INSECT MANAGEMENT IN SWEET CORN

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As a region, the northeastern states lead the nation in fresh-market sweet corn. Soil and early season insects need to be managed to ensure a good plant population, and to avoid Stewart's wilt transmitted by corn flea beetle. These include wireworms, white grubs, seedcorn maggot, black cutworms, corn flea beetles, and western corn rootworm. Rotation controls rootworms, and helps with several of the other soil insects. Cultivars exist that are resistant to Stewart's wilt, and seed treatments are effective for several of these pests.

In-season insect management that affect most insecticide sprays are based on the timing and intensity of pressure from three lepidopterans: the corn earworm (CEW), European corn borer (ECB), and fall armyworm (FAW). CEW infests from tips of the ears. ECB and FAW enter tips, sides and bottoms. Transgenic cultivars are available and effective for CEW and ECB, help control FAW, and sometimes need control from sap beetles or silk-feeding insects. Oil applications to silks, combined with Bt and/or some spinosyn formulations may be a certified organic option. All of these options benefits from understanding the biology, ecology, and monitoring of all 3 species.

The CORN EARWORM, is a night-flying moth able to move long distances. It overwinters as a pupa in soil, at a depth of about 2-4", and we see low densities early in the field season, which may reflect some overwintering, but it does not overwinter well in Pennsylvania, and our heavy flights occur late in the season as part of an annual re-invasion from the south. Adults emerge in the spring. They are tan to buff-colored, sometimes with olive shading, with a wavy darker band near the edge of the wings of younger specimens. The eyes have a distinctive serpentine green reflection when held up to sunlight in live specimens. A darker brown spot is located about midway along the outer edge of the front wings. They fly when evening temperatures exceed 55^0F, with increasing activity at higher temperatures. They can be caught up in winds and storms, and deposited with the weather patterns. Females are strongly attracted to fresh silks, where they lay the eggs individually directly on the silk. A female can lay 500 to 3,000 eggs, and average about 1,000 per female. Eggs will be laid on other tissue or hosts when corn silk is not available. Eggs hatch in 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. They are cannibalistic, which tends larvae to one per 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.

The EUROPEAN CORN BORER can feed on ~ 250 plant species. The moths are yellowish buff to light tan, with dark zigzag marks across the wings, and a ¾-1" wing spread. Moths hide in grass, weeds, and during the day, but readily fly short distances when disturbed. They are active during late evening and night. Adults congregate where dew forms (grassy/weedy areas or alfalfa); the free water increases the potential eggs per female. The eggs are usually glued to the undersides of leaves, in small irregular, white, and very flat clusters which resemble overlapping fish scales. Clusters contain ~12 – 20 eggs, each about half the size of a pin head. After 3-5 days, the eggs change from white to a yellowish color, and just before hatching a dark spot (the head capsule) is visible in each egg. First generation eggs hatch in ~ 7 - 10 days, 2^{nd} generation in ~5 - 7 days. The larvae are dirty white, often with a pinkish tinge. The skin is smooth, free of hairs, with numerous dark spots. The head is dark brown to black. Pupae remain

inside the plant, but are present for only short time in late spring and in July. There are two generations per year in Pennsylvania. They overwinter as fully grown larvae inside stalks and residue of plants, and transform into the pupal stage from late April to early June. Moths emerge over a long period: from early May in southeastern areas to late June in northern counties. The majority of 1st generation eggs are deposited from mid-May to mid-June. The newly hatched larvae chew small, round holes in the leaves, then move to the main stalk or ear, and complete growth inside the stalk or ear in ~ 3 weeks. Pupation takes place during July and early August. 2nd generation moths emerge and lay eggs from late July to late August. 2nd generation larvae complete growth before cold weather, and then overwinter in their plant burrows– those that have not obtained full growth usually die. First symptoms appear a few days after larvae hatch as small pin holes in leaves and fine sawdust-like frass (excrement) scattered over the upper surface of the punctured leaves. Other symptoms include frass and damaged leaves in the whorl. Larvae commonly move to tassel area, and infested tassels break over. Because this species overwinters, we can model the timing of the occurrence of each life stage with degree-day models – which we call phenology models.

