SARE Project ANE95-26

Biointensive Sweet Corn ICM Project

1994-1996 On-Farm Trials Final Report

Using *Bacillus thuringiensis (Bt)* Products for European Corn Borer Control in Sweet Corn

UMass Extension
Working Partners for Agroecology

Vegetable and Small Fruit Integrated Crop and Pest Management Program

University of Massachusetts Extension

United States Department of Agriculture and Massachusetts counties cooperating.

Using *Bacillus thuringiensis* (Bt) Products for European Corn Borer Control in Sweet Corn

1994-1996 On-Farm Trials: Final Report

Ruth Hazzard, Jeffrey Lerner and Suzanne Lyon
Vegetable and Small Fruit Integrated Pest and Crop Management Program, UMass Extension

The UMass Vegetable Integrated Crop and Pest Management Program conducted on-farm trials of Bt products in early-season sweet corn for three years, from 1994-96. The purpose of these trials was to determine whether products containing *Bacillus thuringiensis* (Bt) can control European corn borer (ECB) as effectively as conventional broad-spectrum insecticides.

European corn borer is the only caterpillar pest of sweet corn during the early season, before corn earworm and fall armyworm migrate into the region. Early plantings of sweet corn typically receive one to four insecticide applications for control of ECB. Previously, sweet corn farmers have had no alternative to broad-spectrum insecticides for ECB control. If growers can replace these with products containing *Bacillus thuringiensis,* they will reduce the health risk to themselves as applicators, reduce environmental risk to air and water, and conserve natural enemies of several corn pests. In addition, if growers can use the same timing, equipment, and number of applications as they normally use, then this change can occur at no extra cost to growers.

Methods

Farmers were involved in planning, implementing and evaluating this project. A total of seventeen farmers participated over the three year project, including ten to thirteen farms per year. Farms were located in six counties in central and western Massachusetts (Figure 1). Each farmer divided one early planting of one cultivar into two blocks, one receiving applications of a Bt product and the other a broad-spectrum insecticide for control of ECB. Several additional farms compared Bt treatments to unsprayed corn (control). Scouting was conducted by UMASS field assistants or private IPM consultants, and all the crop management was done by the farmers. Bt products tested included Dipel ES^{tm} (Abbott Laboratories), MVP^{tm} or MVP II^{tm} (Mycogen Corp.) and Condor OF^{tm} or Condor XL^{tm} (Ecogen, Inc.). A spreader-sticker was used with all the Bt products. Conventional products included methomyl, permethrin, esfenvalerate, and thiodicarb. In certain instances, an early corn earworm flight necessitated a single spray of a broad-spectrum insecticide to the entire planting during the silking period. This occurred on four farms in 1994 and six farms in 1996. Corn earworm damage, if it was

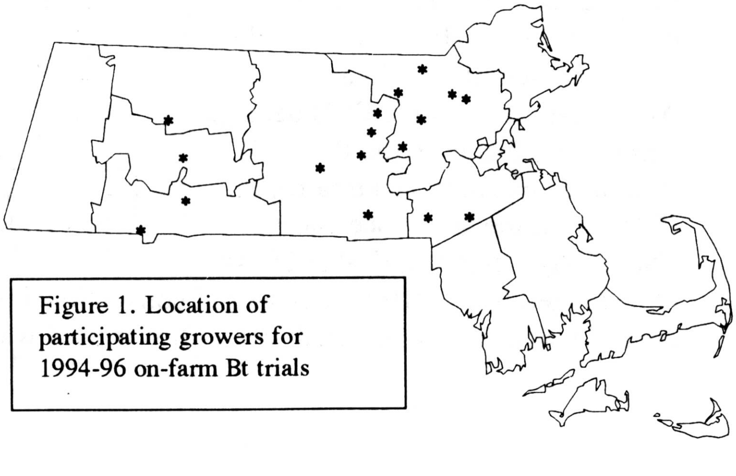


Figure 1. Location of participating growers for 1994-96 on-farm Bt trials

present, was not included in the harvest data.

