Summary of TAP Reviewers' Analyses[1]

6-Benzyladenine (BAP) is being petitioned for use as an apple fruit thinner in order to promote annual fruit production of biennial apple varieties and to improve size, color and overall quality of the fruit. The synthetic production of BAP is more efficient and cost-effective than isolating its natural counterpart, Cytokinin B, from plant sources. Manual thinning is currently the only acceptable method of fruit thinning for organic growers. However, manual fruit thinning is much more expensive than any type of chemical fruit thinning. Since BAP has been reclassified as a botanical pesticide by the U.S. EPA due to its similarity to natural plant growth regulators (cytokinins) and its non-toxic mode of action, the petitioner is requesting that BAP be included on the National List of synthetic substances allowed for use in organic crop production.

All three reviewers concluded that BAP, as petitioned, is a synthetic substance. Two of the reviewers recommended, without hesitation, that BAP should be included on the National List. The other reviewer recommended that BAP should not be permitted on the National List since there is no history of BAP use in organic crop production and since manual fruit thinning is an option. Even though manual thinning is substantially more expensive than chemical thinning, this reviewer stated that cost-effectiveness should not necessarily be a criterion of sustainable agriculture. This reviewer also noted that, in addition to BAP, other ingredients (Gibberellins A_4A_7 and "inert ingredients") are found in Promalin and Accel, the commercially-available plant growth regulators.

Synthetic or Non-synthetic?	***Allow without restrictions?***	***Allow only with restrictions? (See reviewers' comments for restrictions)***
Synthetic (3) **Non-synthetic (0)**	**Yes (2)** **No (1)**	**Yes (0)** **No (0)**

IDENTIFICATION

Chemical Name: 1H-Purin-6-amine, N-(phenylmethyl)-
CAS Registry Number: 1214-39-7

[1] *This Technical Advisory Panel (TAP) report was based upon the information available at the time this report was generated. This report addressed the requirements of the Organic Foods Production Act of 1990, as amended, to the best of the investigator's ability and was reviewed by experts on the petitioned substance. The substance was evaluated according to the criteria found in Section 2119 of the OFPA [7 U.S.C. 6518(m)(1-7)]. Any recommendation(s) presented to the National Organic Standards Board (NOSB) was based on the information contained within the TAP report and the evaluation of that information relative to these criteria. The TAP report does not incorporate commercial availability, socioeconomic impact, or other factors related to the petitioned substance, which NOSB and USDA may want to consider in their decision process.*

Other Names: Benzyladenine; 6-Benzyladenine; N-Benzyladenine; N-6-Benzyladenine; Benzylaminopurine; 6-(Benzylamino)purine; 6-(N-Benzylamino)purine; N(6)-Benzylaminopurine; N-Benzyl-9H-purine-6-amine; 9H-Purine, 6-[(phenylmethyl)amino]-; Adenine, N-benzyl-; Cytokinin B; BA; 6-BA; BAP; 6-BAP; Verdan Senescence Inhibitor

CHARACTERIZATION

Composition: White or buff powder
Properties:

Molecular Formula: $C_{12}H_{11}N_5$
Molecular Weight: 225.25
Melting Point: 233°C
Boiling Point: Not Applicable
Density: 1.4 g/cm^3
Water Solubility: 60 mg/L at 20°C

PRODUCTION

6-Benzyladenine (also referred to as BAP throughout this report) is the synthetic equivalent of Cytokinin B, a growth hormone produced by a wide variety of plants. Cytokinin B plays an important role in the promotion of cell division and development. It also delays the aging process, or senescence, of leaves. Synthesizing BAP in a controlled environment is much more efficient and cost-effective than attempting to isolate Cytokinin B from plant (usually seaweed) sources.

BAP, Gibberellins 4 (A_4), and Gibberellins 7 (A_7) are the active ingredients in Promalin and Accel, two commercially-available plant growth regulators. Like BAP, gibberellins are also plant growth regulators, but they are produced by the fermentation of a pure strain of the fungus *Gibberella fujikorai*. Both Promalin and Accel are formulated as soluble liquid concentrates containing 1.8% BAP w/w. They can be applied by using spray, brush-on, or sponge-on techniques. Although Promalin and Accel contain identical BAP concentrations, their gibberellins concentrations differ. Promalin contains 1.8% w/w gibberellins A_4A_7 while Accel contains 0.18% w/w gibberellins A_4A_7

HISTORY OF USE

Non-Organic Growers: BAP, available as the soluble liquid concentrates Promalin and Accel, has been used by non-organic growers in apple production for many years. BAP is commonly utilized to regulate fruit size through the practice of fruit thinning. This practice also improves the color and quality of the fruit. The improved air circulation that results from fruit thinning reduces problems caused by pests and diseases. For apple varieties with strong biennial fruit production tendencies, BAP promotes annual fruit production. It also enhances lateral bud break and lateral shoot growth, which leads to improved branching. [Faust, 1989] [Childers, 1995]

Organic Growers: No sanctioned methods for fruit thinning, other than manual thinning, currently exist for organic apple growers. [Miller, 2002]

CURRENT STATUS

U.S. Regulatory Agencies:

