayer)	Preventative use only. Tank mix with other registered fungicide for better performance.		

APPENDIX 2. Registered Uses of Polyoxin D Zinc Salt and OMRI Listed Alternatives Grouped by Fungicide Resistance Action Committee (FRAC) Code and Active Ingredient

Registered Uses of Polyoxin D Zinc Salt				OMRI Approved Alternative Products						
Crop	Disease (Pathogen)	Curative [4]	New Use	FRAC Code	Active Ingredient	EPA Reg. No.	Brand Name (Registrant)	Product Label Notes	Efficacy Notes	Efficacy Ref.
Potatoes	Early blight (*Alternaria solani*)	✔		M1	Copper hydroxide	45002-4	Blue Shield DF (Albaugh)	Phytotoxic in spray solution with pH <6.5. DANGER signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				M1	Copper hydroxide	55146-1	Champ WG (NuFarm)	Phytotoxic in spray solution with pH <6.0. DANGER signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				M1	Copper hydroxide	45002-7	Blue Shield (Albaugh)	Crop appearance effects label warning. Phytotoxic in spray solution with pH <6.5. DANGER signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				M1	Copper(I) oxide	26883-20	Chem Copp 50 (American Chemet)	WARNING signal word. Toxic to fish.		
				M1	Copper octanoate	67702-2	Cueva Fungicide Concentrate (Neudorff)	Toxic to fish and aquatic organisms. Runoff warning for poorly draining soils with shallow water tables. Must re-apply after rain. For best results, spray before disease first appears.		
				M1	Cuprous oxide	48142-4	Nordox 75 WG (Nordox)	High rate may be phytotoxic under hot or dry conditions. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product. May corrode aluminum irrigation pipes.		
				M1	Copper oxychloride	45002-17	COC WP (Albaugh)	Toxic to fish and aquatic organisms. Runoff warning for poorly draining soils with shallow water tables. Potential runoff for several months or longer after application.		
				M1	Copper sulfate	45002-8	Basic Copper 53 (Albaugh)	WARNING signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product. Suppression only.		

APPENDIX 2. Registered Uses of Polyoxin D Zinc Salt and OMRI Listed Alternatives Grouped by Fungicide Resistance Action Committee (FRAC) Code and Active Ingredient

Registered Uses of Polyoxin D Zinc Salt				OMRI Approved Alternative Products						
Crop	Disease (Pathogen)	Curative [4]	New Use	FRAC Code	Active Ingredient	EPA Reg. No.	Brand Name (Registrant)	Product Label Notes	Efficacy	
									Notes	Ref.
				P	*Reynoutria sachalinensis*	84059-6	Regalia Maxx (Marrone)	Suppression only. Must be tank mixed with another fungicide. Preventative use only.		
				44	*Bacillus subtilis* strain QST 713	264-1151	Serenade Max (Bayer)	Preventative use only. Suppression only. Tank mix with other registered fungicide for better performance.		
				None	*Bacillus amyloliquefaciens* strain D747	70051-108	Double Nickel 55	Preventative use only. Suppression only.		
				None	*Bacillus pumilus* QST 2808	264-1153	Sonata ASO (Bayer)	Preventative use only. Suppression only. Tank mix with other registered fungicide for better performance.		
				None	Gliocladium catenulatum strain J1446)	64137-11	Prestop Biofungicide Powder (Verdura Oy)	Apply pre-fruiting only. Cannot be tank mixed with any pesticides or concentrated fertilizers. Label does not make specific crop/pathogen specific claims.		
				None	Hydrogen dioxide	70299-2	OxiDate (BioSafe)	Highly toxic to bees and beneficial insects. Toxic to birds and fish. Preventative use only. Corrosive; strong oxidizing agent.		
				None	*Streptomyces lydicus* WYEC 108	73314-1	Actinovate Soluble (Natural Industries)	Preventative use only. Live bacterium; must be applied after sterilant/fumigant has dissipated. Soil temperature must be ≥45°F. Label does not include specific crop/pathogen combinations. Label claims suppression/control, without identifying uses limited to suppression.		

APPENDIX 2. Registered Uses of Polyoxin D Zinc Salt and OMRI Listed Alternatives Grouped by Fungicide Resistance Action Committee (FRAC) Code and Active Ingredient

Registered Uses of Polyoxin D Zinc Salt				OMRI Approved Alternative Products						
Crop	Disease (Pathogen)	Curative [4]	New Use	FRAC Code	Active Ingredient	EPA Reg. No.	Brand Name (Registrant)	Product Label Notes	Efficacy Notes	Efficacy Ref.
Potatoes	Late blight * (*Phytophthora infestans*)		✔	M1	Copper hydroxide	55146-1	Champ WG (NuFarm)	Phytotoxic in spray solution with pH <6.0. DANGER signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				M1	Copper hydroxide	45002-4	Nu Cop DF (Albaugh)	Phytotoxic in spray solution with pH <6.5. DANGER signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				M1	Copper hydroxide	45002-7	Blue Shield (Albaugh)	Crop appearance effects label warning. Phytotoxic in spray solution with pH <6.5. DANGER signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				M1	Copper hydroxide and Copper oxychloride	80289-12	Badge X2 (Isagro)	Phytotoxic in spray solution with pH <6.5. WARNING signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				M1	Copper(I) oxide	26883-20	Chem Copp 50 (American Chemet)	WARNING signal word. Toxic to fish.		
				M1	Cuprous oxide	48142-4	Nordox 75 WG (Nordox)	High rate may be phytotoxic under hot or dry conditions. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product. May corrode aluminum irrigation pipes.		
				M1	Copper oxychloride	45002-17	COC WP (Albaugh)	Toxic to fish and aquatic organisms. Runoff warning for poorly draining soils with shallow water tables. Potential runoff for several months or longer after application. Tank mix recommended for high disease pressure.		

APPENDIX 2. Registered Uses of Polyoxin D Zinc Salt and OMRI Listed Alternatives Grouped by Fungicide Resistance Action Committee (FRAC) Code and Active Ingredient

Registered Uses of Polyoxin D Zinc Salt				OMRI Approved Alternative Products						
Crop	Disease (Pathogen)	Curative [4]	New Use	FRAC Code	Active Ingredient	EPA Reg. No.	Brand Name (Registrant)	Product Label Notes	Efficacy Notes	Efficacy Ref.
				M1	Copper sulfate pentahydrate	66675-3	CS 2005	Phytotoxicity warning. DANGER signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				P	*Ranatra sachalinensis*	84059-3	Regalia Concentrate (Marrone)	Preventative use only. Suppression only.		
				P	*Reynoutria sachalinensis*	84059-6	Regalia Maxx (Marrone)	Suppression only. Must be tank mixed with another fungicide.		
				44	*Bacillus subtilis* strain QST 713	264-1155	Rapsody ASO (Bayer)	Preventative use only. Suppression only. Tank mix with other registered fungicide for better performance.		
				44	*Bacillus subtilis* strain QST 713	264-1151	Serenade Max (Bayer)	Preventative use only. Suppression only. Tank mix with other registered fungicide for better performance.		
				None	*Bacillus amyloliquefaciens* strain D747	70051-108	Double Nickel 55	Preventative use only.		
				None	*Bacillus pumilus* QST 2808	264-1153	Sonata ASO (Bayer)	Preventative use only. Suppression only. Tank mix with other registered fungicide for better performance.		
Potatoes	White mold (*Sclerotinia sclerotiorum*)		✔	P	*Ranatra sachalinensis*	84059-3	Regalia Concentrate (Marrone)	Preventative use only.		
				44	*Bacillus subtilis* strain QST 713	264-1151	Serenade Max (Bayer)	Preventative use only. Suppression only. Tank mix with other registered fungicide for better performance.		
				None	*Bacillus pumilus* QST 2808	264-1153	Sonata ASO (Bayer)	Preventative use only. Tank mix with other registered fungicide for better performance.		
				None	*Coniothyrium minitans* strains CON/M/91-08	7244-1	Contans WG (Prophyta Biologischer Pflanzenschutz)	Registered uses are limited to *Sclerotinia sclerotiorum* and *Sclerotinia minor* only. Application limited to period when temperature is below 81°C for 7 days; soil temperature should be 50-81°F. Soil must remain moist after application. Must be applied after sterilant or fumigant has dissipated. Product must be store at ≤39°F and out of sunlight. [Live fungus active ingredient. Ref: EPA BRAD.]		

APPENDIX 2. Registered Uses of Polyoxin D Zinc Salt and OMRI Listed Alternatives Grouped by Fungicide Resistance Action Committee (FRAC) Code and Active Ingredient										
Registered Uses of Polyoxin D Zinc Salt				OMRI Approved Alternative Products						
Crop	Disease (Pathogen)	Curative [4]	New Use	FRAC Code	Active Ingredient	EPA Reg. No.	Brand Name (Registrant)	Product Label Notes	Efficacy	
									Notes	Ref.
				None	*Streptomyces lydicus* WYEC 108	73314-1	Actinovate Soluble (Natural Industries)	Preventative use only. Live bacterium; must be applied after sterilant/fumigant has dissipated. Soil temperature must be ≥45°F. Label does not include specific crop/pathogen combinations. Label claims suppression/control, without identifying uses limited to suppression.		
Stone fruits	Botrytis blossom blight (*Botrytis cinerea*)	✔	✔	M1	Copper hydroxide	55146-1	Champ WG (NuFarm)	Phytotoxic in spray solution with pH <6.0. DANGER signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				P	*Ranatra sachalinensis*	84059-3	Regalia Concentrate (Marrone)	Preventative use only.		
				P	*Reynoutria sachalinensis*	84059-6	Regalia Maxx (Marrone)	Preventative use only.		
				44	*Bacillus subtilis* strain QST 713	264-1151	Serenade Max (Bayer)	Preventative use only. Tank mix with other registered fungicide for better performance.		
				None	*Bacillus amyloliquefaciens* strain D747	70051-108	Double Nickel 55	Preventative use only.		
				None	*Bacillus pumilus* QST 2808	264-1153	Sonata ASO (Bayer)	Preventative use only. Tank mix with other registered fungicide for better performance.		
				None	*Streptomyces lydicus* WYEC 108	73314-1	Actinovate Soluble (Natural Industries)	Preventative use only. Live bacterium; must be applied after sterilant/fumigant has dissipated. Soil temperature must be ≥45°F. Label does not include specific crop/pathogen combinations. Label claims suppression/control, without identifying uses limited to suppression.		

APPENDIX 2. Registered Uses of Polyoxin D Zinc Salt and OMRI Listed Alternatives Grouped by Fungicide Resistance Action Committee (FRAC) Code and Active Ingredient

Registered Uses of Polyoxin D Zinc Salt				OMRI Approved Alternative Products						
Crop	Disease (Pathogen)	Curative [4]	New Use	FRAC Code	Active Ingredient	EPA Reg. No.	Brand Name (Registrant)	Product Label Notes	Efficacy Notes	Efficacy Ref.
Stone fruits	Powdery mildew (*Podosphaera* spp., *Sphaerotheca pannosa*)	✔	✔	M2	Sulfur (Elemental)	2935-407	Golden Micronized Sulfur (Wilbur-Ellis)	Sulfur may cause severe fruit and foliage injury to certain crops. Sulfur dust suspended in air ignites easily. Keep away from heat, sparks, or flames. Do not smoke while applying this product. Do not apply when shade temperatures exceed or are likely to exceed 90°F. REI = 24 hour.		
				NC	Paraffinic oil	65564-1	Organic JMS Stylet Oil (JMS)	Phytotoxicity warning; enhances phytotoxicity of other products. Contains petroleum distillates. Do not apply when temperature is <50°F or >90°F. Many tank mix prohibitions.		
				NC	Potassium bicarbonate	20231-1	Kaligreen (Otsuka)	Do not mix with highly acidic products. Acidification with a buffering agent may reduce efficacy. Min PHI for food crops is 1 day. Use limited to powdery mildew; curative.		
				P	*Ranatra sachalinensis*	84059-3	Regalia Concentrate (Marrone)	Preventative use only.		
				P	*Reynoutria sachalinensis*	84059-6	Regalia Maxx (Marrone)	Tank mix with another fungicide for improved performance. Preventative use only.		
				44	*Bacillus subtilis* strain QST 713	264-1151	Serenade Max (Bayer)	Preventative use only. Suppression only. Tank mix with other registered fungicide for better performance.		
				None	*Bacillus amyloliquefaciens* strain D747	70051-108	Double Nickel 55	Preventative use only.		
				None	*Bacillus pumilus* QST 2808	264-1153	Sonata ASO (Bayer)	Preventative use only. Tank mix with other registered fungicide for better performance.		
				None	Potassium salts of fatty acids	10163-324	M-Pede Insecticide-Miticide-Fungicide (Gowan)	Phytotoxicity warning. Preventative use only. WARNING signal word. May be hazardous to aquatic invertebrates. Some tank mixes prohibited.		
				None	*Streptomyces lydicus* WYEC 108	73314-1	Actinovate Soluble (Natural Industries)	Preventative use only. Live bacterium; must be applied after sterilant/fumigant has dissipated. Soil temperature must be ≥45°F. Label does not include specific crop/pathogen combinations. Label claims suppression/control, without identifying uses limited to suppression.		

APPENDIX 2. Registered Uses of Polyoxin D Zinc Salt and OMRI Listed Alternatives Grouped by Fungicide Resistance Action Committee (FRAC) Code and Active Ingredient

Registered Uses of Polyoxin D Zinc Salt				OMRI Approved Alternative Products					Efficacy	
Crop	Disease (Pathogen)	Curative [4]	New Use	FRAC Code	Active Ingredient	EPA Reg. No.	Brand Name (Registrant)	Product Label Notes	Notes	Ref.
Strawberries	Anthracnose (*Colletotrichum* spp.)	✔		M1	Copper octanoate	67702-2	Cueva Fungicide Concentrate (Neudorff)	Toxic to fish and aquatic organisms. Runoff warning for poorly draining soils with shallow water tables. Must re-apply after rain. For best results, spray before disease first appears.		
				P	*Reynoutria sachalinensis*	84059-3	Regalia Concentrate (Marrone)	Preventative use only. Suppression only.		
				P	*Reynoutria sachalinensis*	84059-6	Regalia Maxx (Marrone)	Preventative use only.		
				None	*Bacillus amyloliquefaciens* strain D747	70051-108	Double Nickel 55	Preventative use only.		
				None	*Bacillus pumilus* QST 2808	264-1153	Sonata ASO (Bayer)	Preventative use only. Tank mix with other registered fungicide for better performance.		
				None	*Streptomyces lydicus* WYEC 108	73314-1	Actinovate Soluble (Natural Industries)	Preventative use only. Live bacterium; must be applied after sterilant/fumigant has dissipated. Soil temperature must be ≥45°F. Label does not include specific crop/pathogen combinations. Label claims suppression/control, without identifying uses limited to suppression.		
Strawberries	Gray mold (*Botrytis cinerea*)	✔		M1	Copper octanoate	67702-2	Cueva Fungicide Concentrate (Neudorff)	Toxic to fish and aquatic organisms. Runoff warning for poorly draining soils with shallow water tables. Must re-apply after rain. For best results, spray before disease first appears.		
				NC	Paraffinic oil	65564-1	Organic JMS Stylet Oil (JMS)	Phytotoxicity warning; enhances phytotoxicity of other products. Contains petroleum distillates. Do not apply when temperature is <50°F or >90°F. Many tank mix prohibitions.		
				P	*Reynoutria sachalinensis*	84059-3	Regalia Concentrate (Marrone)	Preventative use only.		
				P	*Reynoutria sachalinensis*	84059-6	Regalia Maxx (Marrone)	Preventative use only.		
				None	*Bacillus amyloliquefaciens* strain D747	70051-108	Double Nickel 55	Preventative use only.		
				None	*Bacillus pumilus* QST 2808	264-1153	Sonata ASO (Bayer)	Preventative use only. Suppression only. Tank mix with other registered fungicide for better performance.		
				None	*Streptomyces lydicus* WYEC 108	73314-1	Actinovate Soluble (Natural Industries)	Preventative use only. Live bacterium; must be applied after sterilant/fumigant has dissipated. Soil temperature must be ≥45°F. Label does not include specific crop/pathogen combinations. Label claims suppression/control, without identifying uses limited to suppression.		

APPENDIX 2. Registered Uses of Polyoxin D Zinc Salt and OMRI Listed Alternatives Grouped by Fungicide Resistance Action Committee (FRAC) Code and Active Ingredient

Registered Uses of Polyoxin D Zinc Salt				OMRI Approved Alternative Products						
Crop	Disease (Pathogen)	Curative [4]	New Use	FRAC Code	Active Ingredient	EPA Reg. No.	Brand Name (Registrant)	Product Label Notes	Efficacy	
									Notes	Ref.
Strawberries	Powdery mildew (*Sphaerotheca*)	✔		M1	Copper octanoate	67702-2	Cueva Fungicide Concentrate (Neudorff)	Toxic to fish and aquatic organisms. Runoff warning for poorly draining soils with shallow water tables. Must re-apply after rain. For best results, spray before disease first appears.		
				M2	Sulfur (elemental)	70905-1	Cosavet DF (Sulphur Mills)	Sulfur may cause severe fruit and foliage injury to certain crops. Sulfur dust suspended in air ignites easily. Keep away from heat, sparks, or flames. Do not smoke while applying this product. Do not apply when shade temperatures exceed or are likely to exceed 90°F. REI = 24 hour.		
				M2	Sulfur (elemental)	82571-3	CSC Dusting Sulfur (Martin)	Sulfur may cause severe fruit and foliage injury to certain crops. Sulfur dust suspended in air ignites easily. Keep away from heat, sparks, or flames. Do not smoke while applying this product. Do not apply when shade temperatures exceed or are likely to exceed 90°F. REI = 24 hour.		
				M2	Sulfur (elemental)	2935-407	Golden Micronized Sulfur (Wilbur-Ellis)	Sulfur may cause severe fruit and foliage injury to certain crops. Sulfur dust suspended in air ignites easily. Keep away from heat, sparks, or flames. Do not smoke while applying this product. Do not apply when shade temperatures exceed or are likely to exceed 90°F. REI = 24 hour.		
				NC	Potassium bicarbonate	20231-1	Kaligreen (Otsuka)	Do not mix with highly acidic products. Acidification with a buffering agent may reduce efficacy. Min PHI for food crops is 1 day. Use limited to powdery mildew; curative.		
				NC	Paraffinic oil	65564-1	Organic JMS Stylet Oil (JMS)	Phytotoxicity warning; enhances phytotoxicity of other products. Contains petroleum distillates. Do not apply when temperature is <50°F or >90°F. Many tank mix prohibitions.		
				P	*Reynoutria sachalinensis*	84059-3	Regalia Concentrate (Marrone)	Preventative use only.		
				P	*Reynoutria sachalinensis*	84059-6	Regalia Maxx (Marrone)	Preventative use only.		
				None	*Bacillus amyloliquefaciens* strain D747	70051-108	Double Nickel 55	Preventative use only. Suppression only.		
				None	*Bacillus pumilus* QST 2808	264-1153	Sonata ASO (Bayer)	Preventative use only. Suppression only. Tank mix with other registered fungicide for better performance.		

APPENDIX 2. Registered Uses of Polyoxin D Zinc Salt and OMRI Listed Alternatives Grouped by Fungicide Resistance Action Committee (FRAC) Code and Active Ingredient

Registered Uses of Polyoxin D Zinc Salt				OMRI Approved Alternative Products						
Crop	Disease (Pathogen)	Curative [4]	New Use	FRAC Code	Active Ingredient	EPA Reg. No.	Brand Name (Registrant)	Product Label Notes	Efficacy	
									Notes	Ref.
				None	Potassium salts of fatty acids	10163-324	M-Pede Insecticide-Miticide-Fungicide (Gowan)	Phytotoxicity warning. Preventative use only. WARNING signal word. May be hazardous to aquatic invertebrates. Some tank mixes prohibited.		
				None	*Streptomyces lydicus* WYEC 108	73314-1	Actinovate Soluble (Natural Industries)	Preventative use only. Live bacterium; must be applied after sterilant/fumigant has dissipated. Soil temperature must be ≥45°F. Label does not include specific crop/pathogen combinations. Label claims suppression/control, without identifying uses limited to suppression.		

APPENDIX 2. Registered Uses of Polyoxin D Zinc Salt and OMRI Listed Alternatives Grouped by Fungicide Resistance Action Committee (FRAC) Code and Active Ingredient

Registered Uses of Polyoxin D Zinc Salt				OMRI Approved Alternative Products						
Crop	Disease (Pathogen)	Curative [4]	New Use	FRAC Code	Active Ingredient	EPA Reg. No.	Brand Name (Registrant)	Product Label Notes	Efficacy	
									Notes	Ref.
Sugar beet †	Cercospora leaf spot (*Cercospora beticola*)	✔	✔	M1	Copper hydroxide	55146-1	Champ WG (NuFarm)	Phytotoxic in spray solution with pH <6.0. DANGER signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				M1	Copper hydroxide	45002-4	Nu-Cop 50DF (Albaugh)	Phytotoxic in spray solution with pH <6.5. DANGER signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				M1	Copper hydroxide	45002-7	Blue Shield (Albaugh)	Crop appearance effects label warning. Phytotoxic in spray solution with pH <6.5. DANGER signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				M1	Copper hydroxide and Copper oxychloride	80289-12	Badge X2 (Isagro)	Phytotoxic in spray solution with pH <6.5. WARNING signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				M1	Copper(I) oxide	26883-20	Chem Copp 50 (American Chemet)	WARNING signal word. Toxic to fish.		
				M1	Cuprous oxide	48142-4	Nordox 75 WG	High rate may be phytotoxic under hot or dry conditions. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product. May corrode aluminum irrigation pipes. May be tank mixed with sulfur to enhance control.		
				M1	Copper oxychloride	450025-17	COC WP (Albaugh)	Toxic to fish and aquatic invertebrates. Potential for runoff for several months or more after application. Runoff warning for poorly drained soils and soils with shallow water table.		

APPENDIX 2. Registered Uses of Polyoxin D Zinc Salt and OMRI Listed Alternatives Grouped by Fungicide Resistance Action Committee (FRAC) Code and Active Ingredient

Registered Uses of Polyoxin D Zinc Salt				OMRI Approved Alternative Products						
Crop	Disease (Pathogen)	Curative [4]	New Use	FRAC Code	Active Ingredient	EPA Reg. No.	Brand Name (Registrant)	Product Label Notes	Efficacy Notes	Efficacy Ref.
				M1	Copper sulfate pentahydrate	66675-3	CS 2005	Phytotoxicity warning. DANGER signal word. Toxic to fish and aquatic organisms. Potential for runoff several months or more after application. Poorly drained soils with shallow water tables are more prone to runoff containing product.		
				NC	Paraffinic oil	65564-1	Organic JMS Stylet Oil (JMS)	Phytotoxicity warning; enhances phytotoxicity of other products. Contains petroleum distillates. Do not apply when temperature is <50°F or >90°F. Many tank mix prohibitions.		
				P	*Ranatra sachalinensis*	84059-3	Regalia Concentrate (Marrone)	Preventative use only.		
				None	*Bacillus pumilus* QST 2808	264-1153	Sonata ASO (Bayer)	Preventative use only. Tank mix with other registered fungicide for better performance.		
Sugar beet †	Rhizoctonia crown and root rot (*Rhizoctonia solani*)	✔	✔	P	*Ranatra sachalinensis*	84059-3	Regalia Concentrate (Marrone)	Preventative use only. Suppression only.		
				44	*Bacillus subtilis* strain QST 713	264-1151	Serenade Max (Bayer)	Preventative use only. Tank mix with other registered fungicide for better performance.		
				None	*Bacillus amyloliquefaciens* strain D747	70051-108	Double Nickel 55	Preventative use only.		
				None	*Bacillus pumilus* QST 2808	264-1153	Sonata ASO (Bayer)	Preventative use only. Tank mix with other registered fungicide for better performance.		

† Polyoxin D zinc salt is not registered for use in California for this use.
* Polyoxin D zinc salt is registered for suppression only for this disease.

Color code:
Blue = Recently registered use. Not included in the Technical Evaluation Report.
Gray = Divider between crops or crop groups.
Green = Favorable comment or efficacy.
Yellow = Cautionary issue.
Red = Significant adverse issue or multiple issue types.

1. http://ohioline.osu.edu/sag-fact/pdf/0018.pdf
Cao, et al. (2010), Biopesticide Controls of Plant Diseases: Resources and Products for Organic Farmers in Ohio.
(+) Evidence for disease control and/or yield increase.
(±) Evidence for disease control is mixes with some reports showing positive results and others not.
(0) No obvious response to treatment in one or more published reports.
Efficacy data for uses that are not registered by EPA have been omitted from the above table.
2. http://nofavt.org/sites/default/files/biologicals.pdf
McGrath. Efficacy of Various Biological and Microbial Fungicides - Does That Really Work?
3. http://nysipm.cornell.edu/organic_guide/apples.pdf
Peck and Merwin (2009). A Grower's Guide to Organic Apples.
4. Curative as defined by Mueller and Robertson in http://www.extension.iastate.edu/CropNews/2008/Preventative+or+curative+fungicides.htm

APPENDIX 3. Comparative Efficacy Data Tables Regarding Almonds, Grapes, Pistachios and Strawberries

Source:
Adaskaveg, J., *et al.* (2012)
http://www.ipm.ucdavis.edu/PDF/PMG/fungicideefficacytiming.pdf

ALMOND: FUNGICIDE EFFICACY

Fungicide	Resistance risk (FRAC)[1]	Brown rot	Jacket rot	Anthrac -nose	Shot hole	Scab[3]	Rust[3]	Leaf blight	Alternaria leaf spot[3]	PM-like[5]	Silver leaf
Adament	high (3/11)[3]	++++	++	++++	+++	+++	+++	ND	++	+++	----
Bumper/Tilt[4]	high (3)	++++	+/-	++++	++	++	+++	ND	++	+++	----
Distinguish	high (9/11)	++++	++++	++++	++	ND	ND	ND	ND	ND	----
Indar	high (3)	++++	+/-	+++	++	++	NL	ND	+	ND	----
Inspire Super[4]	high (3/9)	++++	++++	ND	+++	+++	+++	ND	+++	ND	----
Luna Sensation	medium (7/11)[3,7]	++++	++++	++++	++++	++++	+++	ND	+++	+++	----
Pristine	medium (7/11)[3,7]	++++	++++	++++	++++	++++	+++	ND	+++	+++	----
Merivon*	medium (7/11)[3,7]	++++	++++	++++	++++	++++	+++	ND	++++	++++	----
Quash[4]	high (3)	++++	++	++++	+++	+++	++++	ND	++++	+++	----
Luna Experience	medium (3/7)[3]	++++	+++	++++	+++	++++	++++	ND	+++	+++	----
Quadris Top	medium (3/11)[3]	++++	+++	++++	+++	++++	++++	ND	+++	+++	----
Quilt Xcel	medium (3/11)[3]	++++	+++	++++	+++	++++	++++	ND	+++	+++	----
Rovral + oil[8]	low (2)	++++	++++	----	+++	+/-	++	ND	+++[9]	ND	----
Scala[3]	high (9)[3, 7]	++++	++++	ND	++	----	ND	ND	+	----	----
Tebuzol (Elite**)	high (3)	++++	+/-	+++	++	++	+++	ND	+	ND	----
Topsin-M/T-Methyl/ Incognito[2]	high (1)[2, 7]	++++	++++	----	----	+++[8]	+	+++[6]	----	++	----
Vangard	high (9)[3, 7]	++++	++++	ND	++	----	ND	ND	+[9]	----	----
Fontelis*	high (7)[4]	++++	++++	++	++++	+++	+++	ND	+++	ND	----
Abound[4]	high (11)[3, 7]	+++	----	++++	+++	++++	++++	+++	+++[10]	+++	----
Elevate	high (17)[7]	+++	++++	----	+	ND	ND	ND	ND	ND	----
Gem[4]	high (11)[3, 7]	+++	----	++++	+++	++++	++++	+++	+++[10]	+++	----
Laredo	high (3)	+++	----	++	++	----	+	+++	----	+++	----
Rovral/Iprodione /Nevado	low (2)	+++	+++	----	+++	----	----	ND	++[9]	----	----
Bravo/Chloro- thalonil/Echo /Equus[11,12]	low (M5)	++	NL	+++	+++	+++[15]	++++	NL	NL	----	----
Captan[4,12]	low (M4)	++	++	+++	+++	++	----	+++[6]	+	----	----
CaptEvate*	low (M4/17)	+++	+++	+++	+++	+++	----	+++	+	----	----
Maneb**	low (M3)	++	+	++	++	++	+++	++	----	----	----
Ph-D	medium (19)	++	+++	----	++	+++	+++	ND	++++	ND	----
Syllit*	Medium (M7)	+	----	ND	+++	++++	ND	ND	+	ND	----
Rally[13]	high (3)	+++	----	++	+/-	----	+	+++	----	+++	----
Ziram	low (M3)	++	+	+++	+++	+++	----	++	+	----	----
Copper[14]	low (M1)	+/-	+/-	----	+	+[15]	----	----	ND	----	ND
Copper + oil[14]	low (M1)	ND	ND	----	+	+++[15]	----	----	ND	----	ND
Lime sulfur[12]	low (M2)	+/-	NL	----	+/-	++[15]	++	NL	NL	----	NL
Sulfur[4,12]	low (M2)	+/-	+/-	----	----	++	++	----	----	+++	----
PlantShield	low	----	----	----	----	----	----	----	----	----	+++***

Rating: ++++ = excellent and consistent, +++ = good and reliable, ++ = moderate and variable, + = limited and/or erratic, +/- = minimal and often ineffective, ---- = ineffective, NL = not on label, and ND = no data

*** Registration pending in California**

****Not registered, label withdrawn or inactive**

*** Section 24C (special local needs) registration approved in California.

[1] Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of actions (for more information, see http://www.frac.info/). Fungicides with a different group number are suitable to alternate in a resistance management program. In California, make no more than one application of fungicides with mode of action Group numbers 1, 4, 9, 11, or 17 before rotating to a fungicide with a different mode of action Group number; for fungicides with other Group numbers, make no more than two consecutive applications before rotating to fungicide with a different mode of action Group number.

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APPLE AND PEAR: FUNGICIDE EFFICACY

Fungicide	Resistance risk (FRAC#)[1]	Scab Protectant	Scab Eradicant	Powdery mildew (apple only)
Adament	medium (3/11)	++++	++++	++++
Bayleton	high (3)	----	----	+++
Distinguish**	medium (9/11)	+++	+++	+++
Inspire Super	medium (3/9)	++++	++++	++++
Flint[2]	high (11)[3]	++++	++++	++++
Fontelis	high (7)	++++	++	+++
Luna Sensation	Medium (7/11)	++++	++	++++
Pristine	medium (7/11)	++++	----	+++
Procure[4]	high (3)	++++	++++	++++
Rally[5]	high (3)	++++	++	++++
Rubigan/Vintage[4]	high (3)	++++	++++	+++
Scala	high (9)[3]	+++	+++	+
Sovran	high (11)[3]	+++	+++	+++
Syllit	medium (M7)	+++	+++	----
Tebuzol	high (3)	+++	+++	+++
Topsin-M/T-Methyl /Incognito[3]	high (1)[3]	+++	+++	+++
Vangard	high (9)[3]	+++	+++	+++
Ph-D	medium (19)	+	+	+++
Captan[6]	low (M4)	+++	----	----
Dithane/Manzate/ Penncozeb[6]	low (M3)	+++	----	----
Maneb**	low (M3)	+++	----	----
Ziram[6]	low (M3)	++	----	----
Copper[6]	low (M1)	++[7]	----	----
Lime sulfur[6,8]	low (M2)	----	++++[8]	+++[9]
Sulfur[7]	low (M2)	++	----	++++

Bactericide/ Biological	Resistance risk	Fire blight[11] Contact	Fire blight[11] Systemic	Phytotoxicity
Ag Streptomycin/Agri-Mycin /Firewall	high	++++	+++	+/-
MycoShield/FireLine[10] (FlameOut**)	high	+++	+++	+/-
Copper[7]	low (M1)	+++	----	+
Captan[6]	low (M4)	++	----	----
Dithane/Manzate/ Penncozeb[6]	low (M3)	++	----	----
Kasumin*	high	++++	++++	+/-
Blight Ban	low	++	----	+/-
Bloomtime Bio	low	+++	----	+/-
Blossom Protect	low	+++	----	+/-

Rating: ++++ = excellent and consistent, +++ = good and reliable, ++ = moderate and variable, + = limited and/or erratic, +/- = minimal and often ineffective, ---- = ineffective.

*** Registration pending in California**

****Not registered, label withdrawn or inactive**

***** - Postharvest fruit registrations include: TBZ, Alumni, Penbotec, Scholar, and Scholar MP.**

[1] Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of actions (for more information, see http://www.frac.info/). Fungicides with a different group number are suitable to alternate in a resistance management program. In California, make no more than one application of fungicides with mode of action Group numbers 1, 4, 9, 11, or 17 before rotating to a fungicide with a different mode of action Group number; for fungicides with other Group numbers, make no more than two consecutive applications before rotating to fungicide with a different mode of action Group number.

Continued on next page . . .

Apple and Pear—Fungicide Efficacy, continued

GRAPEVINE: FUNGICIDE EFFICACY – Conventional Chemistry

Fungicide	Resistance risk (FRAC#)[1]	Powdery mildew	Downy mildew	Bunch rot		Phomopsis	Eutypa
				Botrytis	Summer		
Abound	high (11)[2]	++++	++++	+	----	+++	NR
Adament	medium (3/11)	++++	+	++	++	++	NR
Flint[3]	high (11)[2]	++++	+++	++	++	++	NR
Elite**/Orius/Tebuzol	high (3)	++++	----	++	++	----	NR
Quadris Top	high (3/11)	++++	+	++	++	++	NR
Inspire Super	medium (3/9)	++++	----	++++	++	----	NR
Luna Experience*	medium (3/7)	++++	----	++++	++	----	NR
Mettle	high (3)	++++	----	----	+	----	NR
Pristine	medium (7/11)[2]	++++	++++	++++	+++	+++	NR
Procure	high (3)	++++	----	----	----	----	NR
Quintec	high (13)	++++	----	----	----	----	NR
Rally	high (3)	++++	----	----	----	----	+++
Rally+Topsin-M[5]	high (1/3)	++++	----	----	----	++++	++++
Rubigan/Vintage	high (3)	++++	----	----	----	----	NR
Sovran	high (11)[2]	++++	++++	++	++	++++	----
Sulfur	low (M2)	++++	----	----	----	----	NR
Topguard*	high (3)	++++	----	----	----	----	NR
Topsin-M/T-Methyl/Incognito	high (1)[2]	++++	----	++	++	+	++++
Torino*	high (3)	++++	----	----	----	----	----
Vivando	high (U8)	++++	----	----	----	----	----
Bayleton	high (3)	++	----	----	----	----	NR
Copper	low (M1)	++	+++	++	+++	+	----
Elevate	high (17)[2]	++	----	++++	++	----	NR
Ph-D*	medium (19)	++	----	+++	+++	ND	NR
Rovral + Oil[4]	low (2)	++	----	++++	----	----	NR
Scala	high (9)[2]	++	----	++++	++	----	NR
Switch	low (9/12)	++	----	++++	+++	----	-----
Vangard	high (9)[2]	++	----	++++	++	----	NR
Captan	low (M4)	----	+	+++	+++	+++	NR
CaptEvate*	low (M4/17)	----	+	+++	+++	+	----
Dithane/Manzate/Penncozeb/(Maneb**)	low (M3)	----	----	++	----	+++	----
Presidio	high (43)	----	++++	----	----	----	----
Revus	high (40)	----	++++	----	----	----	----
Ridomil Gold/(Mefenoxam**)	high (4)	----	++++	----	----	----	----
Rovral/Iprodione/Nevado	low (2)	----	----	+++	----	----	----
Ziram	low (M3)	----	++	+	+	+++	----

Rating: ++++ = excellent and consistent, +++ = good and reliable, ++ = moderate and variable, + = limited and/or erratic, +/- = minimal and often ineffective, ---- = ineffective; and NR = not recommended.

*** Registration pending in California**

PISTACHIO: FUNGICIDE EFFICACY

Fungicide	Resistance risk (FRAC#)[1]	Alternaria late blight	Botrytis blossom & shoot blight	Botryosphaeria panicle & shoot blight
Abound	high (11)[2,3]	+++	----	+++
Adament	medium (3/11)[3]	++	+++	++
Bravo/Chlorothalonil/(Echo**)	low (M5)	++	----	++
Bumper/Tilt	high (3)	++	+	++[5]
Cabrio	high (11)[2,3]	+++	----	+++
Inspire Super	medium (3/9)	++	+++	+++(+)
Elevate	high (17)[3]	ND	++++	ND
Fontelis*	high (7)	++++	+++	+++(+)
Gem	high (11)[2,3]	+++	----	+++
Quash	high (3)	++++	+++(+)	+++[5]
Luna Experience	medium (3/7)	++++	++++	++++
Luna Sensation	medium (7/11)[3]	++++[4]	++++	++++
Merivon*	high (7)	----	++++	++++
Pristine	high (7/11)[3]	++++[4]	++++	++++
Ph-D (Polyoxin-D)	medium (19)	+++	++++	+++
Quadris Top	medium (3/11)[3]	+++	----	+++(+)
Quilt Xcel	medium (3/11)[3]	++++	----	+++(+)
Scala	high (9)[3]	++	+++	+++[6]
Switch	high (9/12)[3]	+++	+++	++
Tebuzol	high (3)	+++	+	+++[5]
Topsin-M/T-Methyl/Incognito[7]	high (1)	----	++	++
Vangard	High (9)[3]	+++	++++	----
Copper	low (M1)	+	----	----
Liquid lime sulfur[8]	low (M2)	----	----	+/-

Rating: ++++ = excellent and consistent, +++ = good and reliable, ++ = moderate and variable, + = limited and/or erratic, +/- = minimal and often ineffective, ---- = ineffective, and ND = no data

*** Registration pending in California.**

****Not registered, label withdrawn or inactive.**

[1] Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of actions (for more information, see http://www.frac.info/). Fungicides with a different group number are suitable to alternate in a resistance management program. In California, make no more than one application of fungicides with mode of action Group numbers 1, 4, 9, 11, or 17 before rotating to a fungicide with a different mode of action Group number; for fungicides with other Group numbers, make no more than two consecutive applications before rotating to fungicide with a different mode of action Group number.

[2] Field resistance of *Alternaria* spp. to Abound and to other strobilurin fungicides (Gem and Cabrio) is widespread in pistachio orchards.

[3] To reduce the risk of resistance development start treatments with a fungicide with a multi-site mode of action; rotate or mix fungicides with different mode of action FRAC numbers for subsequent applications, use labeled rates (preferably the upper range), and limit the total number of applications/season.

[4] Resistance to the SDHI (succinate dehydrogenase inhibitor) boscalid has been detected in high levels (80-90%) in some orchards; Pristine should not be applied if resistance to this fungicide is detected in an orchard. Cross-resistance of SDHI fungicides (FRAC Group 7) may occur.

[5] Do not apply Bumper/Tilt within 60 days of harvest, Quash within 25 days of harvest, or Tebuzol within 35 days before harvest.

[6] Under low and moderate disease pressure.

[7] Registered for bloom treatment only.

[8] Dormant treatment only.

STRAWBERRY: FUNGICIDE EFFICACY

Fungicide	Resistance risk (FRAC)[1]	Powdery mildew	Gray mold	Anthrac -nose	Angular leaf spot	Common leaf spot	Mucor rot	Rhizopus rot	Leather rot	Crown rot	Red steele
Copper	low (M1)	----	----	----	+++[5]	----	----	----	----	----	----
Sulfur	low (M2)	+++	----	----	----	----	----	----	----	----	----
Bumper/Tilt	high (3)	++++	----	++	----	+++	----	----	----	----	----
Mettle*	high (3)	++++	NR	ND	ND	ND	ND	ND	----	----	----
Procure	high (3)	++++	----	+	----	----	----	----	----	----	----
Quilt Xcel	medium (3/11)	++++	++	+++	----	----	ND	+	ND	ND	ND
Rally	high (3)	++++	----	++	----	++++**	----	----	----	----	----
Topsin-M/T-Methyl/Incognito	very high (1)[2]	+++	+++	----	----	++	----	----	----	----	----
Quadris	medium (11)[2]	+++	++	++	----	----	ND	ND	ND	ND	ND
Pristine	medium (7/11)[2]	+++	++++	ND	----	----	ND	ND	ND	ND	ND
Ph-D	medium (19)	+++	++	++	ND	ND	----	----	----	----	----
Fontelis	high (7)	+++	++++	ND	ND	ND	ND	ND	ND	ND	ND
Cinnacure	low	+	----	----	----	----	----	----	----	----	----
Elevate	high (17)[2,6]	+/-	++++[6]	+++	----	----	----	----	----	----	----
M-Pede	low	+	----	----	----	----	----	----	----	----	----
Quintec	high (13)	++++	----	----	----	----	----	----	----	----	----
Rovral/Iprodione/Nevado	low (2)	----	+++	----	----	----	++	----	----	----	----
Switch	high (7/12)	----	++++	+++	----	----	+	+++	----	----	----
Captan	very low (M4)	----	+++	+++	----	----	+	----	----	----	----
Thiram	low (M3)	----	++	++	----	----	----	----	----	----	----
Aliette/Legion[3]	low (33)	----	----	----	----	----	----	----	+++	++	++
Fungi-Phite, K-Phite, Prophyt	low (33)	----	----	----	----	----	----	----	+++	++	++
Ridomil Gold SL[4]	high (4)[2]	----	----	----	----	----	----	----	+++[4]	++	++

Rating: ++++ = excellent and consistent, +++ = good and reliable, ++ = moderate and variable, + = limited and/or erratic, +/- = minimal and often ineffective, ---- = ineffective, NR = not registered, and ND = no data

***Registration pending in California**

** Plant dip or foliar spray.[1] Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of actions (for more information, see http://www.frac.info/). Fungicides with a different group number are suitable to alternate in a resistance management program. In California, make no more than one application of fungicides with mode of action Group numbers 1, 4, 9, 11, or 17 before rotating to a fungicide with a different mode of action Group number; for fungicides with other Group numbers, make no more than two consecutive applications before rotating to fungicide with a different mode of action Group number.

[2] To reduce the risk of resistance development start treatments with a fungicide with a multi-site mode of action; rotate or mix fungicides with different mode of action FRAC numbers for subsequent applications, use labeled rates (preferably the upper range), and limit the total number of applications/season.

[3] Foliar applications provide systemic treatment.

[4] Ridomil Gold SL is the only formulation registered. If the GR formulation is applied to a previous crop that must be removed, it has a 0-day plantback interval.

[5] Greater than 4 applications causes severe stunting.

[6] Nonpersistent resistant populations of *Botrytis cinerea* to fenhexamid occur with repeated use of FRAC Group 17 fungicides.

1.b. 2013/03/06 Kaken written comments for the public hearing

Comments Regarding Polyoxin D Zinc Salt for the April 10, 2013 NOSB Public Hearing

Submitted by
Kaken Pharmaceutical Co., Ltd.
c/o Cynthia Ann Smith
Vice President
Conn & Smith, Inc.
6713 Catskill Road
Lorton, VA 22079 USA

March 6, 2013

CONTENTS

EXECUTIVE SUMMARY

1. NOT AN ANTIBIOTIC

Neither "antibiotic" nor "antibiotic drug" are defined:

- In the Federal Insecticide Fungicide and Rodenticide Act (FIFRA);
- By the U.S. Department of Agriculture; or
- By the National Organic Program.

The decision to include or exclude polyoxin D zinc salt from 7 CFR §205.601 is a regulatory decision. Therefore, only a regulatory definition of "antibiotic" or "antibiotic drug" should be used in NOSB's and NOP's decision making. Otherwise, the regulatory decision would be arbitrary and capricious.

The Federal Food Drug and Cosmetic Act (FFDCA) defines an "antibiotic drug" and requires intended use in humans or animals. Section 201 of 21 U.S.C. 321 states:

"(jj) *The term "antibiotic drug" means any drug (except drugs for use in animals other than humans) composed wholly or partly of any kind of penicillin, streptomycin, chlortetracycline, chloramphenicol, bacitracin, or any other drug intended for human use containing any quantity of any chemical substance which is produced by a micro-organism and which has the capacity to inhibit or destroy micro-organisms in dilute solution (including a chemically synthesized equivalent of any such substance) or any derivative thereof.*" [Emphasis added.]

Polyoxin D zinc salt has always been marketed exclusively as a plant protectant. Polyoxin D zinc salt is not and has never been intended for use in humans or animals. Therefore, polyoxin D zinc salt is not an antibiotic as defined by the FFDCA.

2. POTENTIALLY NON-SYNTHETIC, BUT PROPOSED AS SYNTHETIC

Polyoxin D is produced via a fermentation process and is believed to be non-synthetic. Kaken buys the zinc source to convert polyoxin D to polyoxin D zinc salt. Kaken does not control the production process for the zinc source and cannot assure that it is mined. Therefore, polyoxin D zinc salt is proposed as a synthetic material.

3. UNIQUE, NON-TOXIC MODE OF ACTION

Polyoxin D zinc salt has a non-toxic mode of action. Polyoxin D zinc salt inhibits the chitin synthetase found in fungi. This prevents the growth of fungi without killing the fungi. As such, polyoxin D zinc salt is truly *fungistatic* rather than fungicidal. This makes polyoxin D zinc salt an excellent tool for integrated pest management (IPM).

Polyoxin D zinc salt is the only registered pesticide with this mode of action. This makes polyoxin D zinc salt an excellent tool for resistance management.

4. POLYOXIN D ZINC SALT IS PRACTICALLY NON-TOXIC TO HONEYBEES

The 96-hr LD_{50} of polyoxin D zinc salt to honeybees was determined to be 28.774 µg/bee. Using EPA's classification criteria, polyoxin D zinc salt is practically non-toxic to honeybees.

EPA Bee Hazard Category [1]	96-hr LD_{50} (µg/bee)
Highly toxic	< 2
Moderately toxic	2-11
Practically non-toxic	> 11

1. http://www.epa.gov/oppefed1/ecorisk_ders/toera_analysis_eco.htm

5. POLYOXIN D ZINC SALT HAS NO ADVERSE EFFECTS ON OTHER BENEFICIAL INSECTS

Polyoxin D zinc salt has no adverse effects on silkworm, marmalade hoverfly, and green lacewing.

Beneficial Insect	End-point	Observations
Silkworm (Kinshu x Showa)	LC_{50} > 2100 mg/L	No adverse effects observed.
Marmalade hoverfly	10-day LC_{50} > 2100 mg/L	No adverse effects observed.
Green lacewing	14-day LC_{50} > 2100 mg/L	No deaths.

6. RAPID DEGRADATION UNDER NORMAL ENVIRONMENTAL CONDITIONS

Polyoxin D zinc salt rapidly degrades in the presence of water and sunlight. In sterile natural water, polyoxin D degraded by:

- 50% in 0.4 days (9.6 hours); and
- 90% in 1.2 days (less than 29 hours).

7. NEGLIGIBLE EXPOSURE AND RISK TO FISH AND AQUATIC INVERTEBRATES

Aquatic exposure and aquatic risk are negligible because:

- Polyoxin D zinc salt formulations are for terrestrial use only;
- Application rates are low; and
- Polyoxin D zinc salt degrades rapidly under normal environmental conditions.

8. SAFETY TO HUMANS

The polyoxin D zinc salt formulation developed for the organic market (EPA Reg. No. 68173-4) has such low toxicity that EPA does not require a first aid statement. Also, polyoxin D zinc salt has been determined by EPA to not cause DNA damage or long-term health effects.

On September 12, 2012, EPA established an exemption from the requirement of a tolerance for the residues of polyoxin D zinc salt in or on all food commodities when applied as a fungicide and used in accordance with good agricultural practices (40 CFR § 180.1285). This exemption includes pre-harvest and post-harvest uses.

9. EFFICACY

Polyoxin D zinc salt provides curative control for most diseases; the alternatives generally provide only preventative control.

Polyoxin D zinc salt provides curative control for three crop/disease combinations with no OMRI listed alternatives:

- Cucurbits/Southern blight (*Sclerotium rolfsii*);
- Ginseng/Cylindrocarpon root rot (*Cylinderocarpon destructans*); and
- Pome fruit/Leaf blotch (*Diplocarpon mali*).

Polyoxin D zinc salt is not phytotoxic and does not cause russeting (cosmetic effect with crop value reduction) of apples.

10. LARGE NUMBER OF EPA AND CALIFORNIA REGISTERED USES

There are 73 EPA registered crop/disease combination uses of polyoxin D zinc salt, many of which are for entire crop groups. Most of the uses are also registered in California. New uses are in development.

11. REQUESTED SUPPORT FOR INCLUSION IN 7 CFR §205.601

For the reasons stated above, Kaken Pharmaceutical Co. Ltd. requests the support of the National Organic Standards Board and National Organic Program for the inclusion of polyoxin D zinc salt in 7 CFR §205.601 to permit the use of polyoxin D zinc salt in organic crop production.

DETAILED COMMENTS

<table>
<tr><th colspan="6">Category 1. Adverse Impacts on Humans or the Environment of Polyoxin D Zinc Salt?</th></tr>
<tr><th colspan="5">Crops Subcommittee Petitioned Material Proposal (January 29, 2013)</th><th rowspan="2">Kaken's Comments</th></tr>
<tr><th>Question</th><th>Yes</th><th>No</th><th>N/A</th><th>Documentation
(TAP; petition; regulatory agency; other)</th></tr>
<tr><td>1. Are there adverse effects on environment from manufacture, use, or disposal? [§205.600 b.2]</td><td></td><td></td><td>X</td><td></td><td>Not adverse.</td></tr>
<tr><td rowspan="2">2. Is there environmental contamination during manufacture, use, misuse, or disposal? [§6518 m.3]</td><td rowspan="2">X</td><td rowspan="2"></td><td rowspan="2"></td><td>The TR (lines 190-195) states that the EPA considers polyoxin D zinc salt a low environmental risk, listing several reasons for this rationale. Also, included in the supplemental information submitted by the petitioner on October 2, 2012 as part of an EPA posting to the Federal Register on September 12, 2012.</td><td>Not adverse.</td></tr>
<tr><td>The TR does mention (line 194) that failure to follow the product label could result in death of fish and aquatic organisms. In the TR (lines 197-204) states that biopesticides generally pose lower risks than chemically produced pesticides.</td><td>Aquatic exposure and aquatic risk are very low because:
• Polyoxin D zinc salt formulations are for terrestrial use only;
• Application rates are low;
• Polyoxin D zinc salt degrades rapidly under normal environmental conditions.

Please see pages 19-20 of http://tinyurl.com/C-Smith-1-23-2013 .
The September 12, 2012 published final rule for polyoxin D zinc salt states on page 56131 of the Federal Register:
"2. Drinking water exposure. As stated in the previous tolerance exemption (73 FR 69562), there is a small potential for trace amounts of polyoxin D zinc salt to enter drinking water sources after a significant rainfall, via surface water runoff, and/or via incidental spray drift. The petitioner submitted a photodegradation in water study (MRID 48653305) to support this tolerance exemption. The results of the study show that polyoxin D zinc salt has a net photolytic half-life of 0.4 days in sterile natural water (See Ref.). Even if residues of polyoxin D zinc salt enter water sources, residues are expected to degrade and be so diluted as to be negligible. The data and information demonstrate a lack of aggregate dietary risk via drinking water and is sufficient to support this expansion of the tolerance exemption."</td></tr>
</table>

Category 1. Adverse Impacts on Humans or the Environment of Polyoxin D Zinc Salt?					
Crops Subcommittee Petitioned Material Proposal (January 29, 2013)					Kaken's Comments
Question	Yes	No	N/A	Documentation (TAP; petition; regulatory agency; other)	
				The manufacturing process is CBI, but the TR states the process would be similar to other antibiotics produced from *Streptomyces.* (TR July 11, 2102)	Please see page 5 of http://tinyurl.com/C-Smith-1-23-2013 : Polyoxin D is produced via an aerobic fermentation process. Polyoxin D is converted to polyoxin D zinc salt using an aqueous process. No organic solvent impurities are present in Polyoxin D Zinc Salt Technical. Zinc is a mined mineral. Please see http://www.zinc.org/basics/zinc_production. Zinc is also recycled. Please see http://www.zinc.org/basics/zinc_recycling. Kaken is not the producer of the zinc source used in the production of polyoxin D zinc salt and does not know if the zinc is "virgin" zinc from a mine or recycled zinc.
				The TR states (lines 190-204) that polyoxin D could get into water if misused by not following the label.	Aquatic exposure and aquatic risk are very low because: • Polyoxin D zinc salt formulations are for terrestrial use only; • Application rates are low; • Polyoxin D zinc salt degrades rapidly under normal environmental conditions. Please see pages 19-20 of http://tinyurl.com/C-Smith-1-23-2013 : The September 12, 2012 published final rule for polyoxin D zinc salt states on page 56131 of the Federal Register: *"2. Drinking water exposure. As stated in the previous tolerance exemption (73 FR 69562), there is a small potential for trace amounts of polyoxin D zinc salt to enter drinking water sources after a significant rainfall, via surface water runoff, and/or via incidental spray drift. The petitioner submitted a photodegradation in water study (MRID 48653305) to support this tolerance exemption. The results of the study show that polyoxin D zinc salt has a net photolytic half-life of 0.4 days in sterile natural water (See Ref.). Even if residues of polyoxin D zinc salt enter water sources, residues are expected to degrade and be so diluted as to be negligible. The data and information demonstrate a lack of aggregate dietary risk via drinking water and is sufficient to support this expansion of the tolerance exemption."*

Category 1. Adverse Impacts on Humans or the Environment of Polyoxin D Zinc Salt?					
Crops Subcommittee Petitioned Material Proposal (January 29, 2013)					Kaken's Comments
Question	Yes	No	N/A	Documentation (TAP; petition; regulatory agency; other)	
				Waste may be disposed of on site or at an approved waste facility, but not disposed of in waste water. (TR July 11, 2012)	The Environmental Hazard statement for products containing polyoxin D zinc salt includes: "Do not contaminate water when disposing of equipment wash water or rinsate." This is a standard statement included in the Environmental Hazards section of EPA registered pesticide labels, including OMRI alternative products, *e.g.*, • *Bacillus subtilis* strain QST 713 (Seranade Max; EPA Reg. No. 264-1151); • *Reynoutria sachalinensis* (Regalia Max; EPA Reg. No. 84059-6): • *Streptomyces lydicus* WYEC 108 (Actinovate SP; EPA Reg. No. 73314-1); and • *Bacillus amyloliquefaciens* strain D747 (Double Nickel; EPA Reg. No. 70051-108).

