



## Nontarget effects of Bt corn on pathogenic and toxigenic fungi

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**Abstract:** *There may be nontarget effects of transgenic corn hybrids, positive and negative, on fungi that interact with the targeted pests. What are the effects of Bt corn on fungi that are associated with corn plants and their insect pests?*

### Background

Transgenic corn hybrids (Bt hybrids) are resistant to major insect pests of corn. During 1998 and 1999, these hybrids were integrated into insect management programs nationwide. But nontarget effects of Bt hybrids have received a great deal of attention and there are some unresolved issues. Bt hybrids may have unforeseen effects (both positive and negative) on fungi that interact with the targeted pests. Because of the interactions between insect pests and plant pathogenic fungi, it is possible that Bt hybrids can have a role in the management of certain corn diseases.

In this project investigators examined the role of transgenic hybrids in the integrated management of European corn borers, corn earworms, *Fusarium* and *Aspergillus* ear rots, and the stalk rot complex in corn. *Fusarium* and *Aspergillus* species can produce harmful mycotoxins (fumonisins and aflatoxins) while stalk rots cause more yield loss than any other corn disease. The use of Bt corn also may alter occurrence of beneficial fungi, such as *Beauveria bassiana*, a natural biocontrol agent of European corn borer.

The objectives of this research were to determine the effects of different Bt genes on:

- Corn stalk infection and stalk rot symptoms,
- Corn kernel infection and ear rot symptoms,
- Aflatoxins, fumonisins, and other mycotoxins, and

- The occurrence of *Beauveria bassiana* in corn plants.

### Approach and methods

Field experiments were conducted with Bt hybrids and near-isogenic non-Bt hybrids. Experimental treatments in the field included natural and manual infestation with European corn borers, corn earworms, and fungal inoculum, and insecticide treatments for comparison. Plants were visually evaluated for insect damage, stalk rot, and ear rot symptoms. Tissue samples of stalks and kernels were cultured on selective media for the isolation and identification of fungi. Kernel samples were analyzed for four mycotoxins. Demonstration plots were established in 2000. They were focused on the potential role of Bt hybrids in integrated management of stalk rot and *Fusarium* ear rot.

### Results and discussion

Results from 1999 and 2000 indicated that Bt and non-Bt hybrids differed in terms of disease variables measured. Stalk rot incidence and severity was lower in some Bt hybrids compared to their non-Bt counterparts, but the effect was limited primarily to Bt events BT11 and MON810. Previous experiments had shown dramatic differences in *Fusarium* ear rot between Bt and non-Bt corn. In 1999 and 2000 the differences were smaller but they still appeared.

Fumonisin are the mycotoxins associated with Fusarium ear rot. In previous experiments, Bt hybrids have shown dramatically lower fumonisin concentrations than their non-Bt counterparts. These differences were less dramatic in the two years of this study.

Researchers were unable to generate useful data on the occurrence of Aspergillus ear rot in Bt vs. non-Bt hybrids because of inadequate inoculation methods. There were no significant differences in aflatoxin concentrations between the Bt and non-Bt varieties.

In treatments infested with corn earworms, it was apparent that the Bt hybrids did not provide a level of protection against this pest. In the 1999 naturally infested treatment there also were higher than usual populations of corn earworms. This may have diminished some of the advantages seen previously in terms of ear rot and mycotoxin reductions with Bt hybrids.

## Conclusions

Of the five Bt events studied in this project, only two (BT11 and MON810) will continue to be offered commercially. Other new Bt events have been or will be approved for U.S. use in the near future. BT11 and MON810 were consistently the most effective Bt events in this study, providing better control of insect injury and more frequently demonstrating reductions in ear and stalk rot and fumonisins.

*Fusarium ear rot and fumonisins* Although the 1999 and 2000 differences in Fusarium ear rot and fumonisins between Bt and non-Bt hybrids were not as large as in previous experiments, the current results support the conclusion that BT11 and MON810 hybrids have a lower risk for Fusarium ear rot and fumonisins than their non-Bt counterparts.