Growers timed their sprays according to the standard UMass IPM system. They started applications at the pretassel or green tassel stage, when fields were >15% infested with ECB larvae. Both conventional and Bt plots received the same number of treatments, 5-7 days apart, for a total of one to four applications. Farmers used their standard spray equipment, which included both airblast and boom sprayers. Bt products were applied with a sticker (with three exceptions in 1994 and 1995). Rates were moderately high; Dipel ES, MVP II, and Condor XL were applied at 2, 3, and 1.5 pts. per acre, respectively. At harvest, farmers sampled at least 200 unculled ears from each treatment and examined them for ECB feeding damage. Ears with any damage to the kernels or tip were considered unmarketable. Superficial feeding damage on the husk was noted, but not considered unmarketable.

In the 1996 trials, we also assessed the impact of the two insecticide treatments on beneficial insect populations. On six different farms, fifty plants per treatment were examined on two sample dates after at least one insecticide application. All beneficial insects were counted, identified and classified as either dead or alive. Beneficial insects included coccinellids (including *Coleomegilla maculata*, the 12-spotted ladybeetle, and *Harmonia axyridis*, the multicolored Asian ladybeetle), insidious flower bugs (*Orius insidiousus*), various other species of predatory bugs (Hemiptera) and lacewings (Neuroptera). These predators attack European corn borer eggs and larvae as well as corn leaf aphids.

For statistical analysis, each trial, whether on the same farm or different farms, was considered one replicate. Sprayer type (boom vs. airblast) and Bt products were also tracked and compared for efficacy during the three-year project. These data were analyzed with the SAS[tm] statistics program, using ANOVA and Duncan's Multiple Range Test. Student's t-test ($p = .05$) was used to compare the percent of ECB damage and the beneficial insect counts from the Bt and conventional treatments.

Results

1994 Trials

Bt vs. conventional. Thirteen trials on ten farms were successfully completed and generated harvest data (Figure 2). ECB infestation in the trial fields at the pretassel stage ranged from 12 to 98%, averaging 44%. All but one of the trials were above the 15% treatment threshold at this stage. At harvest, the average ECB damage was slightly higher in the Bt (4.6%) than in the conventional treatments (2.8%), but the difference was not statistically significant (Table 1). Bt plots ranged from 2-19% damage and conventional plots ranged from 0-15% damage. The worst control was achieved in a trial where Bt was used without a spreader-sticker (Farm #10).

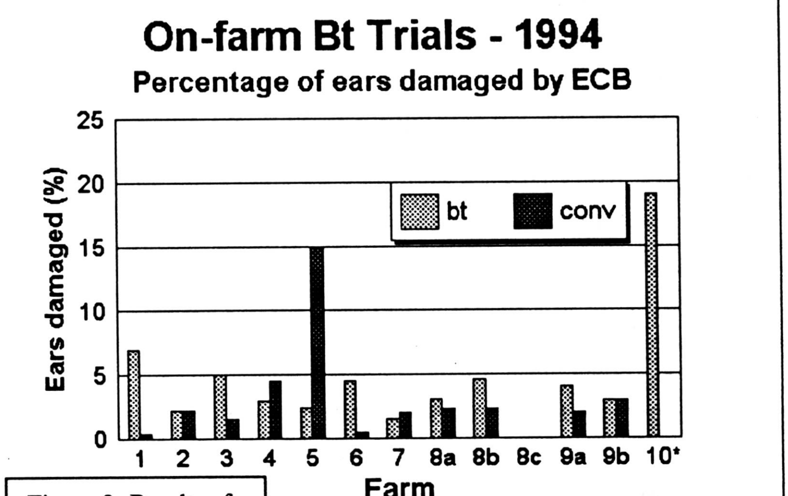


Figure 2. Results of 1994 Trials

If the 1994 trials are separated into those farms where corn earworm flight occurred and farmers applied a broad-spectrum pesticide once during silking, and those farms where no corn earworm was present and silk remained unsprayed, there was no difference in ECB damage (4.7% vs. 4.3% respectively).

