Potassium Sorbate

Crops

Executive Summary

Potassium sorbate was petitioned for use as a preservative for an unspecified seed film coating. The reviewers were unable to fully evaluate the petition since the specific polymer was not identified, the target pests and mode of action were not specified, and the petition justification for use of the product in organic production was incomplete.

The reviewers unanimously found the substance to be synthetic and unanimously found no evidence to support adding potassium sorbate to the National List for the petitioned application or use. All noted that natural analogs exist, and may be used without being added to the National List. One reviewer supported possibly adding the substance to the National List as a preservative for certain specific biological soil amendments, pending a look at the alternatives to these other uses. However, all reviewers explicitly considered the petitioned use to be incompatible with organic farming systems.

Summary of TAP Reviewer's Analyses[1]

Synthetic/ Nonsynthetic	*Allow without restrictions?*	*Allow only with Restrictions?*
Synthetic (3) Nonsynthetic (0)	Yes (0) No (3)	Yes (0) No (3)

Identification

Chemical Name: potassium sorbate

Other Names:
2,4-hexadiennoic acid, potassium salt, sorbic acid, potassium salt, BB powder.

Trade Names:
Food grade is usually sold generically under the names of various manufacturers: Aceto, FBC Industries, Nutrinova, Spectrum, Wuxi Daxin, among others.

CAS Numbers:
590-00-1, 24634-61-5

Other Codes:
RTECS: WG2160000
INS 202
IFN 8-03-761

Characterization

<u>Composition</u>: $CH_3CH{=}CHCH{=}CH\text{-}COOK$

<u>Properties</u>:
Crystals, solubility in water at 20°C. is 58.2%. Solubility in alcohol is 6.5%.

<u>How Made</u>:
Sorbic acid is blended with potassium hydroxide in equimolar portions and recrystallized with aqueous ethylene hydroxide to form potassium sorbate (Patil, 2001). Sorbic acid was first isolated by the hydrolysis of oils distilled from the mountain ash berry (Dorko et al., 1997). Commercial sources are now produced by the condensation of crotonaldehyde and ketene (Ashford, 1994). Yields are increased by reaction in the presence of a catalyst, such as boron trifluoride (Fernholz, Ruths, and Heimann-Trosien, 1962).

<u>Specific Uses</u>:
It is primarily used as a fungistat and as a mold and yeast inhibitor. Most applications are in post-harvest handling and processing for food preservation and extension of shelf-life (Dorko et al., 1997). Among the food uses include use as a preservative in baked goods, chocolate, soda fountain syrups, fruit cocktails, cheeses, and artificially sweetened jellies (Winters, 1989). It is also used in fruit waxes (Nelson, 1981). These handling and processing uses are not considered in this current review.

[1] *This Technical Advisory Panel (TAP) review is based on the information available as of the date of this review. This review addresses the requirements of the Organic Foods Production Act to the best of the investigator's ability, and has been reviewed by experts on the TAP. The substance is evaluated against the criteria found in section 2119(m) of the OFPA [7 USC 6517(m)]. The information and advice presented to the NOSB is based on the technical evaluation against that criteria, and does not incorporate commercial availability, socio-economic impact, or other factors that the NOSB and the USDA may want to consider in making decisions.*

There are few references to uses of potassium sorbate, sorbic acid, or other sorbic acid salts used as crop fungicides in general or seed treatments in particular. While some experiments were conducted in the late 1960s and early 1970s, one reference found in the literature indicates that sorbic acid and potassium sorbate are of little value for this purpose (Davis and Pinckard, 1971). More recent experiments and inventions claim that potassium sorbate is effective as a mold inhibitor with other synthetic fungicides used in tissue culture (Guri and Patel, 1998).

