Field Crops

Department of Entomology

EUROPEAN CORN BORER IN FIELD CORN

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Corn borer populations historically have varied greatly from year to year and from field to field. In recent years, however, many Indiana growers have seen corn borer damage decline to the point that it is no longer considered the key pest it once was. This may be due to a number of factors, not the least of which is the fact that highly effective transgenic (or Bt corn) hybrids have composed a large portion of the market in traditional high pressure areas.

Damage in Indiana corn is typically caused by first or second (in rare case the third), generations of the borer, but seldom by all three in the same planting. Corn planted at "atypical" times in a given region is typically most at risk: For example, early-planted corn is most susceptible to first generation attack and late-planted corn to second and third generations. Larvae of the first generation bore into the stalks, whereas the second and third generations also attack the tassels, ears, and ear shanks (Figure 1).

Preventing Borer Damage

Cultural Practices

In general, the risk of corn borer damage can be reduced by avoiding extremely early or late planting whenever possible. Early planting may increase the potential for first generation attack, which is relatively easy to control with foliar insecticides; but will reduce second or third generation attacks, which are more difficult to control. Late planting increases the likelihood of damage from the more difficult to control second and third generations.

Although the destruction of corn stalks and other crop residue in which the borers overwinter may reduce the overwintering populations in individual fields, there is no evidence that such "clean-up" will eliminate subsequent borer damage. For this reason, practices such as clean plowing, stalk shredding, low cutting, and ensiling are recommended only if they are beneficial agronomic practices. Overwintering larvae are very tolerant of cold temperatures as well, although extreme cold without an insulating snow cover can cause overwintering mortality.

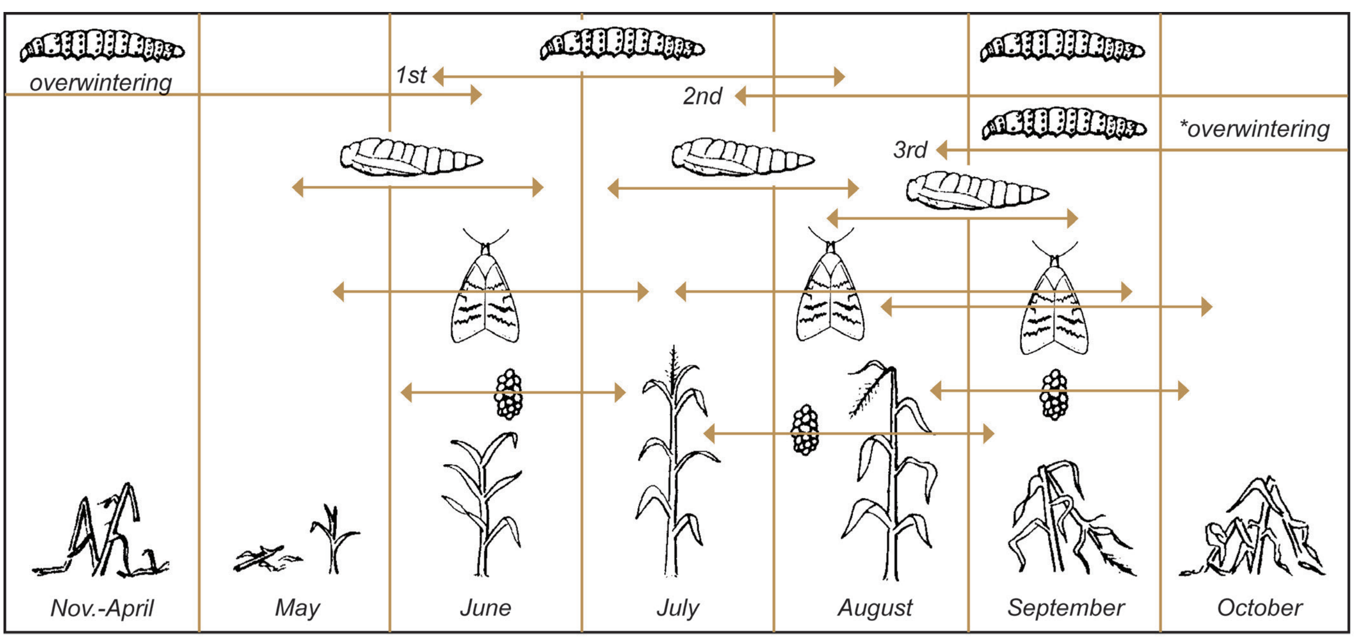


Figure 1. Seasonal life history of European corn borer in Indiana. *Prior to 1991, third generation larvae had not been observed overwintering in Indiana. However, in the fall of 1991, some third generation borers did reach the overwintering fifth instar stage before the first killing frost.