EPA: According to 40 CFR Part 180 (§ 180.1150), "[t]he plant growth regulator 6-benzyladenine is exempt from the requirement of a tolerance when used as a fruit-thinning agent at an application rate not to exceed 30 grams of active ingredient per acre in or on apples. 6-Benzyladenine is temporarily exempt from the requirement of a tolerance in or on apples at ≤182 grams of active ingredient per acre per season...when used in accordance with the Experimental Use Permit 73049-EUP-2. The temporary exemption from tolerance will expire on January 31, 2005." [USEPA, 2003]

FDA/CFSAN: FDA/CFSAN "...is charged with enforcing tolerances in imported foods and in domestic foods shipped in interstate commerce. FDA also acquires incidence/level data on particular commodity/pesticide combinations and carries out its market basket survey, the Total Diet Study." Results obtained from the 2001 Annual Report of the FDA Pesticide Residue Monitoring Program establish that BAP was not found by the analytical methods used during the regulatory monitoring in 2001. When a total of 233 samples of domestic apples were analyzed for pesticides in 2001, only 1 sample was found to test positive for residues with no established tolerance. The specific pesticide residues that tested positive were not named. For residues with established tolerances or action levels, no apple samples tested positive. [USFDA/CFSAN, 2003]

OSHA: "OSHA sets permissible exposure limits (PELs) to protect workers against the health effects of exposure to hazardous substances. PELs are regulatory limits on the amount or concentration of a substance in the air. They may also contain a skin designation. PELs are enforceable. OSHA PELs are based on an 8-hour time weighted average (TWA) exposure." OSHA has not established a PEL for BAP. [USDOL/OSHA, 2003]

Other U.S. Sources: Promalin and Accel are currently registered as plant growth regulator solutions in the New York State Pesticide Product, Ingredient, and Manufacture System (PIMS). [NYS PIMS, 2001] Promalin and Accel are also currently registered as plant growth regulator solutions with the California Department of Pesticide Regulation. [CDPR, 2001]

International Certifiers:

European Union: No maximum residue levels have been established for BAP on apples.

Japan: No maximum residue levels have been established for BAP on apples.

Codex: No maximum residue levels have been established for BAP on apples.

Canada: No maximum residue levels have been established for BAP on apples.

Mexico: No maximum residue levels have been established for BAP on apples. [USDA/FAS, 2003]

APPLICATION

BAP was first registered as a pesticide in the U.S. in 1979. In 1990, BAP was reclassified by the EPA as a botanical pesticide due to its similarity to natural plant growth regulators (cytokinins) and its non-toxic mode of action.

According to the manufacturer, the use rates for Promalin (1.8% w/w BAP) are as follows:

- On apple foliage for improved branching, apply 125-500 ppm of end-use product by spray or apply 5000-7500 ppm of end-use product as latex spot treatments.
- On non-bearing pear and cherry foliage for improved branching, apply 250-1000 ppm of end-use product by spray.
- On developing apple fruit for improved sizing, apply 25-50 ppm of end-use product as spray.

The use rates for Accel (1.8% w/w BAP) are as follows:

- On developing apple fruit to promote thinning, apply 25-50 ppm of end-use product as spray to small fruit (≤ 10 mm diameter).

The College of Agriculture and Life Sciences at North Carolina State University recommends (for North Carolina only) the application rate of 1 pint of Promalin (BAP) per 100 gallons "to improve shape and increase fruit weight of responsive cultivars of apples, such as Delicious, Gala, Fuji, or Pink Lady." [NCSU/CALS, 2004] However, application of BAP is influenced by a wide variety of factors, including the timing, quantity, and quality of the blooms; bee activity and pollen quality; apple variety; tree maturity and health; and numerous weather variables. Past thinning experiences and outcomes provide the best indicators of when and how much BAP should be applied to achieve the desired level of fruit thinning for each orchard block.

INCOMPATIBILITIES

BAP is incompatible with two other chemical fruit thinners, naphthaleneacetic acid (NAA) and naphthaleneacetamide (NAD), on the Red Delicious and Fuji apple varieties. If BAP and either NAA or NAD are applied to the same Red Delicious or Fuji trees within the same growing season, pygmy fruit may develop. [UMFA, 2003-04]

ORGANIC FOODS PRODUCTION ACT OF 1990 (OFPA), AS AMENDED

Section 6517 National List:

"(a) *In General.* The Secretary shall establish a National List of approved and prohibited substances that shall be included in the standards for organic production and handling established under this chapter in order for such products to be sold or labeled as organically produced under this chapter.

(b) *Content of List.* The list established under subsection (a) of this section shall contain an itemization, by specific use or application, of each synthetic substance permitted under subsection (c) (1) of this section or each natural substance prohibited under subsection (c) (2) of this section.

(c) *Guidelines for Prohibitions or Exemptions.*

(1) *Exemption for Prohibited Substances.* The National List may provide for the use of substances in an organic farming or handling operation that are otherwise prohibited under this chapter only if

(A) the Secretary determines, in consultation with the Secretary of Health and Human Services and the Administrator of the Environmental Protection Agency, that the use of such substances

(i) would not be harmful to human health or the environment;

(ii) is necessary to the production or handling of the agricultural product because of unavailability of wholly natural substitute products; and

(iii) is consistent with organic farming and handling;

(B) the substance

(i) is used in production and contains an active synthetic ingredient in the following categories: copper and sulfur compounds; toxins derived from bacteria; pheromones, soaps, horticultural oils, fish emulsions, treated seed, vitamins and minerals; livestock paraciticides and medicines and production aids including netting, tree wraps and seals, insect traps, sticky barriers, row covers, and equipment cleansers;

(ii) is used in production and contains synthetic inert ingredients that are not classified by the Administrator of the Environmental Protection Agency as inerts of toxicological concern; or

(iii) is used in handling and is non-synthetic but is not organically produced; and

(C) the specific exemption is developed using the procedures described in subsection (d) of this section."

