Pest Management

(Janet Knodel and Larry Charlet)

Integrated Pest Management

Sunflower can be a high-risk crop because of potential losses from diseases, insects, birds and weeds. These potential risks require that growers follow integrated pest management (IPM) practices. IPM is a sustainable approach to managing pests by combining biological, cultural, physical and chemical tools in a way that minimizes economic, health and environmental risks to maintain pest populations below levels that cause unacceptable losses to crop quality or yield. The concept of pest management is based on the fact that many factors interact to influence the abundance of a pest. Control methods vary in effectiveness, but integration of these various population-regulating factors can minimize the number of pests in sunflower and reduce the cost of managing pest populations without unnecessary crop losses. IPM also recommends the judicious use of chemical pesticides when needed and suggests ways to maximize effectiveness and minimize impact on nontarget organisms and the environment.

Economic Injury Level and Economic Threshold Levels

One major component of a pest management program is determining when tactics should be implemented to prevent economic loss. Economic loss results when pest numbers increase to a point where they cause crop losses that are greater than or equal to the cost of controlling the pest. An economic injury level (EIL) is defined as the level of pests that will cause economic damage. An EIL recognizes that treatment is justified for some pest population levels while others are not of economic importance.

An economic threshold level (ETL) is the level or number of pests at which tactics must be applied to prevent an increasing pest population from causing economic losses. Usually the ETL is lower than the EIL. The ETL has been defined most extensively for insect pests; fewer ETLs have been established for other types of pests. The ETL varies significantly among different pests and also can vary during different developmental stages of the crop. Crop price, yield potential, crop density, cost of control and environmental conditions influence the ETL and EIL. Generally, the ETL increases as cost of control increases and decreases as the crop value increases.

Monitoring Pest Population Levels

In general, fields should be evaluated regularly to determine pest population levels. A weekly field check is usually sufficient, but field checks should be increased to two or three times a week if the number of pests is increasing rapidly or if the number is approaching an economic threshold level. Pests should be identified accurately because economic threshold levels and con-

trol measures vary for different organisms. In addition, when insects pests are monitored, many insects are beneficial and may help reduce numbers of injurious insects; recognizing which are pests and those that are beneficial is important.

Tools of Pest Management

Tools of pest management include many tactics, of which pesticides are only one. These tactics can be combined to create conditions that are the least conducive for pest survival. Chemical or biological pesticides are used when pests exceed economic threshold levels; sometimes they are necessary when control is needed quickly to prevent economic losses.

Some of the tools or components of pest management that can be used to reduce pest populations are:

Biological Controls
Beneficial insects
Beneficial pathogens
Host Resistance

Cultural Controls
Planting and harvest dates
Crop rotation
Tillage practices

Mechanical/Physical Controls
Temperature
Weather events
Trapping

Chemical Controls
Pesticides
Attractants
Repellents
Pheromones

Summary

Growers should examine their operations and minimize pest damage by adopting integrated pest management practices based on the use of economic threshold levels, when available, plus carefully monitoring and combining various control methods. Significant progress with sunflower pest management has been made and undoubtedly will continue to be made in the future to aid successful sunflower production. The following sections provide current information on management of insects, diseases, weeds, birds and other sunflower pests. A growing season calendar shows the major sunflower pest problems and time of occurrence in the northern Great Plains production area (Figure 16).

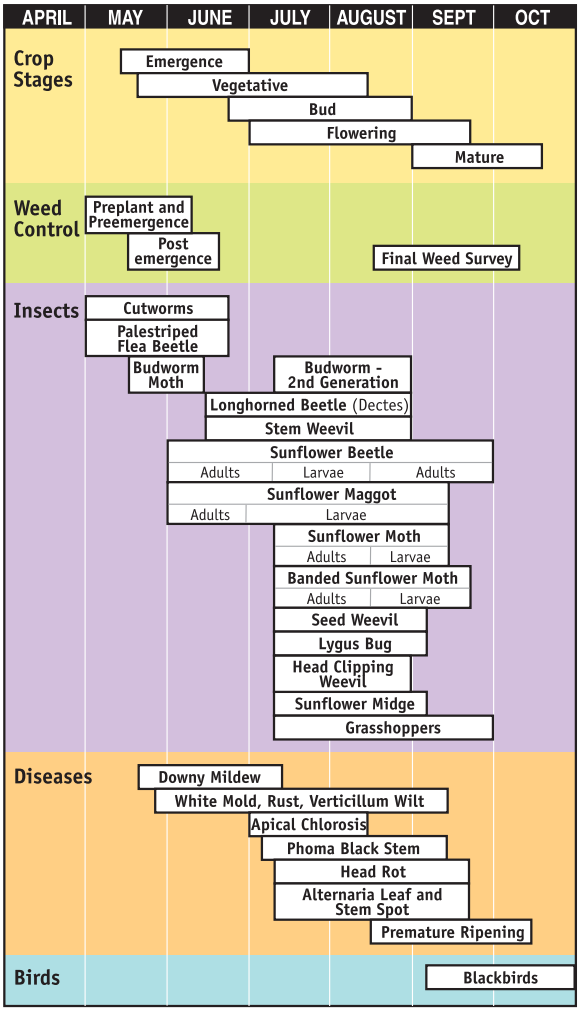

Figure 16. A growing season calendar indicating time of occurrence of major sunflower pests.
(J. Knodel)

Quick Reference Guide to Major Sunflower Insects

The information presented on this page is designed to be a quick reference for growers, crop consultants, field scouts and others. Since this information is very brief, the user should refer to the following pages for more detailed data on life cycles, damage, descriptions, etc.

Insects	Description	Occurrence, Injury and Economic Threshold (ET)
Cutworms (several species)	Dirty gray to gray brown. Grublike larva, 0.25 to 1.5 inches in length.	ET – 1 per square foot or 25 percent to 30 percent stand reduction. Appear in early spring when plants are in the seedling stage, chewing them at or slightly above ground.
Palestriped Flea Beetle	Adult: 1/8 inch long and shiny black, with two white stripes on the back. The hind legs are enlarged and modified for jumping.	ET – 20 percent of the seedling stand is injured and at risk to loss due to palestriped flea beetle feeding. Scout for flea beetles by visually estimating population on seedlings or using yellow sticky cards placed close to the ground.
Sunflower Beetle	Adult: reddish-brown head, cream back with three dark stripes on each wing cover. Body 0.25 to 0.5 inch long. Larva: yellowish green, humpbacked in appearance, 0.35 inch in length.	ET – 1 to 2/seedling (adults), or 10 to 15/seedling (larvae). Adults appear in early June, larvae shortly thereafter. Both adults and larvae chew large holes in leaves.
Sunflower Bud Moth	Adult: wingspread 0.63 to 0.75 inch, gray brown with two dark transverse bands on forewings. Larva: Cream-colored body (0.33 to 0.4 inch) with a brown head.	ET – none. First generation adults appear in late May to mid-June. Second generation adults appear in midsummer. Larvae from first generation damage terminals and stalks, whereas second generation larvae feed in receptacle area.
Longhorned Beetle *(Dectes)*	Adult: pale gray and 5/8 inch (6 to 11 mm) in length, with long gray and black banded antennae. Larvae: yellowish with fleshy protuberances on the first seven abdominal segments (1/3 to 1/2 inch)	No scouting method or ET has been developed. Adults are present from late June through August. Larvae tunnel and feed in the petioles and stem pith and girdle the base of plants. Stalks often break at the point of larval girdling.
Sunflower Stem Weevil	Adult: small (0.19 inch long) weevil with a gray-brown background and white dots on the back.	ET – 1 adult/3 plants in late June to early July. Adults appear in mid to late June, with larvae in stalks from early July to late summer.
Thistle Caterpillar (Painted Lady Butterfly)	Adult: wingspread of 2 inches, upper wing surface brown with red and orange mottling and white and black spots. Larva: brown to black, spiny, with a pale yellow stripe on each side, 1.25 to 1.5 inches in length.	ET – 25 percent defoliation, provided that most of the larvae still are less than 1.25 inches in length. Adults appear in early to mid-June, with larvae appearing shortly thereafter. Larvae chew holes in leaves.
Sunflower Midge	Adult: small (0.07 inch), tan, gnatlike insect. Larva: cream or yellowish, 0.09 inch long, tapered at front and rear.	ET – none. Adult emergence begins in early July. Larvae feed around head margin and at the base of the seeds, causing shrinkage and distortion of heads.
Sunflower Seed Weevils	Adults: the red sunflower seed weevil is about 0.12 inch long and rusty in color. The gray sunflower seed weevil is about 0.14 inch long and gray in color. Larvae: both species are cream-colored, legless and C-shaped.	ET – generally 8 to 14 adult red sunflower weevils per head (oil) and one per head (confectionery). Adults appear in late June to early July. Treat for red sunflower seed weevil at R5.1 to R5.4. Larvae feed in seeds from mid to late summer.
Sunflower Moth	Adult: body is 0.38 inch long, with 0.75 inch wingspread. Color is buff to gray. Larva: brown head capsule with alternate dark and light lines running longitudinally, 0.75 inch in length.	ET – 1 to 2 adults/5 plants at onset of bloom. Adults are migratory and usually appear in early to mid-July. Larvae tunnel in seeds from late July to late August.
Banded Sunflower Moth	Adult: small 0.25-inch straw-colored moth with brown triangular area on forewing. Larva: in early growth stage, off-white, changing to red and then green color at maturity, 0.44 inch in length.	ET – See banded sunflower moth section for egg or adult sampling methods for determining ET. Sampling should be conducted in the late bud stage (R-3), usually during mid-July. Adults appear about mid-July to mid-August. Larvae present in heads from mid-July to mid-September.
Lygus Bug	Adult: small (0.2 inch in length), cryptically colored insects with a distinctive yellow triangle or "V" on the wings and vary in color from pale green to dark brown. Nymph (immature stages): usually green and similar in appearance to the adults, but lack wings.	ET - for CONFECTION SUNFLOWERS ONLY – 1 Lygus bug per 9 heads. Two insecticide sprays are recommended: one application at the onset of pollen shed or 10 percent bloom, followed by a second treatment 7 days later.
Sunflower Headclipping Weevil	Adult: metallic, black, 0.25-inch long body with a long "snout." Larvae: 0.25 inch in length.	ET – none. Adults appear in mid to late July and create feeding punctures around stalk just below the heads. Heads drop off.

