Pocket K

No. 6

Bt INSECT RESISTANCE TECHNOLOGY

GLOBAL KNOWLEDGE CENTER ON CROP BIOTECHNOLOGY

Have you ever seen a leaf eaten off by plant pests? What about an entire harvest destroyed by insects? Plant pests cause a lot of problems to farmers and home gardeners alike. Because of this, they have had very little recourse other than to continually spray their plants with pesticides. Unfortunately, some of these pesticides pose health risks to people who are exposed to them.

It is for this reason that scientists are constantly looking for alternative ways of dealing with plant pests. ❑

The *Bt* Organism

Bt stands for *Bacillus thuringiensis* (*Bt*) a common soil bacterium so called because it was first isolated in the Thuringia region of Germany.

Bt produces a protein that paralyzes the larvae of some harmful insects, including the cotton bollworm and the Asian and European corn borers, all of which are

Cotton Bollworm

common plant pests whose infestations produce devastating effects on important crops. ❑

Mode of Action

When ingested by the larva of the target insect, the Bt protein is activated in the gut's alkaline condition and punctures the mid-gut leaving the insect unable to eat. The insect dies within a few days.

It is because of its ability to produce the insecticidal protein that much research is being done to exploit the organism's agronomic value. To date, there are more than 200 types of *Bt* proteins identified with varying degrees of toxicity to some insects. ❑

Earlier *Bt* Technology

Bt is easily cultured by fermentation. Thus, over the last 40 years, *Bt* has been used as an insecticide by farmers worldwide. Organic farming in particular has benefited from *Bt* insecticide, as it is one of the very few pesticides permitted by organic standards. The insecticide is applied either as a spray, or as ground applications. It comes in both granules and liquefied form.

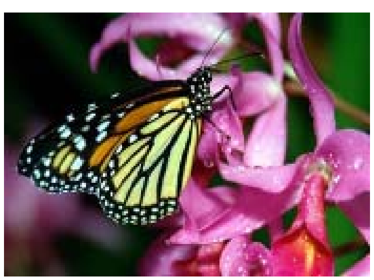
The efficiency of both applications is quite limited, as target organisms often do not come in contact with the insecticide as they are found on the underside of leaves or have already penetrated into the plant. Scientists are working to overcome this problem through the use of modern biotechnology. ❑

Modern *Bt* Technology

Scientists have taken the *Bt* gene responsible for the production of the insecticidal protein from the bacterium and incorporated it into the genome of plants. Thus, these plants have a built-in mechanism of protection against targeted pests. The protein produced by the plants does not get washed away, nor is it destroyed by sunlight. The plant is thus protected from the bollworm or the corn borer round the clock regardless of the situation. ❑

Conclusion

Bt crops are an addition to our arsenal against plant pests. With an increasing population and decreasing arable land, it is necessary to exploit all options with as little compromise to produce more crops. When used side by side with proper agricultural practices, Bt insect resistance technology can bring many benefits to crops, farmers, and consumers alike. ❑



REFERENCES

1. **James, C.** 2005. *Global Status of Commercialized Biotech/GM Crops: 2005. ISAAA Briefs No. 34. Ithaca, NY.*
2. **Donegan, K.K., C.J. Palm, V.J. Fieland, L.A. Porteous, L.M. Ganio, D.L. Schaller, L.Q. Bucao, and R.J. Seidler.** 1995. *Changes in levels, species and DNA fingerprints of soil microorganisms associated with cotton expressing the Bacillus thuringiensis var. kurstaki endotoxin.* Applied Soil Ecology 2:111-124.
3. **Donegan, K.K., D.L. Schaller, J.K. Stone, L.M. Ganio, G. Reed, P.B. Hamm, and R.J. Seidler.** 1996. *Microbial populations, fungal species diversity and plant pathogen levels in field plots of potato plants expressing the Bacillus thuringiensis var. tenebrionis endotoxin.* Transgenic Research 5:25-35.
4. **The Council for Biotechnology Information.** 2001. *Bt Protein in Soil.* http://www.whybiotech.com/pdf/Bt_Protein_in_Soil.pdf
5. **Environmental Protection Agency.** 1999. *EPA and USDA position paper on insect resistance management in Bt crops.* http://www.epa.gov/pesticides/biopesticides/otherdocs/bt_position_paper_618.htm
6. **Extension Toxicology Network.** 1996. *Pesticide Information Profile, Bacillus thuringiensis.*
7. **Monarch butterfly studies.** http://www.pnas.org/papbyrecent.shtml

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INTERNATIONAL SERVICE FOR THE ACQUISITION OF AGRI-BIOTECH APPLICATIONS

Safety Aspects of *Bt* Technology

Effects on Human Health


ISAAA PHOTO

So how safe is the *Bt* protein to non-target organisms? The specificity of *Bt* for its target insects is one of the characteristics that make it an ideal method of biological pest control. In fact, different strains of *Bt* have specific toxicity to certain target insects. The specificity rests on the fact that the toxicity of the *Bt* protein is receptor-mediated. This means that for an insect to be affected by the *Bt* protein, it must have specific receptor sites in its gut where the proteins can bind. Fortunately, humans and majority of beneficial insects do not have these receptors.

