

CHAPTER 5

INSECT MANAGEMENT

LEARNING OBJECTIVES

After completely studying this chapter, you should:

- Understand how insects grow and develop.
- Understand the difference between simple and complete metamorphosis.
- Be able to identify general and major insect pests of alfalfa, corn, dry beans, soybeans, small grains, and sugar beets.
- Be able to describe the life cycles and habitats of the major field crop pests.

Insect damage reduces crop yield or quality, or contaminates the final product. Insects can also transmit plant diseases. To effectively control insect pests, you should understand how insects grow and develop.

GROWTH AND DEVELOPMENT

Growth

An insect's body is confined in a protective **exoskeleton**. This hard outer covering does not grow continuously. A new, soft exoskeleton is formed under the old one, and the old exoskeleton is shed—a process called molting. The new exoskeleton is larger and allows the insect to grow a little more. The new exoskeleton is soft and white at first, but it hardens and darkens in a few hours. After molting, which usually takes place in hiding, the insect resumes its normal activities.

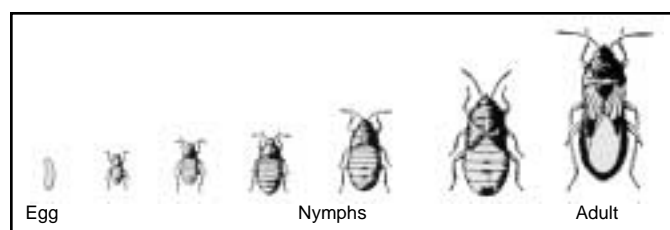
Development

Insects are divided into groups according to the way they change during their development. The technical term for this change is **metamorphosis**, which means

“change in form.” Pests of field crops undergo either simple or complete metamorphosis.

Group 1. Simple Metamorphosis

When insects that develop by simple metamorphosis hatch from their eggs, they resemble the adult insects except that the immatures, or **nymphs**, do not have wings. Nymphs periodically molt, growing larger. After the final molt, nymphs become adults and generally have wings. Many pests of field crops such as potato leafhopper, sugarbeet root aphid, tarnished plant bug, and grasshoppers develop by simple metamorphosis. Nymphs and adults are often found together in the crop and usually eat the same food.



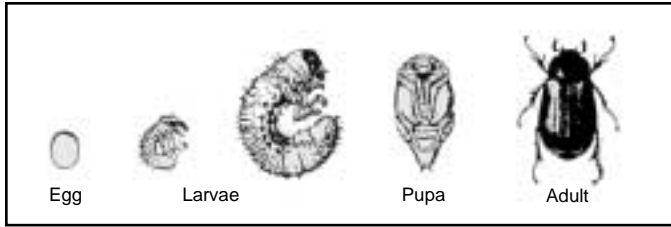
A plant bug is an example of an insect with simple metamorphosis.

Group 2. Complete Metamorphosis

Insects that develop by complete metamorphosis make a radical change in appearance from immature to adult. This major group includes beetles, moths, butterflies, flies, bees, and wasps.

In complete metamorphosis, newly hatched insects are called **larvae**. Grubs, maggots, and caterpillars are types of larvae. The job of larvae is to eat and grow. Larvae molt four to six times and then change into **pupae**. A pupa is an inactive stage of insect development. During pupation, the insect's body rearranges itself, resulting in a complete change in form from immature to adult insect. Insects undergoing complete metamorphosis have very different looking, larva and adult stages. Larvae and

adults are often so different that they do not eat the same food and need different habitats.



A beetle is an example of an insect with complete metamorphosis.

CONSIDERATIONS FOR PEST MANAGEMENT

The developmental stages of insects with complete metamorphosis support rather than compete with each other. It is as if they are two or three completely different animals with different needs and habitats, instead of a single species. The larvae feed and live in one habitat and sometimes leave that area to pupate a short distance away. The adult emerges and often eats a different food and lives in another area, returning to the larval feeding site only to lay eggs. An example is the European corn borer—the larva is a caterpillar living in corn; the adult is a moth. For this reason, species with complete metamorphosis are managed differently according to life stage, where each lives, and what each does. You will want to pay special attention to the following sections that discuss the life cycle and behavior of each insect pest.

INSECT PESTS OF ALFALFA

Alfalfa Weevil (*Hypera postica*)

Pest status: major pest.



Alfalfa weevil adult.

Characteristics and life cycle: This snout-nosed beetle was first found in Michigan in 1966. Adult weevils overwinter in alfalfa fields, fencerows, woodlots and other sheltered places. The adult is $\frac{3}{16}$ inch long with a broad, dark band down the middle of the back and chewing mouthparts at the end of a long, slender snout. Alfalfa weevils begin to feed on alfalfa in the spring as soon as growth starts. After two weeks of feeding, the female chews a hole and lays yellowish, brown eggs in the alfalfa stems. Eggs hatch in one to two weeks. The larvae are cream-colored to yellowish green with black heads and no legs and a distinct white stripe down the middle of the back. The larvae feed on leaf buds and terminal growing areas for three to four weeks. Full-grown larvae make cocoons on the leaves and pupate; adult weevils emerge between mid-June and mid-July. The new adults feed only a short time before preparing to overwinter and rarely cause much damage. There is one generation of alfalfa weevil per year.

Damage: Alfalfa weevil damage is a concern for the first cutting and the regrowth of the second cutting. Adults and larvae feed on leaves and stems. Small larvae feed on leaf buds and terminal growing areas. As larvae grow, they feed on the leaves, leaving only the veins. The majority of damage occurs between mid-May and mid-June. Severe infestations can affect regrowth and reduce yield, quality, and stand longevity.

Control: **Cultural**—Cutting alfalfa at the bud stage will not only directly kill weevil larvae but also expose them to the environment and remove their food source.

Biological—In Michigan, at least three parasitic wasps attack adults and/or larvae. In most years, these biological control agents do an effective job of controlling alfalfa weevil, and pesticide applications are not necessary.

Chemical—Rarely required, a single insecticide application made at threshold will generally provide effective alfalfa weevil control. An insecticide application also kills the biological control agents, however, especially early in the season. Scouting methods and thresholds are available to make a management decision.

Potato Leafhopper (*Empoasca fabae*)

Pest status: key pest.



Potato leafhopper (nymph).



