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Abstract
A study from Cornell University in New York was recently published in the science journal Nature and suggests that pollen from Bt corn may have toxic effects on larvae of the monarch butterfly. The caterpillar, or larval stage, of this insect feeds on milkweed. Because some milkweed grows next to corn in the Midwest, there is the potential that Bt corn pollen may drift onto milkweed and affect monarch larvae. The Cornell study has generated a tremendous amount of coverage in the national media because of the potential clash between biotechnology and wildlife.

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Monarchs and Bt corn: questions and answers

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How was the study conducted?

Cornell researcher John Losey and his colleagues conducted their experiment in the controlled conditions of a laboratory. They collected corn pollen from both Bt and nonBt plants, then with a spatula they dusted moistened milkweed leaves with either of the two pollen types. Milkweed leaves without corn pollen also were included as a control. Three-day-old monarch caterpillars were then placed on the leaves and allowed to feed. After 4 days the experiment was terminated and milkweed leaf consumption, caterpillar survival, and larval weight were recorded.

What did the study report?

First, the Cornell researchers found that after 4 days, 44 percent of the monarch larvae died that fed on the Bt-pollen-coated leaves. No caterpillars died that ate leaves dusted with regular corn pollen or the control leaves. Second, leaf consumption by the larvae was much less on the Bt-pollen-dusted leaves. Third, larvae that survived on Bt-pollen-dusted leaves were less than half the size of larvae that fed on leaves with no pollen. However, the size of larvae that fed on leaves dusted with nonBt pollen was not reported.

How should the Cornell study be interpreted?

This study was conducted only one time for a duration of 4 days in the laboratory. The laboratory setting can be viewed as beneficial for controlling factors that may influence the experiment. Unfortunately, the pollen dosage per milkweed leaf was not reported. The dosage may have been excessive when compared with what would be found on milkweed next to a cornfield. The published study does suggest that some monarch caterpillars feeding on Bt-pollen-coated milkweed leaves will be killed.
Monarch butterfly (Danaus plexippus).

Have other studies examined the effects of Bt pollen on monarchs?

Iowa State University entomologist John Obrycki [2] and graduate student Laura Hansen conducted a field study to examine Bt pollen effects on the monarch. They placed potted milkweed at several distances from the field edge in a Bt cornfield and nonBt field. The highest concentration of pollen was found on plants within the cornfield. Leaf samples were taken from the milkweed within and adjacent to the field and used to assess mortality of newly hatched larvae. Within 48 hours, there was 19 percent mortality in the Bt corn pollen treatment compared with 0 percent in the nonBt corn pollen treatment, and 3 percent in the control, which had no pollen. This study is ongoing and will continue during this year. An abstract of the data may be found at http://www.pme.iastate.edu/info/monarch.htm [3].

Monarch (Danaus plexippus) caterpillar on milkweed.

Is Bt corn a serious problem for monarchs?

Both studies suggest that some, but not all, monarch caterpillars may be killed when they eat Bt corn pollen. It is not known whether monarch larvae can avoid eating pollen on a milkweed in a natural environment or whether corn pollen is evenly distributed on all leaves on a milkweed. No studies have been conducted to assess the actual mortality of monarchs on milkweed near cornfields. Also, not all acres of corn is planted to Bt hybrids; estimates for 1999 suggest that 30 percent of the acres in the Corn Belt will be planted with Bt corn.

Is all Bt corn pollen harmful to monarchs?

The answer to this question is not known. Five genetic events have been registered with the Environmental Protection Agency (EPA) for use in corn. Information in the EPA Pesticide Fact Sheets shows the concentration of Bt protein (expressed as micrograms per gram of pollen) ranges from 7.1 µg/g in one genetic event to presumably 0.0 µg/g in another event because the protein could not be detected. Only two types of Bt corn pollen were used in Cornell and Iowa State studies—Bt 11 and event 176, respectively. Therefore, it is not known how pollen from other Bt events might affect monarchs.

Will monarchs lay their eggs in cornfields?

