Potassium Bicarbonate

Crops

Identification of Petitioned Substance

Chemical Names:

$CHKO_3$ (MW. 100.12), Potassium hydrogen carbonate, potassium acid carbonate, potassium ion bicarbonate

Other Name:

Carbonic Acid, potassium salt, Carbonic acid, monopotassium salt, Carbonic acid, monopotassium salt bicarbonate

Trade Names:

Purple K, Kaligreen

CAS Numbers:

298-14-6

Other Codes:

SID 162102857, MDL Number MFCD00011402, EINECS 206-059-0, PubChem Substance ID 24854226, Beilstein Registry Number 4535309

Summary of Current Use

As required by the Organic Foods Production Act, the National Organic Standards Board has the responsibility to review each substance on the National List within five years of its adoption or previous review. A previous technical report for potassium bicarbonate was completed in July, 2002 and is available on the NOP website (NOP, 2002). For the 2017 sunset review, the NOSB requested an updated limited scope technical evaluation report for potassium bicarbonate covering alternatives to its use. To support their decision-making the document has been limited to the following sections:

- Identification of the Petitioned Substance
- Summary of Current Use
- Evaluation Question #11
- Evaluation Question #12

The current listing for potassium bicarbonate is scheduled to sunset on 6/27/2017 (USDA NOP, 2013).

The National Organic Standards Board (NOSB) voted unanimously to allow the use of potassium bicarbonate for plant disease control at its October 25-28, 1999 meeting (USDA AMS, 1999; USDA NOP 1999). A technical advisory panel review was completed in 1999 and a proposed rule from the Agricultural Marketing Service published in the March 13, 2000 Federal Register recommended adding potassium bicarbonate to the National List (USDA AMS, 2000a). The proposed rule was followed by a final rule in December 2000 adding potassium bicarbonate (USDA AMS, 2000b; Electronic Code of Federal Regulations, 2014) as follows:

> § 205.601 Synthetic substances allowed for use in organic crop production.
>
> (i) As plant disease control.
>
> (9) Potassium bicarbonate.

In June 2005, the National Organic Program (NOP) published proposed rulemaking and a request for comments on the sunset provision for 174 substances including potassium bicarbonate (Clayton, 2005). Following this, a proposed rule published March 6, 2007 reflected NOSB's recommendation to allow the continued use of one hundred and sixty-six substances including use of potassium bicarbonate for plant pathogens (Day, 2007a; USDA NOP, 2005). In the final rule published October 16, 2007, the use of potassium bicarbonate for plant disease was renewed; however, a comment from a national body requested a justification for its use, citing that the use of potassium bicarbonate and several other substances were not consistent with the Codex Alimentarius guide for the production of organic food (Day, 2007b). A meeting notice provided in 2009 indicated the NOSB's intention to review potassium bicarbonate for plant disease control (Pegg, 2009). At the April 29, 2010 meeting of the NOSB, potassium bicarbonate was recommended unanimously for relisting subsequent to its October, 2012 sunset date (Pegg, 2010; Shipman, 2010a; USDA NOP, 2010; Shipman, 2010b). Potassium hydrogen carbonate (i.e., potassium bicarbonate) has since been added to the Codex Alimentarius Commission Guidelines for the Production Processing Labelling and Marketing of Organically Produced Foods (CAC/GL 32-1999—FSIS, 2012).

Evaluation Question #11: Describe all natural (non-synthetic) substances or products which may be used in place of a petitioned substance (7 U.S.C. § 6517 (c) (1) (A) (ii)). Provide a list of allowed substances that may be used in place of the petitioned substance (7 U.S.C. § 6518 (m) (6)).

Foliar application of potassium bicarbonate is useful in control and prevention of *Alternaria* in cucurbits and cole crops; anthracnose in cucurbits, blueberries, grapes, spinach and strawberries; black dot root rot in potatoes; botrytis blossom and twig blight in blueberries and grapes; botrytis bunch rot in grapes; downy mildew in cucurbits, cole crops, grapes, lettuce and spinach; early blight in potatoes; eutypa dieback in grapes; gray mold (*Botrytis cinerea*) in beans, lettuce and strawberries; gummy stem blight and black rot in cucurbits; leaf blight in strawberries; leaf spot in peas; mummy berry in blueberries; phomopsis cane and leaf spot and fruit rot in grapes; phomopsis canker in blueberries; powdery mildew in cucurbits, apples, blueberries, grapes and strawberries; septoria leaf spot in cucurbits; sooty blotch complex in apples; sour rot in grapes; white mold in potatoes and others (Seaman, 2013, 2014 a, b, c, d, e, f; Carroll et al, 2014 a, b; Weigle and Carroll, 2014; Peck and Merwin, 2014). Potassium bicarbonate is best suited for many of the powdery mildew diseases. Powdery mildews have a superficial nature on the plant surface allowing more contact with the product. Many other diseases are not as affected by bicarbonate products. This may be because they penetrate deeper into plant tissues. In some studies, however, the use of potassium bicarbonate resulted in good control of diseases such as black rot and *Phomopsis* on grapes and strawberry leaf spot (Caldwell et al., 2013). Following is a description of non-synthetic or natural substances that could be substituted for potassium bicarbonate.

