Focusing on Corn Earworm and Resistance Management

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Sweet corn receives more foliar insecticides than most vegetable crops in our region to control three lepidopterans - corn earworm (CEW), European corn borer, fall armyworm – that are the "worms" infesting sweet corn ears. Sprays are timed during reproductive plant growth stages, which disrupt conservation biological control. Of these three pests, the corn earworm is the target of the greatest spray intensity. Here, we focus on why and how that influences management, based on (1) movement ecology, (2) feeding ecology, and (3) pyrethroid resistance.

Movement ecology. CEW adults fly when evening temperatures exceed 55^0F, with increasing activity at higher temperatures. Their movement is either (1) resource-directed (in search of mates or food), or (2) migratory. CEW does both very well. An understanding of CEW's evolution helps explain these behavioral adaptations. CEW evolved from tropical or warm-temperate species, feeding on flowers and young fruits, with development continuing throughout the year except where there is a dry season. In contrast to its relatives, CEW retains more anscentral traits. It co-evolved with patchy food resources (flower buds and young fruits), obtained though a resource-directed flight. Thus, CEW successfully widely disperses many, hundreds to even thousands of eggs, far more than the other derived species. It also has a much wider host range. By depositing eggs individually, and by larvae being cannibalistic, the progeny are distributed well and have a good food resource to exploit.

Tied to tropical/warm-temperate ancestors, CEW does not overwinter well. Pupae can overwinter (or escape drought) in soil, at a depth of about 2-4", but literature suggests no overwintering north of 40-degrees latitude (a line through Philadelphia, Lancaster, and south of Pittsburgh). We see some lower densities early in the season, but our heavy flights occur late in the season as part of an annual migratory re-invasion from the south, which affects the entire continental interior extending into Canada. This migration probably involves successive broods advancing northward. Long-range migratory flight is documented through citrus-pollen markers, radar, and carbon-isotope signatures. They can display spiraling vertical takeoff flight at dusk which carries them above the boundary layer where they concentrate into prevailing nocturnal wind jets associated with temperature inversions. Airborne radar indicates that this persistent and straightened-out movement probably enables corn earworm to move a few hundred kilometers a night. We can monitor this re-invasion with wire cone traps baited with sex pheromones which capture only males. They are attracted to lights, and blacklight traps are effective but difficult to maintain. Pheromone lures can be purchased from Great Lakes IPM or Gempler's, and we recommend replacing lures every 2 weeks. Keep lures refrigerated or in a freezer while in storage. A cloth net trap will work, but they have not performed as well. Trap size matters. The larger Hartstack traps capture approximately twice the rate as smaller wire cone traps. Location of traps also matters. The moths are attracted to silking corn. Traps need to be placed near a corn field, and it helps to move the trap to actively silking corn. For CEW, keep the area immediately around the trap kept free of tall weeds or debris. We track these pests on a regional basis. There is a lot of noise in the data - but the data aggregated over a region provides information about trends and advance warning. A regional infrastructure exists through linked GIS and Web technology ("web-mapping"). Data come from Virginia (T. Kuhar & A. Herbert, VA Tech), Maryland (R. Bean, MD Dept. Ag), Delaware (J. Whalon, U. DE), Pennsylvania (PVGA & ~18 Extension Educators), New Jersey (K. Hollstrom, NJ IPM program), New York (A. Seaman NY IPM), Massachusetts (R. Hazzard, U. MA), and Maine (D. Handley, U. of Maine). A website – www.pestwatch.psu.edu – gives you access to pheromone trap data as "Clickable Maps". The software uses MacroMedia Flash to visualize changes over time as animations, while individual dates can be seen as still frames with each sampling site linked to time-series graphics. The default displays the last created corn earworm map and GIS functionality is provided through a small set of graphical function buttons. Move the time bar to relevant time points to see the migration.