Therefore, under Section 6517 National List of the OFPA of 1990, as amended, it must be determined if the use of BAP as an apple fruit thinner is consistent with subsection (c) (1) of this section. If so, then BAP should be allowed an exemption as a synthetic substance and be included on the National List.

SECTION 2119 OF THE OFPA [7 U.S.C. 6518 (m)(1-7)] CRITERIA

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

   With one exception, the compatibility of BAP with other substances used in organic farming and/or production has not been examined. Only the compatibility of BAP with *Bacillus thuringiensis* (Bt) has been studied. Bt is a naturally-occurring bacterium commonly found in soil. It is lethal to some insects, such as caterpillars that feed on leaves and needles, but does not harm beneficial insects. This property makes Bt a popular form of insect control in organic agriculture. Because Bt is also applied as a spray, it is often added to the spray tank along with BAP. No clumping or other problems have been observed in the spray tank when BAP and Bt are applied simultaneously.

2. ***What are the toxicity and mode of action of the substance and its breakdown products/contaminants and their persistence in the environment?***

   When BAP (as either Promalin or Accel) is applied at the recommended use rates and for the recommended two treatments, no accumulation of BAP is expected in the environment during the growing season. It is safe to apply BAP during bloom since it is nontoxic to foraging bees. Laboratory tests do indicate that BAP is slightly toxic to fish and aquatic invertebrates. However, no toxicity to avian or aquatic species has been observed when properly applied in the field.

   The analytical methods for the detection of BAP residues in raw apples and processed apple products was developed by the manufacturer of Promalin and Accel and submitted to the EPA as part of a pesticide petition (PP 2G6378) to expand an existing tolerance exemption. These analytical methods included extraction, cleanup on a strong cation exchange (SCX) solid-phase extraction cartridge, derivitization, and quantitation by gas chromatography (GC).

   The residue studies on raw apples were conducted in New York, Pennsylvania, Virginia, Missouri, Oregon, and Washington on a variety of apple cultivars. The maximum number (4) of BAP applications was applied with the final application averaging 80 days (2.5 months) prior to harvest. Residue levels on the harvested apples were very close to the limit of quantitation (LOQ) of 5 ppb for BAP. Rapid degradation of BAP residues were observed for all regions and apple

varieties. BAP residues in processed apple products did not increase relative to the levels found in the raw apples. These residue levels were below the LOQ. [USEPA, 2002]

3. What is the probability of environmental contamination during manufacture, use, misuse, or disposal of the substance?

The product labels on both Promalin and Accel state that the product should only be used "in accordance with its labeling and with the Worker Protection Standard, 40 CFR Part 170." In addition, the restricted entry interval (REI) after Promalin treatment is 4 hours unless workers use personal protective equipment (PPE) of coveralls, waterproof gloves, and shoes plus socks. The REI after Accel treatment is 12 hours unless workers use PPE of coveralls, waterproof gloves, shoes plus socks, and protective eyewear. The product labels also state that Promalin and Accel should be stored below 75^{o}F (24^{o}C), and the storage or disposal of these products should not be allowed to contaminate water, food, or feed. The resulting wastes from the normal usage of Promalin and Accel may be disposed of on site or at an approved waste disposal facility. Proper container disposal includes triple rinsing plus recycling or reconditioning, puncturing and disposing in a sanitary landfill, or incineration or burning. Burning the container is only permissible if allowed by state and local authorities. Workers must take precautions to stay out of the resulting smoke if the container is disposed of by burning.

4. What are the effects of the substance on human health?

BAP has a low acute toxicity and is considered relatively safe for humans as long as proper handling precautions are implemented. BAP is an eye, skin, and respiratory irritant, and handlers of BAP are instructed to wear proper attire and use adequate ventilation. However, BAP is not associated with any long-term occupational exposure hazards. BAP is also not considered either a carcinogen or a mutagen.

The toxicological profile of BAP was previously published by the EPA as part of the N6-Benzyladenine Reregistration Eligibility Decision (RED) document of June 1994. It included the results of BAP acute toxicity studies on several types of laboratory animals. "Toxicity Category III was assigned to the acute oral toxicity study in the rat (LD_{50} = 1.3 g/kg) and in the eye irritation study in the rabbit (moderate irritant). Toxicity Category IV was assigned to the acute dermal toxicity study in the rabbit (LD_{50} > 5 g/kg), in the acute inhalation toxicity study in the rat (LC_{50} = 5.2 mg/L), and in the dermal irritation study in the rabbit (slight irritant). BAP was not a dermal sensitizer in the dermal sensitization study in the guinea pig." [USEPA, 2003]

5. What are 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?

BAP was classified by the U.S. Environmental Protection Agency (EPA) as a biochemical pesticide in 1990. Therefore, no environmental fate studies are required for this substance. Soil metabolism studies show a 7-9 week half-life for BAP, and no adverse effects on soil organisms have been documented. BAP does not cause phytotoxicity to crops and has no adverse effects on livestock. BAP is slightly toxic to aquatic organisms and should not be used near bodies of water. BAP should not be applied to areas where surface water is present or to intertidal areas below the mean highwater mark. [USEPA, 2004]

6. What are the alternatives to using the substance, including other practices or available materials?

Since fruit thinning is necessary in apple production in order to ensure a reliable and marketable product, the thinning process can not be omitted by the grower. [McArtney, 2000] Two alternative methods to using BAP for apple fruit thinning include manual thinning and other types of chemical thinners.

