MATERIAL FACT SHEET

BACILLUS THURINGIENSIS

MATERIAL NAME: *Bacillus thuringiensis* (Bt)

MATERIAL TYPE: Microbial-derived

U.S. EPA TOXICITY: Category: III, "Caution"

USDA-NOP: considered nonsynthetic, allowed. Preventive, cultural, mechanical and physical methods must be first choice for pest control, and conditions for use of a biological material must be documented in the organic system plan (7CFR 205.206(e).

MATERIAL DESCRIPTION: The active ingredients in *Bt* products are proteins produced by *Bacillus thuringiensis* bacteria. Some activity also occurs from the spores.

Bt is a member of the genus *Bacillus*, a diverse group of spore forming bacteria that consists of more than 20 species. The species *B. thuringiensis* is common in terrestrial habitats, including soil, dead insects, granaries and on plants (AAM 2002). *Bt* has many subspecies that possess a variety of crystalline proteins with distinct insecticidal properties. Some subspecies work only against Lepidoptera (caterpillars), while others work against only Coleoptera (beetles) or the larvae of flies and mosquitoes (Diptera). It is important to match the subspecies of *Bt* with the insect type (Siegel 2000).

The products allowed for certified organic production typically contain derivatives of bacterial cultures that include the protein active ingredient (endotoxin), spores, plus adjuvants such as wetting agents.

HOW IT WORKS: Unlike many insecticides, *Bt* must be eaten by a susceptible insect in order to be effective. The microorganism produces both spores (resting stage) and a crystalline protein (an endotoxin). When eaten by the insect, this endotoxin becomes activated and binds to the insect gut creating a pore through which gut contents can enter the insect's body cavity and bloodstream. The insect ceases to feed and dies within a few days.

APPLICATION GUIDELINES:
There are dozens of *Bt* proteins, some of which are toxic to particular types of insects. Generally, the following guidelines can be used for commercial products:

Bt kustaki: caterpillars
Bt aizawai: caterpillars
Bt tenebrionis (also called *Bt san diego*): beetle larvae
Bt israelensis: fly larvae (including fungus gnats, blackflies, and mosquitoes)

Not all species of caterpillars, beetles or flies are susceptible to the subspecies of *Bt* listed above (see efficacy section). The most important factor is using the right subspecies of *Bt* for the insect you wish to manage.

Because *Bt* must be eaten by the insect to be effective, it is very important to apply the spray to the parts of the plant where and when the insect is feeding. Many insects feed on the undersides of leaves and in concealed parts of the plant, so thorough coverage is required.

As with most insecticides, young larvae are generally more susceptible than older larvae so treatments should be timed accordingly. Early detection and application are crucial for good control.

The spray deposit may only last a few days before it is broken down by sunlight. Additional ingredients such as stickers that promote adherence to leaf surfaces and UV light inhibitors that protect *Bt* from photo degradation may enhance efficacy.

As with any natural or synthetic insecticide, insect populations can develop resistance to *Bt*, such has already occurred with some populations of Colorado potato beetle and diamondback moth (Tabashnik et al. 2003). In order to avoid development of resistance, only apply *Bt* when needed and use as part of an overall integrated pest management program that includes cultural and biological controls. If sprays are needed frequently, it is best to spray a single generation of the insects and then use another material or tactic for the next generation. This lessens the selection for resistance.

REENTRY INTERVAL (REI) AND PRE-HARVEST INTERVAL (PHI): 4 hrs (12 hours for *Bt tenebrionis*). Exempt from tolerance on all raw commodities.

AVAILABILITY AND SOURCES: There are currently over 100 *Bt* microbial insecticides registered in the US, but these are based on only 4 subspecies of *Bt*. *Bt* products are readily available in stores that sell agricultural products. Since not all *Bt* products are allowed for certified organic production because of prohibited inert ingredients or genetically engineered active ingredients, ***be sure to check with your certifier before use.***

Bt products vary in their origin and manufacturing process. There are four major types of manufacturing:

APPROVED TYPES

The first *Bt* products, including many still available today, were made from naturally occurring wild type species of *Bt* (e.g. DiPel®, Javelin®, and XenTari®). Newer strains of *Bts* have been created through a process called conjugation or transconjugation. This phenomenon is known to occur in nature and is analogous to hybridization in higher organisms. Two or more subspecies of *Bt* are mixed together in a way that facilitates the formation of new strains from which individuals with desirable qualities from both parents may be selected. This method is permissible under the NOP definition of "excluded methods" (genetic engineering). Products that fall under this category include Condor® and Cutlass® (although these formulations are not OMRI listed).

