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Utilizing an entomopathogenic fungus, Beauveria bassiana, for season-long suppression of larval populations of the European corn borer

Abstract
The European corn borer (ECB) is the second most significant insect pest of field corn. Though its impact is variable each year, it can cause from $100 to $250 million in crop losses annually in Iowa alone. Presently, growers use chemical insecticides to suppress populations of this insect. But sometimes this approach does not provide adequate protection from this pest, in part because the ECB's tunneling damage within the corn stalk is usually recognized too late (see Figs. 1 and 2). Moreover, because chemical insecticides are not only expensive but potentially threatening to groundwater quality, corn growers need an environmentally compatible management alternative.

Keywords
Entomology, Biocontrol and integrated pest management, Economic and environmental impacts

Disciplines
Agriculture | Entomology | Environmental Indicators and Impact Assessment

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Utilizing an entomopathogenic fungus, *Beauveria bassiana*, for season-long suppression of larval populations of the European corn borer

**Goals**

The European corn borer (ECB) is the second most significant insect pest of field corn. Though its impact is variable each year, it can cause from $100 to $250 million in crop losses annually in Iowa alone. Presently, growers use chemical insecticides to suppress populations of this insect. But sometimes this approach does not provide adequate protection from this pest, in part because the ECB’s tunneling damage within the corn stalk is usually recognized too late (see Figs. 1 and 2). Moreover, because chemical insecticides are not only expensive but potentially threatening to groundwater quality, corn growers need an environmentally compatible management alternative.

Hence the goal of this project was to make progress toward development of a management tool that would be compatible with the environment and offer long-term, residual activity in controlling the ECB. The investigators studied a system based on a naturally occurring fungus, *Beauveria bassiana*, which kills the ECB. *B. bassiana* was a logical choice because it can be readily isolated from soil, decaying crop residue, insect cadavers, and green plants, including corn. Moreover, it occurs naturally in the corn agroecosystem. However, although *B. bassiana* kills ECB, the disease it produces does not spread sufficiently to control large numbers of insects. Thus, the investigators additionally employed a commercially available bacterium (a microbial insecticide or "biological control" called *Bacillus thuringiensis*), along with a recommended, commercial chemical insecticide, carbofuran, to develop a program for managing the ECB.

The objectives of this research were to demonstrate that applying *B. bassiana* in conjunction with these other substances is an effective tool for season-long control of the ECB and that these substances are indeed compatible when used jointly. Investigators undertook the following activities:

- sampling for *B. bassiana* in the soil and in the pith, or spongy center, of the corn plant, under several scenarios employing the two additional insecticides (and a nontreatment check),
- recording the mortality of ECB larvae over time throughout the season, and
- measuring larval tunneling and corn yields in the various treatment scenarios.

**Approach and methods**

The investigators began work in 1988 by using two corn hybrids to determine if the genetics of the plant would influence the effectiveness of the various insecticides. This field research employed conventional corn-production practices: corn following soybeans, chisel-plowing, and recommended amounts of herbicides and fertilizer. The hybrid corns were tested as whole plots, and the toxicants were applied to the corn as split plots. The three toxicants—*B. bassiana*, *B. thuringiensis*, and carbofuran—were tested in three separate, replicated experiments: (1) application at whorl (growth stage V6, when three or more leaves make a circle); (2) application at pollen-shed (R1 development stage), and (3) application at both those stages. The nontreated check allowed investigators to determine the toxicants’ compatibility as well as compare them individually.

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**Budget**

$27,849 for year one  
$30,182 for year two  
$34,358 for year three
Investigators took soil samples just prior to planting to check for the presence of *B. bassiana*. Then they infested corn plants with the ECB larvae at the appropriate development stage. Three to five days later, the toxicants were applied.

Fourteen days later, they randomly chose five plants per split plot and sampled them for *B. bassiana*. At senescence (their mature, or nongrowing state), plants were again sampled for numbers of *B. bassiana*. In addition, investigators randomly selected 25 corn plants from experiments 1 and 3, splitting them from tassel to base to record circular measure (CM) of the tunneling caused by the ECB.