Bacillus amyliquifaciens strain D747 is a gram positive bio-fungicidal/bactericidal bacterium listed by Organic Materials Review Institute (OMRI) under the names "Double Nickel LC Biofungicide," and "Amylo-X"(Highland et al., 2012). It is found naturally in soils including agricultural settings and used commercially for control and prevention of a number of fungal and bacterial infections including *Alternaria* in cucurbits and cole crops; anthracnose in cucurbits, blueberries, grapes, spinach and strawberries; *Botrytis* in blueberries and grapes; downy mildew in cucurbits, cole crops, grapes, lettuce and spinach; eutypa dieback in grapes; gray mold (*Botrytis cinerea*) in beans, lettuce and strawberries; gummy stem blight and black rot in cucurbits; mummy berry in blueberries; *Phomopsis* cane and leaf spot and fruit rot in grapes; powdery mildew in cucurbits, apples, blueberries, grapes and strawberries; sour rot in grapes, white mold in potatoes and others (Seaman, 2013, 2014 a, b, d; Peck and Merwin, 2014; Carroll et al, 2014a, b;

Wiegle andCarroll, 2014). *Bacillus amyliquifaciens* strain D747 kills pathogenic organisms on foliage and other plant parts by producing antibiotic compounds (iturins and surfactins) that disrupt pathogen cell wall production. *Bacillus amyliquifaciens* strain D747 also colonizes plant root hairs, preventing establishment of disease-causing fungi and bacteria (Highland, 2012; EPA, 2011; Carroll et al., 2014).

Several isolates of the bacteria, *Bacillus subtilis* possess anti-fungal activity, e.g. QST 713 and IAB/BS/03, overlapping the range of use for potassium bicarbonate in treatment of *Alternaria* in cucurbits and cole crops; anthracnose in cucurbits, blueberries, grapes, spinach and strawberries; *Botrytis* blossom and twig blight in blueberries and grapes; *Botrytis* bunch rot in grapes; downy mildew in cucurbits, cole crops, grapes, lettuce and spinach; early blight in potatoes; eutypa dieback in grapes; gray mold (*Botrytis cinerea*) in beans, lettuce and strawberries; gummy stem blight and black rot in cucurbits; mummy berry in blueberries; *Phomopsis* cane and leaf spot and fruit rot in grapes; powdery mildew in cucurbits, apples, blueberries, grapes and strawberries and sour rot in grapes and others (Seaman, 2013, 2014 a, d, e, f; Peck and Merwin, 2014; Carroll et al, 2014a, b; Wiegle andCarroll, 2014; Hinarejos, 2014). These bacteria produce bio-pesticides that inhibit the growth of a wide variety of fungal species.

Bacillus pumilis is a rhizobacterium used for prevention and treatment of downy mildew in cucurbits, cole crops, grapes, and lettuce, spinach; powdery mildew in cucurbits, apples, blueberries, grapes and strawberries and white mold in potatoes and others (Seaman, 2013, 2014 a, b, d, f; Carroll et al, 2014 a, b; Weigle and Carroll, 2014; Peck and Merwin, 2014). These pathogenic molds and mildews produce an enzyme that degrades indole acetic acid (IAA), an endogenous plant growth promoting hormone, stunting plant growth. *B. pumilis* secretes growth promoting substances mimicking the effects of gibberellins (Gutierrez-Manero et al., 2001). Production of gibberellins by *B. pumilis* reverses the stunting effect. It has been demonstrated that exogenously applied growth promoting auxins can overcome the degradative effect of these molds on IAA (Benz and Spring, 1995).

Gibberellic acid is a naturally occurring growth regulator commercially prepared from *Gibberella fujikuroi* (NOP, 1996). It has been demonstrated that exogenously applied growth promoting auxins, like gibberellic acid can overcome stunting and the degradative effect of downy and powdery mildew and *Botrytis* molds on endogenous plant growth promoting hormones (Benz and Spring, 1995).

Streptomyces griseovirdis and *Streptomyces lydicus* are naturally occurring gram negative bacteria useful in the treatment and prevention of *Alternaria* in cucurbits and cole crops; anthracnose in cucurbits, blueberries, grapes, spinach and strawberries, *Botrytis* blossom and twig blight in blueberries and grapes; *Botrytis* bunch rot in grapes; downy mildew in cucurbits, cole crops, grapes, lettuce and spinach; *Eutypa* dieback in grapes; gray mold (*Botrytis cinerea*) in beans, lettuce and strawberries; mummy berry in blueberries, powdery mildew in cucurbits, apples, blueberries, grapes and strawberries and white mold in potatoes and others (Seaman, 2013, 2014 a, b, d, e, f; Carroll et al, 2014 a, b; Weigle and Carroll, 2014; Peck and Merwin, 2014). These *Streptomyces* species secrete a class of polyene antimycotics. Polyenes bind ergosterol in the fungal cell membrane causing leakage of potassium and sodium ions and ultimately fungal cell death (Hamilton-Miller, 1973).