NOTE: The insects discussed above are listed in the order that they likely are to occur throughout the growing season; however, the various insects may or may not appear, depending upon overwintering survival and environmental conditions as the season progresses. The table is intended simply as a guide to when fields should be checked for possible presence of the various insects known to infest sunflowers.

Insects

(Janet Knodel and Larry Charlet)

Sunflower plays host to a number of insect pests. In the major sunflower producing areas of the Dakotas, Minnesota and Manitoba, approximately 16 species of sunflower insects can cause plant injury and economic loss, depending on the severity of infestation. However, during any one growing season, only a few species will be numerous enough to warrant control measures. The sunflower insects of major importance in the northern Great Plains have been sunflower midge, *Contarinia schulzi* Gagne'; sunflower beetle, *Zygogramma exclamationis* (Fabricius); sunflower stem weevil, *Cylindrocopturus adspersus* (LeConte); red sunflower seed weevil, *Smicronyx fulvus* LeConte; and the banded sunflower moth, *Cochylis hospes* Walsingham. Recently, Lygus bugs have been an economic problem for the confection and hulling sunflower seed market. Populations of the long-horned sunflower stem girdler, *Dectes texanus* LeConte, have been increasing in North and South Dakota.

Infestation of sunflower insects must be monitored regularly, usually weekly, to determine the species present and if populations are at economic threshold levels. Furthermore, proper timing of insecticidal treatment is essential to maximize control.

The following sections provide information on the identification, life cycle, damage, scouting methods, economic threshold levels and management of some of the most common insect pests of sunflower in the northern Great Plains. A preliminary quick reference guide to sunflower insects is available.

Sunflower pests are not distributed evenly throughout a field, and fields should be checked in several locations. Some insect pests, such as banded sunflower moth, are concentrated in areas of a field or are more abundant near the edge of a field than in the middle. Determining the extent of a pest population on the basis of what is found in only one or two small areas of a field is impossible. At least five sites per 40-acre field should be monitored to collect good information on the nature and extent of a pest infestation.

Sampling sites should be at least 75 feet in from the field margin to determine whether an entire field or a portion of the field requires treatment. When infestations occur primarily along field margins, delineating those and treating as little of the field as needed to provide economic control may be possible. In most cases, 20 plants per sampling site should be examined in the Z or X pattern as shown (Figure 17).

Crop consultants who are trained in pest management scouting may be hired. Consultants should be able to identify pest and beneficial insects and provide information about pest management.

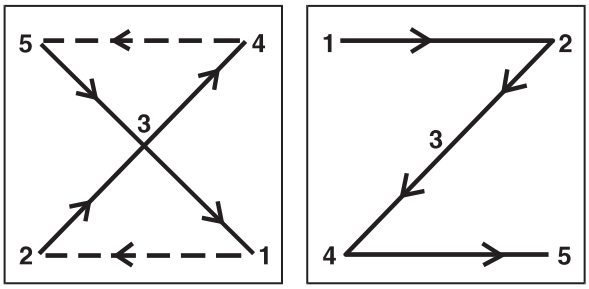

Figure 17. The X and Z scouting patterns.

Wireworms

Species: various

Description: Wireworm larvae (Figure 18) are hard, smooth, slender, wirelike worms varying from 1.5 to 2 inches (38 to 50 mm) in length when mature. They are a yellowish white to a coppery color with three pairs of small, thin legs behind the head. The last body segment is forked or notched.

Adult wireworms (Figure 19) are bullet-shaped, hard-shelled beetles that are brown to black and about ½ inch (13 mm) long. The common name "click beetle" is derived from the clicking sound that the insect makes when attempting to right itself after landing on its back.

Figure 18. Wireworm larvae. (Mark Boetel)

Figure 19. Click beetle or adult wireworm.
(Roger Key, http://www.insectimages.org)

Life Cycles: Wireworms usually take three to four years to develop from the egg to an adult beetle. Most of this time is spent as a larva. Generations overlap, so larvae of all ages may be in the soil at the same time. Wireworm larvae and adults overwinter at least 9 to 24 inches (23 to 61 cm) deep in the soil. When soil temperatures reach 50 to 55 F (10 to 13 C) during the spring, larvae and adults move nearer the soil surface.

Adult females emerge from the soil, attract males to mate, then burrow back into the soil to lay eggs. Females can re-emerge and move to other sites, where they burrow in and lay more eggs. This behavior results in spotty infestations throughout a field. Some wireworms prefer loose, light and well-drained soils; others prefer low spots in fields where higher moisture and heavier clay soils are present.

Larvae move up and down in the soil profile in response to temperature and moisture. After soil temperatures warm to 50 F (10 C), larvae feed within 6 inches (15 cm) of the soil surface. When soil temperatures become too hot (>80 F, 27 C) or dry, larvae will move deeper into the soil to seek more favorable conditions. Wireworms inflict most of their damage in the early spring, when they are near the soil surface. During the summer months, the larvae move deeper into the soil. Later as soils cool, larvae may resume feeding nearer the surface, but the amount of injury varies with the crop.

Wireworms pupate and the adult stage is spent within cells in the soil during the summer or fall of their final year. The adults remain in the soil until the following spring.

Damage: Wireworm infestations are more likely to develop where grasses, including grain crops, are growing. Wireworms damage crops by feeding on the germinating seed or the young seedling. Damaged plants soon wilt and die, resulting in thin stands. In a heavy infestation, bare spots may appear in the field and reseeding is necessary.

Scouting Method: Decisions to use insecticides for wireworm management must be made prior to planting. No rescue treatments are available for controlling wireworms after planting. Producers have no easy

way to determine the severity of infestation without sampling the soil. Infestations vary from year to year. Considerable variation may occur both within and between fields.

Sometimes the past history of a field is a good indicator, especially if wireworms have been a problem in previous seasons. Also, crop rotation may impact population levels.

Two sampling procedures are available. One procedure relies on the use of a corn-wheat seed mixture used as bait, placed in the soil, which attracts the wireworms to the site (Figure 20). The other involves digging and sifting a soil sample for the presence of wireworms.

Economic Threshold: If the average density is greater than one wireworm per bait station, the risk of crop injury is high and a soil insecticide should be used at planting to protect the sunflower. If no wireworms are found in the traps, risk of injury is low; however, wireworms still may be present but were not detected by the traps. When digging soil samples, 12 or more wireworms in 50 3-inch by 3-inch (8 cm by 8 cm) samples, is likely to result in damage to sunflower.

Management: Seeds should be treated with an approved insecticide for protection of germinating seeds and seedlings.

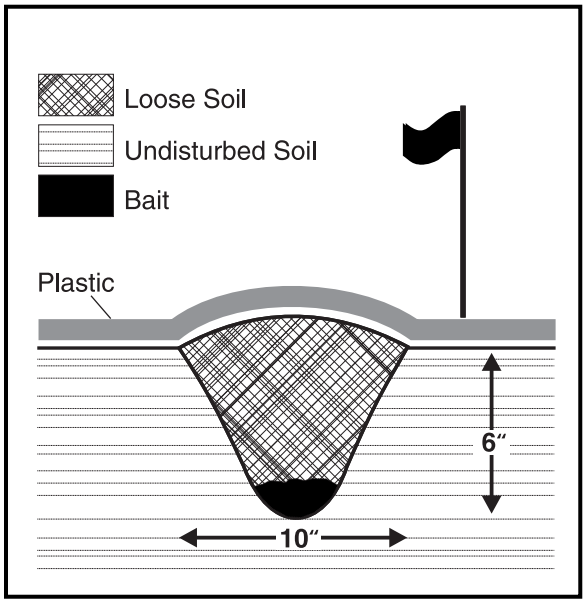

Figure 20. Wireworm bait station. (Extension Entomology)

Seedcorn Maggot

Species: *Delia platura* (Meigan)

Description: Seedcorn maggots are larvae of small flies resembling houseflies. The adult is a light gray fly about 0.2 inch (5 mm) long. Larvae are white, cylindrical, tapered anteriorly and also about 0.2 inch (5 mm) long (Figure 21). Larvae can be found inside damaged seeds or in the soil nearby.

Life Cycle: After soil temperatures reach 50 F (10 C) in the spring, the flies emerge, mate and then deposit eggs in soil, especially where high organic matter exists. Eggs hatch in a few days and the maggots burrow into seeds. Infected seeds often do not emerge, resulting in stand loss. Even when infested seeds do germinate, plants may be weakened. No effective preplant monitoring techniques are available for seedcorn maggots. Fields with extensive decaying organic matter, such as those that are heavily manured or where a cover crop has been turned under, are particularly attractive to egg-laying flies.

Damage: The first sign of seedcorn maggot damage is areas in the field where seedlings have not emerged. Seedcorn maggots hollow out seeds or eat portions of seedlings. Damage is most common in early plantings while the soil is cool, and if organic matter is high, such as when a green plant material is plowed into a field before planting. Females are strongly attracted to decaying organic matter for laying eggs.

Scouting Method: Scouting to determine the risk of seedcorn maggot infestation has not been developed.

Figure 21. Seed corn maggot larvae. (Ric Bessin, University of Kentucky)

Cutworms

Species:
Darksided cutworm *Euxoa messoria* (Harris)
Redbacked cutworm *Euxoa ochrogaster* (Guenee)
Dingy cutworm *Feltia jaculifera* (Walker)

Description: Darksided cutworm — Forewings of the adult darksided cutworm are usually light, powdery and grayish brown with indistinct markings (Figure 22). The larvae are pale brown dorsally and white on the ventral areas (Figure 23). Sides have numerous indistinct stripes. At maturity, they are about 1.25 to 1.5 inches (32 to 38 mm) long and 0.19 inch (5 mm) wide.

