Using IPM in the Field

Sweet Corn Insect Management Field Scouting Guide

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Note

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How to use this guide

Over 40 percent of the vegetable acreage in Massachusetts is used to grow fresh market sweet corn. Consumers demand high quality, worm-free corn throughout the season. An Integrated Pest Management (IPM) approach helps growers achieve high quality corn while protecting natural resources and reducing costs. Using IPM effectively in sweet corn combines several methods to monitor pests, decide when insecticides are needed, and encourage biological control where possible.

This guide is designed as a tool to take to the field to help growers use IPM successfully. It shows step-by-step how to identify and monitor key pests, how to scout, what to look for, and what thresholds to use for insecticide applications.

A companion guide, the *Sweet Corn Insect Management Recordkeeping Book*, provides a place to write down what you find and keep your scouting records all season long in one compact location.

Additional resources

This guide does not cover every pest of sweet corn. Additional information on less common pests, nutrient, weed and disease management, and organic pest management can be found in the following resources:

New England Vegetable Management Guide. Comprehensive guide on crop and pest management updated every two years. Includes Photo Identification Guide with color photos of all insects, diseases and weeds. Available in printed copy from UMass Extension Bookstore, 413-545-2717 (http://umassextensionbookstore.com/catalog) and online at www.nevegetable.org.

UMass Extension Vegetable Notes newsletter. Weekly crop and pest updates during the growing season, including region-wide reports on sweet corn pests. Available through e-mail or hard copy subscription (contact umassvegetable@umext.umass.edu or 413-545-3696) and on the UMass Vegetable Program website: www.umassvegetable.org.

Organic Insect Management in Sweet Corn. This eight page fact sheet with color photos describes pest biology, monitoring and management using organic methods. The fact sheet also provides details on the use of direct applications to corn silk for control of corn earworm. Available from UMass Extension Vegetable Program office (413-545-3696) or online at www.umassvegetable.org/soil_crop_pest_mgt/crops/corn_sweet.html.

University of Massachusetts IPM Guidelines. Provides a list of Integrated Pest Management methods (soil and nutrient, insect, disease, weed and water management) for many vegetable and fruit crops including sweet corn. The most current crop-specific definitions may be found online at www.umass.edu/umext/ipm/guidelines/index.html.

To Grow or Not to Grow Bt Sweet Corn, by T. Jude Boucher, University of Connecticut Cooperative Extension System. Available online at UMass Vegetable website, sweet corn section: www.umassvegetable.org/soil_crop_pest_mgt/crops/corn_sweet.html.

European corn borer (ECB)

Identification

European corn borer survives the winter in the larval stage, protected inside the stalks of wild plants and corn stubble. Destruction of corn stubble in the fall, or in early spring before emergence of moths, is important for controlling overwintering populations of ECB.

In southern and central New England there are two generations of ECB during the growing season. The first flight begins in May and ends by early July; the second flight begins at the end of July and continues into September. Female moths are lighter in color and slightly larger than the males.

Female moths lay flat white egg masses on the undersides of corn leaves, often close to the midrib of the leaf. Eggs may be laid from the whorl stage through early silk stage. Eggs hatch in four to nine days, depending upon temperature.

Caterpillars are light brown or pinkish-gray with dark spots on each body segment. The head capsule is dark brown and flattened in shape. Full grown caterpillars are three-quarters to one inch long. Caterpillars initially feed within the whorl, then on the emerging tassel. After tassels open, they move downward and burrow into the stalk or into the side or base of the ear.

Damage

Caterpillars tunnel into ears through the side, base or tip to feed on kernels causing economic damage. During silking stage, moths lay eggs on leaves near the ear and young caterpillars may move down the silk channel directly to the ear.

ECB caterpillars also tunnel through the shank, sometimes injuring kernels at the base of the ear.

Monitoring for moth flights

Pheromone traps capture male moths and are used to monitor when the moth flight starts, peaks and ends, and how big the population is. There are two strains of ECB: the Iowa strain and the New York strain. Designate one trap for each strain, and place the two traps 50 to 100 feet apart in a weedy or grassy border of the corn field. To catch the beginning of first flight, put traps up by May 15th.

Heliothis net traps are recommended, used with Trécé European corn borer ECB II (NY) and ECB I (IA) lures. Lures should be hung in the center of the opening at the base of the trap. Replace lures every two weeks. Traps should be hung so that the bottom opening is just above the canopy of the weeds. Trim weeds if needed.