Action:
The exact mechanism by which sorbic acid and its potassium salt inhibits microbial growth is not entirely understood. No single mechanism appears to explain the range of toxicity to various spoilage organisms. Sorbic acid inhibits the transport of carbohydrates into yeast cells, inhibits oxidative and fermentative assimilation, and uncouples oxidative phosphorylation in a variety of bacteria (Dorko et al., 1997). Other mechanisms proposed appear to be related to the inability of molds to metabolize sorbic acid (Lindsay, 1996).

Combinations:
Potassium sorbate was petitioned to be used as a seed treatment with sodium propionate and various unspecified polymers used to coat seed (Patil, 2001). It is also used in a number of combinations for food and feed processing (Dorko et al., 1997). Citric acid can be used as a stabilizer for sorbic acid and its salts (Montagna and Lashley, 1958). Sorbic acids and its salts may have a synergistic effect with various synthetic fungicides when used in plant tissue culture media (Guri and Patel, 1998).

Status

Historic Use:
Sorbic acid and other unsaturated aliphatic mono-carboxylic acids and their salts were discovered to be effective at inhibiting the growth of microorganisms between the late-1930s and mid-1940s (Gooding, 1945). Potassium sorbate use in food increased rapidly following this discovery (Dorko, 1997). However, there are few references that potassium sorbate has been used as a seed treatment or for any other crop uses in either organic or conventional agriculture. Only a few experimental references were found in the literature (Oshanina and Ovcharov, 1967; Davis and Pinckard, 1971), and there is no indication that potassium sorbate was ever used commercially. Potassium sorbate may also be used for conditioning seeds, but this treatment is intended to be used on seeds for processing, not planting (White and Swick, 1986). The main historic use in organic production appears to be as an inert ingredient with biorational pesticides and as a preservative for various microbial inoculants and other biological soil amendments.

OFPA, USDA Final Rule:
Not listed in OFPA or the USDA Final Rule. It would be considered for use as a seed treatment or a production aid under 7 USC 6517(c)(1)(B)(1). The NOSB considered a petition for sorbic acids and its salts for use in food processing in 1995. The NOSB determined that sorbic acid was synthetic and not compatible with organic processing or handling, and did not recommend that it be added to the National List (Austin, 1995).

Regulatory: EPA/NIEHS/Other Sources
Potassium sorbate is exempt from EPA pesticide registration requirements [40 CFR 152.25(b)] and is on EPA List 4B. The National Toxicology Program (NTP) does not have a monograph on potassium sorbate.

Status Among U.S. Certifiers
Not listed in the standards of: California Certified Organic Farmers (CCOF), Maine Organic Farmers and Gardeners Association (MOFGA), Northeast Organic Farming Association of New Jersey (NOFA-NJ), Northeast Organic Farming Association of New York (NOFA-NY), Northeast Organic Farming Association of Vermont (NOFA-VT), Oregon Tilth Certified Organic (OTCO), and Organic Crop Improvement Association International (OCIA), Quality Assurance International (QAI), Texas Department of Agriculture (TDA), and Washington State Department of Agriculture (WSDA).

International
CODEX – not listed
EU 2092/91 – not listed
IFOAM – not listed
Canadian General Standards Board – not listed
Japanese Agricultural Standards – not listed

Section 2119 OFPA U.S.C. 6518(m)(1-7) Criteria

1. *The potential of the substance for detrimental chemical interactions with other materials used in organic farming systems.*

Potassium sorbate goes into solution as ionic potassium and sorbic acid. The degradation products are more hazardous than the product itself (Binas, 2001). Like potassium sorbate, sorbic acid has antifungal and antimicrobial activities.

Sorbic acid is reported to have synergistic effects with sodium nitrite (Banerjee and Giri, 1986). Sorbate and nitrite form several species of direct acting mutagens and genotoxic agents, including ethylnitrolic acid and 1,4-dinitro-2-methylpyrrole (Hartman, 1983). Various microorganisms play a role in this transformation (Shu et al., 1991). This has been studied primarily in the context of sodium nitrite and potassium sorbate as food additives, and not under field conditions. However, sodium nitrate is used as a fertilizer on some organic farms in the United States. Nitrite can be formed reduced by denitrification and reduction of sodium nitrate under conditions of poor drainage and anaerobic conditions (see Brady, 1974).

