SESSION 4

Small Group Sessions by Crop or Insect Pest

Each of the small group sessions on the second day focused on a single crop family or on a particular pest. In sessions about a crop family, the moderators were asked to have the group consider the whole range of insect pests on that crop, including pests for which no presentation was scheduled, so that questions about other pests could be addressed. (This either did not happen or was not recorded in some sessions.)

Corn and Sweet Corn

The group identified fall armyworm, aphids (especially as vectors of barley yellows virus), and sap beetles as important pests in addition to corn earworm and European corn borer. Fall armyworm is addressed in Ruth Hazzard's presentation and in the discussion, and sap beetles are addressed near the end of the discussion.

Integrating Microbial Insecticides and Oils into Sweet Corn IPM

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Fresh market sweet corn is a major vegetable crop in the Northeast. In Massachusetts, it comprises about half of the acreage in vegetables, with 8,000 acres grown. Caterpillar pests of corn, which feed directly on sweet corn ears inside the husk, cause from 10 to 100% unmarketable ears if left uncontrolled. Currently, farmers use multiple applications of restricted-use, broad-spectrum insecticides to control these pests. This project has evaluated foliar and direct silk applications of microbial insecticides and vegetable oils as alternatives that pose less risk to applicators and the environment and that conserve natural enemies. Our work with direct silk applications of oil arose from farmer-to-farmer meetings that took place in 1992–1994, in which sweet corn farmers identified corn earworm as their number one unsolved problem in growing corn organically. Farmers have continued to be involved in the conception and evaluation of these methods.

Early-Season Corn: European Corn Borer Control

In early-season corn in New England, European corn borer (ECB) is the primary insect pest. Commercial *Bacillus thuringiensis* products were tested in 1994–1996 in 34 trials conducted on 17 farms in Massachusetts. Standard sweet corn IPM scouting methods, thresholds, and spray intervals were used (15% infested plants, five- to seven-day intervals). Bt products gave nearly equal control of European corn borer compared to conventional materials (within 2%, statistically not different). Higher numbers of beneficial insects were present in Bt-treated plots than conventional plots following insecticide applications. Over 80% of participants were satisfied with the control they achieved and planned to use Bt in their early corn in the future.

Replicated experiments at the University of Massachusetts showed that weekly applications of Bt products were as effective as twice-weekly applications in controlling ECB. The cost per acre for Bt products is equivalent to conventional products. An average of 1.0 pint active ingredient/acre of restricted pesticide would be eliminated by adoption of Bt products for early-season ECB control. These results suggest that Bt products can be integrated into a standard IPM system for ECB control as a direct replacement for conventional insecticides with no extra cost to growers and with positive benefits to the agro-ecosystem.

Late-Season Corn: European Corn Borer, Fall Armyworm, and Corn Earworm Control

In late-season corn (harvested in August and September), second-generation European corn borer (ECB), migratory corn earworm (CEW), and fall armyworm (FAW) are present in varying densities, depending on the location and the season. Corn earworm moths typically lay eggs on the silk, and newly hatched larvae rapidly enter the ear through the tip. Applying an oil/Bt barrier to the silk at the tip of the ear causes mortality to any caterpillars that enter through the silk channel. This includes all corn earworm larvae and many of the European corn borer and fall armyworm larvae.

Through replicated experiments at the University of Massachusetts (UMass) Research Farm, Hampshire College Farm, and at Applefield Farm in Stow, Massachusetts, we determined the timing and rate of application, type of oil, and ratio of Bt to oil to obtain the best control with optimal kernel development. We found that 3–5 milliliters/ear of corn oil, applied when full-grown silk begins to wilt, with a ratio of 20 parts oil to 1 part Bt product, gives optimal control. Oil barrier treatments consistently yielded two to three times more marketable ears than untreated controls, with results ranging from 65% to 100% undamaged ears compared to 18% to 87.5% clean in controls. Commercially acceptable levels of control (90–100% undamaged ears) were achieved in experiments where two foliar applications of Bt were used at the tassel stage, in combination with the direct-silk oil treatment.

Corn oil, though not sold as a pesticide and not registered under FIFRA (Federal Insecticide, Fungicide, and Rodenticide Act), is exempt from FIFRA under section 152.25b. Under a new ruling from the U.S. Environmental Protection Agency (EPA), because it is a food product, it is also exempt from residue tolerance requirements. This means that it can be used on crops that are sold. This may also be true of some other vegetable oils; however, it would be best to check with specific EPA guidelines before using other oils in commercial crops. For example, peanut oil is not exempt from residue tolerance because it is a common allergen. For more information, contact the Biochemical Pesticides Branch in the Division of Biopesticides and Pollution Prevention under the Office of Pesticide Programs at the EPA.

