

Corn Earworm Biology and Management in Soybeans

Ames Herbert, Cathy Hull, and Eric Day*

INTRODUCTION

Corn earworm, *Helicoverpa zea*, is the most common and destructive insect pest of soybeans grown in Virginia. Although infestation severity varies, about one-third of our acreage is treated annually. This costs farmers 1.5 to 2 million dollars annually, and requires the application of many pounds of insecticide to crop lands. We may never eliminate this pest from Virginia soybeans, but knowledge of the biology and use of best management practices can help limit insecticide controls to those fields that meet economic threshold criteria. This publication provides current information on corn earworm biology, prediction of outbreaks, pest advisories, scouting procedures, and recently revised economic thresholds.

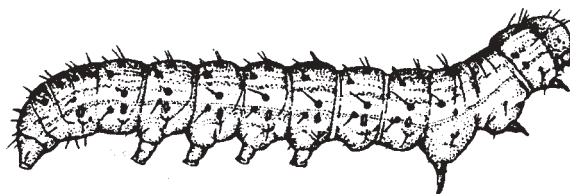
DESCRIPTION OF STAGES

Eggs: Female moths lay eggs singly, mostly on new-leaf soybean terminals and on the undersides of leaves in the upper half of the canopy. Eggs are about the size of a pencil point, are subspherical, have perpendicular toothed ribs and are whitish to cream colored. They turn noticeably darker just before hatching.

Caterpillars: Young corn earworm caterpillars are light green to brownish with small dark spots and dark brown heads. As they grow, they can become yellow, brown, green, even pinkish, depending on the crop they are feeding on, with light and dark stripes that run the entire length of the body and heads that are light green, tan, or orange. Earworms grow to 1 1/2 inches in length and can be distinguished from other caterpillars by the presence of four pairs of prolegs (see drawings) and being covered with tiny dark hairs or spinules. Corn earworm caterpillars also generally curl into a “C” shape when disturbed and remain inactive for a short time.

Pupae: Pupae are shiny, light to dark brown, torpedo-shaped, broad at the head end, tapered to a point at the tail end, and about 1 inch long. Pupae develop in the soil, so they are rarely seen when scouting fields. The pupal stage lasts 2 to 3 weeks.

Adults: Corn earworm moths are tan to yellowish with a small dark spot near the middle of each front wing, and a dark band along the trailing edges of both front and hind wings. They have large green eyes. Their wingspan is about 1 1/2 inches and they hold their wings flat in the delta position when resting on plants.



actual size

Large corn earworm caterpillar with four pairs of prolegs in the middle area of the abdomen.



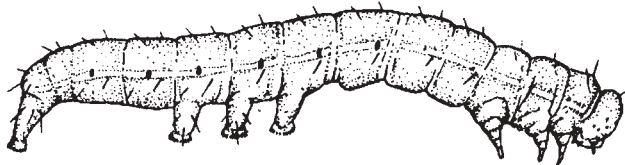
actual size

Medium-sized corn earworm caterpillar, 3/8" long, the first stage capable of damaging pods.

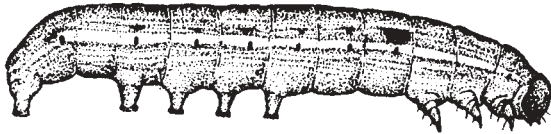
Other common soybean caterpillars: Green cloverworm and yellow-striped armyworm caterpillars (see drawings) are commonly mistaken for corn earworm. Green cloverworm is thinner, lime green in color with white stripes that run the length of the body, has only three pairs of prolegs, and wiggles vigorously when disturbed. Yellow striped armyworm has four pairs of prolegs, like the earworm, but is pale gray-green to jet black. They have prominent yellow stripes that run

*Extension Entomologist; Extension Agent, Integrated Pest Management; Extension Entomologist, Virginia Tech

down either side, a black spot on either side of the first body segment, a pair of triangular spots on the top of each body segment (see dorsal view), and do not appear as spiny or hairy. Both of these insects are defoliators and rarely do pod damage.