Insecticide Treatments

Economically important corn borer populations can usually be controlled if insecticides are properly selected and correctly applied. As a rule, one application will control first generation borers in corn. However, two or more applications may be needed for subsequent generations, because egg laying occurs over a longer period of time and the borers are harder to reach with an insecticide. Treatment with an insecticide is usually economical on seed corn fields. On field corn, treatment depends on the degree of infestation, price of corn, potential corn yield, cost of control, and level of control. For most field corn producers, however, transgenic hybrids are a more foolproof and cost-effective option. This is because treatments for corn borer control often are applied too late to achieve optimal control. In any field, borers are typically exposed (i.e. on the surface of the plant) for only 7-10 days. This is the window when insecticidal control can be achieved. If treatment is delayed until borer damage becomes more evident, it is usually too late. By this time the borers may be nearly half grown and have entered the plant and cannot be reached with insecticidal treatments.

Transgenic Bt Corn

Field corn producers may choose to manage this pest through the use of hybrids, genetically modified, that express a protein toxic to corn borers. Usually called Bt corn, this technology has been in widespread use in the US for over 10 years. This "in-plant protection" prevents corn borers from causing economic damage throughout the season, thus eliminating the need for extensive scouting and application of a corn borer insecticide. This is an excellent option for producers who regularly have problems with corn borers. Although there have been no reports of field-level resistance to this suite of technologies, producers should be aware that EPA guidelines specify a minimum 20% refuge planting in combination with any Bt corn product. The refuge guidelines must be adhered to in order to prevent insect resistance to these valuable pest management tools. Note also that corn borer Bt is now often combined with other traits, in "stacked" hybrids. For example, genes for the production of the Bt toxin lethal to corn borers are often inserted into the plant along with genes for a completely different Bt toxin for rootworm control.

Wherever this is the case, the refuge requirements for the corn rootworm Bt should be observed, as these insects do not disperse as far as corn borers, and are more likely to develop resistance. The general rule of thumb for planting refugia in corn is "The closer, the better." Seed corn suppliers and/or extension personnel can provide resistance-management assistance. For further information on this technology, refer to "Transgenic Bt Corn" in the "Management in Field Corn" section.

Monitoring Moth Flights

Some pest managers use black light and pheromone traps to monitor corn borer moth numbers and their flight periods. The duration of flights and time of occurrence of peak flights (when more adults are flying than at any other time) vary from year to year, primarily due to changing weather conditions. Although "real-time" data are always best for determining the status of the current population, historical data can be used to determine the average peak flight date for a particular generation in a particular region where "real-time" monitoring is not available.

Average dates for peak flights have been established using adult corn borer flight data (black light trap catches) from different areas throughout Indiana (Figure 2). These average dates can be very helpful in estimating the time of year that corn borers may cause problems; however, they should not be completely depended upon for timely sampling or making treatment decisions. For more up-to-date information on peak flights and borer development, contact your county extension educator or refer to the *Pest&Crop* newsletter available free and updated throughout the growing season at: <http://extension.entm.purdue.edu/pestcrop/index.html>.