Oil Applicator Development: The “Zea-later”

With this corn earworm control method, it is critical to apply oil to each individual corn ear. How can this be done economically for the farmer and comfortably for workers? This has been a primary challenge of this project. A hand-held oil applicator was designed and built by a group that included students, faculty, and staff from UMass and Hampshire College. This device uses a syringe pump mechanism inside a specially designed handle and draws oil from a lightweight waistbelt tank. The applicator is designed for ease and comfort of the hand while delivering oil to each ear. It reduces the hours of labor required for direct treatment of silks to eight to ten hours per acre. On a farm with 10–20 acres of sweet corn, one-half to 1 acre would need treatment at any given time during the season. The cost for labor and materials for this late-season biointensive system is estimated to range from $110 to $140 per acre, which is comparable to the cost of conventional or IPM management based on a series of foliar sprays with broad-spectrum insecticides at three- to six-day intervals.

Six farmers tested the oil applicator in 1997, and reported positively on its ease of use and effectiveness. In 1998, we manufactured a small test run of oil applicators at Hampshire College through the Lemelson Program for Innovation and Invention. These — known as the Zea-later— were advertised through brief articles in two national organic magazines. Orders came from California, New Mexico, Tennessee, Illinois, North Dakota, Rhode Island, Massachusetts, Vermont, and New York.

The Future

This strategy is of greatest interest to organic growers who currently have no method of control for corn earworm and face significant loss in crop value and sales due to corn earworm damage. If it proves to be reliable and cost-effective, it may also be of interest to IPM sweet corn growers with 10–15 acres who are seeking alternative methods. The results of this project are applicable throughout North America, wherever fresh market sweet corn is grown and corn earworm is a key pest. Future plans include working with more growers to evaluate the method and the applicator, and encouraging commercial manufacture and distribution of the Zealater applicator.

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Corn Earworm and Other Challenges of Growing Corn Organically

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We've been growing sweet corn organically for our farm stand going on ten years now. In that time, we have developed a system for planting and cultivation that I feel is quite effective in what I consider to be the biggest concern, and that's growing the crop in a cost-effective manner.

Insect pests — corn borer and corn earworm — are problems for which some solutions have been found in the last couple of years. I will talk of our farm strategies, such as trying to convince customers that the worms are okay, and the work that we've done with our state's cooperative extension, testing Bt products for corn borer and using oil/Bt drops applied to the just-emerged silks. (I actually did it to over 3 acres of corn.)

As a farmer, I understand the different needs of the direct retailer versus the wholesale grower, so there is no one-size-fits-all strategy. I'll be telling of my experiences growing about 12 acres of sweet corn on our farm.

P.S. If spraying were banned for corn earworm, I wonder how much sales would actually drop (after people adjusted) and whether the savings in not having to apply all that material would offset the reduced income.

Biological Control of European Corn Borer in Sweet Corn with Trichogramma ostriniae

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Sweet corn is an important crop in the northeastern United States, and several insect pests plague it. The most important insect pest is the European corn borer (ECB), because it is present most of the season. Because of stringent quality standards and the high value of fresh market sweet corn, growers often apply multiple insecticide treatments to each planting to control ECB. This heavy use of insecticides is expensive, poses environmental risks, and can create conflicts between farm and urban neighbors.

One alternative for management of ECB is biological control. As part of a continuing effort to establish natural enemies of ECB in the United States, *Trichogramma ostriniae,* an important egg parasitoid of the Asian corn borer, was introduced into the United States from China in 1991. Several million have been released in New York, but to date we have not recovered it the year following a release. Apparently, it does not overwinter.

Based on trials in the United States and its effectiveness against the Asian corn borer, this species has potential for augmentative biological control of ECB. In augmentative releases, about 120,000 wasps are released weekly for two to three weeks. In the first U.S. trials, Chuck Mason at the University of Delaware (unpublished) recorded 97.3% parasitism of naturally occurring ECB eggs in sweet corn and Hoffmann et al. (1992) reported ~60% parasitism of sentinel eggs. In 1996, on-farm evaluations of *T. ostriniae* showed parasitism rates ranging from 70 to 80% (Seaman et al. 1997). Given all of these reports, *T. ostriniae* appears to be a very promising species for control of ECB in sweet corn and potentially in other crops.