Redbacked cutworm — The forewings of the adult redbacked cutworm are reddish brown with characteristic bean-shaped markings (Figure 24). The larvae are dull gray to brown with soft, fleshy bodies and may be 1 to 1.25 inches (25 to 32 mm) long when fully grown (Figure 25). Larvae can be distinguished by two dull reddish stripes along the back.

Dingy cutworm — Forewings are dark brown with bean-shaped markings as in the redbacked cutworm adults (Figure 26). Hind wings in the male are whitish with a broad, dark border on the outer margin; in the female they are uniform dark gray. The larvae have a dull, dingy, brown body mottled with cream color. The dorsal area is pale with traces of oblique shading (Figure 27).

Life Cycles: The female darksided and redbacked cutworm moths deposit eggs in the soil in late July and early August. The eggs remain dormant until the onset of warm weather the following spring. The larvae of both species emerge from late May to early June. They continue to feed and grow until about the end of June, when fully grown larvae pupate in earthen cells near the soil surface. The pupal period lasts about three weeks. Both species have one generation per year.

The adult dingy cutworms emerge in August and are active until mid-October, with peak activity in September. Eggs are deposited in plants in the Compositae family in the fall. The larvae develop to the second or third instar in the fall and overwinter in the soil. Pupation occurs in the spring to early summer. One generation of this species is produced per year.

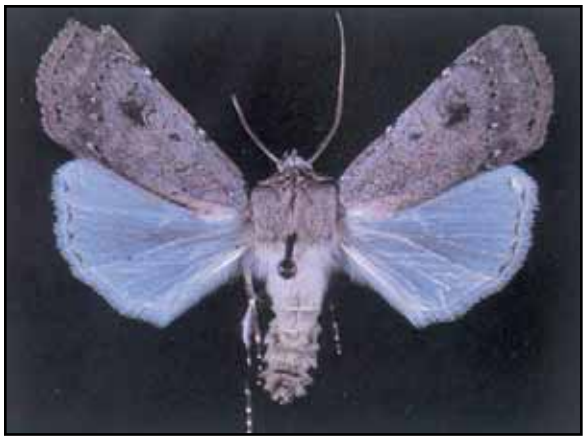

Figure 22. Adult - Darksided cutworm *Euxoa messoria*. (Extension Entomology)

Figure 23. Larva - Darksided cutworm *Euxoa messoria.* (Extension Entomology)

Figure 24. Adult - Redbacked cutworm *Euxoa ochrogaster.* (Extension Entomology)

Figure 25. Larva - Redbacked cutworm *Euxoa ochrogaster.* (Extension Entomology)

Damage: Cutworm damage normally consists of crop plants being cut off from 1 inch (25 mm) below the soil surface to as much as 1 to 2 inches (25 to 50 mm) above the soil surface. Young leaves also may be severely chewed as a result of cutworms (notably the darksided species) climbing up to feed on the plant foliage.

Most cutworm feeding occurs at night. During the daytime, the cutworms usually will be just under the soil surface near the base of recently damaged plants. Wilted or dead plants frequently indicate the presence of cutworms. Cut-off plants may dry and blow away, leaving bare patches in the field as evidence of cutworm infestations.

Scouting Method: Sampling should begin as soon as sunflower plants emerge, and fields should be checked at least twice per week until approximately mid-June. The Z pattern should be used in scouting fields for cutworms, with sampling points one and two near the margin as indicated in Figure 17.

Stand reduction is determined by examining 100 plants per five sampling sites for a total of 500 plants.

Figure 26. Adult - Dingy cutworm *Feltia jaculifera.*
(Extension Entomology)

Figure 27. Larva - Dingy cutworm *Feltia jaculifera.*
(Extension Entomology))

A trowel or similar tool should be used to dig around damaged plants to determine if cutworms are present, since missing plants in a row do not necessarily indicate cutworm damage (damage may be caused by a defective planter, rodents or birds).

The Z pattern should be used again to determine cutworm infestation level by examining five 1-square-foot (30 by 30 cm) soil samples per site (in the row) for a total of 25 samples.

Economic Threshold: One larva per square foot (30 by 30 cm) or 25 percent to 30 percent stand reduction.

Management: Several different insecticides are registered for cutworm control in sunflower. Postemergent treatment with an insecticide provides quick control of surface feeding cutworms.

Palestriped Flea Beetle

Species: *Systena blanda* (Melsheimer)

Description: The adult is about 1/8 inch (3.2 mm) long and shiny black, with two white stripes on the back. The hind legs are enlarged and modified for jumping (Figure 28).

Life Cycle: The life cycle of palestriped flea beetles on sunflower fields is poorly understood. However, the adult flea beetles seem to overwinter in the field under soil clods, field debris and crop residues. They become active again in the spring, perhaps feeding first on alfalfa and weeds before moving to and feeding on sunflower seedlings in June. They have been observed feeding on sunflower through July. Palestriped flea beetles have a wide host range, which includes various weeds, potato, tomato, carrot, peanut, corn, oat, cotton, pea, beans, strawberry, watermelon, grape and

Figure 28. Adult - Palestriped flea beetle.
(Michael Catangui, SDSU)

pumpkin. Palestriped flea beetles are considered an important pest of commercially grown vegetables in some areas of the U.S. Recently, palestriped flea beetles have been observed delaying regrowth of alfalfa and also were observed feeding on soybean seedlings in eastern South Dakota.

Damage: Palestriped flea beetles chew on the cotyledons, leaves and hypocotyls of sunflower seedlings, causing them to wilt and die. Injured leaves become riddled with holes, giving them a "lacey" appearance (Figure 29). The sunflower plant is most sensitive to palestriped flea beetle injury from seedling emergence (V-E) through the four-leaf stage (V-4). Significant stand losses may result from heavy feeding injury by the palestriped flea beetles.

Figure 29. Damaged sunflower leaves by palestriped flea beetle. (Michael Catangui, SDSU)

Scouting Method: Surveys may be accomplished by using yellow sticky cards placed close to the ground (Figure 30). Sampling seedlings for beetles also can aid in estimating populations and feeding injury levels. Palestriped flea beetles move very fast and are hard to count directly on the seedlings or catch with an insect net.

Economic Threshold: Control is recommended when 20 percent of the seedling stand is injured and at risk to loss due to palestriped flea beetle feeding. This economic threshold is a guideline based on published hail injury data that predicts potential yield loss relative to seedling stand loss.

Management: Palestriped flea beetles are hard to control with chemical insecticides; research has shown that treatments may provide up to 75 percent control of adults.

Figure 30. Yellow sticky trap for monitoring palestriped flea beetles. (Michael Catangui, SDSU)

Sunflower Beetle

Species: *Zygogramma exclamationis* (Fabricius)

Description: The sunflower beetle is associated exclusively with sunflower. Adults (Figure 31) closely resemble adult Colorado potato beetles and may be confused with potato beetles. However, sunflower beetles are smaller and do not feed on potatoes, and Colorado potato beetles do not feed on sunflower. The head of the adult is reddish brown and the thorax (area between head and abdomen) is pale cream-colored with a reddish-brown patch at the base. Each front wing cover is cream-colored and has three dark stripes that extend its length. A shorter lateral stripe ends at the middle of the wing in a small dot that resembles an exclamation point. The beetle is ¼ to ½ inch (6 to 12 mm) long and 3/32 to 3/16 inch (2 to 4 mm) wide. Eggs are about 1/16 inch (1.5 to 2 mm) long, cigar-shaped and cream yellow. Sunflower beetle larvae are yellowish green with a brown head capsule and humpbacked in appearance. Newly hatched larvae are about 1/16 inch (1.5 to 1.75 mm long), and will reach a length of about an inch (8 to 10 mm) when fully developed (Figure 32).

Figure 31. Adult - Sunflower beetle *Zygogramma exclamationis.* (Extension Entomology)

Life Cycle: The sunflower beetle has one generation per year in North Dakota. The adults overwinter in the soil, emerging in late May or early June. Shortly after emergence, the beetles begin to feed, mate and lay eggs singly on stems and undersides of leaves. Adults live for about 8½ weeks and lay eggs for a six- to seven-week period. Each female lays approximately 850 eggs, with a range of 200 to 2,000 eggs. Eggs hatch into larvae in about one week (Figure 33). The larvae have four instars, which feed and are present in fields for about six weeks. When mature, the larvae enter the soil to pupate in earthen cells. The pupal stage lasts from 10 days to two weeks. Adults of the new generation emerge and feed for a short period on the bracts of the sunflower head or on the uppermost leaves of the plant before re-entering the soil to overwinter.

Damage: Adult sunflower beetles damage plants soon after they emerge from overwintering. Damage to cotyledons is generally slight, but the first true leaves may be severely damaged or completely consumed. Fields may be severely defoliated if beetles are numerous. Adults feed predominately on leaf margins while

Figure 32. Larva - Sunflower beetle *Zygogramma exclamationis.* (Larry Charlet)

Figure 33. Eggs - Sunflower beetle. (Larry Charlet)

larvae feed on the entire leaf surface. When larvae are numerous, damaged leaves take on a lacy appearance. Most larval feeding occurs at night, and adults will feed during the day. During the daytime, larvae typically rest in the terminal growth area, where they are easily found in leaf axils and flower buds. If larval feeding is severe, defoliation can reduce yield due to poor seed set or fill.

The late summer generation of emerging sunflower beetle adults and late-maturing larvae rarely causes economic damage to the sunflower crop. However, in some cases, they have been abundant enough to cause feeding injury on late-planted sunflower.