2. *The toxicity and mode of action of the substance and of its breakdown products or any contaminants, and their persistence and areas of concentration in the environment.*

Potassium sorbate has an oral LD_{50} of 3,800 mg/kg for mice and 4,340 mg/kg for rats (Binas, 2001). The 'safe' level of potassium sorbate in the diet of a model insect, *Agria affinis* was determined to be 200 ppm (Singh and House, 1970). It is a skin and eye irritant and decomposes into an irritant. There is no indication that potassium sorbate or its breakdown products are carcinogenic, teratogenic, or mutagenic. Replications of earlier trials to evaluate the genotoxicity of potassium sorbate confirmed the earlier negative findings using Drosophilia (fruit flies) (Schlatter et al., 1992) and hamsters (Münzer, 1990) as models. However, there is evidence of cytotoxicity. One study showed that rats exposed to potassium sorbate had detectable cell injury. The injury levels were reduced by the introduction of an antioxidant (Sugihara, Shimomichi, and Furuno, 1997).

3. *The probability of environmental contamination during manufacture, use, misuse, or disposal of the substance.*

Crotonaldehyde and ketene are both produced from fossil fuel sources, primarily natural gas and petroleum. Petroleum production is associated with the destruction of wildlife habitat and creates greenhouse gases that are believed to be the cause of global warming.

4. *The effects of the substance on human health.*

Potassium sorbate is Generally Recognized As Safe (GRAS) as a food additive in the US (21 CFR 182.3640). It is an irritant of skin and eyes. Inhalation and ingestion can also cause acute health hazards (Binas, 2001).

5. *The effects of the substance on biological and chemical interactions in the agroecosystem, including the physiological effects of the substance on soil organisms (including the salt index and solubility of the soil), crops and livestock.*

Potassium sorbate is used for its antimicrobial activity. Therefore, it is reasonable to expect that it would inhibit the growth of soil microorganisms. Dorko (1997) contains a summary table of over 150 different bacteria, molds, and yeasts inhibited by sorbates. Many of these are human or plant pathogens. In particular, sorbic acids and its salts suppress a significant number of organisms regarded as beneficial, such as *Aspergillus niger*—generally non-pathogenic and active in making phosphorous and trace elements more available (Alexander, 1977); *Bacillus subtilis*—an antagonist used to suppress pathogenic strains of *Alternaria, Aspergillus, Fusarium,* and *Rhizotonia* (Meister, 2001); *Trichoderma viride*, an antagonist of *Pythium and Rhizoctonia* (Horst, 1990); and *Saccharomyces cerevisiae*—brewer's yeast and an organism identified as playing a potential role in the sulfur cycle (Alexander, 1977). However, solutions that contain potassium sorbate adjusted to an acid pH using acetic acid and other ingredients were found to be selective in favor of certain *Sporolactobacillus* (Doores and Westhoff, 1983).

Sorbic acid should inhibit the growth of soil bacteria and fungi. It would also inhibit the growth of yeast that contaminated stored seed coated with a protein/carbohydrate polymer. Potassium sorbate is petitioned as a shelf-life extender for a seed coating. The microbial growth inhibition comes at a cost, however. Exposure of microbes to weak acids and bases can turn on resistance genes and "train" the organisms to resist other environmental stresses (Russell, 1991; Piper et al., 2001). Mild acid treatment of *Vibro parahaemolyticus,* using hydrochloric acid at a pH of 5, has been shown to increase the bacteria's resistance to lower pH and give cross protection against heat stress (Wong, 1998). Leyer & Johnson (1993) reported similar findings on *Salmonella typhimurium*. Taormina and Beuchat (2001) also show that exposing *Listeria monocytogenes* to mild alkali or chlorine induces resistance to strong disinfectants agents and heat.