Monarchs prefer to fly in open areas. In the book, The Monarch Butterfly [5], F. A. Urquhart states that monarchs locate milkweed by sight and prefer to lay their eggs on small milkweed plants 3 to 18 inches in height. The female butterfly will most easily find these small plants in fencerows, ditches, pastures, and on rough ground. It is unlikely that very many eggs will be laid on milkweed in tall corn. The potential problem with Bt pollen is that it can drift and land on milkweed outside a cornfield. But because corn pollen is relatively heavy, only about 30 percent of it drifts farther than 8 meters (26 feet). Monarchs that are feeding on milkweed...
closest to a Bt cornfield would likely suffer the greatest mortality because of a higher concentration of Bt pollen.

**Is Bt corn potentially harmful to other insects?**

An Iowa State University study published by Clint Pilcher, John Obrycki [6], and myself examined the effects of corn pollen on the twelvespotted lady beetle, green lacewing, and insidious flower bug. Bt pollen from event 176 (KnockOut), which was known to express the protein in the pollen, was intentionally used in the study. These three species of the insects are beneficial and they eat both European corn borer eggs and corn pollen. The study found that the Bt corn pollen did not affect the development of the immature stages or the survival of any of the three species. However, a different study conducted by Angelika Hilbeck and colleagues in Switzerland found that green lacewing larvae had increased mortality when they ate European corn borers that died after eating Bt corn compared with borers that fed on nonBt corn.

**Are there any potential benefits to monarchs from the use of Bt corn?**

Results from 3,334 Bt corn producers in a 1997 survey from six states showed that 29.5 percent of these farmers were planting Bt corn with the intent of eliminating insecticide use for European corn borer control. During a 5-year period (1991-1995), 30.6 and 15.3 percent of the Bt corn producers had used insecticides for first- and second-generation control, respectively. The average number of years (out of 5) that they had used insecticides against European corn borers was 2.6 and 2.4 years, again for first and second generations, respectively. When asked about insecticide use for European corn borer control during 1997, 19.3 percent said insecticide use against this pest decreased and only 5.5 percent said it increased. This survey suggests that Bt corn is replacing the use of insecticides for European corn borer control. A reduction in broad-spectrum insecticide use should be beneficial not only for the monarch but also for many other insect species.

**Are there other hazards to monarch survival?**

The World Wildlife Fund states that the largest threat to the monarch butterfly is human activities within their wintering grounds (in Mexico), particularly habitat destruction and alteration by logging. Some researchers have suggested that the spraying of herbicides for weed control may consequently be endangering the habitat and food source of the monarch. Other factors that reduce monarch populations include mowing of highway right-of-ways, ditches, and pastures, which destroys the milkweed; urban sprawl, which destroys habitat where the milkweed may grow; collision with cars and trucks; and the spraying of insecticides, including the Bt pesticides.

**Is the monarch endangered?**

The monarch butterfly is neither an endangered nor threatened species in the United States. It is an abundant and widespread insect that ranges from central Mexico to southern Canada. During its annual migration across the continent, there are many factors that cause mortality of monarchs. All of the factors mentioned above, including Bt pollen, should be weighed in proportion to the documented mortality that they cause.

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What should farmers do?

Nothing can be done in the field at this time. If monarch mortality becomes a concern on the farm, then next year the impact of Bt corn might be reduced by planting the border rows and end rows to a nonBt corn hybrid, thereby effectively moving the Bt hybrid away from the field edge. This planting pattern would reduce the amount of Bt pollen that drifts out of the field and onto nearby milkweed. Border and end-row planting also could serve as part of the European corn borer refuge that is necessary for helping to delay the development of European corn borer resistance to Bt corn.

What is the bottom line?

The monarch and Bt pollen research that has been conducted is still preliminary, but it does indicate that the caterpillars may be impacted by Bt pollen. More research needs to be conducted on the effects of Bt corn on monarchs and possibly other nontarget species. Bt corn has proven to be a valuable pest management option for the corn producer. It provides nearly 100 percent control of the European corn borer, which protects the crop from a yield loss and helps reduce insecticide use.

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