Scouting Method: Sampling sites should be at least 75 to 100 feet (23 to 31 m) from the field's margins when determining if an entire field should be treated. Adults and/or larvae should be counted on 20 plants at each of five sampling sites along an X pattern for a total of 100 plants. The average number of adults and/or larvae per plant then should be determined.

The average percent defoliation of plants is determined when damage is evident in the field by examining 20 plants per five sampling sites for a total of 100 plants (Figure 34).

Economic Threshold: As sunflower plants develop, they can tolerate more feeding damage. In the seedling stage, one to two adults per seedling is the recommended economic threshold. For larvae, the treatment threshold is when populations reach 10 to 15 larvae per plant, or when approximately 25 percent defoliation occurs on the upper eight to 12 leaves (active growing part). Management normally is advised if defoliation reaches the 25 percent to 30 percent level at the late vegetative and early bud stages and it appears (based on larval size of less than ¼ inch or 6 mm) that more defoliation will occur on the actively growing part of sunflower plant. However, if defoliation is 25 percent and the majority of larvae are about 1/3 inch (8 mm) long, they have reached maturity and soon will stop feeding. Then, management probably is not warranted.

Management: Insecticide seed treatments and foliar insecticides are effective in reducing spring populations of the adult sunflower beetle. Application of a foliar insecticide is recommended only when beetle populations have reached an economic threshold level in a field. Insecticides are effective in preventing economic loss when applied to actively feeding adults and/or larvae. Adult and larval populations of sunflower beetle decrease as planting date is delayed. Defoliation also is lower at the later planting dates. As a result, delayed planting is effective in preventing yield reductions caused by sunflower beetle feeding, but may make fields more attractive to later season insects, such as red sunflower seed weevil. Spring or fall cultivation does not reduce the overwintering populations of sunflower beetle adults or influence the pattern of emergence from the soil during the spring and summer. Sunflower hybrids with resistance to the sunflower beetle are not available. Natural enemies include parasites of the eggs, larvae and adults. General predators, such as ladybird beetles, carabid beetles, lacewings, stink bugs, nabids and anthocorids, destroy both eggs and larvae of the sunflower beetle.

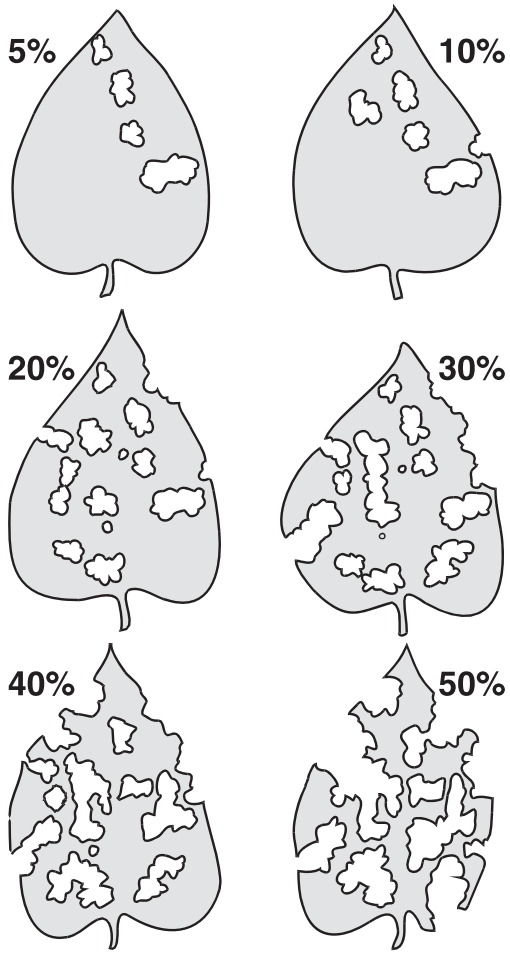

Figure 34. Percent defoliation of sunflower leaves. (Extension Entomology)

Sunflower Bud Moth

Species: *Suleima helianthana* (Riley)

Description: Sunflower bud moths have a wingspread of about 0.63 inch (16 to 18 mm). Each gray-brown forewing has two dark transverse bands (Figure 35). One band extends across the middle of the wing and the second band is near the wing tip. The larva has a dark head capsule with a smooth, cream-colored body and is 0.31 to 0.43 inch (8 to 11 mm) at maturity (Figure 36).

Life Cycle: Two generations of sunflower bud moth are produced per year in North Dakota. Adults emerge from overwintering pupae during the last week of May to mid-June.

A few days after adult emergence, eggs are deposited on the terminals of immature sunflower or on the receptacle of mature sunflower. Eggs also are deposited in leaf axils. The hatched larvae begin tunneling into the sunflower plant. The initial infestation in mid-June is characterized by an entrance hole surrounded by black frass, or insect excrement.

Mature larvae pupate within the sunflower plant. Pupae move to the opening of the entrance holes formed in the stem or head tissue so that adults can emerge easily.

The second-generation adults appear in July and August. Infestation by the second-generation larvae is not economically important.

Damage: In early planted sunflower, 65 percent to 85 percent of the infestations occur in the stalks. In late-planted sunflower, most infestations occur in the pith areas of the head.

Up to 4,000 larvae per acre have been reported in North Dakota and 24,000 larvae per acre have been reported in Texas. Despite these high populations, economic loss due to this insect has been minimal. The only time yield loss is noticeable is when larvae burrow into unopened buds, preventing proper head development. The larvae normally do not feed on developing seeds but confine feeding activities to the fleshy part of the head. Yield loss has not been economically significant, although injury by the larva produces malformations in both the head and stalk.

Figure 35. Adult - Sunflower bud moth *Suleima heliathana.* (Extension Entomology)

Figure 36. Larva - Sunflower bud moth *Suleima heliathana.* (Extension Entomology)

Scouting Method: A field monitoring scheme for this insect has not been established since it is not of economic significance.

Economic Threshold: None established.

Management: Insecticide use has not been warranted for control of sunflower bud moth.

Long-horned Sunflower Stem Girdler or Longhorned Beetle

Species: *Dectes texanus* LeConte

Description: The adult is pale gray and 5/8 inch (6 to 11 mm) in length, with long gray and black banded antennae. (Figure 37) Eggs are about 0.1 inch (1.9 mm) long and elongate, and turn dark yellow prior to hatch. Mature larvae are yellowish and 1/3 to 1/2 inch (7 to 13 mm) in length. Larvae bear fleshy protuberances on the first seven abdominal segments. (Figure 38).

Life Cycle: Adults appear in mid-June to early July in the southern Plains. Emergence continues through August, with 50 percent emerged by mid-July in Texas. Eggs are laid four to eight days after mating and eggs are deposited singly in leaf petioles. Approximately 50 eggs are laid per female, with about one-third viable. Eggs hatch in six to 10 days. Larvae tunnel and feed in the petioles and stem pith and finally move to the base of the plant to overwinter. Larvae develop through six instars. In late summer, the mature larvae girdle the inside of the lower stalk or root crown, move below the girdle and pack frass into the tunnels. Stalks often break at the point of girdling, leaving the larva protected in its frass-packed tunnel during the winter. The larvae are cannibalistic and stalks usually harbor only a single larva, even though several may have hatched in a stalk. This insect has one generation per year. Host plants include sunflower, soybean, ragweed and cocklebur.

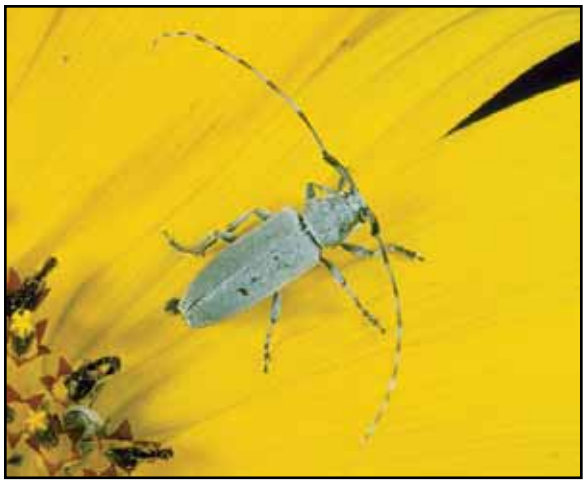

Figure 37. Adult - Longhorned beetle *Dectes texanus.* (Extension Entomology)

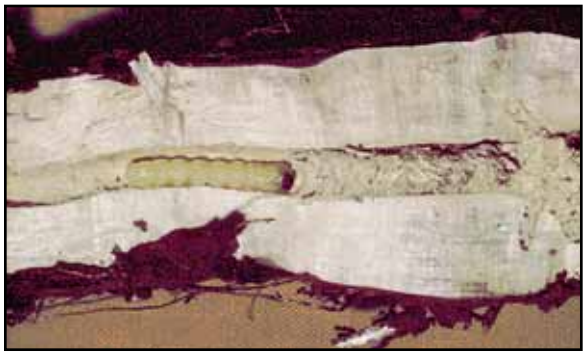

Figure 38. Larva - Longhorned beetle *Dectes texanus.* (Extension Entomology)

Damage: Plant damage due to adult feeding appears to be insignificant since the scars do not penetrate the cortex nor encircle the stalk. Larval feeding is apparent when stalks lodge at the point of the girdle, about 2.5 to 3.5 inches (7 to 9 cm) above the soil surface.

Scouting Method: None has been developed.

Economic Threshold: None established.

Management: In the southern Plains, later planting dates and fall or winter tillage have reduced sunflower infestations by this pest. Perennial sunflower species are resistant to stalk infestation, indicating the possibility of breeding cultivars resistant to the longhorned sunflower stem girdler. Chemical treatments on soybean and sunflower are ineffective against larvae and were determined to be impractical against adults because of the extended emergence period. When larvae are present in the stalks, plants do not always lodge. Utilizing lower plant populations that encourage thicker stalks may help reduce damage from lodging. If fields are suspected to be infested, prompt harvesting will limit losses from lodging.