Category 1. Adverse Impacts on Humans or the Environment of Polyoxin D Zinc Salt?					
Crops Subcommittee Petitioned Material Proposal (January 29, 2013)					Kaken's Comments
Question	Yes	No	N/A	Documentation (TAP; petition; regulatory agency; other)	
3. Is the substance harmful to the environment and biodiversity? [§6517c(1)(A)(I); 6517(c)(2)(A)I]	X	X		Polyoxin D zinc salt is moderately toxic to fish and aquatic invertebrates and should not be discharged into water. (TR lines 279-280). If label instructions followed, those concerns would be mitigated (EPA, 2001)(TR lines 290-291).	Aquatic exposure and aquatic risk are very low because: • Polyoxin D zinc salt formulations are for terrestrial use only; • Application rates are low; • Polyoxin D zinc salt degrades rapidly under normal environmental conditions. Aquatic exposure and aquatic risk are very low. Please see pages 19-20 of http://tinyurl.com/C-Smith-1-23-2013 : The September 12, 2012 published final rule for polyoxin D zinc salt states on page 56131 of the Federal Register: *"2. Drinking water exposure. As stated in the previous tolerance exemption (73 FR 69562), there is a small potential for trace amounts of polyoxin D zinc salt to enter drinking water sources after a significant rainfall, via surface water runoff, and/or via incidental spray drift. The petitioner submitted a photodegradation in water study (MRID 48653305) to support this tolerance exemption. The results of the study show that polyoxin D zinc salt has a net photolytic half-life of 0.4 days in sterile natural water (See Ref.). Even if residues of polyoxin D zinc salt enter water sources, residues are expected to degrade and be so diluted as to be negligible. The data and information demonstrate a lack of aggregate dietary risk via drinking water and is sufficient to support this expansion of the tolerance exemption."*
				Should be considered toxic to various soil fungi and bacteria (TR lines 234-235). However, the TR (lines 241-251) does state that alternative fungicides, such as copper or sulfur, may have similar or more severe effects. No documented studies to verify the effects by comparison to other fungicides.	**Polyoxin D zinc salt is NOT toxic to fungi, including soil fungi.** Please see pages 6-7 of http://tinyurl.com/C-Smith-1-23-2013 : Polyoxin D zinc salt has a non-toxic mode of action. Polyoxin D zinc salt inhibits the chitin synthetase found in fungi. This prevents the growth of fungi without killing the fungi. As such, polyoxin D zinc salt is truly *fungistatic* rather than fungicidal. **Polyoxin D zinc salt is NOT toxic to bacteria, including soil bacteria.** Please see pages 57-62 of http://tinyurl.com/C-Smith-1-23-2013 for the Maximum Inhibitory Concentration data. Polyoxin D zinc salt is not efficacious for use as an antibiotic to kill bacteria.

<table>
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<tr><th>Question</th><th>Yes</th><th>No</th><th>N/A</th><th>Documentation
(TAP; petition; regulatory agency; other)</th></tr>
<tr><td></td><td></td><td></td><td></td><td>In the TR it mentions (TR line 54) Action of Substance: Inhibits cell wall chitin synthesis (Misato, 1977, O'Neill, 2006).</td><td>EPA's May 11, 2012 science review of polyoxin D zinc salt states on page 3,
"[The mode of action of] Polyoxin D and its zinc salt is the inhibition of chitin synthesis in the cell walls of fungi, some of which are pathogenic to plants. This inhibition of chitin synthesis is limited to chitin in fungal cell walls. Polyoxin D and its zinc salt do not inhibit the synthesis of chitin in animals that contain chitin, such as for insects and crustaceans that contain chitin in their exoskeletons. Polyoxin D Zinc Salt does not affect mammals because mammalian cells have plasma membranes that do not contain chitin."</td></tr>
<tr><td></td><td></td><td></td><td></td><td>It further states (TR lines 257-262) it has been shown to inhibit chitin synthetase in cockroaches, and may therefore affect beneficial insects.</td><td>Please see pages 25-26 of http://tinyurl.com/C-Smith-1-23-2013 for data regarding non-target insects. Polyoxin D zinc salt:
• Is practically non-toxic to honeybees using EPA's criteria (EPA's least hazardous classification); and
• Has no adverse effects on:
  • Silkworm;
  • Marmalade hoverfly;
  • Green lacewing; and
  • Wolf spider.
The article by Leighton et al. (1981) referenced in the TR reports research using insect organ cultures, not whole insects. The article makes no statement about any effects of polyoxin D zinc salt or polyoxin D on whole insects as suggested in the TR. A copy of the article is provided as APPENDIX 1.</td></tr>
<tr><td></td><td></td><td></td><td></td><td>EPA: Toxic to Honey Bees. [1]</td><td>Please see page 26 of http://tinyurl.com/C-Smith-1-23-2013 .
The 96-hr LD_{50} of polyoxin D zinc salt to honeybees was determined to be 28.774 µg/bee. Using EPA's classification criteria, polyoxin D zinc salt is practically non-toxic to honeybees (EPA's least hazardous classification).
http://www.epa.gov/oppefed1/ecorisk_ders/toera_analysis_eco.htm
<table>
<tr><th>EPA Bee Hazard Category</th><th>96-hr LD_{50} (µg/bee)</th></tr>
<tr><td>Highly toxic</td><td>< 2</td></tr>
<tr><td>Moderately toxic</td><td>2-11</td></tr>
<tr><td>Practically non-toxic</td><td>> 11</td></tr>
</table>
If polyoxin D zinc salt were toxic to bees, there would be a bee hazard statement in the Environmental Hazards section of the label. None of the polyoxin D zinc salt product labels have a bee hazard statement on the label.</td></tr>
</table>

Category 1. Adverse Impacts on Humans or the Environment of Polyoxin D Zinc Salt?					
Crops Subcommittee Petitioned Material Proposal (January 29, 2013)					Kaken's Comments
Question	Yes	No	N/A	Documentation (TAP; petition; regulatory agency; other)	
				Kaken cites EPA.[2] "Polyoxin D and its zinc salt do not inhibit the synthesis of chitin in animals that contain chitin, such as for insects and crustaceans that contain chitin in their exoskeletons."	Not adverse.

Category 1. Adverse Impacts on Humans or the Environment of Polyoxin D Zinc Salt?					
Crops Subcommittee Petitioned Material Proposal (January 29, 2013)					Kaken's Comments
Question	Yes	No	N/A	Documentation (TAP; petition; regulatory agency; other)	
4. Does the substance contain List 1, 2 or 3 inerts? [§6517 c (1)(B)(ii); 205.601(m)2]		?		The TR states that Polyoxin D Zinc Salt is formulated with undisclosed inert ingredients. TR line 58 (TR July 11, 2012) The TR further states that the preferred surfactants used in the dry flowable form are formalin sodium naphthalenesulfonate (inert list 4B) or non-ionic polyoxyethylene alkyl ethers (inert list 4B) (Tokumura, et al., 2001). Formulation process is CBI.	The formulation that has been developed for the organic market is VEGGIETURBO 5SC Suspension Concentrate Fungicide (EPA Reg. No. 68173-4). None of the ingredients in this formulation are on EPA's Inert Ingredient List 1, 2, or 3.
5. Is there potential for detrimental chemical interaction with other materials used? [§6518 m.1]	X	X		Because of its activity as a fungicide, it may have a negative impact on beneficial fungi. Polyoxin D inhibits the germination of *Trichoderma viride* (Benitez, et al., 1976). *T. viride* is closely related to *T.harzianum,* which is used in organic farming under the brand name Root Shield (OMRI, 2012). There are a couple of other fungi used as biological controls in organic farming. (TR lines 216-222).	Polyoxin D zinc salt: • Does not kill fungi; it prevents its growth. • Degrades rapidly under normal environmental conditions. In 1.2 days, 90% degradation has occurred. Any adverse impacts on beneficial fungi in the soil will be only temporarily. Polyoxin D zinc salt can be used in the same field that is treated with live fungal active ingredients. If it were tank mixed with products with live fungal active ingredients, polyoxin D zinc salt would not kill the other active ingredient but instead would delay its action.
				However, it has also been shown to promote the biocontrol of Bacillus subtilis, with a strong synergistic effect on Alternaria mali suppression. (TR lines 225-226) (TR July 11, 2012)	Not adverse.
				Also, in the TR (TR lines 220-224) it lists *Gliocladium virens, Paecilomyces fumosoroseus,* and *Streptomyces griseoviridis* as other fungi used as biological control agents in organic agriculture. *G virens* is marketed as SoilGard, *P. fumosoroseus* is the active ingredient in PFR-97 and *S.griseoviridis* is sold as Mycostop (OMRI, 2012).	See above.

Category 1. Adverse Impacts on Humans or the Environment of Polyoxin D Zinc Salt?					
Crops Subcommittee Petitioned Material Proposal (January 29, 2013)					Kaken's Comments
Question	Yes	No	N/A	Documentation (TAP; petition; regulatory agency; other)	
				(TR line 223) states that polyoxin D zinc salt was found to reduce the efficacy of the virus used to control the black cutwork (sic)(*Agrotis ipsilon)* (Bixby-Brosi and Potter, 2012)	Please see page 22-23 of http://tinyurl.com/C-Smith-1-23-2013 . Bixby-Brosi and Potter (2012) concludes that polyoxin D <u>is compatible</u> with *Agip*MNPV. The abstract for Bixby-Brosi and Potter (2012) includes: *"This study tested whether applying the virus [<u>Agip</u>MNPV] together with such a fungicide [polyoxin D] can synergize <u>Agip</u>MNPV activity against <u>A. ipsolon</u> in turfgrass."* *"RESULTS: The addition of chitin synthesis inhibitor failed to increase <u>Agip</u>MNPV infectivity to <u>A. ipsolon</u> in the field. Rather, delayed and slightly reduced mortality from viral infection was seen when larvae fed on fungicide/virus treated grasses as opposed to virus-only treatment. Choice tests revealed fungicide residues to be a mild feeding deterrent."* *"CONCLUSION: Because polyoxin-d does not inactivate <u>Agip</u>MNPV, the two substances <u>are compatible</u>. However, combination applications of polyoxin-d and <u>Agip</u>MNPV on turfgrass might interfere with the larval ingestion of a lethal virus dose, resulting in prolonged larval feeding in the field."* [Emphasis added.] A copy of Bixby-Brosi and Potter (2012) is provided as APPENDIX 2.
				In the soil tests, the half-lives were 15.9 days for aerobic soils and 59.2 days for anaerobic soils. (EPA science review, p12). However, in the document provided by the petitioner (January 18, 2013 section 5.2) it states that in the presence of sunlight polyoxin D zinc salt degrades by 50% within 0.4 days (9.6 hours) "in sterile natural water, pH 5.0, pH 7.0, and pH 9.0 buffers, respectively."	Degradation rates are driven by the fastest available route. Please see page 21 of http://tinyurl.com/C-Smith-1-23-2013 . Polyoxin D zinc salt degrades rapidly under normal environmental conditions. The values reported are half-lives ($T_{1/2}$). For example, in the presence of sunlight and water, polyoxin D zinc salt: • Degrades by 50% within 0.4 days (9.6 hours); • Further degrades another 50% within another 0.4 days (another 9.6 hours); and • Further degrades another 50% within another 0.4 days (another 9.6 hours), etc. In 1.2 days (less than 29 hours), 90% degradation has occurred. "In the soil tests, the half-lives were 15.9 days for aerobic soils and 59.2 days for anaerobic soils." These studies were done in the dark (absence of sunlight).

Category 1. Adverse Impacts on Humans or the Environment of Polyoxin D Zinc Salt?					
Crops Subcommittee Petitioned Material Proposal (January 29, 2013)					Kaken's Comments
Question	Yes	No	N/A	Documentation (TAP; petition; regulatory agency; other)	
				The petitioner says that it inhibits fungi growth but does not kill it, maintain that it would not be a detriment to organic products such as Root Shield, currently used in organic farming (same doc. Pg 24 section 5.5).	Not adverse. See above.

<table>
<tr><th colspan="6">Category 1. Adverse Impacts on Humans or the Environment of Polyoxin D Zinc Salt?</th></tr>
<tr><th colspan="5">Crops Subcommittee Petitioned Material Proposal (January 29, 2013)</th><th rowspan="2">Kaken's Comments</th></tr>
<tr><th>Question</th><th>Yes</th><th>No</th><th>N/A</th><th>Documentation
(TAP; petition; regulatory agency; other)</th></tr>
<tr><td rowspan="5">6. Are there adverse biological and chemical interactions in agro-ecosystem? [§6518 m.5]</td><td rowspan="5">X</td><td rowspan="5">X</td><td rowspan="5"></td><td>TR 233-237: "As a broad-spectrum antibiotic and fungicide, polyoxin D Zinc Salt is toxic to soil fungi.</td><td><u>Polyoxin D zinc salt is NOT an antibiotic.</u>
Please see pages 7-14 of http://tinyurl.com/C-Smith-1-23-2013 :
Polyoxin D zinc salt:
• Is and always has marketed in the United States and elsewhere in the world exclusively as a plant protection product.
• Has never been marketed for use as a pharmaceutical for use in human or animal health.
• Is not efficacious for use as an antibiotic to kill bacteria.
• <u>Is not an antibiotic as defined by the Federal Food Drug and Cosmetic Act (FFDCA).</u> (USDA, NOP, and EPA do not have a definition of "antibiotic.")
Polyoxins have been repeatedly described in the literature as antibiotics based upon an <u>arbitrary</u> definition used in a Gottlieb and Shaw (1970). This arbitrary definition would be arbitrary and capricious if used for regulatory decision making.

<u>Polyoxin D zinc salt is NOT toxic to fungi, including soil fungi.</u>
Please see pages 6-7 of http://tinyurl.com/C-Smith-1-23-2013 .
Polyoxin D zinc salt has a non-toxic mode of action. Polyoxin D zinc salt inhibits the chitin synthetase found in fungi. This prevents the growth of fungi without killing the fungi. As such, polyoxin D zinc salt is truly <u>fungistatic</u> rather than fungicidal.</td></tr>
<tr><td>Polyoxins and other antibiotics were found to increase melanins in Alternaria kikuchiana (Kohno, et al., 1983; Butler and Day, 1998). The ecological functions of melanins are still unknown, but they are believed to enhance the phytotoxic and pathogenic properties of plant pathogens (Butler and Day, 1998). Earthworms were shown to have a preference for melanized fungi (Marfenina and Ischenko, 1997; Butler and Day, 1998)."</td><td>Please see pages 23-24 of http://tinyurl.com/C-Smith-1-23-2013 .
• Both Kohno, et al. (1983) and Butler and Day (1998) are <u>not relevant</u> to the NOP petition for polyoxin D zinc salt.
• Kohno, et al. (1983) describes experiments that used exclusively polyoxin B. Neither polyoxin D nor polyoxin D zinc salt were used in the study.
• Butler and Day (1998) is a review article regarding fungal melanins that references Kohno, et al. (1983) without specifying that the findings of Kohno, et al. (1983) are limited to polyoxin B.</td></tr>
<tr><td>There is some concern that polyoxin D used on turf to have a moderate risk of resistance. (Vincelli and Williams 2012)(TR lines 253-261)</td><td>Please see pages 27 of http://tinyurl.com/C-Smith-1-23-2013 .
Polyoxin D zinc salt has been used for over 40 years as a crop protectant <u>without a single observation of pest resistance</u>.</td></tr>
<tr><td>Again alternative materials may have similar or worse effects. (TR lines 246-248) (TR July 11, 2012)</td><td>Not adverse.</td></tr>
<tr><td>In the Jan. 18, 2013 (pages 20 -26) document provided by the petitioner it does not actually kill fungi, just inhibits growth.</td><td>Not adverse.</td></tr>
</table>

Category 1. Adverse Impacts on Humans or the Environment of Polyoxin D Zinc Salt?					
Crops Subcommittee Petitioned Material Proposal (January 29, 2013)					Kaken's Comments
Question	Yes	No	N/A	Documentation (TAP; petition; regulatory agency; other)	
				Also is not harmful to beneficial insects.	Not adverse.
				Same report (pages 27-28) also that polyoxin D zinc salt is a FRAC 19 class (Kaken 2008) (EPA Reg. No. 68173-1) of fungicide. It has a unique mode of action that would aid in resistance management as part of an IPM disease control program. Only class 19 fungicide currently listed.	Not adverse.
7. Are there detrimental physiological effects on soil organisms, crops, or livestock? [§6518 m.5]	X			The TR states that there may be adverse effects to beneficial soil organisms when exposed to polyoxin D. TR lines 241-242. It goes on to state that alternative fungicides may have similar or even greater effects on soil ecology, but that no studies could be found that compare the impacts between polyoxin D and other fungicides in organic production, specifically. TR lines 246-251. (TR July 11, 2012)	**Polyoxin D zinc salt is NOT toxic to fungi, including soil fungi.** Please see pages 6-7 of http://tinyurl.com/C-Smith-1-23-2013 : Polyoxin D zinc salt has a non-toxic mode of action. Polyoxin D zinc salt inhibits the chitin synthetase found in fungi. This prevents the growth of fungi without killing the fungi. As such, polyoxin D zinc salt is truly *fungistatic* rather than fungicidal. **Polyoxin D zinc salt is NOT toxic to bacteria, including soil bacteria.** Please see pages 57-62 of http://tinyurl.com/C-Smith-1-23-2013 for the Maximum Inhibitory Concentration data. Polyoxin D zinc salt is not efficacious for use as an antibiotic to kill bacteria. **Polyoxin D zinc salt degrades rapidly.** Please see page 21 of http://tinyurl.com/C-Smith-1-23-2013 . Polyoxin D zinc salt degrades rapidly under normal environmental conditions. In the presence of sunlight and moisture, Polyoxin D zinc salt: • Degrades by 50% within 0.4 days (9.6 hours); and • Degrades by 90% within 1.2 days.
				Is not labeled for use on livestock or pastures.	Not adverse.

Category 1. Adverse Impacts on Humans or the Environment of Polyoxin D Zinc Salt?					
Crops Subcommittee Petitioned Material Proposal (January 29, 2013)					Kaken's Comments
Question	Yes	No	N/A	Documentation (TAP; petition; regulatory agency; other)	
8. Is there a toxic or other adverse action of the material or its breakdown products? [§6518 m.2]		X		The following refers to polyoxin D zinc's use as an antibiotic: Polyoxin D has been shown to be effective as a drug to treat human and animal pathogens *Candida albicans* and *Cryptococcus neoformans* (Becker, et al., 1983: Hilenski, et al., 1986). Polyoxin D also shows some efficacy in the reduction of the protozoan parasite *Encephalitiozoon cuniculi* infecting immune-compromised AIDS patients (Sobottka, et al., 2002). All three of the above mentioned studies were *in vitro* experiments and not substantiated by any *in vivo* claims or studies. Polyoxin D zinc salt in currently not listed for use in human or veterinary medicine.	Please see #7 above. Please see page 11-12 of http://tinyurl.com/C-Smith-1-23-2013 for additional details.

				Moderate acute dermal toxicity; moderate toxicity primary eye irritation. (TR Table 2.)	Please see Table 2 on page 16 of http://tinyurl.com/C-Smith-1-23-2013 :
					VEGGIETURBO 5SC Suspension Concentrate Fungicide (EPA Reg. No. 68173-4) is the polyoxin D zinc salt formulation developed for the organic market. This formulation:
					• Is practically non-toxic via dermal exposure.
					  • Category IV; EPA's least hazardous category
					  • $LD_{50} \geq 5050$ mg/kg (males, females, and combined); and
					• Is non-irritating to eyes
					  • Category IV; EPA's least hazardous category.
					  • No irritation was observed in any eyes 24 hours after treatment.
					The toxicity of the formulation is so low that EPA does not require a First Aid statement on the label.

Category 1. Adverse Impacts on Humans or the Environment of Polyoxin D Zinc Salt?					
Crops Subcommittee Petitioned Material Proposal (January 29, 2013)					Kaken's Comments
Question	Yes	No	N/A	Documentation (TAP; petition; regulatory agency; other)	
9. Is there undesirable persistence or concentration of the material or breakdown products in environment? [§6518 m.2]		X		The EPA's risk assessment of polyoxin D Zinc Salt to carry a low environmental risk due to its specific mode of action, low toxicity, rapid degradation and low application rate (EPA 2008) TR lines 190-191. "The EPA waived environmental fate and ground water data due to the use pattern, application methods, and mitigation of non-target aquatic organism toxicity with appropriate precautionary label statements under Environmental Hazards."	Not adverse.

<table>
<tr><th colspan="6">Category 1. Adverse Impacts on Humans or the Environment of Polyoxin D Zinc Salt?</th></tr>
<tr><th colspan="5">Crops Subcommittee Petitioned Material Proposal (January 29, 2013)</th><th rowspan="2">Kaken's Comments</th></tr>
<tr><th>Question</th><th>Yes</th><th>No</th><th>N/A</th><th>Documentation
(TAP; petition; regulatory agency; other)</th></tr>
<tr><td></td><td></td><td></td><td></td><td>Failure to follow the label instructions may result in the death of fish and ~~194~~ aquatic organisms (EPA, 2001, 2008)." (TR 191-195)</td><td>Aquatic exposure and aquatic risk are very low because:
• Polyoxin D zinc salt formulations are for terrestrial use only;
• Application rates are low;
• Polyoxin D zinc salt degrades rapidly under normal environmental conditions.
EPA's Biopesticide Registration Action Document (BRAD) was included in the petition as Appendix 8. EPA states on page 122 of the petition (page 3 of the BRAD):
"Potential exposure to freshwater invertebrates and fish, via runoff after application, will be minimized by mitigating Environmental Hazards label text."
The Environmental Hazards section for the EPA stamped accepted labels state:
"For terrestrial use. This pesticide is moderately toxic to aquatic invertebrates and fish. Do not apply directly to water, or to areas where surface water is present or to intertidal areas below the mean high water mark. Do not contaminate water when disposing of equipment wash water or rinsate. Do not allow runoff into lakes, streams, ponds or public waterways. Drift and runoff may be hazardous to aquatic organisms in water adjacent to treated areas. Observe the most restrictive labeling limitations and precautions of all products used in mixtures."
Please see pages 19-20 of http://tinyurl.com/C-Smith-1-23-2013 :
The September 12, 2012 published final rule for polyoxin D zinc salt states on page 56131 of the Federal Register:
"2. Drinking water exposure. As stated in the previous tolerance exemption (73 FR 69562), there is a small potential for trace amounts of polyoxin D zinc salt to enter drinking water sources after a significant rainfall, via surface water runoff, and/or via incidental spray drift. The petitioner submitted a photodegradation in water study (MRID 48653305) to support this tolerance exemption. The results of the study show that polyoxin D zinc salt has a net photolytic half-life of 0.4 days in sterile natural water (See Ref.). Even if residues of polyoxin D zinc salt enter water sources, residues are expected to degrade and be so diluted as to be negligible. The data and information demonstrate a lack of aggregate dietary risk via drinking water and is sufficient to support this expansion of the tolerance exemption."
"194" is a line number from the TR. Inclusion of "194" in the Crops Subcommittee statement is a word processing error.</td></tr>
</table>

<table>
<tr><th colspan="7">Category 1. Adverse Impacts on Humans or the Environment of Polyoxin D Zinc Salt?</th></tr>
<tr><th colspan="5">Crops Subcommittee Petitioned Material Proposal (January 29, 2013)</th><th colspan="2" rowspan="2">Kaken's Comments</th></tr>
<tr><th>Question</th><th>Yes</th><th>No</th><th>N/A</th><th>Documentation
(TAP; petition; regulatory agency; other)</th></tr>
<tr><td rowspan="5"></td><td rowspan="5"></td><td rowspan="5"></td><td rowspan="5"></td><td rowspan="5">Soil half-life from aerobic microbial metabolism is reported to be 15.9 days. Degradation in water and sunlight is reported to be approximately 2.3 days (Smith, 2012). (TR line 153)(July 11, 2012)</td><td colspan="2">The fastest route of degradation drives the overall degradation rate.</td></tr>
<tr><td>Study</td><td>Observed DT_{50}</td></tr>
<tr><td>Aerobic soil metabolism</td><td>15.9 days</td></tr>
<tr><td>Aqueous photolysis:
Sterile natural water</td><td>0.4 days</td></tr>
<tr><td>Sterile water, pH 7 buffer</td><td>2.3 days</td></tr>
<tr><td rowspan="4">10. Is there any harmful effect on human health?
[§6517 c (1)(A)(i); 6517 c(2)(A)i; §6518 m.4]</td><td rowspan="4">X</td><td rowspan="4">X</td><td rowspan="4"></td><td>All polyoxins have shown to have low mammalian toxicity. (Copping and Duke, 2007)(TR lines 305-309)).</td><td colspan="2">Not adverse.</td></tr>
<tr><td>Could case slight skin irritation.</td><td colspan="2">Please see Table 2 on page 16 of http://tinyurl.com/C-Smith-1-23-2013 :
VEGGIETURBO 5SC Suspension Concentrate Fungicide (EPA Reg. No. 68173-4) is the polyoxin D zinc salt formulation developed for the organic market.
• This formulation has Category IV skin irritation (EPA's least hazardous category).
• At 72 hours, the primary irritation index was 0.3.
The toxicity of the formulation is so low that EPA does not require a First Aid statement on the label.</td></tr>
<tr><td>Positive benefits for human and animal pathogens Candida albicans and Cryptococcus neoformans (Becker, et al. 1983: Hilenski, et al., 1986) (TR lines 311-314) Polyoxin D Zinc Salt is currently not listed for use for human or veterinary medicinal uses.</td><td colspan="2">Please see page 11 of http://tinyurl.com/C-Smith-1-23-2013 .
Both Becker, et al. (1983) and Hilenski, et al. (1986) describe in vitro (outside a living organism) experiments only and makes no claim for in vivo (within a living organism) efficacy in humans or other animals.</td></tr>
<tr><td>Also has be shown to have an effect on the protozoan parasite Encephalitozoon cuniculi infecting the immune system in AIDS patients (Sobottka, et al., 2002) (TR lines 311-314) This was the result of one in vitro experiment. (TR July 11, 2012)</td><td colspan="2">Please see pages 11-12 of http://tinyurl.com/C-Smith-1-23-2013 .
Sobottka, et al. (2002) provides no data to support the suggestion in the September 23, 2012 technical evaluation report that polyoxin D is an effective drug for the treatment of Encephalitozoon infections in AIDS patients.</td></tr>
</table>

Category 1. Adverse Impacts on Humans or the Environment of Polyoxin D Zinc Salt?					
Crops Subcommittee Petitioned Material Proposal (January 29, 2013)					Kaken's Comments
Question	Yes	No	N/A	Documentation (TAP; petition; regulatory agency; other)	
				EPA: results of the mutagenicity studies indicated Polyoxin D Zinc Salt Technical was weakly mutagenic in an Ames Assay (MRID# 433230-01) and not mutagenic in a host mediated assay (MRID # 432618-36). If a food/feed use is ever sought, the test results will require a review of the mutagenicity data base to determine the need for additional studies.[3] Mammalian chromosome aberration studies with hamster cells showed highly significant increases in chromosomal aberrations over solvent control.[4] However, in view of other studies submitted by the petitioner, EPA decided that the studies indicate that polyoxin D zinc salt is not mutagenic or clastogenic.	Not adverse. Please note that food/feed use was sought and additional data were submitted to EPA. As noted, EPA concluded that polyoxin D zinc salt is not mutagenic or clastogenic, *i.e.*, <u>polyoxin D zinc salt does not have an adverse effect on DNA.</u>

Category 1. Adverse Impacts on Humans or the Environment of Polyoxin D Zinc Salt?					
Crops Subcommittee Petitioned Material Proposal (January 29, 2013)					Kaken's Comments
Question	Yes	No	N/A	Documentation (TAP; petition; regulatory agency; other)	
11. Is there an adverse effect on human health as defined by applicable Federal regulations? [205.600 b.3]			X		Not adverse.
12. Is the substance GRAS when used according to FDA's good manufacturing practices? [§205.600 b.5]			X		Not adverse.
13. Does the substance contain residues of heavy metals or other contaminants in excess of FDA tolerances? [§205.600 b.5]			X		Not adverse.

1. EPA, May 11, 2012, Science Review of Product Chemistry, Residue Chemistry, Non-Target Organism, and Toxicity Data in Support of Label Amendment for Polyoxin D Zinc Salt. (Included with supplemental petition).
2. EPA, May 11, 2012, Science Review of Product Chemistry, Residue Chemistry, Non-Target Organism, and Toxicity Data in Support of Label Amendment for Polyoxin D Zinc Salt. (Included with supplemental petition).
3. EPA. Consideration of Eligibility for Registration of the New Pesticide Active Ingredient Polyoxin D Zinc Salt – DECISION MEMORANDUM, p 15. (1997)
4. EPA, May 11, 2012. Science Review of Product Chemistry, Residue Chemistry, Non-Target Organism, and Toxicity Data in Support of Label Amendment for Polyoxin D Zinc Salt. (Included with supplemental petition.

http://tinyurl.com/C-Smith-1-23-2013

= http://www.ams.usda.gov/AMSv1.0/getfile?dDocName=STELPRDC5102221

= "Polyoxin D Zinc Salt: Reply to and Comments Regarding the National Organic Program Technical Evaluation Report Dated September 23, 2012" submitted January 18, 2013 and revised January 23, 2013.

Category 2. Is Polyoxin D Zinc Salt Essential for Organic Production?					
Crops Subcommittee Petitioned Material Proposal (January 29, 2013)					Kaken's Comments
Question	Yes	No	N/A	Documentation (TAP; petition; regulatory agency; other)	
1. Is the substance formulated or manufactured by a chemical process? [6502 (21)]	X	X		Included in a new document received on January 18, 2013 from the petitioner it states on page 5 section 1.1, that, polyoxin D is made from an aerobic fermentation process, thus a natural process. However, they do state that they do not know whether the zinc salt is from a mined or from a recycled zinc source. The TR states that the manufacturing process has at least one step that would be similar to other *Streptomyces* products that are classified as synthetic on section 205.601 of the National List: streptomycin and tetracycline (terramycin). Similarly, polyoxin D Zinc Salt may also be classified as a synthetic. TR lines 146-148. It would appear that polyoxin D may be non-synthetic, but it would be assumed that the zinc salt would be synthetic, due to the lack of being able to properly verify its source.	Kaken agrees. Kaken believes that the fermentation product, polyoxin D, is non-synthetic. However, because Kaken: • Does not control the production of the source of zinc used in the production of polyoxin D zinc salt; and • Cannot provide details of the production of the source of zinc used in the production of polyoxin D zinc salt. Kaken agrees that polyoxin D zinc salt should be classified as a synthetic material under these circumstances. If in the future Kaken secures a certified organic source of the zinc starting material, Kaken may seek a non-synthetic classification of polyoxin D zinc salt.
2. Is the substance formulated or manufactured by a process that chemically changes a substance extracted from naturally occurring plant, animal, or mineral, sources? [6502 (21)]	X	X		Refer to the above answer in Category 2, Question 1.	See above.
3. Is the substance created by naturally occurring biological processes? [6502 (21)]		X		It is produced from a natural occurring soil microorganism Streptomyces cacaoi by a controlled fermentation process, according to the TR lines 119 – 120. (TR July 11, 21012) The petition states that polyoxin D Zinc Salt is isolated from a broth (extraction media) and then dried. Actual process is part of their CBI information. One part of the TR states that a review of all the structural forms of polyoxin does not include the Zinc Salt as a natural product (Worthington, 1988). TR lines 141-142. Also, refer to the answers as stated in Category 2, Question 1 & 2.	See above.
4. Is there a natural source of the substance? [§205.600 b.1]		X	X		

Category 2. Is Polyoxin D Zinc Salt Essential for Organic Production?					
Crops Subcommittee Petitioned Material Proposal (January 29, 2013)					Kaken's Comments
Question	Yes	No	N/A	Documentation (TAP; petition; regulatory agency; other)	
5. Is there an organic substitute? [§205.600 b.1]			X		
6. Is the substance essential for handling of organically produced agricultural products? [§205.600 b.6]			X		
7. Is there a wholly natural substitute product? [§6517 c (1)(A)(ii)]	X	X		There is a natural occurring quinone plumbagin, isolated as a botanical that is comparable to polyoxin D (Dekeyser and Downer 1994), but it is not commercially available in the US at this time.	Polyoxin D zinc salt is <u>not</u> comparable to quinone plumbagin. • Dekeyser and Downer (1994) is a review article about the development of miticides. • Polyoxin D zinc salt is <u>not</u> registered for use for control of mites. Based upon efficacy testing, polyoxin D zinc salt does <u>not</u> provide control of mites. Polyoxin D zinc salt is registered for control of crop fungal diseases only.
				There are coppers and sulfur materials currently allowed for use. TR 321-328. (TR July 11, 2012)	The following are listed in 7 CFR §205.601(I) as <u>synthetic</u> materials allowed for use in organic crop production for plant disease control: "(2) Coppers, fixed - copper hydroxide, copper oxide, copper oxychloride, including products exempted from EPA tolerance, *Provided*, That, copper-based materials must be used in a manner that minimizes accumulation in the soil and shall not be used as" herbicides; "(3) Copper sulfate - Substance must be used in a manner that minimizes accumulation of copper in the soil"; "(6) Lime sulfur"; and "(10) Elemental sulfur".
8. Is the substance used in handling, not synthetic, but not organically produced? [§6517 c (1)(B)(iii)]			X		

Category 2. Is Polyoxin D Zinc Salt Essential for Organic Production?					
Crops Subcommittee Petitioned Material Proposal (January 29, 2013)					Kaken's Comments
Question	Yes	No	N/A	Documentation (TAP; petition; regulatory agency; other)	

9. Are there any alternative substances? [§6518 m.6]	X			There are other alternative substances available. The TR lists several that are currently allowed: JMS Stylet Oil, Dow's M-Pede, Regalia, Sonata, and Kaligreen to name just a few. See TR July 12, 2012 table: Comparison of the Endorse WDG label with Alternative Pesticides., located between lines 355-356. The efficacy of each of these materials is not listed.	Please see http://tinyurl.com/C-Smith-1-23-2013 :
					• Pages 43-46 discuss crop/disease combinations with no OMRI listed alternative:
					  • Cucurbits/Southern blight (*Sclerotium rolfsii*);
					  • Gingeng/Cylindrocarpon root rot (*Cylinderocarpon destructans*); and
					  • Pome fruit/Leaf blotch (*Diplocarpon mali*).
					• Pages 63-128 of for a comparison of polyoxin D zinc salt to registered alternatives on a crop/disease basis. Polyoxin D zinc salt provides curative control for most diseases; the alternatives generally provide only preventative control.
					• Pages 6-7 and 37-38 describe the unique, non-toxic mode of action that make polyoxin D zinc salt an important tool in resistance management and integrated pest management.

10. Is there another practice that would make the substance unnecessary? [§6518 m.6]	X	X		(TR lines 376-391) The TR lists several possible practices that could be used possibly in place of polyoxin D Zinc Salt. Antibiosis – using the live organisms rather than their extracts. This seems to be more consistent with organic farming principles. (Milner, et al. 1997)	Please see pages 63-128 of http://tinyurl.com/C-Smith-1-23-2013 . There is only one noted OMRI listed alternative for which the active ingredient is a live organism: • Actinovate Soluble; EPA Reg. No. 73314-1; *Streptomyces lydicus* WYEC 108. • This product is registered for use on only 41 of the 73 crop/disease combinations for which polyoxin D zinc salt is registered.
				Also beneficial antagonistic Streptomyces spp – but commercial development is slow in coming. (Liu, et al., 1997) (TR July 11, 2012)	Please see pages 63-128 of http://tinyurl.com/C-Smith-1-23-2013 for comparisons current to OMRI listed alternative products. Comparisons to possible future products is not a realistic or productive exercise.
				Also, crop rotation, crop nutrient management practices, sanitation to remove disease vectors, selection of resistant species and varieties (where applicable) beneficial antagonistic bacteria, monitoring. TR 367-382	These practices, even when employed judiciously, do not always prevent infection. Polyoxin D zinc salt provides curative control when these preventative measures did not successfully prevent infection. Polyoxin D zinc salt can be an important tool for preventing crop loss on organic farms.

http://tinyurl.com/C-Smith-1-23-2013
= http://www.ams.usda.gov/AMSv1.0/getfile?dDocName=STELPRDC5102221
= "Polyoxin D Zinc Salt: Reply to and Comments Regarding the National Organic Program Technical Evaluation Report Dated September 23, 2012" submitted January 18, 2013 and revised January 23, 2013.

<table>
<tr><th colspan="6">Category 3. Is Polyoxin D Zinc Salt Compatible with Organic Production Practices?</th></tr>
<tr><th colspan="5">Crops Subcommittee Petitioned Material Proposal (January 29, 2013)</th><th rowspan="2">Kaken's Comments</th></tr>
<tr><th>Question</th><th>Yes</th><th>No</th><th>N/A</th><th>Documentation
(TAP; petition; regulatory agency; other)</th></tr>
<tr><td>1. Is the substance compatible with organic handling? [§205.600 b.2]</td><td></td><td></td><td>X</td><td></td><td></td></tr>
<tr><td rowspan="2">2. Is the substance consistent with organic farming and handling? [§6517 c (1)(A)(iii); 6517 c (2)(A)(ii)]</td><td rowspan="2">X</td><td rowspan="2">X</td><td rowspan="2"></td><td>There are concerns with the possible impact on beneficial soil organisms.</td><td>Please see pages 21 of http://tinyurl.com/C-Smith-1-23-2013 :
• Polyoxin D zinc salt has a non-toxic mode of action. Polyoxin D zinc salt does not kill beneficial soil fungi, but instead prevents the growth of fungi. Polyoxin D zinc salt is <u>fungistatic</u>, not truly fungicidal.
• Polyoxin D zinc salt degrades rapidly under environmental conditions. The May 11, 2012 EPA science review regarding the expanded tolerance exemption for polyoxin D zinc salt states on page 12:
"The net photolytic half-lives of [^{14}C]Polyoxin D were calculated to be 0.4 days, 4 days, 2.4 days, and 1.6 days in sterile natural water, pH 5.0, pH 7.0, and pH 9.0 buffers, respectively."
Please note that a half-life is the time during which a material degrades by 50%. Also, the rate of degradation is determined by the fastest route of degradation. In the presence of sunlight, polyoxin D zinc salt degrades by 50% in 0.4 days (9.6 hours). In 1.2 days, 90% degradation has occurred.
• Because polyoxin D zinc salt (1) does not kill fungi and (2) degrades rapidly under environmental conditions, any adverse effects on beneficial fungi would be only temporary.</td></tr>
<tr><td>Toxic to bees. (TR lines 305-309)</td><td>Please see page 26 of http://tinyurl.com/C-Smith-1-23-2013 .
The 96-hr LD_{50} of polyoxin D zinc salt to honeybees was determined to be 28.774 µg/bee. Using EPA's classification criteria, polyoxin D zinc salt is <u>practically non-toxic to honeybees</u> (EPA's least hazardous classification).
http://www.epa.gov/oppefed1/ecorisk_ders/toera_analysis_eco.htm
<table>
<tr><th>EPA Bee Hazard Category</th><th>96-hr LD_{50} (µg/bee)</th></tr>
<tr><td>Highly toxic</td><td>< 2</td></tr>
<tr><td>Moderately toxic</td><td>2-11</td></tr>
<tr><td>Practically non-toxic</td><td>> 11</td></tr>
</table>
If polyoxin D zinc salt were toxic to bees, there would be a bee hazard statement in the Environmental Hazards section of the label. None of the polyoxin D zinc salt product labels have a bee hazard statement on the label.</td></tr>
</table>

Category 3. Is Polyoxin D Zinc Salt Compatible with Organic Production Practices?					
Crops Subcommittee Petitioned Material Proposal (January 29, 2013)					Kaken's Comments
Question	Yes	No	N/A	Documentation (TAP; petition; regulatory agency; other)	
				EPA exempts it from tolerance (40 CFR 180.1285) Also in a petition Addendum dated October 2,2012 the EPA has granted the petitioner an expanded exemption of tolerance to "all food commodities" and given expanded uses for all food and feed crops pre-harvest and post-harvest.	Polyoxin D zinc salt is registered for use on 73 crop/disease combinations. The expanded exemption of tolerance significantly reduces the time needed to commercialize new uses. New uses are in development but are not ready for discussion in a public forum.

3. Is the substance compatible with a system of sustainable agriculture? [§6518 m.7]	X	X		No, because it is not a unnecessary synthetic input.	Please see http://tinyurl.com/C-Smith-1-23-2013 :
					• Pages 43-46 discuss crop/disease combinations with no OMRI listed alternative:
					  • Cucurbits/Southern blight (*Sclerotium rolfsii*);
					  • Gingeng/Cylindrocarpon root rot (*Cylinderocarpon destructans*); and
					  • Pome fruit/Leaf blotch (*Diplocarpon mali*).
					• Pages 63-128 for a comparison of polyoxin D zinc salt to registered alternatives on a crop/disease basis. Polyoxin D zinc salt provides curative control for most diseases; the alternatives generally provide only preventative control.
					• Pages 6-7 and 37-38 describe the unique, non-toxic mode of action that make polyoxin D zinc salt an important tool in resistance management and integrated pest management.

				Also, because it does show toxicity to fungi and bees.	Fungi: Polyoxin D zinc salt is NOT toxic to fungi, including soil fungi. Please see pages 6-7 of http://tinyurl.com/C-Smith-1-23-2013 : Polyoxin D zinc salt has a non-toxic mode of action. Polyoxin D zinc salt inhibits the chitin synthetase found in fungi. This prevents the growth of fungi without killing the fungi. As such, polyoxin D zinc salt is truly ***fungistatic*** rather than fungicidal.
					Bees: Please see page 26 of http://tinyurl.com/C-Smith-1-23-2013 for a summary of the honeybee data. Using EPA toxicity descriptors, polyoxin D zinc salt is practically non-toxic to honeybees (EPA's least hazardous classification)***.*** If polyoxin D zinc salt were toxic to bees, there would be a bee hazard statement in the Environmental Hazards section of the label. None of the polyoxin D zinc salt product labels have a bee hazard statement on the label. See above.
				However, some felt it was a useful tool as part of a rotational disease control program.	Kaken agrees.

Category 3. Is Polyoxin D Zinc Salt Compatible with Organic Production Practices?					
Crops Subcommittee Petitioned Material Proposal (January 29, 2013)					Kaken's Comments
Question	Yes	No	N/A	Documentation (TAP; petition; regulatory agency; other)	
4. Is the nutritional quality of the food maintained with the substance? [§205.600 b.3]			X		
5. Is the primary use as a preservative? [§205.600 b.4]			X		
6. Is the primary use to recreate or improve flavors, colors, textures, or nutritive values lost in processing (except when required by law, e.g., vitamin D in milk)? [205.600 b.4]			X		
7. Is the substance used in production, and does it contain an active synthetic ingredient in the following categories: a. copper and sulfur compounds;		X			
b. toxins derived from bacteria;	X			According to the TR (TR line 110) polyoxin D is a toxin derived from a bacteria (Streptomyces cacaoi var. asoensis) (TR July 11, 2012)	Polyoxin D zinc salt is NOT a toxin. Please see pages 6-7 of http://tinyurl.com/C-Smith-1-23-2013 : Polyoxin D zinc salt has a non-toxic mode of action. Polyoxin D zinc salt inhibits the chitin synthetase found in fungi. This prevents the growth of fungi without killing the fungi. As such, polyoxin D zinc salt is truly ***fungistatic*** rather than fungicidal.
c. pheromones, soaps, horticultural oils, fish emulsions, treated seed, vitamins and minerals?		X			
d. livestock parasiticides and medicines?		X			
e. production aids including netting, tree wraps and seals, insect traps, sticky barriers, row covers, and equipment cleaners?		X			

http://tinyurl.com/C-Smith-1-23-2013
= http://www.ams.usda.gov/AMSv1.0/getfile?dDocName=STELPRDC5102221
= "Polyoxin D Zinc Salt: Reply to and Comments Regarding the National Organic Program Technical Evaluation Report Dated September 23, 2012" submitted January 18, 2013 and revised January 23, 2013.

All questions from §205.600(b) are not applicable. Polyoxin D zinc salt is proposed for use in crop production.

Category 4. Is the Commercial Supply of an Agricultural Substance as Organic, Fragile or Potentially Unavailable?					
Crops Subcommittee Petitioned Material Proposal (January 29, 2013)					Kaken's Comments
Question	Yes	No	N/A	Documentation (TAP; petition; regulatory agency; other)	
1. Is the comparative description provided as to why the non-organic form of the material /substance is necessary for use in organic handling?			X		
2. Does the current and historical industry information, research, or evidence provided explain how or why the material /substance cannot be obtained organically in the appropriate **form** to fulfill an essential function in a system of organic handling?			X		
3. Does the current and historical industry information, research, or evidence provided explain how or why the material /substance cannot be obtained organically in the appropriate **quality** to fulfill an essential function in a system of organic handling?			X		
4. Does the current and historical industry information, research, or evidence provided explain how or why the material /substance cannot be obtained organically in the appropriate **quantity** to fulfill an essential function in a system of organic handling?			X		
5. Does the industry information provided on material / substance non-availability as organic, include (but not limited to) the following: a. Regions of production (including factors such as climate and number of regions);			X		
b. Number of suppliers and amount produced;			X		
c. Current and historical supplies related to weather events such as hurricanes, floods, and droughts that may temporarily halt production or destroy crops or supplies;			X		
d. Trade-related issues such as evidence of hoarding, war, trade barriers, or civil unrest that may temporarily restrict supplies; or			X		
e. Are there other issues which may present a challenge to a consistent supply?			X		

All questions from §205.600(b) are not applicable. Polyoxin D zinc salt is proposed for use in crop production.

APPENDIX 1. Leighton *et al.* (1981)

general, the average R of neural and liver tissues was somewhat lower than that of fibroblasts.

The mobility of a single surface molecule, the neural cell adhesion molecule (N-CAM), was also measured on chick brain and retina cells (Table 1, experiments 6 and 7). This cell surface molecule has been identified with the use of highly specific antiserums, and its role in cell-cell adhesion and development of neural tissue has been intensively studied in our laboratory (*13*). Despite its role in cell-cell adhesion, the mobility of this specific receptor was similar to that of the more general population of receptors measured using polyspecific anti-brain membrane serum.

Our results indicate that the average D's of a wide variety of surface receptors (but not necessarily all) fall within a narrow range, varying less than twofold under different conditions of cell growth and interaction. This variation is much less than the sixfold decrease in D seen on lectin-induced anchorage modulation (*4*). We conclude that if reversible modulation of receptor mobility is a significant mechanism for signaling cell-cell interactions, it must take place by the specific modulation of a small set of particular individual receptors rather than by general modulation of surface properties.

The differences in the fraction of mobile receptors observed between fibroblasts and the other cells suggest that the distribution of individual receptors in the population between the anchored and free mobility states may be characteristic of differentiation states, cell types, or morphologies. Consistent with this suggestion is the observation that about half of the cells measured in liver tissue showed no apparent recovery. Also, it has been shown that half of human lymphocytes labeled uniformly with a fluorescent monoclonal antibody against HLA antigens show no detectable redistribution of fluorescence after photobleaching, while the other half show redistribution with D of 6.9×10^{-10} cm^2/sec (*14*).

In summary, while Con A binding decreases receptor mobility in a variety of cells, the presence of cells in tissues does not appear to mimic this kind of modulation. However, receptors on about half of the cells in liver tissue labeled with polyspecific antibodies recognizing at least 15 different surface antigens, they were essentially immobile ($D < 5 \times 10^{-12}$ cm^2/sec). In contrast, the same receptors on dissociated liver cells showed values for D and R comparable to other cells. This suggests that naturally occurring modulation may take place by an "all or none" change (or greater than 100-fold decrease) in the mobility of specific receptors, rather than by a sixfold decrease as induced by lectins. Further experiments with monoclonal antibodies or other antibodies of very restricted specificity will be required to test this hypothesis.

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15. Supported by NIH grants AM-04256, AI-11378, AI-09273, and RR 07065. We thank A. Waggoner for the lipid probe and M. C. Coogan for technical assistance.

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Pesticides: Insecticides and Fungicides Are Chitin Synthesis Inhibitors

Abstract. *Several important groups of fungicides and insecticides are specific inhibitors of chitin synthesis in a* Phycomyces *enzyme system and in insect organ cultures. The recently discovered benzoylphenylurea insecticides, which prevent chitin synthesis in insect tissues, are apparently not direct-acting chitin synthetase inhibitors. These insecticides may prevent insect chitin synthesis by interfering with the proteolytic activation of the chitin synthetase zymogen.*

The biosynthesis of chitin skeletal structures is a promising molecular target for pesticide action, since chitin is restricted in its biological distribution (*1*). The effects of fungicides and insecticides on chitin synthesis have received increasing attention following reports (*2*, *3*) that several agricultural chemicals affect insect chitin synthesis [also see review (*4*)].

We have developed biochemical and tissue culture methodologies that allow us to examine the mode of action of compounds that specifically interfere with chitin biosynthesis in insects and fungi. Table 1 lists compounds that are specific inhibitors of a cell-free preparation of chitin synthetase derived from the fungus *Phycomyces*. Specificity is defined as resistance of I_{50} level inhibition to the addition of excess protein (ovalbumin) (I_{50} is the concentration in moles of the compound that produces 50 percent inhibition of control chitin synthetase activity). This test establishes that the specific compounds do not react nonselectively with polypeptide functional groups. Compounds active in the *Phycomyces* system include chlorinated hydrocarbons, triazines, nitrophenols, organophosphates, sulfenimides, and thiolanes. Many of these compounds were not pre-

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Table 1. Compounds that are chitin synthesis inhibitors in the *Phycomyces* and cockroach systems. *Phycomyces* germlings were harvested at mid-log growth phase from a defined minimal medium (*22, 23*) by vacuum filtration and were washed with breakage buffer (0.1*M* tris, *p*H 8.0; 0.02*M* $MgCl_2$; 10 percent glycerol; 0.001*M* EDTA, and 0.001*M* dithiothreitol). The washed germlings were resuspended in breakage buffer and disrupted by grinding with glass beads on a chilled mortar and pestle. The homogenate was centrifuged at 10,000*g* for 10 minutes. The pellet fraction was resuspended in breakage buffer and centrifuged again at 10,000*g* for 10 minutes. The resulting supernatant fraction was discarded, and the washed pellet fraction was resuspended in breakage buffer and used as a cell-free chitin synthetase preparation (*24*). The utilization of the cockroach leg regenerate system for assessing chitin synthesis inhibitors has been described in detail (*4*). The cytotoxicity of compounds was assessed by observing explant cultures in Rose chambers in the presence of an I_{90} to I_{99} concentration of the test material. If no interference with cuticle deposition was observed, the compounds were considered nontoxic.

Compound class	Compounds	I_{50} (mole/liter)	
		Phycomyces	Cockroach
Chloro and fluoro hydrocarbons	Chlordane	3.1×10^{-5}	
	p,p',-DDT	3.1×10^{-5}	7.3×10^{-6}
	Endosulfan	3.0×10^{-5}	
	Dieldrin	1.6×10^{-4}	
	2,2'-Methylenebis[4-chlorophenol]	4.9×10^{-5}	4.0×10^{-6}
Nucleoside and base analogs	Polyoxin D	2.9×10^{-4}	3.4×10^{-9}
	2,4-Dichloro-6-methylpyrimidine	1.6×10^{-4}	
Triazines	Azidotriazine	1.5×10^{-3}	4.0×10^{-9}
Sulfenimides	Captan	3.9×10^{-4}	See (*3*)
Dithiazoliums	Dithiazolium iodide	1.1×10^{-3}	7.7×10^{-8}
Organophosphates	Kitazin-P	4.7×10^{-4}	See (*3*)
Dinitrophenols and benzoylphenylureas	Dinocap	5.0×10^{-5}	
	Dimilin	$> 10^{-2}$	9.4×10^{-11}
	SIR8514	$> 10^{-2}$	2.1×10^{-11}
	SIR6874	$> 10^{-2}$	6.0×10^{-11}
	Penfluron	$> 10^{-2}$	1.6×10^{-11}
Thiolanes	Isoprothiolane	6.6×10^{-5}	1.3×10^{-7}

viously suspected to be chitin synthetase inhibitors. Various chemical structures can block chitin synthetase; most of these compounds are reversible inhibitors and in general do not compete with the substrate for access to the active site of the enzyme. The fungicide polyoxin D is a competitive, substrate-analog type of chitin synthetase inhibitor (*5*). A number of chlorinated hydrocarbons, carbamates, and other compounds demonstrate nonspecific inhibition in the *Phycomyces* system (data not shown).