Currently, manual thinning is the only acceptable fruit thinning method available to organic apple growers. However, this fruit thinning method is extremely costly due to its labor-intensive nature. Based on one acre of production for a 20 acre conventional (non-organic) apple farm, the total cost of fruit thinning is estimated to be about $464. This total covers the cost of the chemical thinner ($34) plus the cost of the labor to apply the thinner ($420). However, the total cost of fruit thinning for an organic apple farm of the same size is estimated to be about $1,680. Since no cost is incurred for the purchase of chemical thinner, only the cost of manual thinning needs to be estimated. [BCMAFF, 2002] These figures suggest that a considerable cost differential for fruit thinning exists between conventional and organic apple farms. This places the organic apple grower at a distinct competitive disadvantage relative to the conventional apple grower.

Another alternative to using BAP for apple fruit thinning includes the use of other chemical thinning sprays. Other commercially-available fruit thinners include carbaryl, naphthaleneacetic acid (NAA), and naphthaleneacetamide (NAD). Carbaryl, which is classified as moderately to very toxic, can produce adverse effects in humans by skin contact, inhalation, or ingestion. Carbaryl, sold commercially under the name Sevin, was introduced as an insecticide in 1958, and it was discovered to have thinning properties shortly thereafter. Sevin is a mildly-effective thinner at its full rate of application and has a limited dose-response at lower rates. Unfortunately, carbaryl is also highly toxic to beneficial honey bees. NAA is a reliable, but harsh, thinner. It can be phytotoxic to foliage when applied either during or immediately prior to very hot temperatures (≥

85°F). NAD is a milder formulation of NAA with a propensity to cause the development of pygmy fruit if applied too late in the bloom cycle.

Some experimental trials have been performed to find organic alternatives to conventional chemical fruit thinners, but these have produced mixed results. NC 99 (calcium/magnesium brine solution) and FOLS (fish oil + lime sulfur) were analyzed as organic thinning agents at several locations within the state of New York.

In Modena, NY (Ulster County/Eastern NY State), mature Delicious/M.7 trees were sprayed either once at 80% bloom (single application) or once at 20% bloom and again at 80% bloom (double application) with either NC 99 or FOLS at a rate of 120 gallons/acre. Some phytotoxicity (leaf damage) was observed with all types and frequency of organic thinning agent used, but was not significant enough to be a problem. All four thinning protocols appeared to reduce yield, but only the yield resulting from the single application of FOLS was significantly less than the yield of the untreated controls. Only the FOLS protocols (single and double applications) reduced fruit set compared with untreated controls. The fruit set reduction of the NC 99 protocols (single and double applications) was not significantly lower than the fruit set observed on untreated controls. All four thinning protocols increased fruit size, but the increase in fruit size was no different between the single and double applications of the respective thinning agents.

In Appleton, NY (Niagara County/Western NY State), mature McIntosh, Cortland, and Delicious trees were sprayed once with either NC 99, FOLS, or Ammonium Thiosulfate (ATS) at a rate of 100 gallons/acre. ATS is used as a conventional chemical thinner. McIntosh and Cortland tress were sprayed at 80-100% bloom while Delicious trees were sprayed at 50-80% bloom. None of the thinners resulted in phytotoxicity. Both NC 99 and FOLS caused a significant reduction in fruit set compared with untreated controls. No reduction in fruit yield was observed for either NC 99 or FOLS. However, NC 99 did result in a significant reduction in fruit size compared to controls. ATS treatment did not result in a reduction of fruit set, yield, or size. [DHOFGP, 2001]

A follow-up experimental trial was conducted one year later in Modena, NY (Ulster County/Eastern NY State) and Olcott, NY (Niagara County/Western NY State). In Modena, NY, mature Gala trees were sprayed either once at 80% bloom (80B) with NC 99, FOLS, or Wilthin (Monocarbamide Dihydrogensulfate), once at 20% bloom and again at 80% bloom (20B/80B) with NC 99 or FOLS, or once at petal fall and again at petal fall plus seven days (PF/PF+7) with FOLS. All treatments were applied at a rate of 150 gallons/acre. In Olcott, NY, mature Rome and Delicious trees were sprayed either once at 80% bloom (80B) with either NC 99, FOLS, or ATS, or once at petal fall and again at petal fall plus seven days (PF/PF+7) with FOLS. All treatments were applied at a rate of 100 gallons/acre.