At least once per week, remove the trap top, empty and count number of moths. Keep records of the counts. (see “Yearly Trap Captures” in the *Sweet Corn Insect Management Recordkeeping Book*.)

Monitoring for damage in the field

Close inspection may be needed to find small ECB larvae feeding within whorl or tassels. Pulling tassels for sampling makes inspection easier and will not hurt pollination. After one insecticide spray, do not count old damage that may have occurred before the spray.

Field scouting for ECB begins when the tassels first appear in the whorl. Walk in a V or X pattern to sample plants in groups of five. To make a decision about the need to spray, you will need to sample from 25 to 105 plants. Use sequential sampling for most efficient use of time (see “How to Use the Field Scouting Form” in the recordkeeping book.)

Tiny ECB caterpillars feed inside the florets of the tassel. Look for the black head capsule, brownish damage and frass (excrement).

As they grow, caterpillars move around to feed in the florets or the stalk. Because caterpillars are moving on the surface, this is a good time for spray applications. Target controls from pre-tassel to open green tassel stage, before ears form and ECB caterpillars tunnel into stalks and ears.

As caterpillars move down the stalk, they settle just above the leaf nodes (above) or tunnel into the side of the ear (right). A caterpillar feeding in the stalk produces white or light tan sawdust-like frass.

Deciding when to spray based on action thresholds

The action threshold is the level of pest or damage at which controls are needed and are economically worthwhile; thresholds are based on an economic yield goal of 95% to 100% clean corn at harvest.

Action threshold at pre-tassel to green tassel: If 15% or more of plants have one or more ECB caterpillars or show fresh feeding damage, a spray is needed. Repeat in four to seven days if scouting shows infestation is still above threshold. If infestation is high (greater than 50%), two sprays four to five days apart may be needed to bring infestation below threshold.

Action threshold during silking: If corn is more than one week from harvest and trap captures are greater than 12 moths per week, spray weekly. Target ear zone. This is especially important for early corn that was started under plastic, which reaches silking when the first ECB flight is high and eggs are still being laid.

Biological control of ECB with *Trichogramma ostriniae*

Using *Trichogramma ostriniae (T. ostriniae)* can reduce or eliminate the need for sprays, thus saving time, labor, pesticides, and fuel, and reducing soil compaction.

This method of control prevents the emergence and feeding of caterpillars in the first place, as opposed to rescuing the corn with insecticides after the caterpillars have become a problem. It is especially useful in early corn (corn to be harvested in July) because control measures are not complicated by the need to control corn earworm and fall armyworm, a common situation in late season sweet corn.

T. ostriniae wasps reproduce during the season, and move into later corn plantings that are in the same or nearby fields. These subsequent generations have been shown to suppress second generation ECB later in the growing season.

Ordering Trichogramma: While some native species of Trichogramma persist in the wild, *T. ostriniae* (pronounced aw-STRIN-ay) need to be reared at an insectary, shipped to the farm and released each season. *T. ostriniae* may be ordered from IPM Laboratories in Locke, New York, 315-497-2063 (www.ipmlabs.com). Order well in advance! Place your order based on acreage after you have made your first planting.

Biology

Trichogramma are tiny parasitic wasps, as small as the eye of a needle, that lay their eggs in the egg masses of host insects. Trichogramma larvae feed and pupate inside the egg, killing the egg and preventing hatch.

T. ostriniae lays its eggs in ECB egg masses, and is the species that has given the highest level of ECB control in field trials.

As they mature, normal ECB egg masses turn from a cream color to white (left), to white with a black head mass in the center of each egg; when parasitized by Trichogramma, the entire egg turns black (right). Trichogramma have excellent dispersal in the field. They do not overwinter but they will reproduce and contribute to the control of ECB through the season.

Release timing

Since *T. ostriniae* control ECB by parasitizing egg masses, they should be released in the earliest plantings just as ECB moths start to lay eggs, within a week after the start of ECB moth flight. In the middle of moth flight, begin releases when corn reaches the four to six leaf stage (12-16 inches tall).

