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Integrated Pest Management of Sunflower Insect Pests in the Northern Great Plains

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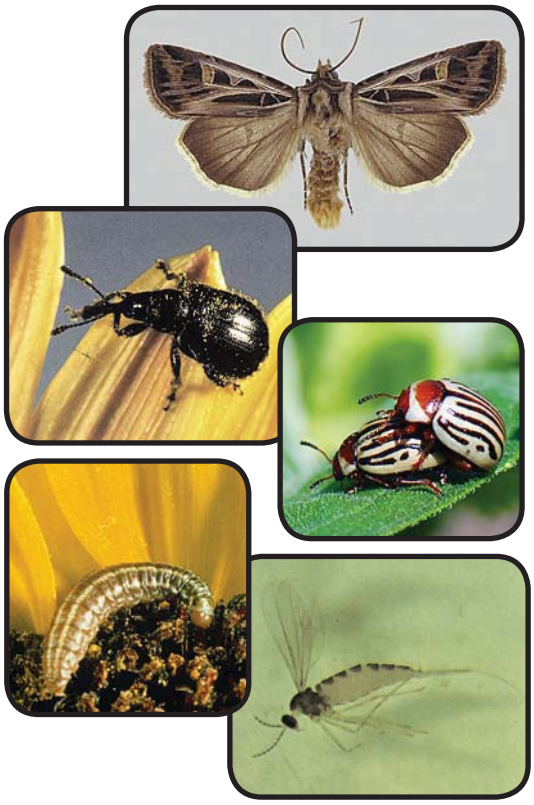

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Cultivated sunflowers, *Helianthus annuus* L., are native to North America and include 50 species in the genus *Helianthus*. Because sunflowers are native, associated insects have coevolved with the plants for centuries. When sunflowers were altered from a wild to a cultivated state, the changes had an impact on the insects associated with sunflowers in their native home. Plant architecture, growth phenology and plant community were altered when sunflowers were changed from wild to cultivated. For plant architecture, sunflowers changed from multiple to a single head, from branched to a single stem and from small to large seeds. The growth phenology also changed from variable emergence and extended periods of flowering in the wild type sunflower to discrete emergence and a short flowering period in cultivated sunflower. The plant community changed from small patches of mixed species of wild sunflowers to large acreage of a monoculture of cultivated sunflowers. A number of insects made the transition from the wild plant type to the cultivated plant to feed and develop. Some of these species affect the producers' ability to increase seed production and thus have become economic pests.

In the major sunflower-producing areas of the Dakotas, Minnesota and Manitoba, approximately 15 species of insects can cause plant injury and economic loss to sunflowers, depending on the severity of infestation. However, during any growing season, only a few species may be numerous enough to warrant control measures. The sunflower insects of major importance in the northern Great Plains have been the sunflower midge (*Contarinia schulzi* Gagné), 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). Tarnished plant bugs (*Lygus* spp.) also have been an economic problem for the confection and hulling sunflower seed market. Populations of the *Dectes* stem borer (*Dectes texanus* LeConte) have been increasing in South Dakota and North Dakota.

In this publication, we provide information on the identification, life cycle, damage and pest management strategies for the insect pests of sunflowers in the northern Great Plains of the United States and southern Canada.

Integrated Pest Management of Insects

Sunflowers 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 and maintains pest populations below levels that cause unacceptable losses to crop quality or yield. The concept of IPM is based on the fact that many factors interact to influence the abundance of a pest. Control methods vary in effectiveness, but integration of various population-regulating factors can minimize the number of pests in sunflowers 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 minimum pest density that will cause economic damage. An EIL recognizes that treatment is justified for some pest species while others are not of economic importance.

An economic threshold (ET) is the level of pest density at which tactics must be applied to prevent an increasing pest population from causing economic losses. Usually the ET is lower than the EIL. The ET has been defined most extensively for economic insect pests. Fewer ETs have been established for non-economical pests, such as sunflower root weevil or sunflower bud moth. The ET varies significantly among different pest species. The economic threshold also varies with pest developmental stages. Crop price, yield potential, crop density, cost and effectiveness of control, and environmental conditions influence the ET and EIL. Generally, the ET increases as cost of control increases and decreases as the crop value increases.