Potato leafhopper (adult).

Characteristics and life cycle: Potato leafhopper is the primary alfalfa pest each year. Adults migrate from the southern United States into Michigan in mid- to late May. The adult is a tiny, lime-green, translucent, wedge-shaped insect with sucking mouthparts. Eggs are laid in the stems and leaf petioles. A leafhopper nymph resembles an adult without fully developed wings. Potato leafhopper populations increase quickly, with a single generation taking only 21 days from egg to adult in a warm summer. There are multiple overlapping generations during the season.

Damage: Because potato leafhoppers migrate into the state, they usually attack only the second and third cuttings. Both adults and nymphs damage alfalfa by sucking plant fluids from the leaves. They inject a toxic substance as they feed that damages the plant cells and creates a characteristic V-shaped yellow marking on the leaf tip called “hopperburn.” Heavy infestations cause leaves to yellow, curl, and die, may severely stunt plants, and reduce plant protein.

Control: **Cultural**—Establishing a healthy alfalfa stand is the first defense against the potato leafhopper. A number of potato leafhopper-tolerant and hairy alfalfa varieties show reduced symptoms. If potato leafhopper populations reach the economic threshold close to cutting time, the alfalfa may be cut to reduce nymph populations. Adults, however, are very active, strong flyers, and may fly away only to return later.

Biological—Generalist predators such as lady beetles and lacewings feed on potato leafhoppers. However, these biological control agents usually do not provide sufficient control to prevent damage under moderate to heavy potato leafhopper pressure.

Chemical—Early detection is the key to keeping potato leafhopper populations under control. Beginning in mid-June, sample fields using a 15-inch-diameter sweep net to determine infestation levels. If samples exceed the economic threshold (Table 5.1), insecticide treatment is justified or, if practical, the field can be cut immediately. Remember, don’t wait until visible damage occurs to treat for potato leafhopper, because heavily damaged plants may not recover.

Table 5.1: Potato leafhopper economic thresholds

Plant height (inches)	No. leafhoppers/ 100 sweeps
Under 3	20 adults
3 to 8	50 adults
8 to 12	100 adults and/or nymphs
12 to 14	200 adults and/or nymphs

Alfalfa fields are home to a large number of insects, and blooming alfalfa fields attract honeybees. Typically, only alfalfa weevil and potato leafhopper are of concern in reducing alfalfa yield and quality. All of the insecticides used to control alfalfa weevil and potato leafhopper are highly toxic to honeybees. If an insecticide application is required, avoid application to a field in bloom, and do not allow drift onto blooming weeds or nearby bee-hives. Also, neighboring beekeepers should be notified when and where applications will take place.

INSECT PESTS OF CORN

Armyworm (*Pseudaletia unipuncta*)

Pest status: occasional.

Characteristics and life cycle: Each year adult armyworms migrate into Michigan. The adult armyworm is a gray-brown moth with a 1-inch wingspan and a white dot on the center of the forewing. Female moths prefer to lay eggs on grasses or grains. Full-grown larvae are 1½ to 1¾ inches long with two orange stripes along each side of the body and dark bands on the **abdominal prolegs** (the false, peglike legs on the abdomen of a caterpillar). There are two to three generations per year.



Armyworm damage in corn.

Damage: Armyworms feed on wild and cultivated grasses, especially corn and small grains. Severe defoliation results from larvae feeding on the leaves of seedlings and mature corn. Larvae may feed only on leaf margins or they may strip the plants, leaving only the stalks. Usually, the corn plant recovers from the damage as long as the growing tip has not been injured. Weedy corn or corn

that has been no-tilled into pasture, fallow ground, or a cover crop is at greater risk for damage. Armyworms can also migrate in large numbers from small grain fields to adjacent cornfields after the grain has matured. These large larval migrations can destroy a cornfield in one to two days.

Control: Cultural—The elimination of grassy weeds from fields and field edges helps to reduce egg-laying sites and the potential for infestations and outbreaks.

Biological—In warm, dry weather, natural enemies usually keep armyworm populations under control.

Chemical—If armyworms deplete the grassy weed hosts and migrate into a cornfield, an insecticide application may be necessary. Spot treatment of infested areas can provide sufficient control if the infestation is confined.

Fall armyworm (*Spodoptera frugiperda*)

Pest status: occasional.

Characteristics and life cycle: Native to the tropics, this late-season pest arrives from the Gulf Coast states. The adult moth is a mottled gray with a white spot near the tip of the forewing. Eggs are deposited in clusters on leaves and covered with hairs and wing scales from the female. The larvae vary in color but have three yellowish white lines from the head to tail and darker stripes on each side. Scattered along the body are black bumps (tubercles) with spines. A white inverted Y on the head capsule of the fall armyworm helps to distinguish it from other corn pests. Fall armyworm completes one to three generations per year and can not overwinter in areas where the ground freezes during the winter.

Damage: Fall armyworm causes more severe problems in late-planted corn. The larvae feed on developing leaves deep inside the whorl, occasionally killing the tassel before it emerges. Usually the plant will outgrow the damage if the tassel has not been injured. Larvae present late in the season feed on developing ears, causing damage similar to that of corn earworm.

Control: Cultural—Avoiding late plantings helps to reduce the risk of fall armyworm damage. Ear damage by fall armyworm can be more abundant in long-season hybrids.

Biological—Parasitoids and predators provide some suppression of fall armyworms.

Chemical—Chemical control is usually not an economical option.

Corn Flea Beetle (*Chaetocnema pulicaria*)

Pest status: common but rarely causes economic damage to field corn.

Characteristics and life cycle: This native beetle is very small (1/16 inch long), shiny, and black with enlarged hind legs. It jumps like a flea when plants are disturbed. Flea beetles overwinter in Michigan at the base of grasses along field edges. In the spring, they emerge and feed



Corn flea beetle (M. Rice, Iowa State University).

on other grasses and winter wheat if no corn is available. Eggs are deposited in the soil and the larvae develop in the soil feeding on corn roots.

Damage: Adult corn flea beetles strip off the top layer of cells on a leaf, giving the leaf a scratched appearance. The most severe injury occurs during cold springs, when slow plant growth allows beetles more time to feed. The beetle also may transmit a bacterial disease, Stewart's wilt. Stewart's wilt can dramatically reduce yields on susceptible hybrids and lines of sweet corn, though it rarely causes a problem in field corn.