PROHIBITED TYPES

Some products derived from wild types employ an encapsulated delivery system (Mattch®, MVP II®) that uses genetic engineering and is therefore prohibited by the NOP definition of "excluded methods." The intention of this encapsulation is to protect the *Bt* toxin from rapid environmental breakdown. In these products, a *Pseudomonas* species of bacteria is genetically modified to produce the *Bt* toxin. The *Pseudomonas* cells, which are carrying the *Bt* toxins, are then killed by ultraviolet light. This method is prohibited for organic production.

The newest form of *Bt* manufacturing is through recombinant DNA (rDNA) techniques where specific genes linked to the expression (production) of crystalline protein toxins are inserted into bacterial cells. Novel combinations of toxins are the result of this process. This method of *Bt* manufacturing is not acceptable in organic production systems.

Products formulated with prohibited solvents or other EPA List 3 inert ingredients are not allowed for organic production. For instance, at the date of this publication, there are no OMRI approved *Bt tenebrionis* based products available for the management of Colorado potato beetle.

In addition to manufactured products, *Bt* genes for the expression of crystalline protein have also been inserted directly into crops by rDNA techniques. *Bt* corn and cotton are grown widely in the US, China, Australia, India and to a lesser extent in about a dozen other countries. Such genetically engineered crops are not permitted in organic production systems.

OMRI LISTED PRODUCTS:

Bacillus thuringiensis subsp. *aizawai*

- Able (Certis USA)
- Agree WG (Green Line) (Certis USA)
- XenTari DF (Valent BioSciences Corp) - wild type
- XenTari WDG (Valent BioSciences Corp) - wild type

Bacillus thuringiensis subsp. *kurstaki*
Deliver (Green Line) (Certis USA)
Biobit HP (Valent BioSciences Corp)
Britz Bt Dust (Britz Fertilizers Inc)
DiPel 2X (Valent BioSciences Corp) - wild type
DiPel DF (Valent BioSciences Corp) - wild type
Javelin WG (Green Line) (Certis USA) - wild type
Bacillus thuringiensis subsp. *israelensis*
Gnatrol WDG (Valent BioSciences Corp)
VectoBac WDG (Valent BioSciences Corp)

GENETICALLY MODIFIED PRODUCTS (EXCLUDED FROM ORGANIC USE):

Mattch, M-Trak (cancelled), MVP II – Encapsulated delivery

EFFECTS ON THE ENVIRONMENT:

Wildlife: As part of the testing procedures for registration, *Bt* products were fed to birds and fish and the results have indicated no adverse effects.

Natural enemies: Parasites and predators, important natural enemies of many insect pests, are generally not harmed directly by sprays or deposits of *Bt*. However, the loss of hosts may indirectly impact natural enemy populations.

Other non-targets: Other susceptible hosts that are not the target of the spray may also be killed. These may include rare moths and butterflies in certain sensitive habitats, but impact is likely to be minimal with carefully targeted applications.

For a more detailed summary of environmental studies of *Bt*, see Siegel (2000).

