Polyoxin D Zinc Salt:
Reply to and Comments Regarding
the National Organic Program Technical Evaluation Report
Dated September 23, 2012

NON-CONFIDENTIAL

Submitted on Behalf of
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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 (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.]

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 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." [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 did not produce significant toxic or oncogenic responses 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. 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."* [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 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."* [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, the residue and toxicity data demonstrate a lack of aggregate dietary risk 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 AgipMNPV, the two substances are compatible. However, combination applications of polyoxin-d and AgipMNPV 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	5×10^7 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	5×10^7 CFU/mL	62	No
			3×10^7 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	5×10^7 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 I.)* (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 $\leq 39^{\circ}$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(μg/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

KPD05-043
Sep. 14, 2005

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 chileraesuis 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

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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.

REFERENCES

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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.		

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Crop	Disease (Pathogen)	Curative [4]	New Use	FRAC Code	Active Ingredient	EPA Reg. No.	Brand Name (Registrant)	Product Label Notes	Efficacy	
									Notes	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.		

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Crop	Disease (Pathogen)	Curative [4]	New Use	FRAC Code	Active Ingredient	EPA Reg. No.	Brand Name (Registrant)	Product Label Notes	Efficacy	
									Notes	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.		

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Crop	Disease (Pathogen)	Curative [4]	New Use	FRAC Code	Active Ingredient	EPA Reg. No.	Brand Name (Registrant)	Product Label Notes	Efficacy	
									Notes	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.		

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Crop	Disease (Pathogen)	Curative [4]	New Use	FRAC Code	Active Ingredient	EPA Reg. No.	Brand Name (Registrant)	Product Label Notes	Efficacy	
									Notes	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.		

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Crop	Disease (Pathogen)	Curative [4]	New Use	FRAC Code	Active Ingredient	EPA Reg. No.	Brand Name (Registrant)	Product Label Notes	Efficacy	
									Notes	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.		

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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.
				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	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.]		

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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.
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.		

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.
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.		

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.
				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	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.		

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.		

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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.
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.		

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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.
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.		

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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.
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.		

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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.
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	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	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	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 / 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.	

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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.
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	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.		

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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.
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.		

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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.
				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			

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Crop	Disease (Pathogen)	Curative [4]	New Use	FRAC Code	Active Ingredient	EPA Reg. No.	Brand Name (Registrant)	Product Label Notes	Efficacy
									Notes / 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.	

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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.		

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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.
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.		

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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.		

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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.
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	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.		

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.
				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	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.		

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	*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.		

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.
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.		

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.	
				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	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.		

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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.
				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.	

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Crop	Disease (Pathogen)	Curative [4]	New Use	FRAC Code	Active Ingredient	EPA Reg. No.	Brand Name (Registrant)	Product Label Notes	Efficacy
									Notes / 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.	

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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.
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.		

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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.
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	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.		

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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.
				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.		

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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.
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

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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.
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.		

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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.
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.		

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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.
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.		

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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.
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.		

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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.
				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.	

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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.
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.		

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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.
				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			

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Crop	Disease (Pathogen)	Curative [4]	New Use	FRAC Code	Active Ingredient	EPA Reg. No.	Brand Name (Registrant)	Product Label Notes	Efficacy	
									Notes	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	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						
Crop	Disease (Pathogen)	Curative [4]	New Use	FRAC Code	Active Ingredient	EPA Reg. No.	Brand Name (Registrant)	Product Label Notes	Efficacy	
									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	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	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	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	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						
Crop	Disease (Pathogen)	Curative [4]	New Use	FRAC Code	Active Ingredient	EPA Reg. No.	Brand Name (Registrant)	Product Label Notes	Efficacy	
									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.		

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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.
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 / 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.

Continued on next page . . .

APPLE AND PEAR: FUNGICIDE EFFICACY

Fungicide	Resistance risk (FRAC#)[1]	Scab		Powdery mildew (apple only)
		Protectant	Eradicant	
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]		Phytotoxicity
		Contact	Systemic	
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/Ipro-dione/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.