Knowing when ECB flight begins, reaches a peak, and ends in a given field is key to the proper timing of *T. ostriniae* releases, as each field has its own ECB population. You can use regional information about flight activity; however, to get the best coordination of timing on your farm, monitor ECB flight in your own fields. For *T. ostriniae*, two or three releases, each approximately seven days apart, will help match the timing of wasps and host eggs. Recommended release rates range from 30,000 to 60,000 per acre per release, depending on the level of infestation and level of control desired.

Handling Trichogramma

Trichogramma are shipped from the insectary as pupae inside protective cards. They are ready to emerge upon arrival, however there will be a range of pupal age so emergence will happen gradually over one to seven days, depending on temperature. It's best to put the cards out in the field the same day as they arrive. If you cannot release them upon their arrival, keep the cards in their shipping box in a cool location at about 50°F. The insects are alive: avoid exposing them to extreme temperatures (below 40°F or above 90°F) so they will still be alive and in good shape when you put them in the field.

Putting Trichogramma in the field

Place the proper number of cards to provide the desired release rate in the center of the field, or at regular intervals throughout the field, away from the field edges. *T. ostriniae* wasps will disperse well throughout the field; one to four release sites per acre is adequate. Tie cards securely to corn leaves or on a stake. Do not put them on the ground. Try to locate them where they will receive some shade, such as under a leaf or on the north side of the plant. Leave the packet stapled shut, so that insect predators do not consume them.

Scouting and spraying release fields

Where *T. ostriniae* has been released, you can scout as usual. Eggs that were parasitized and did not hatch will never reach the larval stage, resulting in a lower rate of caterpillar infestation.

T. ostriniae will suppress ECB, but does not necessarily provide complete control when the timing or rate of the releases is off. In addition, corn earworm may arrive during silking. Thus, insecticide applications may still be needed. Use selective insecticides in the release fields if possible. Trichogramma that are inside host eggs are somewhat protected from the spray and many will survive, but adult wasps may be killed by insecticides that are harsh on beneficials.

Sap beetles

Sap beetles are usually secondary pests of sweet corn and are commonly associated with damage caused by other pests. Sap beetles overwinter as adults or pupae in crop refuse, decomposing corn ears, or decaying fruit on the ground. Eggs are laid in spring. There are several generations per year. They are more likely to be a problem on farms producing a variety of vegetable and fruit crops. They can also be pests of strawberry.

Identification

Dusky sap beetle is black and plain (about 3/16 of an inch long), while four-spotted sap beetle (also known as picnic beetle) is black with four irregular yellow spots (about one-quarter inch long).

Adults are first noticed about the time that tassels appear. They may invade corn borer tunnels or other insect damage, feed on pollen or silks, and lay eggs in these sites or in silks at the tip of ears. Eggs are milky white and resemble tiny grains of rice. The larvae are small, pinkish white or creamy colored grubs about one-quarter inch long. They may hollow out kernels of the upper half of the ear.

Monitoring

Sample for sap beetles when silks begin to wilt. Inspect the silk area at the tip of 20 ears at each of five sites and determine the percent of ears infested with adults, eggs, or larvae. Sprays for other ear pests usually control sap beetles, but if other pests are absent and more than 10% of ears are infested with sap beetles, treat for sap beetles.

Cultural practices

Sanitation is important to prevent successful overwintering and reproduction during the season. Bury corn residue especially decomposing ears; remove or bury alternate hosts such as rotting tree fruit or discarded vegetables. Burial should be deeper than four inches. Sweet corn varieties with long, tight husks and good tip coverage are more resistant to sap beetle damage in the ears.

Corn earworm

Corn earworm (CEW) moths do not survive winters in New England, but migrate annually into the Northeast, traveling north on storm fronts. They may arrive in late season corn anytime from mid-July through September. Heaviest numbers are found in coastal areas and up the major river valleys.

Identification

Adult moths are light tan with a distinctive dark spot on each forewing, and a dark band near the margin of the hind wing. Live moths have bright green eyes.

Female moths lay eggs directly on the fresh silk of newly developing ears. Eggs hatch in 2.5 to six days – more quickly at higher temperatures (up to 90° F) and very slowly as temperatures approach 55° F.

Corn earworm larvae may be brown, tan, green, or pink, with light and dark longitudinal stripes. Caterpillars reach one and one-half to two inches when full grown.

The head capsule is always plain golden brown, and there are small bumps and hairs which give the body a rough texture.

Damage

Newly-hatched caterpillars tunnel into ears by moving down the silks. Once they are in the ear, caterpillars cannot be reached with insecticide sprays. Larvae feed on kernels at the tip of the ear, leaving unsightly frass.