Sunflower Maggots

Species:
Sunflower receptacle maggot, *Gymnocarena diffusa* (Snow)
Sunflower maggot, *Strauzia longipennis* (Wiedemann)
Sunflower seed maggot, *Neotephritis finalis* (Loew)

Description: The adult forms of all three sunflower maggots (flies) have wings with a distinct brown or yellowish-brown pattern. The name "picture-wing fly" has been given to flies of this type. While all three fly species are similar in appearance, they do have distinguishing differences.

Gymnocarena diffusa - This species is the largest of the three, with a body about 0.4 inch (10 mm) long and a wing span of approximately 0.75 inch (19 mm) (Figure 39). The eyes of this species are bright green and the wings have a yellowish-brown and somewhat mottled appearance. *G. diffusa* larvae attain a length of nearly 0.31 inch (8 mm) at maturity. The larvae taper from the front to rear and are yellowish white (Figure 40).

Strauzia longipennis - Adults of this species have a wing spread of about 0.5 inch (13 mm) and a body 0.25 inch (6 mm) long (Figure 41). The wings bear broad, dark bands that form a fairly distinct F-shaped mark near the tips. The larvae of *S. longipennis* are creamy white, headless and legless, as are the other two species (Figure 42). They taper slightly at both ends and attain a length of about 0.28 inch (7 mm) at maturity.

Neotephritis finalis - This sunflower maggot is the smallest of the three species, with the adult having a body length of about 0.25 inch (6 mm) and a wing span of approximately 0.28 inch (7 mm) (Figure 43). The wings have a brown lacelike appearance. *N. finalis* larvae attain a length of 0.19 inch (4.5 mm) at maturity. The small, brown pupa of *N. finalis* is found in the face of the sunflower bud, usually surrounded by a small number of damaged florets (Figure 44).

Life Cycles: Adults of *G. diffusa* emerge in late June to early July after sunflower buds reach 2 to 4 inches (5 to 10 cm) in diameter. Eggs are laid on the bracts

Figure 39. Adult - Sunflower receptacle maggot *Gymnocarena diffusa.* (Extension Entomology)

Figure 40. Larva - Sunflower receptacle maggot *Gymnocarena diffusa.* (Extension Entomology)

Figure 41. Adult - Sunflower maggot *Strauzia longipennis.* (Extension Entomology)

Figure 42. Larva - Sunflower maggot *Strauzia longipennis.* (Extension Entomology)

of the developing sunflower heads. Egg laying occurs from mid-July through August. The hatched larvae tunnel into the spongy tissue of the receptacle. Damage to the head is negligible. After 30 days, the mature larvae cut a small emergence hole on the underside of the receptacle and drop into the soil to pupate. Overwintering pupae are found about 7.5 inches (19 cm) deep in the soil by August or early September. Some larvae will pupate in the sunflower head. Only one generation per year occurs in North Dakota.

Strauzia longipennis has one generation per year. This insect overwinters as a larva in plant debris in the soil. Pupation and adult emergence is completed in early June. Females lay eggs in stem tissue of young sunflower, and larvae feed in the pith tissue for much of the growing season.

Figure 43. Adult - Sunflower seed maggot *Neotephritis finalis.* (Extension Entomology)

Figure 44. Pupae - Sunflower seed maggot *Neotephritis finalis.* (Extension Entomology)

Unlike the other two species of sunflower maggots, two complete generations per year of *N. finalis* occur in North Dakota. Adults of *N. finalis* emerge during the first week of July. Egg deposition occurs on the corolla of incompletely opened sunflower inflorescences. The total larval period is 14 days. The first generation of *N. finalis* pupates in the head; the second generation overwinters in the soil as pupae.

Damage: Damage by sunflower maggots has been negligible.

The maggots of *Gymnocarena diffusa* feed on the spongy receptacle tissue of the sunflower head and feeding may cause partially deformed heads. Larvae do not feed on developing seeds.

The magnitude of damage to sunflower seeds by *N. finalis* larvae depends largely on the stage of larval and seed development. Seed sterility occurs when newly hatched larvae tunnel into the corolla of young blooms. Observations indicate that a single larva feeding on young flowers will tunnel through 12 ovaries. Mature larvae feeding on older sunflower heads will destroy only one to three seeds.

While infestation levels of *S. longipennis* occasionally have reached nearly 100 percent, damage from larval feeding is usually light. Part of a commercial sunflower field next to a grassed waterway or other water source sometimes supports a higher than usual infestation. Under these conditions, high larval numbers of eight to 10 per stalk may be found and stalk breakage can occur. Stalk breakage of up to 30 percent of the plants has been recorded.

Scouting Method: A scouting method has not been developed for sunflower maggots because of the negligible injury caused by these insects.

Economic Threshold: None established.

Management: Insecticide use has not been warranted for control of sunflower maggots.

Sunflower Stem Weevil

Species: *Cylindrocopturus adspersus* (LeConte)

Description: Adult sunflower stem weevils are about 3/16 inch (4 to 5 mm) long and grayish brown, with varying-shaped white spots on the wing covers and thorax (Figure 45). The snout, eyes and antennae are black. The snout is narrow and protrudes down and backward from the head. Eggs are deposited inside the epidermis of sunflower stems and are very small (0.51 mm long by 0.33 mm wide), oval and yellow, making them difficult to see. The larvae are ¼ inch (5 to 6 mm) long at maturity, legless and creamy white with a small, brown head capsule (Figure 46). They are normally in a curled or C-shaped position within the sunflower stalk. Pupae are similar to the adult in size and creamy white

Life Cycle: Only one generation occurs per year. Larvae overwinter in sunflower stalks and crown roots and pupate in the spring, and adults emerge in mid to late June, feeding on the epidermal tissue of the sunflower foliage and stem. This feeding does not affect plant vigor. Mating occurs soon after emergence of adults. Just prior to egg laying, females descend to the lower portion of the plant to deposit eggs individually in the stem tissue. Approximately 50 percent of oviposition occurs by mid-July. Upon hatching in early July, the first instar (larval growth stage) larvae feed on subepidermal and vascular tissue. Feeding is concentrated in the pith tissue as the larvae develop to third and fourth instar stages. By the last week in August, the larvae descend while feeding to just above the soil surface. A chamber is constructed in the stem, and the weevil overwinters there as a fifth instar larva. Pupation of the overwintering larva occurs the following year in early June.

Damage: Adult sunflower stem weevil feeding causes minor damage to the stem and leaf tissue of the plant. More importantly, adult weevils have been implicated in the epidemiology of the sunflower pathogen Phoma black stem *(Phoma macdonaldii Boerma)* and charcoal stem rot *(Macrophomina phaseolina* (Tassi) Goid).

Larval injury can cause the stem to weaken from tunneling, pith destruction and especially by construction of overwintering chambers at the stalk base. At larval infestations of 20 to 25 or more per stalk, the plants run a risk of stalk breakage and loss of the entire capitual (head). Risk of breakage is greatest when plants are under drought stress and/or during periods of high winds. The breakage typically occurs at or slightly above the soil line, in contrast to breakage attributed to a stalk disease, which normally occurs farther up on the stalks.

Scouting Methods: Field monitoring for sunflower stem weevils to estimate population size is important. However, adults are difficult to see on the plants due to their small size, cryptic color and "play dead" behavior. They are inactive on the plant or fall to the ground when disturbed and remain motionless. Adults can be found on both surfaces of the leaves, the lower portions of the stem, in leaf axils, within the dried

Figure 45. Adult - Sunflower stem weevil *Cylindrocopturus adspersus.* (Extension Entomology)

Figure 46. Larva - Sunflower stem weevil *Cylindrocopturus adspersus.* (Extension Entomology)

cotyledons or in soil cracks at the base of the sunflower plant. Yellow sticky traps were unsuccessful in relating captured adult numbers to larval infestations.

Sampling for the larval stage is difficult since they develop totally within the sunflower plant. The only method for detecting the presence of larvae is to split the sunflower stem, a time-consuming process.

Field scouting for adults should begin when plants are in the eight- to 10-leaf stage, developmental stage V-8 to V-10, or late June to early July, and continue until mid-July. Select sampling sites 70 to 100 feet in from the field margin. Count the number of adults on five plants at five randomly selected sampling sites throughout the field for a total of 25 plants. Calculate the average number of weevils per plant. Use an X pattern (or W pattern) to space sample sites throughout the entire field. When scouting for stem weevils, approach plants carefully and slowly to avoid disturbing the adults.

Economic Threshold: Average field counts of one adult sunflower stem weevil per three plants can result in damaging larval densities of more than 40 larvae per stalk at the end of the season.

Management: Insecticidal treatment, if needed based on field counts, should be initiated in late June or early July before significant egg laying has occurred. Cultural control tactics, including delayed planting, altered plant population and tillage, are useful for managing the sunflower stem weevil. Delayed planting of sunflowers until late May or early June has been effective in reducing densities of larvae in the stem. Reducing plant population results in an increased stalk diameter and, as a result, decreases damage from lodging. Combinations of disking to break up stalks and moldboard plowing to bury them at a depth of 6 inches (15 cm) can increase larval/pupal mortality and severely impact the emergence of adult stem weevils. Otherwise, larvae/pupae are physically protected in the woody stalks. Survival is affected only by performing both operations. Greenhouse and field experiments have shown resistance to feeding, oviposition and larval development in many native species of sunflower. Field research for resistant sunflower germplasm is under way. Natural enemies of the sunflower stem weevil include parasitic wasps that attack both the egg and larval stages.

Black Sunflower Stem Weevil

Species: *Apion occidentale* (Fall)

Description: Adults are black and only 0.1 inch (2.5 mm) long from the tip of the snout to the tip of the abdomen (Figure 47). The snout is very narrow and protrudes forward from the head, which is small in relation to the rather large, almost globose body. Larvae of A. occidentale are very similar in appearance to *C. adspersus*, except they are only 0.1 to 0.12 inch (2.5 to 3 mm) long at maturity and yellowish (Figure 48).

