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Transgenic Insecticidal Corn: The Agronomic and Ecological Rationale for Its Use

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Abstract

The scientific community has examined the risks and benefits of Bt plants more than any other novel agricultural technology developed over the past two decades, as demonstrated by the vast body of literature, scientific discussions, and numerous public meetings facilitated by the EPA, the US Department of Agriculture, and the US Food and Drug Administration on this subject. We find the evidence to date supports the appropriate use of Bt corn as one component in the economically and ecologically sound management of lepidopteran corn pests.

Keywords

insecticides, transgenic corn, monarch butterfly

Disciplines

Agricultural Economics | Agronomy and Crop Sciences | Entomology | Plant Breeding and Genetics | Systems Biology

Comments

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Transgenic Insecticidal Corn: The Agronomic and Ecological Rationale for Its Use

We agree with Obrycki et al. (2001) that a broad-based ecological approach for new pest management technologies is desirable, but we unanimously and strongly disagree with some of their assumptions and conclusions about Bt corn.

Bt corn is corn that has been genetically engineered to produce insecticidal proteins from the bacterium *Bacillus thuringiensis*. Because Bt corn is important for effective and ecologically sound management of lepidopteran pests of corn, we provide here relevant data, some of which is new, to help clarify the issues raised by Obrycki et al. (2001).

Obrycki et al. (2001), citing Barry and Darrah (1991), claim that traditional plant breeding has developed corn plants that adequately protect against European corn borer. However, Barry and Darrah (1991) reported only "some resistance to whorl leaf feeding...[or] some resistance to sheath and sheath collar feeding," which is not comparable with the nearly complete protection provided by Bt corn. Carpenter and Gianessi (2001) estimated that, nationally, during "10 of the 13 years between 1986 and 1998, European corn borer infestations...were such that corn growers would have realized a gain from planting Bt corn." Similarly, the Environmental Protection Agency (USEPA 2000) estimated a net benefit to growers of \$8.18 per hectare on 8 million hectares of Bt corn planted in 1999, or a national benefit of \$65.4 million (USEPA 2000). Even considering the inherent year-to-year variability in pest population density, the EPA estimated the annual benefit to corn growers at \$38–\$219 million (USEPA 2001).

Bt corn has proven to prevent yield loss, reduce mycotoxin levels, and reduce the use of insecticides on corn (Munkvold

et al. 1999, Munkvold and Hellmich 2000, Carpenter and Gianessi 2001). Applications of foliar insecticides are used to control populations of European corn borers and southwestern corn borers on non-Bt corn. But they are not used extensively because of difficulty in scouting and timing treatments to control the larvae before they bore into the plant. Consequently, growers have endured lower yields and higher mycotoxin levels. Obrycki et al. (2001) stated that "the use of transgenic corn will not significantly reduce insecticide use in most of the corn-growing areas of the Midwest." On the contrary, a survey of Bt corn producers ($n = 7265$) from six states (Illinois, Iowa, Kansas, Minnesota, Nebraska, and Pennsylvania) documents that growers did reduce insecticide use for European corn borer during the first three growing seasons after commercial introduction of Bt corn. Approximately half of the farmers did not use insecticides to manage European corn borers on their farms. Of those growers using insecticides during the previous 5 years for European corn borer control, the percentage decreasing their usage of pesticides during the 3-year period nearly doubled from 1996 to 1998 (13.2% to 26.0%) (Hellmich et al. 2000). Take Iowa with 5 million hectares of commercial corn as an average example: With 30% of the hectares

planted in Bt corn, allowing 26% of the Bt producers to reduce or eliminate European corn-borer insecticide use, hundreds of thousands of hectares were not sprayed with a broad-spectrum insecticide. This benefit is easily overlooked: Figure 2 in the article by Obrycki and colleagues (2001) includes all insecticides, whereas most use was granular insecticides for control of corn rootworms, *Diabrotica* spp. Considering the benefits pointed out above, concurrence within the scientific community that there are real benefits to ecosystems and human health, including those from a reduction in use of more broad-spectrum foliar insecticides, becomes clear (AMA 2000, APS 2001, Pool and Esnayre 2000).

In addition, contrary to concerns regarding monarch butterflies (Losey et al. 1999), comprehensive new studies show that Bt corn pollen poses little risk to monarchs on a national scale (Hellmich et al. 2001, Oberhauser et al. 2001, Pleasants et al. 2001, Sears et al. 2001, Stanley-Horn et al. 2001). Collectively, these results validate EPA's original and subsequent evaluations of the potential risks posed to nontarget butterflies and moths. As for other potential nontarget effects of Bt corn, the EPA risk assessments relied on laboratory and field trial data from representative organisms that are routinely used in assessment of ecological toxicity, including avian species (quail), aquatic species (catfish and daphnia), beneficial insects (honeybee, parasitic wasp, green lacewing, ladybird beetle), soil invertebrates (springtails and earthworms), and mammals (mice) (USEPA 1995, 2000, 2001). These tests represent toxicological endpoints for single-species components of a larger ecological system and may not necessarily predict all possible interactions. Yet

Letters to the Editor

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they are important because they provide a basis for establishing acute toxicity in indicator organisms and for developing longer-term community studies. One must keep in mind, though—regardless of whether one uses a resistant plant, a biological control agent, an insecticide, a cultural technique, or any other method to control a pest—that if the pest population is reduced, there will be some impact on the biological community.