Although the emphasis to date has focused on repeated inundative releases of *T. ostriniae* for control of second-generation ECB infestations, another release strategy may hold promise for suppression of infestations. Because of its ability to rapidly disperse and successfully reproduce in the field, early season inoculative releases of *T. ostriniae* would essentially "restock" the farm each year. In 1997 and 1998, we demonstrated that this technique has considerable potential.

On four diversified fresh market vegetable farms, we made early-season releases of relatively few *T. ostriniae*. Following releases, we recorded parasitism of ECB egg masses for eleven weeks in 1997 and for eight weeks in 1998. Over the two years, parasitism rates ranged from 44 to 84%, and generally all eggs in egg masses were parasitized. Parasitized egg masses were recovered 100 meters from the release site, supporting earlier observations that *T. ostriniae* disperses considerable distances. Identification of emerged wasps from several dates and locations showed that ECB egg parasitism was due to released *T. ostriniae*. Parasitism of ECB eggs in sweet corn by *Trichogramma* spp. indigenous to New York is generally less than 5%.

These results are very encouraging and suggest that inoculative releases of *T. ostriniae* for control of ECB hold potential. Even under low ECB densities, *T. ostriniae* successfully "established" on the farm, survived insecticide treatments, and dispersed considerable distances. Inoculative releases of *T. ostriniae* would be relatively inexpensive, because only a single release is needed and relatively few wasps are released. We estimate the cost to be about $13/acre ($6 for 60,000 *T. ostriniae* and $7 for labor to deploy). In contrast, a single application of insecticide using a "highboy" sprayer is $20–27/acre. Less labor-intensive release technologies and reduced release rates could reduce the cost greatly.

Because of its simplicity and low cost, growers should adopt this tactic. In its simplest form, growers could make releases to coincide with mid-whorl corn and incorporate the benefit of the release into their IPM programs. Less larval damage would result in fewer fields exceeding damage thresholds. Alternatively, where the number of ECB egg masses is used as the action threshold, parasitized (black) egg masses would not be counted. We plan to refine this biological control tactic over the next two years. The objectives of that work include:

- determine impact of releases on crop quality,
- evaluate releases under a range of environmental conditions and ECB densities,
- optimize number of release points/acre,
- optimize field delivery system, and
- determine compatibility of releases with current insecticides.

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Discussion: Corn

Audience: What do you do to control weeds?

Steve Mong: First, for any direct seeded crop, the seeds must go into freshly prepared ground. If you don't grow much corn, wait until the soil warms up so you get faster germination. Then, blind cultivation before the crop emerges is critical. The time you have depends on the soil temperature and time of year, but it is just a few days — three to six days — and be sure you do your cultivation early enough. It is dangerous to go very deep just before the corn spikes through the ground. If your soil is warm and you time your first blind cultivation right, the corn will come up ahead of the weeds in the row.

My last cultivation is with an aggressive disk tiller. The corn is high, and you just bury it. That gives you good weed control, but I don't get 100% and don't try to.

Audience: How hard is it to use the "Zea-later"? Could you send out hired help to use it to apply the oil?

Ruth Hazzard: Yes, one farmer had a 16-year-old applying it for three or four hours a day. One of our big questions was the physical aspect of using the hand-held applicator — would the motion cause hand or wrist strain? We have concluded that it doesn't.

Applying the oil takes about eight to ten hours per acre. With the cost of hired labor and materials, the maximum cost is about $100 per acre. Most of our growers are growing 10–15 acres of sweet corn or less and doing succession planting, so they probably have to do about an acre a week. They send someone out for three to four hours, maybe two mornings per week. It's practical.

Steve Mong: You don't have to be very precise — touch the oil to the high point of the silk and it will run. You just have to get in close.

Eric Sideman: Do you use the IPM threshold from the pheromone trap to time the oil applications? In Maine, we didn't get earworm in our traps until the end of August this year.

Ruth Hazzard: In the IPM program, you put a net trap with a corn earworm pheromone lure into silking corn. If you catch two moths per week in the trap, with that system, you would begin a spray schedule and spray every six days. That's not very many corn earworm moths in the field, but because they lay so many eggs and all it takes is one per ear, with two moths per week in the pheromone trap, you get some damage. I would certainly say that if you have your traps out and you aren't catching any moths, you don't need to do anything. But if you start catching moths, you have to decide whether to use two moths as the trigger. We need to work this out. There may be a little room for adjustment.