Monitoring

Monitoring moth flight is critical to achieving CEW control all season long. Moth numbers may jump overnight, and sprays must be timed to prevent larvae from entering the ear. Pheromone traps attract male moths. Use Heliothis net traps baited with Hercon CEW lure tape. Traps should be placed in fields as soon as plants start silking.

Moths get a little beat up in the traps, but the characteristic dark dot and wing band are still visible.

Remove the trap top, empty it and count the moths in each trap twice a week. Average the numbers found in the two traps.

Use two traps per farm and move one into a block with fresh silk each week. Suspend the lure in the center of the trap opening, with the base of the trap at ear height. Replace lures every two weeks. Blocks with fresh silk give the best indication of CEW flight activity.

Thresholds

CEW is controlled by maintaining insecticide coverage of the silks. The higher the CEW numbers, the more frequently you need to spray. To determine when to start insecticide sprays and how often to spray, use the average moth count per trap, and divide by the number of nights since the last count was taken. Spray intervals range from three to six days. If maximum daily temperature is below 85° F for two to three days, spray intervals may be extended by one day.

Moths/Night	Moths/Week	Spray Interval
0 - 0.2	0 - 1.4	No spray
0.2 - 0.5	1.4 - 3.5	6 days
0.5 - 1	3.5 - 7	5 days
1 - 13	7 - 91	4 days
Over 13	Over 91	3 days

Alternative corn earworm control: direct silk treatment

This method is especially useful for farmers who grow certified organic sweet corn, do not own a sprayer suitable for sweet corn, or grow relatively small acreage of corn. Direct silk application of vegetable oil, mixed with a microbial or botanical insecticide (*Bacillus thuringiensis*, neem, or spinosad), reduces corn earworm damage to ears. It works by coating the silk channel with oil, which is toxic to caterpillars and which carries the insecticide down the silk and onto the tip where caterpillars feed.

Oil is applied once to each block of corn, at a rate of 0.5 milliliters (about five drops) per ear, for a total of approximately two gallons per acre at a plant population of 16,000 plants per acre. Applying the oil requires about two hours of labor per quarter acre block of corn.

A handheld oil applicator (the Zealater™) was designed specifically for this purpose and is available from Johnny's Selected Seeds (877-564-6697). The tank holds two liters of oil.

Timing of applications

Corn should be treated during early silk stage. The action threshold is anytime CEW trap captures exceed two moths per week. Apply oil six to seven days after silk growth starts. At this time, the silks have just begun to wilt. Oil applied later than eight days after silk initiation can result in more feeding damage from CEW.

Another way to decide when to treat is to open some sample ears. Treat when the silk has detached from all but the top one inch or less of the kernels, which indicates that pollination is complete. This is important because oil applied earlier can interfere with pollination, resulting in unfilled tips.

Materials to use

Certified organic growers must be careful to select approved materials. We recommend using corn oil or soy oil and add *Bt kurstaki*, neem or spinosad at the labeled rate per acre. Carrageenan, made from seaweed, may be used as a carrier place of oil. For further information consult *Organic Insect Management in Sweet Corn* in the “Additional resources” section of this guide.

Fall armyworm (FAW)

Like corn earworm, the fall armyworm is a summer migrant to New England, over-wintering in the south where soils do not freeze. Moths may arrive anytime from mid July into September. Flights are sporadic and difficult to predict, and do not necessarily correspond with corn earworm flights, so monitoring with pheromone traps is very useful. Flights are heavier near the coast, but move inland as well.

Identification

Moths (males) have mottled brown forewings with a slanting white bar across the wing, and plain light tan hindwings. They measure about three-quarters of an inch long.

Female moths lay clusters of eggs on the leaves of a variety of host plants, preferring whorl stage corn over older corn. Eggs hatch in two to 10 days.

Caterpillars are smooth (unlike CEW) and dark green or brown with lengthwise stripes and dark spots. Full-grown larvae reach one and one-half inches. The head capsule is dark with a distinctive light colored marking in the form of an upside-down Y. This is in contrast to CEW (center, above), which has a plain head capsule.

Damage

Feeding damage from fall armyworm caterpillars occurs first in whorl stage corn, deep within the whorl, on leaves and in the newly forming green tassel. Watch whorl stage corn for ragged feeding damage and masses of sawdust-like excrement.