Benzoylphenylureas (60-40, 60-38, DU119111, SIR8514, SIR6874, and Penfluron), herbicides (2,4-dichlorophenoxyacetic acid and simazine), Dichloran, and 5-fluorouracil have no effect on *Phycomyces* chitin synthetase when tested at their aqueous solubility limits or at a concentration of at least $10^{-2}M$. Chymostatin ($1.1 \times 10^{-5}M$), soybean trypsin-chymotrypsin inhibitor ($1.4 \times 10^{-4}M$), and lima bean trypsin-chymotrypsin inhibitor ($1.2 \times 10^{-4}M$) also have no effect on chitin synthetase activity.

A number of compounds that inhibit chitin synthesis in the *Phycomyces* system also inhibit chitin synthesis in cultured insect tissues (Table 1). The organophosphates kitazin-P and parathion, and the sulfenimide captan are inhibitory in this insect system (*3*). Since none of these compounds produce cytotoxic effects in cockroach organ cultures, they selectively prevent chitin synthesis without affecting the biosynthesis of other cuticular components.

The benzoylphenylureas do not inhibit cell-free preparations of either fungal or insect chitin synthetase (*6, 7*) but are highly active in insect systems. Their potency might therefore be explained by assuming that these compounds do not interact with the large amount of active chitin synthetase present in insect cells but rather affect a cascade event involved in enzyme biosynthesis—namely, the proteolytic activation of the chitin synthetase zymogen. The existence of zymogen forms of chitin synthetase in fungi has been reported (*8*).

Table 2. Inhibition of chymotrypsin activity by 60-40 and 60-38. The activity of chymotrypsin was assayed as described by Leighton *et al.* (*9*). In typical protease assays, 6 to 10 pmole of enzyme in 1 ml of reaction mixture was incubated for 18 hours at 37°C. Experiments (30 to 50 pmole of enzyme in 0.2 ml of 0.05*M* tris, *p*H 8.0, and 0.01*M* $CaCl_2$) included appropriate solvent and enzyme controls. All molar ratio circulations were based on the aqueous solubility limits of the inhibitors.

Molar ratio of inhibitor to enzyme	Time before incubation (hours)	Percent inhibition
	Compound 60-40	
20:1	1	36
20:1	2	57
20:1	4	72
20:1	6	87
10:1	3	43
	Compound 60-38	
60:1	1	3
60:1	2	18
60:1	4	20
60:1	6	32
30:1	3	17

Model experiments show that the benzoylphenylurea 60-40 (Dimilin) and the less effective insecticide 60-38 (*10, 11*) are direct-acting serine protease inhibitors (Table 2). These compounds have a slight preference for chymotrypsin-like proteases (data now shown). Several known chymotrypsin inhibitors (*12–14*) prevent chitin synthesis in the cockroach system (I_{50} values of active inhibitors are chymostatin, $2.3 \times 10^{-7}M$; 2-nitro-4-carboxyphenyl-*N,N*-diphenylcarbamate, $4.0 \times 10^{-6}M$; lima bean trypsin-chymotrypsin inhibitor, $1.2 \times 10^{-6}M$; and soybean trypsin-chymotrypsin inhibitor, $1.9 \times 10^{-6}M$). Leupeptin, antipain, and pepstatin A—inhibitors of trypsin, plasmin, pepsin, renin, and a variety of proteolytic enzymes other than chymotrypsin (*12, 15*)—show no effect in this system at $10^{-5}M$. None of these inhibitors produce cytotoxic effects in cockroach organ cultures.

An unexpected finding is that many currently used insecticides and fungicides are specific chitin synthetase inhibitors (Table 1). Surprisingly, neurotoxins (*16, 17*) and oxidative phosphorylation or respiratory chain inhibitors (*18*) affect the process of chitin biosynthesis. Whether the targets of these inhibitors share common receptor sites, or whether these molecules can disturb membrane structure in a manner that affects the activity of a few cognate polypeptides, is not known. Since many of the inhibitory activities we observe are stereochemically constrained, further quantitative structure-activity studies should aid in the design of more selective and effective chitin synthetase inhibitors. Isoprothiolane is a chitin synthesis inhibitor in both the *Phycomyces* and cockroach systems. It also inhibits carbohydrate uptake in fungal cells (*19*). Its low mammalian toxicity makes it an attractive new compound class for the development of antimycotic and anti-insect agents.

The benzoylphenylureas, which control insect populations at extremely low doses, appear to selectively derange the synthesis of insect chitin-containing structural elements (*2*, *3*, *10*). The data presently available indicate that benzoylphenylureas are not direct-acting chitin synthetase inhibitors, but rather that they are direct-acting serine protease inhibitors that block the conversion of chitin synthetase zymogen into active enzyme. Thus a variety of specific chymotrypsin inhibitors, which are not directed against other serine and nonserine active site proteases, are capable of selectively blocking insect chitin synthesis. These data provide evidence for the critical involvement of a chymotrypsin-like protease in insect chitin biosynthesis. Recently, Strauss *et al.* (*20*) implicated a chymotrypsin-like protease in the processing of the pre-segment of human secretory proteins. Furthermore, Green and Ryan (*21*) observed that injury to plant leaf surfaces elicits a hormonally mediated response resulting in the production of large quantities of polypeptide trypsin and chymotrypsin inhibitors. This plant defense system may have the same mode of action as the benzoylphenylureas.

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24. The chitin synthetase reaction mixture contained 0.025*M* tris, *p*H 8.0; 0.05*M* $MgCl_2$; 0.001*M* UDP-*N*-acetylglucosamine (UDP, uridine diphosphate); 0.05*M* *N*-acetylglucosamine; 0.075 μCi of [^{3}H]UDP-*N*-acetylglucosamine ([6-^{3}H]glucosamine, 6.6 Ci/mmole); 80 μg of pellet fraction protein; and H_2O to make a total volume of 150 μl. The reaction mixture was incubated for 90 minutes at 28°C, and chitin synthesis was terminated by the addition of 5 percent trichloroacetic acid (4°C). The reaction mixture was filtered onto a glass fiber filter, washed with trichloroacetic acid and 95 percent ethanol, dried, and counted in a liquid scintillation spectrometer. The protein specificity of an inhibitory molecule was assessed by adding 500 μg of ovalbumin to a reaction mixture containing an amount of the test compound which would result in a 50 percent inhibition of enzyme activity. If the ovalbumin addition caused less than 10 percent deviation from the expected I_{50} value, the compound was classified as a specific chitin synthetase inhibitor. The I_{50} values were determined by graphical analysis of dose-response data; the standard error of these data is in the range of ± 10 percent. In substrate competition experiments, UDP-N-acetylglucosamine concentrations were 1 m*M* to 0.5 μ*M*. The specific activity of the ^{3}H-labeled substrate was increased fivefold in these experiments. The reversible or irreversible nature of inhibition was determined by incubating (90 minutes at 28°C) 25 μl of pellet material in the presence of the test compound at a concentration in that volume known to produce 50 percent inhibition under usual assay conditions. This preliminary incubation was terminated, and the test compound was diluted sevenfold by the addition of the remainder of the assay components. The level of inhibition after a 90-minute assay was observed. A decrement greater than 10 percent from the expected I_{50} value was interpreted as reversible inhibition.
25. We thank A. Glazer for helpful discussions, J. Stock and M. Delbrück for stimulating our interest in fungal biochemistry, and A. B. Borkovec for providing samples of dithiazolium iodide and Penfluron.

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Disease Resistance: Incorporation into Sexually Incompatible Somatic Hybrids of the Genus *Nicotiana*

Abstract. *Somatic hybrid plants of* Nicotiana nesophila *and* N. stocktonii *with* N. tabacum *(cultivated tobacco) were produced by protoplast fusion. These combinations cannot be achieved with conventional sexual hybridization, yet are important in that the wild* Nicotiana *species are resistant to numerous diseases. Hybridity was verified by chromosome number, isoenzyme analysis, morphological characteristics, and genetic behavior. Local lesion-type resistance to tobacco mosaic virus has been observed in leaves of these somatic hybrid plants.*

Wild species of *Nicotiana* have been used to incorporate disease resistance into cultivated tobacco (*1*). The three *Nicotiana* species of the section *Repandae* (*N. nesophila*, *N. repanda*, and *N. stocktonii*) are among those species resistant to the most diseases of cultivated tobacco. Attempts to crossbreed these wild species with cultivated tobacco by conventional breeding techniques have been unsuccessful (*2*, *3*). Two of these species, *N. nesophila* and *N. stocktonii*, have been crossed with *N. tabacum* (*4*) by means of ovule culture in vitro. How-

Table 1. Comparison of morphological characteristics of *N. tabacum* + *N. nesophila* (NN + Su/Su) somatic hybrid plants with the two parental species.

Plant	Flower: Color	Flower: Length* (cm)	Leaf (cm): Length of blade*	Leaf (cm): Maximum width*	Pollen viability (%)
N. tabacum (Su/su)	Dark pink	5.28 ± 0.07	23.00 ± 2.48	7.25 ± 1.23	97.5
NN + Su/Su (somatic hybrids)	Light pink	5.09 ± 0.08	18.25 ± 1.31	8.13 ± 0.32	55.3
N. nesophila (NN)	White	4.95 ± 0.07	13.14 ± 0.46	9.29 ± 0.48	96.5

*Measurement expressed as mean ± standard error with differences significant, with *P* less than .05, for each group of plants.

Table 2. Segregation of the Su locus controlling leaf pigmentation in sexual progeny of *N. tabacum* + *N. nesophila* (NN + Su/Su) somatic hybrid plants.

Sexual cross	Dark green	Light green	Albino
(NN + Su/Su) × *N. tabacum* (su/su)	58	36	0
(NN + Su/Su) × *N. nesophila*	11	14	0
N. tabacum (su/su) × (NN + Su/Su)	3	2	0
(NN + Su/Su) × self	11	35	1

APPENDIX 2. Bixby-Brosi and Potter (2012)

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Can a chitin-synthesis-inhibiting turfgrass fungicide enhance black cutworm susceptibility to a baculovirus?

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Abstract

BACKGROUND: Developmental resistance, i.e. reduced virulence and speed of kill of late instars, is a limiting factor in the use of baculoviruses for caterpillar control. *Agrotis ipsilon* multicapsid nucleopolyhedrovirus (*Agip*MNPV) is highly infective to young black cutworms, *Agrotis ipsilon*, but too slow-acting against late instars for effective curative control on golf courses or sports fields. Chitin-synthesis-inhibiting fungicides containing the active ingredient polyoxin-d are used to control fungal diseases in turfgrass, and similar compounds have been shown in the laboratory to synergize baculoviruses by disrupting peritrophic membrane function. This study tested whether applying the virus together with such a fungicide can synergize *Agip*MNPV activity against *A. ipsilon* in turfgrass.

RESULTS: The addition of a chitin synthesis inhibitor failed to increase *Agip*MNPV infectivity to *A. ipsilon* in the field. Rather, delayed and slightly reduced mortality from viral infection was seen when larvae fed on fungicide/virus-treated grasses as opposed to virus-only treatments. Choice tests revealed the fungicide residues to be a mild feeding deterrent.

CONCLUSION: Because polyoxin-d does not deactivate *Agip*MNPV, the two substances are compatible. However, combination applications of polyoxin-d and *Agip*MNPV on turfgrass might interfere with larval ingestion of a lethal virus dose, resulting in prolonged larval feeding in the field.

Keywords: baculovirus; *Agip*MNPV; fungicide; polyoxin-d; chitin synthesis inhibitor; *Agrotis ipsilon*; turfgrass

1 INTRODUCTION

Baculoviruses (family Baculoviridae, genus Nucleopolyhedroviruses), present a seemingly good alternative to broad-spectrum insecticides because of their efficacy, specificity and safety to humans and other non-target organisms. They have been used worldwide to manage pests in various cropping systems and forests.[1-5] It is striking, however, given that >400 insect species, mostly members of the orders Lepidoptera and Hymenoptera, have been reported as hosts for baculoviruses, how infrequently they are successfully used in integrated pest management programs.[3,6,7]

One of the limitations of baculovirus-based insecticides is their relatively slow speed of kill, especially of late instars.[3-5,8] As larvae mature, they typically become less susceptible to virus infection and may continue to feed for several days after ingesting a lethal dose, so targeting early instars is necessary to avoid economic damage to plants.[9-11] Most research to enhance the usefulness of baculoviruses has focused on using optical brighteners to protect them from degradation by ultraviolet light.[12-14] Another approach is to increase the virulence of the virus itself. For an insect to become infected, it must first ingest virus occlusion bodies (OBs) while feeding. After ingestion, the OBs release virions in the host midgut, which then must pass through the peritrophic membrane to initiate virus infection in the midgut.[10] This chitinous membrane is the insect's first line of defense against a virus, so a compound that disrupts its function may help facilitate infection and increase speed of kill. Additives such as optical brighteners may work this way,[12] but chitin synthesis inhibitors, too, have been shown to synergize baculoviruses and dramatically increase their activity by disrupting peritrophic membrane function.[15,16]

Polyoxins are *Streptomyces*-derived antibiotics that inhibit fungal and insect chitin syntheses.[17-19] Polyoxin-d strongly affected peritrophic membranes *in vitro* in adult blowflies, *Calliphora erythrocephala*, by inhibiting chitin synthesis and by changing the fine structure of the membrane.[20] Nucleopolydrovirus (NPV) susceptibility was increased in larvae of the silkworm, *Bombyx mori*, when commercially available polyoxin fungicidal agents were incorporated into the insect's artificial diet.[15,16] Enhanced biological activity of *Spodoptera litura* NPV by a chitin-synthesis-inhibiting compound was attributed to obvious ruptures on the outer surfaces of the peritrophic membrane, which potentially facilitated the passage of virions through the peritrophic membrane.[21] These compounds have been validated as synergists in laboratory experiments but have not been tested in the field.

The black cutworm, *Agrotis ipsilon* (Lepidoptera: Noctuidae), is nearly a worldwide pest of golf-course putting greens and tees, as

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well as sports fields and various garden crops.[22,23] In turf, the night-active larvae chew down the grass surrounding their burrows, causing brown pock marks that reduce smoothness and uniformity of playing surfaces.[23] Prater *et al.*[11] documented a natural epizootic of *Agrotis ipsilon* multicapsid nucleopolyhedrovirus (*Agip*MNPV) decimating black cutworm populations on Kentucky golf courses, established dose–mortality relationships and demonstrated that a sprayed viral suspension can provide short-term control in the field.[11] When sprayed suspensions of *Agip*MNPV were evaluated for season-long control of black cutworm on creeping bentgrass (*Agrostis stolonifera* L.) golf-course tees under actual maintenance and play, one-week-old virus residues reduced larval populations resulting from introduced eggs by 76–82%. Residual control, however, lasted no more than a few weeks.[24] *Agip*MNPV quickly controls young larvae, but larger late instars require higher dosages and continue to feed for several days before being killed.[11,24] Combinations of *Agip*MNPV with adjuvants, such as optical brightener and lignin, failed to accelerate or extend efficacy of the virus against *A. ipsilon* in the field.[24] Even if they had worked, such adjuvants likely would be too expensive to use in synergizing virus applications targeting grass-feeding caterpillars on golf courses or sports fields.

If baculovirus efficacy could be enhanced by something already being used in the turf or crop system, land managers would incur no additional cost. For example, fungicides containing the active ingredient polyoxin-d are already being used, sometimes several times per season, to control turfgrass diseases such as brown patch, *Rhizoctonia* spp. An overlapping application of polyoxin-d fungicide and baculovirus would be a practical combination in golf-course settings, because fungal diseases and cutworm infestations often occur on the same tees, greens and other highly maintained sites. The purpose of this study was to determine whether the combined use of a chitin-synthesis-inhibiting substance, polyoxin-d, could enhance or synergize *Agip*MNPV activity against *A. ipsilon* in turfgrass.

2 MATERIALS AND METHODS

2.1 Insects, virus and fungicide

Agrotis ipsilon eggs and larvae were obtained from a commercial insectary (Benzon, Carlisle, PA) where they had been maintained on soybean-based diet. They were shipped in cups of diet by overnight mail and transferred to the present assays within a few hours of arrival. The *Agip*MNPV isolate used in all experiments was originally obtained from naturally infected late-instar *A. ipsilon* from central Kentucky golf courses.[11] Frozen infected caterpillars were macerated in 0.1% sodium dodecyl sulfate (SDS) for 10 min and filtered through five layers of cheesecloth. Virus OBs were then centrifuged at $900 \times g$ for 10 min. The pellet was resuspended in 0.5% SDS and centrifuged again. Resuspension and centrifugation were repeated with 0.5 M NaCl with the final suspension in distilled water. Sodium azide was added at 0.02% concentration to prevent bacterial growth. This purified OB suspension was stored at 4 °C. OB concentrations were determined using a phase contrast microscope and a Neubauer bright-line hemocytometer (Fisher, Pittsburgh, PA).

The polyoxin formulation evaluated as a synergist for *Agip*MNPV was Endorse® wettable powder fungicide (Arysta LifeScience, Cary, NC), containing 2.5% active ingredient polyoxin-d zinc salt (equivalent to 2.2% polyoxorim and 0.3% metallic zinc), zinc 5-{[2-amino-5-*O*-(aminocarbonyl)-2-deoxy-L-xylonoyl]amino}-1-[5-carboxy-3,4-dihydro-2,4-dioxo-1(2*H*)-pyrimidinyl]-1,5-dideoxy-β-D-allofuranuronate. Endorse® is a group-19 fungicide and is labeled for controlling fungal diseases on golf courses, residential lawns, parks and commercial and institutional grounds. The wettable powder was dissolved in distilled water for all applications.

2.2 Evaluating virus/fungicide combinations in small field plots

An experiment initiated in July 2010 tested whether increased activity is provided to *Agip*MNPV residues by the fungicide. The trial was conducted in a stand of 'Penncross' creeping bentgrass on a Maury silt loam (fine, mixed, mesic typic Paleudalf; pH = 6) at the University of Kentucky's Turfgrass Research Center (UKTRC), Spindletop Farm, near Lexington, Kentucky. The turfgrass, representative of a golf-course fairway, was mowed at 1.6 cm 3 times per week, irrigated as necessary to prevent drought stress and fertilized in September, October and November at 0.48 kg actual N per 100 m^2 per application from urea (46-0-0). Fungicides (non-polyoxin) had been applied curatively, as needed, for control of fungal diseases, but were not used for at least 4 weeks before the present trials.

Individual plots were 0.5 m^2, with 1 m^2 buffers, and arranged in a randomized complete block with six replicates of each treatment. Virus suspensions were prepared as described above. Treatments included high, medium and low rates of virus (5×10^8, 5×10^7 and 5×10^6 OB m^{-2}) with and without fungicide, fungicide alone and an untreated control. Fungicide treatments were at a high label rate for golf-course fairways [1.2 g (product) m^{-2}]; virus rates were based on previous field experiments.[11,24] Larvae were confined in circular metal enclosures (39.0 cm diameter, 10.2 cm height) which were twisted and pressed to seat their lower edge about 1 cm into the ground. Each solution was dissolved in 50 mL of water and applied using a hand-pump sprayer inserted into a 50 mL plastic vial. The area inside each enclosure (0.12 m^2) was treated, and larvae were introduced as soon as the residues had dried.

Twenty third-instar *A. ipsilon* were introduced into each of the metal enclosures, which were then covered with 0.64 cm mesh wire hardware cloth to prevent bird predation. Grass was not mowed while cutworms and enclosures were in the plots. Surviving larvae were recovered after 4 days by using a soap flush consisting of 1.3 mL of lemon-scented dishwashing detergent (Joy®; Proctor & Gamble, Cincinnati, OH) per liter of water.[23] Larvae were rinsed with distilled water as soon as they surfaced, placed in individual capped 30 mL cups with soybean-based noctuid diet,[25] held at 25 °C and monitored until death or pupation. Death due to viral infection was verified by examining blood for viral OBs by using a phase contrast microscope at 400× magnification.

2.3 Testing for direct insecticidal effects of fungicide

The soap drench brought up relatively few cutworms from fungicide-treated plots in the above experiment, suggesting that there had been a disproportionately high number of escapes from those enclosures, or mortality from the fungicide itself. Therefore, a follow-up trial was conducted at the same field site to determine whether the fungicide alone reduced cutworm survival. Treatments included high and low rates of fungicide (1.2 and 0.6 g m^{-2}) and an untreated control. Plots were again 0.5 m^2 with a 1 m^2 buffer, and set up in a randomized complete block design with six replicates of each treatment. The experiment was carried out as described above; however, the metal enclosures were driven more deeply (3 cm) into the turf to ensure that larvae could not escape by burrowing beneath their edges.

2.4 Testing fungicide/virus synergism; greenhouse trials

In August 2010, creeping bentgrass cores (15.2 cm diameter, 6.5 cm deep) were harvested with an oversized golf-course cup cutter from the aforementioned creeping bentgrass stand. Grass cores were placed in pots with a small amount of potting mix below and around them to help maintain moisture. The potting mix consisted of 3 : 1 Pro-Mix BX (Premier Horticulture, Quakertown, PA) and autoclaved topsoil. Plants were watered as needed. The turfgrass was maintained in a glasshouse under a 14 h photoperiod with supplemental lighting from 1000 W sodium vapor bulbs unless ambient light was $\geq$450 L mol m^{-2} s^{-1}, and watered as needed to maintain vigor. Day and night temperatures were set at 22 and 18 °C respectively.

The treatments (virus/fungicide combinations) included high, medium and low rates of virus (5×10^9, 5×10^6 and 5×10^3 OB m^{-2}) with or without fungicide at high, medium and low rates (2.1, 0.21 and 0.012 g m^{-2}), plus an untreated control. Each solution was dissolved in 50 mL of water and applied using a separate hand-pump sprayer inserted into a disposable tube containing the treatment combination. Six replicates of each treatment were arranged on greenhouse benches in a randomized complete block design. Treatments dried for 20 min before third-instar *A. ipsilon* (12 per pot) were introduced into pots. Larvae were allowed to feed on treated grasses for 24 h. Cutworms were recovered by removing the grass plugs from their containers and examining the soil, roots, thatch and grass. The grass plug was then placed back into the pot, and those few remaining larvae were extracted using a soap disclosing solution and immediately rinsed with fresh water to remove soap as soon as they surfaced. All larvae were placed individually in 30 mL rearing cups with artificial diet and monitored until death or pupation, as above. Days until death were recorded. Death due to viral infection was verified by examining blood for OBs using a phase contrast microscope.

The above experiment was repeated to determine how varying the duration of exposure by feeding cutworms might affect virus synergism by the fungicide. Two virus rates (1×10^8 and 5×10^8 OB m^{-2}) and one fungicide rate (2.1 g m^{-2}) were applied alone and in combination, plus an untreated control. Cohorts of five replicates per treatment were set up in a randomized complete block design to be sampled at three different times (after 1, 2 and 4 days of feeding and exposure).

2.5 Fungicide effects on consumption of treated grass

Feeding preference of neonates and third instars was compared between fungicide-treated and untreated grass to try to reconcile results from the field and greenhouse experiments. More specifically, the hypothesis was tested that reduced consumption of fungicide-treated grass might interfere with cutworm ingestion of a lethal virus dose, thus resulting in lower infection rates. Creeping bentgrass cores were collected from the UKTRC on 13 September and maintained in a glasshouse as described above. Grass clippings were cut into 2.5 cm sections. The clippings were treated with the label rate of fungicide (2.1 g m^{-2}) by dipping them into the mixed fungicide solution for 5 s and then allowing the residues to air dry. Three treated and three untreated clippings were placed in an alternating, spoke-like arrangement on a moistened filter paper in the bottom of a polystyrene petri dish (90 mm × 15 mm). Ten neonates were placed in the center of each dish before replacing the lid. For the no-choice tests, one treated or untreated grass blade and one neonate were placed in each arena. There were 20 replicates for each test. Larvae were left to feed in the dark for 17 h at room temperature (about 22 °C). The total area of leaf tissue consumed in each treatment was visually estimated to the nearest 10% by two independent observers whose ratings were averaged, and the number of larvae actively feeding was also scored for each dish and treatment.

The trials were repeated with third instars, using larger arenas (styrofoam bowls, 115 mm × 50 mm). Grass blades were held in place on moistened filter paper using insect pins to prevent them from being scattered by the larvae. A single larva was added to each bowl; bowls were then capped with plastic wrap, covered with another styrofoam bowl and placed in a dark growth chamber (27 °C). The percentage of each grass blade that had been consumed was visually estimated, as above, at 1, 4 and 18 h.

2.6 Statistical analysis

Larval recovery and weights, percentage mortality from virus and other variables were analyzed by a 2 × 4 (small-plot field experiment) or a 4 × 4 (greenhouse experiment) factorial analysis of variance (ANOVA) for main effects and interaction of fungicide and virus rate (weighted ANOVA was used for field experiment percentages). The effect of virus rate was analyzed by polynomial contrasts for significance of linear or quadratic trends. A three-way repeated-measures ANOVA also was conducted on cumulative percentage mortality for greenhouse experiments. Fixed factors were fungicide rate and virus rate (between-subject factors) and time after exposure to treatments (within-subject factor), with repeated measure (mortalities) on the time factor, as mortalities were recorded on groups of larvae within the same replicates over time. Dunnett's tests were performed to compare virus mortalities in control groups (virus alone) to fungicide/virus combinations. The percentage of fungicide-treated or untreated leaf tissue consumed in the choice and no-choice tests was compared by Wilcoxon signed-rank tests or two sample *t*-tests for no-choice tests respectively. Replicates were omitted from analysis if there was no feeding on either treatment. Chi-square tests also were used to compare total proportions of treated or untreated blades with some feeding damage. Statistix 8[26] was used for all statistical analyses except for weighted ANOVAs, for which SAS[27] was used. Percentage data were normalized by arcsine square root transformation for analysis. All data are reported as original (non-transformed) means ± SE.

3 RESULTS

3.1 Evaluating virus/fungicide combinations in small field plots

Few larvae were recovered from fungicide-treated plots, regardless of whether or not virus was included in the treatment (Table 1). The percentage of recovered larvae that ultimately died from viral infection increased at higher virus rates with a significant linear trend for rate. Lower rates of virus infection occurred in combination treatments than with virus alone, resulting in a significant fungicide by virus interaction; however, there was no main effect of fungicide on percentage mortality (Table 1).

3.2 Testing for direct insecticidal effects of fungicide

Unlike the first experiment, in which the relatively small number of larvae recovered from fungicide-treated plots had suggested mortality from the fungicide itself, or proportionately more escapes from those enclosures, similar numbers of larvae were recovered from fungicide-treated and untreated plots (control = 15.3 ± 0.6;

Table 1. Numbers of *A. ipsilon* recovered from small-plot field experiments, and percentage that died from virus infection

Rate (OB m^{-2})	Fungicide	Larvae recovered	% mortality[a]
0	−	11.3 ± 2.3	1.5 ± 1.5
	+	3.3 ± 1.7	4.8 ± 4.8
5 × 10^6	−	4.1 ± 2.0	8.5 ± 4.7
	+	2.5 ± 1.3	0 ± 0
5 × 10^7	−	8 ± 3.2	24.3 ± 8.9
	+	3.3 ± 1.9	7.8 ± 5.1
5 × 10^8	−	6.5 ± 1.9	61.7 ± 14.3
	+	1.0 ± 1.0	47.7 ± 21.4
ANOVA (*F*-values)[b]			
Fungicide		11.7**	0.2
Virus rate		1.6	18.4**
F × V		0.8	6.1*

[a] Weighted ANOVA.
[b] df = 1, 3, 3 and 35 for fungicide, virus rate, interaction and error respectively.
* and ** denote significance at $P \leq 0.05$ and 0.01 respectively.

Table 2. Numbers of larvae recovered from virus/fungicide-treated pots after 24 h of feeding, and percentage infected by virus in greenhouse trials

Rate (OB m^{-2})	Fungicide	Larvae recovered	% mortality[a]
0	High	10.3 ± 0.8	1.5 ± 1.5
	Medium	9.8 ± 0.9	4.8 ± 4.8
	Low	10.0 ± 0.4	4.8 ± 3.4
	0	11.2 ± 0.3	0 ± 0
5 × 10^3	High	10.7 ± 1.0	17.1 ± 4.7
	Medium	8.8 ± 0.5	1.3 ± 1.3
	Low	7.1 ± 0.8	17.5 ± 9.2
	0	10.1 ± 0.5	4.8 ± 3.1
5 × 10^6	High	7.8 ± 1.3	6.5 ± 3.1
	Medium	9.7 ± 0.7	4.5 ± 2.9
	Low	9.3 ± 1.0	5.3 ± 2.5
	0	9.1 ± 1.0	16.3 ± 6.2
5 × 10^9	High	12.0 ± 0.8	70.3 ± 4.9
	Medium	7.1 ± 1.5	78.5 ± 9.5
	Low	9.7 ± 1.5	87.5 ± 5.6
	0	9.7 ± 1.4	77.1 ± 4.3
ANOVA (*F*-values)[b]			
Fungicide		1.8	1.2
Virus rate		1.4	126.5**
F × V		1.9	2.1*

[a] ANOVA.
[b] df = 3, 3, 9 and 75 for fungicide, virus rate, interaction and error respectively.
* and ** denote significance at $P \leq 0.05$ and 0.01 respectively.

high fungicide rate = 18.0 ± 0.9; low fungicide rate = 15.7 ± 1.5; $F_{2,10} = 2.9$; $P = 0.1$). This indicated that the fungicide itself did not have direct adverse effects on larval survival.

3.3 Testing fungicide/virus synergism; greenhouse trials

When larvae were exposed to treated turfgrass in the greenhouse for 24 h, the number recovered from the pots was similar for all treatments. Percentage mortality from virus infection increased as virus rate increased, but was similar for the two lowest virus rates. There was no significant main effect of fungicide (Table 2). A virus × fungicide interaction was seen; however, when fungicide/virus combinations were compared with comparable rates of virus alone, the percentage mortality from virus was similar regardless of whether or not fungicide was included.

When larvae were exposed to treated grasses for 1, 2 and 4 days, the number recovered from the pots again was similar for all treatments. Longer duration of feeding on treated grasses and exposure to the higher virus rates corresponded to greater mortality from virus infection ($F_{2,67} = 4$; $P = 0.02$ and $F_{2,67} = 115$; $P \leq 0.01$ respectively) for all exposure durations (Table 3). Within rates, larvae exposed to the low rate of virus alone experienced significantly higher mortality (41.8 ± 4.7 versus 22.1 ± 5.5; $F_{1,24} = 10.1$; $P \leq 0.01$) and died more quickly compared with larvae feeding on grasses treated with the low-virus/fungicide combination for all exposure times (Fig. 1 and Table 3). Larvae also died more quickly at the high virus rate compared with high-virus/fungicide combinations when exposed for 2 and 4 days; however, the rate of death was similar when exposed for only 1 day (Fig. 1 and Table 3).

Table 3. Analysis of variance for main effects and interaction of virus rate, fungicide and days of exposure on percentage of black cutworms that died from viral infection

		ANOVA (*F*-values) for cohorts exposed for		
		1 day[a]	2 days[b]	4 days[b]
Main effects	Virus	34.1**	3.9	37.3**
	Fungicide	0.1	16.3*	0.4
Interactions	Virus × fungicide	3.5*	2.7	1.6
	Virus × time	37.9**	0.9	19.5**
	Fungicide × time	0.9	2.6**	1.17
Contrasts[c]	VL versus VLF	17.11**	3.14**	19.17**
	VH versus VHF	0.47	9.24**	65.7**

[a] df = 2, 1, 2, 10, 5 and 120 for virus rate, fungicide, interactions and error respectively.
[b] df = 2, 1, 2, 8, 4 and 96 for virus rate, fungicide, interactions and error respectively.
[c] Preplanned single-degree-of-freedom contrasts.
* and ** denote significance at $P \leq 0.05$ and 0.01 respectively.

3.4 Fungicide effects on consumption of treated grass

In choice tests with neonates, the total number of grass blades with some damage caused by cutworm feeding was similar for the treated and the non-treated grasses (52 versus 58; $\chi^2 = 0.33$; $P = 0.56$). Larvae consumed proportionately less of the treated than of the non-treated grass tissue (17.1 ± 1.8% versus 24.7 ± 1.7% respectively; Wilcoxon signed-rank test, $P \leq 0.01$). The numbers of larvae feeding on treated versus untreated grass blades were similar at the time of assessment, however. In no-choice tests with neonates, the percentage feeding damage on treated grass blades (8.5 ± 2.6%) was significantly lower than for non-treated blades (22 ± 3.9%; $t_9 = -2.76$; $P = 0.01$), but the number of blades with some cutworm damage was similar regardless of treatment. Third

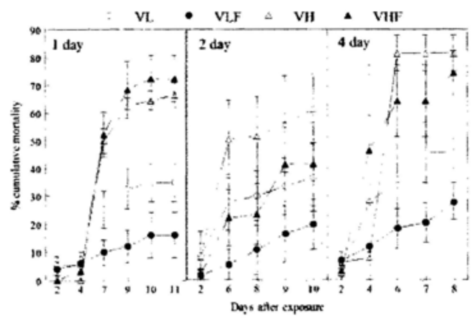

Figure 1. Cumulative lethal virus infection for *A. ipsilon* fed on bentgrass cores treated with two rates of *Agip*MNPV (VL = low virus, 1×10^8; VH = high virus, 5×10^8 OB m^{-2}) and one fungicide rate (F = 2.1 g m^{-2} of formulated product), applied alone and in combination. Larvae were exposed to treated grasses for 1, 2 and 4 days. Data are means (± SE). Delayed and slightly reduced mortality from *Agip*MNPV occurred when larvae fed on fungicide/virus-treated grasses as opposed to virus-only treatments for all cases, except those in which larvae were exposed to the high virus rate for 1 day.

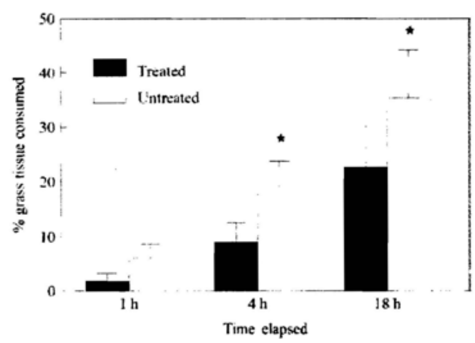

Figure 2. Mean (± SE) percentage of fungicide-treated versus non-treated grass leaf tissue consumed by third-instar *A. ipsilon* in choice tests. Asterisks denote significant feeding preference for untreated grass (Wilcoxon signed-rank tests, $P < 0.05$). The trend after 1 h was significant at $P = 0.08$.

instars showed significant preference for non-treated grass blades in choice tests (Fig. 2).

4 DISCUSSION

Combined or overlapping applications of a labeled polyoxin-d fungicide and *Agip*MNPV would be practical in turfgrass settings, so it was hoped that the combination would enhance infectivity of the virus against the black cutworm, an important golf-course pest, compared with levels of control provided by virus alone. That hypothesis is reasonable given previous laboratory studies with other insect species in which chitin-synthesis-inhibiting agents facilitated passage of virions through the chitinous peritrophic membrane, enhancing viral infection.[15,16,20,21] However, no synergism by the chitin-synthesis-inhibiting fungicide was seen; instead, there was delayed and slightly reduced mortality from *Agip*MNPV when larvae fed on fungicide/virus-treated grasses compared with virus-only treatments.

Poor recovery of larvae from fungicide-treated plots in the first field experiment initially suggested that polyoxin-d might have an insecticidal effect on cutworms. However, in a second experiment, when metal enclosures were driven deeper into the turf, similar numbers of larvae were recovered from fungicide- and non-fungicide-treated plots, revealing that the fungicide does not kill the cutworms. In choice tests, cutworms avoided feeding on polyoxin-d-treated grass. This suggests that larvae disproportionately escaped from the fungicide-treated turf by crawling beneath the shallow-driven enclosures used in the first field experiment. Because polyoxin-d does not deactivate *Agip*MNPV, and high virus rates can knock down and overwhelm cutworm populations in the short term,[24] the two substances are compatible and can be used together in the field. However, polyoxin-d residues on treated grass might interfere with larval ingestion of a lethal virus dose by inhibiting feeding or repelling larvae from putting greens, tees or other treated sites.

Previous studies examining the insecticidal effects of chitin synthesis inhibitors have all been done in laboratory settings and involved direct injection of the compound into the insect or incorporating it into artificial diet.[28-32] To the present authors' knowledge, this is the first study to examine the use of a chitin synthesis inhibitor as a synergist to an entomopathogen on living plants in greenhouse or field settings. Adjuvants such as stilbene optical brighteners, which have been shown to protect baculoviruses from UV degradation, enhance their longevity or act as synergists to virus infection in laboratory studies, may or may not provide the same benefits in the field.[33,34] The optical brightener M2R, for example, reduced the LD_{50} value of *Agip*MNPV to *A. ipsilon* in the laboratory but failed to enhance its efficacy against the same pest in greenhouse- or field-grown corn (*Zea mays* L.),[35] and also failed to accelerate or extend the efficacy of *Agip*MNPV against *A. ipsilon* in turfgrass field plots.[24] Optical brighteners can also deter feeding, and therefore results from a laboratory experiment may not translate to field settings where insects can disperse away from treated plant material.[36] Possibly, polyoxin chitin synthesis inhibitors consumed on plant tissue are less disruptive to caterpillar peritrophic membranes than when ingested in artificial diet. Plant secondary chemicals can alter the susceptibility of insects to naturally encountered pathogens as well as to microbial insecticides applied for biological control.[37] Caterpillar mortality, for example, can differ by as much as 50-fold, depending on the species of host plant upon which baculoviruses are consumed.[38-40]

The authors are still optimistic that *Agip*MNPV has potential as a microbial insecticide for managing black cutworms on golf courses, sports fields and in garden crops. Selecting for more virulent strains, or formulating the virus with adjuvants that enhance its persistence in field settings, could be productive. Testing *Agip*MNPV in combination with other chitin-synthesis-inhibiting fungicides suited for golf-course use is warranted, because some may be more disruptive to peritrophic membranes without discouraging feeding on treated grass as occurred with polyoxin-d. Another approach might be to combine a high dose of virus with a short-lived natural feeding stimulant[41,42] so that targeted larvae more rapidly ingest a lethal dose. The commercial success of *Agip*MNPV, like most entomopathogens, largely depends on future development of *in vitro* production methodology allowing the virus to be produced more economically and in greater amounts.[2,43]

ACKNOWLEDGEMENTS

The authors thank E Dobbs, C Redmond, D Williams, and L Williams for technical assistance, D Houseworth (Arysta Life Sciences) for donating the fungicide for experiments and C Keathley and S Vanek for critically reviewing an earlier draft of this article. This research was partially supported by grants from the United States Golf Association Turfgrass and Environmental Research Program, and from the OJ Noer Research Foundation. This is paper 11-08-034 of the Kentucky Agricultural Experiment Station.

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1.c. 2013/03/19 Additional Kaken written comments for the public hearing

Additional Comments Regarding Polyoxin D Zinc Salt for the April 10, 2013 NOSB Public Hearing

Submitted by
Kaken Pharmaceutical Co., Ltd.
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Vice President
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6713 Catskill Road
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March 19, 2013

1. EFFECTS ON BENEFICIAL SOIL FUNGI

As noted in the petition,

> "The active portion of polyoxin D zinc salt is polyoxin D which is produced by a microorganism that is naturally occurring in the soil. Polyoxin D inhibits the growth of phytopathogenic fungal cell wall chitin by competitively inhibiting chitin synthetase. Without chitin, susceptible fungi are unable to continue growing and infecting plant cells. Polyoxin D zinc salt does not kill the fungi; it simply stops the fungal growth. The action of Polyoxin D is highly specific; it does not affect bacteria, viruses, or mammals."

Polyoxin D zinc salt must be present to have any effect. Polyoxin D degrades rapidly under normal environmental conditions. Therefore, the effects of polyoxin D zinc salt on fungi, including beneficial soil fungi, are temporary.

Degradation Route	DT_{50} (Days)	Conditions / Sample	Ref.
Hydrolysis (water, in the dark)	32.5	pH 7 (neutral), 25°C	1
	9.1	pH 9 (basic), 25°C	
Aqueous photolysis (water and light)	0.4	Irradiated sterile water	2
Aerobic soil metabolism	15.9	Aerobic soil	3
	59.2	Sterile aerobic soil	

DT_{50}. Half-life. Time to degrade by 50%.
1. Herczog, K. and DiFrancesco, D. (2009). A Hydrolysis Study of [^{14}C]Polyoxin D in pH 5.0, 7.0, and 9.0 Buffer. MRID No. 48653304.
2. Miner, P. (2009). Photodegradation of [^{14}C]Polyoxin D in Sterilized Natural Water and Sterilized Buffer by Simulated Sunlight. MRID No. 48653305.
3. DiFrancesco, D. and Grommes, S. (2009). Metabolic Fate of [^{14}C]Polyoxin D in Aerobic Soil. MRID No. 48653306.

2. EFFECTS ON BENEFICIAL INSECTS

As noted in Kaken's reply to the Technical Evaluation Report and March 6, 2013 comments, the paper that reports chitin synthesis inhibition in cockroaches tissue cultures (Leighton *et al.*, 1981) makes no claim that adverse effects would be seen if whole cockroaches were exposed to polyoxin D zinc salt. Furthermore, the paper notes that chitin synthesis inhibition can be reversible.

Studies conducted using live, whole insects resulted in no adverse effects on silkworms, marmalade hoverflies, and green lacewings.

Using EPA's criteria, substances are practically non-toxic to honeybees if the 96-hour LD_{50} is greater than 11 micrograms/bee. For polyoxin D zinc salt, the measured 96-hour LD_{50} in honeybees was 28.774 micrograms/bee. Therefore, polyoxin D zinc salt is practically non-toxic to honeybees.

The available data demonstrate that the use of polyoxin D zinc salt will not adversely effect insects, including beneficial insects.

3. NOT MUTAGENIC

EPA has determined that polyoxin D zinc salt is not mutagenic.

In vivo (whole animal) mutagenicity studies are higher tier studies and are considered to be more reliable than lower tier *in vitro* (bacterial or tissue culture) mutagenicity studies.

Polyoxin D zinc salt was determined to be non-mutagenic in the mouse micronucleus test, a higher tier *in vivo* study.

EPA's August 18, 2008 review of the new mutagenicity data submitted to support the first food uses of polyoxin D zinc salt states:

> "**Mammalian Erythrocyte Micronucleus Study- Tier II (OPPTS 870.5395; MRID 47145102):**
> In a mouse bone marrow micronucleus range-finding assay, five male mice per dose were treated once via oral gavage with Polyoxin D zinc salt technical at doses of 0, 500, 1000 or 2000 mg/kg body weight. Bone marrow cells were harvested at 24 hours following treatment at all doses and additionally at 48 hours following treatment at 2000 mg/kg. The bone marrow polychromatic erythrocytes (PCEs) were evaluated for the presence of micronuclei and the PCE/total erythrocyte ratio was determined. The vehicle was 0.5% methylcellulose. The test material was not toxic to male mice in at any dose tested and there were no reported sex difference in response to the test material and an LD5o of>9600 mg/kg.
>
> In a definitive study, Polyoxin D zinc salt technical was tested to the limit dose of 2000 mg/kg. The mice showed no clinical signs or mortality during the micronucleus test. No statistically or biologically significant increase in the frequency of micronucleated PCEs was seen at any test material dose at either harvest time and the PCE/total erythrocyte ratio was not decreased. The vehicle and Mitomycin C positive control values were appropriate. There was no increase in the frequency of micronucleated bone marrow PCEs as tested in this study.
>
> **Conclusion: ACCEPTABLE**, no additional data are required (see Overall Conclusions for Muagenicity below).
>
> **Previously Reviewed Mutagenicity Studies:** In previously submitted studies, Polyoxin-D was shown to be weakly mutagenic in an Ames Assay (MRID 433230-01) but in a follow-up battery of three mutagenicity tests (see Polyoxin-D Brad), the data supported negative conclusions for mutagenicity. No maternal toxicity or developmental toxicity was observed in a developmental toxicity study (MRID 432618-36).
>
> **Overall Conclusions for Mutagenicity:** Based on the existing data, Polyoxin-D is not a mutagen. These data are acceptable to support the new food uses and the permanent Tolerance Exemption petition."

EPA's May 11, 2012 review of the new mutagenicity data states:

"Two new mutagenicity studies were conducted for polyoxin D zinc salt to support the expansion of the tolerance exemption. The mutagenicity studies along with the mutagenicity studies submitted to support the previous tolerance exemption. The studies determined that polyoxin D zinc salt is not a mutagen. The consumption of food commodities that are treated with polyoxin D zinc salt when used as a pesticide will not be harmful to human health from dietary exposure.

1. A reverse gene mutation assay in bacteria (MRID 48653313) using the technical grade of polyoxin D zinc salt, dissolved in dimethyl sulfoxide (DMSO), with and without metabolic S9 activation, showed no mutagenic effects or evidence of cytotoxicity or insolubility even at the limiting dose of 5000 ug/plate (Ref. 1). Therefore, polyoxin D zinc salt is considered to be non-mutagenic under the conditions of this assay.

2. An *in vitro* mammalian chromosome aberration test (MRID 48653314) using the technical grade of polyoxin D zinc salt, dissolved in DMSO, with and without metabolic S9 activation, showed clastogenic potential in Chinese hamster lung cells (CHL/IU) with and without activation. In Experiment I, polyoxin D zinc salt was tested up to dose levels that caused >50% cell lethality without activation (260 μg/mL) and with activation (1600 μg/mL). Without activation, the frequencies of the metaphases with structural chromosome aberrations (excluding gaps) were 14.5% and 7.5% at test article concentrations of 186 and 260μg/mL, respectively. With activation, the frequency of metaphase cells with structural chromosome aberrations (excluding gaps) was 9.5% at a test article concentration of 1600 μg/mL. The frequency of polyploid metaphase cells showed no increases either without or with activation. In Experiment II, a 24-hour continuous treatment without activation resulted in a 8.0% frequency of metaphases with structural chromosome aberrations (excluding gaps) at the concentration of 133 μg/mL. There were no increases in the frequency of polyploid metaphases.

<u>Although the submitted *in vitro* mammalian chromosome aberration test showed clastogenic potential, the results were not reproducible at the dose levels reported in the experiment. In addition, the mutagenicity data submitted to support the previous tolerance exemption, which included three complimentary Tier I mutagenicity tests and a Tier II mammalian erythrocyte micronucleus *in vivo* test, showed no mutagenic effects including no clastogenic potential (no chromosomal aberrations). Furthermore, the lack of systemic toxicity noted in the following developmental toxicity section indicted no effects in the Tier III two-generation reproduction study. The studies indicate that polyoxin D zinc salt is not mutagenic or clastogenic.</u> The studies support this expansion of the tolerance exemption based on the weight of evidence of the mutagenicity data." [Emphasis added.]

4. COMPATIBILITY WITH ORGANIC AND SUSTAINABLE AGRICULTURE

As noted in Kaken's reply to the Technical Evaluation Report and March 6, 2013 comments, polyoxin D zinc salt can play an important role in organic and sustainable agriculture:

- Though there are a large number of OMRI-listed products that are registered for at least one use for which polyoxin D zinc salt is registered, there are a surprisingly small number of modes of action available to the organic grower. This makes polyoxin D zinc salt an important resistance management tool. Please see Appendix 2 on pages 63 to 130 of Kaken's reply to the Technical Evaluation Report for polyoxin D zinc salt (http://tinyurl.com/C-Smith-1-23-2013). The Appendix summarizes the OMRI-listed alternatives, ordered by FRAC code (mode of action), and the disadvantages of the OMRI-listed alternatives.

- Tools available to the organic grower, *e.g.*,crop rotation, crop nutrient management practices, sanitation to remove disease vectors, selection of resistance species and varieties, beneficial antagonistic bacteria, and monitoring, do not always provide the efficacy needed to protect against significant crop damage or even complete crop loss for a grower. Polyoxin D zinc salt provides not only preventative efficacy but also provides curative efficacy for most registered uses when treatment is applied soon after infection.

- Polyoxin D zinc salt is registered for preventative and curative treatments of Southern blight of cucurbits and fruiting vegetables. The pathogen, *Sclerotium rolfsii*, overwinters in the soil. Most control measures are directed at killing *Sclerotium rolfsii* in the soil before the crop is present (fumigation, solarization, soil-applied fungicides, and deep plowing to bury the sclerotia). These preventative measures are only partially effective. Growers often must follow-up with systemic or protectant fungicides to prevent infection, and/or curative fungicides to limit the spread of the disease once infection has occurred. Conventional growers have access to a number of these fungicides. However, organic growers have no fungicides available to deal with Southern blight once the pathogen is present. Polyoxin D zinc salt represents a backup currently lacking in the organic grower's toolbox for dealing with this difficult disease.

5. ESSENTIAL FOR ORGANIC GROWERS

Polyoxin is registered for preventative and curative treatments for the following uses for which there are no OMRI-listed alternatives:

Uses of Polyoxin D Zinc Salt with No OMRI-Listed Alternatives		
Crop	Disease (Pathogen)	Curative
Cucurbits (Cucumbers, melons, squash and others)	Southern blight (*Sclerotium rolfsii*)	✔
Ginseng †	Cylindrocarpon root rot (*Cylinderocarpon destructans*)	✔
Pome fruit	Leaf blotch (*Diplocarpon mali*)	✔

† Not registered for use in California.

Please see section 4 above for comments regarding Southern blight (*Sclerotium rolfsii*).

1.d. 2013/03/22 Non-target organism study reports

A Laboratory Study to Evaluate the Toxicity of Polyoxin D Zinc Salt Technical on the Green Lacewing, *Chrysoperla carnea*

Study Report

December, 2001

Eco-Science Corporation

1. TITLE

A Laboratory study to evaluate the toxicity of Polyoxin D Zinc Salt Technical on the green lacewing, *Chrysoperla carnea*

2. PURPOSE

The purpose of this study is to assess the acute effects of the test substance on the green lacewing, *Chrysoperla carnea*.

3. TEST GUIDELINES

The method used in this study complies with the following JMAFF Guideline:

- Toxicity studies on natural enemy insects etc. (2-8-3) in the Notification by the Director of Agricultural Production Bureau, 12 Nousan 8147, 'Annex Guidelines for Preparation of Study Results Submitted When Applying for Registration of Agricultural Chemicals'.

4. SPONSOR

Kaken Pharmaceutical Co., Ltd.
Address: 28-8, Honkomagome 2-chome, Bunkyo-ku, Tokyo 113-8650, Japan

5. TESTING FACILITY

Eco-Science Corporation
Address:173-2,Tomitake, Nagano, Nagano Pref. 381-0006, Japan

Head of Testing Facility : Kazutoshi Komiyama

6. TIMING OF STUDY

Initiation of Experiment	: 9 Nov. 2001
Termination of Experiment	: 23 Nov. 2001
Study Completion	: 11 Dec. 2001

7. SIGNATURES

Study Director: Yokichi Tsukidate

Signature date(ddmmyyyy)

Technical Assistance: Hirochika Annoh

Signature date(ddmmyyyy)

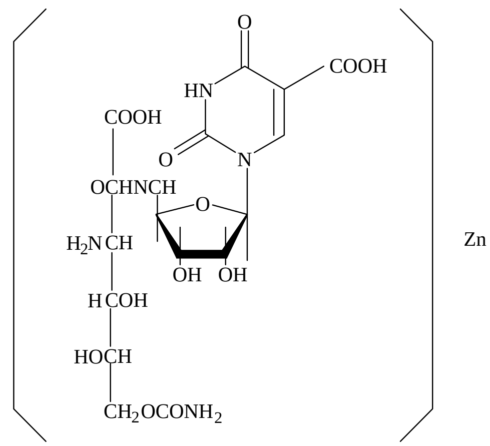
8. MATERIALS AND METHODS

8.1 Test Substance

Common name : Polyoxin D Zinc Salt

Chemical name : Zinc 5-(2-amino-5-*O*-carbamoyl-2-deoxy-L-xylonamido) -5-deoxy-L-(1,2,3,4-tetrahydro-5-carboxy-2,4-dioxopyrimidinyl)-β-D-allofuranuronic acid

Structure :



Appearance : Solid (powder), Brown (10YR6/4)

Lot number : PSB-422

Titer : 188 PsDu/mg

8.2 Test organism

Species : Post-molting 2nd instar larvae of the green lacewing, *Chrysoperla carnea* (Neuroptera)

Source : Natural enemy insecticide 'Kagetaro', purchased from Arysta LifeScience Corporation (Tokyo, Japan)

Rationale for adoption of theinsect : Green lacewing, well-known for its wide distribution in Japan, was selected as a representative species of predatory natural enemy to crop pests such as aphids.