Green cloverworm caterpillar with three pairs of prolegs.

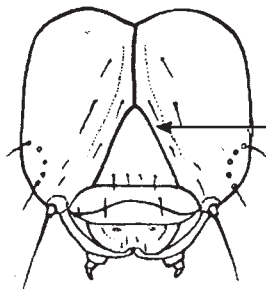


Yellowstriped armyworm caterpillar with dark spot on each side of the first body segment.

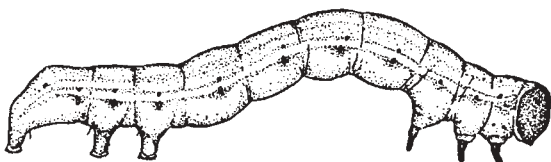


Yellowstriped armyworm, dorsal view, with pairs of triangular spots on the top of each body segment.

Fall armyworm and soybean looper are easily distinguishable from corn earworm. Fall armyworm is smoother-skinned and dull green to tan colored with alternating light and dark brown bands that run down the sides. The head is gray to dark brown with a distinct white inverted Y-shaped marking on the face (see drawing). Small dark spots are visible on the back with four distinct black dots forming a square on the rear end. Soybean looper is light green in color with white lines running the length of the body. They have only two pairs of prolegs (see drawing). They are distinctly largest at the rear end and taper toward the head. They form a characteristic hump or “loop” when crawling.



Fall armyworm with distinct Y-shaped marking on the front of the face.



Soybean looper caterpillar with two pairs of prolegs.

LIFE CYCLE AND DAMAGE

Corn earworms overwinter as pupae in the soil. Caterpillars construct “J”-shaped chambers just prior to going into pupation, 1 to 6 inches deep depending on soil type, condition, and moisture level. Adult moths emerge from chambers from May through August, peaking in early July, and fly to suitable hosts including corn, cotton, soybeans, tomatoes, tobacco, clover, peanuts, sorghum, and many other wild and cultivated plants. In Virginia, many first generation moths lay their eggs on seedling corn in May. Caterpillars feed on corn leaves until they mature, then burrow into soil to form pupae. Second generation moths emerge from soil chambers and again lay eggs on corn, but this time on corn silks. Caterpillars hatch, enter corn ears via the silks, and feed and develop on kernels. The cycle is repeated and a third generation of moths emerges. By this time, corn is generally too mature to be attractive as a food source, so third generation moths seek more suitable hosts, primarily soybeans.

A single female corn earworm moth can lay up to 1,800 eggs. Eggs hatch within 2 to 3 days, depending on temperature. Many corn earworm eggs are destroyed by natural enemies, such as the minute pirate bug. Caterpillars hatch and begin feeding on buds, new leaves, and flowers. Caterpillars grow through six stages called instars. Their distribution on plants changes as they grow and as plants develop. Their highest number usually occurs on leaves and the amount of leaf feeding increases as caterpillars grow. Although not common, defoliation can become extensive in some fields, especially when large populations occur early before plants have set flowers or pods. Caterpillars will occur in high numbers on flowers when they are present and can eat most if not all of them when populations are high. Once pods begin forming, caterpillars will begin feeding on them, but not before caterpillars reach the third instar (about 3/8 inch long), the first stage capable of chewing through pod walls. Each instar develops in about 2 days, therefore earworms reach full size in about 15 days after eggs are laid. During that time, one caterpillar can eat 15 to 20 flat pods, those just prior to seed enlargement, or 6 to 10 older pods depending on pod age and the degree of pod wall toughness. Most pod feeding is by the last two, that is, fifth and sixth, instars. Fully developed pods cannot be damaged by earworms.