Monitoring Pest Population Levels

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. Pests should be identified accurately because economic threshold and control measures vary for different species. Many insects are beneficial and may help reduce numbers of injurious insects. Recognizing which species are pests and which are beneficial is important. Furthermore, proper timing of insecticidal treatment when warranted is essential to maximize pest control.

Sunflower pests are not distributed evenly throughout a field, and fields should be checked in several locations. Some insect pests, such as the banded sunflower moth, can be concentrated in areas of a field or are more abundant near the edges 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 not recommended. At least five sites per 40-acre field should be monitored to collect accurate information on the population density and extent of the 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, treating only the margins of the field can reduce unnecessary, expensive inputs and still provide economic control. In most cases, 20 plants per sampling site should be examined in the Z or X pattern.

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

Tools of Integrated Pest Management

IPM tools include many tactics, of which pesticides are only one. Tactics can be combined to create conditions that are the least conducive for pest survival. Chemical or biological pesticides are used when pests exceed the economic threshold. Pesticides typically provide quick control and prevent economic losses.

Some of the IPM strategies that can be used to reduce pest populations and mitigate yield loss are:

Biological Controls
- Beneficial insects
- Beneficial pathogens

Host-Plant Resistance

Cultural Controls
- Planting and harvesting dates
- Crop rotation
- Tillage practices

Mechanical/Physical Controls
- Trapping

Chemical Controls
- Pesticides
- Attractants
- Repellents
- Pheromones

Summary

Producers should examine their operations and minimize pest damage by adopting IPM practices based on the use of economic thresholds (when available) and by carefully combining monitoring and various pest management strategies. Significant progress in sunflower pest management has been made and undoubtedly will continue to be made in the future to aid successful sunflower production.

Seedling and Root Feeders

Wireworms (Coleoptera: Elateridae)

Various Species: Wireworms are the larvae of click beetles (Coleoptera: Elateridae), which have many species. They often feed on a variety of hosts. Early in the season, they are near the soil surface and may feed on germinating seeds or young seedlings. During the summer months, larvae move deeper into the soil, where temperature and moisture conditions are more favorable.

Description: Wireworms (Figure 1) are hard, smooth, slender larvae ranging from 1½ to 2 inches (38 to 50 millimeters, or mm) in length when mature. They are yellowish white to copper, with three pairs of small, thin legs behind the head. The last body segment is forked or notched. Adults (Figure 2) are bullet-shaped, hard-shelled beetles that are brown to black and about 1/2 inch (13 mm) long. The common name "click beetle" is derived from the clicking sound the insect makes when attempting to right itself after landing on its back.

Life Cycle: Wireworms usually take three to four years to develop from egg to adult. Most of this time is spent as larvae. 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 centimeters, or 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 (greater than 80 F, 27 C) or dry, larvae move deeper into the soil to seek more favorable conditions. Wireworms inflict most of their damage in early spring, when they are near the soil surface. During the summer months, 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 summer or fall of their final year. Adults remain in the soil until the following spring.

Figure 1. Wireworm – Elateridae
(M. Boetel, NDSU)

Figure 2. Wireworm adult (or Click beetle) – Elateridae
(Roger Key, www.insectimages.org)

Seedling and Root Feeders

Damage: Wireworm infestations are more likely to develop where grasses, including grain crops, are grown the previous year. Wireworms damage crops by feeding on germinating seeds, young seedlings or roots. 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.

Management: 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 an 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 soil bait station trap of a corn-wheat seed mixture, which attracts wireworms. If the average density is greater than one wireworm per bait station, the risk of crop injury is high and an insecticide seed treatment or 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 not detected in the traps. The other sampling procedure involves digging and sifting a soil sample for the presence of wireworms. 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.