FALL ARMYWORM adults grayish to buff color with a 1-1/2"wing spread. The front wings of a fresh male are dark gray with mottled splotches and a small whitish area near the wing tips. The front wings of the female are the same color but the markings are less distinct. Adults are seldom seen because they hide during the day and are active at night. The dome-shaped, sculptured eggs are laid on grass blades and plant leaves in clusters of 50 or more. The eggs are dirty white to gray and moderately covered with grayish buff hairs from the female's bodies. Newly hatched larvae have black heads and are white to pale green. Older larvae on vegetative corn consume all leaf tissue except veins and midribs, and hide in the whorl during the day. Fully grown larvae are 1¼ to 1½" and vary from pale green to almost black. The heads have a prominent inverted "Y" and black tubercles from which hairs arise. Pupae are found ~1" in the soil. Their smooth, leathery skin is reddish brown to dark brown. FAW overwinter along the Gulf Coast and migrate into Pennsylvania, usually in late July to mid-August. The eggs hatch in about 5 to 7 days. The larval period lasts ~ 15-18 days. The pupal stage lasts nearly 2 weeks. Fall armyworm activity stops when freezing temperatures approach.

Thresholds change with the corn growth stage.

- Vegetative corn should be scouted, and the percent of infested plants estimated. We can tolerate 15% ECB infestation, and up to 30% on larger, longer-season varieties, before a spray on vegetative corn is warranted. If infestation rates are low, try waiting until the "row-tassel" stage (when you can look down a row and just begin to see the tassels emerge). A single spray timed at row tassel will clean up low infestations prior to the corn moving into the reproductive stages, saving earlier sprays applied to vegetative corn. For multiple plantings on a farm, controlling the early season populations may reduce problems later in the season.
- Reproductive (taseling or silking) conr and the last vegetative stage (V12 stage, just prior to reproductive stages) strongly attracts moths. Spray timing can be adjusted according to moth flight, which is monitored with pheromone traps. Plotting the number of moths caught over time helps determine when populations are increasing or decreasing - which is when to shorten or lengthen your spray schedule. *Remember:* Control programs need to begin at ROW TASSEL. Waiting until silking is late for ECB and FAW.

PHEROMONE MONITORING. Timing insecticides to when the eggs are hatching and the larvae are feeding is critical. This is best done by applying insecticides or oil to silks when the moths are flying, which is within ~ 1 day of when they are laying eggs. The corn earworm is the easiest to monitor with pheromone traps. Traps baited with the proper sex pheromone capture only males. 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. Traps are made from heavy wire hardware cloth, or purchased from Gempler's. A cloth net trap sold by Scentry will work, but they have not performed as well. Traps need to be placed near (or in) a corn field. For CEW, keep the area immediately around the trap kept free of tall weeds or debris, but for ECB higher captures occur in aggregation areas near corn with the mouth of the trap ~1-foot about the weed or crop canopy. Place traps away from trees or wooded areas. Moving traps to V12, taseling, and early silking corn, puts the traps in areas attractive to the moths. Our 2nd best candidate for good quality data from pheromone trapping is FAW. We get very high rates of capture of non-target species, primarily from the non-pest *Leucania phragmatidicola* (there is no common name), but we can clean this up, albeit with reduced FAW capture, using a 2-component lure. Scentry is now selling this as the "FAW-PSU" lure. Data quality is most problematic with ECB, which require separate "E" and "Z" strain pheromone traps - but this is the species for which good phenology models exist. We are working to incorporate phenology models, which would give predictions of the time (but not the intensity) of infestation.

Corn Thresholds based on pheromone trap catch:

We don't have well-developed thresholds for ECB. We have are thresholds designed for CEW, and later adapted to include ECB measured with blacklight (as opposed to pheromone) traps. CEW thresholds were developed on older, large-stemmed, full-season varieties that can withstand more damage. These thresholds (adapted from Dively, Univ. MD) first ask if CEW is a problem:

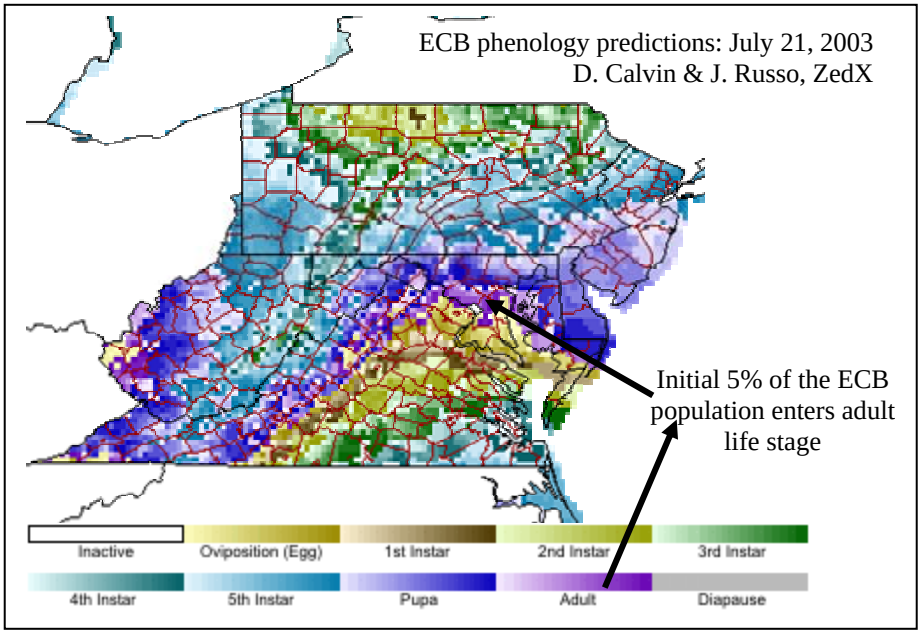
Thresholds based on CEW captures

	CEW catch per week	CEW catch per day	Spray frequency
almost absent	<14	<2	4 days to no spray depending on ECB
very low	14 to 35	3 to 5	5 to 6 day
low	36 to 70	6 to 10	4 to 5 day
moderate	71 to 350	11 to 50	3 to 4 day
high	> 350	> 50	2 to 3 day

When CEW is not a problem, consider ECB. Trapping ECB is improved by placing them near weedy areas, in areas where the dew hangs longest in the day, and keeping the mouth of the trap ~ 12" above canopy height.

ECB thresholds in the absence of CEW, estimated by dividing blacklight data in half because pheromone traps only capture males

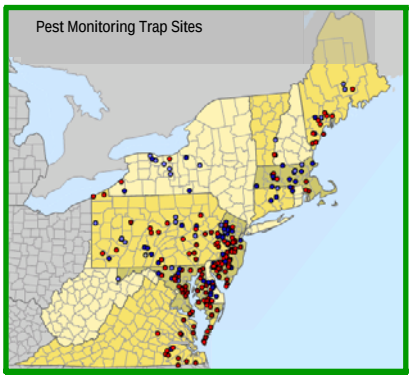
ECB catch per week	ECB catch per day	Spray frequency
< 18 / week	< 2	no treatment
19 to 36	3 to 5	6 day
36 to 70	6 to 10	5 day
> 70	> 10	4 day

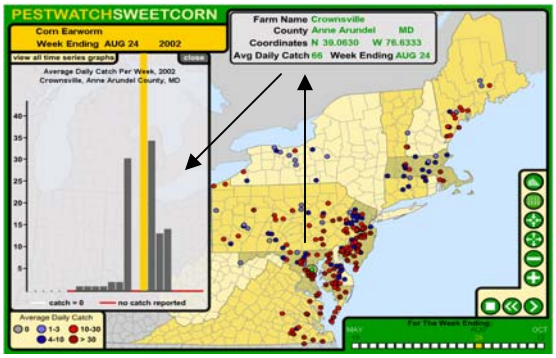


Also, remember that phenology models are now available for ECB. On the website, these estimate when moths are flying at 10-km grid spacing, for the northeast. Models come from Drs. Calvin and Russo, at ZedX, and are linked to the sweet corn website from a USDA grant and the Environment Institute at Penn State.