Life Cycle: *Apion occidentale* overwinters as an adult in soil, plant residue, sod and weed clusters and begins to emerge and feed on volunteer sunflower as soon as the plants reach the early seedling stage. Females deposit eggs under the epidermis of the stem or leaf petioles. Larvae emerging from these eggs tunnel in the pith area of the stem, pupate and emerge as adults in early August. Little or no adult activity is observed

Figure 47. Adult - Black sunflower stem weevil *Apion occidentale.* (Extension Entomology)

Figure 48. Larva - Black sunflower stem weevil *Apion occidentale.* (Extension Entomology)

for about two weeks in late July and early August. Black sunflower stem weevil adults emerging in August also feed on the leaves and stems of the plant, but as the plant matures and the leaves begin to die, the adults move under the bracts of the sunflower head, where they can be observed feeding until the plants are harvested.

Damage: Adult feeding generally is considered as insignificant mechanical injury. Like the sunflower stem weevil, the black sunflower stem weevil is suspected of vectoring Phoma black stem disease in sunflower fields. In situations of extremely high populations feeding on seedling sunflowers, stand loss has occurred. However, in most cases, populations are too low to cause economic damage and stalk tunneling only results in minor injury to the plant.

Scouting Method: A scouting method has not been developed for the black sunflower stem weevil.

Economic Threshold: None established.

Management: Recommendations for insecticidal control of this insect have not been developed.

Figure 49. Adult - Sunflower root weevil *Baris strenua.* (Extension Entomology)

Figure 50. Larva - Sunflower root weevil *Baris strenua.* (Extension Entomology)

Sunflower Root Weevil

Species: *Baris strenua* (LeConte)

Description: Adults are rather robust-looking weevils, with a somewhat oval-shaped body (Figure 49). They are 0.25 inch (6 mm) long and have a short, almost blunt, downward projecting snout. Their coloration is dull black in contrast to the shiny, black appearance of *A. occidentale.* Baris strenua larvae are similar in appearance to *C. adspersus* larvae but much larger and are not located in the sunflower stalk (Figure 50).

Life Cycle: Adult root weevils emerge during the latter part of June. They feed on sunflower foliage in early morning and late afternoon. About two weeks after emergence, the adults begin to congregate around the root zone near the soil surface. Continued feeding and copulation occur during this period. Feeding activity during this period produces callus tissue, under which the bright yellow eggs are deposited two or three at a time. Hatching of the larvae normally occurs during the second week in July. *Baris strenua* larvae are not very mobile. Most of the feeding (consisting of circular tunnels) and development to fourth instar takes place in the same area where hatching occurs. At about the time that the fourth larval stage is reached in late August to early September, the plant becomes significantly dehydrated and encapsulation of the larvae within a “soil cocoon” begins. This “larval cocoon” overwinters among the remaining roots in the soil. Overwintering larvae have been recovered from a depth of 15 inches (38 cm) in North Dakota.

Damage: The sunflower root weevil adult, like the other two stem weevils, causes negligible mechanical injury to the foliage of the sunflower plant. The destruction of root tissue by the larvae of the sunflower root weevil causes the plants to wilt and lodge if the infestation is severe. The damage to fields attacked by the weevil tends to be localized.

Scouting Method: A scouting method has not been developed because damage caused by this pest has been minor.

Economic Threshold: None established.

Management: Insecticide use has not been warranted for the control of the sunflower root weevil.

Thistle Caterpillar (Painted Lady)

Species: *Vanessa cardui* (Linnaeus)

Description: The body of the adult is about 1 inch (25 mm) long with a wingspread of about 2 inches (50 mm) (Figure 51). The upper wing surfaces are brown with red and orange mottling and white and black spots. The undersides of the wings are marble gray, buff and white. Each hind wing possesses a row of four distinct and obscure eyespots. Eggs are small, spherical and white. The larvae are brown to black and spiny, with a pale yellow stripe on each side (Figure 52). When mature, the larvae are 1.25 to 1.5 inches (32 to 38 mm) long. The chrysalis, or pupa, is molten gold and about 1 inch (25 mm) long.

Figure 51. Adult - Painted lady butterfly *Vanessa cardui.* (Extension Entomology)

Figure 52. Larva - Painted lady butterfly *Vanessa cardui.* (Extension Entomology)

Life Cycle: The painted lady butterfly is indigenous to the southern U.S. and migrates annually to the northern U.S. and Canada. The painted lady breeds in the north-central states and Canada, migrates south for the winter and returns to the northern areas in early June. Eggs are laid on Canada thistle, wild and cultivated sunflower, and many other host plants. Hatching occurs in about one week. Larvae feed on sunflower until they reach maturity in late June or early July. Chrysalids are formed and hang from the leaves of the plant. Butterflies will emerge in about 10 days from the chrysalid and a second generation begins.

Damage: The caterpillars (larvae) feed on the leaves and, when numerous, may defoliate infested plants. The larvae produce a loose silk webbing that covers them during their feeding activity. Black fecal pellets produced by the larvae often are found in proximity to the webbing.

The effect of defoliation by the larvae on the yield of sunflower is similar to that described for defoliation by sunflower beetle larvae.

Scouting Method: Sampling sites should be at least 75 to 100 feet (23 to 31 m) from the field margins when collecting data to determine whether an entire field should be treated. Infestations frequently will be concentrated in areas of a field where Canada thistle plants are abundant. Plants should be examined carefully for the presence of eggs and/or larvae.

The field should be monitored by using the X pattern, counting 20 plants per sampling site for a total of 100 plants to determine percent defoliation (Figure 35).

Economic Threshold: The threshold is 25 percent defoliation, provided that most of the larvae are still less than 1.25 inch (32 mm) long. If the majority of the larvae are 1.25 to 1.5 inches (32 to 38 mm) long, most of the feeding damage already will have occurred and treatment is not advised.

Management: Insecticide use generally has not been warranted for control of larvae of the painted lady. However, instances of high localized infestations have occurred within certain fields where spot treating may be necessary. Disease outbreaks, indicated by dying larvae present on leaves, often occur when large populations are present.

Sunflower Midge

Species: *Contarinia schulzi* Gagne'

Description: The tan body of the adult sunflower midge is about 0.07 inch (1.69 mm) long, with a wingspan of about 0.19 inch (4 mm) (Figure 53). The wings are transparent with no markings except the veins. The larvae attain a length of nearly 0.09 inch (2.42 mm) at maturity and they are cream to yellowish orange when fully grown (Figure 54). They are tapered at the front and rear, with no legs or apparent head capsule.

Life Cycle: The sunflower midge overwinters in the soil as a cocooned larva and pupates during June and July in North Dakota and Minnesota. Typically, the initial peak of first-generation adult emergence occurs in early to mid-July. A second peak occurs about seven to 10 days later. They prefer to lay eggs on sunflower buds with a diameter greater than 1 inch (25 mm). Larvae initially feed on margins of the head between the bracts surrounding the heads. Larvae migrate to the base of the developing seeds and to the center of the head as it develops. Presence of the larvae frequently is determined by necrotic areas at the base of or between the bracts. As midge larvae mature, they move to the surface of the head and drop to the ground. A partial, second generation occurs in August. Second-generation adults oviposit among the seeds.

Damage: Damage to sunflower is a result of first-generation larval feeding in developing heads. When populations are low, damage is restricted to the base of the bracts of the head and causes slight localized necrosis but little if any economic loss. When many larvae are present, feeding prevents ray petal formation and distorts the growth of the developing sunflower head. If the abnormal growth is severe, the back of the head overgrows the front and little or no seed production occurs (Figure 55). If an infestation occurs in the early bud stage, the bud may be killed.

Often midge damage is restricted to field margins or small portions of fields and economic losses are minimal. However, when populations are very heavy, damage will extend throughout the field and substantial economic losses occur. The extent of damage from second generation larvae is unknown.

Scouting Method: None established.

Economic Threshold: None established.

Management: Because effective chemical and other controls are not available, sunflower midge management relies on cultural practices done prior to planting. If a midge infestation is anticipated, new fields should be established away from fields damaged the previous season. To minimize the risk of all plantings being at their most susceptible stage at midge emergence, several planting dates should be used. If available, growers should consider using a tolerant hybrid.

Figure 53. Adult - Sunflower midge *Contarinia schulzi.* (Extension Entomology)

Figure 54. Larva - Sunflower midge *Contarinia schulzi.* (Extension Entomology)

Figure 55. Severe damage to receptacle and seed development occurs when midge infection is high. (Extension Entomology)

Red Sunflower Seed Weevil

Species: *Smicronyx fulvus* LeConte

Description: Red sunflower seed weevil adults are 0.1 to 0.12 inch (2.5 to 3.06 mm) long and reddish brown (Figure 56). The larvae are small, 0.10 inch (2.54 mm) long, cream-colored, legless and C-shaped (Figure 57).

Life Cycle: Red sunflower seed weevil emergence occurs in late June and early July. The newly emerged adults feed on sunflower buds or floral tissues. Once pollen is available, the adults include it in their diet. Females need to feed on sunflower pollen for several days prior to egg deposition. Eggs are deposited within young developing seeds. Normally a single egg is placed in each seed, although 8 percent to 12 percent of the seeds may contain several eggs.