Insect size : 2.0 mm (just before treatment)～10.2 mm (just before cocoon)

8.3 Test conditions

Test container	: plastic petri dish, 9 cm diameter
Number of test series	: 2 (Control and test substance)
Number of insect per replicate	: 20 (5 larvae/dish × 4)
Temperature	: 26℃
Photoperiod	: 16-hour light; 8-hour dark
Duration of experiment	: 14 days after treatment

8.4 Concentration of the test substance and the exposure method

The concentration of the test substance was determined based upon the highest spray concentration submitted for registration: 400 ppm (potency). Since this potency is the same as when the test substance is diluted 470-fold, a 470-fold dilution was used as the test concentration.

Since green lacewings are foliage dwellers, it was assumed that the bodies of green lacewings would be wetted directly by a spray solution containing the test substance. Based upon this assumption, the effects of the test substance were observed by immersing the larvae into a dilution of the test substance.

8.5 Preparation of solutions

For the test group, 100 mg of the test substance were dissolved in 47 ml of deionized water [added 100 ppm of Tween 20 and 200 ppm of S-Hatten (Lot No.1624N; Yashima Chemical Industry Co., Ltd)]. The test substance in the solution was finely ground using a sonicator and then dispersed by stirring well.

8.6 Method of exposure and observations

In the test substance series, each larva was immersed in test solution for 5 seconds using the tip of a small brush, excess solution on the body was removed using filter paper. Larvae treated with test solution were transferred to a petri dish lined with a folded filter paper and fed with green-peach aphids reared on leaves of Japanese radish. The application for the control series was conducted in the same manner after being immersed in water containing Tween 20 and S-Hatten.

Test vessels were placed in a constant temperature room. General conditions, existence of dead individuals, and pupation were observed daily for up to 14 days after treatment.

9. RESULTS AND DISCUSSION

The results of general condition and mortality are shown in Table 1, and the rate of pupation is shown in Table 2.

In both the test and control groups, no mortality and no abnormal behavior were observed throughout the experiment.

The number of larvae pupated by 14 days after treatment was 10 and 9 for the test and control groups, respectively.

These results indicate that the solution of Polyoxin D Zinc Salt Technical at 2100 mg/L is unlikely to have an adverse effect on the larvae of green lacewing, *Chrysoperla carnea*.

Table 1. Effect of Polyoxin D Zinc Salt Technical on 2nd instar larvae of the green lacewing, *Chrysoperla carnea* (Abnormal behavior and cumulative mortality)

Series	Number of insects	Total No. of larvae with abnormal behavior During 14 days after treatment	Cumulative No. of dead insects 14 days after treatment	Cumulative mortality rate: % 14 days after treatment
Test substance (Polyoxin D Zinc Salt: 2100 mg/L)	20	0	0	0
Control (Tween20: 100 mg/L, S-Hatten: 200 mg/L)	20	0	0	0

Table 2. Effect of Polyoxin D Zinc Salt Technical on 2nd instar larvae of the green lacewing, *Chrysoperla carnea* (Pupation).

Series	Number of insects	Cumulative No. of pupation (Cumulative pupation rate: %)						
		9	10	11	12	13	14	(Days after treatment)
Test substance (Polyoxin D Zinc Salt: 2100 mg/L, Tween 20 :100 mg/L, S-Hatten: 200 mg/L)	20	1 (5)	3 (15)	5 (25)	9 (45)	10 (50)	10 (50)	
Control (Tween 20: 100 mg/L, S-Hatten: 200 mg/L)	20	0 (0)	4 (20)	6 (30)	9 (45)	9 (45)	9 (45)	

A Laboratory Study to Evaluate the Toxicity of Polyoxin D Zinc Salt Technical on the Marmalade hoverfly, *Epistrophus balteatus*

Study Report

December, 2001

Eco-Science Corporation

1. TITLE

A laboratory study to evaluate the toxicity of Polyoxin D Zinc Salt Technical on the marmalade hoverfly, *Epistrophus balteatus*

2. PURPOSE

The purpose of this study was to assess the effects of the test substance, Polyoxin D Zinc Salt Technical, on the mortality and behavior of the marmalade hoverfly, *Epistrophus balteatus.*

3. TEST GUIDELINES

The method used in this study complies with the following JMAFF Guideline:.

- Toxicity studies on natural enemy insects etc. (2-8-3) in the Notification by the Director of Agricultural Production Bureau, 12 Nousan 8147, ‘Annex Guidelines for Preparation of Study Results Submitted When Applying for Registration of Agricultural Chemicals’.

4. SPONSOR

Kaken Pharmaceutical Co., Ltd.
Address: 28-8, Honkomagome 2-chome, Bunkyo-ku, Tokyo 113-8650, Japan

5. TESTING FACILITY

Eco-Science Corporation
Address: 173-2 Tomitake, Nagano, Nagano Pref. 381-0006, Japan

Head of Testing Facility : Kazutoshi Komiyama

6. TIMING OF STUDY

Initiation of Experiment : 4 Oct. 2001
Termination of Experiment : 14 Oct. 2001
Study Completion : 11 Dec. 2001

7. SIGNATURES

Study Director: Yokichi Tsukidate

Signature date(ddmmyyyy)

Technical Assistance: Hirochika Annoh

Signature date(ddmmyyyy)

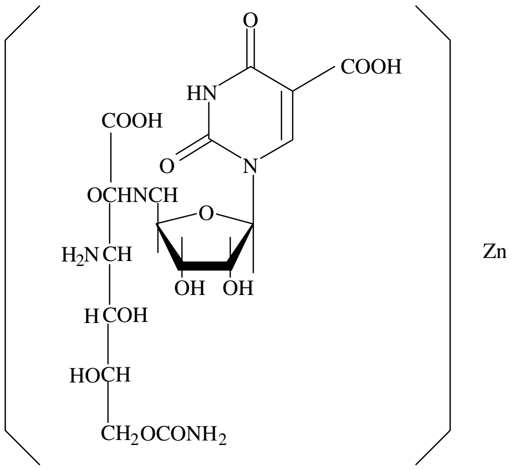
8. MATERIALS AND METHODS

8.1 Test Substance

Common name : Polyoxin D Zinc Salt

Chemical name : Zinc 5-(2-amino-5-*O*-carbamoyl-2-deoxy-L-xylonamido)-5-deoxy-L-(1,2,3,4-tetrahydro-5-carboxy-2,4-dioxopyrimidinyl)-β-D-allofuranuronic acid

Structure :



Appearance : Solid (powder) , Brown (10YR6/4)

Lot number : PSB-422

Titer : 188 PsDu/mg

8.2 Test organism

Species : Marmalade hoverfly, *Epistrophus balteatus* (Diptera: Syrphidae)

Source : Adults flying to flowers such as dandelion and chickweed were collected on local paddy leaves and in the vicinity of the vegetable field in Tomitake (Nagano, Nagano Pref., Japan)
Larvae were collected from leaves infested with a large number of the soybean aphids.

Rationale for adoption of the insect : Marmalade hoverfly was selected as a representative species of a predatory natural enemy of crop pests such as aphids.

Insect size : Adults length 5.2～6.0 mm
Larvae length 2.5mm

8.3 Test conditions

Test container	: Study of adults; Plastic cup (120 mL) Study of larvae; Glass petri dish (9 cm)
Number of test series	: 2 (Control and test substance)
Number of insects per replicate	: 20 (5 insects/container × 4); both adult and larval study
Temperature	: 25℃
Photoperiod	: 16-hour light; 8-hour dark
Duration of experiment	: Study of adults; 5 days after treatment Study of larvae; 10 days after treatment

8.4 Concentration of the test substance and the exposure method

The concentration of the test substance was determined based upon the highest spray concentration submitted for registration: 400 ppm (potency). Since this potency is same as when the test substance is diluted 470-fold, a 470-fold dilution was used as the test concentration.

Adult hoverflies come to grassland or flowers to look for food. Larval hoverflies are commonly found on plants with aphids present. It is assumed that the body of the hoverfly would be wetted directly by a spray solution containing the test substance. It is also assumed that the paddy water containing the test substance would fall on the body of a hoverfly by the wind. From these assumptions, the effect of the test substance was observed by immersing the adult and larval hoverfly into a dilution of the test substance.

8.5 Preparation of solutions

For the test group, 100 mg of the test substance was dissolved in 47 ml of deionized water [added 100 ppm of Tween 20 and 200 ppm of S-Hatten (Lot No. 1624N; Yashima Chemical Industry Co., Ltd)]. The test substance in the solution was finely ground using a sonicator and then dispersed by stirring well.

8.6 Method of exposure and observations

Study of adults: The hoverflies were anesthetized with carbon dioxide until the individual stopped moving, and then the hoverflies were immediately immersed in the test solution for 1 to 2 seconds. Hoverflies treated with test solution were transferred to a plastic cup lined with filter paper after excess fluid was removed using filter paper. Some holes filled with cotton wool were made in the lid for ventilation. Cotton wool soaked with diluted honey was put in the cup as food.

A series of control was treated in the same manner after being immersed in water containing Tween 20 and S-Hatten.

After the hoverflies recovered from the anesthesia, test vessels were placed in a constant temperature room. General conditions and existence of the dead hoverflies were observed daily for up to 5 days after treatment.

Study of Larvae: Larvae on a soybean leaf were immersed in the test solution. After drying, the larvae were gently moved to an untreated soybean leaf infested by aphids. Five larvae were put on one leaf.

Larvae in a series of controls were treated in the same manner after being immersed in water containing Tween 20 and S-Hatten.

9. RESULTS AND DISCUSSION

The result of the mortality with adults is shown in Table 1, and the results of general condition and mortality of larvae are shown in Table 2.

In both the test and control groups, no mortality and no abnormal behavior were observed in adults and larvae throughout the experiment.

No abnormality was observed in the predatory behavior of the larvae tested, and all larvae had become pupae by 10 days after treatment.

These results indicate that the solution of Polyoxin D Zinc Salt Technical at 2100 mg/L is unlikely to have an adverse effect on the adult and larval marmalade hoverfly, *Epistrophus balteatus*.

Table 1. Effect of Polyoxin D Zinc Salt Technical on adults of hoverfly, *Epistropheus balteatus* (Cumulative mortality)

Series	Number of insects	No. of dead insects (Cumulative mortality: %) 0	1	2	3	4	5 (Days after treatment)
Test substance (Polyoxin D Zinc Salt 2100 mg/L Tween 20: 100 mg/L, S-Hatten: 200 mg/L)	20,	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Control (Tween 20: 100 mg/L, S-Hatten: 200 mg/L)	20	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

Table 2. Effect of Polyoxin D Zinc Salt Technical on larvae of hoverfly, *Epistrophus balteatus* (Abnormal behavior, mortality and pupation)

Series	Number of insects	Total No. of larvae With abnormal behavior During 10 days after treatment	No. of dead larvae (Cumulative mortality: %) 10 days after treatment	No. of Pupae (Pupation rate: %) 10 days after treatment
Test substance (Polyoxin D Zinc Salt: 2100 mg/L, Tween 20: 100 mg/L, S-Hatten: 200 mg/L)	20	0	0 (0)	20 (100)
Control (Tween 20: 100 mg/L, S-Hatten :200 mg/L)	20	0	0 (0)	20 (100)

A Laboratory Study to Evaluate the Acute Oral Toxicity of Polyoxin D Zinc Salt Technical on the Silkworm, *Bombyx mori*

Study Report

December, 2001

Eco-Science Corporation

1. TITLE

A laboratory study to evaluate the acute oral toxicity of Polyoxin D Zinc Salt Technical on the silkworm, *Bombyx mori*

2. PURPOSE

The purpose of this study is to assess the acute effects of the test substance on the silkworm, *Bombyx mori*, resulting from feeding of treated leaves.

3. TEST GUIDELINES

The method used in this study complies with the following JMAFF Guideline:

- Silkworm Toxicity Studies (2-8-2) in the Notification of the Director of Agricultural Production Bureau, 12 Nousan 8147, 'Annex Guidelines for Preparation of Study Results Submitted When Applying for Registration of Agricultural Chemicals'.

4. SPONSOR

Kaken Pharmaceutical Co., Ltd.
Address: 28-8, Honkomagome 2-chome, Bunkyo-ku, Tokyo 113-8650, Japan

5. TESTING FACILITY

Eco-Science Corporation
Address: 173-2, Tomitake, Nagano, Nagano Pref. 381-0006, Japan

Representative : Kazutoshi Komiyama

6. SIGNATURES

Study Director: Yokichi Tsukidate

Signature date(ddmmyyyy)

Technical Assistance: Kaoru Fueki

Signature date(ddmmyyyy)

7. TIMING OF STUDY

Initiation of Experiment	: 17 Oct. 2001
Termination of Experiment	: 8 Nov. 2001
Study Completion	: 17 Dec. 2001

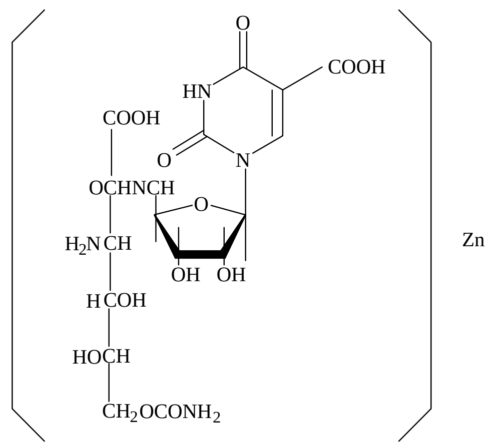
8. MATERIALS AND METHODS

8.1 Test Substance

Common name : Polyoxin D Zinc Salt

Chemical name : Zinc 5-(2-amino-5-*O*-carbamoyl-2-deoxy-L-xylonamido)-5-deoxy-L-(1,2,3,4-tetrahydro-5-carboxy-2,4-dioxopyrimidinyl)-β-D-allofuranuronic acid

Structure :



Appearance : Solid (powder) , Brown (10YR6/4)

Lot number : PSB-422

Titer : 188 PsDu/mg

8.2 Test organism

Species : Silkworm (*Bombyx mori)*

Variety : Kinshu X Showa

Source : Ueda Silkworm Strain Cooperation (Ueda, Nagano Pref., Japan)

Preparation of Larvae : The 1st instar larvae hatched from the purchased eggs were fed with artificial diet (Nihon Nosankogyo, Co., Ltd, Japan) up to termination of 3rd instar period.

Larval stage on application : Post-molting 4th instar larvae

8.3 Test design

Number of test series : 2 (Test substance and control)

Number of test concentrations : 1 per test substance

Number of replicates : 3

Number of silkworms per replicate : 20

8.4 Test condition

Test chambers	: Plastic container (32 x 24 x 12 cm)
Room temperature	: 26℃
Light condition	: Photoperiod of 16h Light/8h Dark
Duration of observations	: From post-molting 4th instar larvae to completion of pupation

8.5 Grounds for the setting of concentration

Concentration of the test substance was determined based on the highest spraying concentration for registration: 2100 mg/L.

8.6 Preparation of the solutions

For the test series, 200 mg of the test substance was dissolved in 47ml of deionized water [added 100 ppm of Tween 20 and 200 ppm of S-Hatten (Lot No.1624N; Yashima Chemical Industry Co., Ltd)]. The test substance in the solution was finely ground using a sonicator and dispersed by stirring well. Deionized water solution was used for the control series.

8.7 Method of application

Mulberry leaves were submerged in the test solution for ten seconds and dried under a hood. The completely dried leaves were put in a container lined with paper towel. Twenty of 4th instar larvae of silkworms were placed in each container and observed for the effect of ingestion of the test substance. The freshly prepared leaves were supplied to larvae.

For control series, leaves treated with water containing Tween20 and S-Hatten were supplied daily in the same manner as in the test substance series.

8.8 Maintenance of silkworms

During the observation, plastic containers were placed in a temperature-controlled room and loosely covered with lids to keep moisture. During 5th instar period, sufficient mulberry leaves were supplied to the silkworms twice a day. The containers were occasionally cleaned.

Mature larvae from each series were placed in a paper grid and kept for cocooning.

8.9 Observations

The observation items were as follows.

Initial body weight of post-molting 4th instar larvae	: Body weight of 30 larvae were measured prior to the initiation of experiment.
Mortality	: Number of dead individuals was recorded daily.
Symptoms of intoxication	: Abnormal behaviors due to the intoxication were recorded.
Feeding behavior	: Abnormal feeding behaviors were recorded.
Duration of 4th instar period	: Number of days passed during 4th instar period was recorded.
Duration of 5th instar period	: Number of days passed during 5th instar period was recorded.
Number of cocooning	: Number of newly formed cocoon was recorded on daily bases.
Rate of pupation	: After the completion of pupation, number of pupae was counted and pupation rate was calculated.
Weight of cocoon	: After the completion of pupation, weight of each cocoon was measured and recorded.
Weight of cocoon layer	: After the completion of pupation, weight of each cocoon layer was measured and recorded.

9 . RESULTS

The results were described according to the observation items in 8.9.

9.1 Initial body weight of post-molting 4th instar larvae

The result of initial body weight of the tested silkworms is indicated in Appendix Table 1. The mean value of initial body weight of post-molting 4th instar larva was 201.2 mg .

9.2 Mortality

The entire number of dead silkworms and mortality rate during the experiment are indicated in Table 1.

The number of dead individuals (mortality rate: %) in the test substance series was 0 (0.0%). In the control series, the total number of dead silkworms was 0 (0.0%).

9.3 Duration of 4th and 5th instar periods

The days required for each developmental stage in the experiment are shown in Appendix Table 2-1 and Appendix Table 2-2.

Both in the test substance and control series, molters were appeared 5 to 7 days after treatment and 5th instar larvae were observed 6 to 8 days after treatment.

A period of matured 5th instar larvae and cocooning was from 13 to 16 days after treatment.

9.4 Number of cocoons and survival rate of pupae

Number of cocoons and survival rate of pupae are summarized in Table 2.

Both in the test substance and control series, all silkworms developed into cocoon and pupae of stages and no abnormal cocoons and pupae were observed.

9.5 Weights of cocoon and cocoon layer

Weights of cocoon and cocoon layer are indicated in Table 2.

Both in the test substance and control series, weights of cocoon and cocoon layer ranged 1.6 to 2.5 g and 0.3 to 0.5 g, respectively.

In the test substance series, average weights of cocoon and cocoon layer ranged 1.89 to 1.99 g and 0.36 to 0.38 g, respectively, and no remarkable fluctuations were observed for weight of cocoon and cocoon layer.

10. CONCLUSION

Feeding of the mulberry leaves treated with the test substance did not show any remarkable difference from control series in mortality, duration of either 4th or 5th instar period, number of cocooning, number of healthy pupae, weight of cocoon, and weight of cocoon layer.

Therefore, it is likely that the application of 2100 mg/L diluted solution of Polyoxin D zinc salt to mulberry leaves have no adverse effects on development of the silkworm, *Bombyx mori.*

11. REFERENCES

Aruga Hisao 1975: New Compendium of Sericulture Science; Yokendo Co., Ltd

Yushima Ken et al 1991: Method for rearing of insects; Japan Plant Protection Association: 168-171

A Laboratory Study to Evaluate the Toxicity of Polyoxin D Zinc Salt Technical on the Wolf Spider, *Pardosa laura*

Study Report

December, 2001

Eco-Science Corporation

1. TITLE

A laboratory study to evaluate the toxicity of Polyoxin D Zinc Salt Technical on the wolf spider, *Pardosa laura*

2. PURPOSE

The purpose of this study was to assess the acute effects of the test substance, Polyoxin D Zinc Salt Technical, on the mortality and behavior of the wolf spider, *Pardosa laura.*

3. TEST GUIDELINES

The method used in this study complies with the following JMAFF Guideline:

- Toxicity studies on natural enemy insects etc. (2-8-3) in the Notification of The Director of Agricultural Production Bureau, 12 Nousan 8147, 'Annex Guidelines for Preparation of Study Results Submitted When Applying for Registration of Agricultural Chemicals'.

4. SPONSOR

Kaken Pharmaceutical Co., Ltd.
Address: 28-8, Honkomagome 2-chome, Bunkyo-ku, Tokyo 113-8650, Japan

5. TESTING FACILITY

Eco-Science Corporation
Address: 173-2 Tomitake, Nagano, Nagano Pref. 381-0006, Japan

Head of Testing Facility : Kazutoshi Komiyama

6. TIMING OF STUDY

Initiation of Experiment : 19 Sept. 2001
Termination of Experiment : 29 Sept. 2001
Study Completion : 11 Dec. 2001

7. SIGNATURES

Study Director: Yokichi Tsukidate

Signature date(ddmmyyyy)

Technical Assistance: Hirochika Annoh

Signature date(ddmmyyyy)

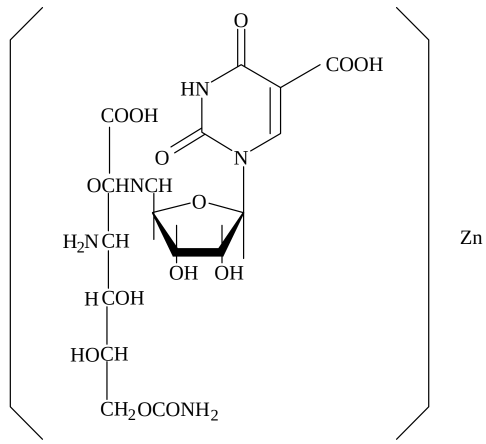
8. MATERIALS AND METHODS

8.1 Test Substance

Common name : Polyoxin D Zinc Salt

Chemical name : Zinc 5-(2-amino-5-*O*-carbamoyl-2-deoxy-L-xylonamido)-5-deoxy-L-(1,2,3,4-tetrahydro-5-carboxy-2,4-dioxopyrimidinyl)-β-D-allofuranuronic acid

Structure :



Appearance : Solid (powder), Brown (10YR6/4)

Lot number : PSB-422

Titer : 188 PsDu/mg

8.2 Test organism

Species : Wolf spider, *Pardosa laura* (Arachnida；Araneae)

Source : Wolf spiders in a local paddy leaves were collected in Tomitake (Nagano, Nagano Pref., Japan)

Rationale for adoption of the species : Wolf spider was selected as a representative species of a predatory natural enemy to crop pests.

Insect size : length 3.5～4.5 mm
4.2±0.3（Average of 10 random individuals）

8.3 Test conditions

Test container	: Glass Screw-top tube (50 mL)
Number of test series	: 2 (Control and test substance)
Number of spiders per replicate	: 20 (1 spider/tube × 20)
Temperature	: 26℃
Photoperiod	: 16-hour light; 8-hour dark
Duration of experiment	: 10 days after treatment

8.4 Concentration of the test substance and the exposure method

Concentration of the test substance was determined based on the highest spray concentration submitted for registration: 400 ppm (potency). Since this potency is the same as when the test substance is diluted 470-fold, a 470-fold dilution was used as the test concentration.

Since wolf spider roams the ground, it was assumed that the bodies of wolf spiders would be wetted directly by a spray solution containing the test substance. Based upon this assumption, the effect of the test substance was observed by immersing the spiders into a dilution of the test substance.

8.5 Preparation of solutions

For the test group, 100 mg of the test substance was dissolved in 47 ml of deionized water [added 100 ppm of Tween 20 and 200 ppm of S-Hatten (Lot No. 1624N; Yashima Chemical Industry Co., Ltd)]. The test substance in the solution was finely ground using a sonicator and then dispersed by stirring well.

8.6 Method of exposure and observations

The spiders were anesthetized with carbon dioxide until an individual stopped moving, and then they were immediately immersed in the test solution for 5 seconds. A spider treated with test solution was transferred to a screw-top tube after excess fluid was removed by the filter paper. The screw-top tube had a lid designed for ventilation. Moreover, to prevent the organisms from drying out, a moist filter paper was placed in each screw-top tube.

After spiders recovered from anesthesia, two flies were placed in the screw-top tube as food at 0, 3, and 6 days after treatment, and predatory behaviors of the spiders were observed.

Spiders in a series of controls were treated in the same manner after being immersed in water containing Tween 20 and S-Hatten.

Test vessels were placed in a constant temperature room. General conditions and existence of dead spiders were observed daily for up to 10 days after treatment.

9. RESULTS AND DISCUSSION

The results of general condition and mortality are shown in Table 1.

In the test substance series, one wolf spider death was observed due to dryness 4 days after treatment. The filter paper was completely dried in the test tube. No abnormal behavior and no mortality were observed in the remaining individuals of the treated and the control groups. Spiders started preying on flies immediately after the flies were fed, and all spiders preyed on the flies next feeding day as well. All spiders (except the one dead spider) were observed preying on flies on the 3^{rd} and 6^{th} day after treatment..

These results indicate that the solution of Polyoxin D Zinc Salt Technical at 2100 mg/L is unlikely to have an adverse effect on the wolf spider, *Pardosa laura*.

10. REFERENCES

Hamamura Tetsuzo 1997: Method for rearing of wolf spiders; J. of Plant Protection 51, 541-543.

Table 1. Effect of Polyoxin D Zinc Salt Technical on wolf spider, *Pardosa laura*
(Abnormal behavior and cumulative mortality)

Series	Number of spiders	Total No. of spiders with abnormal behavior During 10 days after treatment	Cumulative No. of dead spiders 10 days after treatment	Cumulative mortality rate: % 10 days after treatment
Test substance (Polyoxin D Zinc Salt: 2100 mg/L, Tween 20: 100 mg/L, S-Hatten: 200 mg/L)	20	0	1*	5*
Control (Tween 20:1 00 mg/L, S-Hatten: 200 mg/L)	20	0	0	0

*Death due to dehydration; not treatment related.

Table 2. Effect of Polyoxin D Zinc Salt Technical on wolf spider, *Pardosa laura* (Predation of prey)

Series	Number of spiders	Number of spiders that prey on flies		
		Feeding immediately after treatment	Feeding 3 days after treatment	Feeding 6 days after treatment
Test substance (Polyoxin D Zinc Salt:2100 mg/L, Tween20:100 mg/L, S-Hatten:200 mg/L)	20	20	20	19*
Control (Tween20:100 mg/L, S-Hatten:200 mg/L)	20	20	20	20

Number of individuals preying on more than one fly by the next day after the fruit flies have been placed.

* The number of individuals in the 19 live spiders.

1.e. 2013/04/04 Earthworm study report summary

Polyoxin D Zinc Salt: Acute Toxicity to the Earthworm, *Eisenia fitida* Michaelsen (Haplotaxida, Lumbricidae) in Artificial Soil (Dose-Response Test)

Eurofins Agroscience Services
Study Code S12-04057
Study Director: Eiko Wagenhoff

April 4, 2013
Final report in preparation

Summary

Mortality

No mortality was observed in any of the treatment groups up to and including 1000 mg Polyoxin D Zinc Salt/kg soil dry weight, the highest concentration tested.

Test Item (mg/kg soil dry weight)	Mean Mortality (%)	
	Day 7	Day 14
Water Control	0	0
100	0	0
178	0	0
316	0	0
562	0	0
1000	0	0

Behavior

No abnormal behavior was observed.

Body Weight

Compared to the control treatment, body weight development was observed to be significantly increased at 100 mg/kg dry soil weight (Dunnett's t test, two-tailed; $p \leq 0.05$), the lowest rate tested. However, at higher concentrations, no effects on body weight change could be detected.

Test Item (mg/kg soil dry weight)	Test Start		After 14 Days			
	Mean Weight (mg/worm)	Std. Dev. ±	Mean Weight (mg/worm)	Std. Dev. ±	Mean Weight Change (mg/worm)	Mean Weight Change (%)
Control	423.7	10.6	384.9	3.39	-38.8	-9.16
100	414.4	8.46	419.6	16.5	5.2	+1.25
178	414.4	12.9	391.6	14.3	-22.8	-5.50
316	425.2	11.1	401.3	21.9	-23.9	-5.62
562	410.0	5.29	389.8	13.1	-20.2	-4.93
1000	424.9	11.3	397.7	12.6	-27.2	-6.40

2. Current EPA Registered Labels for Products Proposed for Use in Organic Crop Production

2.a EPA Reg. No. 68713-1: Polyoxin D Zinc Salt Technical

Polyoxin D Zinc Salt Technical (EPA Reg. No. 68173-1)
August 24, 2012 revised proposed label based upon comments received by email on August 23, 2012 regarding the November 15, 2011 proposed amended label to permit use on all for and feed crops
Changes implemented.
Page 1 of 3
068173-00001.20120824.all crops.pdf

ACCEPTED

AUG 29 2012

Under the Federal Insecticide, Fungicide, and Rodenticide Act, as amended, for the pesticide registered under EPA Reg. No. 68173-1

Polyoxin D Zinc Salt Technical

For Manufacturing Use Only

GROUP 19 FUNGICIDE

Active Ingredient:	
Polyoxin D zinc salt (1:1)[1],	
Zinc 5-[[2-amino-5-*O*-(aminocarbonyl)-2-deoxy-L-xylonyl]amino]-1-(5-carboxy-3,4-dihydro-2,4-dioxo-1(2*H*)-pyrimidinyl)-1,5-dideoxy-β-D-allofuranuronate	23.8%
Other Ingredients:	76.2%
Total:	100.0%

[1] Equivalent to 21.1% polyoxorim and 2.65% metallic zinc.

KEEP OUT OF REACH OF CHILDREN
CAUTION

FIRST AID	
If on skin or clothing	• Take off contaminated clothing. • Rinse skin immediately with plenty of water for 15-20 minutes. • Call a poison control center of doctor for treatment advice.
If in eyes	• Hold eye open and rinse slowly and gently with water for 15-20 minutes. • Remove contact lenses, if present, after the first 5 minutes, then continue rinsing eye. • Call a poison control center or doctor for treatment advice.
If swallowed	• Call a poison control center or doctor immediately for treatment advice. • Have person sip a glass of water if able to swallow. • Do not induce vomiting unless told to by a poison control center or doctor. • Do not give anything by mouth to an unconscious person.
If inhaled	• Move person to fresh air. • If person is not breathing, call 911 or an ambulance, then give artificial respiration, preferable by mouth-to-mouth, if possible. • Call a poison control center or doctor for further treatment advice.

HOTLINE NUMBER

Have the product container or label with you when calling a poison control center or doctor, or going for treatment.

FOR 24-HOUR EMERGENCY MEDICAL ASSISTANCE:

Call CHEMTREC at 1-800-424-9300 or POISON CONTROL CENTER at 1-800-222-1222 or 1-703-527-3887 if calling from outside of the U.S.

Polyoxin D Zinc Salt Technical (EPA Reg. No. 68173-1)
August 24, 2012 revised proposed label based upon comments received by email on August 23, 2012 regarding the November 15, 2011 proposed amended label to permit use on all for and feed crops
Changes implemented.
Page 2 of 3
068173-00001.20120824.all crops.pdf

PRECAUTIONARY STATEMENTS

HAZARDS TO HUMANS AND DOMESTIC ANIMALS

CAUTION: Causes moderate eye irritation. Harmful if absorbed through the skin, swallowed or inhaled. Avoid contact with skin, eyes or clothing. Avoid breathing dust. Wash thoroughly with soap and water after handling and before eating, drinking, chewing gum, using tobacco, or using the toilet.

ENVIRONMENTAL HAZARDS

This pesticide is moderately toxic to aquatic invertebrates and fish. Do not discharge effluent containing this product into lakes, streams, ponds, estuaries, oceans, or other waters unless in accordance with the requirements of a National Pollutant Discharge Elimination System (NPDES) permit and the permitting authority has been notified in writing prior to discharge. Do not discharge effluent containing this product to sewer systems without previously notifying the local sewage treatment plant authority. For guidance contact your State Water Board or Regional Office of the EPA.

DIRECTIONS FOR USE

It is a violation of Federal law to use this product in a manner inconsistent with its labeling.

Polyoxin D Zinc Salt Technical is for manufacturing use only for the production of fungicide formulations for use on all food and feed crops (pre-harvest and post-harvest), ornamentals, golf courses, residential lawns, parks, and commercial and institutional grounds.

STORAGE AND DISPOSAL

Do not contaminate water, food or feed by storage or disposal.
PESTICIDE STORAGE: Store in dry place away from food or feed.
PESTICIDE DISPOSAL: Wastes resulting from the use of this product may be disposed of on site or at an approved waste disposal facility.
CONTAINER HANDLING: Nonrefillable container. Do not reuse or refill this container. Completely empty bag into manufacturing equipment. Then dispose of empty bag in a sanitary landfill or by incineration, or, if allowed by State and local authorities, by burning. If burned, stay out of smoke.

FOR 24-HOUR CHEMICAL EMERGENCY ASSISTANCE:

(Spill, leak, fire, exposure or accident), call CHEMTREC 1-800-424-9300
or 1-703-527-3887 if calling from outside of the U.S.

WARRANTY AND DISCLAIMER STATEMENT

1. Kaken Pharmaceutical Co., Ltd. ("Kaken") warrants that this product conforms to the chemical description on the label and is reasonably fit for the purposes stated in the Directions for Use, subject to the inherent risks described above, when used in accordance with the Directions for Use under normal conditions.

2. This warranty does not extend to the use of this product contrary to label instructions or under conditions not reasonably foreseeable to Kaken, and is subject to the inherent risks described above. **TO THE EXTENT CONSISTENT WITH APPLICABLE LAW, KAKEN DISCLAIMS ALL OTHER WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. TO THE EXTENT CONSISTENT WITH APPLICABLE LAW, KAKEN, MANUFACTURER, AND SELLER DISCLAIM AND SHALL NOT BE LIABLE FOR ANY SPECIAL, INCIDENTAL, INDIRECT, OR CONSEQUENTIAL DAMAGES RESULTING FROM THE USE, HANDLING, APPLICATION, STORAGE OR DISPOSAL OF THIS PRODUCT OR FOR DAMAGES IN THE NATURE OF PENALTIES, AND THE USER AND BUYER WAIVE ANY RIGHT THAT THEY MAY HAVE TO SUCH DAMAGES. NO AGENT, REPRESENTATIVE OR EMPLOYEE OF KAKEN IS AUTHORIZED TO MAKE ANY WARRANTY, GUARANTEE OR REPRESENTATION BEYOND THOSE CONTAINED HEREIN OR TO MODIFY THE WARRANTIES CONTAINED HEREIN.**

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EPA Reg. No: 68173-1
EPA Est. No: 68173-JP-001

Net Contents:

Produced by:
Kaken Pharmaceutical Co., Ltd.
Agrochemicals & Animal Health Products Division
28-8 Honkomagome 2-chome
Bunkyo, Tokyo 113-8650, Japan

2.b. EPA Reg. No. 68173-4: Veggieturbo 5SC Suspension Concentrate Fungicide

ACCEPTED

JAN 29 2015

Under the Federal Insecticide, Fungicide, and Rodenticide Act, as amended, for the pesticide registered under EPA Reg. No. 68173-4

068173-00004.20141212.Changes_IMPLEMENTED.pdf
VEGGIETURBO 5SC (EPA File Symbol 68173-4) • Page 1 of 21
December 12, 2014 Proposed Master Label Fast-Track Amendment
Based upon the December 12, 2012 EPA accepted label.
Adds directions for use on bananas, plantains, herbs and spices and additional apples diseases.
Adds new stone fruit group members.

[Front Panel]

GROUP 19 FUNGICIDE

VEGGIETURBO™ 5SC

Suspension Concentrate Fungicide

Optional text:

For Control of Fungal Diseases of Listed Vegetable and Fruit Crops
Biofungicide For Control of Fungal Diseases of Listed Vegetable and Fruit Crops
Biochemical Fungicide For Control of Fungal Diseases of Listed Vegetable and Fruit Crops
Biofungicide
Biochemical Fungicide

Active Ingredient	
Polyoxin D zinc salt	5.0%
Other Ingredients	95.0%
Total	100.0%
Contains 7.03 ounces of active ingredient per gallon.	

KEEP OUT OF REACH OF CHILDREN

CAUTION

See back panel for additional precautionary statements.
[Alternate statements:]
See below for additional precautionary statements.
See inside panel for additional precautionary statements.
See inside panels for additional precautionary statements.
See inside panels for additional precautionary statements and directions for use.
See inside panels for additional Precautionary Statements, First Aid Statements, Directions for Use, and Storage and Disposal Statements.
See inside panels for complete label.
See booklet for additional precautionary statements.
See booklet for additional precautionary statements and directions for use.
See booklet for additional precautionary statements, directions for use, and storage and disposal statement.
See booklet for complete label
See attached booklet for additional Precautionary Statements, First Aid Statements, Directions for Use, and Storage and Disposal Statements.

[Containers up to 2.5 gallons:]
SHAKE WELL BEFORE USE

Produced by:
Kaken Pharmaceutical Co., Ltd.
28-8, Honkomagome 2-chome, Bunkyo-ku,
Tokyo, JAPAN 113-8650

EPA Reg. No. 68173-4
EPA Est. No. ______________

NET CONTENTS: **1 Quart (32 Fluid Ounces)**
1 Gallon (128 Fluid Ounces)
2.5 Gallons (320 Fluid Ounces)
266 Gallons (1000 Liters)

[Back Panel]

PRECAUTIONARY STATEMENTS
HAZARDS TO HUMANS & DOMESTIC ANIMALS

Caution. Prolonged or frequently repeated skin contact may cause allergic reactions in some individuals. Avoid contact with skin and clothing. Wash thoroughly with soap and water after handling and before eating, drinking, chewing gum, using tobacco, or using the toilet. Remove and wash contaminated clothing before reuse.

Optional Statements (EPA Category IV toxicity for acute oral, acute dermal, acute inhalation, eye irritation and dermal irritation)

FIRST AID	
IF ON SKIN OR CLOTHING:	• *Take off contaminated clothing.* • *Rinse skin immediately with plenty of water for 15-20 minutes.* • *Call a poison control center or doctor for treatment advice.*
IF IN EYES:	• *Hold eye open and rinse slowly and gently with water for 15-20 minutes.* • *Remove contact lenses, if present, after the first 5 minutes, then continue rinsing eye.* • *Call a poison control center or doctor for further treatment advice.*
IF SWALLOWED:	• *Call a poison control center or doctor immediately for treatment advice.* • *Have person sip a glass of water if able to swallow.* • *Do not induce vomiting unless told to do so by the poison control center or doctor.* • *Do not give anything to an unconscious person.*
IF INHALED:	• *Move person to fresh air.* • *If person is not breathing, call 911 or an ambulance, then give artificial respiration, preferably mouth-to-mouth if possible.* • *Call a poison control center or doctor for further treatment advice.*
Have the product container or label with you when calling a poison control center or doctor, or going for treatment. *HOTLINE NUMBER: 1-800-255-3924*	

PERSONAL PROTECTIVE EQUIPMENT (PPE)

All mixers, loaders, applicators and other handlers must wear:

- Long-sleeved shirt and long pants;
- Socks;
- Shoes; and
- Chemical-resistant gloves.

Follow manufacturer’s instructions for cleaning and maintaining PPE. If no instructions are available, use detergent and hot water for washables. Keep and wash PPE separately from other laundry.
When handlers use closed systems, enclosed cabs, or aircraft in a manner that meets requirements listed in the Worker Protection Standard (WPS) for agricultural pesticides, the handler PPE requirements may be reduced or modified as specified in the WPS.

USER SAFETY RECOMMENDATIONS

Users should:

- Remove clothing/PPE immediately if pesticides get inside. Then wash thoroughly and put on clean clothing.
- Remove PPE immediately after handling this product. Wash the outside of gloves before removing. As soon as possible, wash thoroughly and change into clean clothing.

ENVIRONMENTAL HAZARDS

[For 1 liter, 1 gallon and 2.5 gallon containers:]
For terrestrial use. This pesticide is moderately toxic to aquatic invertebrates and fish. Do not apply directly to water, or to areas where surface water is present or to intertidal areas below the mean high water mark. Do not contaminate water when disposing of equipment wash water or rinsate. Do not allow runoff into lakes, streams, ponds or public waterways. Drift and runoff may be hazardous to aquatic organisms in water adjacent to treated areas. Observe the most restrictive labeling limitations and precautions of all products used in mixtures.

[For 1000 liter container:]
For terrestrial use. This pesticide is moderately toxic to aquatic invertebrates and fish. Do not apply directly to water, or to areas where surface water is present or to intertidal areas below the mean high water mark. Do not contaminate water when disposing of equipment wash water or rinsate. Do not allow runoff into lakes, streams, ponds or public waterways. Drift and runoff may be hazardous to aquatic organisms in water adjacent to treated areas. Observe the most restrictive labeling limitations and precautions of all products used in mixtures. Do not discharge effluent containing this product into lakes, streams, ponds, estuaries, oceans, or other waters unless in accordance with the requirements of a National Pollutant Discharge Elimination System (NPDES) permit and the permitting authority has been notified in writing prior to discharge. Do not discharge effluent containing this product to sewer systems without previously notifying the local sewage treatment plant authority. For guidance contact your State Water Board or Regional Office of the EPA.

GENERAL INFORMATION

VEGGIETURBO 5SC can be applied as a preventative or curative treatment in conjunction with good management practices.
VEGGIETURBO 5SC can be used alone or, when diseases not specified on this label are present or expected, in combination and/or rotation with other appropriately labeled fungicides as a tool for integrated disease management in labeled agricultural crops. See "Mixing and Handling Instructions" below for additional information.
Preharvest Interval (PHI) = 0 days. VEGGIETURBO 5SC is exempt from the requirement for residue tolerance and therefore can be applied up to and including the day of harvest.

RESISTANCE MANAGEMENT RECOMMENDATIONS

VEGGIETURBO 5SC contains a fungicide classified in FRAC target site of action Group 19. Fungal isolates with acquired resistance to Group 19 may eventually dominate the fungal population if Group 19 fungicides are used repeatedly in the same field or in successive years as the primary method of control for targeted species. This may result in partial or total loss of control of those species by VEGGIETURBO 5SC or other Group 19 Fungicides.

The following actions may prevent or delay fungicide resistance:

- Avoid consecutive use of VEGGIETURBO 5SC or other Group 19 fungicides against the same pathogens.
- Use tank-mixes or premixes with fungicides from different target site of action Groups. Do this only with products that are registered for the same use and are effective at the tank mix or premix rate against the target pathogen(s).
- Use fungicides as part of a comprehensive Integrated Pest Management (IPM) program.
- Monitor treated fungal populations for loss of field efficacy.

Contact your local extension specialist, certified crop advisor, and/or manufacture representative for fungicide resistance management and/or IPM recommendations for specific crops and resistant pathogens.

DIRECTIONS FOR USE

It is a violation of Federal law to use this product in a manner inconsistent with its labeling.

For any requirements specific to your State or Tribe, consult the State or Tribal agency responsible for pesticide regulation.

Do not apply this product in a way that will contact workers or other persons, either directly or through drift. Only protected handlers may be in the area during application.

AGRICULTURAL USE REQUIREMENTS

Use this product only in accordance with its labeling and with the Worker Protection Standard 40 CFR Part 170. This standard contains requirements for the protection of agricultural workers on farms, forests, nurseries, and greenhouses and handlers of agricultural pesticides. It contains requirements for training, decontamination, notification, and emergency assistance. It also contains specific instructions and exceptions pertaining to the statements on this label about personal protective equipment (PPE), and restricted entry intervals. The requirements in this box only apply to uses of this product that are covered by the Worker Protection Standard.

Do not enter or allow worker entry into treated areas during the restricted entry interval (REI) of 4 hours unless wearing appropriate PPE.

PPE required for early entry to treated areas that is permitted under the Worker Protection Standard and that involves contact with anything that has been treated, such as plants, soil or water is: coveralls, socks, shoes, and chemical-resistant gloves.

Low rate (3.75 fl. oz./acre) may be used for preventative applications before onset of visible disease, in periods of low disease pressure, or in a tank mix with other fungicides for resistance management. Use higher rates (6.5 to 13.0 fl. oz./acre) when disease pressure is high, or in stand-alone applications.

MIXING AND APPLICATION INSTRUCTIONS

VEGGIETURBO 5SC may be applied by ground or aerial spray equipment, as a soil drench, or by chemigation through sprinklers or drip irrigation. See the table below for information on application methods and timing for specific crops and diseases.

For spray application, mix VEGGIETURBO 5SC in water and apply as a spray to foliage, fruit, or other above-ground plant parts. For optimum control of labeled diseases, apply in sufficient volume of water to provide thorough coverage with minimal run-off.

See "Chemigation Instructions" below for information about applying VEGGIETURBO 5SC through irrigation systems.

[For 1 quart, 1 gallon and 2.5 gallon containers:]
Mixing instructions for VEGGIETURBO 5SC:

- *Shake well before use.*
- *Fill tank with water to ½ of the intended final volume.*
- *Start agitation of the spray tank.*
- *Add the appropriate amount of product to the tank according to the rates in this label.*
- *Agitate to ensure thorough mixing while adding the remaining required water.*
- *Do not allow the mixture to stand without agitation.*
- *Mix only the amount of solution needed to treat the desired area.*

[For 1000 Liter container:]
Thoroughly agitate product when product is in use.

When tank mixing VEGGIETURBO 5SC with other products, observe all precautions and limitations on each separate product label.

When planning to mix this product with others, it advisable to conduct a "jar test" to determine the physical compatibility of this product with the others. Using a quart jar, add the products (with agitation) to approximately one quart of water in the proportions they will appear in the final mixture. Add dry formulations first, followed by flowables, then emulsifiable concentrates like VEGGIETURBO 5SC last. After thorough mixing, allow this mixture to stand for 5 minutes. If the combination remains mixed or can be readily remixed, it is physically compatible. Once compatibility has been proven, use the same sequence for adding required ingredients to the tank.

To assess the potential for phytotoxicity, test tank mixtures on a small number of plants prior to more widespread application.

If more applications or shorter intervals than indicated in the table below are needed to maintain disease control, alternate VEGGIETURBO 5SC with other fungicides having different modes of action to avoid or slow development of pathogen resistance. See "Resistance Management Recommendations" above for more information.

Use of an adjuvant may enhance spray coverage of dense crop canopy, or plants that are difficult to wet due to waxy or hairy surfaces. Use only adjuvants that are labeled for such uses. Refer to "Mixing and Application Instructions" above for information on testing physical compatibility of VEGGIETURBO 5SC with other products.

BANDED (IN-FURROW) APPLICATION

Use the table below to determine the correct application rate in fluid ounces of product per 1,000 row feet based on row spacing and desired rate per acre. Mix the required amount of VEGGIETURBO 5SC in water and apply as banded spray (4” to 6” wide) or seedline drench centered over the planting furrow. Apply to soil immediately before seeding or directly over seeds in the furrow just before they are covered with soil. The volume of water required per acre or per 1,000 row feet will depend on the application equipment used. Consult your local cooperative extension service if you need assistance calibrating band spraying equipment.

Rates for banded (in-furrow) application: Find desired application rate in the left column. Read across the line to the correct row spacing indicated at the top to find the number of fluid ounces per 1000 row feet that will provide the desired application rate per acre.

Fluid oz. per acre	Fluid ounces per 1000 row feet														
	Space between rows (inches)														
	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40
3.75	0.09	0.10	0.11	0.13	0.14	0.16	0.17	0.19	0.20	0.22	0.23	0.24	0.26	0.27	0.29
6.50	0.15	0.17	0.20	0.22	0.25	0.27	0.30	0.32	0.35	0.37	0.40	0.42	0.45	0.47	0.50
13.00	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95	0.99

CHEMIGATION INSTRUCTIONS

GENERAL INFORMATION:

- Apply this product through pressurized irrigation systems such as drip (trickle) irrigation (including micro-irrigation through spaghetti tubes or individual tubes) or sprinkler irrigation (including impact or microsprinklers, microjet, overhead boom, water gun, solid set, lateral move, end tow, side-roll, center pivot, or hand move, including mist-type systems); or with hand-held calibrated irrigation equipment (such as a hand-held wand with injector). Do not apply this product through any other type of irrigation system.
- Crop injury or lack of effectiveness can result from non-uniform distribution of treated water.
- If you have questions about calibration, contact State Extension Service specialists, equipment manufacturers or other experts.
- Do not connect an irrigation system (including greenhouse systems) used for pesticide application to a public water system unless the pesticide label-prescribed safety devices for public water systems are in place.
- A person knowledgeable of the chemigation system and responsible for its operation, or under the supervision of the responsible person, shall shut the system down and make necessary adjustments should the need arise.
- Public water system means a system for the provision to the public of piped water for human consumption if such system has at least 15 service connections or regularly serves an average of at least 25 individuals daily at least 60 days out of the year.
- Chemigation systems connected to public water systems must contain a functional, reduced-pressure zone, backflow preventer (RPZ) or the functional equivalent in the water supply line upstream from the point of pesticide introduction. As an option to the RPZ, the water from the public water system should be discharged into a reservoir tank prior to pesticide introduction. There shall be a complete physical break (air gap) between the outlet end of the fill pipe and the top or overflow rim of the reservoir tank of at least twice the inside diameter of the fill pipe.
- The pesticide injection pipeline must contain a functional, automatic, quick-closing check valve to prevent the flow of fluid back toward the injection.

- The pesticide injection pipeline must contain a functional, normally closed, solenoid-operated valve located on the intake side of the injection pump and connected to the system interlock to prevent fluid from being withdrawn from the supply tank when the irrigation system is either automatically or manually shut down.
- The system must contain functional interlocking controls to automatically shut off the pesticide injection pump when the water pump motor stops, or in cases where there is no water pump, when the water pressure decreases to the point where pesticide distribution is adversely affected.
- Systems must use a metering pump, such as a positive displacement injection pump (e.g., diaphragm pump) effectively designed and constructed of materials that are compatible with pesticides and capable of being fitted with a system interlock.
- Do not apply when wind speed favors drift beyond the area intended for treatment.
- Remove scale, pesticide residues, and other foreign matter from the chemical supply tank and injector system and flush with clean water before use. Failure to provide a clean tank, free of scale or residues may reduce effectiveness of this product.

DRIP (TRICKLE) AND MICRO-IRRIGATION CHEMIGATION:
- The system must contain a functional check valve, vacuum relief valve and low pressure drain appropriately located on the irrigation pipeline to prevent water source contamination from backflow.
- The pesticide injection pipeline must contain a functional, automatic, quick-closing check valve to prevent the flow of fluid back toward the injection pump.
- The pesticide injection pipeline must also contain a functional, normally closed, solenoid-operated valve located on the intake side of the injection pump and connected to the system interlock to prevent fluid from being withdrawn from the supply tank when the irrigation system is either automatically or manually shut down.
- The system must contain functional interlocking controls to automatically shut off the pesticide injection pump when the water pump motor stops.
- The irrigation line or water pump must include a functional pressure switch which will stop the water pump motor when the water pressure decreases to the point where pesticide distribution is adversely affected.
- Systems must use a metering pump such as a positive displacement injection pump (i.e., diaphragm pump) effectively designed and constructed of materials that are compatible with pesticides and capable of being fitted with a system interlock.
- Dilute the product in water following the label mixing directions. It may be premixed in a supply tank with water, fertilizer, or other appropriate tank-mixed agricultural chemicals. Agitation is necessary. Apply to moderately moist soils. Use volumes that thoroughly wet the soil but that do not cause significant runoff or excessive drip from pots. Application should be continuous in sufficient water to apply the recommended rate evenly to the entire treated area.

SPRINKLER CHEMIGATION:
- The system must contain a functional check valve, vacuum relief valve, and low pressure drain appropriately located on the irrigation pipeline to prevent water source contamination from backflow.
- The pesticide injection pipeline must contain a functional, automatic, quick-closing check valve to prevent the flow of fluid back toward the injection pump.
- The pesticide injection pipeline must also contain a functional, normally closed, solenoid-operated valve located on the intake side of the injection pump and connected to the system interlock to prevent fluid from being withdrawn from the supply tank when the irrigation system is either automatically or manually shut down.
- The system must contain functional interlocking controls to automatically shut off the pesticide injection pump when the water pump motor stops.

- The irrigation line or water pump must include a functional pressure switch which will stop the water pump motor when the water pressure decreases to the point where pesticide distribution is adversely affected.
- Systems must use a metering pump, such as a positive displacement injection pump (i.e., diaphragm pump) effectively designed and constructed of materials that are compatible with pesticides and capable of being fitted with a system interlock.
- Dilute the product in water following the label mixing directions. It may be premixed in a supply tank with water, fertilizer or other appropriate tank-mixed agricultural chemicals. Agitation is necessary. Apply to moderately moist soils. Use volumes that thoroughly wet the soil but that do not cause significant runoff or excessive drip from pots. Application should be continuous in sufficient water to apply the recommended rate evenly to the entire treated area.
- Do not apply when wind speed favors drift beyond the area intended for treatment.

CROPS, DISEASES AND APPLICATION RATES

ARTICHOKES (Chinese and Jerusalem)		
DISEASES/PATHOGENS	**RATES**	**ADDITIONAL INFORMATION**
Gray mold/Botrytis rot (*Botrytis cinerea*) **Powdery mildew** (*Leveillula taurica, Erysiphe cichoracearum*)	3.75 – 13.0 fl. oz./acre (0.21 – 0.72 oz. a.i./acre) Do not apply more than 4.2 oz. a.i./acre/season (6 appl. at max. rate).	Begin applications at first sign of disease symptoms and repeat on 7-14 day interval as long as conditions favor disease development. Apply as a foliar spray in sufficient water to achieve thorough coverage of all above-ground plant parts. May also be applied through overhead sprinkler irrigation. See "Chemigation Instructions" for additional information.