White mold is caused by *Sclerotina sclertiorum* (Wharton and Wood, 2013). *Coniothyrium minitans* is mycoparasite of the fungus *Sclerotina sclertiorum*, useful in the biocontrol of white mold also called *Sclerotina* stem rot in potatoes (Seaman, 2014d). Hyphal–hyphal interactions between *C. minitans* and other fungi, competition or mycoparasitism between mycelium of *C. minitans* and *Sclerotinia* on petals, pollen or infected plant tissues and the mycoparasitic attack of mycelium of

C. minitans on host sclerotia are the most common mode of action for *C. mintans* biocontrol (Whipps et al., 2008; Whipps and Gerlagh, 1992).

Gliocladium catenulatum is a naturally occurring widespread parasitic fungus that can be used to control various fungal diseases in food and non-food crops, indoors and outdoors. It does not have any adverse effects on humans (EPA, 2002). *G. catenulatum* has been found effective against *Alternaria* in cucurbits and cole crops, gummy stem blight and black rot in cucurbits and white mold in potatoes (Seaman, 2013, 2014 a,d). It is also useful for preventing damping-off in bedding plants (McQuilken et al., 2001). Like *Gliocatenulata*, *Trichoderma asperellum* and *Trichoderma gamsii* are parasitic fungi useful in the control of white mold in potatoes (Seaman, 2014d). Trichoderma species can inhibit plant pathogenic fungi by inducing resistance and plant defense, mycoparacitism, antibiosis and parasiticism (Anees et al., 2010).

Aqueous and dried powder preparations of ethanol extracts from the giant knotweed, *Reynoutria sachalinensis* are effective in treatment and prevention of *Alternaria* in cucurbits and cole crops, anthracnose in cucurbits, blueberries, grapes, spinach and strawberries, *Botrytis* blossom and twig blight in blueberries and grapes, *Botrytis* bunch rot in grapes, downy mildew in cucurbits, cole crops, grapes, lettuce and spinach, early blight in potatoes, *Eutypa* dieback in grapes, gray mold (*Botrytis cinerea*) in beans, lettuce and strawberries, gummy stem blight and black rot in cucurbits, leaf blight in strawberries, mummy berry in blueberries, *Phomopsis* cane and leaf spot and fruit rot in grapes, *Phomopsis* canker in blueberries, powdery mildew in cucurbits, apples, blueberries; grapes and strawberries, sour rot in grapes, white mold in potatoes and others (Konstantinidou-Doltsinis and Schmitt, 1998, Seaman, 2013, 2014 a, b, d, e, f; Carroll et al, 2014 a, b; Weigle and Carroll, 2014; Peck and Merwin, 2014). *R. sachalinensis* appears to contain aglycones that stimulate plant defense mechanisms inducing production of anti-fungal β-glycosidically bound phenolic compounds (Daayf et al., 1995).

The Bordeaux mixture is a combination of calcium oxide (quicklime), copper sulfate and water originally developed in 1890 to prevent pilfering of wine grapes along French highways, but later was found to prevent infection with downy mildew. Chemically, the combination produces cupric oxide, lime sulfur and copper hydrate (Butler, 1923). Copper application in the form of copper sulfate, copper hydroxide, copper oxychloride and copper octanoate is effective in treatment and prevention of *Alternaria* in cucurbits and cole crops; anthracnose in cucurbits, blueberries, grapes, spinach and strawberries; *Botrytis* blossom and twig blight in blueberries and grapes; downy mildew in cucurbits, cole crops, grapes, lettuce and spinach; early blight in potatoes; gray mold (*Botrytis cinerea*) in beans, lettuce and strawberries; gummy stem blight and black rot in cucurbits; leaf blight in strawberries; leaf spot in peas; *Phomopsis* cane and leaf spot and fruit rot in grapes; powdery mildew in cucurbits, apples, blueberries, grapes and strawberries; *Septoria* leaf spot in cucurbits and white mold in potatoes and others (Seaman, 2013, 2014 a, b, c, d, e, f; Carroll et al, 2014 a, b; Weigle and Carroll, 2014; Peck and Merwin, 2014). Intensive use of copper for mold and mildew control has raised concerns of phytotoxicity. Copper compounds, e.g. copper hydroxide, copper oxide, copper oxychloride, and copper sulfate, are products that may be exempted from EPA tolerance and synthetic substances allowed for use in organic crop production. They are not to be used as herbicides and must be used in a manner that minimizes accumulation of copper in the soil (205.601(i) (2) and (3)). In the case of Bordeaux mixture and grape horticulture, application results in changes in leaf and fruit physiology including increased copper levels in grape berry tissues; changed leaf and fruit sugar concentrations and a reduction in amino acid production and nitrogen metabolism (Martins et al, 2014). However, copper also appears to stimulate the plant's natural defenses against molds and mildews (Aziz et al., 2006).