Like European corn borer, fall armyworm larvae tunnel through the side of corn ears, leaving behind frass and a large hole.

Fall armyworm larvae also feed in the tip, making a mess of the kernels. The most effective way to prevent ear damage is to apply controls during whorl and pre-tassel stage. If flights are very high, silk sprays may be needed.

Monitor fall armyworm moths with a bucket trap (Universal Moth Trap or Multipher trap) with a lure clipped under the lid and a vapor strip placed inside the trap. Count moths at least weekly.

Hang the trap on a metal stake placed at plant height in whorl stage corn. Mark the trap and the end of the row with bright surveyor's tape – corn quickly hides the trap as it grows! Use a Scentry lure (PSU type is most effective), replace every two weeks and dispose old lures in a plastic bag. Handle the vapor strips with gloves and replace each season.

Thresholds

The scouting method and threshold for FAW is similar to ECB scouting. Check plants in a V or X pattern across the field in groups of 10. Avoid checking only field edges, and start at random, not only where you can see damage. A plant is infested if at least one caterpillar is found. If 15% or more of plants are infested with FAW, a control is needed. Use the sequential sampling plan to determine how many samples to take and what decision to make (see page 22).

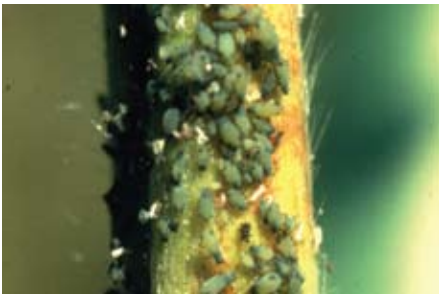
Sometimes feeding damage is old and no larvae are found; this usually means that the larvae have left the plants to pupate in the soil. In emerging tassels, combine counts for ECB and FAW. For example, if 10% of plants have FAW and 12% have ECB, the combined infestation is 22%, above the 15% threshold.

Corn leaf aphids and beneficial insects

Corn leaf aphids feed in cereal grains and grasses as well as field and sweet corn. In Massachusetts, adult females arrive in sweet corn fields each year beginning in June, initially feeding in the furled leaves of the whorl or the tender young tassel. As the tassel emerges, aphids disperse over the entire plant to feed.

Moisture stress increases corn susceptibility to aphids. Ample rainfall or irrigation during silk stage can prevent damage from aphids. Using selective insecticides that are less toxic to natural enemies, especially early in the season, will help to sustain populations of beneficial insects and reduce aphid problems later on in the season. See *New England Vegetable Management Guide* for more information on selective products.

Identification



This species of aphid is green to bluish-green (female wingless adults) or with black head and throrax (males and winged adults) with a pear shaped body and black legs. Wingless females produce live nymphs, and populations can build up rapidly especially in hot weather. Thick colonies may form in tassels, then move to leaves and corn husks. When aphids feed they produce a sticky substance called honeydew, which encourages the growth of dark sooty mold on leaves and husks. Presence of aphids or sooty mold on the ears makes them unsightly and unmarketable.

Biological control of aphids

Several insect predators and parasites feed on aphids and are very important in suppressing aphid populations in sweet corn. The twelve-spotted ladybeetle feeds on sweet corn pollen, aphids, insect eggs and newly hatched ECB larvae.

Another aphid predator, the insidious flower bug, may be difficult to spot because it is less than one-eighth of an inch long. This predator is commonly found on leaves, silks and tassels of sweet corn.

The multicolored Asian ladybeetle has increased in numbers in recent years, and feeds on aphids. Coloration and patterns are highly variable.

Ladybeetle larvae are voracious aphid feeders. Sweet corn provides an excellent habitat for reproduction of ladybeetles. This larva is feeding on corn leaf aphids.

Using transgenic sweet corn hybrids

A relatively new option for managing damage from caterpillar pests is the use of transgenic hybrids which express the protein toxin of the bacteria *Bacillus thuringiensis* (Bt). Trade-marked 'Attribute insect-protected hybrids', these varieties incorporate a gene from Bt that was inserted into field corn through genetic engineering and then bred into sweet corn through traditional breeding methods. The protein toxin is expressed in leaves, tassel, stalks, husk, fresh silk, and in 75% of kernels, so that caterpillars feeding on these tissues ingest the toxin and die.