Control: Cultural—Avoid early planting of susceptible hybrids or plant resistant sweet corn hybrids.

Chemical—Seed corn producers can be affected by Stewart's wilt and may need to use insecticides to control corn flea beetles.

Corn Rootworm

Pest status: occasional to common, depending on species.

Characteristics and life cycle: Three species of corn rootworm beetles occur in Michigan.

1. Northern corn rootworm (*Diabrotica barberi*)

The 1/4-inch-long adult is pale to dark green with no markings on the wing coverings.

2. Southern corn rootworm (*Diabrotica undecimpunctata howardi*)

Also known as the spotted cucumber beetle, the adult is yellow-green with 12 black spots on the wing covers. The southern corn rootworm is more commonly a garden pest.

3. Western corn rootworm (*Diabrotica virgifera virgifera*)

This is the most common and serious pest species of rootworm in Michigan. Western corn rootworm adults are light yellow to light green with three black stripes on the wing covers that tend to blend together toward the back of the beetle.



Western corn rootworm (adult).

The northern and western corn rootworms overwinter as eggs in the soil and begin hatching in late May, with peak hatch in June. The white larva has a brown head and three pairs of small legs behind the head. After feeding on corn roots, the larvae pupate in the soil, and adult beetles begin to emerge in late June, with peak emergence in August. Each female can deposit as many as 1,000 eggs in the top few inches of soil, primarily in cornfields. Egg laying goes on until the first frost. During dry years, western corn rootworms eggs may be laid up to 1 foot deep. Corn rootworms have one generation per year.

Damage: ADULT—The adult beetles are usually active during silking and eat (clip) silks and pollen. If the adults emerge before pollen shed and begin feeding on the silks, poor kernel fill can occasionally result. Typically, the adults do not cause economic damage in field corn.

LARVAL—Corn rootworm larvae feed on root hairs, layer roots, and growing tips. In young plants, the damage can reduce plant stand and plant vigor. Root destruction also causes plant stress, decreases plant stability, and creates entry wounds for plant pathogens. Economic loss due to corn rootworm larval feeding depends on the number of larvae, the size of the root mass, soil moisture, nutrients, hybrid, and weather conditions. Root regeneration and establishment of brace roots can be inhibited if moisture and heat stress are present during peak root feeding. This may result in severe lodging. After the larvae pupate and the lodged plants try to regenerate roots, the plants may then straighten, resulting in a “gooseneck” appearance. The end result may be extreme yield reduction and harvest complications.

Control: ADULTS: Adult corn rootworms rarely cause economic damage, and it is not common practice to control them.

LARVAE: Cultural—In mid- to late summer, adult corn rootworms mate and lay eggs in the soil. These eggs overwinter, and the following spring, the larvae emerge and feed on corn roots. If no corn roots are available, the larvae will die in a few days. Crop rotation, therefore, is a very effective method of preventing economic loss from corn rootworm damage, and it eliminates treating first-year corn with soil insecticides.



Lodging caused by corn rootworm damage.

Chemical—Most growers who plant corn after corn apply a soil insecticide at planting. A product with a long residual, six to 10 weeks, is needed, because there is a four-to-six week time lapse between planting and corn rootworm egg hatch. Also, larvae feed for three to four weeks. Soil insecticide applications typically reduce larval survival by only 50 percent. Field scouting for adults the previous year will help to determine the corn rootworm pressure and whether a soil insecticide application will be needed the following year.

Western corn rootworm damage in first-year corn

A new behavior in the western corn rootworm, first noticed in Illinois, has also been found in Ohio and southwestern Michigan. The female western corn rootworm lays a portion of its eggs in other crops, such as soybeans. In strict corn-soybean rotations, the eggs hatch into corn the following spring and larvae feed on the roots. In parts of Illinois and Indiana, the rootworms cause extensive root injury, lodging, and yield reduction in rotated corn. To date, crop rotation is still an effective control option against corn rootworms in most parts of Michigan.



Western corn rootworm feeding on soybean (M. O'Neal, Michigan State University).

Field scouting and population sampling with yellow sticky cards placed just above the soybean canopy can indicate a potential problem for rotated corn. The mere presence of a few western corn rootworm beetles in soybeans does not mean that economic damage will occur if the field is rotated to corn. This is an emerging problem in Michigan; in 2000 it was confined to the southwestern part of the state. A soil insecticide may be needed in rotated corn if large numbers of beetles are trapped in the previous crop or if you are targeting other soil pests. Consult your county agriculture agent for updated information on scouting and treatment recommendations.

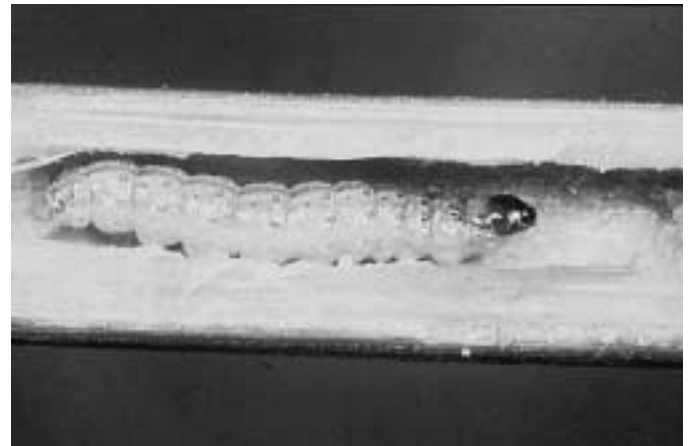


Yellow sticky card trapping corn rootworms in the soybean canopy (M. O'Neal, Michigan State University).

European Corn Borer (*Ostrinia nubilalis*)

Pest status: common.