EFFECTS ON HUMAN HEALTH:

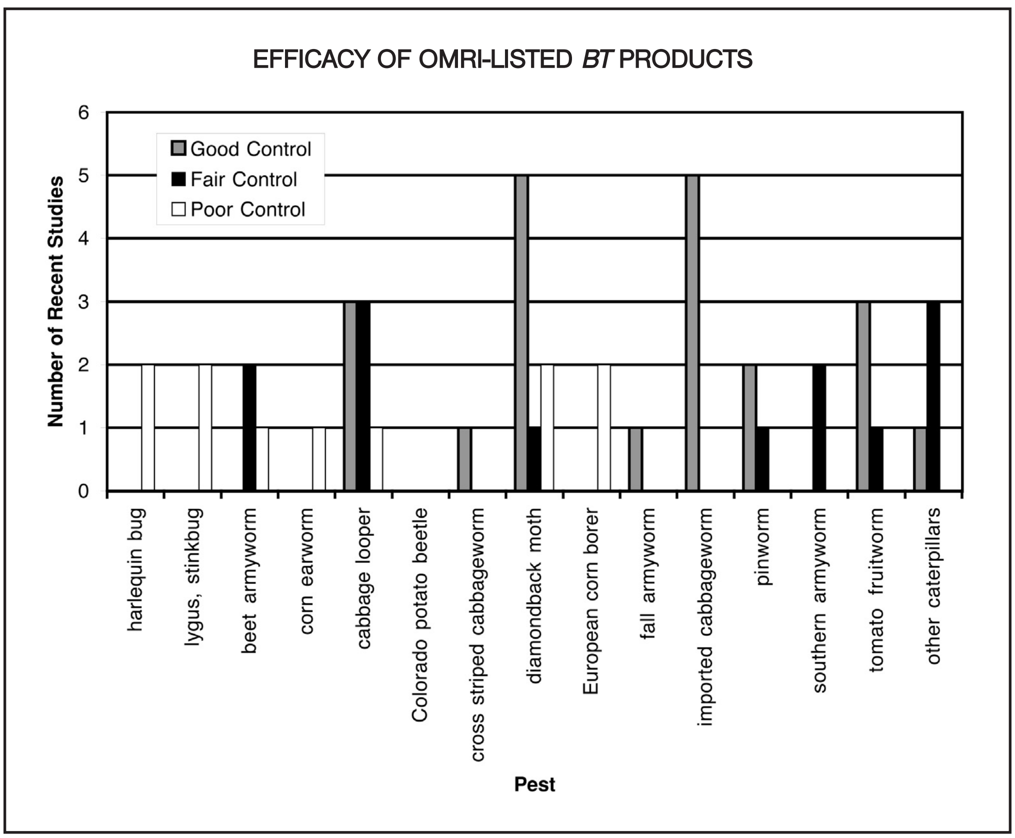
Because an insect's gut structure and physiology is vastly different from that of humans, Bt does not have the same effect on the human gut. The rapid break down by solar radiation results in little or no residues on crops. There have been very isolated reports of Bt being found in human tissues, but these appear to be secondary infections. Caution should be exercised in protecting eyes and open wounds when spraying Bt. A very small percentage of the human population is susceptible to allergic responses from exposure to Bt in relatively high doses (Bernstein et al. 1999).

VEGETABLE EFFICACY TRIALS SUMMARY:

OMRI-approved *Bt* products have very similar efficacy results to the entire array of *Bt* products, except that currently there are no approved formulations effective against Colorado potato beetle. Approved *Bt* products are generally effective against most lepidopteran species affecting brassicas and tomatoes. They can also be effective against the European corn borer on corn but, because it is difficult to deliver the product to the site of feeding they have not been as effective against corn earworm caterpillars. However, recent trials with the "Zea-later", which is a hand-held device that squirts a measured amount of material into the silk channel, have proved very promising (Hazzard and Westgate 2004). *Bt* formulations for caterpillar pests have little effect on other types of insects such as beetles or aphids. While no recent studies tested *Bts* against European corn borer on peppers, properly timed applications of *Bt* products could be effective in this situation. Approved products with either *Bt aizawai* or *Bt kurstaki* strains have performed similarly against caterpillars in recent studies.

A database of recent university trials of *Bt* products was compiled for this fact sheet. These university-based trials typically test products with untreated buffer rows and other conditions that create unusually severe pest pressure. The level of pest control is likely to be higher on fields in which a good program of cultural controls has been implemented.

In the table below, "good control" means statistically significant reductions in pest numbers or damage of 75% or more, compared to an untreated control. "Fair control" includes those with significant reductions of 50-74%, and any non-significant reductions of over 50%. The "poor control" group includes any results with less than 50% reduction.



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