SOYBEAN RESPONSE TO EARWORM INJURY

The degree of injury is determined by the size of the earworm infestation, its timing, and the stage of soybean

plants. Plants are capable of withstanding considerable defoliation, deflowering, and depodding without substantial yield loss, but the ability is dependent on planting date, and variety, and a number of factors including rainfall, soil moisture, and frost date. If an infestation is early, most injury will be to leaves. Usually defoliation does not exceed percentage thresholds (40 percent prebloom, 15 percent podfill, 35 percent full pods), but if this occurs treatments may be needed. Generally, if plants are still flowering at the end of an infestation period, that is, if an early infestation has occurred, pod set will be delayed but not be significantly reduced. Simulated studies have shown that even 20 percent to 30 percent flat pod loss does not reduce yield provided that plants are not moisture stressed and there is ample time for plants to develop to full maturity. Soybeans will compensate by increasing seed size in remaining pods and, to a lesser extent, by setting new pods. Compensation may not offset damage if dry conditions occur or frost stops growth before full maturity. Later infestations that coincide with pod formation and filling have the biggest potential to reduce yields because plants have less time to compensate. But again, some pod damage is allowable because plants can compensate if conditions remain favorable.

PREDICTING OUTBREAKS

Traditionally, corn earworm moth activity has peaked in mid-August, but in some years it has occurred in early or late August. The timing of moth peaks largely determines the number of gelds that become infested and the level of pod damage. The most serious problem arises if moth activity peaks in early August. Many fields are flowering at that time and many are attacked. Also, development of caterpillars to third instar coincides with the formation of young pods, and many pods can be destroyed before they develop tough pod walls. Peak activity later in August results in less damage in fewer fields, usually only late-planted, double-cropped fields, because by that time many pods have developed tough walls and are no longer susceptible to feeding.

Female moths, when searching for egg laying sites, are particularly attracted to soybean fields that are flowering. Although low levels of caterpillars may be found feeding on soybean foliage during the vegetative period, most severe infestations occur between flowering and when pods become fully developed. The occurrence of large-scale outbreaks is associated with the following simultaneous events: 1) peak flowering, 2) open crop canopy, and 3) large peak moth flight. Weather conditions also play an important role. For unknown reasons, moths are attracted to drought stressed soybeans, or fields that have poor growth due

to other stresses such as cyst nematode infestation. Dry weather favors the development of more severe outbreaks by speeding the drying of corn plants which compels moths to leave earlier to seek other hosts. In contrast, heavy or sustained rainfall decreases corn earworm populations by drowning pupae in their soil chambers, hampering moth flight, washing eggs from leaves, and increasing the incidence of diseases that kill caterpillars.

Because of the close relationship to weather conditions, the severity of corn earworm outbreaks varies greatly with years and locales. From 1976-1990 the percentage of soybean acreage treated for corn earworms varied between 8 percent and 60 percent. And because of differences in planting dates, row spacings, and flowering dates, even adjacent fields may have different numbers of earworms in the same season. Clearly, scouting fields to determine which have economically damaging infestations and spraying only those fields offers a significant economic advantage.

Virginia Cooperative Extension operates a **Corn Earworm advisory** to predict earworm outbreak severity and monitor the activity of moths as they leave corn fields. Each July, the percentage of field corn ears infested with second generation corn earworm caterpillars is determined. That percentage is used to predict the severity of the third generation that will follow in soybeans. Once moths start to emerge from corn fields, activity is monitored using a system of blacklight traps placed throughout eastern Virginia. An updated advisory is issued weekly to Extension agents during August and early September so that farmers can be notified of peak moth activity.

In addition to accessing weekly moth advisory information, farmers are encouraged to buy and operate pheromone traps on their own farms. Although the blacklight trap system provides the best information for regional advisories, pheromone traps have proven to be good indicators of on-farm moth activity. Traps are not a substitute for field scouting, but they can alert farmers to when scouting efforts should begin. Pheromone traps are relatively inexpensive and easy to operate. For information on purchase and operation of pheromone traps refer to Pest Management Report, Vol. 7, No. 4, Tidewater Agricultural Experiment Station, Suffolk, VA 23437.