Characteristics and life cycle: Introduced from Europe in the 1900s, the European corn borer has adapted to many hosts, including many agronomic and horticultural crops, and environmental conditions. European corn borers overwinter as full-grown larvae in corn debris and stubble on the soil surface. The larvae pupate in late April and May. Beginning in mid-June, adult moths emerge and mate in tall grasses. The female moth is 1 inch long with yellow-brown and medium brown, wavy lines on the wings, and a swollen abdomen when eggs are fully developed. The males have similar darker wing patterns and a hairy tuft at the tip of the abdomen. After mating, the female lays eggs on the undersides of corn leaves. Each egg mass contains 15 to 40 white eggs that overlap like fish scales. The egg mass darkens just before hatching, when the black heads of the larvae become visible ("black head" stage). The larvae hatch and feed on leaves, eventually moving to the whorl. Mature larvae are $\frac{3}{4}$ to 1 inch long with a medium to dark brown head and a creamy-white to gray body. As the larvae mature, they enter the stalk to feed, then pupate. Adult moths emerge in late July or early August to congregate and mate in grassy areas. The females then migrate to the cornfields and deposit their eggs on the leaves in the ear zone of the silking corn. This second generation of European corn borer feeds on the developing ears, causing kernel damage, or enters the stalk, ear shank or cob. Whether there are two or three generations per year depends on the temperature.



European corn borer in a cornstalk.

Damage: First generation European corn borer larvae feed primarily in the whorl and leaves, giving them a "shot-hole" appearance. Larger larvae feed within the leaf midrib and burrow into the stalk. Both of these activities disrupt normal movement of plant nutrients and water and have potential to reduce yield. Older fields with the tallest corn plants (i.e., early planted) are more likely to suffer first generation damage.

Second generation European corn borer larvae feed on the stalks, tassels, ear shanks, leaves, and kernels. Feeding on the ear shank causes the ear to drop, while stalk boring can lead to stalk breakage and harvesting difficulties and create entry wounds for stalk-rot fungi.

Younger fields with the shortest corn (i.e., late planted) are more likely to suffer second generation damage. Grain reduction also occurs from kernel feeding.

Control: Non-chemical—Destruction of overwintering sites (cornstalks) in the fall kills many European corn borer larvae but does not reduce the population enough to provide adequate control the following year. Resistant hybrids and early-season hybrids are all useful in managing European corn borer.

Because older corn is more attractive to egg laying early in the season, there is often more first generation damage. Likewise, the second generation tends to attack late silking and pollen-shedding corn. Therefore, avoid extremely early and late plantings, or plant such fields with resistant hybrids. Concentrate scouting efforts on fields planted early and late.

A number of factors that are out of your control affect the potential economic loss caused by European corn borer damage. A series of cool evenings (below 65 degrees F) or a heavy rain can reduce the number of eggs laid or the survival of small larvae. In addition, young larvae can dehydrate and blow away on hot, windy days. Thus, conditions present during European corn borer mating, egg laying, and development of eggs and small larvae are critical in determining the population from year to year.



Lady beetle, *Harmonia axyridis* (H. Russell, Michigan State University).

Biological—Numerous natural enemies attack all life stages of European corn borer. Generalist predators such as ladybeetle larvae and adults, lacewing larvae, and minute pirate bugs feed on egg masses and small larvae. Other insects and birds eat large larvae and pupae. In locations with large populations of predators, their role in controlling European corn borer should be taken into consideration when determining a management strategy.

Though parasitoids were imported from Europe to control European corn borer, only a few became successfully established. The amount of control from these parasitoids varies from year to year and depends on the location and shape of each field.

Two main pathogens affect European corn borer populations. *Beauveria bassiana* is a naturally occurring fungus

that usually kills overwintering larvae, giving dead larvae a white, furry appearance. Most epidemics of *B. bassiana* occur during and after periods of rainfall late in the season when temperatures are around 85 degrees F. *Nosema pyrausta*, a protozoan, reduces European corn borer egg laying, kills some larvae, and increases overwintering mortality. An increase in stress caused by other factors increases the mortality caused by *N. pyrausta*.

Chemical—A decision to treat for European corn borer depends on many factors, including percent infestation, stage of plant, larval life stage, expected yield, and availability of equipment. European corn borer populations are largely influenced by the weather, so it is difficult to predict pest pressure from year to year. Scout for first generation European corn borers by examining plants for shot-holing. Second generation European corn borers are scouted by looking for egg masses laid on the undersides of leaves, especially in the ear zone.

Insecticide applications to whorl-stage corn can be effective against the first generation. Research and field experience shows that granular insecticides, though not commonly used in Michigan, control first generation European corn borer more efficiently than liquid insecticides. Timing is critical because once the larvae enter the stalk, insecticide applications are not effective. Thus, scouting is crucial for first generation European corn borer. Second generation European corn borer are more difficult to control and the timing of the application becomes even more critical.

A common soil bacterium, *Bacillus thuringiensis* subspecies *kurstaki* (Berliner), usually known as Bt, produces spores and protein crystals that are toxic to European corn borer larvae. Commercial formulations of Bt applied by conventional methods are effective against whorl, sheath, and collar feeding. Bt kills European corn borer only when it is ingested, and it is more effective on smaller larvae. Therefore, once the larvae burrow into the stalk, Bt is not effective. Though Bt kills European corn borer and other caterpillars, it is much less toxic to other organisms (including beneficial insects and humans) than broad-spectrum conventional insecticides.

Another option for controlling European corn borer is planting transgenic Bt corn. The gene for the Bt insecticide protein was put into the genetic structure of the plant, allowing the plant to produce Bt protein. When larvae feed on transgenic Bt corn plants, they ingest the proteins and die. Like Bt insecticide applications, transgenic Bt corn is much less toxic to beneficial insects such as lady beetles than conventional insecticides and offers safety for the grower.

INSECT PESTS OF DRY BEANS

Tarnished Plant Bug (*Lygus lineolaris*)

Pest status: common.

Characteristics and life cycle: The tarnished plant bug overwinters as an adult in leaf litter. The adult is ¼ inch long, light brown with a tarnished appearance, and relatively long antennae and legs. There is usually a white triangle between

its “shoulders.” Females deposit eggs into stems and midribs of plants. Nymphs are similar to the adult but smaller and without wings. Both nymphs and adults have sucking mouthparts.



Tarnished plant bug.

Damage: Tarnished plant bug adults and nymphs use their needlelike mouths to suck plant juices and inject toxic saliva. The saliva causes leaves to yellow and curl; severe damage may stunt plants. They can also feed on flowers and small pods so that beans shrivel.

Control: Scout fields from blossom to small pod development. A sweep net can be used to scout. The action threshold is one or more tarnished plant bugs per plant at the first flower to green pod stage.

