AN OVERVIEW OF *BACILLUS THURINGIENSIS* BIOPESTICIDES

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The leading biological insecticide is based on the common soil bacterium *Bacillus thuringiensis* (Bt). Formulations of these insecticides, containing mixtures of spores and crystals safely control insect pests of vegetables, forestry and vectors of human disease. Despite its high target specificity and environmentally favorable "green" characteristics, the Bt insecticide market commands a small fraction of the global crop protection market.

Between 1980 and the early 1990s there was an extended effort to improve Bt biopesticides. Part of this effort was directed at strain and cry gene isolation yielding over 250 distinct Cry proteins (http://www.biols.susx.ac.uk/home/Neil_Crickmore/Bt/toxins.html). Usually Cry proteins display a narrow spectrum of insecticidal activity against one or more genera in the orders Coleoptera (beetles and weevils), Diptera (flies and mosquitoes), Hymenoptera (wasps and bees), and most importantly Lepidoptera (butterflies and moths), including most of the insect pests of agricultural importance. Some Cry proteins are active against nematodes.

In the early 1990s, a novel encapsulated Cry protein insecticide and recombinant Bt strains and introduced to the U.S. market. Mycogen's MVP product was the first recombinant Bt-based biopesticide to be registered by the U.S. EPA. Ecogen commercialized several recombinant Bt biopesticides. There were also efforts to develop a Bt for control of grass grubs. However, there has been a lack of interest in further developments in the sprayable biopesticide area. The efficacy and economic returns from Bt corn and cotton have restricted the use of novel *cry* genes to transgenic plant applications.

Features of Bt biopesticides limit their use in insect control. In contrast to contact insecticides, Bt insecticides must be ingested by the target insect. The timing of Bt sprays is critical to attaining economic levels of insect control. Usually Bt is applied when early instar larvae are present, as older larvae are more tolerant. Bt sprays persist only a few days on the leaf surface. The chemistry of the leaf surface, proteinases and sunlight contribute to the degradation of Cry proteins. It is rare for a Bt insecticide to have greater efficacy than the best available chemical control. Hence, Bt adoption suffers at the hand of more efficacious chemical insecticides.

Bt biopesticides have inherent advantages in certain pest control applications. They are used as a resistance management tools in insect control. Due to their distinct mode-of-action, they are alternated or combined with chemical pesticides. Bt is especially suited for specialty or 'high value crops.' The tightening of registration procedures for new chemical pesticides has led many of the larger crop protection companies to take the decision not to register products for use on specialty crops. Increased usage of Bt biopesticides will occur as organic markets expand and consumer demand for ecofriendly pest control alternatives in home gardens and treatments for high-value alternative crops.