Short chain fatty acid preservatives like sorbic and propionic acid have been specifically shown to induct resistance to environmental stresses in *Salmonella typhimurium* and yeasts in the genus *Saccharomyces* (Piper et al., 2001; Stratford & Anslow, 1996; Kwon & Ricke, 1998). Kwon & Ricke (1998) show that exposure of *Salmonella typhimurium* to propionic acid can induce acid resistance in as little as 30 minutes. Weak acid resistance is becoming a problem in the food industry where acids such as sorbic and propionic are widely used to preserve food against yeast and fungi spoilage (Piper et al., 2001). Propionic acid is currently being phased into the meat packing industry as an antibacterial spray for beef carcasses (Hardin et al., 1995). Weak organic acid antimicrobials are important to the food industry, and manufacturers should use them wisely. Indiscriminate use can lead to widespread acid tolerance in microbial populations (Levy, 2001).

Livestock: Potassium sorbate is GRAS for use in animal feed with no limitations or restrictions other than following good manufacturing or feeding practice (21 CFR 582.3640).

6. *The alternatives to using the substance in terms of practices or other available materials.*

The petitioned use, and the only crop application supported in the literature, is as a seed treatment. This is tied to the practice of coating the seed. One alternative is to not coat the seed. Admixtures are documented to decrease the storage life of seeds, particularly those that absorb moisture and serve as a substrate for plant pathogens (Agrawal and Sinclair, 1996). By not coating the seed with such substances, one could effectively increase the storage life. If coating the seed is desirable, then timing the treatment to within two weeks of planting should be sufficient to avoid infection, based on the information provided in the petition (Patil, 2001). This would preclude saving coated seed for more than a season.

Proper seed storage begins at planting. Some varieties are more prone to seed-borne diseases than others (Agrawal and Sinclair, 1996). By sowing disease-free seed, one is more likely to reap disease-free seed. Techniques are available to exclude, quarantine, and reduce inoculum (Maude, 1996). Selecting a field that has not grown a host crop for a suitable period reduces the chance of soil-borne infection (Agrawal and Sinclair, 1996). Preventing infection in the field is an important step to maintaining disease-free seed.

Harvest is a critical stage for preventing seed-borne diseases. Timing must be right. Delayed harvest favors seed infection (Agrawal and Sinclair, 1996). Yet seed should not be harvested too soon either. Seeds should be harvested when the moisture levels are low enough to prevent the growth of mold. Care should be taken in harvesting to not damage the seeds in a way that permits opportunistic infection by mold or bacteria. Test methods are available to help predict and ensure storability (Neergaard, 1977). Once harvested, seeds need to be maintained in cool, dry conditions (Copeland and McDonald, 1995). Insect damage can also create opportunities for infection (Neergaard, 1977; Agrawal and Sinclair, 1996). Construction and maintenance of appropriate storage containers and facilities can also regulate conditions so that they favor long-term seed storage (Neergaard, 1977).

A number of biological control agents are commercially available to protect seeds from microbial pathogens, including *Bacillus subtilis, Trichoderma spp.,* and *Gliocladium* spp. (Campbell, 1989; OMRI, 2001). Biological control methods are compatible and are particularly well suited for use with coating technology (Campbell, 1989). Copper sulfate [7 CFR 205.601(i)(2)] and elemental sulfur [7 CFR 205.601(i)(8)] both appear on the National List and are both effective as seed treatments (Maude, 1996). Various natural edible plant extracts show equal or greater efficacy as antimicrobial agents, including Chinese chive, cinnamon, and Corni fructus when compared with potassium sorbate (Mau, Chen, and Hsieh, 2001).

7. *Its compatibility with a system of sustainable agriculture.*

Synthetic biocides are not considered compatible with a system of sustainable agriculture, with few exceptions. However, compared with other synthetic fungicides that have long been used to treat seed planted by organic producers, potassium sorbate is considerably less toxic to both humans and soil organisms. Because sorbic acid and its potassium salt can be derived from common cultivated plants, they can conceivably be obtained from a sustainable, renewable source. While the natural analog of the petitioned substance is sustainable, the synthetic form is not.