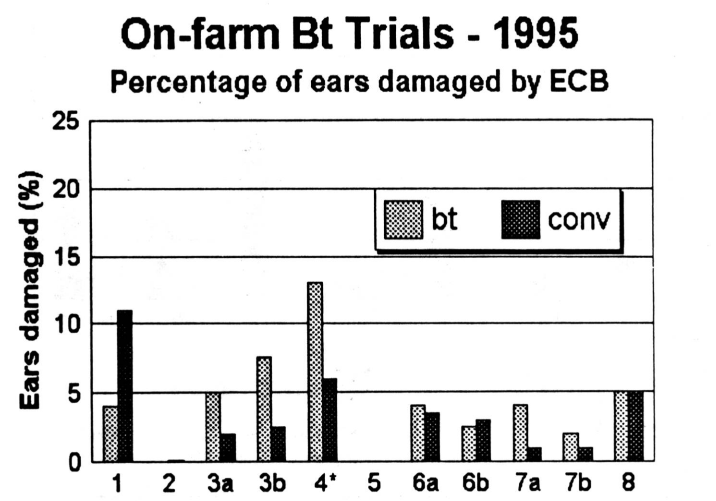


Figure 3. Results of 1995 Trials

1995 Trials

Bt vs. conventional. Eleven trials, on eight farms, successfully completed the trial (Figure 3). ECB infestation in the trial fields at the pretassel stage ranged from 6% to 72%, with an average of 32%; all but one of the trials were above the 15% treatment threshold. There was no statistical difference between the ECB damage in Bt vs. conventional plots (4.3 vs. 3.2%, respectively). The level of ear damage ranged from 0 to 13% in Bt plots, and 0-11% in conventional plots. As in 1994, the worst control in Bt treatments occurred where no spreader-sticker was used (Farm # 4)

1996 Trials

Bt vs. conventional. Twelve trials on ten farms were completed (Figure 4). ECB pressure was high, and all trials exceeded the action threshold of 15%. ECB infestation at the pretassel stage ranged from 28 to 78%, averaging 51%. The level of ear damage ranged from 1 to 24% in Bt plots and 0 to 24% in conventional plots. On average, there was no difference in damage between Bt (6.6%) and conventional treatments (5.9%). Farms that needed to use a single silk spray to control an early CEW flight and those that did not showed no difference in ECB damage at harvest.

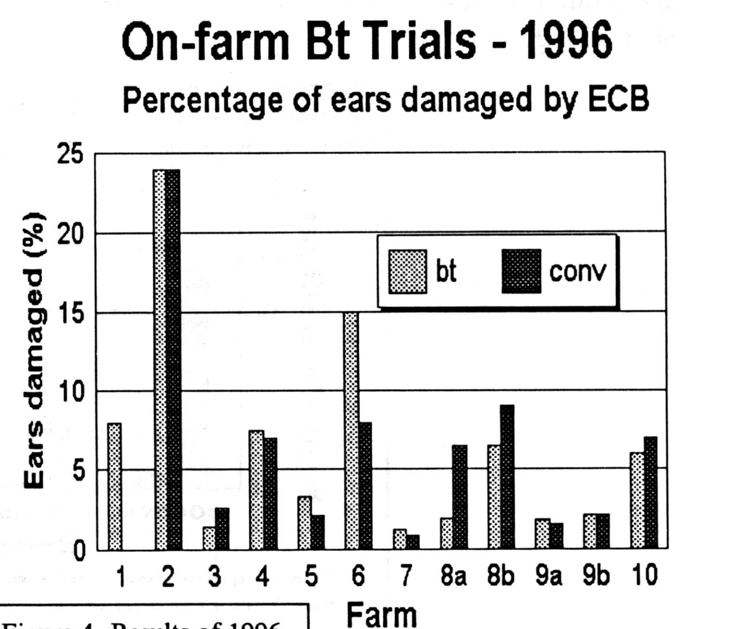


Figure 4. Results of 1996 Trials

Bt vs. unsprayed:.

1994. In 1994, three trials compared Bt with unsprayed blocks (Figure 5). Because of an early corn earworm flight, tip damage from corn earworm was significant on all three farms. In their harvest sample, growers separated ECB damage from CEW damage. The average damage from ECB in Bt blocks was 3.4 % compared to 19.9% in unsprayed blocks.

1995. Two additional farms compared Bt to unsprayed treatments. Unsprayed corn averaged 33% infested ears at harvest, compared to 6% infested ears in the Bt blocks. One farm had 99% clean corn with Bt, and the other 89% clean corn.