BANANAS AND PLANTAINS ✷		
DISEASES/PATHOGENS	**RATES**	**ADDITIONAL INFORMATION**
Black Sigatoka leaf streak (*Mycosphaerella fijiensis* Morelet) **Yellow Sigatoka leaf spot** (*Mycosphaerella musicola*)	3.75 – 13.0 fl. oz./acre (0.21 – 0.72 oz. a.i./acre) Do not apply more than 4.2 oz. a.i./acre/season (6 appl. at max. rate).	Begin applications when leaves first appear and repeat on a 7-21 day interval or as needed. Apply in sufficient water to obtain thorough coverage of foliage. For improved control, product may be tank-mixed with other fungicides registered for control of Sigatoka at label rates. When conditions are conducive to rapid disease development and/or heavy disease pressure, higher application rates and rotational spray programs with other fungicides registered for control of Sigatoka are recommended.
✷ For use in Hawaii and Puerto Rico only.		

BERRIES AND SMALL FRUITS:
Amur river grape, Aronia berry, Bayberry, Bearberry, Bilberry, Blackberry, Blueberry, Buffalo currant, Buffaloberry, Che, Chilean Guava, Chokecherry, Cloudberry, Cranberry, Currant (red and black), Elderberry, European barberry, Gooseberry, Highbush cranberry, Honeysuckle (edible), Huckleberry, Jostaberry, Juneberry, Kiwi (fuzzy and hardy), Loganberry, Maypop, Mountain pepper berries, Mulberry, Muntries, Native currant, Partridgeberry, Phalsa, Pincherry, Raspberry (black and red), Riberry, Salal, Schisandra berry, Sea buckthorn, Serviceberry, Strawberry, Wild raspberries, Cultivars, varieties, and/or hybrids of these
(See separate table for grapes.)

DISEASES/PATHOGENS	RATES	ADDITIONAL INFORMATION
Alternaria **leaf spot and fruit rot** (*Alternaria* spp.) **Anthracnose leaf & fruit rot** (*Colletotrichum* spp.)* **Gray mold/fruit rot/Botrytis blight** (*Botrytis cinerea*) **Powdery mildew** (*Sphaerotheca macularis*, *Erysiphe* spp.)	3.75 – 13.0 fl. oz./acre (0.21 – 0.72 oz. a.i./acre) Do not apply more than 4.2 oz. a.i./acre/season (6 appl. at max. rate).	Apply as a foliar spray in sufficient water to provide thorough coverage. Can also be applied through overhead sprinkler irrigation. See “Chemigation Instructions” for additional information. Begin as a preventative application and continue on a 7-14 day interval as needed to maintain control. For control of *Botrytis* and other fruit diseases, begin applications at flowering.

* Suppression only. A rate of 6.5 fl. oz./acre may be used for preventative applications before onset of visible disease, in periods of low disease pressure, or in a tank mix with other fungicides for resistance management. Otherwise, use a rate of 13.0 fl. oz./acre.

BRASSICA (COLE) LEAFY VEGETABLES: **Broccoli, Broccoli raab, Brussels Sprouts, Cabbage, Chinese broccoli, Chinese Cabbage (Bok Choi, Napa, Gai choy), Cauliflower, Cavalo broccolo, Collards, Kale, Kohlrabi, Mizuna, Mustard Greens, Mustard spinach, Rape greens**		
DISEASES/PATHOGENS	**RATES**	**ADDITIONAL INFORMATION**
Alternaria leaf spot (*Alternaria* spp.) **Anthracnose** (*Colletotrichum* spp.) **Gray mold** (*Botrytis cinerea*) **White spot** (*Cercosporella* spp.)	3.75 – 13.0 fl. oz./acre (0.21 – 0.72 oz. a.i./acre) Do not apply more than 4.2 oz. a.i./acre/season (6 appl. at max. rate).	Apply as a foliar spray in sufficient water to attain thorough coverage. Use of an adjuvant may enhance spray coverage, especially of waxy leaves. Begin preventive sprays when conditions favor disease development, and continue on a 7-14 day spray interval as needed.
Bottom rot (*Rhizoctonia solani*) **Sclerotinia rot** (*Sclerotinia sclerotiorum)*		Apply in 30 – 50 gallons of water per acre as a directed spray toward soil surface and lower leaves. Begin applications at head formation, before leaves contact the ground. Repeat every 7-14 days as needed to maintain control.

BULB VEGETABLES: **Chive, Daylily, Elegans hosta, Fritillaria, Garlic, Kurrat, Lady's leek, Leek, Lily, Onion, Shallot, Cultivars, varieties, and/or hybrids of these**		
DISEASES/PATHOGENS	**RATES**	**ADDITIONAL INFORMATION**
Alternaria blight and Purple blotch (*Alternaria* spp.) **Botrytis leaf blight /Leaf spot/Neck rot** (*Botrytis* spp.) **Downy mildew** (*Peronospora* spp.)* **Rust** (*Puccinia alii* or *Puccinia porri*)	3.75 – 13.0 fl. oz./acre (0.21 – 0.72 oz. a.i./acre) Do not apply more than 4.2 oz. a.i./acre/season (6 appl. at max. rate).	Apply as foliar preventative spray (ground, aerial, or through overhead sprinklers) before disease onset and continue at 7-14 day intervals as needed to maintain control. Coverage may be enhanced by use of a spray adjuvant.
* Suppression only. A rate of 6.5 fl. oz./acre may be used for preventative applications before onset of visible disease, in periods of low disease pressure, or in a tank mix with other fungicides for resistance management. Otherwise, use a rate of 13.0 fl. oz./acre.		

CARROTS and PARSNIPS		
DISEASES/PATHOGENS	**RATES**	**ADDITIONAL INFORMATION**
Alternaria leaf blight (*Alternaria dauci*) **Cercospora leaf blight** (*Cercospora carotae*) **Powdery mildew** (*Erysiphe polygoni*) **Rhizoctonia crown rot and leaf blight** (*Rhizoctonia solani*)	3.75 – 13.0 fl. oz./acre (0.21 – 0.72 oz. a.i./acre) Do not apply more than 4.2 oz. a.i./acre/season (6 appl. at max. rate).	Begin applications soon after plant emergence and repeat on 7-14 day interval as long as conditions favor disease development. Apply as a foliar spray in sufficient water to achieve thorough coverage of all above-ground plant parts. May also be applied through overhead sprinkler irrigation. See "Chemigation Instructions" for additional information.

CITRUS FRUITS: Calamondin, Citron, Citrus hybrids (Chironja, Tangelo, Tangor), Clementine, Grapefruit, Kumquat, Lemon, Lime, Mandarin (Tangerine), Orange, Pummelo, Sutsuma mandarin		
DISEASES/PATHOGENS	**RATES**	**ADDITIONAL INFORMATION**
Alternaria **brown spot** (*Alternaria alternata*)	3.75 – 13.0 fl. oz./acre (0.21 – 0.72 oz. a.i./acre) Do not apply more than 4.2 oz. a.i./acre/season (6 appl. at max. rate).	Apply as preventative foliar spray before disease development, when spring flush is ¼ to ½ expanded. If needed, make second application to fully expanded flush.
Botrytis rot (*Botrytis cinerea*)		Begin preventative applications during bloom when rain or fog is expected. Repeat every 7-14 days as long as conditions favoring disease persist.
Septoria spot (*Septoria citri*)		Apply as a preventative spray in late fall or early winter, just before or after the first rain. Additional applications may be necessary during seasons of heavy rainfall.

CUCURBIT VEGETABLES:
Chayote (fruit), Chinese waxgourd (Chinese preserving melon), Citron melon, Cucumber, Gherkin, Gourd (edible, including hyotan, cucuzza, hechima, Chinese okra), *Momordica* spp. (includes balsam apple, balsam pear, bitter melon, Chinese cucumber), Muskmelon (includes true cantaloupe, cantaloupe, casaba, crenshaw melon, golden pershaw melon, honeydew melon, honey balls, mango melon, Persian melon, pineapple melon, Santa Claus melon, and snake melon), Pumpkin, Squash (including acorn squash, butternut squash, calabaza, crookneck squash, hubbard squash, scallop squash, spaghetti squash, straightneck squash, vegetable marrow, zucchini), Watermelon, Hybrids and varieties of these

DISEASES/PATHOGENS	RATES	ADDITIONAL INFORMATION
Anthracnose (*Colletotrichum orbiculare*) **Early blight** (*Alternaria* sp.) **Gray mold** (*Botrytis* sp.) **Gummy stem blight** (*Didymella bryoniae* and *Phoma cucurbitacearum*) **Powdery mildew** (*Erysiphe* and *Sphaerotheca* spp. and *Podosphaera xanthii*) **Scab** (*Cladosporium* sp.) **Target leaf spot/Corynespora leaf spot/ Corynespora blight** (*Corynespora crassiicola*)	3.75 – 13.0 fl. oz./acre (0.21 – 0.72 oz. a.i./acre) Do not apply more than 4.2 oz. a.i./acre/season (6 appl. at max. rate).	Mix in sufficient volume of water for good spray coverage (typically 50-100 gallons per acre). Begin preventive sprays when conditions favor disease development, and continue on a 7-14 day spray interval as needed.
Southern blight (*Sclerotium rolfsii*)		See additional instructions under BANDED (IN-FURROW) APPLICATION. Can also be applied through surface (not buried) drip or overhead sprinkler irrigation. See "Chemigation Instructions" for additional information. Make subsequent applications at 7-14 day intervals either through surface drip or overhead sprinkler irrigation, or as a spray/drench directed at the base of each plant.

FRUITING VEGETABLES: Eggplant, Groundcherry, Peppers (all types), Tomatillo, Tomatoes (all types)		
DISEASES/PATHOGENS	**RATES**	**ADDITIONAL INFORMATION**
Anthracnose (*Colletotrichum* spp.)* **Early blight** (*Alternaria solani*) **Gray mold/Botrytis rot** (*Botrytis* spp.) **Late blight*** (*Phytophthera infestans*) **Leaf mold** (*Fulvia (Cladosporium) fulvum,* also known as *Passalora fulva*) **Powdery mildew** (*Leveillula, Oidiopsis, Erysiphe*, and *Sphaerotheca* spp.)	3.75 – 13.0 fl. oz./acre (0.21 – 0.72 oz. a.i./acre) Do not apply more than 4.2 oz. a.i./acre/season (6 appl. at max. rate).	Apply as a preventative foliar spray when conditions favor disease development. Repeat application at 7-14 day intervals as needed during infection periods. Mix in sufficient water to attain thorough coverage of foliage and fruit (if present).
Southern blight (*Sclerotium rolfsii*)* **Verticillium wilt** (*Verticillium dahliae*)*		See additional instructions under BANDED (IN-FURROW) APPLICATION. Can also be applied through surface (not buried) drip or overhead sprinkler irrigation. See "Chemigation Instructions" for additional information. Make subsequent applications at 7-14 day intervals either through surface drip or overhead sprinkler irrigation, or as a spray/drench directed at the base of each plant.
* Suppression only. A rate of 6.5 fl. oz./acre may be used for preventative applications before onset of visible disease, in periods of low disease pressure, or in a tank mix with other fungicides for resistance management. Otherwise, use a rate of 13.0 fl. oz./acre.		

GINSENG		
DISEASES/PATHOGENS	**RATES**	**ADDITIONAL INFORMATION**
Alternaria blight (*Alternaria panax*) **Botrytis blight** (*Botrytis cinerea*)	3.75 – 13.0 fl. oz./acre (0.21 – 0.72 oz. a.i./acre) Do not apply more than 4.2 oz. a.i./acre/season (6 appl. at max. rate).	Apply as foliar spray every 7-10 days beginning within 2 weeks after plant emergence, prior to disease development (consult local extension service for advice on timing against these diseases). Continue throughout the season as needed to maintain control.
Cylindrocarpon root rot (*Cylindrocarpon destructans*) **Rhizoctonia root and crown rot** (*Rhizoctonia solani*)		Apply as soil drench every 14-28 days, beginning within 2 weeks after plant emergence.

GRAPES: For pre-harvest use on all grapes		
DISEASES/PATHOGENS	**RATES**	**ADDITIONAL INFORMATION**
Gray mold/bunch rot (*Botrytis cinerea*) **Powdery mildew** (*Erysiphe* (*Uncinula*) *necator*)	3.75 – 13.0 fl. oz./acre (0.21 – 0.72 oz. a.i./acre) Do not apply more than 4.2 oz. a.i./acre/season (6 appl. at max. rate).	For powdery mildew, begin as a preventative spray and repeat every 14 days as needed to maintain control. For *Botrytis* bunch rot, apply at veraison and 7 days before harvest.

HERBS AND SPICES †:

Allspice, angelica, anise, anise, star, annatto (seed), balm, basil, borage, burnet, camomile, caper buds, caraway, caraway, black, cardamom, cassia bark, cassia buds, catnip, celery seed, chervil (dried), chive, chive, Chinese, cinnamon, clary, clove buds, corainder leaf (cilantro or Chinese parsley), coriander seed (cilantro), costmary, cilantro (leaf), culantro (seed), cumin, curry (leaf), dill (dillweed), dill (seed), fennel (common), fennel, Florence (seed), fenugreek, grains of paradise, horehound, hyssop, juniper berry, lavender, lemongrass, lovage (leaf), lovage (seed), mace, marigold, marjoram, mustard (seed), nasturtium, nutmeg, parsley (dried), pennyroyal, pepper, black, pepper, white, poppy (seed), rosemary, rue, saffron, sage, savory, summer and winter, sweet bay, tansy, tarragon, thyme, vanilla, wintergreen, woodruff, and wormwood.

DISEASES/PATHOGENS	RATES	ADDITIONAL INFORMATION
Downy mildew (*Peronospora* spp. and others)	3.75 – 6.5 fl. oz./acre (0.21 – 0.36 oz. a.i./acre)	Begin preventive sprays when conditions favor disease development, and continue on a 7-10 day spray interval as needed.
Powdery mildew (*Oidium* spp. and others)	Do not apply more than 2.2 oz. a.i./acre/season (6 appl. at max. rate).	

Notes:
† Not for use in California.
- Product may harm herbs and spices, especially new leaves. Do not apply to herbs and spices without prior testing on a small number of plants.

LEAFY VEGETABLES:
Amaranth, Arugula (garden rocket), Asparagus chicory, Beet greens (spinach beet), Borage, Catalogna, Celery, Chard, Chaya, Chicory, Colocasia, Corn salad (mâche), Dandelion, Endive, Escarole, Fenugreek, Garden cress, Ground-elder, Kailan, Lettuce (Head, Leaf, Iceberg, Romaine), Mizuna, Purslane, Radichetta, Radicchio, Sorrel, Spinach, Spinach beet (beet greens), Spring greens (Spring mix), Stinging nettle, Tatsoi, Tropaeolum (*Nasturtium*), Turnip greens, Watercress (*Nasturtium*), Water spinach (ong choy), Yarrow

DISEASES/PATHOGENS	RATES	ADDITIONAL INFORMATION
Alternaria leaf spot (*Alternaria* spp.) **Downy mildew** (*Bremia lactucae* and *Peronospora* spp.)* **Powdery mildew** (*Golovinomyces (Erysiphe) cichoracearum*)	3.75 – 13.0 fl. oz./acre (0.21 – 0.72 oz. a.i./acre) Do not apply more than 4.2 oz. a.i./acre/season (6 appl. at max. rate).	Begin applications soon after plant emergence or transplanting and repeat on 7-14 day interval as long as conditions favor disease development. Apply as a foliar spray in sufficient water to achieve thorough coverage of all above-ground plant parts. May also be applied through overhead sprinkler irrigation. See "Chemigation Instructions" for additional information.
Botrytis damping off (*Botrytis* spp.)		Apply as banded spray (4-6" wide) over the seed furrow at planting or transplanting. See additional instructions under BANDED (IN-FURROW) APPLICATION.
Botrytis leaf blight, **Botrytis rot** (*Botrytis* spp.)		Begin preventative foliar applications when conditions favor disease development and continue at 7-14 day intervals as long as needed to maintain control.
Bottom rot (*Rhizoctonia solani*)		Apply in 30 – 50 gallons of water per acre as a directed spray toward soil surface and lower leaves. Begin applications at head formation, before leaves contact the ground. Repeat every 7-14 days as needed to maintain control.
Lettuce drop (*Sclerotinia* spp.)		Apply in 30 – 50 gallons of water per acre as a directed spray toward soil surface and lower leaves. Make first application to direct-seeded lettuce immediately after emergence. For transplanted lettuce, make first application immediately after transplanting. In both cases, apply prior to disease development. Apply again if soil is disturbed by cultivation or thinning and conditions continue to favor disease development.

* Suppression only. A rate of 6.5 fl. oz./acre may be used for preventative applications before onset of visible disease, in periods of low disease pressure, or in a tank mix with other fungicides for resistance management. Otherwise, use a rate of 13.0 fl. oz./acre.

LEGUME VEGETABLES:
Bean (Lupines spp.), Bean (*Phaseolus* spp., including Field bean, Kidney bean, Lima bean, Navy bean, Pinto bean, Runner bean, Snap bean, Tepary bean, Wax bean), Bean (*Vigna* spp., including Adzuki bean, Asparagus bean, Blackeyed pea, Catjang, Chinese longbean, Cowpea, Crowder pea, Moth bean, Mung bean, Southern pea, Urd bean, Yardlong bean) Broad bean (Fava bean), Chickpea (Garbanzo bean), Guar, Jackbean, Lablab bean (hyacinth bean), Lentil, Pea (*Pisum* spp., including Dwarf pea, Edible pod pea, English pea, Field pea, Garden pea, Green pea, Snow pea, Sugar snap pea), Pigeon pea, Soybean, Sward bean.

DISEASES/PATHOGENS	RATES	ADDITIONAL INFORMATION
Asian Soybean Rust (*Phakopsora pachyrhizi*) **Gray mold** (*Botrytis cinerea*) **Powdery mildew** (*Erysiphe pisi*)	3.75 – 13.0 fl. oz./acre (0.21 – 0.72 oz. a.i./acre) Do not apply more than 4.2 oz. a.i./acre/season (6 appl. at max. rate).	Begin applications at first sign of disease symptoms and repeat on 7-14 day interval as long as conditions favor disease development. Apply as a foliar spray in sufficient water to achieve thorough coverage of all above-ground plant parts. May also be applied through overhead sprinkler irrigation. See “Chemigation Instructions” for additional information.
Stem rot / White mold (*Sclerotinia sclerotiorum*)		Apply in 30 – 50 gallons of water per acre as a directed spray toward soil surface, lower leaves, and stems. May also be applied through overhead sprinkler irrigation. See “Chemigation Instructions” for additional information.

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VEGGIETURBO 5SC (EPA File Symbol 68173-4) • Page 18 of 21
December 12, 2014 Proposed Master Label Fast-Track Amendment
Based upon the December 12, 2012 EPA accepted label.
Adds directions for use on bananas, plantains, herbs and spices and additional apples diseases.
Adds new stone fruit group members.

POME FRUITS: Apple, Crabapple, Loquat, Mayhaw, Pear, Quince		
DISEASES/PATHOGENS	**RATES**	**ADDITIONAL INFORMATION**
Alternaria leaf spot (*Alternaria mali*) **Leaf blotch** (*Diplocarpon mali*) **Powdery mildew** (*Podosphaera leucotricha*, *Phyllactinia mali*) **Scab** (*Venturia* spp.)*	3.75 – 13.0 fl. oz./acre (0.21 – 0.72 oz. a.i./acre) Do not apply more than 4.2 oz. a.i./acre/season (6 appl. at max. rate).	Apply as foliar spray in sufficient water to attain thorough coverage of foliage and fruit. For powdery mildew control, begin as preventative and repeat on 7-14 day interval as needed. Use in an alternating program with a sterol inhibitor (DMI) fungicide. For scab suppression, begin sprays at green tip and continue every 7-10 days as needed.
* Suppression only. A rate of 6.5 fl. oz./acre may be used for preventative applications before onset of visible disease, in periods of low disease pressure, or in a tank mix with other fungicides for resistance management. Otherwise, use a rate of 13.0 fl. oz./acre.		
Alternaria rot (*Alternaria tenuis*) **Bitter rot** (*Glomerella cingulata*) **Cedar apple rust**** (*Gymnosporangium juniperi-virginianae*) **Flyspeck** (*Schizothyrium pomi*, formerly *Microthyriella rubi*) **Sooty blotch** (*Gloeodes pomigena*) **White rot**** (*Botryosphaeria dothidea*)	3.75 - 6.5 fl. oz./acre (0.21 - 0.36 oz. a.i./acre) Do not apply more than 2.16 oz. a.i./acre/season (6 appl. at max. rate).	Begin applications prior to disease development. Repeat at 7-10 day interval as needed. May be applied from green-tip to day of harvest.
** Suppression only.		

POTATOES

DISEASES/PATHOGENS	RATES	ADDITIONAL INFORMATION
Black scurf (*Rhizoctonia solani*)	3.75 – 13.0 fl. oz./acre (0.21 – 0.72 oz. a.i./acre) Do not apply more than 4.2 oz. a.i./acre/season (6 appl. at max. rate).	Apply as banded spray in-furrow at planting, either just before placement of seed pieces or over seed pieces before covering with soil. See additional instructions under BANDED (IN-FURROW) APPLICATION.
Early blight (*Alternaria solani*) **Late blight** (*Phytophthora infestans*)*		Apply as a foliar spray in sufficient water to provide thorough coverage of all foliage. May also be applied through overhead sprinkler irrigation. See "Chemigation Instructions" for additional information. Begin as a preventative application and continue on a 7-14 day interval as needed to maintain control.
White mold (*Sclerotinia sclerotiorum*)		Apply in 30 – 50 gallons of water per acre as a directed spray toward soil surface, lower leaves, and stems. May also be applied through overhead sprinkler irrigation. See "Chemigation Instructions" for additional information.

* Suppression only. A rate of 6.5 fl. oz./acre may be used for preventative applications before onset of visible disease, in periods of low disease pressure, or in a tank mix with other fungicides for resistance management. Otherwise, use a rate of 13.0 fl. oz./acre.

STONE FRUITS:
Apricot (including Japanese), Capulin, Cherry (including Black, Nanking, Sweet, Tart), Jujube (Chinese), Nectarine, Peach, Plum (including American, Beach, Canada, Cherry, Chickasaw, Damson, Japanese, Klamath, prune), Plumcot, Sloe, Cultivars, varieties, and/or hybrids of these.

DISEASES/PATHOGENS	RATES	ADDITIONAL INFORMATION
Botrytis blossom blight (*Botrytis cinerea*) **Powdery mildew** (*Podosphaera* spp., *Sphaerotheca pannosa*)	3.75 – 13.0 fl. oz./acre (0.21 – 0.72 oz. a.i./acre) Do not apply more than 4.2 oz. a.i./acre/season (6 appl. at max. rate).	Apply as foliar spray in sufficient water to attain thorough coverage of foliage and fruit. For powdery mildew control, begin as preventative and repeat on 7-14 day interval as needed. Use in an alternating program with a sterol inhibitor (DMI) fungicide. Apply at full bloom for control of *Botrytis* blossom blight if wet weather occurs during bloom.

SUGAR BEET		
DISEASES/PATHOGENS	**RATES**	**ADDITIONAL INFORMATION**
Cercospora leaf spot (*Cercospora beticola*)	3.75 – 13.0 fl. oz./acre (0.21 – 0.72 oz. a.i./acre) Do not apply more than 4.2 oz. a.i./acre/season (6 appl. at max. rate).	Begin applications at first sign of disease symptoms and repeat on 7-14 day interval as long as conditions favor disease development. Apply as a foliar spray in sufficient water to achieve thorough coverage of all above- ground plant parts. May also be applied through overhead sprinkler irrigation. See “Chemigation Instructions” for additional information.
Rhizoctonia crown and root rot (*Rhizoctonia solani*)		Apply as banded spray or drench in seed furrow at planting. See additional instructions below for banded application rates. Can also be applied through overhead sprinkler irrigation. See “Chemigation Instructions” for additional information. Make subsequent applications at 7-14 day intervals either through chemigation, or as a spray/drench directed at the base of each plant.

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Adds new stone fruit group members.

STORAGE AND DISPOSAL

Do not contaminate water, food or feed by storage or disposal.
PESTICIDE STORAGE: Store in dry place away from food or feed.
PESTICIDE DISPOSAL: Wastes resulting from the use of this product may be disposed of on site or at an approved waste disposal facility.
CONTAINER HANDLING:
[*Containers ≤ 5 gallons:*]
Nonrefillable container. Do not reuse or refill this container. Completely empty container into application equipment. Triple rinse container (or equivalent) promptly after emptying. Triple rinse as follows: Empty the remaining contents into application equipment or a mix tank and drain for 10 seconds after the flow begins to drip. Fill the container ¼ full with water and recap. Shake for 10 seconds. Pour rinsate into application equipment or a mix tank or store rinsate for later use or disposal. Drain for 10 seconds after the flow begins to drip. Repeat this procedure two more times. Then offer for recycling or reconditioning (if available), or puncture and dispose of in a sanitary landfill or by incineration, if allowed by State and local authorities. If burned, stay out of smoke.

[*Containers > 5 gallons:*]
Nonrefillable container. Do not reuse or refill this container. Completely empty container into application equipment. Triple rinse or pressure rinse container (or equivalent) promptly after emptying. *Triple rinse as follows:* Empty the remaining contents into application equipment or a mix tank. Fill the container ¼ full with water. Replace and tighten closures. Tip container on its side and roll it back and forth, ensuring at least one complete revolution, for 30 seconds. Stand the container on its end and tip it back and forth several times. Turn the container over onto its other end and tip it back and forth several times. Empty the rinsate into application equipment or a mix tank or store rinsate for later use or disposal. Repeat this procedure two or more times. *Pressure rinse as follows:* Empty the remaining contents into application equipment or a mix tank and continue to drain for 10 seconds after the flow begins to drip. Hold container upside down over application equipment or mix tank or collect rinsate for later use or disposal. Insert pressure rinsing nozzle in the side of the container, and rinse at about 40 PSI for at least 30 seconds. Drain for 10 seconds after the flow begins to drip. Then offer for recycling or reconditioning (if available), or puncture and dispose of in a sanitary landfill or by incineration, if allowed by State and local authorities. If burned, stay out of smoke.

WARRANTY

Kaken Pharmaceutical Co., Ltd. warrants that the material contained herein conforms to the description on the label and is reasonably fit for the purpose referred to in the directions for use. Timing and method of application, weather, watering practices, nature of soil, the disease problem, condition of the crop, incompatibility with other influencing factors in the use of this product are beyond the control of the seller. Buyer assumes all risks of use, storage, or handling of this material not in strict accordance with directions given herein. TO THE EXTENT CONSISTENT WITH APPLICABLE LAW, NO OTHER EXPRESSED OR IMPLIED WARRANTY OF THE FITNESS OR MERCHANTABILITY IS MADE.

VEGGIETURBO™ is a trademark of Kaken Pharmaceutical Co., Ltd.

Label Version No. _______

2.c. EPA Reg. No. 68173-5: Polyoxin D Zinc Salt 5SC Post-Harvest Fungicide

GROUP 19 FUNGICIDE

Polyoxin D Zinc Salt 5SC Post-Harvest Fungicide

[*Optional statements:*]

For post-harvest use on listed fruits

Polyoxin D Zinc Salt 5SC Post-Harvest Fungicide is a suspension concentrate fungicide of polyoxin D zinc salt for control of certain post-harvest diseases of fruits in storage

Active Ingredient	
Polyoxin D zinc salt*	5.0%
Other Ingredients	95.0%
Total	100.0%

* CAS No. 146659-78-1

Polyoxin D Zinc Salt 5SC Post-Harvest Fungicide is a suspension concentrate fungicide.

Polyoxin D Zinc Salt 5SC Post-Harvest Fungicide contains 7.03 ounces of active ingredient per gallon.

KEEP OUT OF REACH OF CHILDREN

CAUTION

[1 quart, 1 gallon, and 2.5 gallon containers]:
See booklet label for additional precautionary statements and directions for use.
[266 gallon (1000 liter) container]:
See accompanying shipping documents for complete label.

Produced by:
Kaken Pharmaceutical Co., Ltd.
28-8, Honkomagome 2-chome,
Bunkyo-ku, Tokyo
JAPAN 113-8650

Correspondence may be sent to:
Kaken Pharmaceutical Co., Ltd.
c/o Conn & Smith, Inc.
6713 Catskill Road
Lorton, VA 22079-1113

EPA Reg. No. 68173-__
EPA Est. No. ________

NET CONTENTS: 1 Quart (32 Fluid Ounces)
1 Gallon (128 Fluid Ounces)
2.5 Gallons (320 Fluid Ounces)
266 Gallons (1000 Liters)

ACCEPTED
DEC 11 2014
Under the Federal Insecticide, Fungicide, and Rodenticide Act, as amended, for the pesticide registered under EPA Reg. No.
68173-5

[1 quart, 1 gallon, and 2.5 gallon containers]:
VIGOROUSLY SHAKE THE PRODUCT CONTAINER BEFORE MIXING.
[266 gallon (1000 liter) container]: **MIX THOROUGHLY BEFORE USE.**

Optional Statements (EPA Category IV toxicity for acute oral, acute dermal, acute inhalation, eye irritation and dermal irritation)

FIRST AID	
IF ON SKIN OR CLOTHING:	• *Take off contaminated clothing.* • *Rinse skin immediately with plenty of water for 15-20 minutes.* • *Call a poison control center or doctor for treatment advice.*
IF IN EYES:	• *Hold eye open and rinse slowly and gently with water for 15-20 minutes.* • *Remove contact lenses, if present, after the first 5 minutes, then continue rinsing eye.* • *Call a poison control center or doctor for further treatment advice.*
IF SWALLOWED:	• *Call a poison control center or doctor immediately for treatment advice.* • *Have person sip a glass of water if able to swallow.* • *Do not induce vomiting unless told to do so by the poison control center or doctor.* • *Do not give anything to an unconscious person.*
IF INHALED:	• *Move person to fresh air.* • *If person is not breathing, call 911 or an ambulance, then give artificial respiration, preferably mouth-to-mouth if possible.* • *Call a poison control center or doctor for further treatment advice.*
HOTLINE NUMBERS *Have the product container or label with you when calling a poison control center or doctor, or going for treatment. FOR 24-HOUR EMERGENCY MEDICAL ASSISTANCE, call 1-800-255-3924.*	

PRECAUTIONARY STATEMENTS

HAZARDS TO HUMANS & DOMESTIC ANIMALS

Caution. Prolonged or frequently repeated skin contact may cause allergic reactions in some individuals. Avoid contact with skin and clothing. Wash thoroughly with soap and water after handling and before eating, drinking, chewing gum, using tobacco, or using the toilet. Remove and wash contaminated clothing before reuse.

ENVIRONMENTAL HAZARDS

[For 1 quart, 1 gallon and 2.5 gallon containers:]
This pesticide is moderately toxic to aquatic invertebrates and fish. Do not contaminate water when disposing of equipment wash water or rinsate. Observe the most restrictive labeling limitations and precautions of all products used in mixtures.

[For 266 gallon (1000 liter) container:]
This pesticide is moderately toxic to aquatic invertebrates and fish. Do not contaminate water when disposing of equipment wash water or rinsate. Observe the most restrictive labeling limitations and precautions of all products used in mixtures. Do not discharge effluent containing this product into lakes, streams, ponds, estuaries, oceans, or other waters unless in accordance with the requirements of a National Pollutant Discharge Elimination System (NPDES) permit and the permitting authority has been notified in writing prior to discharge. Do not discharge effluent containing this product to sewer systems without previously notifying the local sewage treatment plant authority. For guidance contact your State Water Board or Regional Office of the EPA.

DIRECTIONS FOR USE

It is a violation of Federal law to use this product in a manner inconsistent with its labeling.

For any requirements specific to your State or Tribe, consult the State or Tribal agency responsible for pesticide regulation.

Do not formulate this product into other end-use products.

PRODUCT INFORMATION

FAILURE TO FOLLOW THE DIRECTIONS FOR USE AND PRECAUTIONS ON THIS LABEL MAY RESULTS IN POOR DISEASE CONTROL.

Polyoxin D Zinc Salt 5SC Post-Harvest Fungicide is a protective fungicide used to aid in the control of several post-harvest diseases **in post-harvest treatment facilities**.

For post-harvest control of Gray mold (caused by *Botrytis cinerea*), Alternaria rot (caused by *Alternaria alternata*), and Brown Rot (caused by *Monilinia fructicola*), and suppression of Rhizopus Rot (caused by *Rhizopus stolonifer*) and Sour Rot (caused by *Geotrichum candidum*) on Pome Fruit, Pomegranates, and Stone fruit.

Polyoxin D Zinc Salt 5SC Post-Harvest Fungicide may be tank mixed or alternated with other post-harvest fungicides (*e.g.*, Scholar® SC, Scholar® Max MP, Graduate® SC, Graduate® A+, Graduate® Max MP, Alumni®, or Mertect® 340F) for resistance management or extended efficacy.

GROUP 19 FUNGICIDE

Polyoxin D Zinc Salt 5SC Post-Harvest Fungicide contains a fungicide classified in FRAC target site of action Group 19. Fungal isolates with acquired resistance to Group 19 may eventually dominate the fungal population if Group 19 fungicides are used repeatedly in the same field or in successive years as the primary method of control for targeted species. This may result in partial or total loss of control of those species by Polyoxin D Zinc Salt 5SC Post-Harvest Fungicide or other Group 19 Fungicides.
The following actions may prevent or delay fungicide resistance:

- Avoid consecutive use of Polyoxin D Zinc Salt 5SC Post-Harvest Fungicide or other Group 19 fungicides against the same pathogens.
- Use tank-mixes or premixes with fungicides from different target site of action Groups. Do this only with products that are registered for the same use and are effective at the tank mix or premix rate against the target pathogen(s).
- Use fungicides as part of a comprehensive Integrated Pest Management (IPM) program.
- Monitor treated fungal populations for loss of field efficacy.

Contact your local extension specialist, certified crop advisor, and/or manufacture representative for fungicide resistance management and/or IPM recommendations for specific crops and resistant pathogens.

MIXING PROCEDURES

[For 1 quart, 1 gallon and 2.5 gallon containers:]
Vigorously shake the product container before mixing. Prepare no more spray mixture than is needed for the immediate operation. Thoroughly clean spray equipment before using this product. Vigorous

agitation is necessary for proper dispersal of the product. Maintain maximum agitation throughout the spraying operation. Do not let the spray mixture stand overnight in the spray tank. Flush the spray equipment thoroughly following each use.

[For 266 gallon (1000 liter) container:]
Thoroughly agitate product when product is in use.

To determine the physical compatibility of Polyoxin D Zinc Salt 5SC Post-Harvest Fungicide with other products, use a jar test as described below.

JAR COMPATIBILITY TEST: Using a quart jar, add the proportionate amounts of the products to 1 qt of water or wax/oil emulsion. Add wettable powders and water dispersible granular products first, then liquid flowables, and emulsifiable concentrates last. After thoroughly mixing, let stand for at least 5 minutes. If the combination remains mixed or can be remixed readily, it is physically compatible. Once compatibility has been proven, use the same procedure for adding required ingredients to the spray tank.

If using Polyoxin D Zinc Salt 5SC Post-Harvest Fungicide in a tank mixture, observe all directions for use, crops/sites, use rates, dilution ratios, precautions and limitations which appear on the tank mix product label. Do not exceed label dosage rates. The most restrictive label precautions and limitations must be followed. This product must not be mixed with any product which prohibits such mixing. Tank mixtures are permitted only in those states where the tank mix partner is registered.

THE CROP SAFETY OF ALL POTENTIAL TANK MIXES INCLUDING ADDITIVES AND OTHER PESTICIDES ON ALL CROPS HAS NOT BEEN TESTED. BEFORE APPLYING ANY TANK MIXTURE, THE SAFETY TO THE TARGET CROP SHOULD BE CONFIRMED.

Add ½ of the required amount of water or wax/oil emulsion (or aqueous dilution of a wax/oil emulsion) to the spray or mixing tank. With the agitator running, open the container and add the Polyoxin D Zinc Salt 5SC Post-Harvest Fungicide to the tank Continue agitation while adding the remainder of the carrier. Begin application of the solution after the Polyoxin D Zinc Salt 5SC Post-Harvest Fungicide has completely and uniformly dispersed into the mix carrier. Maintain agitation until all of the mixture has been applied.

If tank-mixing, add the desired amount of other products recommended for tank mixture after Polyoxin D Zinc Salt 5SC Post-Harvest Fungicide has completely and uniformly dispersed into the mix carrier. Add tank mix partners in this order unless label directions or other considerations indicate otherwise wettable powders, wettable granules (dry flowables), liquid flowables, liquids, and emulsifiable concentrates. Always allow each tank mix partner to become fully dispersed before adding the next product. Continue agitation to maintain a uniform suspension until all of the spray solution has been applied. Maintain agitation until all of the mixture has been applied.

To assess the potential for phytotoxicity, test tank mixtures on a small number of plants prior to more widespread application.

CROP USE DIRECTIONS

It is a violation of Federal law to use this product in a manner inconsistent with its labeling.

<table>
<tr><th colspan="4">POME FRUIT</th></tr>
<tr><th>Application Method</th><th>Disease</th><th>Rate (fl. oz.)</th><th>Remarks</th></tr>
<tr><td>In-line Dip, Drench or aqueous Spray</td><td>Gray Mold or
Botrytis Fruit Rot
(Botrytis cinerea)

Alternaria Rot
(Alternaria alternata)</td><td>3.5-16 fl. oz./100 gal</td><td>• Mix 3.5-16 fl. oz. of product in 100 gallons of water carrier.
• Treat for approximately 15-30 seconds and allow fruit to drain.
• Make no more than one application.
• Make an application either before storage or after storage prior to shipping.</td></tr>
<tr><td colspan="4">• Pome Fruit includes - Apple (Malus domestica); Azarole (Crataegus azarolus); Crabapple (Malus spp.); Loquat (Eriobotrya japonica); Mayhaw (Cratagus aestivalis, C. opaca, and C. rufula); Medlar (Mespilus germanica); Pear (Pyrus communis); Pear, Asian (Pyrus spp.); Quince (Cydonia oblonga); Quince, Chinese (Chaeonomeles speciosa); Quince, Japanese (Chaenomeles japonica); Tejocote (Crataegus mexicana) and cultivars, varieties and/or hybrids of these.</td></tr>
<tr><td colspan="4">Recommendations
• Do not apply in a wax. If applied with wax or fruit coating on the same line, apply Polyoxin D Zinc Salt 5SC Post-Harvest Fungicide FIRST, then apply the wax or fruit coating second in sequence.
• Ensure the solution remains in suspension by using agitation.
• If a chlorine based product (such as sodium hypochlorite) is to be used to address bacteria and organic load in the dip or drench tank, follow these steps: first replenish with the required amount of chlorinated product, then water and the appropriate volume of fungicide, and adjust the solution pH to between 5.0-7.0, and then replenish the appropriate amount of Polyoxin D Zinc Salt 5SC Post-Harvest Fungicide.
• Maintain the spray solution at a pH between 5.0 and 7.0 to extend the solution half-life.
• Minimize exposure to Polyoxin D Zinc Salt 5SC Post-Harvest Fungicide, spray mixture solution, and Polyoxin D Zinc Salt 5SC Post-Harvest Fungicide treated fruit to light.</td></tr>
</table>

POMEGRANATE

Application Method	Disease	Rate (fl. oz.)	Remarks
In-line Dip, Drench or aqueous Spray	Gray Mold or Botrytis Fruit Rot (*Botrytis cinerea*)	3.5-16 fl. oz./100 gal	• Mix 3.5-16 fl. oz. of product in 100 gallons of water carrier. • Treat for approximately 15-30 seconds and allow fruit to drain. • Make no more than one application. • Make an application either before storage or after storage prior to shipping.

Recommendations

- Do not apply in a wax. If applied with wax or fruit coating on the same line, apply Polyoxin D Zinc Salt 5SC Post-Harvest Fungicide FIRST, then apply the wax or fruit coating second in sequence.
- Ensure the solution remains in suspension by using agitation.
- If a chlorine based product (such as sodium hypochlorite) is to be used to address bacteria and organic load in the dip or drench tank, follow these steps: first replenish with the required amount of chlorinated product, then water and the appropriate volume of fungicide, and adjust the solution pH to between 5.0-7.0, and then replenish the appropriate amount of Polyoxin D Zinc Salt 5SC Post-Harvest Fungicide.
- Maintain the spray solution at a pH between 5.0 and 7.0 to extend the solution half-life.
- Minimize exposure to Polyoxin D Zinc Salt 5SC Post-Harvest Fungicide, spray mixture solution, and Polyoxin D Zinc Salt 5SC Post-Harvest Fungicide treated fruit to light.

STONE FRUIT

Application Method	Disease	Rate (fl. oz.)	Remarks
In-line Dip, Drench or aqueous Spray	Gray Mold (*Botrytis cinerea*) Brown Rot (*Monilinia fructicola*) Suppression of Rhizopus Rot (*Rhizopus stolonifer)* and Sour Rot (*Geotrichum candidum*)	3.5-16 fl. oz./100 gal	• Mix 3.5-16 fl. oz. of product in 100 gallons of water carrier. • Treat for approximately 15-30 seconds and allow fruit to drain. • For Rhizopus Rot and/or Sour Rot use highest rate. • Make no more than one application. • Make an application either before storage or after storage prior to shipping.

- Stone Fruit Includes - Apricot (*Prunus armeniaca*); Apricot, Japanese (*Prunus mume*); Capulin (*Prunus serotina*); Cherry, black (*Prunus serotina*); Cherry, Nanking (*Prunus tomentosa*); Cherry, sweet (*Prunus avium*); Cherry, tart (*Prunus cerasus*); Jujube, Chinese (*Ziziphus jujuba*); Nectarine (*Prunus persica*); Peach (*Prunus persica*); Plum (*Prunus domestica*); Plum, American (*Prunus americana*); Plum, beach (*Prunus maritima*); Plum, Canada (*Prunus nigra*); Plum, cherry (*Prunus cerasifera*); Plum, Chickasaw (*Prunus angustifolia*); Plum, Damson (*Prunus domestica*); Plum, Japanese (*Prunus salicina*); Plum, Klamath (*Prunus subcordata*); Plum, prune (*Prunus domestica*); Plumcot (*Prunus* hybr.); Sloe (*Prunus spinosa*); Cultivars, varieties, and/or hybrids of these.

Recommendations

- Do not apply in a wax. If applied with wax or fruit coating on the same line, apply Polyoxin D Zinc Salt 5SC Post-Harvest Fungicide FIRST, then apply the wax or fruit coating second in sequence.
- Ensure the solution remains in suspension by using agitation.
- Maintain the spray solution at a pH between 5.0 and 7.0 to extend the solution half-life.
- Minimize exposure to Polyoxin D Zinc Salt 5SC Post-Harvest Fungicide, spray mixture solution, and Polyoxin D Zinc Salt 5SC Post-Harvest Fungicide treated fruit to light.

STORAGE AND DISPOSAL

Do not contaminate water, food or feed by storage or disposal.

PESTICIDE STORAGE: Store in original container only. Keep container closed when not on use. Store in dry place away from food or feed. In case of spill on floor or paved surfaces, mop and remove to chemical waste storage area until proper disposal can be made if product cannot be used according to the label. Take special care to avoid contamination of equipment and facilities during cleanup procedures and disposal of wastes.

PESTICIDE DISPOSAL: Improper disposal of unused pesticide, spray mixture, or rinsate is a violation of Federal law. If these wastes cannot be disposed of by use according to the label instructions, contact your State Pesticide or Environmental Control Agency, or the Hazardous Waste representative of the nearest EPA Regional Office for guidance.

CONTAINER HANDLING:
[containers up to and including 5 gallons]:
Nonrefillable container. Do not reuse or refill this container. Completely empty container into application equipment. Triple rinse (or equivalent). Then offer for recycling or reconditioning (if available), or puncture and dispose of in a sanitary landfill or by incineration, if allowed by State and local authorities. If burned, stay out of smoke.

[containers larger than 5 gallons]:
Nonrefillable container. Do not reuse or refill this container. Completely empty container into application equipment. Triple rinse or pressure rinse container (or equivalent) promptly after emptying.

Triple rinse as follows: Empty the remaining contents into application equipment or a mix tank. Fill the container ¼ full with water. Replace and tighten closures. Tip container on its side and roll it back and forth, ensuring at least one complete revolution, for 30 seconds. Stand the container on its end and tip it back and forth several times. Turn the container over onto its other end and tip it back and forth several times. Empty the rinsate into application equipment or a mix tank or store rinsate for later use or disposal. Repeat this procedure two or more times.

Pressure rinse as follows: Empty the remaining contents into application equipment or a mix tank and continue to drain for 10 seconds after the flow begins to drip. Hold container upside down over application equipment or mix tank or collect rinsate for later use or disposal. Insert pressure rinsing nozzle in the side of the container, and rinse at about 40 PSI for at least 30 seconds. Drain for 10 seconds after the flow begins to drip.

Then offer for recycling or reconditioning (if available), or puncture and dispose of in a sanitary landfill or by incineration, if allowed by State and local authorities. If burned, stay out of smoke.

CONTAINER IS NOT SAFE FOR FOOD, FEED OR DRINKING WATER.

CONDITIONS OF SALE AND LIMITATION OF WARRANTY AND LIABILITY

NOTICE. Read the entire direction for Use And Conditions of Sale and limitations of Warranty and Liability before buying or using this product. If the terms are not acceptable, return the product at once, unopened, and the purchase price will be refunded.

The Directions for Use of this product must be followed carefully. It is impossible to eliminate all risks inherently associated with the use of this product. Crop injury, ineffectiveness, or other unintended consequences may result because of such factors as manner of use or application, weather or crop conditions, presence of other materials, or other influencing factors in the use of the product which are beyond the control of Kaken Pharmaceutical Co., Ltd. (KAKEN) or Seller. To the extent permitted by applicable law, Buyer and User agree to hold KAKEN and Seller harmless for any claims relating to such factors.

KAKEN warrants that this product conforms to the chemical description on the label and is reasonably fit for the purposes stated in the Directions for Use, subject to the inherent risks referred to above, when used in accordance with directions under normal use conditions. To the extent permitted by applicable law, (1) this warranty does not extend to the use of the product contrary to label instructions or under conditions not reasonably foreseeable to or beyond the control of Seller or KAKEN, and, (2) Buyer and User assume the risk of any such use TO THE EXTENT PERMITTED BY APPLICABLE LAW. KAKEN MAKES NO WARRANTIES OF MERCHANTABILITY OR OF FITNESS FOR A PARTICULAR PURPOSE NOR ANY OTHER EXPRESS OR IMPLIED WARRANTY EXCEPT AS WARRANTED BY THIS LABEL.

To the extent permitted by applicable law, in no event shall KAKEN be liable for any incidental, consequential or special damages resulting from the use or handling of this product. **TO THE EXTENT PERMITTED BY APPLICABLE LAW, THE EXCLUSIVE REMEDY OF THE USER OR BUYER, AND THE EXCLUSIVE LIABILITY OF KAKEN AND SELLER FOR ANY AND ALL CLAIMS, LOSSES, INJURIES OR DAMAGES (INCLUDING CLAIMS BASED ON BREACH OF WARRANTY, CONTRACT, NEGLIGENCE, TORT, STRICT LIABILITY OR OTHERWISE) RESULTING FROM THE USE OR HANDLING OF THIS PRODUCT, SHALL BE THE RETURN OF THE PURCHASE PRICE OF THE PRODUCT OR, AT THE ELECTION OF KAKEN OR SELLER, THE REPLACEMENT OF THE PRODUCT.**

KAKEN and Seller offer this product, and Buyer and User accept it, subject to the foregoing Conditions of Sale and Limitation of Warranty and Liability, which may not be modified except by written agreement signed by a duly authorized representative of KAKEN.

2.d. EPA Reg. No. 70051-116: Novel 0.5%SC Fungicide

ACCEPTED

MAR - 5 2014

Under the Federal Insecticide, Fungicide, and Rodenticide Act, as amended, for the pesticide registered under EPA Reg. No. 70051-116

Novel™ 0.5%SC Fungicide

Alternate Brand Names:
Novel™ Suspension Concentrate Fungicide
Novel™ SC Fungicide
Novel™ Fungicide

(Development Code: CX-10455)

For Use on Vegetables, Fruits, Nuts, Flowers, Houseplants, Ornamental Plants, Roses, Trees and Shrubs in Home Gardens or Containers (Indoors or Outdoors), and Turfgrass in Residential Lawns

For Use In and Around the Home and Home Garden

Controls Black Spot, Powdery Mildew, Rust, Blight, Anthracnose, *Botrytis*, *Alternaria*, Turf Diseases and Other Fungi

Can be Used up to Day of Harvest

Active Ingredient:	
Polyoxin D zinc salt	0.5%
Other Ingredients	99.5%
Total	100.0%

Contains 0.7 ounces of active ingredient per gallon.

KEEP OUT OF REACH OF CHILDREN
CAUTION

**See side panel for additional Precautionary Statements –or-
See attached booklet for additional Precautionary Statements, First Aid Statements, Directions for Use, and Storage and Disposal Statements**

Manufactured by
Certis USA, L.L.C.
9145 Guilford Road
Suite 175
Columbia, MD 21046

Net contents: ____________

EPA Reg. No. 70051-116
EPA Est. No. 70051-CA-001
Lot No. ____________

CERTIS

FIRST AID

If in eyes: Hold eye open and rinse slowly and gently with water for 15-20 minutes. Remove contact lenses, if present, after the first 5 minutes, then continue rinsing eye. Call a poison control center or doctor for treatment advice.
If on skin or clothing: Take off contaminated clothing. Rinse skin immediately with plenty of water for 15-20 minutes. Call a poison control center or doctor for treatment advice.

Have the product container or label with you when calling a poison control center or doctor, or going for treatment. Hot Line Number: 1-800-255-3924.

PRECAUTIONARY STATEMENTS
HAZARDS TO HUMANS & DOMESTIC ANIMALS

CAUTION: Prolonged or frequently repeated skin contact may cause allergic reactions in some individuals. Avoid Contact with skin and clothing. Wash thoroughly with soap and water after handling and before eating, drinking, chewing gum, using tobacco, or using the toilet. Remove and wash contaminated clothing before reuse.

ENVIRONMENTAL HAZARDS STATEMENT

For terrestrial uses. This product is moderately toxic to aquatic invertebrates and fish. To protect the environment, do not allow pesticide to enter or run off into storm drains, drainage ditches, gutters or surface waters. Applying this product in calm weather when rain is not predicted for the next 24 hours will help to ensure that wind or rain does not blow or wash pesticide off the treatment area. Rinsing application equipment over the treated area will help avoid run off to water bodies or drainage systems.

GENERAL INFORMATION

Novel™ 0.5%SC Fungicide controls fungi that cause plant disease by interfering with the formation of fungal cell walls. It can be used on all food and non-food crops, including vegetables, fruits, flowers, foliage plants, ornamental shrubs, and turf grasses in residential lawns.

DIRECTIONS FOR USE

It is a violation of Federal Law to use this product in a manner inconsistent with its labeling.

SHAKE WELL BEFORE USE.

Novel™ 0.5%SC Fungicide is a concentrate and must be diluted before application by mixing with clean water.

Do not use a sprayer or container that has been used to mix or apply weed killers or other herbicides.

Mix only the amount of spray solution needed to treat the desired area. Apply immediately after mixing Novel™ 0.5%SC Fungicide with water. Do not allow mixture to stand for extended periods.

Stir or shake the mixture thoroughly before spraying to ensure uniform mixing.

Unless otherwise indicated in the additional directions provided below, begin as a preventative spray when conditions favor disease development. Repeat applications every 7 to 14 days as needed to maintain disease control.

FOR USE ON VEGETABLES, FRUITS, AND NUTS IN HOME GARDENS

Mix 1 to 2 teaspoons of Novel™ 0.5%SC Fungicide per quart of clean water (equivalent to 1:200 or 1:100 dilution by volume).

The lower rate (1 teaspoon per quart) may be used in preventative applications before disease symptoms are visible.

Use the higher rate (2 teaspoons per quart) when symptoms are already visible to prevent further development of disease, or when "suppression" is indicated.

Application method and timing:

Unless instructed otherwise under "**Additional Instructions for Specific Plants/Diseases**" (below):

Apply diluted Novel™ 0.5%SC Fungicide as a fine spray to foliage, flowers, fruit, and other above ground plant parts using a hand pump sprayer, garden sprayer, mister, or other suitable sprayer to uniformly wet the plant without excessive dripping. Do not apply to wilted or otherwise stressed plants, to newly-transplanted plants, or to seedlings prior to root establishment.

For best results, begin as a preventative spray when conditions favor disease development.

Repeat applications every 7 to 14 days as needed to maintain disease control.

Diseases controlled or suppressed by Novel™ 0.5%SC Fungicide: See additional instructions in the table below for those diseases marked with an asterisk (*).

