Commonly Asked Questions About *Btk* (*Bacillus thuringiensis* var. *kurstaki*)

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What is *Bacillus thuringiensis*?

Bacillus thuringiensis is a rod-shaped bacterium that occurs naturally on dead or decaying matter in soil. It was first isolated in 1902 from diseased silkworm larva. Various strains of *Bacillus thuringiensis* have been used commercially in the United States since 1958 on insect pests of food, forage crops, and forests. Commercial landscapers and home gardeners frequently use *Bacillus thuringiensis* for pest control because it is effective, selective, and safe.

There are many different strains of *Bacillus thuringiensis* that attack specific kinds of insects. For example, *Bacillus thuringiensis* var. *israeliensis* is used to control mosquitoes, and *Bacillus thuringiensis* var. *tenebrionis* is used to treat some pest beetles specie. ***Bacillus thuringiensis* var. *kurstaki* (*Btk* for short)** is used to control caterpillar pests such as gypsy moths.

Helicopter spraying pesticide over wooded area (Photo by Terry McGovern, USDA APHIS PPQ)

Is *Btk* a good choice for controlling gypsy moths on my trees?

There are many advantages to using *Btk* to control caterpillar pests:

- Caterpillars that become ill or die after ingesting *Btk* are not considered dangerous to birds or other animals that feed on them.
- In general, sunlight and other microbes destroy *Btk* applied to foliage within three to five days, so *Btk* does not multiply or accumulate in the environment.
- Perhaps most importantly, *Btk* does not appear to pose any significant threat to human health or to pets. *Btk* is often sprayed over large areas from planes or helicopters in formal gypsy moth control programs over large areas but commercial applicators or homeowners can apply *Btk* effectively to individual trees from the ground.

How does *Btk* kill caterpillars?

When *Btk* is ingested by a susceptible caterpillar, the highly alkaline environment of the caterpillar's gut triggers the *Btk* bacterium to release a crystalline protein called an "endotoxin" that poisons the insect's digestive system. The endotoxin acts by killing cells and dissolving holes in the lining of the insect's gut. When a mixture of food, *Btk* spores, and digestive juices leaks through these holes into the insect's blood, it causes a general infection that kills the caterpillar.

Multiple, late instar caterpillars note shiny dark pupal case near center, bottom of picture (Photo by Terry McGovern, USDA APHIS PPQ)

When should I apply *Btk* for control of gypsy moths on my trees?

Timing of *Btk* applications is critical to successful control of caterpillars. Because *Btk* is a stomach poison, it must be eaten by the insect in order for it to work. Since gypsy moths only feed when they are in the caterpillar stage, it is important that *Btk* be sprayed on leaves of trees when caterpillars are actively feeding. *Btk* has little effect on the gypsy moth's non-feeding life stages (eggs, pupa, and adult stages).

Btk is most effective against young, actively feeding caterpillars. Make two applications of the spray over the course of 2 weeks to ensure that susceptible caterpillars are treated. Apply the first spray on the tree foliage about 10 days after caterpillars have hatched from their eggs, and apply *Btk* again 2 weeks later while caterpillars are still less than 3/8-inch long. In Indiana, caterpillars are usually in these stages from late April through May, but variations in weather and other conditions may alter this timetable.

Apply *Btk* according to label directions, using the doses recommended by the manufacturer. As with any pesticide, be sure to follow all safety precautions and wear personal protective equipment (goggles, gloves, hat, long pants, and long-sleeved shirt) as specified on the label.

Schedule For Spraying *Btk* for Gypsy Moths in Indiana

	Date of application	Look for:	Target of spray
First *Btk* spray	Late April/early May	First bloom of redbud trees	7-10 day old caterpillars
Second *Btk* spray	Approx. 2 wks after first spray	Redbud trees in full bloom; blooms beginning to fade	Older caterpillars (but still less than 3/8-inch in length)

Tips for best results:
- Do not apply the first spray until all caterpillars in the area have hatched.
- Apply *Btk* late in the day to avoid intense sunshine, which breaks it down.
- Apply *Btk* when winds are relatively calm to avoid spray drifting.
- Always follow label directions and obey all safety precautions.

How effective is *Btk* in controlling gypsy moth caterpillars?