Do not base spray decisions solely on pheromone trap catches. Traps measure the number of male moths present, not the number of eggs laid, where the eggs were laid, or if the eggs and caterpillars survived. Natural enemies and rainfall can destroy many eggs and young

caterpillars thus preventing earworm buildup and the need for sprays. For example, in 1989, a large number of earworms were found in corn and even though moth activity increased in August, few caterpillars were ever found in soybean fields. Frequent rainfall in July and August hampered moth flight, drowned eggs and young caterpillars, and created favorable conditions for a fungal disease that killed caterpillars, all of which prevented populations from reaching economically damaging levels.

MANAGEMENT

Early planting and use of Group IV and early Group V varieties both increases the chances that the soybeans will be beyond the susceptible flowering stage when the moths fly and enables natural enemies to increase their populations before earworms arrive. Full-season soybean fields are therefore much less likely to develop earworm outbreaks. Double-cropped and late-planted soybean fields are more susceptible to infestations.

Avoiding unnecessary insecticide sprays can also benefit management of corn earworm. Many defoliating caterpillars feed on soybean leaves and, although they rarely cause economic damage, they serve as food for natural enemies which allows the populations of natural enemies to increase. Natural enemies often can effectively suppress earworm outbreaks by destroying large numbers of eggs and caterpillars. Earworm natural enemies include lady beetles, lacewings, big-eyed bugs, damsel bugs, spined soldier bugs, pirate bugs, spiders, and bacterial, fungal, and viral diseases. Recognizing beneficials is an important aspect of scouting. Your Extension agent can help you identify them.

FIELD SCOUTING

Begin scouting fields weekly within 5 to 7 days of when moth activity peaks or when on-farm pheromone traps catch 25 to 30 moths a night for 3 to 4 consecutive nights. Begin by scouting high risk fields, such as, late-planted fields, those that are flowering or have young pods, those in light soils that show drought stress or poor growth, or those located on high spots or knolls. Scout all fields in dry years and increase frequency to twice each week in any fields where earworms are detected. Scout using a standard beat cloth, a rigid beat cloth, or a sweep net depending on the row spacing and your preference. Samples should be taken in all areas of the field characterized by differences in soil, variety, planting date, or elevation. Knolls or ridges will often have higher numbers of caterpillars. Use an "X"-shaped pattern to cover the field and a minimum of 1 sample per 4 acres, or a maximum of 10

samples per field. Make sure that each sample is located at least 50 feet from the field edge because earworm populations are generally higher around field borders. Remember that the more areas you sample, the less likely you are to miss an infestation. Only count earworms longer than 3/8 inch. Those under 3/8 inch cannot damage pods and may be killed by natural enemies before ever doing damage.

Standard beat cloth: A beat cloth (or ground cloth) is most efficient if used to sample fields with 3-inch or wider row spacing. Simply lay the cloth down between the rows. Bend the plants bordering each side of the cloth over the cloth and beat them vigorously with your hand and forearm. Count the number of earworms that fall on the cloth. If you use a 3-foot long cloth and shake the plants bordering both sides you will have sampled 6 row feet. Divide the number of earworms on the cloth by 6 to get the number per row foot. Average the results of all of the samples taken in a field to determine the average number per row foot for that field. Thresholds are based on the number of earworms per row foot.

Rigid beat cloth: Traditionally, both the ground cloth (or beat cloth) and sweep net have been used in Virginia to sample soybeans for insect pests. The beat cloth can be used in wider row spacings but the sweep net must be used in narrow-row plantings. Another tool, the Rigid Beat Cloth (RBC), has been used to sample narrow-row soybeans in North Carolina and other states. It is a dependable and proven tool for sampling narrow-row plantings and offers farmers a good option.

The RBC works on the same principle as a standard beat cloth but the RBC is not flexible. Samples are taken by placing the sampler on its side between two rows of plants (plants cannot be seriously lodged) and beating or vigorously shaking adjacent plants into the sampler while it is leaned away from those plants at about a 45 degree angle. Two 7-inch rows are beaten and one 14-inch or 21-inch row is beaten per sample. Thresholds are based on the number of earworms per sample. Illustrations and construction plans are available in Pest Management Report, Vol. 8, No. 6, Tidewater Agricultural Experiment Station, Suffolk, VA 23437.