Non-chemical—Tarnished plant bugs have a wide host range (dozens of crops and weeds), so there are no practical non-chemical control options at this time.

Chemical—Insecticide applications made to manage potato leafhoppers will also reduce tarnished plant bug populations. However, tarnished plant bugs are active and move about freely and thus avoid treatment. Therefore, feeding injury can resume soon after an insecticide application.

Potato Leafhopper (*Empoasca fabae*)

Pest status: common economic pest.

Characteristics and life cycle: Potato leafhopper adults migrate from the southern United States into Michigan in mid- to late May. The adult is a tiny, lime-green, translucent, wedge-shaped insect with sucking mouthparts. Eggs are laid in stems and leaf petioles. A nymphal leafhopper resembles an adult but lacks fully developed wings. Potato leafhopper populations increase quickly—a single generation takes only 21 days from egg to adult in a warm summer.

Damage: Adults and nymphs damage plants by sucking plant fluids from the leaves. They inject a toxic substance as they feed, creating a characteristic V-shaped, yellow marking on the leaf tip called “hopperburn.” Heavy feeding causes leaves to yellow and curl, may severely stunt plants, and may kill plants.

Control: **Cultural**—Promoting healthy, vigorous plants minimizes the impact of potato leafhopper damage in fields.

Biological—Potato leafhoppers are native to the United States so there is no foreign biological control agent to import. Native predators and parasitoids play only a minor role in controlling populations. A fungal pathogen controls potato leafhopper under cool, moist conditions later in the summer.

Chemical—Early detection is the key to controlling potato leafhopper populations. Fields are sampled by examining leaves to determine the number of potato leafhoppers per leaf. Fields should be scouted regularly, especially after nearby alfalfa fields have been cut. If samples exceed five or more adults and/or nymphs per leaf, insecticide treatment is justified. Full coverage is necessary. Remember, adults are very active and strong flyers; after a field is treated, adult potato leafhoppers can recolonize from neighboring areas.

Mexican Bean Beetle (*Epilachna varivestris*)

Pest status: occasional.



Mexican bean beetle life cycle.

Characteristics and life cycle: Adult beetles overwinter in plant debris, along field edges, and in fencerows. Mexican bean beetles are oval and orange to copper-colored with 16 black spots in three distinct rows. In early spring, the adults move into bean fields. The females deposit clusters of up to 50 yellow-orange, oval eggs on the undersides of leaves. Larvae are up to $\frac{3}{8}$ inch long, oval, and yellowish with prominent spines on the back that gives them a fuzzy appearance. Generally, there are two generations per year.

Damage: Adults and larvae have chewing mouthparts and defoliate plants. They eat irregularly shaped holes from the lower leaf surface. This gives heavily infested plants a lacy, skeletonized appearance. If the infestation is large when leaves begin to yellow, larvae and adults may begin to feed on stems and pods. Yield reductions are

usually the result of defoliation, however, not pod feeding. Economic damage caused by Mexican bean beetle varies from year to year. Defoliation during flowering and pod development poses the greatest threat for economic loss.

Control: *Non-chemical*—Avoid planting early—overwintering adults are attracted to early-emerging fields.

Biological—Many predators (such as stink bugs, nabids, and minute pirate bugs) and some parasitic wasps reduce Mexican bean beetle populations.

Chemical—Scout fields for larval and adult damage. Larvae are more damaging and harder to control than adults. Reducing adult populations early can eliminate the need for future applications.

INSECT PESTS OF SMALL GRAINS

Aphids

Pest status: common but usually not an economic problem.

Characteristics and life cycle: Aphids are small ($\frac{1}{16}$ to $\frac{1}{8}$ inch), pear-shaped, soft-bodied insects. They are found in a variety of colors. Aphids have projections called cornicles (“tailpipes”) that extend from the rear of the body. They live in colonies made up of both winged and wingless insects. Female aphids do not have to mate with males to reproduce. They also produce live young (no eggs involved). This allows an aphid population to



Aphids on wheat.

increase quickly.

Damage: Aphids use sucking mouthparts to remove plant juices from leaves and stems. If populations are large, their feeding causes plants to turn yellow and brown. They may feed on developing kernels. Aphids also vector a number of viruses, including barley yellow dwarf virus (see diseases of small grains).

Control: *Cultural*—Quick stand establishment and vigorous plants help to reduce the impact of aphid damage.

Biological—Many common predators—including ladybeetle adults and larvae, lacewing larvae, and syrphid fly larvae—feed on aphids, keeping the population under control. There are also a number of parasitic wasps. After the adult wasp emerges from an infested aphid, it leaves behind a hard shell of its host, a “mummy”. When scouting fields for aphids, it is important to note the number of aphid mummies to determine the effectiveness of the natural parasitoid population.

Chemical—Aphids are usually noticed when the grain heads, though they have been present on the grain since earlier in the season. Begin scouting fields at tillering, randomly examining plants for aphids. A threshold of 12 to 15 aphids per tiller during seedling to boot stage is usually used. Consult current MSU Extension bulletins for sampling methods. Most years, a careful and proper scouting program shows that chemical treatments are not needed.

Cereal Leaf Beetle (*Oulema melanopus*)

Pest status: occasional.

Characteristics and life cycle: The cereal leaf beetle was discovered in the United States in Berrien County, Michigan, in 1962. Adult beetles overwinter in plant stubble, under tree bark, in small crevices, and in similarly sheltered places. When temperatures reach the upper 60s F, the overwintering adults emerge to feed and mate. Soon after mating, the female lays single oblong eggs or chains of eggs on the upper surfaces of grain leaves. After hatching, the larvae cover all but their heads with their own fecal material, giving them a sluglike appearance and protecting them from predators. Larvae feed for about two weeks. Full-grown larvae shed the fecal covering, typically in early June, and move to the soil to pupate. A new generation of adults emerges and feeds for about three weeks before preparing to overwinter. The cereal leaf beetle has one generation per year in Michigan.

Damage: Larvae and adults have chewing mouthparts and feed on leaves between the veins. The adults chew entirely through the leaves; the larvae feed on the upper layer of the leaf. This gives a severely infested field a frosted appearance. Feeding before the boot stage reduces plant vigor; after boot, feeding on the flag leaf may reduce seed set and grain test weight. Damage is more serious when it occurs during early heading than during tillering.