Silica from aluminum silicate (kaolin) and potassium silicate contributes to the formation of phytoliths, strengthening cell walls and reinforcing plant disease resistance in plants (Guntzer et al., 2012). Both substances are useful in the prevention and control of downy mildew. Respectively, soil and foliar application of kaolin and potassium silicate to plants under stress from disease or parasites grown under otherwise silica depleted conditions are effective for restoring plant defenses and improving plant health (Menzies et al., 1992; Nofal and Haggag, 2006). In "Humus and the Farmer", Friend Sykes provides that the "well-being of mankind is interdependent with that of the animal, the plant and the living soil" and a fertile soil is one rich in humus (Sykes, 1949). Humus maintains silica in soil. Its components, compost and manure are rich sources of plant derived silica. Silica in compost is maintained by phytolith recycling. Silica in manure is increased as a result of the effect silica has on plant tissue digestion of specific forage grass species. Thus, maintenance and addition of humus through careful recycling of compost and manure will maintain silica in the soil.

Lime sulfur and sulfur are effective in the control and prevention of leaf spot in peas; *Phomopsis* cane and leaf spot and fruit rot in grapes; and powdery mildew in cucurbits, apples, blueberries, grapes and strawberries (Seaman, 2013, 2014c; Peck and Merwin, 2014; Carroll et al, 2014a, b; Wiegle and Carroll, 2014, Gadoury et al., 1994). Balanced plant nutrition is critical for disease resistance. A nutrient starved plant is more vulnerable to disease (Singh et al., 2014).

Hydrogen dioxide, also known as hydrogen peroxide, and peroxyacetic acid are surface disinfectants used to control molds and mildew. These substances have a wide application in the control and prevention of *Alternaria* in cucurbits and cole crops; anthracnose in cucurbits, blueberries, grapes, spinach and strawberries; blueberry leaf rust in blueberries; *Botrytis* blossom and twig blight in blueberries and grapes; *Botrytis* bunch rot in grapes; downy mildew in cucurbits, cole crops, grapes, lettuce and spinach; early blight in potatoes; gray mold (*Botrytis cinerea*) in beans, lettuce and strawberries, leaf blight in strawberries; leaf spot in peas; mummy berry in blueberries, powdery mildew in cucurbits, apples, blueberries, grapes and strawberries; sour rot in grapes, white mold in potatoes and others (Seaman, 2013, 2014 d; Peck and Merwin, 2014; Carroll et al, 2014a, b; Wiegle and Carroll, 2014).

Seeds from the Neem tree (*Azadirachta indica*) contain natural fungicides (Schultz et al., 1992). Extracts from these seeds are effective in prevention and control of *Alternaria* in cucurbits and cole crops, anthracnose in cucurbits, blueberries, grapes, spinach and strawberries, black dot root rot in potatoes, blueberry leaf rust in blueberries, *Botrytis* blossom and twig blight in blueberries and grapes, *Botrytis* bunch rot in grapes, downy mildew in cucurbits, cole crops, grapes, lettuce and spinach, early blight in potatoes, gray mold (*Botrytis cinerea*) in beans, lettuce and strawberries, gummy stem blight and black rot in cucurbits, leaf blight in strawberries, leaf spot in peas, powdery mildew in cucurbits, apples, blueberries, grapes and strawberries, *Septoria* leaf spot in cucurbits, sour rot in grapes, white mold in potatoes and others (Seaman, 2013, 2014 a, b, c, d, e, f; Peck and Merwin, 2014; Carroll et al, 2014a, b; Wiegle and Carroll, 2014). Essential plant oils such as cottonseed, corn, garlic, sesame, sesame oil, rosemary, thyme, and clove are also effective in control or prevention of many of the same infections as Neem extracts. These are generally pressed from leaves, stems, or flowers, rather than seeds, and then separated by distillation. They may be formulated with mineral oil in products labeled for disease control. Some are exempt from EPA labeling requirements (Caldwell et al., 2013). Thyme, clove bud and origanum oils provide broad-spectrum and dose-dependent inhibitory and/or biocidal activity against mycelium of a number soilborne pathogens. In pots, thyme, clove bud and origanum oils applied pre-planting as 5 % aqueous emulsions controlled *Rhizoctonia solani* AG2.1 infection on broccoli seedlings. Clove bud and origanum oils are phytotoxic at 10 % in soil (McMaster et al., 2013).

Evaluation Question #12: Describe any alternative practices that would make the use of the petitioned substance unnecessary (7 U.S.C. § 6518 (m) (6)).