When properly applied, *Btk* kills 80%- 85% of gypsy moth caterpillars with each spray. After two consecutive sprays that are timed about 2 weeks apart, approximately 99% of caterpillars will be killed.

Would humans or other animals be harmed if they accidentally ingested *Btk*?

Humans and other mammals have highly acidic environments in their stomachs that destroy *Btk* before it can causes infection. Because the *Btk* endotoxin requires extremely alkaline conditions to become active (such as those found in the guts of gypsy moths and other caterpillars). *Btk* does not affect animals with acidic stomach environments such as birds, fish, and mammals.

I heard about a healthy farm-worker who developed an infection after he accidentally splashed a *Btk* product in his eye. Did *Btk* cause the infection?

Researchers who investigate the safety of *Btk* in the workplace do not believe that *Btk* caused the infection. After the accident, the farm-worker "self-treated" the affected eye with a corticosteroid ointment for 7 days before the problem developed (Samples and Buettner, 1983). Corticosteroids greatly interfere with wound-healing, and probably allowed another microorganism to cause the infection. (Siegel, 2001). The *Btk* found in the worker's eye may simply have persisted in the tissue.

Some sources suggest that *Btk* can be found in people's bodies days or weeks after their neighborhoods were sprayed for gypsy moths. Doesn't that mean that they were infected with *Btk?*

After a person or animal has been exposed to bacteria of almost any kind, the amount of bacteria in the tissue can be measured. When the amount of bacteria increases over time and damages or destroys tissue, it is said to have caused an **infection**. If the bacteria is found in the person's tissue for a period of weeks yet no tissue damage results, the bacteria is said to merely be **persistent**. Almost all reports of *Btk* in tissues have been associated with persistence rather than infection. Remember, the world is full of microbes that our bodies encounter on a regular basis, but only a tiny few of them cause any problems. *Btk* behaves like most persistent bacteria and fades away after a period of time.

Isn't it better to "be safe than sorry" and completely avoid exposure to *Btk?*

Most North Americans have already been repeatedly exposed to *Btk.* Because *Btk* naturally persists in soil and is also sprayed on many crops (including those that are organically grown), it is likely that you are exposed to *Btk* during the course of your daily life. If you eat fruits and vegetables, you have probably already ingested *Btk*, probably without any ill effects.

If *Btk* already exists in soil, why do we need to spray trees to control gypsy moths?

Btk normally is found in the soil but not on tree leaves. As such, caterpillars don't encounter *Btk* that occurs naturally in the environment and so do not become infected that way.

Manufacturers of *Btk* products usually don't publicly disclose inert ingredients they use in their formulations because it is considered proprietary information, but I've heard that these ingredients might be harmful to people and animals. Should I be concerned?

Under typical circumstances, the inert ingredients in *Btk* formulations will not harm humans or animals. In 2000, a group of Canadian scientists used gas chromatography and mass spectrometry to analyze volatiles produced by sprays of a commonly used *Btk* formulation. Volatiles are the chemicals in the insecticide that easily vaporize into the air that people breathe. After careful testing, the scientists concluded that the volatile agents in *Btk* did not constitute a health hazard (Van Netten et. al., 2000).

Btk products contain a number of inert ingredients, including stickers and binders that allow the spray to remain on vegetation after it is applied. These ingredients include food products that also provide nutrition for bacteria, such as potato starch, glucose or sucrose, proteins from corn or soy, and water. Additional ingredient might be sodium hydroxide (a chemical also used to adjust pH levels in chocolates, ice cream, and margarine), potassium phosphate, and a thickening agent found in cream cheese and ice cream. Other inert ingredients might be used but always in much smaller quantities than those mentioned above. No petroleum products are used as carriers (Capitol Health Region, 1999).

It is important to keep in mind that almost any product – from insecticides to seemingly innocent substances such as vinegar, dish soap, or table salt – can be harmful if used improperly or under inappropriate conditions. Some *Btk* formulations do contain residues of grains and other foods used to help the bacteria grow that could be of some concern to people with food allergies. If you are in this group, you may contact the Indiana Department of Natural Resources after you receive notification of a forthcoming spray for advice.

Are *Btk* and *Bacillus cereus* (a bacterium often implicated in cases of food poisoning) really the same thing?