Feeding ecology. CEW is well-adapted to our ephemeral cropping systems. It achieves pest status in maize, cotton, tomatoes, snap beans, sorghum, soybeans and other row crops. Larvae feed on flowers, fruits, and seeds, boring quickly into reproductive tissue, resulting in direct damage to the economically and nutritionally important plant parts. Management through insecticides or biological control is difficult once larvae gain access to the interior of fruiting bodies. Coupled with distributing eggs singly among fruiting structures, damage rates become economically significant very quickly, and can be disproportionately high relative to moth density. Females are strongly attracted to fresh silks, where they lay 500 to 3,000 eggs (average ~ 1,000 individually directly on the silk, or other tissue or hosts when corn silk is not available. Eggs hatch within ~2 to 4 days during the Pennsylvania summer. Larvae crawl away from light, and towards moist, shaded areas. When on silks, hatching larvae feed on the silk and burrow into the ear. As they mature through 6 instars, they leave large amounts of frass. Larvae vary from greenish to yellow to reddish, with longitudinal stripes which are actually microspines along the body giving the larvae a rougher feel then the other species. The head is tan to yellow, which helps distinguish it from FAW or ECB, which have darker head capsules. Foliar sprays need to contact the developing larvae as it moves down the silk tube into the ear. Transgenic cultivars (Bt-sweet corn) can also be effective against CEW. To work, young CEW larvae need to feed on silks expressing the Bt protein toxin. Stressed plants or drying silks may not express the protein as well. More research is needed to develop reliable IPM efforts with Bt sweet corn.

Pyrethroid resistance. Most of the selection pressure is occurring in agroecosystems to the south. Pyrethroid resistance is well documented from the deep south, but we have had difficulty demonstrating resistance in our area. We tested moths collected in two methods, in standarized adult vial test (AVT) bioassays. First, we used moths collected from pheromone traps – this tests only males that have flown for an unknown distance, and are of unknown ages. Second, we collected larvae from corn ears in the field, and reared them on a diet. This tests both males and females, prior to them flying, and at a very young adult age. In both cases, adult moths were held in cages for 24 hours with sugar water prior to the bioassay, and we only tested moths that appeared healthy at the time of the test. The bioassays were in glass vials were coated with 5 micrograms or 10 micrograms of cypermethrin/vial. Control vials were treated with acetone alone. Mortality was recorded at 24 h. In a perfect situation, we should expect to see 100% survival of the moths in the control vials, very close to 0% survival of the moths tested at the 5 microgram rate, and definitely 0% survival at the 10 microgram rate. With moths from pheromone traps, most die as would be expected. This suggests that we do not have resistance here, and most of our data are of this type. However, survival rates are high with moths reared from larvae taken from ears of corn. We cannot say if this is an artifact of the bioassay procedure, gender, age, or a sign of resistance. Scientists from the Upper Midwest also see high survival with moths reared from ears of corn. But the Midwestern scientists also see significant increases in LD50s and LC50s in complete laboratory bioassays, and poor control in replicated small-plot efficacy trials, with several pyrethroids. One Pennsylvania population showed small to negligible increases in LD50s, and mid-Atlantic small plot efficacy trials have not shown problems with pyrethroids. So we have conflicting information about pyrethroid resistance in our area: most of the data are showing no resistance, and there is no consensus opinion. In my opinion, it is time to stop asking if we have pyrethroid resistance. We need to rephrase the question, and ask where and to what degree we have pyrethroid resistance, and recognize that we have significant resistance populations to the south and west of our region. My opinion is that pyrethroid-resistant corn earworms occur in the northeastern U.S., but that they may be rare and hard to find. Since we are dealing primarily with migrants, we cannot do much to alter the selective pressure that the moths are subjected to. In other words, altering the chemicals we use here will probably not have much impact on the population genetics of the corn earworm. That will require alterations at the place where breeding is occurring, which is to the south of us.

So what alternatives exist? First, realize that corn earworm often arrives late. Using pheromone traps on your farm, and watching the immigration approximated by a network of pheromone traps, helps you gauge when this pest is arriving. Second, we currently expect the pyrethroids to continue to work, especially at lower population densities, and most of Pennsylvania rarely gets extremely high densities. Third, Bt-sweet corn is an option. You could use Bt-cultivars for plantings you expect to harvest in late August or thereafter. Do NOT expect to eliminate all sprays: Bt-sweet corn is very effective against European corn borer and corn earworm, but less effective against fall armyworm, and in the absence of any sprays we have seen problems with sap beetles, several species feeding on silks, and some aphid problems. Fourth, tank-mixing with, or switching to, the older carbamates or phosphates (Lannate or Larvin) if high rates of immigration occurs is an option. Be careful, these are materials with lower LD50s (and thus are more toxic to humans), and while we expect them to work today, the corn earworm had a history of resistance with carbamates and phosphates in cotton many years ago. Fifth, switching to an entirely new class of chemistry, with SpinTor® or Entrust®, is an option. This has shown to be effective in tests in New York, but less so under higher pressure in neighboring mid-Atlantic states, and we don't currently have much data from Pennsylvania. Sixth, there is the old method of putting oil on the silks. This has been developed as a method for growing organic sweet corn, with a backpack application method called the Zealator.