Potassium bicarbonate is slightly basic in solution, fungistatic and effective as a foliar spray for the control and prevention of a number of important fungal pathogens, including *Alternaria*, anthracnose and gray mold (Armand, 2014; Ivanovic et al., 2002). Specifically, potassium bicarbonate has been shown to inhibit *in vitro* mycelial growth, spore germination and germ tube elongation in *Botrytis cinera* and *Alternaria alternata*. As a result, fungal hyphae produce fewer spores, and both spores and conidiophores appear shriveled and collapsed in photomicrographs after treatment with potassium bicarbonate (Fallik et al., 1997). Bicarbonate is physiologically involved in fungal morphology, branching and senescence with gradients of this salt naturally forming between branching peripheral hyphae and dormant centrally located fused syncytia (Rodriguez-Urra et al., 2009). Addition of exogenous bicarbonate appears to disrupt a natural concentration gradient. Potassium bicarbonate is an effective treatment for damping off fungi.

Molds and mildews differ in their biology and their pattern of infestation in various crops, but there are some similarities in their life histories that permit development of effective management strategies with the common principles of avoidance/exclusion, eradication, and protection. Avoidance/exclusion focuses on preventing pathogen introduction and minimizing factors that favor their establishment like selecting sites with good soil drainage, promoting good air circulation, removing diseased, dead or senescent plant material, reducing weeds, planting disease free stock, applying a thick mulch layer or ground cover and managing insects. Eradication includes sanitizing artificial surfaces, sterilizing growth medium, sanitary planting practices and destruction or removal of litter and plants at season's end. Protection includes planting resistant or less susceptible varieties, avoiding excessive use of soil amendments, avoiding excessive humidity in the canopy, keeping fruit cool and off the ground and prompt harvesting (Carrol et al., 2014a; Pappas, 2000).

Close plant spacing and a dense canopy favor disease development. Canopy manipulation as a means to prevent or delay disease epidemics, and minimize the need and amount of synthetic and non-synthetic substances used in organic crops, while maintaining economically viable production is sufficient to manage disease in some cases; however in other instances, canopy modification can increase the efficacy of fungicide application and further reduce disease severity. Whereas, canopy control through trimming or cultivar choice is beneficial for control of powdery mildew (*Sclerotina spp.)* in carrot, soybean, field pea and chickpea, other fungal diseases such as *Alternaria* may require additional treatment for control (McDonald et al., 2013).

In orchards, rotary mowing the orchard floor after leaf drop reduces overwintering scab inoculum and promotes earthworm activity. Light manure applications after harvest provide nitrogen for decomposers promoting leaf decomposition. Pruning out mildew-infested shoots will also reduce the infection potential (Darwin, C., 1881; Peck and Merwin, 2014).

Sooty blotch and flyspeck are common diseases of pome fruits particularly in moist temperate regions. Cultural control practices include site selection where trees receive good air circulation and sunshine, pruning trees to ensure good air circulation and choosing resistant cultivars (Williamson and Sutton, 2000).

Mixed-species hay cropping and annual compost applications for 3 years can enhance soil suppressiveness to damping-off in farmland transitioning to certified organic vegetable production. Mixed-hay treatment consists of a combination of eight hay species in equal proportions, including: festulolium (or rye fescue) undersown with alfalfa, red and white clover, timothy, chicory, orchard grass and plantain, cut two or three times per year by mowing off foliage, allowed to dry on the ground, and removed from the plots. Compost amendments applied during transition can improve crop vigor by significantly enhancing soil fertility (Baysal et al., 2008).

Composting is an agricultural practice that improves soil health, nutrient levels, organic matter, plant growth and suppresses diseases caused by soilborne pathogens. Compost teas and humus resulting from the composting process contains a variety of organisms (bacteria, fungi, nematodes, actinomyces) that remove pathogens through competition, induction of systemic plant defenses, physicochemical activity, antagonism and hyperparasitism (Mehta et al., 2014).

Hairy vetch is known to activate defense genes in tomato plants. Hairy vetch, grown with rye as a winter cover crop and compost teas are useful in fungi control for tomato crops (McGrath, 2009).

Genes conferring resistance to powdery mildew have been identified in melons, although the mechanism of resistance is not completely understood. The ability to develop resistant varieties in melon through marker assisted breeding is under study (Ning et al., 2014).

For crops susceptible to a particular fungal pathogen, rotations to a non-susceptible crop allow germination of spores, but without a host the fungus life cycle is terminated. This is particularly true with white mold infection of potatoes, where the longer a field is out of potatoes the lower white mold counts become (Wharton and Wood, 2013).

References

Anees, M., Tronsmo, A., Edel-Hermann, Hjeljord, L., Heraud, C., and Steinberg, C. (2010) Characterization of field isolates of *Trichoderma* antagonistic against *Rhizoctonia solani,* Fungal Biology, 114, pp. 691-701.

Armand Products Co. (2014) Potassium bicarbonate handbook.

Aziz,A., Trotel-Aziz, P., Dhuicq, L., Jeandet, P., Couderchet, M. and Vernet, G. (2006) Chitosan oligomers and copper sulfate induce grapevine defense reactions and resistance to gray mold and downy mildew, Phytopathology, 96, pp.1188-1194.