TAP Reviewer Discussion

Reviewer 1 *[research chemist who serves on an organic certification committee, East Coast]*

Sorbic Acid is a straight chain monocarboxylic fatty acid with antifungal properties. It has no odor or strong taste, making it suitable as a food preservative (Chichester & Tanner, 1972). It is only slightly soluble in water and when added to water-based products it needs to be converted to potassium sorbate or pre-dissolved in propylene glycol or ethanol (Chichester & Tanner, 1972). Potassium sorbate is very water-soluble and is made by dissolving sorbic acid in potassium hydroxide.

Sorbic acid is a weak acid (HA). The dissociation of the acid to H^+ and A^- is governed by the pH of the solution, with low pH favoring the undissociated acid (Cherrington et al., 1991). Fatty acid preservatives generally inhibit microbe growth, causing cell stasis or lag phases in growth, rather than killing microbe cells (Stratford & Anslow, 1996). The main antimicrobial effect of fatty acids like sorbic is attributed to the undissociated acid penetrating the microbial cell wall and then dissassociating in the higher pH cytoplasm. The H^+ released is believed to inhibit glycolysis and growth (Stratford & Anslow, 1996; Piper et al., 2001). The antimicrobial activity is therefore very dependent on the pH of the material being preserved. The sorbates work best at low pHs (< 5). They can be used at lower effectiveness at pHs up to 6.5 (Chichester

& Tanner, 1972). Sorbic acid and potassium sorbate are used to preserve and extend the shelf life of many food items. It is extensively used in cheese products, smoked fish, and dried fruit (Chichester & Tanner, 1972).

Sorbic acid is active against many molds and yeast and is less useful against bacteria. It equally inhibits the growth of gram + and gram-bacteria, however, (Russell, 1991). There is some evidence that sorbic acid does not behave in the same way as other antimicrobial fatty acids (Stratford & Anslow, 1996) and may act against the cell wall membrane (Stratford & Anslow, 1998). . .

<u>*1) Interactions*</u>
Potassium sorbate and sorbic acid are stable compounds. They are not compatible with strong oxidizing or reducing agents. The acid also reacts with strong caustics (but the heat of neutralization would mostly depend on the base, not the weak acid).

The compounds are antimicrobial to many soil fungi but would be metabolized by other fungi and bacteria. Mold can metabolize sorbate via a ß oxidation, similar to the route used by mammals (Chichester & Tanner, 1972). Exposure to weak acids like sorbic can induce resistance in bacteria and yeast to other environmental stresses (see section 5).

<u>*2) Toxicity*</u>
As stated above, the compound inhibits growth of fungi and some bacteria. Although sorbic acid has been reported to be potentially genotoxic in the presence of sodium nitrite (Banerjee and Giri, 1986)—another food preservative—most in-vitro studies have found no evidence of mutagenesis or genotoxicity of sorbic acid or its reaction products (Ferrand et al., 2000 a and b; Schlatter et al., 1992). Schlatter et al., 1992, notes that the low pH weak acids alter the osmotic pressure of cell cultures, *[thus]* causing false positives in *in vitro* genotoxicity studies.

<u>*3) Environmental Contamination*</u>
There are no unusual problems with manufacturing sorbic acid. Dust powdered sorbates can be eye and skin irritants, but can be controlled by normal industrial powder handling procedures.

<u>*4) Human Health*</u>
[Mammals metabolize] sorbic acid . . . in the same way as other fatty acids. It has very low toxicity, even at levels of 10% of diet (Walker, 1990). Sorbic acid and its saturated analog, caproic acid, have been fed to puppies at 4% dietary levels for 90 days without problems (Chichester & Tanner, 1972). Sorbic acid is less toxic than benzoic acid and is also better tolerated by rats than sodium sorbate (Duel et al., 1954).

<u>*5) Effects in agroecosystem*</u>
[See paragraphs two and three in #5 above.]