Because the two hybrids responded differently to the extremely hot, dry weather conditions of 1988, they did not illuminate how genetic differences might influence the insecticides' effectiveness. So investigators planted a single hybrid in 1989 and 1990, and *B. bassiana* was applied as a crop protectant. Then, either *B. thuringiensis* or carbofuran was applied as a "rescue" treatment. Again, the investigators used conventional practices and the same development stages as in 1988 in three separate experiments. But this time the whole plots were either treated with *B. bassiana* or not; the split corn plots received the commercial toxicants *B. thuringiensis* or carbofuran (and an untreated check). Again, split plots were infested at the appropriate development stages with ECB larvae, and toxicants were applied three to five days following infestation. Ten days later, investigators counted the number of live ECB larvae in the whorls of 15 randomly selected plants in all subplots that received the commercial toxicants. They also pulled 25 randomly selected plants, this time to obtain information both on tunneling and yield.

**Findings**

Effectiveness comparisons within a hybrid showed that *B. bassiana* was equal to the chemical insecticide and, at times, better than the microbial insecticide *B. thuringiensis* in reducing tunneling by the ECB. However, in 1988 one hybrid silked a full two weeks before the other, and several plants were barren, rendering comparisons impossible. The results in experiments 1 and 2 that year showed no differences in tunneling between toxicants when summed over the hybrids; in experiment 3, those plants treated with carbofuran had
more tunneling. But these interactions were highly variable. By altering the experiment in 1989 and 1990 to use only one hybrid corn line, investigators could determine the effect of combining the carbofuran and B. thuringiensis with B. bassiana. Moreover, the weather during these two years was much more uniform.

The incidence of B. bassiana was determined for all three years. In 1988, B. bassiana was found in the soil in insignificant amounts. B. bassiana was readily prevalent 14 days after application but not at senescence. In 1989 and 1990, measurements were taken only at senescence; however, B. bassiana was present in a large percentage of the plants. Earlier work by other researchers also underscored this evidence that climatic conditions in 1988 detracted from the survival of B. bassiana.

The fungus B. bassiana reduces larval populations of the ECB when it is applied to corn during whorl stage and pollen-shed stage. In addition, it remains in the plant throughout the growing season, and it is readily isolated from the pith of the corn plant upon senescence. Investigators also determined that the microbial insecticide B. thuringiensis and the chemical insecticide carbofuran do not reduce the effect of the fungus B. bassiana. In fact, when either of these toxicants was added to B. bassiana, investigators observed increased mortality of the ECB. Although B. bassiana alone reduced tunneling by ECB larvae, tunneling was further reduced when B. thuringiensis or carbofuran was applied to whorl-stage corn. When applied to pollen-shedding corn, B. bassiana reduced tunneling but had no significant effect on yield except when B. thuringiensis was added.

Although B. bassiana, B. thuringiensis, and carbofuran reduced tunneling by the first-generation ECB, increased yields did not always result. Tunneling by second-generation ECB was significantly reduced by B. bassiana in all three experiments in both 1989 and 1990. Even so, yields were variable enough in all experiments in 1989 and 1990 to suggest that a number of factors aside from insects affect yields. In general, in all of the treatments, yields were better than in the untreated checks. In no case were there indications that B. bassiana decreased yields.

In conclusion, B. bassiana suppresses populations of the ECB larvae, reduces tunneling,
and plays a role in yield increases both alone and in combination with *B. thuringiensis* or carbofuran. All indications are that this fungus should be considered as an important component of a system for managing the ECB.

**Implications**

*B. bassiana*, a naturally occurring fungus, can be produced in the laboratory and applied to corn plants to suppress populations of the European corn borer. Because it propagates both on crop residue and the growing corn plant, it is always available to play a role in suppressing the ECB. The 1990 data show that under certain conditions, it can colonize almost all corn plants in a field. Moreover, *B. bassiana* interacts with the ECB throughout the growing season.

But scientists still lack information on just how the fungus enters the plant. Further study of this mechanism will increase the possibilities for conserving and enhancing the ubiquitous inoculum of *B. bassiana* so that it can be optimized as an insect management tool. In-depth study will also help to determine if corn genetics plays a role in the endophytic (or dependent) relationship of *B. bassiana* to the corn plant.

This study was important because it confirms earlier work with *B. bassiana* and its compatibility with *B. thuringiensis*. It goes a significant step further in confirming this fungus's compatibility with a chemical insecticide. Finally, it provides the basis for future work to manipulate and conserve the existing *B. bassiana* in the corn ecosystem until scientists can further harness its potential to displace the use of environmentally harmful chemicals for ECB control.