Sunflower Root Weevil
(Coleoptera: Curculionidae)

Species: *Baris strenua* (LeConte)

Description: Adults (Figure 3) are rather robust weevils, with a somewhat oval-shaped body. Adults are dull black and 1/4 inch (6 mm) long with a short, almost blunt, downward-projecting snout. Larvae (Figure 4) are 1/4 inch (6 mm) long at maturity, legless, and have a white body with a small, brown head capsule.

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, adults begin to congregate around the root zone near the soil surface. Continued feeding and mating 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. Eggs hatch during the second week in July. Larvae are not very mobile and feed on the epidermal and cortical cells of the roots. Most feeding (consisting of circular tunnels) and development to fourth instar takes place in the same area where egg hatching occurs. At about the time the fourth larval stage is reached (typically late August to early September), the plant becomes significantly dehydrated and encapsulation of the larvae within a soil cocoon begins. Larvae overwinter within the cocoon among the remaining roots in the soil. Overwintering larvae have been recovered from a depth of up to 15 inches (38 cm) in North Dakota.

Damage: The sunflower root weevil adult causes negligible mechanical injury to the foliage of the sunflower plant. The main injury is feeding by the larvae on the roots, which cause plants to wilt and lodge if the infestation is severe. Damage to fields attacked by sunflower root weevil tends to be localized.

Management: A scouting method has not been developed because damage caused by this species has been minor. No economic thresholds have been established, and, thus far, insecticide use has not been warranted for the control of sunflower root weevil.

Figure 3. Sunflower root weevil adult - *Baris strenua* (LeConte) *(Extension Entomology)*

Figure 4. Sunflower root weevil larva - *Baris strenua* (LeConte) *(Extension Entomology)*

Figure 5. Darksided cutworm adult - *Euxoa messoria* (Harris) *(G. Fauske, NDSU)*

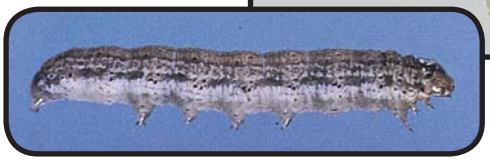

Figure 6. Darksided cutworm larva - *Euxoa messoria* (Harris) *(Extension Entomology)*

Cutworms (Lepidoptera: Noctuidae)

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 (Figure 5) are usually light and grayish brown with indistinct markings. Larvae (Figure 6) are pale brown dorsally and white on the ventral areas. The sides have numerous indistinct stripes. At maturity, they are about 1¼ to 1½ inches (32 to 38 mm) long and 1/4 inch (6 mm) wide.

Redbacked cutworm – Forewings of the adult (Figure 7) are reddish brown with characteristic bean-shaped markings. Larvae (Figure 8) are dull gray to brown and are 1 to 1¼ inches (25 to 32 mm) long when mature. Larvae can be distinguished from other cutworm species by two dull reddish stripes along the back.

Dingy cutworm – Forewings are dark brown with bean-shaped markings as in redbacked cutworm adults (Figure 9). Hind wings of the male are whitish with a broad, dark border on the outer margin; in the female, they are uniform dark gray. Larvae (Figure 10) are dull, dingy brown body mottled with cream color and have a thin light line down the middle of the back with a series of diagonal markings on either side.

Life Cycles: 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. Larvae of both species emerge from late May to early June. They continue to feed and grow until about the end of June. When mature, larvae pupate in earthen cells near the soil surface. The pupal period lasts about three weeks. Both species have one generation per year.

Adult dingy cutworms emerge in August and are active until mid-October, with peak activity in September. Eggs are deposited on plants in the family Asteraceae in the fall. Larvae develop to the second or third instar in the fall and overwinter in the soil. Larvae resume feeding in the spring and pupation occurs in the spring to early summer. One generation of this species is produced per year.

Damage: Cutworm damage is caused by larval feeding and normally consists of seedlings 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 from cutworms (notably the darksided cutworm) climbing up to feed on the plant foliage. Most cutworms feed at night. During the daytime, cutworms usually are found just beneath the soil surface near the base of recently damaged plants. Wilted or dead plants frequently indicate the presence of cutworms. Cut plants may dry and blow away, leaving bare patches in the field as evidence of cutworm infestations.