Alternaria blight
Anthracnose (*Colletotrichum* species)
Apple scab (*Venturia inaequalis*) suppression*
Black scurf of potato (*Rhizoctonia solani*)*
Botrytis blossom blight*
Bottom rot of lettuce and cabbage (*Rhizoctonia*)*
Brown spot of citrus (*Alternaria alternata*)*
Bunch rot of grapes*
Crown and root rots (*Rhizoctonia, Cylindrocarpon*)*
Damping off (*Botrytis*) in lettuce and other leafy vegetables grown from seed*
Downy mildew (suppression)
Early blight
Fruit rots caused by *Alternaria, Botrytis*, other fungi*
Gray mold (*Botrytis cinerea*)
Leaf blotch of apples (*Diplocarpon mali*)
Leaf mold of tomatoes (*Fulvia, Cladosporium*, or *Passalora*)
Leaf spots caused by *Alternaria, Cercospora*, other fungi
Lettuce drop (*Sclerotinia* species)*
Neck rot (*Botrytis*) of onions and garlic
Powdery mildew
Purple blotch (*Alternaria*) of onions and garlic
Rusts
Sclerotinia rot
Septoria spot of citrus*
Southern blight (*Sclerotium rolfsii*)*
Verticillium wilt (suppression)*
White mold/stem rot (*Sclerotinia sclerotiorum*)*
White spot of cabbage and other cole crops

***Additional Instructions for Specific Plants/Diseases:**

Disease	Additional Instructions
Apple scab (suppression)	Begin sprays as soon as green tips are visible on buds. Repeat every 7 – 10 days as needed.
Black scurf of potato	Spray over seed potatoes in the planting hole or furrow before covering with soil.
Botrytis blossom blight	Apply at full bloom if wet weather occurs during the bloom period
Bottom rot of lettuce and cabbage	Begin applications at head formation, before leaves contact the ground. Direct the spray toward the soil surface and lower leaves. Repeat every 7 – 14 days as needed to maintain control.
Brown spot of citrus	Apply as preventative foliar spray before disease is visible, when new growth is ¼ to ½ expanded. Make a second application (if needed) to fully expanded new growth.
Bunch rot of grapes Fruit rots	Begin preventive applications at flowering. Repeat every 7 – 14 days as long as conditions favor disease. More frequent reapplication (every 3 – 7 days) may be needed under wet conditions such as extended rainfall or fog.
Crown and root rots	Apply 4 – 6 fl. oz. of diluted Novel™ 0.5%SC Fungicide as a soil drench at the base of each plant, within 2 weeks after plant emergence. Repeat every 2 – 4 weeks.
Damping off in leafy vegetables grown from seed	Spray a narrow band (about 4" wide) directly over the line of seeds before covering with soil.
Lettuce drop	Make the first application immediately after plant emergence or transplanting, before disease is evident. Repeat application if soil is disturbed by cultivation or thinning and conditions are still conducive to disease development.
Septoria spot of citrus	Apply as a preventative spray in late fall or early winter, just before or after the first rain. Additional applications may be necessary during seasons of heavy rainfall.
Southern blight *Verticillium* wilt (suppression)	If planting seeds, spray or drench diluted Novel™ 0.5%SC Fungicide directly over the seeds before covering with soil. After plant emergence (or transplanting), spray the base of each plant every 7 – 14 days.
White mold Stem rot	Spray the lower leaves, stems, and immediate soil surface around the base of the plant. Repeat every 7 – 14 days as long as conditions favor disease development.

FOR USE ON FLOWERS, FOLIAGE PLANTS, SHRUBS, ROSES, AND OTHER ORNAMENTAL PLANTS (INDOORS AND OUTDOORS)

Mix 1 to 2 teaspoons of Novel™ 0.5%SC Fungicide per quart of clean water (equivalent to 1:200 or 1:100 dilution by volume).

The lower rate (1 teaspoon per quart) may be used in preventative applications before disease symptoms are visible.

Use the higher rate (2 teaspoons per quart) when symptoms are already visible to prevent further development of disease, when "suppression" is indicated, or for control of root and crown diseases.

For control or suppression of the following diseases affecting foliage, flowers, or fruit:

Alternaria blight
Anthracnose (*Colletotrichum* species)
Apple scab (*Venturia inaequalis*) suppression
Black spot of roses (*Diplocarpon rosae*)
Botrytis blight (*Botrytis cinerea*)
Curvularia blight
Downy mildew (suppression)
Petiole rot (*Myrothecium*)
Powdery mildew
Rhizoctonia aerial blight

Apply as a fine spray to foliage, flowers, fruit, and other above ground plant parts using a hand pump sprayer, garden sprayer, mister, or other suitable sprayer to uniformly wet the plant without excessive dripping. Begin preventative applications when conditions are conducive to disease and before disease symptoms appear. Repeat application every 7 to 14 days as needed to maintain control (unless indicated otherwise below).

Novel™ 0.5%SC Fungicide may harm flowers and other tender tissues of sensitive plant species such as baby's breath (*Gypsophila*), impatiens, fuchsia, hibiscus, and some varieties of roses and carnations. Do not apply directly to flowers without prior testing on a small number of plants. Do not apply to wilted or otherwise stressed plants, to newly-transplanted plants, or to seedlings prior to root establishment.

For control of Black root rot (*Thielaviopsis*) and *Rhizoctonia* crown and root rot:

Use the higher rate (2 teaspoons per quart). Thoroughly drench the soil at the base of the plant with at least 4 fluid ounces of diluted Novel™ 0.5%SC Fungicide per plant. Repeat every 14 to 28 days.

FOR USE ON TURF GRASSES IN RESIDENTIAL LAWNS

To control brown patch and large patch (caused by *Rhizoctonia solani*): Mix 1½ fluid ounces (3 tablespoons) of Novel™ 0.5%SC Fungicide per gallon of clean water and apply as a spray to the affected turf area.

To control foliar and basal Anthracnose and *Curvularia* blight: Mix 3 fluid ounces (6 tablespoons) of Novel™ 0.5%SC Fungicide per gallon of clean water and apply as a spray to the affected turf area.

Apply at least 2 gallons of spray mix per 1,000 square feet of treated area. Repeat application every 7 to 14 days during periods when environmental conditions favor disease development. If disease symptoms are already visible, repeat every 7 days.

For best results, apply after mowing.

Used as directed above, Novel™ 0.5%SC Fungicide will aid in suppression of these other turf diseases:

- *Rhizoctonia* damping off
- Gray leaf spot
- Gray snow mold
- Leaf spot/melting out
- Pink snow mold
- Red thread
- Waitea patch
- Yellow patch (cool weather brown patch)
- Zoysia patch

For suppression and short term control of Fairy Ring: Mix 1½ fluid ounces (3 tablespoons) of Novel™ 0.5%SC Fungicide per gallon of clean water and apply as a spray to the affected turf area. Apply at least 2 gallons of spray mix per 1,000 square feet of treated area. Immediately after each application, water in the treatment with sufficient sprinkler irrigation (⅛ – ¼") to wet the active root zone. Make 2 to 3 applications at 7 day intervals.

HOSE END SPRAYER INSTRUCTIONS

The sprayer attached to the container is ready to use. Simply attach the container to your garden hose and follow these instructions:

1. Insure the large, round "on/off" knob is set to OFF.
2. Turn on water.

3. PUSH IN the small knob near front of sprayer, allowing water and product to mix.
4. Hold sprayer and container level and point towards area to be sprayed.
5. Turn large, round "on/off" knob to ON.
6. Begin spraying product evenly over the area you wish to treat.
7. Spray until the area is visibly wet.
8. To stop spraying, turn the large, round "on/off" knob to OFF.
9. PULL OUT the small knob near front of sprayer, preventing the product from mixing with water.
10. Turn off water at the faucet. Relieve water pressure in the hose by turning the large, round "on/off" knob ON until water pressure is reduced.
11. Turn the knob to OFF for disposal of empty container.

Covers 5,000 square feet or equivalent per 32 fluid ounce container size. Single use container. Do not store unused product for later use.

Alternate (Optional) Hose End Sprayer Instructions:

The sprayer attached to the container is ready to use. Simply attach to your garden hose and follow these instructions:

1. Connect sprayer to hose.
2. Turn on water.
3. To begin spraying, point nozzle in the direction you want to spray.
4. Bend plastic tab back and turn knob back to ON position.
5. Spray evenly onto area being treated.
6. To stop spraying, turn knob to OFF position.
7. Turn off water.
8. Relieve water pressure by bending plastic tab back and turning knob to ON position until water slows to a drip. Then turn knob back to OFF position.
9. Disconnect sprayer from hose.

STORAGE & DISPOSAL

Do not contaminate water, food, ro feed by storage or disposal.

Pesticide storage: Keep in original container. Keep container tightly sealed when not in use. Store at room temperature out of direct sunlight and away from food.

Pesticide & container handling: Non-refillable container. Do not reuse or refill this container.

For containers less than 5 gallons:

If empty: Place in trash or offer for recycling if available.

If partly filled: Call your local solid waste agency or 1-800- CLEANUP for disposal instructions. Never place unused product down any indoor or outdoor drain.

For containers greater than 5 gallons:

Triple rinse as follows: Empty the remaining contents into application equipment or a mix tank. Tip container on its side and roll it back and forth, ensuring at least one complete revolution, for 30 seconds. Stand the container on its end and and tip it back and forth several times. Turn the container over onto its other end and tip it back and forth several times. Empty the rinsate into application equipment or a mix tank or store rinsate for later use or disposal. Repeat the procedure two more times.

Then offer for recycling, if available, or puncture or dispose of in a sanitary landfill, or by incineration, or if allowed by state and local authorities, by burning. If burned, stay out of smoke.

WARRANTY

Certis USA, L.L.C. warrants that the material contained herein conforms to the description on the label and is reasonably fit for the purposes referred to in the directions for use. Timing and method of application, weather, watering practices, nature of soil, the disease problem, condition of the target plants, incompatibility with other chemicals not specifically recommended, and other influencing factors in the use of this product are beyond the control of the seller. To the extent consistent with applicable law, buyer assumes all risks of use, storage or handling of this material not in strict accordance with directions given herein. NO OTHER EXPRESS OR IMPLIED WARRANTY OF THE FITNESS OR MERCHANTABILITY IS MADE.

3. Pending EPA Label

3.a. EPA Reg. No. 68173-4: Veggieturbo 5SC Suspension Concentrate Fungicide

May 17, 2016 Proposed Master Label Fast-Track Amendment
Based upon the January 29, 2015 EPA accepted label.
New disease claims added.

[Front Panel]

GROUP 19 FUNGICIDE

VEGGIETURBO™ 5SC

Suspension Concentrate Fungicide

Optional text:

For Control of Fungal Diseases of Listed Vegetable and Fruit Crops
Biofungicide For Control of Fungal Diseases of Listed Vegetable and Fruit Crops
Biochemical Fungicide For Control of Fungal Diseases of Listed Vegetable and Fruit Crops
Biofungicide
Biochemical Fungicide

Active Ingredient	
Polyoxin D zinc salt	5.0%
Other Ingredients	95.0%
Total	100.0%

Contains 7.03 ounces of active ingredient per gallon.

KEEP OUT OF REACH OF CHILDREN

CAUTION

See back panel for additional precautionary statements.
[Alternate statements:]
See below for additional precautionary statements.
See inside panel for additional precautionary statements.
See inside panels for additional precautionary statements.
See inside panels for additional precautionary statements and directions for use.
See inside panels for additional Precautionary Statements, First Aid Statements, Directions for Use, and Storage and Disposal Statements.
See inside panels for complete label.
See booklet for additional precautionary statements.
See booklet for additional precautionary statements and directions for use.
See booklet for additional precautionary statements, directions for use, and storage and disposal statement.
See booklet for complete label
See attached booklet for additional Precautionary Statements, First Aid Statements, Directions for Use, and Storage and Disposal Statements.

[*Containers up to 2.5 gallons:*]
SHAKE WELL BEFORE USE

Produced by:
Kaken Pharmaceutical Co., Ltd.
28-8, Honkomagome 2-chome, Bunkyo-ku,
Tokyo, JAPAN 113-8650

EPA Reg. No. 68173-4
EPA Est. No. ________________

NET CONTENTS: **1 Quart (32 Fluid Ounces)**
1 Gallon (128 Fluid Ounces)
2.5 Gallons (320 Fluid Ounces)
266 Gallons (1000 Liters)

[Back Panel]

PRECAUTIONARY STATEMENTS
HAZARDS TO HUMANS & DOMESTIC ANIMALS

Caution. Prolonged or frequently repeated skin contact may cause allergic reactions in some individuals. Avoid contact with skin and clothing. Wash thoroughly with soap and water after handling and before eating, drinking, chewing gum, using tobacco, or using the toilet. Remove and wash contaminated clothing before reuse.

Optional Statements (EPA Category IV toxicity for acute oral, acute dermal, acute inhalation, eye irritation and dermal irritation)	
FIRST AID	
IF ON SKIN OR CLOTHING:	• *Take off contaminated clothing.* • *Rinse skin immediately with plenty of water for 15-20 minutes.* • *Call a poison control center or doctor for treatment advice.*
IF IN EYES:	• *Hold eye open and rinse slowly and gently with water for 15-20 minutes.* • *Remove contact lenses, if present, after the first 5 minutes, then continue rinsing eye.* • *Call a poison control center or doctor for further treatment advice.*
IF SWALLOWED:	• *Call a poison control center or doctor immediately for treatment advice.* • *Have person sip a glass of water if able to swallow.* • *Do not induce vomiting unless told to do so by the poison control center or doctor.* • *Do not give anything to an unconscious person.*
IF INHALED:	• *Move person to fresh air.* • *If person is not breathing, call 911 or an ambulance, then give artificial respiration, preferably mouth-to-mouth if possible.* • *Call a poison control center or doctor for further treatment advice.*
Have the product container or label with you when calling a poison control center or doctor, or going for treatment. *HOTLINE NUMBER: 1-800-255-3924*	

PERSONAL PROTECTIVE EQUIPMENT (PPE)

All mixers, loaders, applicators and other handlers must wear:

- Long-sleeved shirt and long pants;
- Socks;
- Shoes; and
- Chemical-resistant gloves.

Follow manufacturer's instructions for cleaning and maintaining PPE. If no instructions are available, use detergent and hot water for washables. Keep and wash PPE separately from other laundry. When handlers use closed systems, enclosed cabs, or aircraft in a manner that meets requirements listed in the Worker Protection Standard (WPS) for agricultural pesticides, the handler PPE requirements may be reduced or modified as specified in the WPS.

USER SAFETY RECOMMENDATIONS

Users should:

- Remove clothing/PPE immediately if pesticides get inside. Then wash thoroughly and put on clean clothing.
- Remove PPE immediately after handling this product. Wash the outside of gloves before removing. As soon as possible, wash thoroughly and change into clean clothing.

ENVIRONMENTAL HAZARDS

[For 1 liter, 1 gallon and 2.5 gallon containers:]
For terrestrial use. This pesticide is moderately toxic to aquatic invertebrates and fish. Do not apply directly to water, or to areas where surface water is present or to intertidal areas below the mean high water mark. Do not contaminate water when disposing of equipment wash water or rinsate. Do not allow runoff into lakes, streams, ponds or public waterways. Drift and runoff may be hazardous to aquatic organisms in water adjacent to treated areas. Observe the most restrictive labeling limitations and precautions of all products used in mixtures.

[For 1000 liter container:]
For terrestrial use. This pesticide is moderately toxic to aquatic invertebrates and fish. Do not apply directly to water, or to areas where surface water is present or to intertidal areas below the mean high water mark. Do not contaminate water when disposing of equipment wash water or rinsate. Do not allow runoff into lakes, streams, ponds or public waterways. Drift and runoff may be hazardous to aquatic organisms in water adjacent to treated areas. Observe the most restrictive labeling limitations and precautions of all products used in mixtures. Do not discharge effluent containing this product into lakes, streams, ponds, estuaries, oceans, or other waters unless in accordance with the requirements of a National Pollutant Discharge Elimination System (NPDES) permit and the permitting authority has been notified in writing prior to discharge. Do not discharge effluent containing this product to sewer systems without previously notifying the local sewage treatment plant authority. For guidance contact your State Water Board or Regional Office of the EPA.

GENERAL INFORMATION

VEGGIETURBO 5SC can be applied as a preventative or curative treatment in conjunction with good management practices.
VEGGIETURBO 5SC can be used alone or, when diseases not specified on this label are present or expected, in combination and/or rotation with other appropriately labeled fungicides as a tool for integrated disease management in labeled agricultural crops. See “Mixing and Handling Instructions” below for additional information.
Preharvest Interval (PHI) = 0 days. VEGGIETURBO 5SC is exempt from the requirement for residue tolerance and therefore can be applied up to and including the day of harvest.

RESISTANCE MANAGEMENT RECOMMENDATIONS

VEGGIETURBO 5SC contains a fungicide classified in FRAC target site of action Group 19. Fungal isolates with acquired resistance to Group 19 may eventually dominate the fungal population if Group 19 fungicides are used repeatedly in the same field or in successive years as the primary method of control for targeted species. This may result in partial or total loss of control of those species by VEGGIETURBO 5SC or other Group 19 Fungicides.

The following actions may prevent or delay fungicide resistance:

- Avoid consecutive use of VEGGIETURBO 5SC or other Group 19 fungicides against the same pathogens.
- Use tank-mixes or premixes with fungicides from different target site of action Groups. Do this only with products that are registered for the same use and are effective at the tank mix or premix rate against the target pathogen(s).
- Use fungicides as part of a comprehensive Integrated Pest Management (IPM) program.
- Monitor treated fungal populations for loss of field efficacy.

Contact your local extension specialist, certified crop advisor, and/or manufacture representative for fungicide resistance management and/or IPM recommendations for specific crops and resistant pathogens.

DIRECTIONS FOR USE

It is a violation of Federal law to use this product in a manner inconsistent with its labeling.

For any requirements specific to your State or Tribe, consult the State or Tribal agency responsible for pesticide regulation.

Do not apply this product in a way that will contact workers or other persons, either directly or through drift. Only protected handlers may be in the area during application.

AGRICULTURAL USE REQUIREMENTS

Use this product only in accordance with its labeling and with the Worker Protection Standard 40 CFR Part 170. This standard contains requirements for the protection of agricultural workers on farms, forests, nurseries, and greenhouses and handlers of agricultural pesticides. It contains requirements for training, decontamination, notification, and emergency assistance. It also contains specific instructions and exceptions pertaining to the statements on this label about personal protective equipment (PPE), and restricted entry intervals. The requirements in this box only apply to uses of this product that are covered by the Worker Protection Standard.

Do not enter or allow worker entry into treated areas during the restricted entry interval (REI) of 4 hours unless wearing appropriate PPE.

PPE required for early entry to treated areas that is permitted under the Worker Protection Standard and that involves contact with anything that has been treated, such as plants, soil or water is: coveralls, socks, shoes, and chemical-resistant gloves.

Low rate (3.75 fl. oz./acre) may be used for preventative applications before onset of visible disease, in periods of low disease pressure, or in a tank mix with other fungicides for resistance management. Use higher rates (6.5 to 13.0 fl. oz./acre) when disease pressure is high, or in stand-alone applications.

MIXING AND APPLICATION INSTRUCTIONS

VEGGIETURBO 5SC may be applied by ground or aerial spray equipment, as a soil drench, or by chemigation through sprinklers or drip irrigation. See the table below for information on application methods and timing for specific crops and diseases.

For spray application, mix VEGGIETURBO 5SC in water and apply as a spray to foliage, fruit, or other above-ground plant parts. For optimum control of labeled diseases, apply in sufficient volume of water to provide thorough coverage with minimal run-off.

See "Chemigation Instructions" below for information about applying VEGGIETURBO 5SC through irrigation systems.

[For 1 quart, 1 gallon and 2.5 gallon containers:]
Mixing instructions for VEGGIETURBO 5SC:
- *Shake well before use.*
- *Fill tank with water to ½ of the intended final volume.*
- *Start agitation of the spray tank.*
- *Add the appropriate amount of product to the tank according to the rates in this label.*
- *Agitate to ensure thorough mixing while adding the remaining required water.*
- *Do not allow the mixture to stand without agitation.*
- *Mix only the amount of solution needed to treat the desired area.*

[For 1000 Liter container:]
Thoroughly agitate product when product is in use.

When tank mixing VEGGIETURBO 5SC with other products, observe all precautions and limitations on each separate product label.

When planning to mix this product with others, it advisable to conduct a "jar test" to determine the physical compatibility of this product with the others. Using a quart jar, add the products (with agitation) to approximately one quart of water in the proportions they will appear in the final mixture. Add dry formulations first, followed by flowables, then emulsifiable concentrates like VEGGIETURBO 5SC last. After thorough mixing, allow this mixture to stand for 5 minutes. If the combination remains mixed or can be readily remixed, it is physically compatible. Once compatibility has been proven, use the same sequence for adding required ingredients to the tank.

To assess the potential for phytotoxicity, test tank mixtures on a small number of plants prior to more widespread application.

If more applications or shorter intervals than indicated in the table below are needed to maintain disease control, alternate VEGGIETURBO 5SC with other fungicides having different modes of action to avoid or slow development of pathogen resistance. See "Resistance Management Recommendations" above for more information.

Use of an adjuvant may enhance spray coverage of dense crop canopy, or plants that are difficult to wet due to waxy or hairy surfaces. Use only adjuvants that are labeled for such uses. Refer to "Mixing and Application Instructions" above for information on testing physical compatibility of VEGGIETURBO 5SC with other products.

BANDED (IN-FURROW) APPLICATION

Use the table below to determine the correct application rate in fluid ounces of product per 1,000 row feet based on row spacing and desired rate per acre. Mix the required amount of VEGGIETURBO 5SC in water and apply as banded spray (4" to 6" wide) or seedline drench centered over the planting furrow. Apply to soil immediately before seeding or directly over seeds in the furrow just before they are covered with soil. The volume of water required per acre or per 1,000 row feet will depend on the application equipment used. Consult your local cooperative extension service if you need assistance calibrating band spraying equipment.

Rates for banded (in-furrow) application: Find desired application rate in the left column. Read across the line to the correct row spacing indicated at the top to find the number of fluid ounces per 1000 row feet that will provide the desired application rate per acre.

Fluid oz. per acre	Fluid ounces per 1000 row feet														
	Space between rows (inches)														
	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40
3.75	0.09	0.10	0.11	0.13	0.14	0.16	0.17	0.19	0.20	0.22	0.23	0.24	0.26	0.27	0.29
6.50	0.15	0.17	0.20	0.22	0.25	0.27	0.30	0.32	0.35	0.37	0.40	0.42	0.45	0.47	0.50
13.00	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95	0.99

CHEMIGATION INSTRUCTIONS

GENERAL INFORMATION:

- Apply this product through pressurized irrigation systems such as drip (trickle) irrigation (including micro-irrigation through spaghetti tubes or individual tubes) or sprinkler irrigation (including impact or microsprinklers, microjet, overhead boom, water gun, solid set, lateral move, end tow, side-roll, center pivot, or hand move, including mist-type systems); or with hand-held calibrated irrigation equipment (such as a hand-held wand with injector). Do not apply this product through any other type of irrigation system.
- Crop injury or lack of effectiveness can result from non-uniform distribution of treated water.
- If you have questions about calibration, contact State Extension Service specialists, equipment manufacturers or other experts.
- Do not connect an irrigation system (including greenhouse systems) used for pesticide application to a public water system unless the pesticide label-prescribed safety devices for public water systems are in place.
- A person knowledgeable of the chemigation system and responsible for its operation, or under the supervision of the responsible person, shall shut the system down and make necessary adjustments should the need arise.
- Public water system means a system for the provision to the public of piped water for human consumption if such system has at least 15 service connections or regularly serves an average of at least 25 individuals daily at least 60 days out of the year.
- Chemigation systems connected to public water systems must contain a functional, reduced-pressure zone, backflow preventer (RPZ) or the functional equivalent in the water supply line upstream from the point of pesticide introduction. As an option to the RPZ, the water from the public water system should be discharged into a reservoir tank prior to pesticide introduction. There shall be a complete physical break (air gap) between the outlet end of the fill pipe and the top or overflow rim of the reservoir tank of at least twice the inside diameter of the fill pipe.
- The pesticide injection pipeline must contain a functional, automatic, quick-closing check valve to prevent the flow of fluid back toward the injection.

- The pesticide injection pipeline must contain a functional, normally closed, solenoid-operated valve located on the intake side of the injection pump and connected to the system interlock to prevent fluid from being withdrawn from the supply tank when the irrigation system is either automatically or manually shut down.
- The system must contain functional interlocking controls to automatically shut off the pesticide injection pump when the water pump motor stops, or in cases where there is no water pump, when the water pressure decreases to the point where pesticide distribution is adversely affected.
- Systems must use a metering pump, such as a positive displacement injection pump (e.g., diaphragm pump) effectively designed and constructed of materials that are compatible with pesticides and capable of being fitted with a system interlock.
- Do not apply when wind speed favors drift beyond the area intended for treatment.
- Remove scale, pesticide residues, and other foreign matter from the chemical supply tank and injector system and flush with clean water before use. Failure to provide a clean tank, free of scale or residues may reduce effectiveness of this product.

DRIP (TRICKLE) AND MICRO-IRRIGATION CHEMIGATION:
- The system must contain a functional check valve, vacuum relief valve and low pressure drain appropriately located on the irrigation pipeline to prevent water source contamination from backflow.
- The pesticide injection pipeline must contain a functional, automatic, quick-closing check valve to prevent the flow of fluid back toward the injection pump.
- The pesticide injection pipeline must also contain a functional, normally closed, solenoid-operated valve located on the intake side of the injection pump and connected to the system interlock to prevent fluid from being withdrawn from the supply tank when the irrigation system is either automatically or manually shut down.
- The system must contain functional interlocking controls to automatically shut off the pesticide injection pump when the water pump motor stops.
- The irrigation line or water pump must include a functional pressure switch which will stop the water pump motor when the water pressure decreases to the point where pesticide distribution is adversely affected.
- Systems must use a metering pump such as a positive displacement injection pump (i.e., diaphragm pump) effectively designed and constructed of materials that are compatible with pesticides and capable of being fitted with a system interlock.
- Dilute the product in water following the label mixing directions. It may be premixed in a supply tank with water, fertilizer, or other appropriate tank-mixed agricultural chemicals. Agitation is necessary. Apply to moderately moist soils. Use volumes that thoroughly wet the soil but that do not cause significant runoff or excessive drip from pots. Application should be continuous in sufficient water to apply the recommended rate evenly to the entire treated area.

SPRINKLER CHEMIGATION:
- The system must contain a functional check valve, vacuum relief valve, and low pressure drain appropriately located on the irrigation pipeline to prevent water source contamination from backflow.
- The pesticide injection pipeline must contain a functional, automatic, quick-closing check valve to prevent the flow of fluid back toward the injection pump.
- The pesticide injection pipeline must also contain a functional, normally closed, solenoid-operated valve located on the intake side of the injection pump and connected to the system interlock to prevent fluid from being withdrawn from the supply tank when the irrigation system is either automatically or manually shut down.
- The system must contain functional interlocking controls to automatically shut off the pesticide injection pump when the water pump motor stops.

- The irrigation line or water pump must include a functional pressure switch which will stop the water pump motor when the water pressure decreases to the point where pesticide distribution is adversely affected.
- Systems must use a metering pump, such as a positive displacement injection pump (i.e., diaphragm pump) effectively designed and constructed of materials that are compatible with pesticides and capable of being fitted with a system interlock.
- Dilute the product in water following the label mixing directions. It may be premixed in a supply tank with water, fertilizer or other appropriate tank-mixed agricultural chemicals. Agitation is necessary. Apply to moderately moist soils. Use volumes that thoroughly wet the soil but that do not cause significant runoff or excessive drip from pots. Application should be continuous in sufficient water to apply the recommended rate evenly to the entire treated area.
- Do not apply when wind speed favors drift beyond the area intended for treatment.

CROPS, DISEASES AND APPLICATION RATES

ARTICHOKES (Chinese and Jerusalem)		
DISEASES/PATHOGENS	**RATES**	**ADDITIONAL INFORMATION**
Gray mold/Botrytis rot (*Botrytis cinerea*) **Powdery mildew** (*Leveillula taurica, Erysiphe cichoracearum*)	3.75 – 13.0 fl. oz./acre (0.21 – 0.72 oz. a.i./acre) Do not apply more than 4.2 oz. a.i./acre/season (6 appl. at max. rate).	Begin applications at first sign of disease symptoms and repeat on 7-14 day interval as long as conditions favor disease development. Apply as a foliar spray in sufficient water to achieve thorough coverage of all above-ground plant parts. May also be applied through overhead sprinkler irrigation. See "Chemigation Instructions" for additional information.

BANANAS AND PLANTAINS ✷		
DISEASES/PATHOGENS	**RATES**	**ADDITIONAL INFORMATION**
Black Sigatoka leaf streak (*Mycosphaerella fijiensis* Morelet) **Yellow Sigatoka leaf spot** (*Mycosphaerella musicola*)	3.75 – 13.0 fl. oz./acre (0.21 – 0.72 oz. a.i./acre) Do not apply more than 4.2 oz. a.i./acre/season (6 appl. at max. rate).	Begin applications when leaves first appear and repeat on a 7-21 day interval or as needed. Apply in sufficient water to obtain thorough coverage of foliage. For improved control, product may be tank-mixed with other fungicides registered for control of Sigatoka at label rates. When conditions are conducive to rapid disease development and/or heavy disease pressure, higher application rates and rotational spray programs with other fungicides registered for control of Sigatoka are recommended.
✷ For use in Hawaii and Puerto Rico only.		

BERRIES AND SMALL FRUITS:
Amur river grape, Aronia berry, Bayberry, Bearberry, Bilberry, Blackberry, Blueberry, Buffalo currant, Buffaloberry, Che, Chilean Guava, Chokecherry, Cloudberry, Cranberry, Currant (red and black), Elderberry, European barberry, Gooseberry, Highbush cranberry, Honeysuckle (edible), Huckleberry, Jostaberry, Juneberry, Kiwi (fuzzy and hardy), Loganberry, Maypop, Mountain pepper berries, Mulberry, Muntries, Native currant, Partridgeberry, Phalsa, Pincherry, Raspberry (black and red), Riberry, Salal, Schisandra berry, Sea buckthorn, Serviceberry, Strawberry, Wild raspberries, Cultivars, varieties, and/or hybrids of these
(See separate table for grapes.)

DISEASES/PATHOGENS	RATES	ADDITIONAL INFORMATION
Alternaria **leaf spot and fruit rot** (*Alternaria* spp.) **Anthracnose leaf & fruit rot** (*Colletotrichum* spp.)* **Cottonball** (*Monilinia oxycocci*) **Cranberry Fruit Rot Complex** (*Colletotrichum acutatum*, *Colletotrichum gloeosporioides*, *Coloepnoma empetri*, *Phomosis vaccinii*, *Physalospora vaccinii*, *Phyllosticta vaccinii*) **Gray mold/fruit rot/Botrytis blight** (*Botrytis cinerea*) **Mummyberry** (*Monilinia vaccinii-corymbosi*) **Powdery mildew** (*Sphaerotheca macularis*, *Erysiphe* spp.)	3.75 – 13.0 fl. oz./acre (0.21 – 0.72 oz. a.i./acre) Do not apply more than 4.2 oz. a.i./acre/season (6 appl. at max. rate).	Apply as a foliar spray in sufficient water to provide thorough coverage. Can also be applied through overhead sprinkler irrigation. See "Chemigation Instructions" for additional information. Begin as a preventative application and continue on a 7-14 day interval as needed to maintain control. For control of *Botrytis* and other fruit diseases, begin applications at flowering.

* Suppression only. A rate of 6.5 fl. oz./acre may be used for preventative applications before onset of visible disease, in periods of low disease pressure, or in a tank mix with other fungicides for resistance management. Otherwise, use a rate of 13.0 fl. oz./acre.

BRASSICA (COLE) LEAFY VEGETABLES: **Broccoli, Broccoli raab, Brussels Sprouts, Cabbage, Chinese broccoli, Chinese Cabbage (Bok Choi, Napa, Gai choy), Cauliflower, Cavalo broccolo, Collards, Kale, Kohlrabi, Mizuna, Mustard Greens, Mustard spinach, Rape greens**		
DISEASES/PATHOGENS	**RATES**	**ADDITIONAL INFORMATION**
Alternaria leaf spot (*Alternaria* spp.) **Anthracnose** (*Colletotrichum* spp.) **Gray mold** (*Botrytis cinerea*) **White spot** (*Cercosporella* spp.)	3.75 – 13.0 fl. oz./acre (0.21 – 0.72 oz. a.i./acre) Do not apply more than 4.2 oz. a.i./acre/season (6 appl. at max. rate).	Apply as a foliar spray in sufficient water to attain thorough coverage. Use of an adjuvant may enhance spray coverage, especially of waxy leaves. Begin preventive sprays when conditions favor disease development, and continue on a 7-14 day spray interval as needed.
Bottom rot (*Rhizoctonia solani*) **Sclerotinia rot** (*Sclerotinia sclerotiorum)*		Apply in 30 – 50 gallons of water per acre as a directed spray toward soil surface and lower leaves. Begin applications at head formation, before leaves contact the ground. Repeat every 7-14 days as needed to maintain control.

BULB VEGETABLES: **Chive, Daylily, Elegans hosta, Fritillaria, Garlic, Kurrat, Lady's leek, Leek, Lily, Onion, Shallot, Cultivars, varieties, and/or hybrids of these**		
DISEASES/PATHOGENS	**RATES**	**ADDITIONAL INFORMATION**
Alternaria blight and Purple blotch (*Alternaria* spp.) **Botrytis leaf blight /Leaf spot/Neck rot** (*Botrytis* spp.) **Downy mildew** (*Peronospora* spp.)* **Rust** (*Puccinia alii* or *Puccinia porri*)	3.75 – 13.0 fl. oz./acre (0.21 – 0.72 oz. a.i./acre) Do not apply more than 4.2 oz. a.i./acre/season (6 appl. at max. rate).	Apply as foliar preventative spray (ground, aerial, or through overhead sprinklers) before disease onset and continue at 7-14 day intervals as needed to maintain control. Coverage may be enhanced by use of a spray adjuvant.
* Suppression only. A rate of 6.5 fl. oz./acre may be used for preventative applications before onset of visible disease, in periods of low disease pressure, or in a tank mix with other fungicides for resistance management. Otherwise, use a rate of 13.0 fl. oz./acre.		

CARROTS and PARSNIPS		
DISEASES/PATHOGENS	**RATES**	**ADDITIONAL INFORMATION**
Alternaria leaf blight (*Alternaria dauci*) **Cercospora leaf blight** (*Cercospora carotae*) **Powdery mildew** (*Erysiphe polygoni*) **Rhizoctonia crown rot and leaf blight** (*Rhizoctonia solani*)	3.75 – 13.0 fl. oz./acre (0.21 – 0.72 oz. a.i./acre) Do not apply more than 4.2 oz. a.i./acre/season (6 appl. at max. rate).	Begin applications soon after plant emergence and repeat on 7-14 day interval as long as conditions favor disease development. Apply as a foliar spray in sufficient water to achieve thorough coverage of all above-ground plant parts. May also be applied through overhead sprinkler irrigation. See "Chemigation Instructions" for additional information.

CITRUS FRUITS: Calamondin, Citron, Citrus hybrids (Chironja, Tangelo, Tangor), Clementine, Grapefruit, Kumquat, Lemon, Lime, Mandarin (Tangerine), Orange, Pummelo, Sutsuma mandarin		
DISEASES/PATHOGENS	**RATES**	**ADDITIONAL INFORMATION**
Alternaria **brown spot** (*Alternaria alternata*)	3.75 – 13.0 fl. oz./acre (0.21 – 0.72 oz. a.i./acre) Do not apply more than 4.2 oz. a.i./acre/season (6 appl. at max. rate).	Apply as preventative foliar spray before disease development, when spring flush is ¼ to ½ expanded. If needed, make second application to fully expanded flush.
Botrytis rot (*Botrytis cinerea*)		Begin preventative applications during bloom when rain or fog is expected. Repeat every 7-14 days as long as conditions favoring disease persist.
Septoria spot (*Septoria citri*)		Apply as a preventative spray in late fall or early winter, just before or after the first rain. Additional applications may be necessary during seasons of heavy rainfall.

CUCURBIT VEGETABLES: **Chayote (fruit), Chinese waxgourd (Chinese preserving melon), Citron melon, Cucumber, Gherkin, Gourd (edible, including hyotan, cucuzza, hechima, Chinese okra), *Momordica* spp. (includes balsam apple, balsam pear, bitter melon, Chinese cucumber), Muskmelon (includes true cantaloupe, cantaloupe, casaba, crenshaw melon, golden pershaw melon, honeydew melon, honey balls, mango melon, Persian melon, pineapple melon, Santa Claus melon, and snake melon), Pumpkin, Squash (including acorn squash, butternut squash, calabaza, crookneck squash, hubbard squash, scallop squash, spaghetti squash, straightneck squash, vegetable marrow, zucchini), Watermelon, Hybrids and varieties of these**		
DISEASES/PATHOGENS	**RATES**	**ADDITIONAL INFORMATION**
Anthracnose (*Colletotrichum orbiculare*) **Early blight** (*Alternaria* sp.) **Gray mold** (*Botrytis* sp.) **Gummy stem blight** (*Didymella bryoniae* and *Phoma cucurbitacearum*) **Powdery mildew** (*Erysiphe* and *Sphaerotheca* spp. and *Podosphaera xanthii*) **Scab** (*Cladosporium* sp.) **Target leaf spot/Corynespora leaf spot/ Corynespora blight** (*Corynespora crassiicola*)	3.75 – 13.0 fl. oz./acre (0.21 – 0.72 oz. a.i./acre) Do not apply more than 4.2 oz. a.i./acre/season (6 appl. at max. rate).	Mix in sufficient volume of water for good spray coverage (typically 50-100 gallons per acre). Begin preventive sprays when conditions favor disease development, and continue on a 7-14 day spray interval as needed.
Southern blight (*Sclerotium rolfsii*)		See additional instructions under BANDED (IN-FURROW) APPLICATION. Can also be applied through surface (not buried) drip or overhead sprinkler irrigation. See "Chemigation Instructions" for additional information. Make subsequent applications at 7-14 day intervals either through surface drip or overhead sprinkler irrigation, or as a spray/drench directed at the base of each plant.

<table>
<tr><th colspan="3">FRUITING VEGETABLES:
Eggplant, Groundcherry, Peppers (all types), Tomatillo, Tomatoes (all types)</th></tr>
<tr><th>DISEASES/PATHOGENS</th><th>RATES</th><th>ADDITIONAL INFORMATION</th></tr>
<tr><td>Anthracnose (Colletotrichum spp.)*

Early blight (Alternaria solani)

Gray mold/Botrytis rot (Botrytis spp.)

Late blight* (Phytophthera infestans)

Leaf mold (Fulvia (Cladosporium) fulvum, also known as Passalora fulva)

Powdery mildew (Leveillula, Oidiopsis, Erysiphe, and Sphaerotheca spp.)

<u>Target spot</u> <u>(Corynespora cossiicola)</u></td><td rowspan="2">3.75 – 13.0 fl. oz./acre (0.21 – 0.72 oz. a.i./acre)

Do not apply more than 4.2 oz. a.i./acre/season (6 appl. at max. rate).</td><td>Apply as a preventative foliar spray when conditions favor disease development. Repeat application at 7-14 day intervals as needed during infection periods. Mix in sufficient water to attain thorough coverage of foliage and fruit (if present).</td></tr>
<tr><td>Southern blight (Sclerotium rolfsii)*

Verticillium wilt (Verticillium dahliae)*</td><td>See additional instructions under BANDED (IN-FURROW) APPLICATION.

Can also be applied through surface (not buried) drip or overhead sprinkler irrigation. See “Chemigation Instructions” for additional information.

Make subsequent applications at 7-14 day intervals either through surface drip or overhead sprinkler irrigation, or as a spray/drench directed at the base of each plant.</td></tr>
<tr><td colspan="3">* Suppression only. A rate of 6.5 fl. oz./acre may be used for preventative applications before onset of visible disease, in periods of low disease pressure, or in a tank mix with other fungicides for resistance management. Otherwise, use a rate of 13.0 fl. oz./acre.</td></tr>
</table>

GINSENG		
DISEASES/PATHOGENS	**RATES**	**ADDITIONAL INFORMATION**
Alternaria blight (*Alternaria panax*) **Botrytis blight** (*Botrytis cinerea*)	3.75 – 13.0 fl. oz./acre (0.21 – 0.72 oz. a.i./acre) Do not apply more than 4.2 oz. a.i./acre/season (6 appl. at max. rate).	Apply as foliar spray every 7-10 days beginning within 2 weeks after plant emergence, prior to disease development (consult local extension service for advice on timing against these diseases). Continue throughout the season as needed to maintain control.
Cylindrocarpon root rot (*Cylindrocarpon destructans*) **Rhizoctonia root and crown rot** (*Rhizoctonia solani*)		Apply as soil drench every 14-28 days, beginning within 2 weeks after plant emergence.

GRAPES: For pre-harvest use on all grapes		
DISEASES/PATHOGENS	**RATES**	**ADDITIONAL INFORMATION**
Gray mold/bunch rot (*Botrytis cinerea*) **Powdery mildew** (*Erysiphe* (*Uncinula*) *necator*)	3.75 – 13.0 fl. oz./acre (0.21 – 0.72 oz. a.i./acre) Do not apply more than 4.2 oz. a.i./acre/season (6 appl. at max. rate).	For bunch rot, begin application at early bloom. Apply a maximum of 6 applications per season at a minimum of 7-day intervals. For optimal control, include application at veraison as one of the 6 applications. For powdery mildew, begin as a preventative spray and repeat every 14 days as needed to maintain control. ~~For *Botrytis* bunch rot, apply at veraison and 7 days before harvest.~~

HERBS AND SPICES †: **Allspice, angelica, anise, anise, star, annatto (seed), balm, basil, borage, burnet, camomile, caper buds, caraway, caraway, black, cardamom, cassia bark, cassia buds, catnip, celery seed, chervil (dried), chive, chive, Chinese, cinnamon, clary, clove buds, ~~coraindor~~ coriander leaf (cilantro or Chinese parsley), coriander seed (cilantro), costmary, cilantro (leaf), culantro (seed), cumin, curry (leaf), dill (dillweed), dill (seed), fennel (common), fennel, Florence (seed), fenugreek, grains of paradise, horehound, hyssop, juniper berry, lavender, lemongrass, lovage (leaf), lovage (seed), mace, marigold, marjoram, mustard (seed), nasturtium, nutmeg, parsley (dried), pennyroyal, pepper, black, pepper, white, poppy (seed), rosemary, rue, saffron, sage, savory, summer and winter, sweet bay, tansy, tarragon, thyme, vanilla, wintergreen, woodruff, and wormwood.**		
DISEASES/PATHOGENS	**RATES**	**ADDITIONAL INFORMATION**
Downy mildew (*Peronospora* spp. and others) **Powdery mildew** (*Oidium* spp. and others)	3.75 – 6.5 fl. oz./acre (0.21 – 0.36 oz. a.i./acre) Do not apply more than 2.2 oz. a.i./acre/season (6 appl. at max. rate).	Begin preventive sprays when conditions favor disease development, and continue on a 7-10 day spray interval as needed.
Notes: † Not for use in California. • Product may harm herbs and spices, especially new leaves. Do not apply to herbs and spices without prior testing on a small number of plants.		

LEAFY VEGETABLES:
Amaranth, Arugula (garden rocket), Asparagus chicory, Beet greens (spinach beet), Borage, Catalogna, Celery, Chard, Chaya, Chicory, Colocasia, Corn salad (mâche), Dandelion, Endive, Escarole, Fenugreek, Garden cress, Ground-elder, Kailan, Lettuce (Head, Leaf, Iceberg, Romaine), Mizuna, Purslane, Radichetta, Radicchio, Sorrel, Spinach, Spinach beet (beet greens), Spring greens (Spring mix), Stinging nettle, Tatsoi, Tropaeolum (*Nasturtium*), Turnip greens, Watercress (*Nasturtium*), Water spinach (ong choy), Yarrow

DISEASES/PATHOGENS	RATES	ADDITIONAL INFORMATION
Alternaria leaf spot (*Alternaria* spp.) **Downy mildew** (*Bremia lactucae* and *Peronospora* spp.)* **Powdery mildew** (*Golovinomyces (Erysiphe) cichoracearum*) **White rust** (*Albugo occidentalis*)	3.75 – 13.0 fl. oz./acre (0.21 – 0.72 oz. a.i./acre) Do not apply more than 4.2 oz. a.i./acre/season (6 appl. at max. rate).	Begin applications soon after plant emergence or transplanting and repeat on 7-14 day interval as long as conditions favor disease development. Apply as a foliar spray in sufficient water to achieve thorough coverage of all above-ground plant parts. ~~May also be applied through overhead sprinkler irrigation. See "Chemigation Instructions" for additional information.~~
Botrytis damping off (*Botrytis* spp.)		Apply as banded spray (4-6" wide) over the seed furrow at planting or transplanting. See additional instructions under BANDED (IN-FURROW) APPLICATION.
Botrytis leaf blight, **Botrytis rot** (*Botrytis* spp.)		Begin preventative foliar applications when conditions favor disease development and continue at 7-14 day intervals as long as needed to maintain control.
Bottom rot (*Rhizoctonia solani*)		Apply in 30 – 50 gallons of water per acre as a directed spray toward soil surface and lower leaves. Begin applications at head formation, before leaves contact the ground. Repeat every 7-14 days as needed to maintain control.
Lettuce drop (*Sclerotinia* spp.)		Apply in 30 – 50 gallons of water per acre as a directed spray toward soil surface and lower leaves. Make first application to direct-seeded lettuce immediately after emergence. For transplanted lettuce, make first application immediately after transplanting. In both cases, apply prior to disease development. Apply again if soil is disturbed by cultivation or thinning and conditions continue to favor disease development.

LEAFY VEGETABLES: **Amaranth, Arugula (garden rocket), Asparagus chicory, Beet greens (spinach beet), Borage, Catalogna, Celery, Chard, Chaya, Chicory, Colocasia, Corn salad (mâche), Dandelion, Endive, Escarole, Fenugreek, Garden cress, Ground-elder, Kailan, Lettuce (Head, Leaf, Iceberg, Romaine), Mizuna, Purslane, Radichetta, Radicchio, Sorrel, Spinach, Spinach beet (beet greens), Spring greens (Spring mix), Stinging nettle, Tatsoi, Tropaeolum (*Nasturtium*), Turnip greens, Watercress (*Nasturtium*), Water spinach (ong choy), Yarrow**		
DISEASES/PATHOGENS	**RATES**	**ADDITIONAL INFORMATION**
• May also be applied through overhead sprinkler irrigation. See "Chemigation Instructions" for additional information. * Suppression only. A rate of 6.5 fl. oz./acre may be used for preventative applications before onset of visible disease, in periods of low disease pressure, or in a tank mix with other fungicides for resistance management. Otherwise, use a rate of 13.0 fl. oz./acre.		

LEGUME VEGETABLES:
Bean (Lupines spp.), Bean (*Phaseolus* spp., including Field bean, Kidney bean, Lima bean, Navy bean, Pinto bean, Runner bean, Snap bean, Tepary bean, Wax bean), Bean (*Vigna* spp., including Adzuki bean, Asparagus bean, Blackeyed pea, Catjang, Chinese longbean, Cowpea, Crowder pea, Moth bean, Mung bean, Southern pea, Urd bean, Yardlong bean) Broad bean (Fava bean), Chickpea (Garbanzo bean), Guar, Jackbean, Lablab bean (hyacinth bean), Lentil, Pea (*Pisum* spp., including Dwarf pea, Edible pod pea, English pea, Field pea, Garden pea, Green pea, Snow pea, Sugar snap pea), Pigeon pea, Soybean, Sward bean.

DISEASES/PATHOGENS	RATES	ADDITIONAL INFORMATION
Asian Soybean Rust (*Phakopsora pachyrhizi*) **Gray mold** (*Botrytis cinerea*) **Powdery mildew** (*Erysiphe pisi*)	3.75 – 13.0 fl. oz./acre (0.21 – 0.72 oz. a.i./acre) Do not apply more than 4.2 oz. a.i./acre/season (6 appl. at max. rate).	Begin applications at first sign of disease symptoms and repeat on 7-14 day interval as long as conditions favor disease development. Apply as a foliar spray in sufficient water to achieve thorough coverage of all above-ground plant parts. May also be applied through overhead sprinkler irrigation. See “Chemigation Instructions” for additional information.
Stem rot / White mold (*Sclerotinia sclerotiorum*)		Apply in 30 – 50 gallons of water per acre as a directed spray toward soil surface, lower leaves, and stems. May also be applied through overhead sprinkler irrigation. See “Chemigation Instructions” for additional information.

068173-00004.20160517.Changes_noted.pdf
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May 17, 2016 Proposed Master Label Fast-Track Amendment
Based upon the January 29, 2015 EPA accepted label.
New disease claims added.

POME FRUITS: Apple, Crabapple, Loquat, Mayhaw, Pear, Quince		
DISEASES/PATHOGENS	**RATES**	**ADDITIONAL INFORMATION**
Alternaria leaf spot (*Alternaria mali*) **Leaf blotch** (*Diplocarpon mali*) **Powdery mildew** (*Podosphaera leucotricha*, *Phyllactinia mali*) **Scab** (*Venturia* spp.)*	3.75 – 13.0 fl. oz./acre (0.21 – 0.72 oz. a.i./acre) Do not apply more than 4.2 oz. a.i./acre/season (6 appl. at max. rate).	Apply as foliar spray in sufficient water to attain thorough coverage of foliage and fruit. For powdery mildew control, begin as preventative and repeat on 7-14 day interval as needed. Use in an alternating program with a sterol inhibitor (DMI) fungicide. For scab suppression, begin sprays at green tip and continue every 7-10 days as needed.
* Suppression only. A rate of 6.5 fl. oz./acre may be used for preventative applications before onset of visible disease, in periods of low disease pressure, or in a tank mix with other fungicides for resistance management. Otherwise, use a rate of 13.0 fl. oz./acre.		
Alternaria rot (*Alternaria tenuis*) **Bitter rot** (*Glomerella cingulata*) **Cedar apple rust**** (*Gymnosporangium juniperi-virginianae*) **Flyspeck** (*Schizothyrium pomi*, formerly *Microthyriella rubi*) **Sooty blotch** (*Gloeodes pomigena*) **White rot**** (*Botryosphaeria dothidea*)	3.75 - 6.5 fl. oz./acre (0.21 - 0.36 oz. a.i./acre) Do not apply more than 2.16 oz. a.i./acre/season (6 appl. at max. rate).	Begin applications prior to disease development. Repeat at 7-10 day interval as needed. May be applied from green-tip to day of harvest.
** Suppression only.		

POTATOES		
DISEASES/PATHOGENS	**RATES**	**ADDITIONAL INFORMATION**
Black scurf (*Rhizoctonia solani*)	3.75 – 13.0 fl. oz./acre (0.21 – 0.72 oz. a.i./acre) Do not apply more than 4.2 oz. a.i./acre/season (6 appl. at max. rate).	Apply as banded spray in-furrow at planting, either just before placement of seed pieces or over seed pieces before covering with soil. See additional instructions under BANDED (IN-FURROW) APPLICATION.
Early blight (*Alternaria solani*) **Late blight** (*Phytophthora infestans*)*		Apply as a foliar spray in sufficient water to provide thorough coverage of all foliage. May also be applied through overhead sprinkler irrigation. See "Chemigation Instructions" for additional information. Begin as a preventative application and continue on a 7-14 day interval as needed to maintain control.
White mold (*Sclerotinia sclerotiorum*)		Apply in 30 – 50 gallons of water per acre as a directed spray toward soil surface, lower leaves, and stems. May also be applied through overhead sprinkler irrigation. See "Chemigation Instructions" for additional information.
* Suppression only. A rate of 6.5 fl. oz./acre may be used for preventative applications before onset of visible disease, in periods of low disease pressure, or in a tank mix with other fungicides for resistance management. Otherwise, use a rate of 13.0 fl. oz./acre.		

STONE FRUITS: **Apricot (including Japanese), Capulin, Cherry (including Black, Nanking, Sweet, Tart), Jujube (Chinese), Nectarine, Peach, Plum (including American, Beach, Canada, Cherry, Chickasaw, Damson, Japanese, Klamath, prune), Plumcot, Sloe, Cultivars, varieties, and/or hybrids of these.**		
DISEASES/PATHOGENS	**RATES**	**ADDITIONAL INFORMATION**
Botrytis blossom blight (*Botrytis cinerea*) **Monilinia brown rot and blossom blight** (*Monilinia fructicola*) Powdery mildew (*Podosphaera* spp., *Sphaerotheca pannosa*)	3.75 – 13.0 fl. oz./acre (0.21 – 0.72 oz. a.i./acre) Do not apply more than 4.2 oz. a.i./acre/season (6 appl. at max. rate).	Apply as foliar spray in sufficient water to attain thorough coverage of foliage and fruit. For powdery mildew control, begin as preventative and repeat on 7-14 day interval as needed. Use in an alternating program with a sterol inhibitor (DMI) fungicide. Apply at full bloom for control of *Botrytis* blossom blight if wet weather occurs during bloom.

SUGAR BEET		
DISEASES/PATHOGENS	**RATES**	**ADDITIONAL INFORMATION**
Cercospora leaf spot (*Cercospora beticola*)	3.75 – 13.0 fl. oz./acre (0.21 – 0.72 oz. a.i./acre) Do not apply more than 4.2 oz. a.i./acre/season (6 appl. at max. rate).	Begin applications at first sign of disease symptoms and repeat on 7-14 day interval as long as conditions favor disease development. Apply as a foliar spray in sufficient water to achieve thorough coverage of all above- ground plant parts. May also be applied through overhead sprinkler irrigation. See "Chemigation Instructions" for additional information.
Rhizoctonia crown and root rot (*Rhizoctonia solani*)		Apply as banded spray or drench in seed furrow at planting. See additional instructions below for banded application rates. Can also be applied through overhead sprinkler irrigation. See "Chemigation Instructions" for additional information. Make subsequent applications at 7-14 day intervals either through chemigation, or as a spray/drench directed at the base of each plant.