Although *Btk* and *Bacillus cereus* are related, they are not the same thing. Each requires a very different environment in which to thrive. *Bacillus cereus*, like *Btk*, is widespread in our environment and is found in soil, air, dust, water, and decaying matter. However, *Bacillus cereus* does best in raw, dried, or processed foods, especially items containing custard and cream. *Btk* does not flourish in food items and is not characteristically associated with food poisoning.

For *Btk* to cause a serious systemic infection in a human being, he or she would have to take in colossal amounts of *Btk* spores (far more spores than one would encounter during spraying for gypsy moths). Even if a person somehow managed to ingest an enormous amount of *Btk* spores, a serious problem would be extremely unlikely in the presence of a functioning immune system (Tayabali and Seligy, 2000).

Are *Btk* and anthrax (*Bacillus anthracis*) the same thing?

No, they are not the same organism and work in very different ways. Unlike *Btk*, *Bacillus anthracis* is an extremely virulent pathogen, which means that it is able to easily overcome bodily defensive mechanisms and cause a rapid and severe infection in its host. *Btk*, on the other hand, has exceptionally low virulence in humans and other mammals. Although *Btk* could theoretically infect mammals, the circumstances in which this could happen would be exceptionally rare and unusual.

To put this in perspective, scientists have found that it takes up to **one trillion** (1,000,000,000,000) times more *Btk* than *Bacillus anthracis* to cause a lethal infection in mice (Siegel, 2001). The odds of a human being exposed to such a proportionally massive dose of *Btk*, even during an intense spraying program, are virtually non-existent.

It would be imprudent to say that any product is 100% risk-free for all people at all times. This certainly isn't true in our normal surroundings, where commonly encountered items such as wheat, peanuts, mold, or pollen can trigger severe reactions in susceptible individuals. Under the right conditions almost any common bacterium that we routinely encounter in our environment can cause serious infections, but our immune systems do not normally permit this. For example, gardeners routinely apply fertilizers derived from cow manure containing many potentially infectious organisms such as *Escherichia coli* (commonly referred to as *E. coli*) without incident. Of course, common sense dictates that people with weakened or malfunctioning immune systems are more susceptible to infections in general, regardless of the infective organism, and should take extra precautions.

Is *Btk* really safe to use for treatment of gypsy moths?

Numerous studies over many years have yielded no evidence of significant problems to humans and mammals from using *Btk* on crops, in home gardens, or in gypsy moth sprays. Thousands of pounds of *Btk* have been used over decades with little or no detectable adverse effects (Hoffmaster (CDC), personal communication).

Btk's exceptional safety record extends all the way back to the 1960s, when it first came into use in the United States. After a thorough review of the toxicity of *Btk* products, including both active and inert ingredients, the U.S. Environmental Protection Agency, Health Canada, the World Health Organization, and many other groups have judged it safe and effective for aerial applications when used according to label directions.

Spraying Bt for gypsy moth by helicopter near Helen, GA (Photo by G. Keith Douce, The University of Georgia)

Sources

Capitol Health Region in consultation with the Canadian Provincial Ministry of Health, Capital Health Region and the Central Vancouver Island Health Region. March 1999. Victoria, British Columbia, Canada. 1999. <http://www.for.gov.bc.ca/hfp/gypsymoth/chr.htm>.

Hoffmaster, A. R. 2002. Center for Disease Control. Personal communication.

Samples, J. R. and H. Buettner. 1983. Ocular infection caused by a biological insecticide. Journal of Infectious Diseases 148:614.

Siegel, J. P. 2001. The mammalian safety of *Bacillus thuringiensis*-based insecticides. Journal of Invertebrate Pathology 77:13-21.

Tayabali, A.F. and V. L. Seligy. 2000. Human cell exposure assays of *Bacillusthuringiensis* commercial insecticides: Production of *Bacillus cereus*-like cytolytic effects from outgrowth of spores. Environmental Health Perspectives 108:919-930.

Van Netten, C., K. Teshke, V. Leung, Y. Chow, and K. Bartlett. 2000. The measurement of volatile constituents in Foray 48**B**, an insecticide prepared from *Bacillus thuringiensis* var. *kurstaki*. The Science of the Total Environment 263:155-160.

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