<u>*6) Alternatives*</u>
The weak acid preservatives in the petitions would be used for protection of a polymer seed coating. There are two questions regarding the need to place the preservative on the National List of Allowed Synthetics: (1) Are there alternatives to the seed coating, and (2) Are there alternatives to the synthetic weak acid preservative?

Neither the seed coating nor its purpose is described in the petition. It is difficult to evaluate the alternatives to the petitioned preservatives without some knowledge of the material that they are meant to preserve. Assuming that the seed coat is the OMRI Listed material produced by the petitioning company, and assuming that the material uses a similar technology to a related non-organic product by the same company, we will attempt to address question 1.

The purpose of the seed coating is to slow hydration of sown seed. Inhibiting hydration allows cold-susceptible seeds to be sown earlier in the planting season than normally possible (Ni, 2001). A normal planting time or proper choice of plant variety for local conditions would eliminate the need to coat.

The polymer to be protected by the potassium sorbate appears to be very susceptible to attack by mold. Carbohydrate polymers based on alginic acid, ethyl cellulose, or maltodextrins exist that can be formulated to be less susceptible to mold.

Naturally derived fatty acids such as lauric, palmatic, or linoleic acid also have antimicrobial activity and could be substituted for sorbic or propionic acid (Kabara et al., 1972). Natural extracts of cinnamon, Chinese chive, or Welsh onions also have been shown to be useful antimicrobials (Mau et al., 2001; Fan and Chen, 1999). Welsh onion extract is more active against yeast than either sorbates or propionates at neutral pH (Fan and Chen, 1999). Essential plant oils such as oregano or lemongrass show activity against both bacteria and fungi (Hammer et al., 1999). They can penetrate fungal cell walls, opening holes from which cell contents leak out (Piper et al., 2001). Sorbic *[acid and]* propionic acid are widely used in the food industry due to their mild taste and lack of odor. Taste or odor are not an issue with seed coatings, and the use of preservatives better suited for food products seems unnecessary, especially in light of resistance issues.

If the seed coating uses the Fantesk technology developed by USDA scientists, essential oil preservatives would fit into the polymer very well. In the Fantesk technology, a starch and oil are turned into a gel through steam processing. The oil droplets remain suspended in the starch, and will not un-mix during further processing. Essential oil preservatives could be incorporated into the main vegetable oil (probably soy), and would present a large contact surface to invading microbes.

The petitioner notes that natural sorbate extracts from blueberries are commercially available. Under current NOP guidelines, natural sorbate should not need to be placed on the National List of Synthetics.

7) Compatibility

Potassium sorbate is an antimicrobial of low toxicity. It inhibits microbial growth rather than kill organisms. It is not listed for organic food processing or as an organic feed additive. Weak acid preservatives have a long history in food storage, starting with acetic acid (vinegar). Widespread use is now creating a problem with acid resistant bacteria and fungi. Better management of these antimicrobials in the food industry is needed. Non-food uses of potassium sorbate should be limited. Alternatives unsuitable for use in food products (strong taste and odor) can be substituted for potassium sorbate in non-food applications.

The use of potassium sorbate to extend the shelf life of a polymer seed coating is not compatible in a system of sustainable agriculture, which extends from the soil to the table. Proper planting would eliminate the need for seed coat that limits moisture uptake. It has not been demonstrated in the literature packet accompanying this TAP Review that the particular polymer chosen for this product is the best chemical for seed coatings. Finally, there are natural antimicrobial compounds that are active against mold and yeast, including one that appears to have equivalent activity to sorbates (Fan and Chen, 1999).

Reviewer 1 Conclusion

Synthetic potassium sorbate is a weak acid antimicrobial. It is most active at low pH. It has been shown to "train" bacteria and fungi to become more resistant to environmental stresses. Since it is an important antimicrobial in the food industry, use for a non-food seed coat is not advisable. Natural antimicrobials would be more suitable for crop use. Potassium sorbate should not be added to the National List of Synthetic Materials for use in organic crop production.