1996. One farm compared Bt to unsprayed corn. The result was 4.8 % damage in the Bt block, and 27.8 % in the unsprayed block.

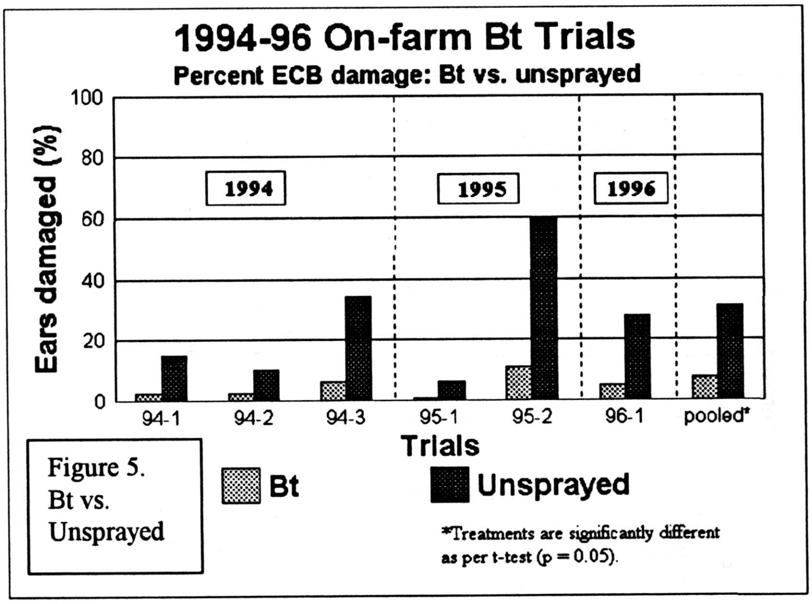


Figure 5. Bt vs. Unsprayed

Beneficial insects: The purpose of this sampling, conducted twice on each of six farms, was to determine whether beneficial insects survive better when Bt is used instead of a broad-spectrum insecticide. All four groups of predators (ladybeetles, insidious flower bugs, other Hemiptera, and lacewings) were more numerous in the Bt blocks than in blocks where broad-spectrum insecticides were used. There were more dead beneficial insects in all conventional blocks (Figure 6).

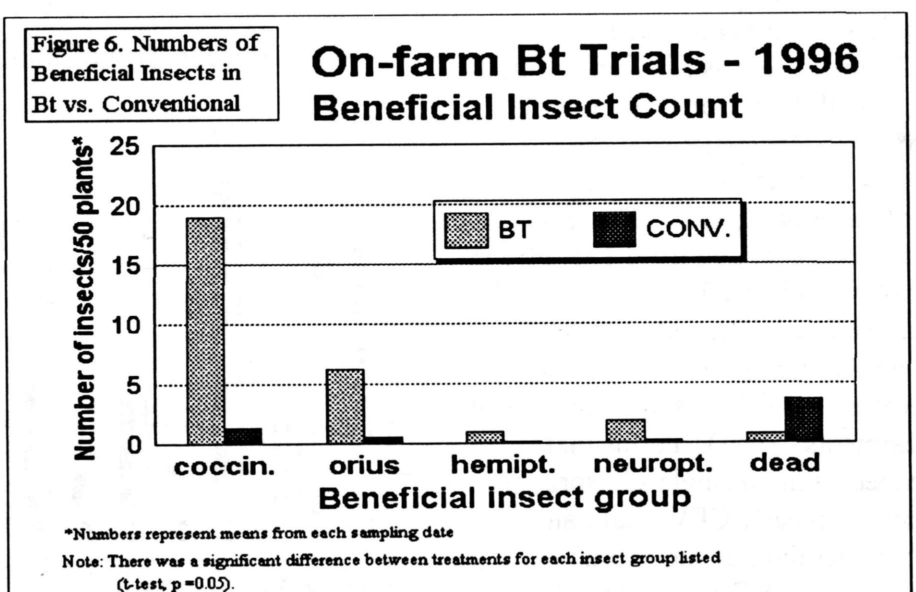
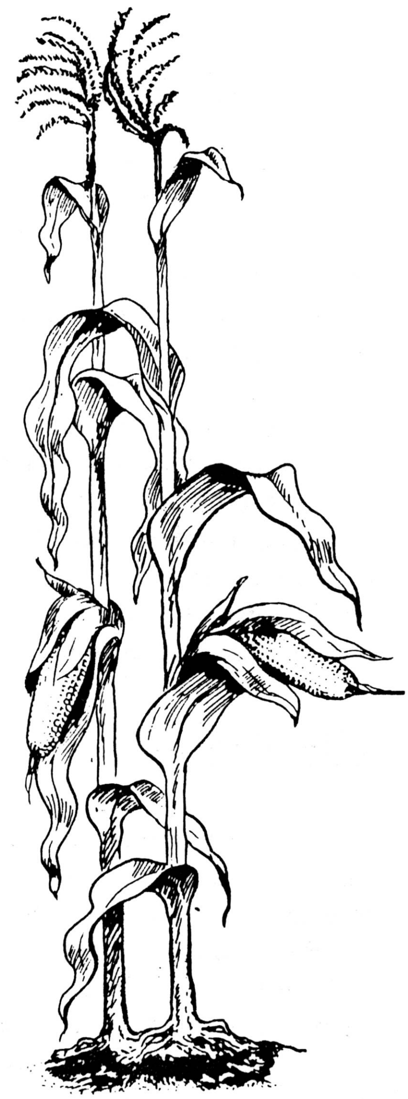