Management: Sampling should begin as soon as sunflower plants emerge, and fields should be checked at least twice per week until approximately mid-June. 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 (gaps may be caused by a defective planter, poor germination, rodents or birds). The size of the cutworm larvae also should be estimated. Small larvae pose the greatest potential for damage because they still have to feed and grow. The economic threshold is one larva per square foot (30 by 30 cm) or 25 to 30 percent stand reduction. The Z pattern should be used to determine cutworm population levels by examining five 1-square-foot (30 by 30 cm) soil samples per site (in the row) for a total of 25 samples. Several different insecticides are registered for cutworm control in sunflowers. Postemergent treatment with an insecticide provides quick control of surface feeding cutworms. Best results occur if insecticide applications are made at night. Sunflower seed treated with an insecticide seed treatment will provide suppression only of cutworm activity.

Figure 9. Dingy cutworm adult - *Feltia jaculifera* (Walker) *(G. Fauske, NDSU)*

Figure 7. Redback cutworm adult - *Euxoa ochrogaster* (Guenee) *(G. Fauske, NDSU)*

Figure 8. Redback cutworm larvae - *Euxoa ochrogaster* (Guenee) *(J. Gavloski, MAFRI)*

Figure 10. Dingy cutworm larvae - *Feltia jaculifera* (Walker) *(J. Gavloski, MAFRI)*

Stem Feeders

Dectes Stem Borer (Coleoptera: Cerambycidae)

Species: *Dectes texanus* LeConte

Description: The *Dectes* stem borer has been recognized as a potential pest of sunflowers since the early 1970s, when it caused considerable damage in south-central Texas. The *Dectes* stem borer also occurs in North Dakota and South Dakota. It also has been reported as an important pest of soybeans. The adult (Figure 11) is pale gray and 5/8 inch (16 mm) in length, with long gray and black banded antennae. Eggs are greater than 1/16 inch (1.9 mm) long and elongate, and turn dark yellow prior to hatching. Mature larvae (Figure 12) 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.

Life Cycle: Adults appear in late June and early July, although emergence continues through August. Eggs are laid four to eight days after mating and 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, 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 during the winter in its frass-packed tunnel. Larvae are cannibalistic and stalks usually harbor only a single larva even though several may have hatched in a stalk. The *Dectes* stem borer has one generation per year. Host plants include sunflowers, soybeans, ragweed and cocklebur.

Damage: Stalks often break at the point of girdling. Plant damage due to adult feeding appears to be insignificant because 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 2½ to 3½ inches (7 to 9 cm) above the soil surface.

Management: In the southern Great Plains, later planting dates and fall or winter tillage have reduced infestations of sunflowers by this pest. Irrigated sunflowers in the southern states also have thick stalk, which may reduce lodging and yield losses from the *Dectes* stem borer. Perennial sunflower species are resistant to stalk infestation, indicating the possibility of breeding cultivars resistant to the *Dectes* stem borer. Chemical treatments on soybeans or sunflowers 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 results in thicker stems may help reduce damage from lodging. If fields are suspected to be infested, prompt harvesting will limit losses from lodging. No scouting method or economic threshold is available for this pest.

Sunflower Stem Weevil (Coleoptera: Curculionidae)

Species: *Cylindrocopturus adspersus* (LeConte)

Description: The sunflower stem weevil has been reported from most states west of the Mississippi River and into Canada. Adult sunflower stem weevils (Figure 13) are less than 3/16 inch (4 to 5 mm) long and grayish brown with white markings on the wing covers and thorax. 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. Eggs are very small (0.51 mm long by 0.33 mm wide), oval and yellow, and are difficult to see. Larvae (Figure 14) are 1/4 inch (6 mm) long at maturity. Larvae are legless and creamy white with a small, brown head capsule. They are normally in a curled or C-shaped position within the sunflower stalk. The number of larval instars appears to be variable and five to seven have been noted. Pupae are similar in size to the adult and are creamy white.