Positive and negative impacts of new technologies must be compared with those of existing technologies. All possible impacts of any technology or farming practice are impossible to foresee, but we can focus on known and probable risks. When risks of a technology are characterized as low, based on actual data, then the potential impact should be evaluated proportional to that level of concern. This reasonable approach should reduce the chances of rejecting safe technologies simply because they are new and unfamiliar. Ultimately, the goal is to replace current pest management practices with ones that are more economical and sustainable, as well as environmentally safer. A dynamic equilibrium between benefits and risks will be developed as a result of this ongoing process. Over time, this equilibrium will change as improved practices are developed. In the meantime, if unexpected problems should occur, failsafe mechanisms exist. Any pesticidal technology registered by the EPA can have its registration suspended or canceled when an unreasonable adverse effect is identified.

The scientific community has examined the risks and benefits of Bt plants more than any other novel agricultural technology developed over the past two decades, as demonstrated by the vast body of literature, scientific discussions, and numerous public meetings facilitated by the EPA, the US Department of Agriculture, and the US Food and Drug Administration on this subject. We find the evidence to date supports the appropriate use of Bt corn as one component in the economically and ecologically sound management of lepidopteran corn pests.

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Response from Obrycki and colleagues:

We agree with our colleagues (Ortman et al.) that the appropriate use of Bt transgenic corn can be one component in an economically and ecologically sound management program for lepidopteran corn pests. However, we disagree that the current use of Bt corn represents ecologically based management of lepidopteran pests of corn. We argue that planting 20%–30% of the corn acreage with Bt corn as a prophylactic treatment for lepidopteran pests is not ecologically based management. This approach is analogous to continuous spraying of up to 30% of the field corn in the United States with a selective insecticide every year, just in case there is an infestation by a lepidopteran pest.

We acknowledge that this technology is relatively new, and that data being collected will provide a clearer understanding of the benefits and risks of transgenic Bt corn. For example, a recent study

has determined that nine transgenic Bt corn hybrids, developed from two separate transformation events, have significantly higher lignin levels than isogenic hybrids (Saxena and Stotzky 2001). We welcome the engagement of our colleagues in meaningful discussions of this technology and its role in pest management. We respond to several aspects of the letter from Ortman and colleagues to clarify points made in our original paper.

In Obrycki et al. (2001) we stated that “most corn hybrids already have substantial resistance to corn borers.” We do not believe that this statement means that we “claim that traditional plant breeding has developed corn plants that adequately protect against European corn borer.” Unfortunately, shooting at a straw man that has very little relation to original statements is all too common a tactic in scientific discourse (Collins and Pinch 1998), and it is of particular concern regarding an issue as important as the appropriate use of biotechnology (Shelton and Roush 1999). Corn plants express varying levels of resistance at different life stages, a fact that plays a vital role in the management of corn borers. In addition, modern corn hybrids have relatively high levels of tolerance to corn borer feeding. The combination of partial resistance and tolerance in modern corn hybrids contrasts with “the nearly complete protection provided by Bt corn.” Is complete protection—virtually 100% mortality of corn borers—a goal of ecologically based pest management?

Human-derived selective forces have been identified as one of the most important evolutionary factors on the planet (Palumbi 2001). Recently, the molecular bases of two different Bt resistance mechanisms were identified (Gahan et al. 2001, Griffitts et al. 2001). Planting approximately 25% of the corn in the United States with Bt corn that causes almost 100% mortality of corn borers does not appear to be a wise use of this biotechnology from either an ecologically based approach for population management or an evolutionary perspective relative to maintaining susceptible genotypes of the pest.

Ortman and colleagues state that the use of Bt corn over the last 5 years has re-

duced the level of insecticide use. This is puzzling, because Carpenter and Gianessi (2001) state that “attributing any observed changes in insecticide since 1995 to the introduction of Bt corn is necessarily problematic for several reasons.” One difficulty in demonstrating any difference in insecticide use is that the level of insecticide use before the introduction of Bt corn was minimal (Rice and Ostlie 1997, Wintersteen and Hartzler 1997, Carpenter and Gianessi 2001). For example, from 1995 to 1998, 1%–2% of the corn grown in Iowa was treated with insecticides for corn borer infestations. If Bt corn is replacing insecticides, we might expect 2% of the corn to be planted to transgenic Bt corn. Furthermore, Ortman and colleagues cite data that indicate only 26% of growers who planted Bt corn in 1998 actually used less insecticide to control the European corn borer (Hellmich et al. 2000).

As stated by Rice and Pilcher (1998), the economic benefits of this technology will vary with a number of factors related to levels of corn borer infestations, value of field corn, and cost of transgenic Bt seed. Ortman and colleagues cited the following from the National Center for Food and Agricultural Policy Web site (Carpenter and Gianessi 2001): In “10 of the 13 years between 1986 and 1998, European corn borer infestations...were such that corn growers would have realized a gain from planting Bt corn.” Extracting this single phrase out of context presents several potential misconceptions. If data for 1999 are added, then some farmers would have made a profit in 10 of 14 years. We emphasize the word “some,” because even in years with relatively high European corn borer levels, many fields will not exceed economically damaging levels. Recent evaluations of Bt transgenic corn have not demonstrated consistent economic benefits (Hyde et al. 1999, Archer et al. 2000). We believe that the data collected over 2 years in replicated field studies under natural infestations of corn borers (Rice 1998, Farnham and Pilcher 1998), as cited in our paper, are some of the best data to evaluate the performance of transgenic Bt corn hybrids in comparison with non-transgenic lines. Carpenter and Gianessi