Baysal, F., Benitez, M., Kleinhenz, M.D., Miller, S.A., Gardener, B.B.M. (2008) Field management effects on damping-off and early season vigor of crops in a transitional organic cropping system, Phtopathology, 98:5, pp. 562-570.

Benz, A. and Spring, O. (1995) Identification and characterization of an auxin-degrading enzyme in downy mildew infected sunflower, Physiological and Molecular Plant Pathology, 46, pp. 163-175.

Butler, O. (1923) Chemical, physical, and biological properties of Bordeaux mixtures, Industrial and Engineering Chemistry, 15:10, pp. 1039-1041.

Caldwell, B., Sideman, E., Seaman, A., Shelton, A and Smart, C. (2013) Resource guide for organic insect and disease management, 2nd edition, New York State Agricultural Experiment Station.

Carroll, J., Pritts, M. and Heidenreich, C. (2014a) Production guide for organic strawberries, New York State Department of Agriculture and Markets, Cornell University Cooperative Extension, NYS IPM Publication No. 226.

Carroll, J., Pritts, M. and Heidenreich, C. (2014b) Production guide for organic blueberries, New York State Department of Agriculture and Markets, Cornell University Cooperative Extension, NYS IPM Publication No. 225.

Cerkauskas, R.F. and Ferguson, G. (2014) Management of powdery mildew (*Podoshraera xanthii*) on greenhouse cucumber in Ontario, Canadian Journal of Plant Pathology, 36:1, pp. 22-37.

Clayton, K. (2005) National Organic Program, Sunset Review: Advance notice of proposed rulemaking with request for comments, USDA, Agricultural Marketing Service, 7 CFR Part 205, Docket Number TM–04–07, Federal Register, 70:116, Friday, June 17, 2005, pp. 35177-35182.

Daayf, F., Schmitt, A., and Belanger, R.R. (1995) The effects of plant extracts of *Reynoutria sachalinensis* on pwdery mildew development and leaf physiology on long English cucumber, Plant Dis., 79, pp.577-580.

Darwin, C. (1881) On humus and the earthworm, Faber and Faber, Ltd., London, UK.

Day, L. (2007b) National Organic Program, Sunset Review, USDA, Agricultural Marketing Service, 7 CFR Part 205, Docket Number AMS–TM–06–0222; TM–04–07FR, RIN 0581–AC51, Federal Register, 72:199, Tuesday, October 16, 2007, pp. 58469-58473.

Day, Lloyd (2007a) National Organic Program, Sunset Review, USDA, Agricultural Marketing Service, 7 CFR Part 205, Docket Number AMS–TM–06–0222; TM–04–07PR, RIN 0581–AC51, Federal Register, 72:43, Tuesday, March 6, 2007, pp. 9872-9877.

Electronic Code of Federal Regulations (2014) § 205.601 Synthetic substances allowed for use in organic crop production.

Fallik, E., Grinberg, S. and Ziv, O. (1997) Potassium bicarbonate reduces postharvest decay development on bell pepper fruits, Journal of Horticultural Science, 72:1, pp. 35-41.

Food Safety Inspection Service (FSIS—2010b) International Standard-Setting Activities, USDA, Food Safety Inspection Service Docket Number FSIS-2012-0017, Federal Register, 77:119, Wednesday, June 20, 2012, pp. 36984-36994.

Gadoury, D.M., Cole-Davidson, L., Wilcox, W.F., Dry, I.B., Seem, R.C., and Milgroom, Michael (2012) Grapevine powdery mildew (*Erysiphe necator*): a fascinating system for the study of the biology, ecology and epidemiology of an obligate biotroph, Molecular Plant Pathology, 13:1, pp. 1-16.

Gadoury, D.M., Pearson, R.C., Riegel, D.G., Seem, R.C., Becker, C.M., and PScheidt, J.W. (1994) Reduction of powdery mildew and other diseases by the over the trellis application of lime sulfur to dormant grapevines, Plant Dis., 78, pp. 83-87.

Guntzer, F., Keller, C., and Meunier, J. (2012) Benefits of plant silicon for crops: a review, Agron. Sustain. Dev, 32, pp201-213.

Gutierrez-Manero, F.J., Ramos-Solano, B., Probanza, A., Mehouachi, J., Tadeo, F.R. and Talon, M.(2001) The plant-growth-promoting rhizobacteria *Bacillus pumilus* and *Bacillus licheniformis* produce high amounts of physiologically active gibberellins, Physiologia Plantarum, 111, pp. 206–211.

Hamilton-Miller, J.M.T. (1973) Chemistry and biology of the polyene macrolide antibiotics, Bacteriological Reviews, 37:2, pp. 166-196.

Highland, H., Ockey, S., and Dimrock, M. (2012) A new generation of bacterial biofungicides based on the bacterium *Bacillus amyloliquefaciens* (strain D747) from Certis USA for use in vegetable and fruit disease control, Phytopathology, 102:S4.53.

Hinarejos, E. (2014) New strain of *Bacillus subtilis* for combating plant diseases, European patent Application, EP 2781592A1.