Eric Sideman: Michael, have you used pheromone traps to time releases of *Trichogramma* against the corn borer?

There was some discussion back and forth. Trying to use pheromone traps to time the release precisely is tricky. The relationship between trap catch and the beginning of oviposition is not perfect. Also, the emergence of the *Trichogramma* may vary depending on temperature. It seems that, ideally, you might want to release the *Trichogramma* just before you begin catching moths in the pheromone traps. But *Trichogramma* parasitize eggs of other moth species besides corn borers, and the adults survive in the field for a while, so they would probably successfully establish themselves even if they were released well before the corn borer flight. That is why releasing at mid-whorl is his current recommendation.

Steve Mong: When I did the *Trichogramma* releases, I would order them to begin arriving in mid-June, and I had a scheduled delivery preordered to arrive every week for the next three to four weeks.

Audience: How many releases do you recommend per acre?

The Europeans recommend 20 release points per acre. Mike Hoffmann mentioned that *Trichogramma pretiosum* is not as effective as *Trichogramma ostriniae* against European corn borer. *T. ostriniae* is not yet widely available, though — so far, only from the Beneficial Insectary. (See appendix B, Sources of Commercially Available Biological Control Agents, for an address. Note that their supply of *T. ostriniae* is currently limited, so they would appreciate ordering well in advance.)

A discussion of European corn borers in peppers followed. There has been some research into the relationship between trap catch and when the first instar (newly hatched) corn borers appeared. In peppers, the current recommendation for using *Bacillus thuringiensis* (Bt) or for other insecticides is to begin treatment seven days after the moth flight begins and then apply the Bt twice per week. This is a conservative threshold in some ways — there are sometimes moth flights detected by the pheromone traps which are not followed by an infestation in the peppers. The frequency of application of Bt is necessary because the newly hatched corn borers have to eat the Bt while they are still outside the pepper — once they tunnel inside, there is no way to get the Bt to them. And, because Bt lasts only three to four days on the plant, you have to apply it every three to four days to be sure to have it present during the short window when the caterpillars can be killed.

The discussion then moved back to corn and how to use Bt to control corn borers in corn. Pheromone traps are used to detect flights in corn, followed by field scouting to look for damage or actual caterpillars on the plants. If 15% of the plants show feeding damage or have corn borers present, that is the threshold for putting on a foliar application. The same threshold and spray intervals are used for Bt as for conventional chemical insecticides.

Because it had been mentioned earlier that European corn borer has many plant hosts, including smartweed and many other weeds, someone asked if smartweed could be used as a trap crop. The answer was that European corn borer tends to be more of a problem in weedy corn. In some cases, an alternative host might lure insects away, but in other cases it may increase the problem. Someone else brought up the use of a living mulch of red clover. There is evidence that it can decrease the abundance of corn borers, but Ruth Hazzard pointed out the potential problems. If you have established red clover and till strips in it to plant the corn, it is tricky to do this without creating competition between the clover and the corn. You would have to know how wide the strips need to be and when to mow the clover to minimize the competition. If you planted the clover after the corn, it might not be large enough to have an effect by the time the corn borers arrive.

Next, the discussion moved on to fall armyworm. Ruth Hazzard and Steve Mong said that a combination of Bt and oil applied to the silk works well for fall armyworms entering the ear from the top when the ear is silking. But fall armyworms can also enter the ear early, before the oil is applied, or they can enter the ear from the side. Ruth Hazzard also said that the use of traps with pheromone lures does not work as well with fall armyworm as with the other species, because it does not give enough early warning. For fall armyworm, you must rely more heavily on scouting the corn in the whorl and tassel stages.

Then, sap beetles: Sap beetles lay eggs in the corn silk. Their larvae look like maggots. They are generally a secondary problem on an ear already damaged by European corn borer or feeding by birds, etc. Some steps that may help are: (1) sanitation — reduce populations by eliminating other hosts — bury excess fruit on the farm, and (2) grow corn varieties with tight husks.

Ruth Hazzard reported on the progress of the "Zealater" device. She still needs to find a company to manufacture it. There are already companies that want to distribute it. The example she exhibited cost $80 to make and sold for $100. She would like to reduce the manufacturing cost to $30. Because the device is not now in commercial production, anyone who would like to purchase the device should contact Ruth Hazzard directly.