Control: *Cultural*—Hairy varieties are less desirable to cereal leaf beetle adults for egg laying and to larvae for feeding.

Biological—In the 1970s, a wasp egg parasitoid (*Anaphes flavipes*) was imported from Europe and distributed throughout Michigan. The spotted lady beetle (*Coleomegilla maculata lengi*) is an important predator that feeds on eggs early in the season. Larval parasitoids include three wasps, and a tachinid fly parasitoid attacks adults. In combination, the natural enemies of the cereal leaf beetle usually control this pest.

Chemical—Cereal leaf beetle infestations often start along field borders of winter grains, with adults moving to preferred spring grains. Begin looking for adult feeding damage in the spring after the first warm spell (above 60 degrees F). Check adult-damaged fields for eggs and larvae. The decision to manage cereal leaf beetle is based on plant stage and the number and stage of development of the larvae. (See MSU Extension bulletin E-2549, *Insect Management in Wheat and Other Small Grains*.) Timing of application is extremely important, and applications are more effective when small rather than large larvae are present.

INSECT PESTS OF SOYBEANS

DEFOLIATORS

Many pests defoliate soybeans. Most are general feeders, capable of infesting many crops. High infestations of fall armyworms cause the most severe damage to soybeans. Fall armyworms prefer grass crops but can be a problem in weedy fields or when soybeans are double-cropped with small grains.

Taking whole-plant samples is best when you are scouting seedling-stage soybeans for defoliators. Sweep nets or ground cloths can be used for sampling larger plants. When making a management decision, it is important to consider all damage from all caterpillars (lepidopteran defoliators).

Bean Leaf Beetle (*Cerotoma trifurcata*)

Pest status: occasional.



Bean leaf beetle adult.

Characteristics and life cycle: Upon emergence in the spring, adult beetles feed on alfalfa. After the first alfalfa cutting and soybean emergence, bean leaf beetles move to soybean fields to lay eggs. Eggs are deposited in the soil and larvae feed on roots as they develop. Mature larvae build an earthen cell and pupate inside. Adult beetles emerge after approximately seven days. Usually peak emergence for this second generation is late August to mid-September. Second generation bean leaf beetles feed on soybeans and alfalfa before moving into overwintering sites.

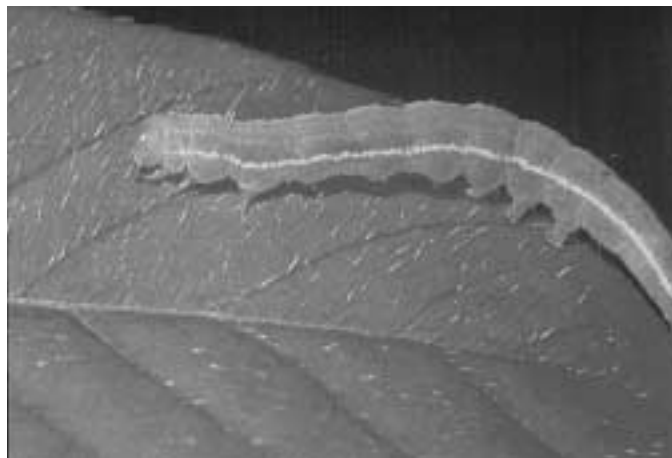
Damage: Bean leaf beetle larvae use their chewing mouthparts to eat roots, root hairs, and nodules. Adult beetles defoliate plants by chewing small, round holes in the leaves. Defoliation is a concern early in the season. Later in the season, beetles feed on pods all the way down to the seeds. This feeding damage creates lesions on the pod that remain visible at harvest and increase seed vulnerability to secondary pathogens. Seeds beneath lesions become shrunken, discolored, and sometimes moldy, resulting in loss of grain weight and quality.

Control: **Cultural**—Planting soybeans as late as possible (within the recommended planting period for a variety) can reduce bean leaf beetle colonization.

Chemical—Adult sampling should begin early in the season. Management is not usually necessary because of soybean tolerance of defoliation.

Green Cloverworm (*Plathypena scabra*)

Pest status: occasional outbreaks.



Green cloverworm.

Characteristics and life cycle: The adult moth migrates into Michigan each spring from overwintering grounds along the Gulf Coast. Eggs are laid on the undersides of leaves. The eggs turn brownish with red specks about 48 hours before hatching. Green cloverworm larvae (caterpillars) are pale green with two white stripes running horizontally along each side of the body. They have three pairs of abdominal prolegs plus one pair of **anal prolegs** (false, peglike legs near the anus of the caterpillar).

Damage: Green cloverworm larvae consume soybean foliage, giving leaves a tattered appearance.

Control: Biological—A primary factor controlling green cloverworm populations is a disease caused by the fungus *Nomuraea rileyi*. Several predators and parasitoids also attack larvae.

Chemical—Insecticide applications are rarely used to manage green cloverworm.

Japanese Beetles (*Popillia japonica*)

Pest status: occasional.



Japanese beetle.

Characteristics and life cycle: Japanese beetles overwinter as larvae, commonly known as grubs, in the soil. Typically, they are found in grassy areas surrounding a field but can also be found in the soybean field. In late May or June, adults emerge and begin feeding on soybeans. Adult beetles are metallic green with reddish brown wing covers and white tufts on the abdomen. There is one generation per year.

Damage: Adult beetles feed on leaf tissue between veins, giving the plant a skeletonized, lacy appearance. Responding to pheromones, Japanese beetles congregate. A soybean field may have multiple areas with large concentrations of beetles. Defoliation at these congregation sites can be heavy. Though Japanese beetle adults do most of the damage to soybeans, grubs do feed on soybean roots.

Control: Feeding by Japanese beetles alone usually is not sufficient to justify chemical treatment. Generally, a threshold of 25 percent defoliation due to combined feeding from Japanese beetles and other defoliators is used.

Two-spotted Spider Mite (*Tetranychus urticae*)

Pest status: occasional.

Characteristics and life cycle: This extremely small (0.3 to 0.4 mm) arthropod is more closely related to spiders than to insects and is distributed worldwide. Adults are greenish yellow to dull orange with eight legs and two large, black dots on their bodies. They produce noticeable webbing on heavily infested plants. Female mites lay

eggs on the undersides of leaves. Spider mites go through a six-legged larval stage and two eight-legged nymphal stages. Rapid reproduction—four to 14 days per generation—results in exponential population growth.