Reviewer 2 *[M.S. Plant Breeding with experience in the seed trade and as an organic farmer, West Coast]*

Potassium sorbate should be considered for use as a preservative in microbial inoculants and other biological soil amendments. Since it is on EPA List 4 and is therefore allowed in approved biorational pesticide formulations as an inert ingredient, it should be granted the same status in microbial and biological soil amendments. Based on the TAP Review presented (with perhaps some further discussion of alternatives for those specific purposes), I would vote to add it to the National List for those uses. Since the petition implies that the material comes from blueberries, there should be a verification or not in the characterization section about that claim. . . .

Environmental Contamination

While I sort of agree, this is an extreme oversimplification of the issues involved in petroleum-based materials. It is unlikely that those two compounds in particular have an impact that is greater than automobile emissions or oil spills. . . . *[The]* handling of petroleum from the ground to the end product has a high potential for environmental contamination and misuse.

Alternatives

It is very difficult to assess alternatives because the petition lacked the basic information of what seed species it is used for and against what "molds". There is also no indication of what is the coating polymer used in conjunction with it…. The petitioner has stated that the material is needed to prevent mold formation and to extend the shelf life of his product, but not why his product is necessary for organic production. The TAP Review also gives no indication of why the coating is necessary. Therefore, the alternatives all are very general, but have to be looked at as what is historically supported in organic farming practice.

Biological control agents, copper sulfate, elemental sulfur, and some plant extracts are all mentioned as alternative seed treatments, but the viability of these cannot be assessed without knowing if they target the same "molds" and without knowing if there has been any commercial product development in the latter three materials.

. . . There is . . . no indication of what coating polymer is used other than a brand name product. The question about what the storage life of uncoated and preservative-free seeds was not answered . . . *[One]* can only assume that the coating polymer is natural . . . If a product is on the market without these preservatives, then it is unclear why the preservatives are necessary. It is also troubling that the petitioner only conducted experiments with both materials together instead of a controlled experiment with each material individually as well as the two combined. No additional information was provided as to why the seeds would be coated with a polymer at all. Does it help germination in cold soil? Help prevent damping off? Keep moisture in the seed?

Without a basic understanding of why seeds benefit from this treatment, it can only be concluded by this reviewer that the alternatives presented, particularly not treating the seeds in the first place, are superior choices. The materials mentioned as coating agents in the alternative section are also very intriguing but without any information presented on whether they have been actually used rather than just experimented with, it would come back to the untreated seed being best.

Compatibility

Neither the petition nor the TAP Review is compelling as to why the material should be considered compatible with organic production….

That being said, this reviewer sees that there may be situations where this material may play a role in organic agriculture, because as stated in this section, "compared with other synthetic fungicides that have long been used to treat seed planted by organic producers, potassium sorbate is considerably less toxic to both humans and soil organisms."

As mentioned *[in]* the TAP review . . . "The main historic use in organic production appears to be as an inert ingredient with biorational pesticides and as a preservative for various microbial inoculants and other biological soil amendments." These uses may encompass a seed treatment if there were more complete information in a petition, but use as a seed treatment should not be looked at by itself, without the other uses as preservatives in inoculants and biological amendments also considered. In these historic uses, the small amount used . . . the benefits in each situation of use, as well as the fate in the soil may result in a determination that this material is indeed compatible with sustainable agriculture for several uses. This reviewer would welcome the opportunity for a full review of uses of this material.

. . . If a new section of the TAP Review is prepared covering the alternatives to these materials for all uses in crop production such as preservatives in fish, kelp, microbial products and soil amendments, . . . these materials *[might]* have a compatible place in organic agriculture for several uses that may include seed treatments. As it stands, however, the petition is so incomplete as to make *[it impossible to determine that this use is compatible with a system of sustainable agriculture]*.