Sweep net: A 15-inch diameter sweep net may also be used to sample narrow-row soybeans. Each sample should consist of 15 net sweeps done continuously one after the other. Each sweep consists of swinging the net in one direction through the foliage so that the top of the net passes 2 or 3 inches below the tops of plants. Fifteen consecutive sweeps are done from one side to

the other while walking down a row middle. Swing the net with enough force to dislodge insects into the net. If some leaves are not broken off and in the net after the sample, the sampler is not using enough force. Each swing should pass through the tops of 5, 3, or 2 rows in 7-inch, 14-inch, or 21-inch row-space plantings, respectively. After each sample, stop and count how many earworms are in the net. Thresholds are based on the number of earworms per sample (15 sweeps).

TREATMENT

If insecticide treatment becomes necessary, the best treatment strategy is to wait to spray until most of the earworms are at least 3/8 inch long or more and then treat when pod damage is first evident. Waiting allows for most egg laying and hatching to occur before treatment and thus reduces the chances of needing a second spray. If other defoliating insects are present in large numbers, you may need to spray at a lower level of earworms. The latest chemical recommendations are available in Virginia Cooperative Extension Pest Management Guide for Field Crops, Publication 456-016, and Soybean Production Guide, Info. Ser. No. 295, Tidewater Agricultural Experiment Station, Suffolk, VA 23437,

ECONOMIC THRESHOLDS

Results from 4 years of field research at North Carolina State have shown that currently used thresholds for corn earworm in Virginia need revision. Results showed that a single large earworm per row foot in wide-row soybeans can reduce yields by an average of 1.93 bushels per acre. When this statistic is considered along with the 10 year average market value of \$6.28/bu and an average control cost of \$10.20, it suggests that the break even number of earworms is 0.84 worms per row foot ($\$10.20 \div (\$6.28 \times 1.93 \text{ bu/A/earworm} = 0.84)$). However, if done properly we do not scout for or wait for large earworms because by that time it is too late to apply treatments or protect yield. Another research finding showed that on average only 68 percent of medium-sized worms, those counted in scouting procedures, survived to the large stage. Therefore, the current suggested threshold for medium-sized larvae in wide-row beans where earworm presence will coincide with podding is 1.24 per row foot (0.84 worms per foot divided by 68 percent survival). The whole equation is as follows:

$$\begin{aligned} \text{Thresholds} &= \\ & \frac{\$10.20 \div (\$6.28/\text{bu} \times 1.93 \text{ bu/A/earworm})}{.68} \\ & = 1.24 \text{ worms/row foot} \end{aligned}$$

As you realize, both market price and control costs affect this threshold. For instance, a \$7.50 market price would lower the threshold to 1.0 earworms per row foot if control cost remained the same. You can use the equation to adjust the threshold if you feel that your market value or control costs vary considerably.

In the following table are thresholds for the three sampling tools discussed above, in selected row spacings. Numbers are based on current field research where catch efficiency of each sample tool was determined by comparison to an absolute number of earworms per acre determined from extensive sampling. Research showed that sample tools do not catch all the caterpillars in the area sampled, and catch efficiency varies in the different row spacings, but each does consistently catch a known portion of the earworms present. Although these threshold numbers appear quite different, they represent the same number of earworms per acre. The thresholds presented below are to be compared to the average number of caterpillars caught **per sample**, or in the case of the beat cloth, the average number **per foot of row**.

CORN EARWORM THRESHOLDS IN SOYBEANS¹

Sampling Tool	Row Width	Rows Sampled	Threshold
Sweep Net ²	7"	5	2.5
	14"	3	2.4
	21"	2	3.1
	36"	1	3.1
Rigid Beat Cloth ³	7"	2	0.9
	14"	1	0.7
	21"	1	1.2
Beat Cloth	30"	1 or 2	1.0
Standard or Rigid ⁴	36"	1 or 2	1.2

¹ Only count worms 3/8 inch or longer.

² Based on a 15 sweep sample.

³ Number per sample.

⁴ Number per row foot rather than number per sample.