Spider mite.

In northern states, spider mites overwinter as adults. Two-spotted spider mites disperse via air and by crawling, and they can infest a field extremely quickly. Spider mite populations increase quickly during hot, dry conditions, and damage is aggravated in water-stressed plants. Though a microscope is needed to correctly identify mites, the two-spotted spider mite is the only mite commonly found on soybeans in Michigan.

Damage: Feeding occurs on the undersides of leaves. The spider mite uses its needlelike mouthparts to pierce and suck the contents of individual plant cells. Infested leaves have small, white or yellow spots called stippling. This reduces the photosynthetic capacity of the leaf and creates leaf water stress. Eventually, with increased mite infestation, leaves become yellow, then brown, and drop from the plant. Maximum infestation of 1,000 spider mites per leaf causes complete defoliation. Early-season attacks can reduce overall plant growth.

Control: Biological—The fungal pathogen *Neozygites floridana* is the most effective natural enemy of the two-spotted spider mite. Specific to spider mites, this pathogen attacks all mite stages by attaching to the mite's legs or body. Infected mites usually have a waxy or cloudy appearance and die within one to three days after infection. The effectiveness of this fungal pathogen depends on environmental conditions—it requires a temperature below 89 degrees F (29 degrees C) and at least 90 percent relative humidity for 12 to 24 hours.

Chemical—Begin sampling along field edges, closely examining leaves in the middle and lower canopy for stippling. Herbicide injury may resemble mite damage, so use a hand lens to confirm the presence of mites. Unfortunately, by the time that damage has been recognized, mites have infested the entire field. Late-season treatments may be difficult because of the 21- to 28-day preharvest intervals for most labeled chemicals. Mite populations can recover rapidly after treatment, adding to the expense and difficulty of control. They also have a tremendous capacity to develop insecticide resistance.

Soybean Aphid (*Aphis glycines*)



Soybean aphids.

In 2000, a new pest of soybeans, the soybean aphid (*Aphis glycines*), was detected in Michigan. Soybean aphids are small ($\frac{1}{16}$ to $\frac{1}{8}$ inch), pear-shaped, soft-bodied insects that live in colonies made up of both winged and wingless insects. Female aphids do not have to mate with males to reproduce. This allows an aphid population to increase quickly. Though aphids have been found across the state, the heaviest infestations to date (2000) have been in southwestern Michigan.

Soybean aphids have sucking mouthparts and remove water and nutrients from leaves and stems. The impact of soybean aphids on Michigan soybean production is not known. Research is underway to determine thresholds and treatment guidelines. Consult your county agriculture agent for updated information on scouting and treatment recommendations.

INSECT PESTS OF SUGAR BEETS

Sugar Beet Root Aphid (*Pemphigus betae*)

Pest status: localized occasional pest.



Sugar beet root aphid on sugar beets.

Characteristics and life cycle: Sugar beet root aphids are localized pests. Adult females overwinter in soil. In spring, they move to roots of lambsquarter and then to beets later in the season, producing young. Aphids present during the field season are all female and reproduce without mating. There are multiple generations per year.

Damage: Adults and nymphs use their sucking mouthparts to remove plant fluids from beet roots. This reduces root yield, sugar content, and juice purity. Sugar beet root aphids secrete a white, waxy material, which remains on colonized roots and interferes with water uptake. In severe infestations, beet leaves turn yellowish green and plants shrink and wilt.

Control: Non-chemical—In fields where aphids have overwintered in the soil, crop rotation (three or more years) and good weed control reduce infestations. Resistant varieties are available.

Chemical—Consult current MSU Extension bulletins for current insecticide recommendations.

Spinach Leaf Miner (*Pegomya hyoscyami*)

Pest status: occasional.

Characteristics and life cycle: In late April and May, the adult spinach leaf miner emerges from its overwintering site in the soil. The adult fly resembles a housefly. Adult females deposit small, whitish eggs on the undersides of sugar beet leaves. Larvae (maggots) feed inside leaves and pupate in the soil. There are several generations per year.

Damage: The spinach leaf miner is an occasional pest that rarely causes economic losses. The larvae feed between the upper and lower surfaces of the leaf tissue, forming a characteristic tunnel or “mine.” As the maggots grow, the mines enlarge, forming blotches.

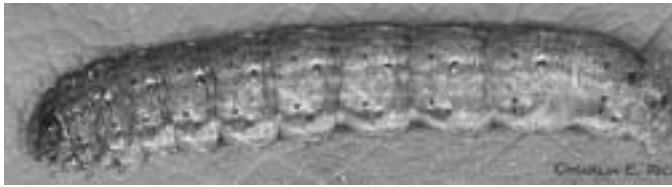


Spinach leafminer damage on sugarbeets.

Control: Chemical—Insecticides should be applied when eggs are present on 50 percent or more of small plants and when the first mines are seen.

GENERAL INSECT PESTS

Cutworms



Black cutworm (M. Rice, Iowa State University).

Characteristics and life cycle: Various cutworms occasionally attack Michigan crops. Some overwinter in Michigan; others migrate to Michigan as adults each spring. Adult cutworms are moths. The larvae (caterpillars) are up to 2 inches long and come in a variety of colors (black, tan, greenish yellow) with a row of light yellow spots down the back. Each cutworm species has a slightly different life cycle and feeding behavior.

Damage: With their chewing mouthparts, larvae feed on leaves and cut stems. New seedlings are at the greatest risk for damage.

Control: Because several species of cutworms attack field crops in Michigan, correct identification is extremely important to adequately control the pest. Infestations are sporadic, so scouting fields and early diagnosis is also necessary. Also, because infestations are sporadic, foliar insecticides (curative) are recommended rather than soil insecticides at planting (preventive).

Grubs



Grub.

Characteristics and life cycle: Grubs are the C-shaped larval stage of beetles. Many are turf pests, but others occasionally cause damage in field crops. True white grubs are the larvae of May and June beetles; they require three years to complete development. Other grubs are the larvae of Japanese beetles or chafers; they require only a year to complete their life cycle (annual grubs). Correct identification of a grub problem is key to recommending control options.