In both New York locations, NC 99 and FOLS caused significant cropload reductions. Although NC 99 applied at 20B/80B and FOLS applied at 80B reduced fruit set, FOLS applied at PF/PF+7 resulted in the greatest fruit-set reduction. NC 99 applied at 20B/80B and FOLS applied at 80B, 20B/80B, and PF/PF+7 all reduced fruit yield. Applications of NC 99 and FOLS at 20B/80B also increased fruit size. Wilthin proved to be an ineffective bloom thinner, while the thinning results for ATS were not discussed. Unfortunately, NC 99 and FOLS applied at either 80B or 20B/80B resulted in leaf burning. FOLS applied at 20B/80B also slightly increased fruit russet, the undesirable formation of cork cambium caused by the cracking of the cuticle due to its failure to keep pace with the growth of internal tissues. [DHOFGP, 2002]

Some of the thinning results from NC 99 and FOLS are promising. However, the experimental trial authors noted that fish oil is both malodorous and relatively expensive. Because the effects of lime-sulfur sprays are cumulative, inadvertent over-treatment can result in reduced fruit yield and size. [NYSAES, 2004] It is also not known if NC 99 and FOLS contribute to consistent annual bloom cycles. Consequently, more studies are need before either NC 99 or FOLS can be recommended for use as organic alternatives to conventional chemical fruit thinners.

7. Is the substance compatible with a system of sustainable agriculture?

Sustainable agriculture is defined as the integration of environmental health, economic profitability, and social/economic equity.[2] Utilizing BAP as a fruit thinner in organic apple production appears to meet all three of the goals for sustainable agriculture. Organic farming is an area of agriculture that continues to expand both locally and internationally. [Garcia, 2003] As demand for organic commodities increases in the U.S. and in other countries, various methods will be explored to improve product quality and reliability while maintaining product integrity. If BAP is used according to EPA and manufacturers' guidelines, it does not appear to cause environmental harm. BAP would also allow organic apple growers to reduce production costs and more effectively compete with conventional apple growers. This, in turn, allows organic apple growers to provide a high quality product to an even greater number of local and international communities.

[2] University of California Sustainable Agriculture Research and Education Program. "What is Sustainable Agriculture?" 1997; http://www.sarep.ucdavis.edu/concept.htm.

REFERENCES

1. NIST Chemistry WebBook. "NIST Standard Reference Database Number 69." http://webbook.nist.gov/chemistry/.

2. Chengdu Newsun Biochemistry Company, Ltd. "Product List." http://www.plant-hormones.com/product-e17.htm.

3. Syracuse Research Corporation. "The Physical Properties Database (PHYSPROP)." http://esc.syrres.com/interkow/PhysProp.htm.

4. ChemIndustry.com. "Chemical Info." http://www.chemindustry.com/chemicals/index.asp.

5. Faust, M. Physiology of Temperate Zone Fruit Trees. John Wiley & Sons (Hoboken, NJ) 1989.

6. Childers, N. Modern Fruit Science: Orchard and Small Fruit Culture. Horticultural Publications (Gainesville, FL) 1995.

7. Miller, F. "Research Supports Organic Apple Production." *University of Arkansas Agricultural Communication Services* 2002; Life Science Column No. 63.

8. U.S. Environmental Protection Agency. "6-Benzyladenine: Temporary Exemption From the Requirement of a Tolerance." *Federal Register* 2003; 68:5835-9.

9. U.S. Food and Drug Administration's Center for Food Safety and Applied Nutrition. "Pesticides, Metals, Chemical Contaminants and Natural Toxins." *Annual Reports from FDA's Pesticide Residue Monitoring Program (1993-2001)* 2003; http://www.cfsan.fda.gov/~lrd/pestadd.html.

10. U.S. Department of Labor's Occupational Safety and Health Administration. "Permissible Exposure Limits (PELs)." *Table Z-1* 2003; http://www.osha.gov/SLTC/pel/index.html.

11. New York State Pesticide Product, Ingredient, and Manufacturer System (PIMS). "Benzyladenine (116901)." *NYS PIMS Current Products* 2001; http://pmep.cce.cornell.edu/pims/current/.

12. California Department of Pesticide Regulation. "Product-Specific Inquiries." *California Product/Label Database Queries and Lists* 2001; http://www.cdpr.ca.gov/docs/label/labelque.htm#regprods.

13. U.S. Department of Agriculture's Foreign Agricultural Service. "Food and Agricultural Import Regulations and Standards (FAIRS)." *Global Agriculture*

Information Network (GAIN) Reports 2003; http://www.fas.usda.gov/itp/ofsts/fairs_by_country.asp.

14. North Carolina State University's College of Agriculture and Life Sciences. "Plant Growth Regulators." *North Carolina Agricultural Chemicals Manual* 2004; Chapter IX.

15. University of Massachusetts Fruit Advisor. "Growth Regulator, Thinning, Calcium and Postharvest Treatments." *New England Apple Pest Management Guide* 2003-04; Part III:145-9.

16. U.S. Environmental Protection Agency. "Notice of Filing a Pesticide Petition to Establish a Tolerance for a Certain Pesticide Chemical in or on Food." *Federal Register* 2002; 67:14949-50.

17. U.S. Environmental Protection Agency. "Cytokinin, Kinetin, N^6-Benzyladenine (116801, 116802, 116901)." *Biopesticide Fact Sheets* 2004; http://www.epa.gov/pesticides/biopesticides/ingredients/factsheets/factsheet_116801.htm.

18. McArtney, S, Campbell, J, and Foote, K. "Thinning Options for Organic Apple Production." *The Orchardist* 2000; 10:32.