Figure 11. *Dectes* stem borer adult - *Dectes texanus* LeConte *(L. Charlet, USDA-ARS)*

Figure 12. *Dectes* stem borer larva - *Dectes texanus* LeConte *(P. Beauzay, NDSU)*

Figure 13. Sunflower stem weevil adult - *Cylindrocopturus adspersus* (LeConte) *(Extension Entomology)*

Figure 14. Sunflower stem weevil larva - *Cylindrocopturus adspersus* (LeConte) *(Extension Entomology)*

Life Cycle: Adult sunflower stem weevils emerge from overwintered stalks and root crowns in mid- to late June in the northern Great Plains. Mating occurs soon after emergence of adults. Adults feed on stem and leaf tissue. Adults are present in the fields in the northern Great Plains until late August, with peak densities in mid-July. Just prior to egg laying, females descend to the lower portion of the plant and deposit eggs individually in the stem tissue around the first node (cotyledon). The height of egg placement in the stalk increases through time. Higher numbers of adult weevils, probably due to competition for sites, increases the height at which eggs are laid. Approximately 50 percent of oviposition occurs by mid- to late July. Upon hatching, first instar larvae feed on subepidermal and vascular tissue in the stem. Feeding is concentrated in the pith tissue as the larvae develop to third and fourth instar stages. Larvae feed apically until early August and then descend to the lower portion of the stalk or root crown by late August and excavate overwintering chambers by chewing cavities into the stem cortex. The sunflower stem weevil has only one generation per year. Pupation occurs the following year in early June.

Damage: Feeding by adults causes minor damage to the stem and leaf tissue of the plant. If the larval population in a plant is high, the stem may become weakened by tunneling, pith destruction or overwintering chambers. The stem may break, causing a loss of the entire head prior to harvest. Stalk lodging due to sunflower stem weevil is most severe during drought stress or when high winds occur as plants are drying prior to harvest. At larval infestations of 20 to 25 or more per stalk, plants are at risk of stalk breakage and loss of the entire sunflower head. However, one study showed that populations of greater than 80 larvae/stalk in irrigated sunflowers were required to cause a yield loss from larval feeding. Lodging typically occurs at or slightly above the soil line, in contrast to breakage attributed to stalk diseases, which normally occur farther up on the stalks. Lodging is a good indicator of larval densities; however, lodging also is influenced by other factors, including stalk diameter, cortex and pith thickness of the stem, weight of sunflower heads, wind velocity and direction, position of larvae in overwintering chambers in the stalk and incidence of disease.

The sunflower stem weevil also has been implicated in the epidemiology of sunflower pathogens, such as Phoma black stem (*Phoma macdonaldii* Boerma), and may predispose plants to infection by *Macrophomina phaseolina* (Tassi) Goid, the causative agent of charcoal stem rot in sunflowers in the southern Great Plains. Phoma has been implicated as one of the major biotic causes of premature ripening syndrome (early dry down) of sunflowers in North Dakota. Although premature ripening probably is caused by a combination of both abiotic and biotic factors, evidence shows that stem-infesting insects may transmit disease organisms or encourage the disease by causing stress to the plant.

Scouting and Economic Threshold: Field monitoring is important to estimate sunflower stem weevil densities. 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 cotyledons or in soil cracks at the base of the plant. Sampling for the larval stage is difficult because they develop within the plant. The only method for detecting the presence of larvae is to split the stem, which is a time-consuming process. Field scouting for adults should begin when plants are in the eight- to 10-leaf 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. The economic threshold is one adult sunflower stem weevil per three plants, which results in larval densities of about 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 cultivation, 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, decreased damage from lodging. Natural enemies of the sunflower stem weevil include parasitic wasps that attack both the egg and larval stages.

Black Sunflower Stem Weevil
(Coleoptera: Curculionidae)

Species: *Apion occidentale* Fall

Description: Adults (Figure 15) are shiny black and less than 1/8 inch (3 mm) long. The snout is very narrow and protrudes forward from the head, which is small in relation to the rather large, almost globose body. Larvae (Figure 16) are similar in appearance to the sunflower stem weevil larvae, except they are only 1/8 inch (3 mm) long at maturity and more yellow with a more pointed posterior.