Damage: Grubs prefer to feed on the roots of grasses, but they can cause irregular emergence, reduced plant stand, stunting, and wilting by feeding on the roots and root hairs of field crops. They can also sever taproots.

Control: Non-chemical—Spring and summer plowing of established sod is recommended before a crop is planted. Predators such as birds play a minor role in grub management.

Chemical—Depending on the crop, a soil insecticide can be applied in-furrow or banded at time of planting. Chemical treatment is not usually required, however.

Wireworms (*Limonius* spp.)



Wireworms.

Characteristics and life cycle: Wireworms are the larval stage of click beetles. They are slender and shiny brown with wiry, segmented bodies. Larvae live for two to six years in the soil. Because of the long life cycle, crops planted into less disturbed ground (sod, pasture, old alfalfa, or reduced tillage fields) are at a greater risk for wireworm damage.

Damage: Wireworms feed on seeds and roots. They can reduce plant stand by preventing seed germination and attacking young plants.

Control: Non-chemical—Spring and summer plowing of established sod is recommended before a crop is planted.

Chemical—A seed treatment or insecticide application at planting can help protect the crop from wireworm damage.

Seedcorn Maggot (*Hylemya platura*)

Characteristics and life cycle: Seedcorn maggots are small (1/4 inch), white maggots. The adults are small, gray flies that emerge in early spring to lay eggs in disturbed soil with high organic matter (for example, a field with manure or plowed cover crops). The maggots feed for one to three weeks and then pupate in the soil. There are multiple generations per year.

Damage: Seedcorn maggots are usually a problem during cold, wet springs and in soils with high organic mate-

rial. Feeding on germinating seeds, they may cause variable emergence, stand loss, or delayed development. They also create an entrance for disease organisms.

Control: Non-chemical—Using reduced tillage, planting later in the season, and shallow planting in a well prepared seed bed decrease seedcorn maggot damage potential.

CHAPTER 5

Review Questions

Chapter 5: Insect management

Write the answers to the following questions and then check your answers with those in the back of the manual.

1. Insect damage can result in:
 - A. An unmarketable product.
 - B. Disease transmission.
 - C. Yield reduction.
 - D. All of the above.
2. Molting is the process of shedding an old skeleton to reveal a new, larger exoskeleton.
 - A. True.
 - B. False.
3. Define metamorphosis.
- 4-8. Match the following forms of metamorphosis with the correct statement.
 - A. Simple
 - B. Complete
 - C. Both simple and complete
 4. ___ Immature insects resemble adults.
 5. ___ Adult and nymphs usually live in the same environment.
 6. ___ Adult insects have wings.
 7. ___ Immature insects do not look like the adults.
 8. ___ Immature insects are referred to as larvae.
9. During which insect life stage does an insect undergo a complete change?
 - A. Nymph
 - B. Larva
 - C. Pupa
 - D. Adult
10. The corn rootworm goes through which type of metamorphosis?
 - A. Simple
 - B. Complete
11. Why is it important to understand an insect's life cycle for pest management?

Chemical—If a maggot problem is expected, treating seed with an insecticide before planting is the most effective and convenient control method. Though more expensive, a soil insecticide can be applied if seed and planter box treatments are not possible.

12-18. Match the following insects with the correct statement below. Answers can be used more than once.

- A. Alfalfa weevil
- B. Potato leafhopper
- C. Corn flea beetle
- D. Armyworm
- E. European corn borer

- 12. ___ Damage causes "hopperburn."
- 13. ___ Occasional pest of corn that can migrate in large numbers.
- 14. ___ Transgenic Bt corn plants are used to control.
- 15. ___ Primarily feeds on alfalfa leaves and stems in the spring.
- 16. ___ Transmits Stewart's wilt.
- 17. ___ Begin sampling alfalfa using a sweep net in mid-June.
- 18. ___ Feeds on leaves and burrows into corn stalks.

19. The larval corn rootworm causes damage to corn by feeding on the:

- A. Silks.
- B. Root hairs and root tips.
- C. Ear shank.
- D. Foliage.

20. Corn-soybean crop rotations do not control the variant _____ corn rootworm populations.

- A. Northern
- B. Southern
- C. Western
- D. Eastern

21. First generation European corn borers feed primarily in the:

- A. Ear.
- B. Shank.
- C. Whorl.
- D. Roots.

22. European corn borer feeding can result in:

- A. Ear drop.
- B. Stalk breakage.
- C. Grain reduction.
- D. All of the above.

23. The tarnished plant bug has what type of mouth parts?

- A. Chewing.
- B. Sucking.
- C. Rasping.

24. Aphids and leafhoppers can spread plant disease.

- A. True
- B. False

25. Which insect has chewing mouthparts and usually moves to soybeans after the first cutting of alfalfa?

- A. Spider mites.
- B. Green cloverworms.
- C. Bean leaf beetles.
- D. Aphids.

26. Which of the following larvae is a common predator of aphids?

- A. Lacewing
- B. Monarch
- C. Housefly
- D. None of the above

27. Fungal pathogens usually keep which two soybean pests from reaching high pest densities?

- A. Bean leaf beetle and green cloverworm.
- B. Two-spotted spider mite and bean leaf beetle.
- C. Two-spotted spider mite and green cloverworm.
- D. Bean leaf beetle and lepidopteran defoliators.

28-31. Match the following insects with the characteristics given below.

- A. Cutworms
- B. Grubs
- C. Wireworms
- D. Seedcorn maggot

28. ___ Prefer to feed on grass roots.

29. ___ Can live for two to six years in the soil.

30. ___ Feeds on leaves and stems.

31. ___ More commonly a problem during a cold, wet spring.

32. A farmer complains that a large group of caterpillars has just moved into his/her corn field and eaten all the leaves off the plants. This pest is most likely:
- A. Corn earworm.
 - B. Armyworm.
 - C. Green cloverworm.
 - D. Wireworm.
33. It is difficult to control this insect in alfalfa and dry beans because adults are very mobile and often quickly reinfest fields after a pesticide application.
- A. Potato leafhopper
 - B. Aphids
 - C. Mites
 - D. None of the above
34. Aphids must mate to produce offspring.
- A. True
 - B. False
35. Which of the following insects does NOT have sucking mouthparts?
- A. Alfalfa weevil
 - B. Potato leafhopper
 - C. Sugar beet root aphid
 - D. Tarnished plant bug