Figure 56. Adult - Red sunflower seed weevil *Smicronyx fulvus.* (Extension Entomology)

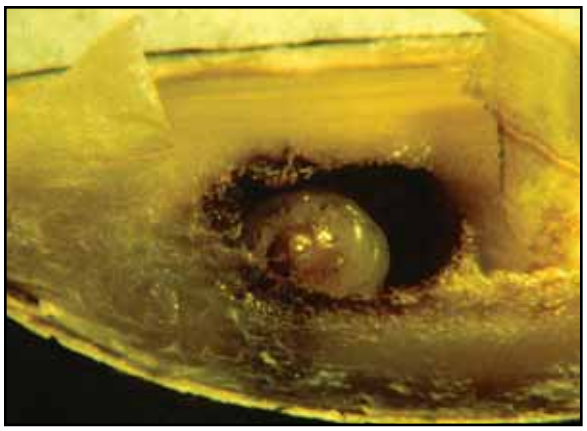

Figure 57. Larva - Red sunflower seed weevil *Smicronyx fulvus.* (Extension Entomology)

The small, white eggs hatch in approximately one week. The larvae consume a portion of the kernel, and this feeding causes economic damage. After completion of larval development, the majority of the larvae drop to the ground. Larval drop occurs from mid-August through September. The larvae overwinter in the soil at a depth of about 6 inches (15 cm). Larvae pupate in late June of the following year and the pupal period lasts about one week. A single generation per year is produced in North Dakota.

Damage: While the kernel of some seeds may be totally eaten, most seeds are only partially consumed. The separation of undamaged from weevil-damaged seed is difficult.

Most larvae drop from the head to the soil after completing their development, but a small percentage may remain in the seed and are present at harvest. Growers who encounter a seed weevil infestation may want to delay harvest to allow most of the weevil larvae to exit the seeds to avoid having larvae in the harvest bin.

Larvae that are still in the seed at bin filling time are done feeding and can cause heating and moisture problems. Larvae harvested with the seed cannot be controlled until they have completed development and have emerged from the infested seeds. Once emerged, they are susceptible to fumigation. But fumigation normally is not recommended. However, the most advantageous time to initiate control of seed weevil is in the field when the adult weevils are active, but prior to egg deposition.

Economic Thresholds: The economic threshold varies with differences in plant population, the cost of insecticide application and the market price of sunflower. The procedure for calculating the economic threshold is discussed in the NDSU Extension sunflower seed weevil publication (E-817). Currently, an infestation level of four to seven seed weevil adults per head in oil sunflower or one seed weevil per head in confectionery sunflower is the average economic threshold.

The optimal period for insecticide treatment is when at least three out of 10 plants in the field are at early bloom (R-5.1 to R-5.4, Figure 4) and the economic threshold has been reached. If spray application is delayed past when more than four out of 10 plants are at stage R-5.4, many eggs already will be laid in the developing seeds and those eggs and larvae cannot be controlled. If fields are sprayed too early, reinfesta-

tion may occur in areas with a high weevil population. After spraying, fields should be rechecked periodically to determine if reinfestation is reaching the economic threshold. Continue rechecking until most of the heads in the field have reached the R-5.7 stage. At that stage, most eggs already will have been laid and most seeds will be too mature to be suitable for further red seed weevil egg oviposition.

Scouting Method: Begin by taking samples from 12 plants, three plants from each of the four field sides. Sampling sites should be at least 75 feet (21 m) in from field borders, which often have an inordinately high number of weevils. The total number of weevils counted should be compared to the sequential sampling table in the most recent NDSU Extension sunflower seed weevil publication (E-817). According to the table, take one of three possible actions: Stop sampling, no action is needed; stop sampling and treat; or, take more samples because a decision cannot be reached. When populations are low or high, sequential sampling allows a quick decision with few samples. If populations are near the economic threshold, more precision is needed to making an accurate determination and more samples are required.

NOTE: To more precisely check individual sunflower heads for red sunflower seed weevils, the face of the heads should be sprayed with a commercial formulation of mosquito repellent containing diethyl toluamide (DEET). This will cause the weevils to move out from between the florets where they can be more accurately counted. Consult the most recent NDSU Extension sunflower seed weevil publication (E-817) for a table to convert the visual counts to the absolute number of weevils (both counted and uncounted).

Management: Several federally registered insecticides are available for control of sunflower seed weevils in the U.S. Early planting of sunflower reduces achene damage caused by the red sunflower seed weevil without causing a measurable reduction in oil content and achene weight.

Surrounding a sunflower field with a ring of early blooming sunflower effectively can trap immigrating red sunflower seed weevils into a small portion of the field, where they can be controlled efficiently. The trap cropping method given in publication E-817 is as effective and more cost efficient than standard insecticide treatment for control of red sunflower seed weevils.

Gray Sunflower Seed Weevil

Species: *Smicronyx sordidus* LeConte

Description: Adults of the gray sunflower seed weevil are slightly larger (0.14 inch long) than *S. fulvus* and gray (Figure 58). The larvae are small, 0.12 inch long (3.1 mm), cream-colored, legless and C-shaped (Figure 59).

Life Cycle: Gray sunflower seed weevil emergence occurs in late June and early July and reaches 50 percent emergence about 10 days before the red sunflower seed weevil. The newly emerged adults feed on floral buds. Oviposition occurs on flowers in the bud stage and before red sunflower seed weevil oviposition begins. Female gray sunflower seed weevils do not lay as many eggs as do females of the red sunflower seed weevil.

Figure 58. Adult - Gray sunflower seed weevil *Smicronyx sordidus.* (Extension Entomology)

Figure 59. Larva - Gray sunflower seed weevil *Smicronyx sordidus.* (Extension Entomology)

The larvae feed in a single achene, and infested achenes are enlarged and protrude above surrounding uninfested achenes. The majority of the larvae drops to the ground from mid-August through September and overwinters in the soil. Larvae pupate in late June and a single generation per year is produced in North Dakota.

Damage: Seeds infested by the gray seed weevil lack a kernel and, due to their light weight, the seeds may be lost during the harvesting process. Because of their low population levels and low fecundity, the gray sunflower seed weevil usually does not cause economic damage, especially in oil sunflower fields. In confection fields, however, populations of the gray sunflower seed weevil may be sufficiently high to warrant treatment at the late bud stage (R-3 to R-4).

As with the red sunflower seed weevil, larvae normally drop from the head to the soil after completing their development. Larvae that do not emerge will present the grower with the same problem as unemerged red sunflower seed weevil larvae.

Scouting Method: Normally, gray sunflower seed weevil populations are too low to cause economic damage. However, if an area has had a history of high populations, fields, especially confection fields, should be sampled beginning at bud stage R-2 (Figure 4). Sampling should be done as for the red sunflower seed weevil and continue until plants are blooming.

Economic Thresholds: None established.

Management: Several insecticides are federally registered for control of sunflower seed weevils in the U.S. If fields are to be treated with insecticides, they should be sprayed while the plants are still in early bud stage. By late bud stage, most oviposition already will have occurred.

Sunflower Moth

Species: *Homoeosoma electellum* (Hulst)

Description: The adult is a shiny gray to grayish tan moth about 0.38 inch (9 mm) long, with a wingspan of about 0.75 inch (19 mm) (Figure 60). The hind wings are devoid of markings; however, the forewings have a small, dark, discal dot near the center of each wing and two or three small, dark dots near the leading margin of each wing. When at rest, the wings are held tightly to the body, giving the moth a somewhat cigar-shaped appearance. The larva has alternate dark and light-colored longitudinal stripes on a light brown body (Figure 61). The larva is about 0.75 inch (19 mm) long at maturity.

Figure 60. Adult - Sunflower moth *Homoeosoma electellum.* (Extension Entomology)

Figure 61. Larva - Sunflower moth *Homoeosoma electellum.* (Extension Entomology)

Life Cycle: Sunflower moth migrations from the south-central U.S. normally appear in North Dakota in early to mid-July. The moths are highly attracted to sunflower that is beginning to bloom. Individual female moths will deposit up to 30 eggs per day on the surface of open sunflower heads. The eggs hatch within 48 to 72 hours and the newly emerged larvae feed on pollen and florets. The larvae begin tunneling into seeds upon reaching the third instar (larval growth stage). This tunneling continues throughout the remainder of larval development. Larval development from hatching to full maturity takes about 15 to 19 days.

Damage: The young larvae of the sunflower moth feed primarily on florets and pollen. Older larvae tunnel through immature seeds and other parts of the head. A single larva may feed on three to 12 seeds and forms tunnels in both the seeds and head tissue. Larvae spin silken threads, which bind with dying florets and frass to give the head a trashy appearance. Severe larval infestations can cause 30 percent to 60 percent loss, and in some cases, the entire head can be destroyed. Sunflower infested with sunflower moth has an increased incidence or risk of Rhizopus head rot.

Scouting Method: Sampling sites should be at least 75 to 100 feet (23 to 31 m) from field margins. The X pattern should be used in monitoring a field, counting moths on 20 heads per sampling site for a total of 100 heads. Scouting is most accurate in the early morning or late evening, when moths are active. Sex pheromone lures are available commercially for monitoring with traps to indicate their arrival and local populations. Insecticide applications should be considered when pheromone trap catches average four moths per trap per day from the R-3 through R-5 growth stages.

Economic Threshold: The economic threshold for sunflower moth is one to two adults per five plants at the onset of bloom or within seven days of the adult moth's first appearance. If using pheromone traps, consider the threshold mentioned in the Scouting Method section.

Management: A number of federally labeled insecticides are registered for control of the sunflower moth.

Banded Sunflower Moth

Species: *Cochylis hospes* Walsingham

Description: The adult has a dark band across the buff or yellowish-tan forewings (Figure 62). The wingspan is about 0.5 inch (13 mm). Early instar larvae are off-white; late instar larvae are pinkish to red with a brown head capsule (Figure 63). Larvae will be about 0.44 inch (11 mm) at maturity.

Life Cycle: The life cycle of the banded sunflower moth is similar to that of the sunflower moth, except that the adults emerge from local overwintering sites rather than migrating into North Dakota. Banded

Figure 62. Adult and eggs - Banded sunflower moth *Cochylis hospes.* (Extension Entomology)

Figure 63. Larva - Banded sunflower moth *Cochylis hospes.* (Extension Entomology)

sunflower moths begin to emerge from the soil about mid-July and are present in the field until mid-August. Adults tend to congregate in field margins on weeds or adjacent crops during the day and then move into the crop in the evening. Within a week after emergence, they begin to lay eggs on the outside of the bracts of the sunflower head. Eggs may be found through early August and hatch in five to eight days. Larvae develop through five instars and are present in sunflower heads from mid-July to mid-September. After feeding to maturity, larvae drop to the ground and spin cocoons in the soil to overwinter. Pupation takes place in late June or early July the following year. The pupal period lasts about 12 days.