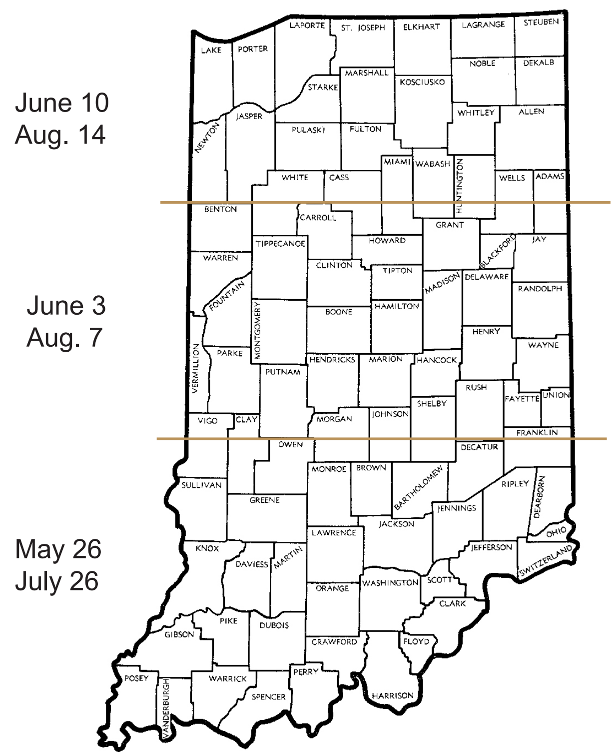


Figure 2. Mean date for peak adult corn borer flights in three areas of Indiana (earlier date in each area = first generation mean peak flight; later date = second generation mean peak flight). Third generation moths do not occur each year, mean peak flight dates have not been established.

Corn Borer Development and Sampling

First Generation

First generation eggs, in masses of 15-30 eggs, normally are laid on the undersides of leaves near the midrib. Young larvae migrate from the mass to the whorl to feed. The larvae feed on the leaves in the whorl or in the midribs of leaves until the 3rd larval stage, when they move to the stalk and burrow into it leaving excrement that looks like wet saw dust. They continue to feed in the stalk until pupation takes place at the end of the 5th larval stage.

Sampling. Begin sampling for first generation borers when their flight is underway and corn is 16-22 inches in extended leaf height (from base of stalk to the tip of the longest extended leaf). Examine the whorl leaves of 20 consecutive plants for fresh "shot-hole" feeding (small random holes) in at least five areas of a field. Calculate the percentage of plants with shot-hole feeding damage. Pull out the whorl from at least one damaged plant in each sample area, unroll the leaves, and examine them for live larvae. Determine the average number of live larvae per plant.

Second and Third Generations

Second and third generation moths typically lay their eggs in the middle third of the plant on the undersides of the leaves near the midrib. These larvae are difficult to locate but usually can be found feeding on pollen in the leaf axil, on plant tissue in the leaf midrib, on pollen and plant tissue behind the leaf sheath, or on the ear itself. This feeding generally occurs in the "ear zone" (two leaves above and below the primary ear). These areas should be carefully examined for borers and feeding activity.

Like the first generation, second and third generation larvae bore into the plant once the third-instar stage is reached. Pupation takes place within the plant at the end of the fifth-instar stage (this may occur in late summer and/or the following spring, depending on how early the second and third generations occur).

Sampling. Field observations should begin approximately 7 days prior to the projected or average moth peak flight date. In at least five areas of a field, inspect leaves in the "ear zone" of 20 consecutive plants. Note if egg masses and/or live larvae are present. The larvae may be observed around the egg masses, in leaf axils, behind leaf sheaths, on tassels, or on the ear. Determine the percentage of plants infested and the average number of live larvae per plant.

Treatment Decision Guidelines Based On Field Conditions & Economics

The need for European corn borer control can be determined by using a system developed by researchers at Kansas State University and modified at Purdue University. This method produces variable treatment thresholds depending on level of infestation, control costs, stage of corn development, estimated yields, market value, and anticipated control.

Use the following steps to determine whether treatment is economically justified:

1. Preventable yield loss (bu/A) = anticipated yield (bu/A) x level of infestation* (decimal) x percent yield loss** (decimal) (from Table 1) x anticipated level of control*** (decimal)

   *While sampling for the second/third generation, consider a plant with either live larvae or egg masses as infested.
   **For each egg mass, assume a survival rate of 20% (4 borers/egg mass).
   ***It is impractical to expect 100% control. A reasonable estimate of control is 80% for the first generation and 60% for the second.

2. Preventable dollar loss/A = Preventable yield loss (bu/A) x market value ($/bu).
3. Compare preventable dollar loss/A to cost of insecticide and application to determine if treatment is warranted.

Example #1: A field in the pre-tassel stage has 60% of the plants with shot-hole feeding and an average of 2 live larvae per whorl. Anticipated yield is 150 bu/A and the crop is valued at $2.25 per bushel. The cost of the insecticide and application is $15.00 and 80% control can be expected. Would it pay to apply a control?