Ivanovic, M., Mijatovic, M., and Antonijevic, D. (2002) Effect of sodium bicarbonate on *Alternaria solani* in tomato, Proc. 2nd Balkan Symp. on Veg. & Potatoes, Eds. G. Paroussi et al., ACTA Hort. 579, International Society of Horticultural Scientists.

Kostantinidou-Doltsinis, S. and Schmitt, A. (1998) Impact of treatment with plant extracts from *Reynoutria sachalinensis* (E Schmidt) Nakai on intensity of powdery mildew severity and yield in cucumber under high disease pressure, Crop Protection, 17:8, pp. 649-656.

M.T. McGrath, M.T. (2009) Evaluation of Treatments for Managing Foliar Diseases in Organically-Produced Tomato, Proc. Second Intl. Symposium on Tomato Diseases, *eds*, H. Saygili et al., Acta Hort. 808, International Society of Horticultural Scientists, pp. 137-142.

Martins, V., Teixeira, A., Bassil, E., Blumwald, E. and Geros, H. (2014) Metabolic changes of *Vitis vinifera* berries and leaves exposed to Bordeaux mixture, Plant Physiology and Biochemistry, 82, pp. 270-278

McDonald, M.R., Gossen, B.D., Kora, C., Parker, M. and Boland, G. (2013) Using crop canopy modification to manage plant diseases, Eur. J. Plant Pathol., 135, pp. 581-503.

McMaster C. A., Plummer, K. M., Porter, I. J. and Donald, E. C. (2013) Antimicrobial activity of essential oils and pure oil compounds against soilborne pathogens of vegetables, Australasian Plant Pathol., 42, pp. 385–392.

McQuilken, M.P., Gemmell, J. and Lahdenper, M-L (2001) *Gliocladium catenulatum* as a potential biological control agent of damping-off in bedding plants, J. Phytopathology 149, pp.171-178.

Mehta, C.M., Palni, U., Franke-Whittle, I.H., Sharma, A.K. (2013) Compost: Its role, mechanism and impact on reducing soil-borne plant diseases, Waste Management, 34, pp. 607–622

Menzies, J., Bowen, P., Ehret, D., and Glass, A.D.M. (1992) foliar applications of potassium silicate reduce severity of powdery milew on cucumber, muskmelon and zucchini squash, J. Amer. Hort. Sci., 117:6, pp. 902-905.

Ning, X., Wang, X., Gao, X., Zhang, Z., Zhang, L., Yan, W. and Li, G. (2014) Inheritances and location of powdery mildew resistance gene in melon Edisto47, Euphytica, 195, pp. 345–353.

Nofal, M.A. and Haggag, W.M. (2006) Integrated management of powdery mildew of mango in Egypt, Crop Protection, 25, pp. 480-486.

Pappas, A.C. (2000) Epidemiology and control of *Botrytis cinerea* in tomato crops grown under cover in Greece, OEPP/EPPO, Bulletin OEPP/EPPO Bulletin 30, 269-274.

Peck, G.M. and Merwin, I.A. (2014) A grower's guide to apples, New York State Department of Agriculture and Markets, Cornell University Cooperative Extension, NYS IPM Publication No. 223.

Pegg, R. (2009) Notice of Meeting of the National Organic Standards Board, USDA, Agricultural Marketing Service, 7 CFR Part 205, Docket Number AMS–TM–09–0060; TM–09–07, Federal Register, 74:173, Wednesday, September 9, 2009, pp. 46411-46413.

Pegg, R. (2010) National Organic Program, Sunset Review (2012), USDA, Agricultural Marketing Service, 7 CFR Part 205, Docket Number AMS–TM–09–0074; TM–09–01, RIN 0581–AC96, Federal Register, 75:58, Friday, March 26, 2010, pp. 14500-14509.

Rodrıguez-Urra, A. B., Jimenez, C., Duenas, M. and Ugalde, U. (2009) Bicarbonate gradients modulate growth and colony morphology in *Aspergillus nidulans*, FEMS Microbiol Lett, 300, pp. 216–221.

Schultz, E.B., Bhatnagar, D., Jacobson, M., Metcalf, R.L., Saxena, R.C., Unander, D. and Vietmeyer, N.D. (1992) Neem: a tree for solving global problems, Report of an Ad Hoc Panel of the Board of Science and Technology for International Development, National Research Council, National Academies Press, Washington, DC.

Seaman, A. (2013) Production guide for organic cucumbers and squash, New York State Department of Agriculture and Markets, Cornell University Cooperative Extension, NYS IPM Publication No. 135.