STORAGE AND DISPOSAL

Do not contaminate water, food or feed by storage or disposal.

PESTICIDE STORAGE: Store in dry place away from food or feed.

PESTICIDE DISPOSAL: Wastes resulting from the use of this product may be disposed of on site or at an approved waste disposal facility.

CONTAINER HANDLING:

[*Containers ≤ 5 gallons:*]

Nonrefillable container. Do not reuse or refill this container. Completely empty container into application equipment. Triple rinse container (or equivalent) promptly after emptying. Triple rinse as follows: Empty the remaining contents into application equipment or a mix tank and drain for 10 seconds after the flow begins to drip. Fill the container ¼ full with water and recap. Shake for 10 seconds. Pour rinsate into application equipment or a mix tank or store rinsate for later use or disposal. Drain for 10 seconds after the flow begins to drip. Repeat this procedure two more times. Then offer for recycling or reconditioning (if available), or puncture and dispose of in a sanitary landfill or by incineration, if allowed by State and local authorities. If burned, stay out of smoke.

[*Containers > 5 gallons:*]

Nonrefillable container. Do not reuse or refill this container. Completely empty container into application equipment. Triple rinse or pressure rinse container (or equivalent) promptly after emptying. *Triple rinse as follows:* Empty the remaining contents into application equipment or a mix tank. Fill the container ¼ full with water. Replace and tighten closures. Tip container on its side and roll it back and forth, ensuring at least one complete revolution, for 30 seconds. Stand the container on its end and tip it back and forth several times. Turn the container over onto its other end and tip it back and forth several times. Empty the rinsate into application equipment or a mix tank or store rinsate for later use or disposal. Repeat this procedure two or more times. *Pressure rinse as follows:* Empty the remaining contents into application equipment or a mix tank and continue to drain for 10 seconds after the flow begins to drip. Hold container upside down over application equipment or mix tank or collect rinsate for later use or disposal. Insert pressure rinsing nozzle in the side of the container, and rinse at about 40 PSI for at least 30 seconds. Drain for 10 seconds after the flow begins to drip. Then offer for recycling or reconditioning (if available), or puncture and dispose of in a sanitary landfill or by incineration, if allowed by State and local authorities. If burned, stay out of smoke.

WARRANTY

Kaken Pharmaceutical Co., Ltd. warrants that the material contained herein conforms to the description on the label and is reasonably fit for the purpose referred to in the directions for use. Timing and method of application, weather, watering practices, nature of soil, the disease problem, condition of the crop, incompatibility with other influencing factors in the use of this product are beyond the control of the seller. Buyer assumes all risks of use, storage, or handling of this material not in strict accordance with directions given herein. TO THE EXTENT CONSISTENT WITH APPLICABLE LAW, NO OTHER EXPRESSED OR IMPLIED WARRANTY OF THE FITNESS OR MERCHANTABILITY IS MADE.

VEGGIETURBO™ is a trademark of Kaken Pharmaceutical Co., Ltd.

Label Version No. _______

4. EPA Documents

4.a. May 11, 2012 EPA Science Review

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

WASHINGTON, D.C. 20460

**OFFICE OF
PREVENTION, PESTICIDES
AND TOXIC SUBSTANCES**

MEMORANDUM

DATE: May 11, 2012

SUBJECT: Polyoxin D zinc salt (EPA Reg. #: 68173-1), Containing 23.8% of polyoxin D zinc salt (Active Ingredient). Science Review of Product Chemistry, Residue Chemistry, Non-Target Organism and Toxicity Data in Support of label Amendment

Decision Number: 457591
DP Number: 397074
EPA Symbol #: 68173-1
Chemical Class: Biochemical
PC Code: 230000
MRIDs: 48653302-48653307; 48653313-48653315; 48660403 & 48660404

From: Manying Xue, Chemist Manying Xue
BPB/BPPD (7511P)

To: Colin Walsh, Regulatory Action Leader
BPB/BPPD (7511P)

Action Requested:

Karen Pharmaceutical Co., Ltd. has submitted a petition for exemption from the requirement of a tolerance for residues of Polyoxin D zinc salt (EPA Reg. #: 68173-1). Karen Pharmaceutical Co., Ltd. has proposed to expand the exemption to all agricultural commodities.

In support of this petition, the registrant had submitted data for product chemistry, label, toxicity, residue chemistry, and proposed tolerances, etc..

An exemption from the requirement of a tolerance has been established on 40 CFR 180.1285 for the residues of the biochemical pesticide polyoxin D zinc salt when used as a fungicide on almonds, cucurbit vegetables, fruiting vegetables, ginseng, grapes, pistachios, pome fruits, potatoes and strawberries.

BPPD has examined the submitted data for product chemistry, label, toxicity, residue chemistry, and proposed tolerances, etc. for Polyoxin D zinc salt (EPA EPA #: 68173-1). The decisions are made to reflect the current OCSPP's policies.

Recommendations and Conclusions:

1. The submitted scientific data of product chemistry, toxicity, non-target organism and Insect Testing, etc. support the petition for expanding exemption from the requirement of a tolerance the residues of the biochemical pesticide polyoxin D zinc salt in all agriculture commodities.

2a. The submitted nature of residue study is **ACCEPTABLE**. The TRR level in fruit from grape plant treated with [^{14}C]Polyoxin D (three applications at a rate of 1.67 times of 150 g a.i./ha) was 0.520 ppm at Day 1, 0.538 ppm at Day 14 and 0.495 ppm at Day 30 after the final application; total radioactive residues (TRR) were 3.078 ppm detected in the tomato fruits from tomato plants treated with Polyoxin D at 28, 21, and 14 days before final harvest at the rate of 100 grams a.i./ha per application; the TRR in the head (edible part) from the lettuce plant treated with [^{14}C]Polyoxin D at the rate of 300 g a.i./ha was low: 0.025 ppm and 0.107 ppm at Day-7 and Day-14, respectively.

2b. The major metabolic pathway of Polyoxin D in grape plant was formation of uracil-5-carboxylic acid. This metabolite was further metabolized and considered to be incorporated into plant constituents of pectin, lignin and hemi-cellulose etc. followed by formation of bound residues.

2c. The metabolism of Polyoxin D in tomato involved cleavage of the pyrimidinyl linkage to produce uracil-5-carboxylic acid. These results are consistent with those obtained from other Polyoxin D plant metabolism studies, including experiments with grape and lettuce. A metabolic pathway is proposed based on metabolites identified.

2d. The major metabolic pathway of Polyoxin D in lettuce plant was formation of uracil-5-carboxylic acid. This metabolite was considered to be further metabolized into various polar metabolites followed by formation of bound residues.

3. The waiver request for nature of the residue study in livestock is **ACCEPTABLE.**

4. The submitted waiver requests for all residue chemistry data requirements are **ACCEPTABLE**.

5. The photolysis study is **ACCEPTABLE**. The photolytic degradation of [^{14}C]Polyoxin D was analyzed in an 11-day study in sterile buffers at pH 5.0, pH 7.0, pH 9.0, and sterile natural water. The net photolytic half-lives of [^{14}C]Polyoxin D were calculated to be 0.4 days, 4 days, 2.4 days, and 1.6 days in sterile natural water, pH 5.0, pH 7.0, and pH 9.0 buffers, respectively.

6. The hydrolysis study is **ACCEPTABLE**. The hydrolysis of [^{14}C]Polyoxin D was analyzed in a 30-day study in sterile buffers at pH 4.0, pH 5.0, pH 7.0 and pH 9.0. The half-lives of [^{14}C]Polyoxin D were calculated to be 301.3 days, 231.0, 32.5 and 9.1 days in sterile pH 4.0, pH 5.0, pH 7.0 and pH 9.0 buffers, respectively.

7. The study of UV/Visible Absorption is **ACCEPTABLE.** The UV absorbance of Polyoxin D Zinc Salt in neutral, acidic and basic solutions was 270.0 nm, 274.0 nm and 268.5 nm, respectively.

8. The developmental toxicity study in the rat is classified **ACCEPTABLE** and satisfies the guideline requirement for a developmental toxicity study (OCSPP 870.3700; OECD 414) in the rat. The developmental toxicity LOAEL for Polyoxin D zinc salt is not determined. The NOAEL is ≥1000 mg/kg bw/day.

9. The submitted gene mutation assay is **ACCEPTABLE.** There was no evidence of cytotoxicity or insolubility. Acceptable experimental protocols were followed, and solvent and positive control values were appropriate for the respective strains. The test article did not increase the mean number of revertants per plate by a factor of two or more over the corresponding solvent control values for any of the five strains tested at any of the tested concentrations, without or with S9-mix. None of the experimental numbers of revertant colonies even approached a number that would suggest a biologically significant positive result, even at the limiting dose of 5000 μg/plate.

10. The submitted cell cytogenetics assay is classified as **ACCEPTABLE** and satisfies the guideline requirement for Test Guideline OCSPP 870.5375 [*In vitro* mammalian chromosome aberration test; OECD 473] for *in vitro* cytogenetic mutagenicity data.

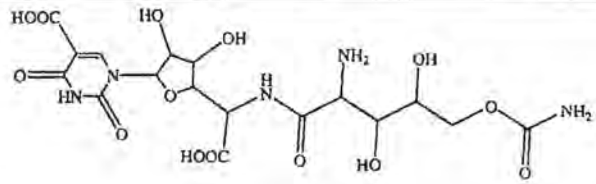
11. The submitted study for insect testing is **ACCEPTABLE.** Polyoxin D zinc salt was toxic to honeybees, with 8% mortality after 96 hr. The 96-hr LD_{50} was 28.77μg/bee.

12. The submitted study of Algal Toxicity (OCSPP 850.5400) is **ACCEPTABLE.** Based on the results, the E_bC_{50} (0-72 hr) was 6.47 mg/L (95% CI = 6.31-6.63 mg/L), and the $NOEC_b$ (0-72 hr) was 5 mg/L. Based on growth rate data, the E_rC_{50} (24-48 hr) was 7.19 mg/L (95% CI = 6.94-7.47 mg/L), and the NOEC was 5 mg/L; and the E_rC_{50} (24-72 hr) was 7.05 mg/L (95% CI = 6.84-7.28 mg/L), and the NOEC was 5 mg/L.

Background Information and Study Summaries

Polyoxin D and its zinc salt is the inhibition of chitin synthesis in the cell walls of fungi, some of which are pathogenic to plants. This inhibition of chitin synthesis is limited to chitin in fungal cell walls. Polyoxin D and its zinc salt do not inhibit the synthesis of chitin in animals that contain chitin, such as for insects and crustaceans that contain chitin in their exoskeletons. Polyoxin D Zinc Salt does not affect mammals because mammalian cells have plasma membranes that do not contain chitin.

Polyoxin D Zinc Salt is used exclusively on plants as an anti-fungal agent in the United States and elsewhere. Based upon maximum inhibitory concentration (MIC) evaluations, Polyoxin D Zinc Salt is not effective as an anti-bacterial agent. Polyoxin D Zinc Salt has never been used as an antibiotic in human or veterinary medicine. Polyoxin D Zinc Salt is not effective in inhibiting bacteria and yeast, but in the 14 fungal species tested, effectiveness of inhibition ranged from highly effective to ineffective. The chemical structure and chemical names of Polyoxin D Zinc Salt are provided (MRID 48653307) in Table 1.

Table1. Test Compound Nomenclature.	
Compound	 Chemical Structure
Common name	Polyoxin D Zinc Salt
Company experimental name	Polyoxin D Zinc Salt
IUPAC name	5-(2-amino-5-*O*-carbamoyl-2-deoxy-L-xylonamido)-5-deoxy-1-(1,2,3,4-tetrahydro-5-carboxy-2,4-dioxopyrimidinyl)-ß-D-allofuranuronic acid
CAS name	β-D-allofuranuronic acid, 5-[[2-amino-5-*O*-(aminocarbonyl)-2-deoxy-L-xylonyl]amino]-1-(5-carboxy-3,4-dihydro-2,4-dioxo-1(2*H*)-pyrimidinyl)-1,5-dideoxy-, zinc salt (1:1)
CAS registry number	146659-78-1
Use product	Polyoxin D Zinc Salt Technical

<u>860.1200 Directions for Use (MRID 48653307)</u>

Polyoxin D Zinc Salt is applied as a foliar spray to food crops, turf and ornamentals to control and/or suppress fungal diseases. Registered food uses were summarized for the United States and internationally. In the United States maximum use rates range from 2.1 to 4.2 oz active ingredient/acre/season, with a minimum pre-harvest interval of 0 days for all crops except ginseng, for which it is 365 days. Information was summarized for this chemical in the United States regarding EPA registration numbers, primary brand names, and application rates per application and per season. Information was also summarized for this chemical in international usage regarding countries, brand names, application rates per application and per season, and pre-harvest intervals.

It is acknowledged that if the proposed tolerance exemption for all crops is approved, the application rates in the United States might increase and the maximum number of applications per season might increase. However, such increases are unlikely to result in much increase in exposure to humans from residues of this fungicide because of the considerable expense of its production and because growers are advised to not make consecutive applications of fungicides with the same mode of action to avoid development of resistance. The mode of action of Polyoxin D and its zinc salt is the inhibition of chitin synthesis in the cell walls of fungi, some of which are pathogenic to plants. Polyoxin D and its zinc salt do not inhibit the synthesis of chitin in animals that contain chitin, and it does not affect mammals because mammalian cells have plasma membranes that do not contain chitin. Polyoxin D Zinc Salt is used exclusively on plants as an anti-fungal agent in the United States and elsewhere. It is not effective as an anti-bacterial agent, and it has never been used as an antibiotic in human or veterinary medicine. The data reported on minimum inhibitory concentrations in numerous species of bacteria, yeast, and fungi demonstrated no effectiveness in inhibiting bacteria and yeast, but in the 14 fungal species tested, effectiveness of inhibition ranged from highly effective to ineffective.

In tests on 14 bacterial species (10 aerobic, 3 anaerobic, and 1 acid-fast), there was no demonstrated inhibition of bacterial growth in agar at concentrations up to 400 μg/mL (MRID 48653308). The species tested included pathogenic, intestinal, and other general bacteria that exist widely in nature. As expected, because bacteria contain no chitin, polyoxin D appears to have no effect on bacterial growth.

Nature of the Residue— Plants (OCSPP 860.1300)

The test substance in the study was ^{14}C-radiolabeled Polyoxin D ([^{14}C]Polyoxin D), which was radiolabeled on the second carbon of the pyrimidine ring. The specific radioactivity was 55 mCi/mmole (225.662 dpm/ μg), and the radiopurity was 97.50 %. The test substance was isotopically diluted to a calculated specific activity of 94,733 dpm/μg before it was applied to tomatoes.

Three residue trials on grapes (MRID 48653309), tomatoes (MRID 48653310), and head lettuce (MRID 48653311) in greenhouses were conducted. The application rate on grapes was 1.5 $\mu g/cm^2 \times 1.67 = 2.5\ \mu g/cm^2$, 100 g a.i./ha = 1 $\mu g/cm^2$ on tomatoes, and 300 g a.i./ha = 3 $\mu g/cm^2$ on head lettuce.

Results

The total radioactive residue (TRR) levels in fruit from grape plants treated with [^{14}C]Polyoxin D (three applications at a rate of 1.67 times the recommended rate of 150 g a.i./ha) were 0.520, 0.538, and 0.495 mg eq./kg in samples collected on days 1, 14, and 30 after the final application. The TRR level in leaves from those grape plants was 20.690 mg eq./kg in samples collected 30 days after the final application.

Low levels of TRRs were detected in ripe tomatoes harvested from tomato plants treated with [^{14}C]Polyoxin D at 28, 21, and 14 days before final harvest at the rate of 100 grams a.i./ha per application. By far most of the radioactivity in the tomato fruit was detected in the surface wash residues. Only a small percentage of the radioactivity was present in the juice (6.9% TRR) and pomace (5.4% TRR). Polyoxin D was the major residue present and was detected on the fruit surface only. No Polyoxin D was associated with the juice or pomace fraction. Uracil-5-carboxylic acid was present at 9.3% TRR. A number of minor ^{14}C residues in the mature fruit were present, none exceeding 3.3% of the TRR. The TRRs in the tomato foliage were 3.078 ppm. The major ^{14}C residues identified from the foliage included Polyoxin D and Uracil-5-carboxylic acid. The study demonstrated that Polyoxin D was readily removed from the surface of the fruit. Because only a small percentage of the recovered radioactivity was detected in the fruit juice or pomace, there was clearly slow, or lack, of penetration of test material into the fruit. Any radioactivity that entered the fruit was extensively metabolized.

The TRR in the head (edible part) from the lettuce plant treated with [^{14}C]Polyoxin D at the rate of 300 g a.i./ha was low: 0.025 mg eq./kg and 0.107 mg eq./kg in samples collected 7 and 14 days after the last treatment. On those same days, the TRRs in the outer (wrapper) leaves from the lettuce head were 2.491 mg eq./kg and 1.890 mg eq./kg, respectively. In the studies on all three dissimilar crops, recoveries of spiked samples were acceptable and storage stability studies showed reasonable agreement between initial HPLC chromatographic profiles and HPLC chromatographic profiles taken after periods of frozen storage comparable to those occurring in the studies. Based on the results, it is appears that the major metabolic pathway of Polyoxin D in grapes, tomatoes, and head lettuce involves cleavage of the pyrimidinyl linkage to produce Uracil-5-carboxylic acid. This metabolite is then further metabolized and incorporated into plant constituents such as pectin, lignin and hemicellulose, followed by formation of bound residues.

Table 2 shows that the major radioactive components in the fruit and leaves (including both the surface rinse and extract) were unchanged [^{14}C]Polyoxin D and [^{14}C]Uracil-5-carboxylic acid.

Table 2. Measured primary radioactive residues in unwashed fruit and leaves of grape plants sprayed with [^{14}C]Polyoxin D

	Measured residues in mg eq./kg[a] (% TRR[b])			
	Fruit			Leaves
Primary radioactive residues	Day 1 ALT[c]	Day 14 ALT	Day 30 ALT	Day 30 ALT
Polyoxin D	0.3645 (69.90%)	0.2077 (39.40%)	0.1333 (26.88%)	2.5511 (12.70%)
Uracil-5-carboxylic acid	0.0339 (6.47%)	0.0621 (11.59%)	0.0673 (13.62%)	3.4666 (16.81%)
Total Identified	0.3984 (76.37%)	0.2698 (50.99%)	0.2006 (40.50%)	6.0177 (29.51%)
TRR	0.5201 (100.00%)	0.5375 (100.00)	0.4953 (100.00%)	20.6902 (100.00%)

Data copied from Table 11 on p. 74, MRID 48653309.
[a]mg eq./kg = [^{14}C]Polyoxin D equivalent concentration, that is, the radioactivity in a one kilogram of fresh plant sample when divided by the specific radioactivity of [^{14}C]Polyoxin D.
[b]% of total radioactive residues
[c]ALT = After Last Treatment

Tables 3 and 4, which show the major radioactive components in the fruit and leaves of treated tomatoes, make it clear that the major residues were unchanged [^{14}C]Polyoxin D and [^{14}C]Uracil-5-carboxylic acid.

Table 3. Measured primary radioactive residues in unwashed fruit of tomato plants sprayed with [^{14}C]Polyoxin D and collected 14 days after the last treatment

	Measured residues in ppm[a] (% TRR[b])			
Primary radioactive residues	Surface wash	Juice	Pomace	Total
Polyoxin D	0.073 (70.9%)	ND[c]	ND	0.073 (70.9%)
Uracil-5-carboxylic acid	0.005 (4.8%)	0.003 (2.5%)	0.002 (2.0%)	0.010 (9.3%)

Identified/characterized	0.078 (75.7%)	0.003 (2.5%)	0.002 (2.0%)	0.083 (80.2%)

Data copied from Table 8, p. 66 and second table, p. 15, MRID 48653310.
[a]ppm = parts per million polyoxin D equivalents determined using Liquid Scintillation Counting analysis of the liquid fractions and combustion analysis of extracted solids.
[b]% of total radioactive residues; [c]ND = not detected

Table 4. Measured primary radioactive residues in foliage extracts of tomato plants sprayed with [^{14}C]Polyoxin D and collected 14 days after the last treatment

	Measured residues in ppm[a] (% TRR[b])		
Primary radioactive residues	Water wash of homogenate	Water extract	Total
Polyoxin D	1.606 (52.2%)	0.336 (10.9%)	1.942 (63.1%)
Uracil-5-carboxylic acid	0.227 (7.4%)	0.013 (0.4%)	0.240 (7.8%)
Identified/characterized	1.833 (59.6%)	0.349 (11.3%)	2.181 (70.9%)

Data copied from Table 9, p. 67 and second table, p. 16, MRID 48653310.
[a]ppm = parts per million polyoxin D equivalents determined using Liquid Scintillation Counting analysis of the liquid fractions and combustion analysis of extracted solids.
[b]% of total radioactive residues

Tables 5 and 6 show the major radioactive components in head lettuce harvested 7 and 14 days after the final treatment, respectively. In the surface rinse of the outer (wrapper) leaves, the major residues were unchanged [^{14}C]Polyoxin D and [^{14}C]Uracil-5-carboxylic acid. At neither time of harvest was [^{14}C]Polyoxin D detected in the extract of the outer leaves or in the extract of the lettuce head; however, [^{14}C]Uracil-5-carboxylic acid was detected in both of those samples, albeit at very low levels.

Table 5. Measured primary radioactive residues in head lettuce plants harvested 7 days after last treatment with [^{14}C]Polyoxin D

	Measured residues in mg eq./kg[a] (% TRR[b])				
Primary radioactive residues	Surface Rinse of Outer Leaves	Extract of Outer Leaves	Total for Outer Leaves	Extract of Lettuce Head	Grand Total
Polyoxin D	0.7456 (29.64%)	ND[c]	0.7456 (29.64%)	ND	0.7456 (29.64%)
Uracil-5-carboxylic acid	0.3910 (15.54%)	0.0797 (3.17%)	0.4707 (18.71%)	0.0021 (0.09%)	0.4728 (18.79%)
Total identified	1.1366 (45.18%)	0.0797 (3.17%)	1.2163 (48.35%)	0.0021 (0.09%)	1.2184 (48.43%)

Data copied from Table 7A on p. 56, MRID 48653311.
Data are the mean of duplicate experiments except for the surface rinse fraction.
[a]mg eq./kg = [^{14}C]Polyoxin D equivalent concentration, that is, the radioactivity in a one kilogram of fresh plant sample when divided by the specific radioactivity of [^{14}C]Polyoxin D.
[b]% of total radioactive residues; [c]ND = not detected

Table 6. Measured primary radioactive residues in head lettuce plants harvested 14 days after last treatment with [^{14}C]Polyoxin D

	Measured residues in mg eq./kg[a] (% TRR[b])				
Primary radioactive Residues	Surface Rinse of Outer Leaves	Extract of Outer Leaves	Total for Outer Leaves	Extract of Lettuce Head	Grand Total
Polyoxin D	0.3748 (18.77%)	ND[c]	0.3748 (18.77%)	ND	0.3748 (18.77%)
Uracil-5-carboxylic acid	0.3826 (19.16%)	0.0623 (3.12%)	0.4449 (22.28%)	0.0273 (1.37%)	0.4721 (23.65%)
Total	0.7574 (37.93%)	0.0623 (3.12%)	0.8197 (41.05%)	0.0273 (1.37%)	0.8469 (42.42%)

Data copied from MRID 48653311.
Data are the mean of duplicate experiments except for the surface rinse fraction.
[a]mg eq./kg = [^{14}C]Polyoxin D equivalent concentration, that is, the radioactivity in a one kilogram of fresh plant sample when divided by the specific radioactivity of [^{14}C]Polyoxin D.
[b]% of total radioactive residues; [c]ND = not detected

Based on the metabolism studies, the proposed metabolic pathway in these three dissimilar plants is as follows:

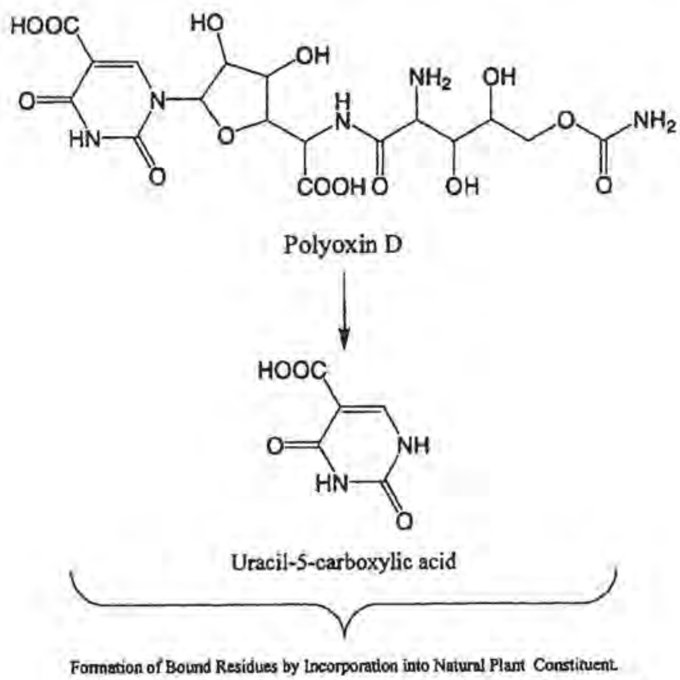


Figure copied from Fig. 10. p. 59, MRID 48653307

Conclusions:

The submitted nature of residue study is **ACCEPTABLE**. The TRR level in fruit from grape plant treated with [^{14}C]Polyoxin D (three applications at a rate of 1.67 times of 150 g a.i./ha) was 0.520 ppm at Day 1, 0.538 ppm at Day 14 and 0.495 ppm at Day 30 after the final application; total radioactive residues (TRR) were 3.078 ppm detected in the tomato fruits from tomato plants treated with Polyoxin D at 28, 21, and 14 days before final harvest at the rate of 100 grams a.i./ha per application; the TRR in the head (edible part) from the lettuce plant treated with [^{14}C]Polyoxin D at the rate of 300 g a.i./ha was low: 0.025 ppm and 0.107 ppm at Day-7 and Day-14, respectively.

The major metabolic pathway of Polyoxin D in grape plant was formation of uracil-5-carboxylic acid. This metabolite was further metabolized and considered to be incorporated into plant constituents of pectin, lignin and hemi-cellulose etc. followed by formation of bound residues.

The metabolism of Polyoxin D in tomato involved cleavage of the pyrimidinyl linkage to produce uracil-5-carboxylic acid. These results are consistent with those obtained from other Polyoxin D plant metabolism studies, including experiments with grape and lettuce. A metabolic pathway is proposed based on metabolites identified.

The major metabolic pathway of Polyoxin D in lettuce plant was formation of uracil-5-carboxylic acid. This metabolite was considered to be further metabolized into various polar metabolites followed by formation of bound residues.

Nature of the Residue--Livestock

No nature of the residue study has been conducted in livestock. Kaken Pharmaceutical Co. Ltd. requests a waiver of the requirement for data regarding the nature of the residue in livestock based upon the available data. It was demonstrated that residues levels in crops grown in greenhouses were low and that rinsing of the raw agricultural commodities with water significantly reduced those residue levels. As a result, no significant residues would be anticipated in or on livestock feed. Based on the environmental fate data, there will be significant degradation of residues under field conditions, that is, at pH 5.0, 7.0, and 9.0, Polyoxin D undergoes rapid aqueous photolysis; at pH 7.0 and 9.0, Polyoxin D undergoes rapid hydrolysis, and Polyoxin D degrades rapidly in the soil under aerobic conditions. Also, based on environmental fate data, the route of environmental degradation is consistent with the route of crop metabolism, that is, Polyoxin is degraded to Uracil-5-carboxylic acid and several smaller metabolites, each at levels below those requiring identification. Any residues of Polyoxin D ingested by livestock should be readily eliminated in urine, based on the Polyoxin D's physical properties. Based on the carbohydrate-like structure of Polyoxin D and the crop metabolism data, it is also anticipated that Polyoxin D will be metabolized in ruminants and poultry to Uracil-5-carboxylic acid and a large number of small minor metabolites that would be used in the carbon pool for the building of ruminant and poultry body tissues.

Conclusion:

The waiver request for nature of the residue study in livestock is **ACCEPTABLE.**

Residue Analytical Method (OCSPP 860.1340)

No residue analytical method has been submitted with this petition. However, an acceptable explanation has been submitted by the registrant: "a residue analytical method suitable for the enforcement of the tolerance is not required because a numerical tolerance is not proposed. Instead, a tolerance exemption for all agricultural commodities is proposed."

Multiresidue Method (OCSPP 860.1360)

No mutiresidue method has been submitted with this petition. However, an acceptable explanation has been submitted by the registrant: "a multiresidue try-out is not required because a numerical tolerance is not proposed. Instead, a tolerance exemption for all agricultural commodities is proposed."

Food Handling (OCSPP 860.1460)

No food handling data has been submitted with this petition. However, an acceptable explanation has been submitted by the registrant: "no uses of the fungicide polyoxin D Zinc Salt in food handling establishments are registered, proposed, or even contemplated".

Meat/Milk/Poultry/Eggs (OCSPP 860.1480)

No data for meat/milk/poultry/eggs has been submitted with this petition. However, an acceptable explanation has been submitted by the registrant: "based upon available crop metabolism and environmental fate data, no significant residues of Polyoxin D Zinc Salt are anticipated to be in meat, milk, poultry, and eggs. In addition, it was noted that because polyoxin D Zinc Salt is a polar compound with high water solubility, it should be excreted readily in the urine whenever it is ingested by livestock".

Crop Field Trials (OCSPP 860.1500)

No field trial study has been submitted with this petition. However, the registrant has analyzed data from 1) the nature of the residue data collected on grapes, tomatoes, and head lettuce grown in greenhouses (including metabolism data); 2) environmental fate data, and 3) expectations regarding the directions for use. The registrant concluded that"Greenhouse–grown and field-grown raw agricultural commodities treated with polyoxin D zinc salt are anticipated to have low residues. Residues can be easily and significantly reduced by rinsing the raw agricultural commodities with water." The conclusions are **ACCEPTALE.**

Processed Food/Feed (OCSPP 860.1520)

No processing study has been submitted with this petition. However, Kaken Pharmaceutical Co. Ltd. has submitted an acceptable waiver request regarding the magnitude of residue in processed food and feed because (1) crop metabolism and environmental fate data show that the magnitude of the residues of Polyoxin D Zinc Salt in RACs should be low, (2) food processing generally begins with a water rinse of the RAC, and crop metabolism data show that rinsing of the RAC removes a significant amount of the residue, and (3) the low levels of bound residues demonstrated are likely to be small molecules produced by catabolism that have been incorporated into natural constituents of the plants themselves such as pectin, lignin, and hemicellulose.

Anticipated Residues (OCSPP 860.1540)

No data for anticipated residue has been submitted with this petition. However, an acceptable explanation has been submitted by the registrant: "as noted in the crop metabolism studies, significant reduction results from rinsing raw agricultural commodities with water. Therefore, through the normal rinsing of raw fruits and vegetables before consumption, residues of polyoxin D in raw agricultural commodities are anticipated to be less at the point of consumption than at the farm gate. Polyoxin D readily hydrolyzes. Therefore, cooking of raw agricultural commodities will further reduce polyoxin D residues prior to consumption of the treated commodities."

Hydrolysis (OCSPP 835.2120)

The hydrolysis study (MRID 48653304) is **ACCEPTABLE**. The hydrolysis of [^{14}C]Polyoxin D was analyzed in a 30-day study in sterile buffers at pH 4.0, pH 5.0, pH 7.0 and pH 9.0. At intervals during incubation, aliquots were collected from each sample and analyzed directly by high-performance liquid chromatography with radiochemical flow detection (HPLC-RAD) to determine the distribution of radioactivity and identification of degradation products. At 25 ± 0.1°C, Polyoxin D hydrolyzes very rapidly at pH 9.0 and pH 7.0 and hydrolyzes at a slow rate at pH 4.0 and pH 5.0. The half-lives of [^{14}C]Polyoxin D were calculated to be 301.3 days, 231.0, 32.5 and 9.1 days in sterile pH 4.0, pH 5.0, pH 7.0 and pH 9.0 buffers, respectively.

The hydrolysis product observed at pH 4.0, pH 5.0, pH 7.0 and pH 9.0 was formed by cleavage of the pyrimidinyl linkage to produce the corresponding uracil-5-carboxylic acid probably via Polyoxin C acid as a possible intermediate. The major hydrolysis products observed solely at pH 7.0 and pH 9.0 were formed by cleavage of the side chain amide linkage to produce Polyoxin d2 or rearrangement of the side chain to produce Polyoxin d1a and Polyoxin d1b. These products may also be degraded to uracil-5-carboxylic acid via Polyoxin C acid.

Water, Fish, and Irrigated Crops (OCSPP 860.1400)

The submitted waiver request (MRID 48653307) regarding water, fish and irrigated crop is **ACCEPTALE.** Polyoxin D Zinc Salt is not currently registered for uses that could result in residues in potable water, fish and irrigated crops. Environmental fate data were summarized for the degradation routes of hydrolysis, aqueous photolysis, and aerobic soil metabolism, and it was argued that if new aquatic uses were registered, no significant residues would be anticipated due to the rapid environmental degradation of polyoxin D Zinc Salt.

Photodegradation in Water (OCSPP 835.2240)

The photolysis study (MRID 48653305) is **ACCEPTABLE**. The photolytic degradation of [^{14}C]Polyoxin D was analyzed in an 11-day study in sterile buffers at pH 5.0, pH 7.0, pH 9.0, and sterile natural water. At intervals during incubation, aliquots were collected from each sample and analyzed directly by high-performance liquid chromatography with radiochemical flow detection (HPLC-RAD) to determine the distribution of radioactivity and identification of degradation products. The net photolytic half-lives of [^{14}C]Polyoxin D were calculated to be 0.4 days, 4 days, 2.4 days, and 1.6 days in sterile natural water, pH 5.0, pH 7.0, and pH 9.0 buffers, respectively.

Photolytic degradation proceeded initially through cleavage of the pyrimidinyl linkage to produce the corresponding Uracil-5-Carboxylic Acid probably via Polyoxin C acid as a possible intermediate. Further degradation of Polyoxin D was formed by cleavage of the side chain amide linkage to produce Polyoxin d2 or rearrangement of the side chain to produce Polyoxin d1a and Polyoxin d1b. Unknown degradate having the estimated molecular weight of 475 (10.9-minute unknown) was also detected. Further photochemical degradation of Polyoxin D and/or its degradates led to formation of a complex mixture of polar components in the pH 5.0 buffer, pH 7.0 buffer, pH 9.0 buffer and natural water solutions. Based on the results of this study, photolysis will be a viable route of elimination of Polyoxin D from the environment.

Environmental Fate Summary

The submitted environmental fate data (MRID 48653303) is **ACCEPTABLE**. This submission is a summary of environmental fate data of polyoxin D zinc salt and contains duplicative information presented in the hydrolysis study (MRID 48653304), the photodegradation in water study (MRID 48653305), and the aerobic soil metabolism study (MRID 48653306). The summary information is presented to support the petition for exemption of requirement of a tolerance for residues polyoxin D zinc salt on all food and feed commodities.

Aerobic Soil Metabolism (OCSPP 835.4100)

The study of aerobic soil metabolism (MRID 48653306) is **ACCEPTABLE**. The aerobic soil metabolism of [^{14}C]Polyoxin D was determined with an agricultural soil from Saitama, Japan in soil test systems incubation at 25 ± 2°C in the dark for 90-days. At intervals during incubation, radiolabeled $^{14}CO_2$ was collected and extracts of soil were analyzed directly by high-performance liquid chromatography with radiochemical flow detection (HPLC-RAD) to determine the distribution of radioactivity and identification of degradation products. Polyoxin D was degraded rapidly under the aerobic soil conditions employed in this study with the major soil metabolites identified as Polyoxin C acid and $^{14}CO_2$. The Polyoxin C acid increased to maximum levels at Day 14 and then steadily declined in the aerobic soil. The amount of $^{14}CO_2$ steadily increased throughout the study as Polyoxin D declined in the system. The minor degradation products of Polyoxin D were Uracil-5-Carboxylic Acid and unknown metabolites at 3.3-, 3.6-, 11.3- and 30-minutes were observed at low levels and decreased to the end of the study.

The DT_{50} values for degradation of Polyoxin D in the aerobic soil test system were estimated using a linear regression analysis. The DT_{50} values were 15.9 and 59.2 days for the aerobic soil and sterile aerobic soil, respectively.

Under aerobic soil metabolism conditions using microbially active soils, Polyoxin D was metabolized rapidly. Based on the results of this study, Polyoxin D should dissipate under aerobic soil conditions from natural soil systems.

UV/Visible Absorption (OCSPP 830.7050)

The study of UV/Visible Absorption (MRID 48653302) is **ACCEPTABLE.** A laboratory study was conducted to determine the UV/visible absorption of Polyoxin D Zinc Salt by spectrophotometer analysis. The UV absorbance of Polyoxin D Zinc Salt in neutral, acidic and basic solutions was 270.0 nm, 274.0 nm and 268.5 nm, respectively.

Algal Toxicity (OCSPP 850.5400)

Methods and Materials (MRID 48660403)

Test Species: Green alga, *Selenastrum capricornutum*, strain ATCC22662.

Test Material: Polyoxin D zinc salt technical. The test solutions were prepared by dissolving Polyoxin D zinc salt in 2% 2Na·EDTA.

Test Concentrations: The final test concentrations were selected on the basis of results from a preliminary algal study which utilized Polyoxin D zinc salt concentrations of 3, 10, 30 and 100 mg/L. In the preliminary study the NOEC was around 3 mg/L and the EC_{50} was 3-10 mg/L.

Study Protocol: The test solutions were prepared in 100 ml water with an OECD-recommended culture medium (Table 2). The tests were conducted in 200 mL Erlenmeyer flasks under sterile, shaken (100 rpm) culture conditions (23.0-23.4°C, 4456-4638 Lux continuous illumination at 400-700 nm). The pH of the test solutions (8.0-8.2) was not adjusted. The initial cell density was 1.1×10^4 cells/mL. The exposures were for 72 hr. Cell densities in the cultures were determined at 24, 48 and 72 hr with a flow cytometer. There were three replicates for each test concentration and control.

Results

It was reported that there were no unexpected circumstances that may have had adverse effects on the reliability of the study. Observations made at the end of the study did not reveal any algal abnormalities in any of the test solutions.

Algal cell densities in each replicate at each time interval (0, 24, 48, and 72 hr). The mean algal cell counts at 72 hr were 46.1×10^4 cells/mL in the untreated control; 32.2×10^4 cells/mL in the solvent control; 43.6×10^4 cells/mL at 3 mg/L; 30.9×10^4 cells/mL at 4 mg/L; 38.6×10^4 cells/mL at 5 mg/L; 5.9×10^4 cells/mL at 7 mg/L; and 1.8×10^4 cells/mL at 10 mg/L.

Relative to solvent controls, growth inhibition was significantly ($p \leq 0.01$) different at nominal concentrations of 7 mg/L (78.8%) and 10 mg/L (95.2%). Algal growth inhibition rates, based on the growth rates (I_m) for 24-48 hr, are shown in Table 5; and algal growth inhibition rates, based on the growth rates (I_m) for 24-72 hr. Relative to solvent controls, growth inhibition for 24-48 hr, was significantly ($p \leq 0.01$) different at nominal concentrations of 7 mg/L (45.0%) and 10 mg/L (88.6%), and that for 24-72 hr significantly ($p \leq 0.01$) different at nominal concentrations of 7 mg/L (51.0%) and 10 mg/L (92.36%).

EC_{50} and NOEC values were calculated or estimated by comparing the algal cell growth inhibition in the treated solutions with that of the solvent control because "the stronger inhibition was observed in the solvent control group compared with the control group". Based on the areas under the curve, the E_bC_{50} (0-72 hr) was 6.47 mg/L (95% CI = 6.31-6.63 mg/L), and the $NOEC_b$ (0-72 hr) was 5 mg/L. Based on growth rate data, the E_rC_{50} (24-48 hr) was 7.19 mg/L (95% CI = 6.94-7.47 mg/L), and the NOEC was 5 mg/L; and the E_rC_{50} (24-72 hr) was 7.05 mg/L (95% CI = 6.84-7.28 mg/L), and the NOEC was 5 mg/L.

Conclusions:

The submitted study of Algal Toxicity (OCSPP 850.5400) is **ACCEPTABLE.** The test showed measured concentrations at the start and at the end of the test period. Growth inhibition was significantly different from the solvent control at concentration levels 6.09 mg/L and 8.80 mg/L. Based on the results, the E_bC_{50} (0-72 hr) was 6.47 mg/L (95% CI = 6.31-6.63 mg/L), and the $NOEC_b$ (0-72 hr) was 5 mg/L. Based on growth rate data, the E_rC_{50} (24-48 hr) was 7.19 mg/L (95% CI = 6.94-7.47 mg/L), and the NOEC was 5 mg/L; and the E_rC_{50} (24-72 hr) was 7.05 mg/L (95% CI = 6.84-7.28 mg/L), and the NOEC was 5 mg/L.

Non-target Insect Testing (OCSPP 880.4350)

The objective of the study was to test the oral toxicity of Polyoxin D zinc salt to the honeybee (*Apis mellifer*). For the Polyoxin D zinc salt treatments, 150, 75, 37.5, 18.75, or 9.375 µg was diluted with 20 µL of a 50% sucrose solution to make five dosage levels. Each dose of the test material (200 µL) was injected into a feeding tube with a micropippette, and the tube was inserted into one end of the test container into which 10 bees had been placed. Exposures were for approximately 3 hrs during which time the test containers were kept in an incubator. The actual dose levels were calculated from specific gravity measurements and the decrease in the feeding tube weights. Dimethoate was used as a reference material. Controls were untreated. There were five replicates per treatment and control. At the lowest oral dose tested (9.2616 µg/bee), Polyoxin D zinc salt was toxic to honeybees, with 8% mortality after 96 hr. The 96-hr LD_{50} was 28.77µg/bee.

Conclusion:

The submitted study for insect testing is **ACCEPTABLE.** Polyoxin D zinc salt was toxic to honeybees, with 8% mortality after 96 hr. The 96-hr LD_{50} was 28.77μg/bee.

Prenatal Developmental Toxicity Study - Rat; OCSPP 870-3700

(MRID 4853315) In a teratology (developmental toxicity) study (MRID 48653315), Polyoxin D zinc salt (204, Lot/batch No. 124-164-W9-00) in 5% methylcellulose was administered by gavage to groups of 24 mated and presumed pregnant female Br/Han:WIST@Jcl (GALAS) rats at doses of 0, 100, 300, or 1000 mg/kg bw/day from gestation day (GD) 6-19 inclusive. One dam in the control group not pregnant was not evaluated. The dams were killed on GD 20 for examination of uterine content. The fetuses were examined externally, sexed, and weighed. Approximately one-half the fetuses were examined for visceral variations and anomalies and the remaining half was fixed, stained, and cleared for examination of skeletal variations and anomalies.

No deaths or changes in general appearance were observed in maternal rats treated with any dose of Polyoxin D zinc salt. Body weight, weight gain, body weight adjusted for gravid uterine weight, and food consumption were not adversely affected by treatment with the test substance. At necropsy, 20/24 maternal rats administered 1000 mg/kg/day had thickening of the limiting ridge in the stomach compared with 0/23 controls. This lesion was not observed at 100 or 300 mg/kg/day.

Therefore, the lowest-observed-adverse-effect level (LOAEL) for maternal toxicity of Polyoxin D zinc salt in rats is 1000 mg/kg bw/day based on gross lesions in the stomach (thickening of the limiting ridge). The no-observed-adverse-effect level (NOAEL) is 300 mg/kg bw/day.

No treatment-related effects were observed on developmental parameters including gravid uterine weight, placental weight, mean numbers of corpora lutea and implantation sites, numbers of early and late resorptions (dead or resorbed embryos or fetuses), number of live fetuses per dam, implantation index, viability index, sex ratio, and male and female fetal body weight. The incidence of external, visceral, and skeletal variations and anomalies were not affected by treatment with Polyoxin D zinc salt.

Conclusions:

The developmental toxicity study in the rat is classified **ACCEPTABLE** and satisfies the guideline requirement for a developmental toxicity study (OCSPP 870.3700; OECD 414) in the rat. The developmental toxicity LOAEL for Polyoxin D zinc salt is not determined. The NOAEL is ≥1000 mg/kg bw/day.

Mutation Assay OCSPP 870.5100

In a reverse gene mutation assay in bacteria (MRID 48653313), *S. typhimurium* strains TA98, TA100, TA1535, and TA1537 and *E. coli* strain WP2 *uvrA* were exposed to

Polyoxin D zinc salt (technical grade, chemical purity not given, lot number PSB-625) dissolved in DMSO, without and with activation, in a pre-experiment for cytotoxicity and in two independent mutation assays each using the pre-incubation method. The pre-test cytotoxicity assay used single plates at concentrations of 0, 1.2, 4.9, 19.5, 78.1, 313, 1250, and 5000 µg/plate. The first mutation assay used concentrations of 0, 61.7, 185, 556, 1667, and 5000 µg/plate and the second mutation assay used 0, 313, 625, 1250, 2500, and 5000 µg/plate. All mutation assays were done using triplicate plating. The S9 fraction was obtained from phenobarbital + 5,6-benzoflavone-induced male Sprague Dawley rat liver.

The test material Polyoxin D zinc salt was tested at concentrations up to the limit concentration for the assay, and there was no evidence that the assays were affected by cytotoxicity or insolubility. The number of revertants per plate was not significantly increased, never reaching 2x the concurrent solvent control value, at any test article concentration, with or without S9-mix, in any tester strain. The solvent and positive controls induced the appropriate responses in the corresponding strains and were in agreement with the historical control data from this laboratory. There was no evidence of induced mutant colonies over background.

Conclusions:

The submitted gene mutation assay is **ACCEPTABLE.** There was no evidence of cytotoxicity or insolubility. Acceptable experimental protocols were followed, and solvent and positive control values were appropriate for the respective strains. The test article did not increase the mean number of revertants per plate by a factor of two or more over the corresponding solvent control values for any of the five strains tested at any of the tested concentrations, without or with S9-mix. None of the experimental numbers of revertant colonies even approached a number that would suggest a biologically significant positive result, even at the limiting dose of 5000 µg/plate.

In Vitro Mammalian Chromosome Aberration Test OCSPP 870.5375

In a mammalian cell cytogenetics assay for chromosome aberrations (MRID 48653314), cultured Chinese hamster lung cells (CHL/IU) were exposed to Polyoxin D Zinc Salt (technical grade, chemical purity not given, Batch PSB-625) dissolved in dimethylsulfoxide. In Exp. I, cells were exposed without activation for 6 hours, at concentrations of 0, 67.7, 94.8, 133, 186, and 260 µg/mL and were exposed with activation for 6 hours at concentrations of 0, 19.8, 59.3, 178, 533, and 1600 µg/mL. After treatment, the test article was removed from the cultures and replaced with fresh medium and the cells were allowed to recover for 18 hours before fixation. In Exp. II, cells were exposed without activation continuously for 24 hours at concentrations of 0, 34.5, 48.3, 67.7, 94.8, and 133 µg/mL followed by fixation and analysis. The S9 used for activation was obtained using livers of Sprague-Dawley male rats induced with phenobarbital and 5,6-benzoflavone and obtained commercially.

In Experiment I Polyoxin D Zinc Salt was tested up to dose levels that caused >50% cell lethality without activation (260 µg/mL) and with activation (1600 µg/mL). Without activation, the frequencies of the metaphases with structural chromosome aberrations (excluding gaps) were 14.5% and 7.5% at test article concentrations of 186 and 260µg/mL, respectively. These were statistically highly significant ($p \leq 0.001$) increases over the solvent control; with activation, the frequency of metaphase cells with structural chromosome aberrations (excluding gaps) was 9.5% at a test article concentration of 1600 µg/mL, which was a statistically highly significant ($p \leq 0.001$) increase over the solvent control. There was also precipitation of the test article at this concentration. The frequency of polyploid metaphase cells showed no increases either without or with activation. In Experiment II, a 24 hour continuous treatment without activation resulted in a 8.0% frequency of metaphases with structural chromosome aberrations (excluding gaps) at the concentration of 133 µg/mL, which was a statistically highly significant ($p \leq 0.001$) increase over the solvent control. There were no increases in the frequency of polyploid metaphases. All of the solvent and positive controls gave appropriate responses in both experiments and were within the ranges of the corresponding historical controls.

Conclusions: The submitted cell cytogenetics assay is classified as **ACCEPTABLE** and satisfies the guideline requirement for Test Guideline OCSPP 870.5375 [*In vitro* mammalian chromosome aberration test; OECD 473] for *in vitro* cytogenetic mutagenicity data.

Reasonable Grounds in Support of the Petition (OCSPP 860.1560)

The registrant summarized data submitted in separate data volumes to support petition for expanding exemption from the requirement of a tolerance the residues of the biochemical pesticide polyoxin D zinc salt in all agriculture commodities. The petitioner has provided the following acceptable arguments:

1. Both the chemical identity and product chemistry of Polyoxin D Zinc Salt are known.
2. The registered directions for the use of this chemical in the United States and in the rest of the world are known. Current and future uses of this chemical are limited by the high cost of treatment using this chemical relative to other fungicides and by the need to alternate the use of fungicides with different modes of action to minimize the potential for the development of resistance. These practical limitations make it unlikely that approval of a tolerance exemption for all food and feed commodities will cause problems from increases in the number of uses and in application rates.
3. Polyoxin D Zinc Salt is an anti-fungal fermentation product that is produced by a bacterium that occurs naturally in the soil.
4. This chemical has a non-toxic mode of action that is specific to fungi because it inhibits synthesis of cell wall chitin in fungi. Instead of killing fungi, it simply stops fungal growth. Humans and other mammals have cell membranes, but they no not have cell walls or structures that contain chitin. Polyoxin D Zinc Salt in not

effective as an anti-bacterial agent, and it has never been used in human or veterinary medicine.

5. The toxicology of this chemical is well understood, with more data available than are usually available for biochemicals. These data show that Polyoxin D Zinc Salt has low acute, subacute, chronic, and developmental toxicity, that it is not mutagenic *in vivo*, that it has low immunotoxicity and reproductive toxicity, and that it is not oncogenic.
6. Data suggest that this chemical is not an endocrine disruptor.
7. The nature of the residue in plants is understood and has been shown to be the same in three dissimilar crops, namely grapes, tomatoes and head lettuce. The primary residues are Polyoxin D and Uracil-5-carboxylic acid. These two residues are further metabolized to a large number of small molecule metabolites, each of which is present at levels too low to require identification.
8. The studies of the nature of the residue in plants are supported by storage-stability data, by acceptable recoveries from spiked samples, and by acceptable mass balance (that is, accounting for the total radioactive residues).
9. Based on the available crop metabolism data and environmental fate data, there is thought to be an adequate understanding of the nature of the residue in ruminants and poultry. As in plants, the anticipated residues are expected to be Polyoxin D and Uracil-5-carboxylic acid. Rapid elimination of residues is expected in the urine.
10. Also based on the available crop metabolism data and environmental fate data, residues resulting from treatments with this chemical according to good agricultural practices are expected to be low in raw agricultural crop commodities, processed agricultural crop commodities, meat, milk, poultry, eggs, potable water, fish (should there be any possible future uses on aquatic crops), and drinking water.
11. Based on the crop metabolism data, significant reduction of Polyoxin D residues is easily achieved by simply rinsing raw agricultural commodities with water. Based on the hydrolysis data, a further reduction in residues would be expected to result from cooking.
12. Because Polyoxin D Zinc Salt has low toxicity and very low dietary exposure levels, the dietary risk from this chemical should be very low.

Risk Characterization

An exemption from the requirement of a tolerance has been established for the residues of the biochemical pesticide polyoxin D zinc in 40 CFR 180.1285 when used as a fungicide on almonds, cucurbit vegetables, fruiting vegetables, ginseng, grapes, pistachios, pome fruits, potatoes and strawberries.

The submitted toxicological studies of acute (six-pack) toxicity, mutagenicity, subchronic (90-day oral), developmental, and chronic/oncogenicity support the existing tolerance exemption in 40 CFR 180.1285 for the biochemical pesticide polyoxin D zinc. Although the studies indicate a lack of toxicity hazards for mammals; however, EPA concluded that there is a reasonable certainty of no harm to humans, including infants and children; from the proposed food uses of polyoxin D zinc salt.

Developmental Toxicity

A new developmental study (MRID 48653315) was contacted for polyoxin D zinc salt to support the expansion of the tolerance exemption. No treatment-related effects were observed in general appearance, body weight, body weight adjusted for gravid uterine weight, weight gain, or food consumption in maternal rats at the doses tested (0, 100, 300, and 1000 mg/kg bw/day). Necropsy observations showed that almost all rats (20/24) in the 1,000 mg/kg/day group (highest dose tested) had thickening of the limiting ridge. Therefore, the lowest observed adverse effect level (LOAEL) for maternal toxicity of polyoxin D zinc salt in rats is 1,000 mg/kg bw/day based on gross lesions in the stomach (thickening of the limiting ridge). The no observed adverse effect level (NOAEL) for maternal toxicity is 300 mg/kg bw/day based on no effects observed at this dose. Although an effect of gross lesions in the stomach was found in maternal rats at the limit dose tested (1,000 mg/kg bw/day), there were no reported systemic effects in maternal rats at this dose. The effect in the stomach lining was limited to a localized gastric irritation due to the route of entry (oral gavage) at the limit dose tested (1,000 mg/kg bw/day), which is typical of the nature of the test substance.