Damage: The newly hatched larvae move from the bracts to the florets of the sunflower head, where they enter open florets to feed. When the eggs hatch, young larvae feed on bract tissue before moving into the head. A sunflower head is susceptible to infestation only during the flowering period. The larvae feed in the florets until the third instar. During later stages of larval development, the insect tunnels through the base of the floret into the seed. The larvae may consume part or all of the contents of the developing seed. The larvae usually enter near the top of the seed and leave by way of the same opening after the contents are eaten. Each larva may destroy several (five to seven) seeds. Small areas of silken webbing on mature sunflower heads indicate the presence of banded sunflower moth larvae within the head.

Adult Scouting Method and Economic Threshold: Sampling sites should be at least 75 to 100 feet from the field margins. In monitoring a field, use the X pattern (Figure 17), counting moths on 20 plants per sampling site to obtain the total number of moths per 100 plants. Sampling should be conducted in the late bud stage (R3), usually during mid-July. If treatment is warranted, it should be applied at the R5.1 sunflower plant growth stage (when 10% of head area has disk flowers that are flowering or completed flowering.)

During the day (late morning to early afternoon) the moths remain quiet, resting on upper or lower surfaces of the leaves of sunflower plants. When disturbed, they flutter from plant to plant. When sampling for moths during the day, the decision to treat or not is based on comparing the mean number of adult moths in the field to the EIL for moths. The EIL number is the number of moths per head that will, if not managed, result in seed damage with a value equal to the cost of treatment. Use the following formula based on treatment costs, plant population and market price to determine the adult EIL for day sampling.

$$\frac{\textbf{EIL}}{\text{(moths per 100 plants)}} = \left[\left[\frac{\text{(Treatment Cost (\$)/Market Price)}}{\text{Plant Population}}\right] \times 582.9\right] - 0.7$$

The constants in the formula simplify the calculation and include the amount of loss attributable to each banded sunflower moth larva produced per plant.

A sample calculation of the EIL based on moth sampling for the following conditions is given below.

Insecticide treatment cost = $8/acre
Market price = $0.09/lb.
Plant population = 20,000/acre

$$\textbf{EIL} = \left[\left[\frac{(\$8/\$0.09)}{20{,}000}\right] \times 582.9\right] - 0.7$$

= 19 moths per 100 plants

For this set of variables, an infestation of about 1.9 moths per 100 plants will result in sufficient larvae to destroy seeds in the sunflower head equal to the $8 treatment cost per acre in a field of 20,000 plants per acre with a market value of 9 cents per pound. If the adult population has reached or exceeded this level, then the grower should consider the use of a chemical insecticide to prevent larval seed damage.

Egg Scouting Method and Economic Threshold: Banded sunflower moth eggs can be counted accurately using a low power magnifier. A head-mounted 3.5X magnifier is recommended. Egg counts should be made when most of the sunflower plants are at stage R-3. However, buds should be selected randomly to avoid bias. Sampling for banded sunflower moth egg populations in commercial fields should be conducted as follows:

1. Divide each side of the field to be surveyed into 1,312-foot (400 m) sections.
2. Sample the center of each 1,312-foot (400 m) section at 20 feet (6 m) into the field from the field margin.
3. Randomly select five buds at each sample site.
4. Randomly select six bracts from the outer whorl on each bud and count the banded moth eggs. Average the egg counts from the five buds.

Compare the average egg count to the EIL.

Economic Injury Level (EIL) is the number of eggs per six bracts.

$$EIL = \frac{TC}{V \times PP \times 0.00078}$$

V = Market value per lb
PP = Plant population per acre
TC = Treatment cost

Example: TC = $8, V = $0.10, and PP = 16,000
The EIL is 6.4 eggs per six bracts.

Economic Distance (ED) is the distance into a field from a sample site on the field edge where an economically damaging population is expected to extend. ED gives you the capability to diagram the extent of the EIL within a field. Economic Distance:

$$ED = e^{\left[\frac{\frac{EIL}{(E)} - 1.29}{-.194}\right]}$$

E = Average six bract egg count at 20 feet (6 m)
*EIL based on eggs per six bracts

Economic Distance Example:

Field Size: 800 m by 800 m with average egg counts of 15 per six bracts per sample site.

The EIL is 6.4 eggs per six bracts.

The ED is 280 feet.

In this case, only 37 percent of the field would need treatment, resulting in a savings of 63 percent.

Management: Deep fall plowing of sunflower stubble in Manitoba has reduced moth emergence the following season by about 80 percent; however, this is not practical for areas practicing conservation tillage. Research in North Dakota has demonstrated that delaying planting of sunflower until late May or early June helps reduce infestation levels of the banded sunflower moth. Parasitic wasps attack both the eggs and larvae of the moth. Predators also consume eggs and larvae.

Since banded sunflower moths have a tendency to congregate around field margins, perimeter spraying has been used with some success. This will minimize insecticide treatment costs and impact on pollinators.

Lygus bugs

Species: Tarnished plant bug, *Lygus lineolaris* (Palisot de Beauvois) and other *Lygus* species

Description: The most common species occurring in sunflower fields is the tarnished plant bug. It attacks at least 385 different plant species and occurs in 39 U.S. states and five Canadian provinces. Adults (Figure 64) are small, cryptically colored insects with a distinctive yellow triangle or "V" on the wings and 0.2 inch (4 to 5 mm) in length. They vary in color from pale green to dark brown. The immature stages, or nymphs (Figure 65), are similar in appearance to the adults, but lack wings and are usually green in color. They often are confused with aphids, but lygus move much more rapidly.

Figure 64. Adult - Lygus bug (Tarnished plant bug) *Lygus lineolaris.* (Scott Bauer, http://www.ars.usda.gov/is/graphics/photos/insectsimages.new.htm)

Figure 65. Nymphs - Lygus bug *Lygus lineolaris.* (Scott Bauer, http://www.ars.usda.gov/is/graphics/photos/insectsimages.new.htm)

Life Cycle: Adults overwinter in plant debris along field margins and shelterbelts. Populations probably move to sunflower from alfalfa, canola or other crops when those plants either have senesced or been harvested. Sticky trap catches in North Dakota showed that lygus bugs were present throughout the reproductive growth stages of sunflower. These insects produce at least two generations per year in the northern Plains. The biology of other Lygus species is similar.

Damage: Oilseed sunflower are not believed to be at risk to damage from Lygus feeding at this time. The presence of scarring on confection or nonoilseed sunflower seeds, known as kernel brown spot (Figure 66), is caused by lygus bugs feeding on the developing seed. The quality issue is significant because processors discount the finished product with only 0.5 percent damage. The incidence of damage in 2006 ranged between 1 percent and 5 percent in some production areas of the northern Plains. Lygus feed preferentially on either the developing reproductive organs or on the apical meristematic and leaf primordial tissue, causing a necrosis around the feeding site due to the injection of enzymes. This tissue destruction causes the brown spot on the sunflower kernel, resulting in a bitter taste to the seeds. Greenhouse and field studies showed that 33 to 38 seeds were damaged per adult lygus bug, and that all reproductive growth stages (R-4 to R-5) were vulnerable to attack. Damage was reduced if heads were infested after flowering was completed (R-6 to R-7).

Figure 66. Kernel brown spot caused by Lygus bug. (Larry Charlet)

Scouting Method: A scouting method has not been developed for lygus bug in sunflower.

Economic Threshold: Approximately 36 seeds are damaged by each adult. Therefore, 0.5 percent damage on heads with 800 seeds would occur with feeding on only four seeds per head. Thus, populations of adult lygus at levels of one per nine heads could result in economic loss to the producer through the reduction of seed quality.

Management: Lygus can be treated at the same time confection sunflower is treated for other insects, such as the seed weevil and banded sunflower moth. Two treatments are recommended to sufficiently protect confection sunflower heads from insect feeding: one application at the onset of pollen shed, or approximately 10 percent bloom, followed by a second treatment seven days later. This program should control insects adequately on confection sunflower throughout flowering, minimizing the potential feeding damage.

Sunflower Headclipping Weevil

Species: *Haplorhynchites aeneus* (Boheman)

Description: The sunflower headclipping weevil adult is shiny black (Figure 67). The weevil is about 0.31 inch (8 mm) long from the tip of the snout to the rear of the abdomen. The area behind the head and thorax is large and "squared" in relation to the narrow and prolonged head and snout.

Headclipping weevil larvae are cream-colored, somewhat C-shaped and grublike and 0.16 to 0.24 inch (4 to 6 mm) long (Figure 68).

Life Cycle: Adults emerge in mid-July and are active for a two- to three-week period. The females feed on pollen and nectar of flowering heads. In preparation for egg laying, the female makes one nearly complete row of feeding punctures around the circumference of the stalk just below the head and then lays an egg in the head. The girdled head subsequently falls to the ground, where larval development and overwintering occur.

Damage: Head clipping by *H. aeneus* is the most apparent type of damage caused by this weevil and frequently occurs along field margins. The percent of "clipped heads" in a field is normally very low (1 percent to 3 percent). However, losses up to 25 percent have been reported in individual fields (Figure 69).

Scouting Method: The weevils' presence is determined using the X scouting pattern. If the adults are encountered only periodically throughout the sampling sites, controls should not be necessary.

Economic Threshold: None established.

Management: Insecticide use has not been warranted for control of the sunflower headclipping weevil.

Figure 67. Adult - Sunflower headclipping weevil *Haplorhynchites aeneus.* (Extension Entomology)

Figure 68. Larva- Sunflower headclipping weevil *Haplorhynchites aeneus.* (Extension Entomology)

Figure 69. Sunflower headclipping weevil damage. (Extension Entomology)