Seaman, A. (2014a) Production guide for organic cole crops, New York State Department of Agriculture and Markets, Cornell University Cooperative Extension, NYS IPM Publication No. 1342

Seaman, A. (2014b) Production guide for organic lettuce, New York State Department of Agriculture and Markets, Cornell University Cooperative Extension, NYS IPM Publication No. 136

Seaman, A. (2014c) Production guide for organic peas, New York State Department of Agriculture and Markets, Cornell University Cooperative Extension, NYS IPM Publication No. 137

Seaman, A. (2014d) Production guide for organic potatoes, New York State Department of Agriculture and Markets, Cornell University Cooperative Extension, NYS IPM Publication No. 138

Seaman, A. (2014e) Production guide for organic snap beans, New York State Department of Agriculture and Markets, Cornell University Cooperative Extension, NYS IPM Publication No. 132

Seaman, A. (2014f) Production guide for organic spinach, New York State Department of Agriculture and Markets, Cornell University Cooperative Extension, NYS IPM Publication No. 139

Select Committee on Generally Recognized as Safe Substances (1979) Potassium Silicate, Report #61, ID Code: 1313-76-1, US Food and Drug Administration, p. 1.

Shipman, D.R. (2010a) Notice of Meeting of the National Organic Standards Board, USDA, Agricultural Marketing Service, 7 CFR Part 205, Docket Number AMS–NOP–10–0021, Federal Register, 75:51, Wednesday, March 17, 2010, pp. 12723-12725.

Shipman, D.R. (2010b) Meeting of the National Organic Standards Board, USDA, Agricultural Marketing Service, 7 CFR Part 205, Docket Number AMS–NOP–10–0068, NOP-10-08, Federal Register, 75:181, Monday, September 20, 2010, pp. 57194-57200.

Singh, A.K., Singh, K.M., Bharati, R.C., Chandra, N. Bhatt, P. and Pedapati, A. (2014) Potential of residual sulfur and zinc nutrition in improving powdery mildew (*Erysiphe trifolii*) disease tolerance of lentil (*Lens culunaris L.)*, Communications in Soil Science and Plant Analysis, 45:21, pp. 2807-2818.

Sykes, F. (1949) Humus and the farmer, Rodale Press, Emmaus, PA.

US Department of Agriculture, Agricultural Marketing Service (USDA AMS—1999) Notice of Meeting of the National Organic Standards Board, Federal Register, Vol. 64, No. 195, p. 54858.

US Department of Agriculture, Agricultural Marketing Service (USDA NOP—2000a) National Organic Program, Proposed Rule: 7 CFR Part 205, Docket Number: TMD–00–02–PR2, RIN 0581–AA40, Federal Register, 65: 49, pp. 13512-13658.

US Department of Agriculture, Agricultural Marketing Service (USDA NOP—2000b) National Organic Program, Proposed Rule: 7 CFR Part 205, Docket Number: TMD–00–02–FR, RIN 0581–AA40, Federal Register, 65: 246, pp. 80548-80684.

US Department of Agriculture, National Organic Program (USDA NOP—1999a) National Organic Standards Board Meeting Minutes, October 25-28, 1999.

US Department of Agriculture, National Organic Program (USDA NOP—2005) National Organic Standards Board Meeting Minutes, November 17, 2005.

US Department of Agriculture, National Organic Program (USDA NOP—1999b) National List: Potassium Bicarbonate.

US Department of Agriculture, National Organic Program (USDA NOP—2010) National Organic Standards Board Meeting Transcript, April 29, 2010.

US Department of Agriculture, National Organic Program (USDA NOP—2013) National List Sunset Dates, NOP5 5611, Rev. 11 06 13.

US Department of Agriculture, National Organic Program—NOP (1996) Gibberellic Acid, Technical Advisory Panel Report.

US Environmental Protection Agency—EPA (2002) Gliocladium catenulatum strain J1446 (021009) Fact Sheet, U.S. Environmental Protection Agency, Office of Pesticide Programs, Biopesticides and Pollution Prevention Division.

US Environmental Protection Agency—EPA (2011) *Bacillus amyloliquefaciens* strain D747, Pesticide Chemical (PC) Code: 016482, Biopesticides Registration Action Document, U.S. Environmental Protection Agency, Office of Pesticide Programs, Biopesticides and Pollution Prevention Division.

Weigle, T and Carroll, J. (2014) Production Guide for Organic Grapes, New York State Department of Agriculture and Markets, Cornell University Cooperative Extension, NYS IPM Publication No. 224.

Wharton, P. and Wood, E. (2013) White Mold of Potatoes, University of Idaho Extension, CIS 1200.

Whipps, J. M. and Gerlagh, M. (1992) Biology of *Coniothyrium mintans* and its potential for use in disease biocontrol, Mycological Research, 96:11, pp. 897-907.

Whipps, J.M., Sreenivasaprasad, S., Muthumeenakshi, S., Rogers, C.W. and Challen, M.P. (2008) Use of *Coniothyrium minitans* as a biocontrol agent and some molecular ascpects of sclerotial mycoparasitism, Eur. J. Plant Patol., 121, pp. 323-330.

Williamson, S.M. and Sutton, T.B. (2000) Sooty blotch and flyspeck of apple: etiology, biology and control, Plant Diseases, 84:7, pp. 714-724.