19. British Columbia Ministry of Agriculture, Food, and Fisheries. "Transition to Certified Organic Apple Production—Southern Interior 20 Acre Farm." *Planning for Profit* 2002.

20. Department of Horticulture Organic Farming Grants Program. "A Commercial Organic Apple Production System for New York." Toward Sustainability Foundation Progress Report 2001; http://www.organic.cornell.edu/research/tsfsumms/organicpdfs/4apples.pdf.

21. Department of Horticulture Organic Farming Grants Program. "A Commercial Organic Apple Production System for New York." Toward Sustainability Foundation Progress Report 2002; http://www.organic.cornell.edu/research/tsfsumms/2001/pdfs/1apple.pdf.

22. New York State Agricultural Experiment Station. "Organic Tree Fruit Production in New York State." *Pest Management Guidelines for Commercial Tree-Fruit Production* 2004; http://www.nysaes.cornell.edu/ent/treefruit/.

23. Garcia, M. "Economic Significance of Organic Fruit Production in New England, the US, and the World." *Proceedings of the 2003 New England Fruit School and Trade Show* 2003; Vol. 109.

REVIEWER 1

USDA Accredited Certifier, Midwest, USA

A. Comments on Database

Are we reviewing BAP or Promalin and Accel? From the TAP, "BAP, Gibberellins 4 (A_4), and Gibberellins 7 (A_7) are the active ingredients in Promalin and Accel, two commercially-available plant growth regulators."

B. OFPA Criterion Evaluation

1. *What is the potential of the substance for detrimental chemical interactions with other materials used in organic farming?*

   There is insufficient data to determine this. From the TAP, "With one exception, the compatibility of BAP with other substances used in organic farming and/or production has not been examined. Only the compatibility of BAP with *Bacillus thuringiensis* (Bt) has been studied. Bt is a naturally-occurring bacterium commonly found in soil. It is lethal to some insects, such as caterpillars that feed on leaves and needles, but does not harm beneficial insects. This property makes Bt a popular form of insect control in organic agriculture. Because Bt is also applied as a spray, it is often added to the spray tank along with BAP."

2. *What are the toxicity and mode of action of the substance and its breakdown products/contaminants and their persistence in the environment?*

   BAP does not appear to have toxic persistence or be a potential contaminant in the environment when used appropriately. From the TAP, "When BAP (as either Promalin or Accel) is applied at the recommended use rates and for the recommended two treatments, no accumulation of BAP is expected in the environment during the growing season. It is safe to apply BAP during bloom since it is nontoxic to foraging bees. Laboratory tests do indicate that BAP is slightly toxic to fish and aquatic invertebrates. However, no toxicity to avian or aquatic species has been observed when properly applied in the field."

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

   There is minimal possible environmental contamination if all goes well with manufacture, use and disposal.

4. *What are the effects of the substance on human health?*

When properly used and applied, BAP has little potential for negative effects on human health. However, the procedures used to minimize work exposure indicate that health hazards may exist. According to the Biopesticides and Pollution Prevention Division of the Office of Pesticide Programs, "N^6-Benzyladenine showed some maternal and developmental adverse effects when it was given to pregnant rats. To minimize exposure to workers who handle large amounts of N^6-benzyladenine, EPA requires that all such workers wear specified personal protective equipment (PPE)."

Also, from the TAP, "The product labels on both Promalin and Accel state that the product should only be used 'in accordance with its labeling and with the Worker Protection Standard, 40 CFR Part 170.' In addition, the restricted entry interval (REI) after Promalin treatment is 4 hours unless workers use personal protective equipment (PPE) of coveralls, waterproof gloves, and shoes plus socks. The REI after Accel treatment is 12 hours unless workers use PPE of coveralls, waterproof gloves, shoes plus socks, and protective eyewear. The product labels also state that Promalin and Accel should be stored below 75°F (24°C), and the storage or disposal of these products should not be allowed to contaminate water, food, or feed. The resulting wastes from the normal usage of Promalin and Accel may be disposed of on site or at an approved waste disposal facility. Proper container disposal includes triple rinsing plus recycling or reconditioning, puncturing and disposing in a sanitary landfill, or incineration or burning. Burning the container is only permissible if allowed by state and local authorities. Workers must take precautions to stay out of the resulting smoke if the container is disposed of by burning."

"BAP has a low acute toxicity and is considered relatively safe for humans as long as proper handling precautions are implemented. BAP is an eye, skin, and respiratory irritant, and handlers of BAP are instructed to wear proper attire and use adequate ventilation. However, BAP is not associated with any long-term occupational exposure hazards. BAP is also not considered either a carcinogen or a mutagen."

5. *What are 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?*

If properly used, there seems to be little potential for negative effects. From the TAP, "BAP was classified by the U.S. Environmental Protection Agency (EPA) as a biochemical pesticide in 1990. Therefore, no environmental fate studies are required for this substance. Soil metabolism studies show a 7-9 week half-life for BAP, and no adverse effects on soil organisms have been documented. BAP does not cause phytotoxicity to crops and has no adverse effects on livestock. BAP is slightly toxic to aquatic organisms and should not be used near bodies of water.

BAP should not be applied to areas where surface water is present or to intertidal areas below the mean highwater mark."

