ChemicalWatch Factsheet
A Beyond Pesticides/ NCAMP Factsheet

Bacillus Thuringiensis

Various strains of the biological pest control agent Bacillus thuringiensis variety berliner (B.t.) have come to be widely incorporated into rural and urban integrated pest management plans both in the U.S. and abroad. Since the commercialization of B.t. around 1970, nearly 400 registered products have been marketed in this country by 94 different firms, providing effective control of such major insect pests as gypsy moths, mosquitoes and blackflies, and many others. B.t. products are now registered and sold worldwide in more than 40 countries.

chemicalWATCH Stats:

Chemical Class: Soil bacterium insecticide
Use: Agriculture, Mosquitoes
Toxicity Rating: Least-Toxic
Signal Words: Caution
Health Effects: None noted.
Environmental Effects: Toxic to Bees.
Other: Genetically engineered into corn and cotton, leading to concern about overuse and resistance.

While EPA considers B.t. to be among the safer pesticides, and finds the toxicological database essentially complete, the Agency is still requiring additional data on ecological effects to fulfill numerous data gaps. B.t. is a naturally-occurring soil bacterium, it is a gram-positive, spore-forming rod, and an insect pathogen. Different strains are toxic to particular kinds of insects.

All of the three commercially important strains produce a crystalline glycoprotein, called the "delta-endotoxin." Strain kurstaki (B.t.k.) is effective against lepidopteran insects, moths and butterflies, like gypsy moths and cabbage loopers. Strain israelensis (B.t.i.) is effective against mosquitoes, blackflies and certain midges. Strain aizawai (B.t.a.) is effective against the wax moth, a plague to beekeepers. More strains are being isolated all the time. The latest isolate is strain san diego, which produces a unique toxin of great potency against certain species of beetle (elm bark, Colorado potato) and even the boll weevil.

These B.t. strains are only effective against insects in their larval feeding stages, since B.t. must be ingested to be effective; B.t. is completely ineffective against adult insects. Thus, a critical component of any successful application is monitoring to ensure that the insect population is at its most susceptible stage for B.t. application.

Delta-endotoxin originates within the outer membrane of the bacterium during spore development, and is activated both by alkaline (basic) pHs, such as are found in the guts of caterpillars, and larval proteolytic enzymes. Once the endotoxin is fully activated, it dissolves the larval gut wall allowing B.t. spores to pass freely into the larval body cavity. The spores then germinate, as B.t. reproduces vegetatively, further weakening any remaining insects by causing septicemia (blood-poisoning). Depending on how much B.t. is ingested, insect larva soon stop feeding and damaging host plants, and are dead in a few days to a few weeks.

A major producer of B.t.k. says that, under normal conditions, their product is effective for 3-7 days after application, and may be effective for as long as 22 days, depending on conditions. B.t. is completely biodegradable, and does not persist in the digestive systems of birds or mammals. There is no evidence that B.t. goes on to reproduce in the wild, since competitive pressure from the existing and highly varied microbial population makes this unlikely.

B.t. strains have been extensively tested for infectivity in mammals, and do not persist in the digestive tracts of animals that ingest B.t. Massive infections of up to 6.7 X 10^{11} spores/animal were also without toxic effect. However, as is true of most chemical pesticides, B.t. formulations can contain anywhere from 0-99+% "inert" ingredients, the identity of which is trade secret and thus need not be disclosed on the label. A major B.t.k. manufacturer says that the principal inert ingredients in their product are fermentation by-products, but others (wetting agents, surfactants) may be present as well. Manufacturers often recommend that a "sticker /spreader" be added to B.t. products to be used under conditions of heavy dew or rain. It is unclear how much of the observed toxicity, including skin sensitization in animals and eye irritation in animals and people, can be ascribed to these "inert" ingredients.

B.t.'s short biological half-life and high specificity makes the development of field resistance much more unlikely than with chemical pesticides. However, W.H. McGaughey of the U.S. Department of Agriculture has reported resistance occurring in populations of the Indian meal moth, a pest of stored grain, collected from B.t.-treated storage bins. Resistance in the out-of-door environment, where the toxin is subject to the usual environmental stresses, (sun, rain, etc.), has yet to be reported.

EPA's major area of concern focuses on what they consider to be serious data-gaps in the area of ecological effects, particularly with B.t.i., which is used against mosquitoes and blackflies primarily in aquatic environments. EPA is also concerned that B.t.k. can kill endangered species of butterflies along with lepidopteran pests. The Agency reports that high concentrations of B.t.k. spores can be toxic to bees and earthworms, and possibly also to brine shrimp and mussels, though EPA feels this evidence is as yet inconclusive.

Some strains of B.t. can produce another protein called beta-exotoxin (thuringiensin), which is toxic to many insects and to non-insect forms of life, for instance, coho salmon. Beta-exotoxin is released from the bacterium, and is not part of the cell membrane. No B.t. strains producing beta-exotoxin are registered for use in this country, and indeed, a major manufacturer claims that all B.t. strains are assayed lot-by-lot to assure that none contain it.

EPA has been critical of an apparent lack of standardization in the measurement of B.t. product potency, as reflected on B.t. product ingredient statements. Currently, the percentage active ingredient statement on the label cannot be assumed to correspond with potency in all products marketed.

EPA has reviewed the available testing data, accumulated since the first U.S. registration in 1961, in a September, 1986 Registration Standard. The Agency concludes that the various strains of B.t. products are exempted from residue "tolerance" requirements for use on any food crops, and has issued no restrictions for use around bodies of water.

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Text reprinted from Pesticides and You, Volume 8, Number 2. June 1988

Update, *March 2007*:

In 2003, EPA announced that it had approved the use of "YieldGard Rootworm corn," what the agency calls a Bacillus thuringiensis (Bt) plant-incorporated protectant (PIP) to control corn rootworm. "Plant-incorporated protectant" is basically an EPA-euphemism for a genetically engineered plant. The new corn pest control, referred to as "MON 863" and developed by Monsanto, produces its own insecticide, derived from B.t., within the corn. The B.t. protein, called Cry3Bb1, controls corn rootworm, a highly destructive pest that thrives in the large monoculture fields associated with conventional chemical-intensive agriculture.

Organic farmers, who rely on B.t. as a means of controlling pests, are concerned that the over-use of B.t., which is inevitable when Bt is genetically engineered into every cell of a plant, will lead to insect resistance and leave many farmers without an important tool of organic agriculture. Previously, in 2001, Beyond Pesticides wrote comments to EPA saying that B.t. should not be incorporated into plants until issues of resistance, efficacy, cross-contamination and other adverse effects had been thoroughly studied. The comments are available online at www.beyondpesticides.org/watchdog/comments.