Reviewer 2 Conclusion

This material as presented should not be allowed for this particular use in organic systems. This is primarily because not enough reason to allow it was provided in the petition. Based on the TAP Review presented (with perhaps some further discussion of alternatives for those specific purposes), I would probably vote to the material to the National List for use as a preservative in biological and microbial soil amendments.

Reviewer 3 *[Ph.D. food science and nutrition, minor in biochemistry. Organic processing consultant, organic inspector, nutrition researcher. Western US]*

. . . [S]orbates are functionally fungistatic agents. At proper concentrations of 0.02-0.05%, they inhibit the growth of mold, yeast, and some aerobic bacteria in foods (Aurand, Wood, and Wells, 1989). *[They]* also can be applied and are used on wrappers for food products such as cheese and can be added to the dough or batter of baked products to sharply inhibit mold growth . . . *[and are]* widely used in the food industry (Meyer, 1978).

[Potassium sorbate appears to be used at concentrations of] 50 to 150 milligrams per 100 pounds of seeds. . . In other words, the concentration of anti-microbial is sufficient to inhibit microbial growth or vegetation of bacterial spores. In the soil . . . the concentration of anti-microbial *[hypothetically]* becomes further diluted especially in the presence of irrigation water, thereby diluting the anti-microbial concentration, rendering it much less effective in anti-microbial activity. . .

In the soil, . . . *[potassium]* sorbate . . . at . . . diluted levels become assimilated by soil microorganisms as a carbon source, with eventual metabolism by microorganisms to CO_2 under anaerobic soil conditions. One could also explain these hypotheses on the following: "The solution to the pollution is the dilution."

. . . *[B]*lueberries and perhaps other berries have been shown to be sources of sorbic acid. Please see article in reference entitled: "What are potassium sorbate and methyl paraben?" listed in the ingredients of Calorad®.

Environmental Contamination

Potassium sorbate has been shown to be extracted from blueberries on a commercial level (Nutrition Advisor.com). If the source of sorbic acid can be obtained from blueberries, then the negative environmental issues associated with the manufacture of the potassium salt of sorbic acid can be significantly reduced.

Effects on the Agroecosystem

Even though potassium sorbate is used for its anti-microbial activity directly on seed products at the level of 50 milligrams to 150 milligrams per 100 pounds of seeds as indicated in the petition, this amounts to 500 to 1500 micrograms per one pound of seeds. At this extremely low level of application, the risk of detrimental effects on natural soil microorganisms may be questionable since there is no data to support this issue. Extrapolation of anti-microbial activity from *in vitro* studies to field level must be reviewed with caution since there does not seem to be any comparative data.

Compatibility

The petition could be strengthened if the source of sorbic acid was a natural extract from blueberries or other agricultural commodities with intrinsically high levels of sorbic acid. This would mitigate both environmental and manufacturing concerns with regard to its overall compatibility with the basic premise of sustainable agriculture.

Reviewer 3 Conclusion

Due to the manufacturing operations required for the chemical synthesis of sorbic acid (i.e., from crotonaldehyde and ketene from fossil fuel sources) and the adverse environmental effects documented from their use, it is very hard to create an argument for the use of potassium sorbate not only as an anti-microbial seed treatment but for any organic product system. Therefore, approval of potassium sorbate as an anti-microbial seed treatment is not compatible with sustainable agricultural systems.

[End of TAP Reviewer Comments]

Conclusion

Given that potassium sorbate occurs in nature as the petition notes, there is no need to list this product. Because sorbic acid is naturally occurring, reviewers did not find a compelling reason to advise the NOSB to recommend adding the synthetic version to the National List for the petitioned use. While at least one reviewer noted that some additional crop uses might be compatible, this was not a consensus shared by the reviewers based on currently available information.

References

** = included in packet*

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Alexander, M. 1977. *Introduction to Soil Microbiology*. Malabar, FL: Krieger.

Ashford, R.D. 1994. *Ashford's Dictionary of Industrial Chemicals*. London: Wavelength Publishers, Ltd.

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