The number of available varieties is steadily increasing and includes bicolor, white and yellow synergistic-type hybrids. This is expanding the market for Bt varieties beyond large wholesale and processing to retail and smaller wholesale fresh-market growers as well. These varieties are considered genetically-modified (GM) crops and are not allowed in organic production. Some New England states prohibit purchase of Bt corn seed. Growers who purchase the seed must sign a stewardship agreement pledging not to resell the seed and to incorporate crop residue within 30 days.

Like all new technology, Bt corn comes with both advantages and disadvantages. It is important to consider both risks and benefits for your business and farm. Based on current price differential between comparable Bt and non-Bt hybrids, growers need to save three to five sprays to cover the extra cost of seed. This may not be worthwhile for early season plantings with low pest pressure. One risk of widespread use is selection for resistance to Bt. For a discussion of some of the risks and benefits associated with growing transgenic sweet corn, see *To Grow or Not to Grow Bt Sweet Corn* in the "Additional resources" section of this guide.

The major advantage of Bt corn is the reduced need for insecticide applications. Bt corn provides excellent control of European corn borer, eliminating the need for pre-silk ECB sprays. FAW control at the whorl and pre-tassel stage is also very good. Bt corn reduces, but does not eliminate the need for all corn earworm silk sprays. Although it controls low to moderate levels of corn earworm, protection breaks down at higher population levels, when the plant is under stress, and as the silk begins to dry, which stops the production of the toxin.

Some of the newer Bt sweet corn varieties have shown less consistent levels of CEW control. Modified thresholds for CEW sprays for Bt corn are being developed. While thresholds may be adjusted for Bt corn, growers still need to monitor moth flight and scout fields regularly to determine pest conditions and the need for sprays.

Bt corn does not control non-caterpillar pests, such as flea beetles, cutworms, sap beetles, corn rootworms, and aphids.

What you'll need to start

Below is a list of the traps and lures that you will need. These items are available from Great Lakes IPM, Inc. in Vestaburg, MI (800-235-0285, www.greatlakesipm.com) as well as other IPM suppliers. Great Lakes offers a New England Sweet Corn Kit which provides two traps for ECB, two traps for CEW, one trap for FAW and enough lures for one season (16 weeks for ECB, 10 weeks for CEW and FAW).

Store lures in the freezer until use; if kept in the freezer, lures will stay fresh for many years. Brands listed have proven reliable in New England. The thresholds listed in this guide are based on using these trap and lure combinations.

1. Scentry Helitothis net traps for monitoring both European corn borer (two traps) and corn earworm (two traps) (total: 4 traps)
2. Universal Moth Trap for monitoring fall armyworm (one trap)
3. Trécé lures for European corn borer (Iowa strain, IA or ZI; and New York strain, NY or EII)
4. Scentry lure for fall armyworm (type: two-component PSU lure)
5. Hercon lure tape for corn earworm
6. Hercon vapor tape for Universal Moth Trap

Photography credits

All photographs are by Ruth Hazzard, University of Massachusetts Amherst, unless otherwise noted.

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- Ladybeetle larvae with corn aphids - Clemson University, USDA Cooperative Extension Slide Series, www.ipmimages.org.
- Insidious flower bug - photographer unknown, www.ipmimages.org.

Quick reference guide

Sweet corn action thresholds

At the following crop growth stages, an insecticide application is warranted IF:

Whorl stage (based on field scouting)

More than 15% of plants are infested with fall armyworm.

Pre-tassel to first silk stage (based on field scouting)

More than 15% of plants are infested with fall armyworm and/or European corn borer (combined count).

Silk stage (based on moth captures in pheromone traps)

Trap captures of European corn borer (sum of two traps) exceed 12 moths per week (spray at weekly intervals).

OR

Trap captures of corn earworm moths exceed 0.2 per night or 1.4 per week. Use the table below to determine the recommended spray interval (average moths per trap).

When corn is less than five days to harvest, further sprays are not needed.

Corn earworm thresholds

Moths/Night	Moths/Week	Spray Interval
0 - 0.2	0 - 1.4	No spray
0.2 - 0.5	1.4 - 3.5	6 days
0.5 - 1	3.5 - 7	5 days
1 - 13	7 - 91	4 days
Over 13	Over 91	3 days

Note: spray intervals can be lengthened one day if daily maximum temperatures are below 85° F over a two to three day period.