Figure 6. Numbers of Beneficial Insects in Bt vs. Conventional

Summary, 1994-1996:



A total of forty-two trials were completed over the three years. Thirty-six of these compared Bt to conventional insecticides, six compared Bt to an unsprayed plot.

Throughout the three-year trial period, European corn borer pressure was high. The level of infestation at the pretassel stage when treatments were initiated exceeded the action threshold in 34 of the 36 trials. Infestation ranged from 6% to 98% with an overall average of 43%, far in excess of the level that will result in ear damage if left uncontrolled. In many cases, infestations remained high during tasseling and two to three applications were required to achieve control. This occurred in both Bt and conventional blocks.

In trials with unsprayed corn, damage from corn borer in untreated plots was high, averaging 25.5%. Bt significantly reduced the damage from ECB, with an average damage level of 4.6 % (Figure 5).

The Bt-based products were as effective as conventional products in controlling pest damage to the ears. The average damage for all 36 trials was 5.1% in Bt blocks and 3.9% in conventional blocks, a difference that is not statistically significant (see Table 1). Over the three year period, control with both Bt and conventional products ranged from 76-100%.

The three Bt products were comparable in effectiveness. Based on three years of data, the average ECB damage was 6.1% for Dipel ES, 4.9% for Condor and 4.4% for MVP, not a significant difference.
Airblast and boom sprayers resulted in equally good control (up to 100% clean ears) when applying Bt. Ear damage averaged 5.6% for airblast sprayers (n= 20) and 5.0% (n=13) for boom sprayers.

The use of a spreader-sticker may have improved the effectiveness of the Bt products. Two instances where growers did not include a sticker with Bt, one in 1994 and one in 1995, resulted in poorer levels of control than conventional products. 1996 trials at UMass Research Farm did showed a slight, though not statistically significant benefit from a sticker. The benefit was greater with Dipel ES than with MVP.

Table 1. Comparison of Avg. % Damage fromECB in Bt and Conventional Blocks

Year	# of Trials	Bt	Conventional
1994	13	4.6	2.8
1995	11	4.3	3.2
1996	12	6.6	5.9
1994-96, pooled	36	5.1	3.9

[1] Means of the two treatments in each row are not significantly different. (t-test, $p = 0.05$)

Grower Evaluations

Growers were asked about their assessment of the Bt products. Fourteen (82%) were satisfied with the control they achieved with Bt and plan to use Bt in all or part of their early corn in the future. Three (18%) were not completely satisfied, and felt that they needed to test the Bt products further, on a trial basis, before using them widely on their farm. Two growers observed more feeding damage on the husk than was acceptable to them; the rest had no problem with husk damage in Bt plots.