*Aspergillus ear rot and aflatoxins* Natural aflatoxin contamination is Iowa in too unpredictable for this type of experiment. Investigators were not successful in designing an inocu-

lation method that would result in adequate levels of infection without bypassing the potential mechanism of natural insect-Aspergillus interactions. Silk-channel inoculation was too intrusive and spraying the silks did not induce adequate infection. The experiment did not generate data to determine the potential influence of Bt corn on the risk of aflatoxin contamination.

*Stalk rot* Although there appear to be many situations where Bt hybrids will not differ in stalk rot compared to non-Bt hybrids, overall these results indicate a lower risk of stalk rot in hybrids with Bt events BT11 and MON810. However, the background genetics of a corn hybrid will influence its vulnerability to stalk rot much more than the presence or absence of a Bt gene. Stalk rot also is very heavily influenced by year-to-year weather variability. Additionally, the fungal species composition of stalk rot pathogens appears to be altered in some Bt hybrids. Species that are closely associated with European corn borers, such as *Fusarium verticillioides*, are less prevalent in Bt hybrids, but are replaced by other species.

*Beauveria bassiana* The occurrence of this fungus in stalks was much less frequent than expected. The researchers were unable to generate useful data to determine the potential

**Question:** How does the use of Bt hybrids affect the interactions between insect pests and fungi occurring on corn, including the fungi that cause ear rots and stalk rots, and those producing mycotoxins in the grain? **Answer:** The very effective insect protection offered by Bt hybrids translates into reduced risk for Fusarium ear rot and fumonisins in the grain. There were no consistent differences in other mycotoxins among hybrids. In stalks, insect protection reduced the risk of stalk rot and altered the fungal species composition in stalks somewhat, but other factors influenced this disease complex more than the use of Bt genes.

**Corn borers such as this one can cause stalk injuries that lead to fungal infections**



influence of Bt corn on the occurrence of this fungus in corn plants and fields.

### Impact of results

On November 6, 2001, the U.S. Food and Drug Administration (FDA) released guidelines for safe levels of fumonisins in foods and feeds. This action was taken because of the widespread occurrence of fumonisins in corn and evidence of their toxicity and carcinogenicity. The FDA concluded, "Human health risks associated with fumonisins are possible." This experiment showed that Bt hybrids have a lower risk for Fusarium and fumonisins than their non-Bt counterparts.

The contribution of Bt hybrids toward reducing risk of stalk rot is less clear, but results indicate that there is some effect. Because stalk rots are overall the most economically important diseases of corn, it would be appropriate to consider this effect in an assessment of the economic benefits of Bt corn. The results cited here could serve as a basis for developing a probability function that would describe the likelihood of stalk rot reduction through the use of Bt corn.

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**Fusarium ear rot often follows insect injury to corn ears**



Aflatoxins are an equal or greater health concern than fumonisins. It was not clear whether any aflatoxin reduction could be expected with Bt hybrids. It seems likely that the current Bt hybrids do not control a wide enough spectrum of insects to make a significant impact in parts of the world where aflatoxins are more prevalent than in Iowa.

The results with *Beauveria bassiana* suggest that this question will not be answered by assessing endophytic infection of corn plants in isolated experiments. A different approach is needed in which mortality due to *B. bassiana* would be gauged in fields with different crop sequences that included or did not include Bt hybrids.

### Education and outreach

Results of this project were presented at conferences in Wisconsin, Maryland, and Georgetown University, as well as at the ISU Seed Technology Conference and the ISU Integrated Crop Management Conference. The work also was discussed at two ISU research farm field days in 2000.

Media coverage has included *National Geographic* magazine, the *Ames Tribune*, the *Des Moines Register*, more than 20 Midwestern radio stations, and ABC-TV Nightline.

The project produced five published papers and supported one ISU graduate student.