1. Preventable yield loss (bu/A) = 150 bu/A x .60 (60% infestation) x .099 (9.9% loss for 2 borers/plant) x .80 (80% control) = 7.13 bu/A
2. Preventable dollar loss/A = 7.13 bu/A x $2.25/bu = $16.04/A
3. Compare preventable dollar loss/A with cost of control/A $16.04/A - $15.00/A = $1.04 return from treatment.

Example #2: A field that is shedding pollen has 60% of the plants infested with larvae and/or egg masses. The number of actual larvae observed averages 2 per plant. The number of egg masses averages 1/4 per plant. For 1/4 egg mass/plant, an average of 1 borer would survive per plant (assuming survival of 4 borers/egg mass). Therefore, two live borers plus one borer from egg masses equals 3 borers/plant. Anticipated yield is 150 bu/A and the crop is valued at $2.25 per bushel. The cost of the insecticide and application is $15.00 and 60% control can be expected. Would it pay to apply a control?

1. Preventable yield loss (bu/A) = 150 bu/A x .60 (60% infestation) x .081 (8.1% loss for 3 borers/plant) x .60 (60% control) = 4.37 bu/A
2. Preventable dollar loss/A = 4.37 bu/A x $2.25/bu = $9.83/A
3. Compare preventable dollar loss/A with cost of control/A $9.83/A - $15.00/A = $-5.17 loss from treatment.

Management in Field Corn

As shown in Table 1, yield loss depends on both upon the plant stage attacked and the numbers of borers. Also

Table 1. Yield Losses Caused by European Corn Borers for Various Corn Growth Stages[1]

Plant Stage	Percent Yield Loss - # Borers/Plant		
	1	2	3
Early Whorl	5.5	8.2	10.0
Late Whorl	4.4	6.6	8.1
Pre-tassel	6.6	9.9	12.1
Pollen Shedding	4.4	6.6	8.1
Blister	3.0	4.5	5.5
Dough	2.0	3.0	3.7

[1]These percentages are based on physiological stresses and do not include losss due to stalk breakage and/or ear droppage.

weather and the presence of stalk rot pathogens can increase losses. This should be considered when making management decisions, whether it be the use of insecticides or the planting of corn borer Bt corn. Another consideration when making management decisions is the probability that corn borer will be present in a field and cause economic damage. These data are not readily available, but based on many years of experience with this insect the likelihood of economic damage occurring in most fields is approximately 1 years in 5.

Insecticides (See Table 2)

Granules. If insecticides are applied in-season, the best corn borer control is usually obtained by applying an insecticide in granular form. This is because the granules fall into the whorl and/or lodge in the axil of leaves where most of the borers are, or soon will, be located. Granules can be applied with either ground or aerial equipment. Aerial applications are broadcast applications. Ground applications are band applications and are most effective when the insecticide is directed into the whorl or leaf axil.

Liquids-Air or Ground. By the time corn borer treatments are justified, most of the borers already have reached the plant whorl, leaf sheath, or ear. For this reason, the spray must be applied directly into the plant whorl or ear zone. A spray application has almost no chance of contacting larvae if droplets are simply broadcast over the top surface of exposed leaves. The use of raindrop nozzles, which results in larger droplet size and greater whorl and leaf axil penetration, should provide better control than atomizing nozzles.

Transgenic Bt Corn

Hybrids that have been genetically engineered to provide protection against attack by the corn borer, and are referred to as “Bt corn borer,” were on the market for the first time in Indiana in 1996. These genetically modified corn hybrids contain a gene derived from a naturally occurring bacterium, Bacillus thuringiensis, which produces a protein that is toxic to corn borers. This gene can be expressed throughout the plant or in specific structures depending on the part of the plant needing protection. In the case of the products targeting European corn borer, the protein is produced in multiple above-ground plant structures.

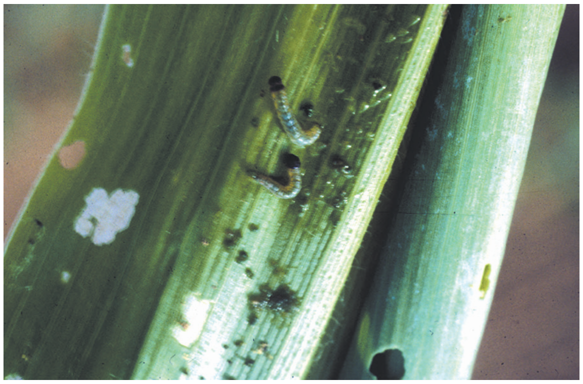
This technology reduces the need for laborious scouting for this pest, although field scouting should not be eliminated where Bt corn is planted. Several other above and below ground insects may be present during the season, including corn rootworms, white grubs and black cutworms. Remember also that the Bt for corn borer offers no protection against corn rootworms – although both are commonly referred to as “Bt corn” the proteins produced are completely different for each of these pests, and one offers no protection against the other.