When asked about their reasons for using Bt, growers most often listed applicator safety, noting that they like handling a safer material. Relations with neighbors was also given as a plus; with the Bt's, they don't have be as concerned about drift of highly toxic materials, and fields do not have to be posted with bright "restricted pesticide" signs as they do with conventional products. Farmers also like the fact that Bt-based materials are easy on beneficial insects, and that workers can re-enter the fields within hours after an application. As long as they can count on good control, growers said they that, if necessary, they would be willing to pay a little more for a product that is safer to handle.

Discussion

These results show that Bt products can be integrated into a standard IPM system for European corn borer control, as a direct replacement for conventional broad-spectrum insecticides. Monitoring procedures and action thresholds do not need to be changed in order to use BT products. This is a situation where a safer, equally effective product can be used without additional cost to the grower. Cost, in this context, is more than just the cost of the product itself. Bt products do cost the same or only slightly more than conventional products ($9-15/acre/application). Other significant costs are the farmer's management time for scouting and spraying, the cost of equipment, and the cost of any crop losses from insect damage. These, too, are equivalent with conventional and Bt products. The benefits of Bt -- more worker safety and easier relations with neighbors -- should not be underestimated. These are also part of the cost of farming today.

Successful use of Bt's for ECB control was not limited to any single type of sprayer design. Growers with either airblast or boom sprayers should be able to achieve effective control, assuming their equipment provides spray good coverage.

The beneficial insects that are conserved under a Bt regime can potentially have an impact on the whole farm. Early corn is one of the most attractive habitats on the farm for predators seeking food in June and early July. Aphids, insect eggs, pollen, and caterpillars are all found there. The ladybeetles, insidious flower bugs and other predators that feed in early corn will reproduce, and along with their offspring will move into other habitats as the season progresses.

Recommendations

The following practices are suggested for farmers who want to use Bt for European corn borer control in sweet corn:

* As with any new product or practice, test Bt products on just one section of early corn first, before committing a large amount of acreage.
* Monitor European corn borer flight with pheromone traps, and begin scouting early corn fields at the pretassel stage after first-generation flight has begun. Use the 15% threshold.
* When applying Bt products, use an adequate rate. We have used rates that are at least two-thirds of the maximum label rate. Lower rates may give poorer control.
* Spreader-stickers are recommended. Our results are inconclusive on this issue; replicated trials showed only a small benefit from using a sticker, while grower trials suggest a significant benefit. Spreader-stickers can be used without adding significantly to the cost (less than $1 per acre/application).
* As always, make sure you have good spray coverage of the tassel and ear zones of the plant throughout the entire block of corn.
* Make applications 5-7 days apart. A study at UMass showed that weekly treatments with Bt were as effective as twice-weekly treatments. Use spray intervals that have worked effectively for you in the past.
* Corn should be re-scouted after one or two applications to determine the need for more treatments. If ECB flight is high during tasseling and silking, new larvae may be hatching and controls may be needed to protect ears.
* If corn earworm arrives during the silking period, switch to a broad-spectrum material. Although corn earworm larvae are susceptible to Bt toxins, many larvae enter the ear without feeding and so will not ingest a toxic dose. Bt will suppress corn earworm, but not to an acceptable market level.
* In late-season corn, during the second ECB flight, Bt can be used whenever corn is susceptible and infested with ECB, but is not with corn earworm. For example, Bt can be used to control ECB at the tassel stage, followed by broad-spectrum materials against corn earworm during silking.

Note: We would like to express our appreciation to the following farmers and consultants who participated in this study: John Arena, Jr., Gordon Bemis, Jeff Bober, Jeff Cole, Paula Cruz, Ken Foppema, Dave Harper, Al McKinstry, John Miczek, Steve Mong, Ron Patenaude, Ray Rex, Laura Tangerini, Jim Ward, John Weinach, Tim Wheeler, Paul Willard, Sandy Williams, Mike Yates, and Jim Mussoni; and to Abbot Laboratories, Mycogen Corp. and Ecogen, Inc. for supplying product and financial support. We would also like to thank Dan Wasiuk, Mark Mazzola, and Joe Marcoccia for technical support. This work was supported in part by funding from USDA, Northeast Region SARE/ACE program, grant # 95ANE95.26 #1.

Issued in furtherance of Cooperative Extension work, Acts of May 8 and June 30, 1914, in cooperation with the United States Department of Agriculture.

Publication # C-220

AG-1270/300-6/97