6. *What are the alternatives to using the substance, including other practices or available materials?*

   Alternatives do exist. From the TAP, "Two alternative methods to using BAP for apple fruit thinning include manual thinning and other types of chemical thinners."

   "Currently, manual thinning is the only acceptable fruit thinning method available to organic apple growers. However, this fruit thinning method is extremely costly due to its labor-intensive nature. Based on one acre of production for a 20 acre conventional (non-organic) apple farm, the total cost of fruit thinning is estimated to be about $464. This total covers the cost of the chemical thinner ($34) plus the cost of the labor to apply the thinner ($420). However, the total cost of fruit thinning for an organic apple farm of the same size is estimated to be about $1,680. Since no cost is incurred for the purchase of chemical thinner, only the cost of manual thinning needs to be estimated. These figures suggest that a considerable cost differential for fruit thinning exists between conventional and organic apple farms. This places the organic apple grower at a distinct competitive disadvantage relative to the conventional apple grower."

   "Some experimental trials have been performed to find organic alternatives to conventional chemical fruit thinners, but these have produced mixed results. NC 99 (calcium/magnesium brine solution) and FOLS (fish oil + lime sulfur) were analyzed as organic thinning agents at several locations within the state of New York."

7. *Is the substance compatible with a system of sustainable agriculture?*

   BAP is not compatible with sustainable agriculture. Natural alternatives exist and should be explored and researched. Additionally, part of sustainable agriculture is creating on-farm jobs and keeping farmers on the land. Switching to chemical solutions as an alternative to farmers working in the field is not an example of sustainability regardless of the economic profitability. From the TAP, "Sustainable agriculture is defined as the integration of environmental health, economic profitability, and social/economic equity. Utilizing BAP as a fruit thinner in organic apple production appears to meet all three of the goals for sustainable agriculture. Organic farming is an area of agriculture that continues to expand both locally and internationally. As demand for organic commodities increases in the U.S. and in other countries, various methods will be explored to improve product quality and reliability while maintaining product integrity. If BAP is used according to EPA and manufacturers' guidelines, it does not appear to cause environmental harm. BAP would also allow organic apple growers to reduce production costs and more effectively compete with conventional apple

growers. This, in turn, allows organic apple growers to provide a high quality product to an even greater number of local and international communities."

C. Conclusion--Summarize Why This Material Should Be Allowed or Prohibited for Use in Organic Systems

Seaweed and other plant sources seem to be available. Cost-effectiveness is not a criterion for consideration under the National List process. From the TAP, "Synthesizing BAP in a controlled environment is much more efficient and cost-effective than attempting to isolate Cytokinin B from plant (usually seaweed) sources."

Also, there has been no history of use of BAP in organic production. From the TAP, "No sanctioned methods for fruit thinning, other than manual thinning, currently exist for organic apple growers.

D. Recommendation Advised to the NOSB

6-Benzyladenine (BAP) is a synthetic. From the TAP, "6-Benzyladenine (also referred to as BAP throughout this report) is the synthetic equivalent of Cytokinin B, a growth hormone produced by a wide variety of plants."

Accel and Promalin are the products used that contain BAP. They also contain other materials not reviewed (*) or not disclosed (**) in this TAP.

Accel's Ingredients:
N-(phenylmethyl)-1H-purine-6-amine.....1.80% w/w
Gibberellins A_4A_7*.....0.18% w/w
Inert Ingredients**.....98.02% w/w

Promalin's Ingredients:
N-(phenylmethyl)-1H-purine-6-amine.....1.8% w/w
Gibberellins A_4A_7*.....1.8% w/w
Inert Ingredients**.....96.4% w/w

Source: Valent BioSciences Corporation
870 Technology Way, Suite 100
Libertyville, IL 60048

Gibberellins are not on the National List of allowed substances, and it is unclear whether they would be determined to be non-synthetic or synthetic. The inert ingredients in these products are not divulged. Therefore, even if NOSB should vote to allow BAP, this would not allow the products that contain it without disclosure, petition and/or a review of them as well.

REVIEWER 2

Ph.D., Research Associate Professor of Chemistry, Gulf Coast, USA

A. Comments on Database

This is a very complete summary of the available data, which is unfortunately a little sparse.

B. OFPA Criterion Evaluation

1. *What is the potential of the substance for detrimental chemical interactions with other materials used in organic farming?*

   There is no potential of the substance to have detrimental interactions with other materials used in organic farming. Only incompatibilities noted are with alternate thinners which are not used in organic farming. The chemistry of BAP is such that few detrimental interactions would be expected with any other substances.

2. *What are the toxicity and mode of action of the substance and its breakdown products/contaminants and their persistence in the environment?*

   The toxicity and mode of action of the substance and its breakdown products/contaminants are not harmful to the environment. BAP is very non-toxic. All breakdown products are also not expected to be toxic or harmful.

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

   There is no probability of environmental contamination during manufacture, use, misuse, or disposal of the substance. There is always a possibility, but the only real stage at which contamination could occur is during the synthesis. This is unlikely given the stringent testing and other procedures in place.

4. *What are the effects of the substance on human health?*

   There are no adverse effects on human health unless the substance is taken in huge excess. At this stage, everything has adverse effects.

5. *What are 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?*

There are no adverse effects of the substance on biological and chemical interactions in the agroecosystem other than the noted fact that it should not be used near bodies of water.