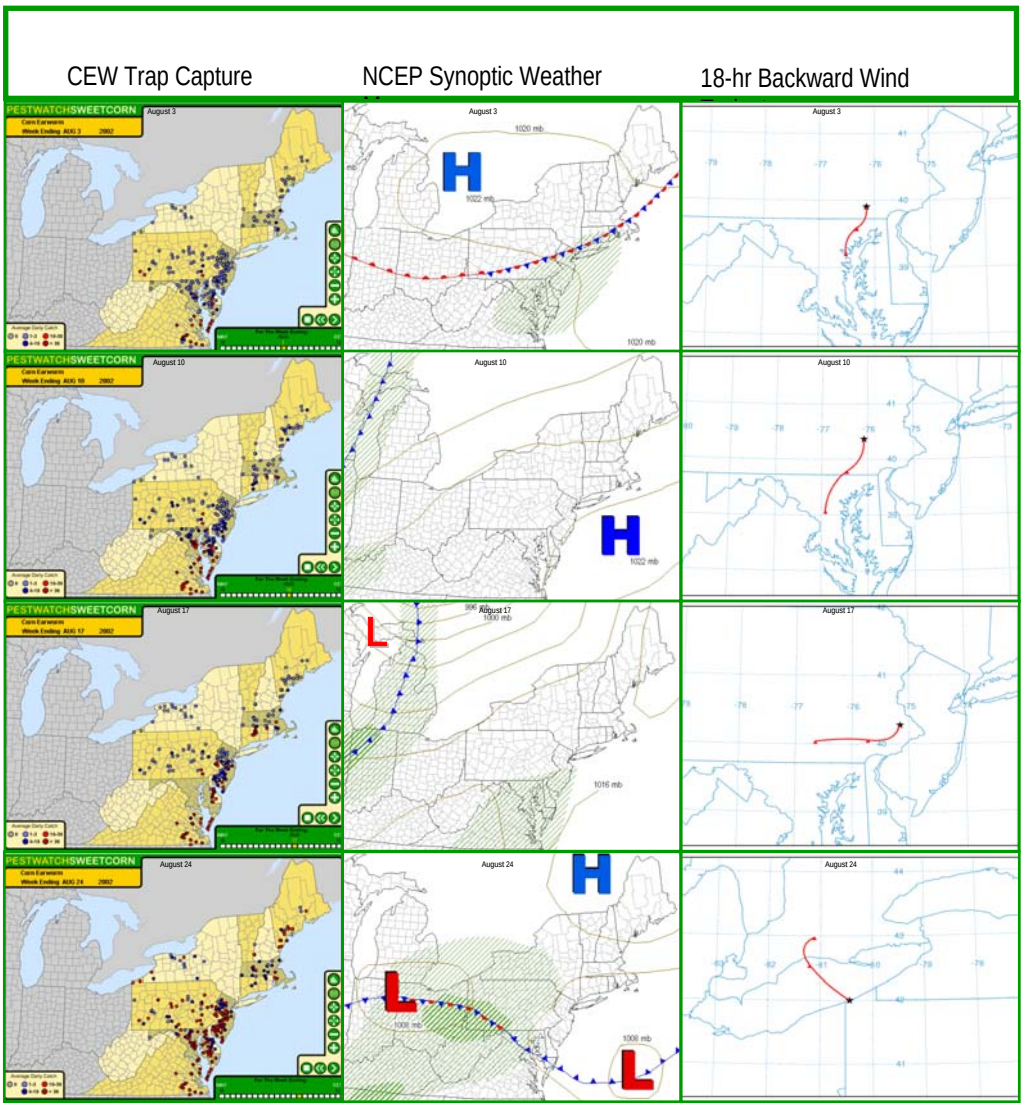
It is better to make decisions based on density of a life stage (such as an egg stage) that is closest to the stage for which management decisions are made (such as early instar larva). But not all fields/farms are able to do this, and it is extremely difficult to monitor CEW eggs. If we assume egg-laying occurs at about the same time as moth flight, and that egg density if related to flight activity, then pheromone trapping makes sense. Furthermore, CEW and FAW are primarily annually re-invasive species, where most of the population arrives from the south. If we track these pests on a regional basis, we have some advance warning of their time and intensity of immigration. Pheromone trapping is becoming increasingly easy to accomplish. There is a lot of noise in the data - but the data aggregated over a region provides information about trends. A regional infrastructure exists for pest monitoring 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 & M. Spellman, U. DE), Pennsylvania (PVGA & ~15 Extn. agents), New Jersey (K. Hollstrom, NJ IPM program), New York (A. Seaman NY IPM), Massachusetts (R. Hazzard, U. MA), Connecticut, and Maine (D. Handley, U. of Maine). A website - http://www.pestwatch.psu.edu – gives you access to pheromone trap data for all 3 species in the form of "Clickable Maps".

Pest Monitoring Sites with "*Clickable Maps*" :local and regional views of pest pressure





We are working to incorporate two types of meterological data. One is phenology maps for ECB. These provide accurate estimates of when ECB adults are present based on temperature accumulations. The second is seeing if air flow trajectories relate to corn earworm flights. The graphs, below, shows relationships among CEW trap captures, synoptic weather, and air parcel models, in 2002.



In summary, you should first think of early season insects issues to ensure a good plant stand, and these will be discussed in the talk. Rotation and cultivar selection is important. Then you need to time management activities against the 3 worm species. This management varies with the species. Transgenic cultivars control ECB and CEW, and help with FAW. ECB occurs throughout the season - phenology maps are now available to help time this management, and pheromone monitoring also helps. CEW and FAW occur later. Pheromone monitoring helps time management for these two annually re-invasive species.

Regionally, in 2004, the degree of moth activity as estimated with pheromone traps for all three worm species, and the phenology models that estimate the timing of ECB life stages, is available at http://www.pestwatch.psu.edu.