Table 2. Insecticides for European Corn Borer Control in Field Corn

Insecticide	Formulation	Rate Per Acre
Granules - Air & Ground		
Bacillus thuringiensis[4]	[6]	[6]
chlorpyrifos (Lorsban)	15 G	3.5 - 8 lb.
permethrin (Pounce)[2]	1.5 G	6.7 - 13.3[3] lb.
Liquids - Air & Ground		
Bacillus thuringiensis[4]	6	6
bifenthrin (Capture)[1,2]	2 EC	2.1 - 6.4[3]oz.
carbofuran (Furadan)[1,2]	4 F	1 qt.
chlorpyrifos (Lorsfan)[1,2]	4 E	1 qt.
cyfluthrin (Baythroid2)[1,2]	2 E	1.6 - 2.8[3] oz.
lambda-cyhalothrin (Warrior)[1,2]	1 CS	2.56 - 3.84[3] oz.
methyl parathion (Penncap-M)[1,2]	2 FM	1 qt. (band) 2 qt. (broadcast)[7]
permethrin[1,2,5] (Ambush) (Pounce)	 2 EC 3.2 EC	 6.4 - 12.8[3] oz. 4 - 8[3] oz.
spinosad (Tracer)[1]	4 SC	1.3[3] oz.
zeta-cypermethrin (Mustang Max)[1,2]	0.8 EW	2.7 - 4.0[3] oz.
Liquids - Irrigation Equipment		
bifenthrin (Capture)[1,2]	2 EC	2.1 - 6.4[3] oz.
chlorpyrifos (Lorsban)[1,2]	4 E	1 qt. + 1 qt. non-emulsifiable crop oil
cyfluthrin (Baythroid2)[1,2]	2 E	1.6 - 2.8[3] oz.
lambda-cyhalothrin (Warrior)[1,2]	1 CS	2.56 - 3.84[3] oz.
methyl parathion (Penncap-M)[1,2]	2 FM	2 qt.
permethrin1,2,5 (Ambush) (Pounce)	 2 EC 3.2 EC	 6.4 - 12.8[3] oz. 4 - 8[3] oz.
spinosad (Tracer)[1]	4 EC	1-3[3] oz.
zeta-cypermethrin (Mustang Max)[1,2]	0.8 EW	2.7 - 4.0[3] oz.

[1]Product highly toxic to bees if exposed to direct treatment.
[2]Restricted use pesticide.
[3]Use higher rate when broadcasting insecticide.
[4]var. *kurstaki*
[5]Use prior to brown silk.
[6]See label.
[7]May be split as 2-1 qt. applications for second or third generations.


Freshly laid egg mass (*Photo credit: J. Obermeyer*)


Young borers and "windowpane" damage (*Photo credit: J. Obermeyer*)


Mature larva in stalk tunnel (*Photo credit: B. Christine*)


Larval frass outside entrance hole of stalk (*Photo credit: B. Christine*)


Pupa inside stalk cavity (*Photo credit: B. Christine*)


Female moth (*Photo credit: B. Christine*)

European Corn Borer: *Ostrinia nubilalis* (Hubner)

READ AND FOLLOW ALL LABEL INSTRUCTIONS. THIS INCLUDES DIRECTIONS FOR USE, PRECAUTIONARY STATEMENTS (HAZARDS TO HUMANS, DOMESTIC ANIMALS, AND ENDANGERED SPECIES), ENVIRONMENTAL HAZARDS, RATES OF APPLICATION, NUMBER OF APPLICATIONS, REENTRY INTERVALS, HARVEST RESTRICTIONS, STORAGE AND DISPOSAL, AND ANY SPECIFIC WARNINGS AND/OR PRECAUTIONS FOR SAFE HANDLING OF THE PESTICIDE.

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