6. *What are the alternatives to using the substance, including other practices or available materials?*

   There are no alternatives to using the substance in terms of other practices or available materials other than the noted human thinning process, which is excessively expensive. All alternative substances are far less appropriate.

7. *Is the substance compatible with a system of sustainable agriculture?*

   The substance is absolutely compatible with a system of sustainable agriculture.

C. Conclusion--Summarize Why This Material Should Be Allowed or Prohibited for Use in Organic Systems

There are no noted negative factors associated with the use of BAP and many positives. It is a very innocuous substance.

D. Recommendation Advised to the NOSB

While BAP is a synthetic substance, its use is appropriate within the organic guidelines and should be allowed for the stated use of crop thinning.

REVIEWER 3

Ph.D., Assistant Professor of Chemistry, Gulf Coast, USA

A. Comments on Database

BAP, which is 6-Benzyladenine, is derived from a natural source, namely DNA, where it is one of the four compounds that make up the genetic code. Therefore, the breakdown products of BAP, primarily the natural base adenine, are evolutionarily not harmful to man or nature. BAP has been used to thin the abundance of fruit on fruit trees and is being investigated for this same application on so-called "organically grown" fruit trees. Its past use has been successful, which is a very strong argument in favor of continuing to use this agent, versus any new chemicals that have not been tested under actual conditions.

B. OFPA Criterion Evaluation

1. *What is the potential of the substance for detrimental chemical interactions with other materials used in organic farming?*

   BAP has been found compatible in conjunction with naturally occurring *Bacillus turengiensus* bacterium. The parent natural product compound, adenine, is compatible and part of all living organisms and should not pose any hazard. BAP is a modification of adenine, a purine base, which hydrogen-bonds to thymine in DNA. This is a minor bond and does not serve to increase any reactivity of adenine. Therefore, the modification does not have an adverse effect on any potential reactions with environmental conditions.

2. *What are the toxicity and mode of action of the substance and its breakdown products/contaminants and their persistence in the environment?*

   BAP is not toxic to the recommended environment due to its breakdown to natural products in the environment. There is not expected to be toxicity of its breakdown substances because adenine is biodegraded rapidly in any living organism without any harmful effects. Extensive studies on raw apples after four exposures showed BAP levels close to the limit of detection because degradation is rapid. This data is true for all regions and varieties of apples. Non-intended aquatic environments have exhibited slight toxicity to fish but not to birds.

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

   Environmental contamination by BAP should not be considered a risk since it will be sprayed into the environment. Moreover, it will only be applied in the targeted environment and biodegradation will not be a problem. Preventing the spread of

BAP to non-targeted environments should not be a problem. This same argument is valid for any potential problems of "misuse," which is interpreted to mean introduction into the environment. The breakdown products are either innocuous or have been previously used in perfumes and flavorings. All impurities are listed at very low levels. The manufacture of BAP must be carried out under supervision using safe procedures that are common to industry and do not contaminate the environment. Although there is heat applied to the reaction, there are no burned products to contend with.

4. *What are the effects of the substance on human health?*

   There are no severe adverse effects on human health. BAP is not considered either a carcinogen or a mutagen, so there are no long-term health problems. Minor irritations associated with BAP are not a problem if handled as instructed.

5. *What are 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?*

   There are not anticipated to be adverse effects on the agroecosystem. Since BAP is designated by the EPA as part of the N6-Benzyladenine Reregistration profile document of June 1994, no environmental fate studies are required. BAP does not cause phytotoxicity to crops, has no effect on livestock, and is not fated to be used near aquatic systems.

6. *What are the alternatives to using the substance, including other practices or available materials?*

   One of the main alternatives to BAP for thinning fruit orchards is manual thinning, i.e. a human being must cut away excess fruit. Estimation of the cost difference between BAP spraying and manual thinning has quoted a four-fold increase in the cost by manual thinning. Another problem with manual methods is the physical damage that will be incurred by excess human trampling of roots and vegetation, incorrect pruning methods, and hazards (such as falling) to persons performing the pruning process.

   Other commercially-available chemical fruit thinners are napthaleneacetic acid (NAA) and napthaleneacetamide (NAD). NAA can be phytotoxic to plants at temperatures above 85°F, and thus should not be used in fruit orchards exposed to the sun. NAD is associated with the problem of stunted growth of fruit, which invalidates its original use to aid crop growth. Natural substances for crop thinning include a mixture of fish oil and sulfur, which is noxious to humans in close proximity. Water with salts of calcium and magnesium have been investigated but deemed ineffective.

7. Is the substance compatible with a system of sustainable agriculture?

BAP is the best candidate for sustainable agriculture, primarily due to the lack of long-term effects. There also appears to be no accumulation with sustained use. This is in keeping with the "organic growers" philosophy. The cost savings versus manual thinning more than cover the costs of BAP production. Therefore, this method will be preferred in any economic situation.

C. Conclusion--Summarize Why This Material Should Be Allowed or Prohibited for Use in Organic Systems

BAP is the most suitable compound of any available for use as a crop thinner that can be sprayed onto target areas effectively. Moreover, BAP does not present any threat for maintaining a healthy environment and has no long-term effects on humans.

D. Recommendation Advised to the NOSB

BAP is synthetic and should be allowed for use in organic fruit thinning.