The developmental toxicity showed that no treatment-related effects were observed on developmental parameters including gravid uterine weight, placental weight, mean numbers of corpora lutea and implantation sites, numbers of early and later resorptions (dead or resorbed embryos or fetuses), number of live fetuses per dam, implantation index, viability index, sex ratio, and male and female body weight. The incidence of external, visceral, and skeletal variations and anomalies were not affected by treatment of polyoxin D zinc salt. Based on no effects observed for developmental toxicity at any doses tested, the NOAEL for developmental toxicity is greater than 1,000 mg/kg bw/day (highest dose tested). The LOAEL was not identified for developmental toxicity, suggesting that the test animals could have tolerated a higher dose.

The submitted developmental toxicity data and the previous submitted toxicity studies of Tier III two-generation reproduction indicate that no reproductive effects at the limit dose tested. The toxicity profile is adequately determined that polyoxin D zinc salt is not a developmental toxicant. The consumption of food commodities that are treated with polyoxin D zinc salt when used as a pesticide will not be harmful to human health from dietary exposure.

Mutagenicity Studies

Two new mutagenicity studies were conducted for polyoxin D zinc salt to support the expansion of the tolerance exemption. The mutagenicity studies along with the mutagenicity studies submitted to support the previous tolerance exemption. The studies determined that polyoxin D zinc salt is not a mutagen. The consumption of food commodities that are treated with polyoxin D zinc salt when used as a pesticide will not be harmful to human health from dietary exposure.

1. A reverse gene mutation assay in bacteria (MRID 48653313) using the technical grade of polyoxin D zinc salt, dissolved in dimethyl sulfoxide (DMSO), with and without metabolic S9 activation, showed no mutagenic effects or evidence of cytotoxicity or insolubility even at the limiting dose of 5000 ug/plate (Ref. 1). Therefore, polyoxin D zinc salt is considered to be non-mutagenic under the conditions of this assay.

2. An *in vitro* mammalian chromosome aberration test (MRID 48653314) using the technical grade of polyoxin D zinc salt, dissolved in DMSO, with and without metabolic S9 activation, showed clastogenic potential in Chinese hamster lung cells (CHL/IU) with and without activation. In Experiment I, polyoxin D zinc salt was tested up to dose levels that caused >50% cell lethality without activation (260 µg/mL) and with activation (1600 µg/mL). Without activation, the frequencies of the metaphases with structural chromosome aberrations (excluding gaps) were 14.5% and 7.5% at test article concentrations of 186 and 260µg/mL, respectively. With activation, the frequency of metaphase cells with structural chromosome aberrations (excluding gaps) was 9.5% at a test article concentration of 1600 µg/mL. The frequency of polyploid metaphase cells showed no increases either without or with activation. In Experiment II, a 24-hour continuous treatment without activation resulted in a 8.0% frequency of metaphases with structural chromosome aberrations (excluding gaps) at the concentration of 133 µg/mL. There were no increases in the frequency of polyploid metaphases.

Although the submitted *in vitro* mammalian chromosome aberration test showed clastogenic potential, the results were not reproducible at the dose levels reported in the experiment. In addition, the mutagenicity data submitted to support the previous tolerance exemption, which included three complimentary Tier I mutagenicity tests and a Tier II mammalian erythrocyte micronucleus *in vivo* test, showed no mutagenic effects including no clastogenic potential (no chromosomal aberrations). Furthermore, the lack of systemic toxicity noted in the following developmental toxicity section indicted no effects in the Tier III two-generation reproduction study. The studies indicate that polyoxin D zinc salt is not mutagenic or clastogenic. The studies support this expansion of the tolerance exemption based on the weight of evidence of the mutagenicity data.

Proposed Tolerances (OCSPP 860.1550)

Kaken Pharmaceutical Co., Ltd. proposes that §180.1285 are amended as follows (MRID48653307): **"§180.1285 Polyoxin D zinc salt; exemption from the requirement of a tolerance.** An exemption from the requirement of a tolerance is established for the residues of the biochemical pesticide polyoxin D zinc salt in or on all agricultural commodities when polyoxin D zinc salt is used as a fungicide in accordance with good agricultural practices." The study makes this request and provides no further argument in this section. It does, however, point out a typographical error in the spelling of the CAS chemical name of Polyoxin D Zinc Salt that occurred on page 69559 of the November 19, 2008, Federal Register. The letters "in" at the end of the published chemical name are extraneous letters. The correct CAS chemical name for polyoxin D zinc salt, based on the ninth chemical index and a search of the CAS database and expressed as salt, is: zinc 5-[[2-amino-5-*O*-(aminocarbonyl)-2-deoxy-L-xylonyl]amino]-1-(5-carboxy-3,4-dihydro-2,4-dioxo-1(2*H*)-pyrimidinyl)-1,5-dideoxy-β-D-allofuranuronate.

cc: C.Walsh; BPPD Chron File; OHAD/ARS
M. Xue, BPPD, 05/11/12

4.b. September 12, 2012 Final Rule (Amended Tolerance Exemption)

56128 Federal Register / Vol. 77, No. 177 / Wednesday, September 12, 2012 / Rules and Regulations

EPA-APPROVED REGULATIONS IN THE WEST VIRGINIA SIP

State citation [Chapter 16–20 or 45 CSR]	Title/subject	State effective date	EPA approval date	Additional explanation/ citation at 40 CFR 52.2565
* *	*	*	*	* *
[45 CSR] Series 8 Ambient Air Quality Standards				
Section 45–8–1	General	6/16/11	9/12/12 [*Insert page number where the document begins*].	Incorporation by reference of the National Ambient Air Quality Standards.
Section 45–8–2	Definitions	6/16/11	9/12/12 [*Insert page number where the document begins*].	Revised section moved from 45–8–3 to 45–8–2.
Section 45–8–3	Adoption of Standards	6/16/11	9/12/12 [*Insert page number where the document begins*].	Section was revised to read new title and content.
Section 45–8–4	Inconsistency Between Rules	6/16/11	9/12/12 [*Insert page number where the document begins*].	Revised section moved from 45–8–7 to 45–8–4.
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[FR Doc. 2012–22338 Filed 9–11–12; 8:45 am]

BILLING CODE 6560–50–P

ENVIRONMENTAL PROTECTION AGENCY

40 CFR Part 180

[EPA–HQ–OPP–2011–1028; FRL–9360–6]

RIN 2070

Polyoxin D Zinc Salt; Amendment to an Exemption From the Requirement of a Tolerance

AGENCY: Environmental Protection Agency (EPA).

ACTION: Final rule.

SUMMARY: This regulation amends the existing exemption from the requirement of a tolerance for residues of polyoxin D zinc salt when used as a fungicide on almonds, cucurbit vegetables, fruiting vegetables, ginseng, grapes, pistachios, pome fruits, potatoes, and strawberries by expanding the current exemption to include all food commodities. This regulation establishes an exemption from the requirement of a tolerance for residues of polyoxin D zinc salt in or on all food commodities when applied as a fungicide and used in accordance with good agricultural practices. On behalf of Kaken Pharmaceutical Co., Ltd., Conn & Smith, Inc. submitted a petition to EPA under the Federal Food, Drug, and Cosmetic Act (FFDCA), requesting that EPA amend the existing exemption from the requirement of a tolerance for polyoxin D zinc salt. This regulation eliminates the need to establish a maximum permissible level for residues of polyoxin D zinc salt under the FFDCA.

DATES: This regulation is effective September 12, 2012. Objections and requests for hearings must be received on or before November 13, 2012, and must be filed in accordance with the instructions provided in 40 CFR part 178 (see also Unit I.C. of the **SUPPLEMENTARY INFORMATION**).

ADDRESSES: The docket for this action, identified by docket identification (ID) number EPA–HQ–OPP–2011–1028, is available at http://www.regulations.gov or at the Office of Pesticide Programs Regulatory Public Docket (OPP Docket) in the Environmental Protection Agency Docket Center (EPA/DC), EPA West Bldg., Rm. 3334, 1301 Constitution Ave. NW., Washington, DC 20460–0001. The Public Reading Room is open from 8:30 a.m. to 4:30 p.m., Monday through Friday, excluding legal holidays. The telephone number for the Public Reading Room is (202) 566–1744, and the telephone number for the OPP Docket is (703) 305–5805. Please review the visitor instructions and additional information about the docket available at http://www.epa.gov/dockets .

FOR FURTHER INFORMATION CONTACT: Colin G. Walsh, Biopesticides and Pollution Prevention Division (7511P), Office of Pesticide Programs, Environmental Protection Agency, 1200 Pennsylvania Ave. NW., Washington, DC 20460–0001; telephone number: (703) 308–0298; email address: *walsh.colin@epa.gov.*

SUPPLEMENTARY INFORMATION:

I. General Information

A. Does this action apply to me?

You may be potentially affected by this action if you are an agricultural producer, food manufacturer, or pesticide manufacturer. The following list of North American Industrial Classification System (NAICS) codes is not intended to be exhaustive, but rather provides a guide to help readers determine whether this document applies to them. Potentially affected entities may include:

- Crop production (NAICS code 111).
- Animal production (NAICS code 112).
- Food manufacturing (NAICS code 311).
- Pesticide manufacturing (NAICS code 32532).

B. How can I get electronic access to other related information?

You may access a frequently updated electronic version of 40 CFR part 180 through the Government Printing Office's e-CFR site at *http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?&c=ecfr&tpl=/ecfrbrowse/Title40/40tab_02.tpl.*

To access the OCSPP test guidelines referenced in this document electronically, please go to *http://www.epa.gov/ocspp* and select ''Test Methods and Guidelines. ''

C. How can I file an objection or hearing request?

Under FFDCA section 408(g), 21 U.S.C. 346a, any person may file an objection to any aspect of this regulation and may also request a hearing on those objections. You must file your objection or request a hearing on this regulation in accordance with the instructions provided in 40 CFR part 178. To ensure proper receipt by EPA, you must identify docket ID number EPA–HQ–OPP–2011–1028 in the subject line on the first page of your submission. All objections and requests for a hearing must be in writing, and must be received by the Hearing Clerk on or before November 13, 2012. Addresses for mail and hand delivery of objections and hearing requests are provided in 40 CFR 178.25(b).

In addition to filing an objection or hearing request with the Hearing Clerk as described in 40 CFR part 178, please submit a copy of the filing (excluding any Confidential Business Information (CBI) for inclusion in the public docket. Information not marked confidential pursuant to 40 CFR part 2 may be disclosed publicly by EPA without prior notice. Submit the non-CBI copy of your objection or hearing request, identified by docket ID number EPA–HQ–OPP–2011–1028, by one of the following methods:

- *Federal eRulemaking Portal : http://www.regulations.gov* . Follow the online instructions for submitting comments. Do not submit electronically any information you consider to be (CBI) or other information whose disclosure is restricted by statute.
- *Mail:* OPP Docket, Environmental Protection Agency Docket Center (EPA/DC), (28221T), 1200 Pennsylvania Ave. NW., Washington, DC 20460–0001.
- *Hand Delivery:* To make special arrangements for hand delivery or delivery of boxed information, please follow the instructions at *http://www.epa.gov/dockets/contacts.htm.*

Additional instructions on commenting or visiting the docket, along with more information about dockets generally, is available at *http://www.epa.gov/dockets*.

II. Background and Statutory Findings

In the **Federal Register** of March 14, 2012 (77 FR 15012) (FRL–9335–9), EPA issued a notice pursuant to FFDCA section 408(d)(3), 21 U.S.C. 346a(d)(3), announcing the filing of a pesticide tolerance petition (PP 1F7940) by Conn & Smith, Inc., Agent, 6713 Catskill Road, Lorton, VA 22079, on behalf of Kaken Pharmaceutical Co., Ltd. The petition requested that 40 CFR 180.1285 be amended by expanding the current exemption to include all food commodities, thus establishing an exemption from the requirement of a tolerance for residues of polyoxin D zinc salt in or on all food commodities. This notice referenced a summary of the petition prepared by the petitioner Conn & Smith, Inc., on behalf of Kaken Pharmaceutical Co., Ltd., which is available in the docket, *http://www.regulations.gov*. There were no comments received in response to the notice of filing.

Section 408(c)(2)(A)(i) of FFDCA allows EPA to establish an exemption from the requirement for a tolerance (the legal limit for a pesticide chemical residue in or on a food) only if EPA determines that the exemption is ''safe.'' Section 408(c)(2)(A)(ii) of FFDCA defines ''safe'' to mean that ''there is a reasonable certainty that no harm will result from aggregate exposure to the pesticide chemical residue, including all anticipated dietary exposures and all other exposures for which there is reliable information.'' This includes exposure through drinking water and in residential settings, but does not include occupational exposure. Pursuant to FFDCA section 408(c)(2)(B), in establishing or maintaining in effect an exemption from the requirement of a tolerance, EPA must take into account the factors set forth in FFDCA section 408(b)(2)(C), which require EPA to give special consideration to exposure of infants and children to the pesticide chemical residue in establishing a tolerance and to ''ensure that there is a reasonable certainty that no harm will result to infants and children from aggregate exposure to the pesticide chemical residue. * * *'' Additionally, FFDCA section 408(b)(2)(D) requires that the Agency consider'' available information concerning the cumulative effects of such residues and other substances that have a common mechanism of toxicity.''

EPA performs a number of analyses to determine the risks from aggregate exposure to pesticide residues. First, EPA determines the toxicity of pesticides. Second, EPA examines exposure to the pesticide through food, drinking water, and through other exposures that occur as a result of pesticide use in residential settings.

III. Toxicological Profile

Consistent with FFDCA section 408(b)(2)(D), EPA has reviewed the available scientific data and other relevant information in support of this action and considered its validity, completeness and reliability, and the relationship of this information to human risk. EPA has also considered available information concerning the variability of the sensitivities of major identifiable subgroups of consumers, including infants and children.

EPA established a tolerance exemption for polyoxin D zinc salt in a final rule published in the **Federal Register** on November 19, 2008, (73 FR 69559) (FRL–8389–5), which supported the uses as a fungicide on almonds, cucurbit vegetables, fruiting vegetables, ginseng, grapes, pistachios, pome fruits, potatoes, and strawberries. The toxicological data submitted to support the previous tolerance exemption included the following: Acute (six-pack) toxicity, mutagenicity, subchronic (90-day oral), developmental, and chronic/oncogenicity studies. All of the studies/information submitted to support the previous tolerance exemption indicated a lack of toxicity hazards for mammals, and EPA concluded that there is a reasonable certainty of no harm to humans, including infants and children, from the proposed food uses of polyoxin D zinc salt. This amendment proposes to expand the tolerance exemption to include all food commodities when applied as a fungicide and used in accordance with good agricultural practices. In support of this expansion of the tolerance exemption, new data have been generated by the petitioner and reviewed by EPA to further address the developmental toxicity (OCSPP Guideline No. 870.3700) and mutagenicity (OCSPP Guideline Nos. 870.5100 and 870.5375) data requirements. The data are required when the use of the substance under widespread and commonly recognized practices may reasonably be expected to result in significant exposure to humans, specifically females of child-bearing age for the developmental toxicity data requirement. The rest of the toxicological profile as stated in the **Federal Register** of November 19, 2008, and referenced herein, has not changed. A copy of the November 19, 2008 final rule document (73 FR 69559) is located under docket ID number EPA–HQ–OPP–2008–0417. A copy of the risk assessment cited herein (See Ref.) is located under docket ID number EPA–HQ–OPP–2011–1028.

As discussed in the **Federal Register** of November 19, 2008 polyoxin D zinc salt is a brown musty smelling powder derived through the fermentation of the microbe *Streptomyces cacaoi var. asoensis* , which was isolated from a soil sample collected from Japan. This biochemical active ingredient has a non-toxic mode of action, which acts against fungi by inhibiting chitin growth in the cell walls, thus precluding the development of fungal colonies. Its effects are considered fungi-exclusive in that it has no mode of action relative to mammals and passes through mammalian digestive systems. Polyoxin D zinc salt does not persist in the environment and has a well understood low toxicity profile.

As stated previously in this Unit (III), new toxicity data have been submitted in support of the request by the petitioner to expand the current tolerance exemption to cover all food commodities. These data include:

1. A prenatal developmental toxicity study; and
2. Two mutagenicity studies.

All new data, coupled with the data submitted to support the previous tolerance exemption (73 FR 69561), confirm a lack of human health hazard, as noted and reported in the original assessment of the tolerance exemption, associated with dietary exposures of polyoxin D zinc salt and fully demonstrate the lack of acute, subchronic, and chronic toxicity. Summaries of the new toxicological data submitted in support of the expansion of the tolerance exemption follow.

A. Mutagenicity

Two new mutagenicity studies were performed for polyoxin D zinc salt to support the expansion of the tolerance exemption. The mutagenicity studies as described herein, along with the mutagenicity studies submitted to support the previous tolerance exemption (73 FR 69561), confirm that polyoxin D zinc salt is not a mutagen and that consumption of food commodities that have been treated with this substance when used as a pesticide is safe and will not result in any harm to human health from dietary exposure.

1. A reverse gene mutation assay in bacteria Master Record Identification Number ((MRID) 48653313) using the technical grade of polyoxin D zinc salt, dissolved in dimethyl sulfoxide (DMSO), with and without metabolic S9 activation, showed no mutagenic effects or evidence of cytotoxicity or insolubility even at the limiting dose of 5,000 ug/plate (See Ref.). Therefore, polyoxin D zinc salt is considered to be non-mutagenic under the conditions of this assay.

2. An *in vitro* mammalian chromosome aberration test (MRID 48653314) using the technical grade of polyoxin D zinc salt, dissolved in DMSO, with and without metabolic S9 activation, showed clastogenic potential in Chinese hamster lung cells (CHL/IU) with and without activation (See Ref.). In Experiment I, polyoxin D zinc salt was tested up to dose levels that caused >50% cell lethality without activation (260 μg/mL) and with activation (1,600 μg/mL). Without activation, the frequencies of the metaphases with structural chromosome aberrations (excluding gaps) were 14.5% and 7.5% at test article concentrations of 186 and 260μg/mL, respectively. With activation, the frequency of metaphase cells with structural chromosome aberrations (excluding gaps) was 9.5% at a test article concentration of 1,600 μg/mL. The frequency of polyploid metaphase cells showed no increases either without or with activation. In Experiment II, a 24-hour continuous treatment without activation resulted in a 8.0% frequency of metaphases with structural chromosome aberrations (excluding gaps) at the concentration of 133 μg/mL. There were no increases in the frequency of polyploid metaphases.

Although the submitted *in vitro* mammalian chromosome aberration test showed clastogenic potential, the results were not reproducible at the dose levels reported in the experiment. In addition, the mutagenicity data submitted to support the previous tolerance exemption (73 FR 69562), which included three complimentary Tier I mutagenicity tests and a Tier II mammalian erythrocyte micronucleus *in vivo* test, showed no mutagenic effects, including no clastogenic potential (no chromosomal aberrations). Furthermore, the lack of systemic toxicity noted in the following developmental toxicity section (Unit III.B) and the fact that no effects were reported in the Tier III 2-generation reproduction study submitted for the previous tolerance exemption (73 FR 69562), indicate that polyoxin D zinc salt is not mutagenic or clastogenic. Therefore, based on the weight of evidence of the mutagenicity data submitted to support this expansion of the tolerance exemption and the previous tolerance exemption (73 FR 69561), the mutagenicity data and information are sufficient to confirm that polyoxin D zinc salt is not a mutagen, and that consumption of food commodities that have been treated with this substance when used as a pesticide is safe and will not result in any harm to human health from dietary exposure.

B. Developmental Toxicity

A new developmental study (MRID 48653315) was performed for polyoxin D zinc salt to support the expansion of the tolerance exemption. No treatment-related effects were observed in general appearance, body weight, adjusted for gravid uterine weight, weight gain, or food consumption in maternal rats at the doses tested (0, 100, 300, and 1,000 milligrams/kilograms bodyweight/day (mg/kg bw/day) (See Ref.). Necropsy observations showed that almost all rats (20/24) in the 1,000 mg/kg/day group highest dose tested (HDT) had thickening of the limiting ridge. Therefore, the lowest observed adverse effect level (LOAEL) for maternal toxicity of polyoxin D zinc salt in rats is 1,000 mg/kg bw/day based on gross lesions in the stomach (thickening of the limiting ridge). The no observed adverse effect level (NOAEL) for maternal toxicity is 300 mg/kg bw/day based on no effects observed at this dose. Although an effect of gross lesions in the stomach was found in maternal rats at the limit dose tested (1,000 mg/kg bw/day), there were no reported systemic effects in maternal rats at this dose. The effect in the stomach lining was limited to a localized gastric irritation due to the route of entry (oral gavage) at the limit dose tested (1,000 mg/kg bw/day), which is typical of the nature of the test substance.

For developmental toxicity, no treatment-related effects were observed on developmental parameters including gravid uterine weight, placental weight, mean numbers of corpora lutea and implantation sites, numbers of early and later resorptions (dead or resorbed embryos or fetuses), number of live fetuses per dam, implantation index, viability index, sex ratio, and male and female body weight. The incidence of external, visceral, and skeletal variations and anomalies were not affected by treatment of polyoxin D zinc salt. Based on no effects observed for developmental toxicity at any doses tested, the NOAEL for developmental toxicity is greater than 1,000 mg/kg bw/day HDT. The LOAEL was not identified for developmental toxicity, suggesting that the test animals could have tolerated a higher dose.

Based on the developmental toxicity data submitted for this expansion to the tolerance exemption, and the Tier III 2-generation reproduction study submitted for the previous tolerance exemption (73 FR 69562), which showed no reproductive effects at the limit dose tested, there are sufficient data and information to confirm that polyoxin D zinc salt is not a developmental toxicant, and that consumption of food commodities that have been treated with this substance when used as a pesticide is safe and will not result in any harm to human health from dietary exposure.

IV. Aggregate Exposures

In examining aggregate exposure, FFDCA section 408 directs EPA to consider available information concerning exposures from the pesticide residue in food and all other non-occupational exposures, including drinking water from ground water or surface water and exposure through pesticide use in gardens, lawns, or buildings (residential and other indoor uses).

A. Dietary Exposure

Dietary risks to humans are considered negligible based on the lack of dietary toxicological endpoints for polyoxin D zinc salt and its non-toxic mode of action as a fungi-specific chitin synthetase inhibitor that passes through mammalian digestive systems. No significant acute, subchronic, mutagenic, immunotoxic, developmental, or chronic dietary toxicity hazards were identified in the studies submitted to support this expansion of the tolerance exemption or the previous tolerance exemption (73 FR 69562). Based on polyoxin D zinc salt's lack of dietary toxicity hazards for mammals, no aggregate dietary exposure concerns are expected.

1. *Food* . The petitioner submitted three nature of residue studies (MRIDs 486533–09 through –11) in plants (grapes, tomatoes, and lettuce) to support this expansion of the tolerance exemption. The three nature of residue studies represent EPA Crop Groups 13 (grapes), 08 (tomatoes), and 04 (lettuce). The total radioactive residue (TRR) levels measured were 0.520 parts per million (ppm) at day 1; 0.538 ppm at day 14; and 0.495 ppm at day 30 after the final application for the grape plant (See Ref.). For tomato plants, 0.073 ppm of polyoxin D was found 14 days after the last treatment on the tomato fruit. For lettuce, 0.025 ppm at day 7 and 0.107 ppm at day 14 were detected in the head of lettuce after final application.

In addition, a terrestrial exposure model (T-Rex) was performed for the previous tolerance exemption (73 FR 69562), which indicated that it is highly unlikely that there will be adverse effects resulting from the use of polyoxin D zinc salt via the oral route of exposure. EPA's T-Rex calculations delimit aggregate dietary consumption of residues to no more than 40 ppm, a level that is far below the HDT in any of the toxicity testing.

Based on the residue data submitted for this expansion of the tolerance exemption, and the T-Rex residue modeling data from the previous tolerance exemption (73 FR 69562), any residues found are far below any toxicological endpoints identified in this expansion of the tolerance exemption (developmental toxicity NOAEL greater than 1,000 mg/kg bw/day; maternal toxicity NOAEL of 300 mg/kg/day) or in the previous tolerance exemption (73 FR 69561). The previous tolerance exemption showed an acute oral toxicity median lethal dose (LD_{50}) greater than 10,000 mg/kg; a subchronic oral toxicity NOAEL of greater than 1,333 mg/kg/day and 119 mg/kg/day in female and male rats, respectively; a subchronic oral toxicity LOAEL of 1,166 mg/kg/day in male rats based on decreased body weight gain, food consumption, and food efficiency; and a chronic oral toxicity NOAEL 2,058.7 mg/kg bw/day in male rats and 2,469.8 mg/kg bw/day in female rats.

In summary, the residue and toxicity data demonstrate a lack of aggregate dietary risk that is sufficient to support this expansion of the tolerance exemption.

2. *Drinking water exposure* . As stated in the previous tolerance exemption (73 FR 69562), there is a small potential for trace amounts of polyoxin D zinc salt to enter drinking water sources after a significant rainfall, via surface water runoff, and/or via incidental spray drift. The petitioner submitted a photodegradation in water study (MRID 48653305) to support this tolerance exemption. The results of the study show that polyoxin D zinc salt has a net photolytic half-life of 0.4 days in sterile natural water (See Ref.) . Even if residues of polyoxin D zinc salt enter water sources, residues are expected to degrade and be so diluted as to be negligible. The data and information demonstrate a lack of aggregate dietary risk via drinking water and is sufficient to support this expansion of the tolerance exemption.

B. Other Non-Occupational Exposure

No new non-occupational exposure is expected to result from the new food uses of polyoxin D zinc salt. No health risks are expected from any non-occupational exposure to polyoxin D zinc salt based on the data submitted for the previous tolerance exemption (73 FR 69562) and for this expansion of the tolerance exemption.

1. *Dermal exposure* . No new non-occupational dermal exposures are expected to result from the new food uses of polyoxin D zinc salt resulting from this expansion of the tolerance exemption. Any new dermal exposure associated with this expansion of the tolerance exemption is expected to be occupational in nature.

2. *Inhalation exposure* . No new non-occupational inhalation exposures are expected to result from the new food uses of polyoxin D zinc salt resulting from this expansion of the tolerance exemption. Any new inhalation exposure associated with this expansion of the tolerance exemption is expected to be occupational in nature.

V. Cumulative Effects From Substances With a Common Mechanism of Toxicity

Section 408(b)(2)(D)(v) of FFDCA requires that, when considering whether to establish, modify, or revoke a tolerance, the Agency consider ''available information concerning the cumulative effects of a particular pesticide's residues and other substances that have a common mechanism of toxicity.''

EPA has not found polyoxin D zinc salt to share a common mechanism of toxicity with any other substances, and polyoxin D zinc salt does not appear to produce a toxic metabolite produced by other substances. For the purposes of this tolerance action, therefore, EPA has assumed that polyoxin D zinc salt does not have a common mechanism of toxicity with other substances. For information regarding EPA's efforts to determine which chemicals have a common mechanism of toxicity and to evaluate the cumulative effects of such chemicals, see EPA's Web site at *http://www.epa.gov/pesticides/cumulative.*

VI. Determination of Safety for U.S. Population, Infants and Children

FFDCA section 408(b)(2)(C) provides that EPA shall assess the available information about consumption patterns among infants and children, special susceptibility of infants and children to pesticide chemical residues, and the cumulative effects on infants and children of the residues and other substances with a common mechanism of toxicity. In addition, FFDCA section 408(b)(2)(C) provides that EPA shall apply an additional tenfold margin of safety for infants and children in the case of threshold effects to account for prenatal and postnatal toxicity and the completeness of the database unless EPA determines that a different margin of safety will be safe for infants and children. Margins of exposure safety, which are often referred to as uncertainty factors, are incorporated into EPA risk assessments either directly or through the use of a margin of exposure analysis, or by using uncertainty (safety) factors in calculating a dose level that poses no appreciable risk.

Relevant data and information submitted for the previous tolerance exemption (73 FR 69560) and for this expansion of the tolerance exemption indicate that polyoxin D zinc salt has negligible acute, subchronic, chronic, and developmental toxicity. Moreover, polyoxin D zinc salt is defined by its fungistatic non-toxic mode of action, and demonstrates no significant mammalian effect. Therefore, the

Agency concludes that there is a reasonable certainty that no harm will result to the U.S. population, including infants and children, from aggregate exposure to the residues of polyoxin D zinc salt. This includes all anticipated dietary exposures and all other exposures for which there is reliable information. EPA has arrived at this conclusion because the data and information available on polyoxin D zinc salt do not demonstrate toxic potential to mammals. Thus, there are no threshold effects of concern and, as a result, an additional margin of safety is not necessary.

VII. Other Considerations

A. Analytical Enforcement Methodology

An analytical method is not required for enforcement purposes for the reasons stated above, and because EPA is establishing an exemption from the requirement of a tolerance without any numerical limitation.

B. International Residue Limits

In making its tolerance decisions, EPA seeks to harmonize U.S. tolerances with international standards whenever possible, consistent with U.S. food safety standards and agricultural practices. EPA considers the international maximum residue limits (MRLs) established by the Codex Alimentarius Commission (Codex), as required by FFDCA section 408(b)(4). The Codex Alimentarius is a joint United Nations Food and Agriculture Organization/World Health Organization food standards program, and it is recognized as an international food safety standards-setting organization in trade agreements to which the United States is a party. EPA may establish a tolerance that is different from a Codex MRL; however, FFDCA section 408(b)(4) requires that EPA explain the reasons for departing from the Codex level.

The Codex has not established a MRL for polyoxin D zinc salt.

VIII. Conclusions

EPA concludes that there is a reasonable certainty that no harm will result to the U.S. population, including infants and children, from aggregate exposure to residues of polyoxin D zinc salt. Therefore, the existing exemption from the requirement of a tolerance for residues of polyoxin D zinc salt when used as a fungicide on almonds, cucurbit vegetables, fruiting vegetables, ginseng, grapes, pistachios, pome fruits, potatoes, and strawberries is amended by establishing an exemption from the requirement of a tolerance for residues of polyoxin D zinc salt in or on all food commodities when applied as a fungicide and used in accordance with good agricultural practices.

IX. References

The reference used in this document is in the OPP docket listed under docket ID EPA–HQ–OPP–2011–1028 and may be seen by accessing the *www.regulations.gov* Web site. A copy of the previous final rule published in the **Federal Register** on November 19, 2008, is in the OPP docket listed under docket ID EPA–HQ–OPP–2008–0417.

U.S. EPA. 2011. Memorandum from Manying Xue to Colin Walsh. Polyoxin D zinc salt (EPA Reg. #: 68173–1), Containing 23.8% of Polyoxin D Zinc Salt (Active Ingredient). Science Review of Product Chemistry, Residue Chemistry, Non-Target Organism and Toxicity Data in Support of label Amendment. U.S. Environmental Protection Agency Office of Pesticide Programs. May 11, 2012.

X. Statutory and Executive Order Reviews

This final rule establishes a tolerance under FFDCA section 408(d) in response to a petition submitted to the Agency. The Office of Management and Budget (OMB) has exempted these types of actions from review under Executive Order 12866, entitled ''Regulatory Planning and Review'' (58 FR 51735, October 4, 1993). Because this final rule has been exempted from review under Executive Order 12866, this final rule is not subject to Executive Order 13211, entitled ''Actions Concerning Regulations That Significantly Affect Energy Supply, Distribution, or Use'' (66 FR 28355, May 22, 2001) or Executive Order 13045, entitled ''Protection of Children from Environmental Health Risks and Safety Risks'' (62 FR 19885, April 23, 1997). This final rule does not contain any information collections subject to OMB approval under the Paperwork Reduction Act (PRA), 44 U.S.C. 3501 *et seq* ., nor does it require any special considerations under Executive Order 12898, entitled ''Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations'' (59 FR 7629, February 16, 1994).

Since tolerances and exemptions that are established on the basis of a petition under FFDCA section 408(d), such as the tolerance exemption in this final rule, do not require the issuance of a proposed rule, the requirements of the Regulatory Flexibility Act (RFA) (5 U.S.C. 601 *et seq* .), do not apply.

This final rule directly regulates growers, food processors, food handlers, and food retailers, not States or tribes, nor does this action alter the relationships or distribution of power and responsibilities established by Congress in the preemption provisions of FFDCA section 408(n)(4). As such, the Agency has determined that this action will not have a substantial direct effect on States or tribal governments, on the relationship between the national government and the States or tribal governments, or on the distribution of power and responsibilities among the various levels of government or between the Federal Government and Indian tribes. Thus, the Agency has determined that Executive Order 13132, entitled ''Federalism'' (64 FR 43255, August 10, 1999) and Executive Order 13175, entitled ''Consultation and Coordination with Indian Tribal Governments'' (65 FR 67249, November 9, 2000) do not apply to this final rule. In addition, this final rule does not impose any enforceable duty or contain any unfunded mandate as described under Title II of the Unfunded Mandates Reform Act of 1995 (UMRA) (2 U.S.C. 1501 *et seq* .).

This action does not involve any technical standards that would require Agency consideration of voluntary consensus standards pursuant to section 12(d) of the National Technology Transfer and Advancement Act of 1995 (NTTAA) (15 U.S.C. 272 note).

XI. Congressional Review Act

Pursuant to the Congressional Review Act (5 U.S.C. 801 *et seq* .), EPA will submit a report containing this rule and other required information to the U.S. Senate, the U.S. House of Representatives, and the Comptroller General of the United States prior to publication of the rule in the **Federal Register**. This action is not a ''major rule'' as defined by 5 U.S.C. 804(2).

List of Subjects in 40 CFR Part 180

Environmental protection, Administrative practice and procedure, Agricultural commodities, Pesticides and pests, Reporting and recordkeeping requirements.

Dated: August 29, 2012.

Keith A. Matthews,

Director, Biopesticides and Pollution Prevention Division, Office of Pesticide Programs.

Therefore, 40 CFR chapter I is amended as follows:

PART 180—[AMENDED]

■ 1. The authority citation for part 180 continues to read as follows:

Federal Register / Vol. 77, No. 177 / Wednesday, September 12, 2012 / Rules and Regulations 56133

Authority: 21 U.S.C. 321(q), 346a and 371.

■ 2. Section 180.1285 is revised to read as follows:

§ 180.1285 Polyoxin D zinc salt; exemption from the requirement of a tolerance.

An exemption from the requirement of a tolerance is established for the residues of polyoxin D zinc salt in or on all food commodities when applied as a fungicide and used in accordance with good agricultural practices.

[FR Doc. 2012–22315 Filed 9–11–12; 8:45 am]

BILLING CODE 6560–50–P

ENVIRONMENTAL PROTECTION AGENCY

40 CFR Part 180

[EPA–HQ–OPP–2011–0433; FRL–9359–6]

Dinotefuran; Pesticide Tolerances

AGENCY: Environmental Protection Agency (EPA).

ACTION: Final rule.

SUMMARY: This regulation establishes tolerances for residues of dinotefuran in or on multiple commodities which are identified and discussed later in this document. Also, due to the tolerances established by this document, the Agency is removing the existing tolerances for grape and potato as unnecessary. Interregional Research Project Number 4 (IR–4) requested these tolerances under the Federal Food, Drug, and Cosmetic Act (FFDCA).

DATES: This regulation is effective September 12, 2012. Objections and requests for hearings must be received on or before November 13, 2012, and must be filed in accordance with the instructions provided in 40 CFR part 178 (see also Unit I.C. of the **SUPPLEMENTARY INFORMATION**).

ADDRESSES: The docket for this action, identified by docket identification (ID) number EPA–HQ–OPP–2011–0433, is available at *http://www.regulations.gov* or at the Office of Pesticide Programs Regulatory Public Docket (OPP Docket) in the Environmental Protection Agency Docket Center (EPA/DC), EPA West Bldg., Rm. 3334, 1301 Constitution Ave. NW., Washington, DC 20460–0001. The Public Reading Room is open from 8:30 a.m. to 4:30 p.m., Monday through Friday, excluding legal holidays. The telephone number for the Public Reading Room is (202) 566–1744, and the telephone number for the OPP Docket is (703) 305–5805. Please review the visitor instructions and additional information about the docket available at *http://www.epa.gov/dockets.*

FOR FURTHER INFORMATION CONTACT: Andrew Ertman, Registration Division, Office of Pesticide Programs, Environmental Protection Agency, 1200 Pennsylvania Ave., NW., Washington, DC 20460–0001; telephone number: (703) 308–9367; email address: *ertman.andrew@epa.gov.*

SUPPLEMENTARY INFORMATION:

I. General Information

A. Does this action apply to me?

You may be potentially affected by this action if you are an agricultural producer, food manufacturer, or pesticide manufacturer. The following list of North American Industrial Classification System (NAICS) codes is not intended to be exhaustive, but rather provides a guide to help readers determine whether this document applies to them. Potentially affected entities may include:

- Crop production (NAICS code 111).
- Animal production (NAICS code 112).
- Food manufacturing (NAICS code 311).
- Pesticide manufacturing (NAICS code 32532).

B. How can I get electronic access to other related information?

You may access a frequently updated electronic version of EPA's tolerance regulations at 40 CFR part 180 through the Government Printing Office's e-CFR site at http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?&c=ecfr&tpl=/ecfrbrowse/Title40/40tab_02.tpl.

C. How can I file an objection or hearing request?

Under FFDCA section 408(g), 21 U.S.C. 346a, any person may file an objection to any aspect of this regulation and may also request a hearing on those objections. You must file your objection or request a hearing on this regulation in accordance with the instructions provided in 40 CFR part 178. To ensure proper receipt by EPA, you must identify docket ID number EPA–HQ–OPP–2011–0433 in the subject line on the first page of your submission. All objections and requests for a hearing must be in writing, and must be received by the Hearing Clerk on or before November 13, 2012. Addresses for mail and hand delivery of objections and hearing requests are provided in 40 CFR 178.25(b).

In addition to filing an objection or hearing request with the Hearing Clerk as described in 40 CFR part 178, please submit a copy of the filing (excluding any Confidential Business Information (CBI)) for inclusion in the public docket. Information not marked confidential pursuant to 40 CFR part 2 may be disclosed publicly by EPA without prior notice. Submit the non-CBI copy of your objection or hearing request, identified by docket ID number EPA–HQ–OPP–2011–0433, by one of the following methods:

- *Federal eRulemaking Portal: http://www.regulations.gov.* Follow the online instructions for submitting comments. Do not submit electronically any information you consider to be CBI or other information whose disclosure is restricted by statute.
- *Mail:* OPP Docket, Environmental Protection Agency Docket Center (EPA/DC), (28221T), 1200 Pennsylvania Ave. NW., Washington, DC 20460–0001.
- *Hand Delivery:* To make special arrangements for hand delivery or delivery of boxed information, please follow the instructions at *http://www.epa.gov/dockets/contacts.htm.*

Additional instructions on commenting or visiting the docket, along with more information about dockets generally, is available at *http://www.epa.gov/dockets.*

II. Summary of Petitioned-For Tolerance

In the **Federal Register** of September 7, 2011 (76 FR 55329) (FRL–8886–7), EPA issued a notice pursuant to FFDCA section 408(d)(3), 21 U.S.C. 346a(d)(3), announcing the filing of a pesticide petition (PP 1E7863) by IR–4, 500 College Rd. East, Suite 201 W, Princeton, NJ 08540. The petition requested that 40 CFR 180.603 be amended by establishing tolerances for residues of the insecticide dinotefuran, (*RS*)-1-methyl-2-nitro-3-((tetrahydro-3-furyl)methyl)guanidine, including its metabolites and degradates, in or on berry, low growing, except strawberry, subgroup 13–07H at 0.2 parts per million (ppm); watercress at 5.0 ppm; onion, green, subgroup 3–07B at 6.0 ppm; onion, bulb, subgroup 3–07A at 0.07 ppm; peach at 0.9 ppm; vegetable, tuberous and corm, subgroup 1C at 0.05 ppm; fruit, small, vine climbing, except fuzzy kiwifruit, subgroup 13–07F at 0.9 ppm; and tea, plucked leaves at 25.0 ppm. That notice referenced a summary of the petition prepared by Mitsui Chemicals Agro, Inc., the registrant, which is available in the docket, *http://www.regulations.gov.* There were no comments received in response to the notice of filing.

Also, due to the tolerances established by this document, the following existing tolerances are being removed as unnecessary: Grape and potato.

Based upon review of the data supporting the petition, EPA has

5. Letters of Support

CLEMSON
PUBLIC SERVICE ACTIVITIES

March 13, 2013

To Whom It May Concern:

I am the research and Extension vegetable pathologist for the state of South Carolina. I have been employed by Clemson University as a faculty member since 1991, and currently hold the rank of Professor. I test conventional and organic products for control of cucurbit diseases. My expertise is in the cucurbit disease gummy stem blight, for which no suitable organic controls exist.

I have tested Polyoxin D both in the greenhouse and the field and have been very impressed with its performance. Sulfur and copper are both ineffective against this disease. The other two alternatives to Polyoxin D, Bacillus products and *Reynoutria* extract, have some efficacy in the greenhouse. However, Polyoxin D was more effective than either of these products in the greenhouse. In the field, Polyoxin D was not as effective as conventional fungicides, yet it reduced the severity of gummy stem blight on watermelon compared to the non-sprayed control. This level of control represents significant efficacy for an organic product.

Gummy stem blight is found on watermelon and melon (cantaloupe) throughout the Southeastern United States in years with normal to above normal rainfall. Because of the widespread occurrence and lack of suitable control measures, I recommend that Polyoxin D be approved as an allowed synthetic material for organic production in the United States.

In addition, I have noted that Polyoxin D also has efficacy against Southern blight. This disease has become more severe and frequent across the Southeastern United States in recent years. The reason for this is unknown, although drier springs and less use of soil fumigants may each play a role. Nevertheless, I have seen Southern blight develop on an organic farm three years after it was established in a former pasture without a history of vegetable production. Biofungicides, such as the *Trichoderma* and *Gliocladium* products, are ineffective against Southern blight. Thus, there is a need for a new organic-approved product to combat this disease.

Sincerely,

Anthony P. Keinath

Anthony P. Keinath,
Professor of Plant Pathology
Research and Extension Vegetable Pathologist
tknth@clemson.edu

PUBLIC SUBMISSION

As of: 3/20/13 1:56 PM
Tracking No. 1jx-84ae-ji05
Comments Due: March 19, 2013

Docket: AMS-NOP-12-0070
Notice of Meeting of the National Organic Standards Board (NOSB)

Comment On: AMS-NOP-12-0070-0001
Meetings: National Organic Standards Board

Document: AMS-NOP-12-0070-1773
CS-Polyoxin D-Sances, Frank: Alliance Farm Group, Pacific Ag Group

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Submitter Information

Name: Frank Sances
Address:
San Luis Obispo, CA,
Organization: Alliance Farm Group, Pacific Ag Group
Government Agency Type: Federal
Government Agency: USDA

General Comment

I have been a researcher and organic strawberry and blueberry grower for over 30 years. I have received awards from EPA for my work on alternative soil pest management, as well as scientific recognition for my work on non chemical pest controls of high value fruits and vegetables. I write this letter of support for Organic Certification of Polyoxin D zinc salt produced by the Kaken company now under consideration by USDA-NOSB for organic certification.
I work with the most difficult organic crops to produce anywhere in the world. Coastal fruits and vegetables in both California and Florida are subject to numerous foliar and soil-borne diseases that are periodically severe enough that complete crop losses can occur at the field level. This is despite efforts to control them with Baccilus subtilis, copper, or botanical SAR inducing products currently registered organically. This is because our leafy greens exhibit foliar fungal and bacterial disease lesions that aesthetically ruin the marketability of the crop, or move onto developing fruits and create rots that not only reduce yields at harvest, but more importantly, develop during post harvest transport and storage. In the later case, the farmer must also must pay the transportation costs associated with the product that breaks down in transit and storage. This is simply unacceptable commercially and not sustainable to the smaller growers in my districts.
I have worked with Polyoxin D zinc salt for several years now in California and Florida. I have seen excellent efficacy across many fungal and bacterial diseases of lettuce, cole crops, strawberries, wine grapes, and tree fruits. We need this product to use in combination with currently registered organic fungicides during periods of intense disease episodes to avoid the crop losses described herein. I urgently request you support this organic certification of Polyoxin D for the high value crops I work with.

Gary L. Cloud, Ph.D.

GLC Consulting LLC

Tallahassee, FL 32312

To Whom It May Concern:

I am writing this letter in support of the use of Polyoxin D for use in any organic market. I have conducted a few trials with this product and found it to be quite efficacious on specific plant pathogenic fungi economically important to various vegetable species. When compared to standard fungicides which are synthetic in nature the level of control was identical statistically. This is extremely valuable when one considers the lack of good fungicides registered for the organic market. This product would have a very good fit in the organic market.

In addition this chemistry of fungicides could be used in a program approach to help slow down or eliminate the development of resistance similar to many known fungi to exist already to several classes of fungicides. Too me this is the most important reason for using Polyoxin D is slowing down the development of resistance to other classes of fungicides.

Sincerely;

Gary L. Cloud, Ph.D.

Owner, GLC Consulting LLC

PUBLIC SUBMISSION

As of: 3/20/13 4:08 PM
Tracking No. 1jx-84an-eus6
Comments Due: March 19, 2013

Docket: AMS-NOP-12-0070
Notice of Meeting of the National Organic Standards Board (NOSB)

Comment On: AMS-NOP-12-0070-0001
Meetings: National Organic Standards Board

Document: AMS-NOP-12-0070-1899
CS-Polyoxin D-Davis, Gerald: Grimmway Farms

Submitter Information

Name: Gerald Davis
Address:
Lamont, CA,
Organization: Grimmway Farms

General Comment

Polyoxin D -
I am a former NOSB member and Crops Committee Chairman. I will also present verbal comments in Portland. This material is a fermentation product of a soil bacterium and would be allowed as a natural if not for the attached zinc salt form. This makes it a synthetic, subject to NOSB review for inclusion on the National List. The Crops SC, on a nearly split vote, recommended not to list. Here are some reasons why the full NOSB should vote to approve listing the material.

- Naturally derived fermentation product much like many others already allowed by definition in the OFPA, but material offers specific help with diseases that others don't
- A simple zinc salt addition to a natural material is easy to understand and calculate potential risk to organic integrity.
- Natural zinc from mined sources (zinc ores) are no good as a zinc source. Most ores(90+%) are zinc sulfides mixed with iron, silver, and lead. Purified zinc is synthetic due to change from sulfide form to zinc oxide by high temp. (Irrelevant if zinc added to Polyoxin D by chemical reaction)
- The environmental risk of killing aquatic organisms with the material is a non-issue. Virtually all pesticide labels contain statements such as "Do not apply directly to water or allow runoff into lakes and streams." Organic farmers are good stewards of the land and our pocketbooks, not stream polluters and money wasters.
- Polyoxin D is not a bactericide like Streptomycin or Tetracycline. It is active on fungi as a fungistatic material and not classified as 'toxic' to fungi. Beware of off-hand

suggestions that attempt to broad brush the material as "toxic to beneficial soil organisms".

This material could be very helpful to the economic sustainability of organic growers in high humidity areas where fungal pressure on crops is intense in some years and seasons (e.g. late blight in East Coast tomatoes, Alternaria in late carrots).

Certis USA
9145 Guilford Road
Suite 175
Columbia, MD 21046
(301) 604-7340
FAX: 301-604-7015
www.certisusa.com

DATE: 19 March 2013
RE: Polyoxin D zinc salt petition/NOSB Spring 2013 meeting

To Whom It May Concern:

Certis USA is a leading developer, manufacturer, and marketer of biopesticides for plant protection, and currently markets two fungicides containing Polyoxin D zinc salt from Kaken. Although certified organic crops represent a small part of our overall market, we usually do not undertake to develop a product unless the active ingredient is acceptable under the National Organic Program for listing by the Organic Materials Review Institute (OMRI).

Polyoxin D zinc salt has the potential to provide organic growers with a curative disease management tool similar to what spinosad (another microbial fermentation product) has provided for insect management. Growers of organic pome fruits have several preventive inputs (horticultural oils, granulosis virus, mating disruption) for dealing with codling moth, the “worm in the apple.” Nevertheless, codling moth outbreaks may occur due to factors beyond the control of the organic orchardist, such as immigration of mated female moths from nearby orchards not under mating disruption. Few of the curative insecticides available for organic use are cost effective for dealing with these outbreaks, and some may have undesirable non-target effects. Compared to most biopesticides, spinosad causes relatively quick knockdown of many difficult to control insects, with less impact on beneficial insects compared to most synthetic chemical insecticides. An OMRI-listed formulation of spinosad provides a means for organic apple growers to reduce the risk to their crops and livelihoods from such events.

Disease control in organic crops often faces similar challenges. Nearly all OMRI-listed fungicides are most effective when deployed as preventive tactics. These include foliar sprays (containing copper, sulfur, or beneficial microbes) which prevent spore germination and infection, soil-applied beneficial microbes which parasitize or outcompete pathogenic fungi that attack plant roots, or botanical extracts which stimulate the plant’s inherent defense mechanisms to reduce disease severity. While these can limit infection, none is particularly effective in dealing with disease outbreaks once they occur, and some (notably copper) carry restrictions to limit applicator and field worker exposure, residues in food, or environmental contamination.

Polyoxin D zinc salt addresses this need for an effective curative fungicide to back up preventive measures in organic crops. It is exempt from the requirement for residue tolerance, with minimal restrictions on field re-entry and personal protective equipment. Its unique mode of action complements other biopesticides with little risk that pathogenic fungi or bacteria will develop cross resistance. From this standpoint, Polyoxin D zinc salt fits the profile Certis seeks in the products it offers for use in organic crops, and Certis supports Kaken’s petition to NOSB to allow its use in organic production.

Sincerely,

Michael B. Dimock

Michael B. Dimock, PhD
Director, Field Development

UNIVERSITY OF CALIFORNIA, RIVERSIDE

BERKELEY • DAVIS • IRVINE • LOS ANGELES • MERCED • RIVERSIDE • SAN DIEGO • SAN FRANCISCO SANTA BARBARA • SANTA CRUZ

PLANT PATHOLOGY DEPARTMENT
RIVERSIDE, CALIFORNIA 92521-0122

COLLEGE OF NATURAL AND AGRICULTURAL SCIENCES
CITRUS RESEARCH CENTER AND AGRICULTURAL EXPERIMENT

March 21, 2013

To whom it may concern:

This is a letter of support for acceptance of the fungicide polyoxin-D (Docket ID: AMS-NOP-12-0070) as an organic fungicide by the National Organic Standards Board (NOSB). I am a professor of plant pathology at the University of California, Riverside and I conduct research on the biology, epidemiology, and management of fruit and nut tree diseases in California. I have been studying tree diseases and developing management programs for over 26 years in California. I have evaluated hundreds of products for the management of blossom, foliar, and fruit diseases of tree and vine crops and, in my opinion, the fungicide polyoxin-D is a highly effective fungicide for managing Alternaria leaf spot of almond and for controlling grape diseases such as Cladosporium fruit rot and powdery mildew. With its broad spectrum of activity, the fungicide has the potential to be integrated into other management programs in many other pathosystems.

Since I assisted Arysta life Science in the development and registration of polyoxin-D as one of the first biofungicides as classified by the US-EPA, this material has been a highly effective as a management tool against Alternaria leaf spot of almond. Additionally, it holds a key role in plant pathogen resistance management. Because it has a unique mode of action and when used in rotations with other fungicides with different modes of action, this application strategy can prevent the development of resistant pathogen populations. Only a few fungicide classes have high activity against *Alternaria* spp. and if any one class is over used resistance has and will develop to them. For example, when the QoI and SDHI fungicide classes (Fungicide Resistance Action Committee or FRAC Groups 11 and 7) were used exclusively, populations of the pathogen developed resistance. In response to this situation, we registered two distinct modes of action – the DMI fungicides (FRAC Group 3), metconazole and difenconazole, that inhibit sterol production and the chitin synthase inhibitor polyoxin-D (FRAC Group 19) for the management of Alternaria leaf spot. Rotations of these fungicides have been highly efficacious and resistance has not developed to either group.

In recent years we have also tested both conventional and organic formulations of polyoxin-D and have found them to be equivalent in performance against several diseases when the products were compared based on equivalent active ingredient. I have provided this information to representatives of tree fruit commodities in California and they have endorsed and encouraged the development of organic fungicides that have activity against tree fruit pathogens. Other organic fungicides that we have tested have had very low activity against fungal pathogens that infect blossom, leaves and fruit. An organic fungicide with high performance such as polyoxin-D is very much needed in the tree fruit and nut industries of California.

Thus, in summary, I highly endorse acceptance of polyoxin-D by theNOSB. Polyoxin-D is produced by *Streptomyces* spp. and can be formulated as an organic fungicide. This material could be revolutionary for foliar disease management of organic production of tree fruit and nut crops in California, as well as many other crops in the United States.

Sincerely,

J. E. Adaskaveg

Dr. James E. Adaskaveg, Professor
951-827-3880
jim.adaskaveg@ucr.edu