Before Bt crops are placed on the market, they must pass very stringent regulatory tests, including those for toxicity and allergenicity.

The U.S. Environmental Protection Agency (US-EPA) has already administered toxicology assessments, and *Bt* proteins have already been tested even at relatively higher dosages. According to the Extension Toxicology Network (Extoxnet), a pesticide information project of several universities in the US, "no complaints were made after 18 humans ate one gram of commercial *Bt* preparation daily for five days, on alternate days...Humans who ate one gram per day for three consecutive days were not poisoned or infected." Furthermore, the protein was shown to be degraded rapidly by human gastric fluid *in vitro* (Extoxnet, 1996).

Effects on the Environment

Soil ecosystems and groundwater

The *Bt* protein is moderately persistent in soil and is classified as immobile, as it does not move, or leach, with groundwater. It does not particularly persist in acidic soil conditions and, when exposed to sunlight, is rapidly destroyed due to UV radiation.

Independent experts have conducted studies to investigate the impact of *Bt* crops on soil organisms and other insect species that are considered beneficial in agriculture. No adverse effects have been found on non-target soil organisms, even when these organisms were exposed to quantities of *Bt* far higher than what would actually occur under natural crop-growing conditions. Likewise, research done by the US-EPA revealed no changes in the soil microbiota in fields with *Bt* plant material or conventional plant material (Donegan, et al., 1995), or between fields of *Bt* and non-*Bt crops* (Donegan, et al., 1996).

Animals and insects

On tests conducted on dogs, guinea pigs, rats, fish, frogs, salamanders, and even birds, the *Bt* protein was found not to have any harmful effects. It is also noteworthy that no toxic effects were found on beneficial or predator insects, such as honeybees and lady beetles. (Extoxnet, 1996).

In 1999, it was reported that pollen from *Bt* corn had a negative impact on Monarch butterfly larvae. This report raised concerns and questions about the risks of *Bt crops* on non-target organisms. Recent studies, however, show that *Bt* corn poses "negligible" threat to Monarch butterflies in the field. A collaborative research effort by scientists in the US and in Canada has produced information to develop a formal risk assessment of the impact of *Bt* corn on Monarch butterfly populations. They concluded that in most commercial hybrids, *Bt* expression in pollen is low, and laboratory and field studies show no acute toxic effects at any pollen density that would be encountered in the field. ❑


OSCAR GUTIERREZ PHOTO

Advantages of *Bt* Crops

Improved pest management. Insect-protected *Bt crops* provide the farmer with season-long protection against several damaging insect pests, and reduce or eliminate the need for insecticide sprays. This eliminates the yield loss that results from less than optimal pest control by applied farm insecticides, and it allows the farmer more time for other farm management duties.

Reduction in insecticide use. A study by the US Department of Agriculture reported that 8.2 million pounds of pesticide active ingredients were eliminated by farmers who planted *Bt crops* in 1998. Significant reductions have also been reported in China and Argentina, where the use of Bt cotton resulted in a 60-70% reduction in pesticide use.)


USDA PHOTO

Greater net return. Lower input costs often contribute to a higher net return compared to conventional crops. *Bt* cotton farmers in the US earned an incremental $99 million as a result of decreased pesticide costs and/or increased yields. Similarly, *Bt* cotton farmers in Argentina reported that *Bt* cotton generated an average incremental benefit of $65.05/ha

Improved conditions for non-target organisms. Since *Bt crops* are able to defend themselves against pests, the use of chemical insecticides is significantly reduced, thereby encouraging the proliferation of beneficial organisms. These beneficial organisms can help control other secondary pests, which can often become a problem when predator and parasite populations are reduced by conventional broad-spectrum insecticides.

Less mycotoxin in corn. Aside from being effective against insect pests, *Bt* crops have lower incidences of opportunistic microbial pathogens, such as the fungus *Fusarium.* This fungus produces mycotoxins that can be deadly to livestock and also cause cancer in humans.

Insect Resistance Management (IRM)

Since *Bt* crops are capable of season long expression of the *Bt* protein, precautionary steps have to be taken in order to avoid the development of insect resistance. In the US, for example, the EPA usually requires a "buffer zone," or a structured refuge of non-*Bt* crops that is planted in close proximity to the *Bt* crops.

IRM is said to be the key to sustainable use of the insecticide in both genetically modified crops and *Bt* microbial spray formulations. ❑


USDA PHOTO

Corn Borer

Current Status of Bt Technology

At the end of 2005, an estimated 26.2 million hectares of land were planted with crops containing the Bt gene. Table 1 shows countries that have commercialized Bt cotton and/or Bt corn, from 1996 to 2005.

Table 1.

CROP	COUNTRY	
Cotton	Argentina	Australia
	China	Colombia
	India	Indonesia
	Mexico	South Africa
	United States	
Corn	Argentina	Canada
	France	Germany
	Honduras	Philippines
	Portugal	Spain
	South Africa	United States
	Uruguay	

Source: Clive James, 2005.