Life Cycle: Adults overwinter in soil or plant residue and emerge from late May to early June. Eggs are deposited under the epidermis in leaf petioles or stems near leaf axils. Adults

feed from early spring to late July on leaf and stem tissue. Larvae feed in vascular and pith tissues of stems and petioles. Newly emerged larvae tunnel in the pith of the stem, pupate and emerge as adults in early August. Little or no adult activity is observed for about two weeks in late July and early August. 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, adults move under the bracts of the sunflower head, where they can be observed feeding until the plants are harvested. Adults move into the soil from late August to September to overwinter.

Damage: Although feeding damage is seldom significant, this species has been associated with the transmission of the pathogen *Phoma macdonaldii* Boerma, the causal agent of Phoma black stem. Stand loss can occur where extremely high populations are feeding on sunflower seedlings. In most cases, however, populations are too low to cause economic damage, and stalk tunneling only results in minor injury to the plant.

Management: This species, although numerous in cultivated sunflower fields, has not been considered an economically important pest. A scouting method has not been developed for black sunflower stem weevil, an economic threshold has not yet been established and recommendations for insecticidal control of this insect have not been developed.

Sunflower Maggot (Diptera: Tephritidae)

Species: *Strauzia longipennis* (Wiedemann)

Description: The sunflower maggot is the only tephritid species found in the stalks of cultivated sunflowers. It is a widespread species, occurring in most areas of the United States and many Canadian provinces. The showy yellow adult (Figure 17) has a wing span of about 1/2 inch (13 mm) and a body length of 1/4 inch (6 mm). The eyes are bright green and the wings bear broad dark bands that form a fairly distinct F pattern near the wing tip. Eggs are 1 mm long and are white and elongated. Larvae (Figure 18) are yellow-white, headless and legless, tapered from anterior to posterior and approximately 9/32 inch (7 mm) long at maturity.

Life Cycle: Larvae develop through three instars in approximately six weeks. Adults emerge in mid-June, although adult flies have been noted in shelterbelts and field margins as early as late May. The adult fly is very active during the day and is present in fields until late July. Eggs are deposited singly in stem tissue near the apical meristem, and larvae feed in the stalk pith, creating large tunnels. The maggots, when fully developed, emerge from the stalk beginning in mid-August. This species overwinters as a larva in plant debris in the soil. Pupation and adult emergence are completed in early June. The sunflower maggot has one generation per year.

Damage: Economic loss due to larval feeding has not been documented for this species, even though larvae commonly are found in up to 100 percent of sunflower stalks. Feeding is confined to the pith, which acts as a supporting structure, and is not critical to plant nutrition. Secondary fungal infections also are associated with tunneling by the larvae within the stalk. Stalks are not weakened and seed yield is not reduced, even with severe pith destruction. Insecticide use has not been warranted for control of sunflower maggot and no scouting methods or economic thresholds have been established.

Figure 15. Black sunflower stem weevil adult - *Apion occidentale* Fall *(Extension Entomology)*

Figure 16. Black sunflower stem weevil larva - *Apion occidentale* Fall *(Extension Entomology)*

Figure 17. Sunflower maggot adult - *Strauzia longipennis* (Wiedemann) *(Extension Entomology)*

Figure 18. Sunflower maggot larva - *Strauzia longipennis* (Wiedemann) *(J. Gavloski, MAFRI)*

Palestriped Flea Beetle (Coleoptera: Chrysomelidae)

Species: *Systena blanda* (Melsheimer)

Description: The adult (Figure 19) 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.

Life Cycle: The life cycle of palestriped flea beetles on sunflowers is poorly understood. However, 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 sunflowers through July. The palestriped flea beetle has a wide host range, which includes various weeds, potatoes, tomatoes, carrots, peanuts, corn, oats, cotton, peas, beans, strawberries, watermelon, grapes and pumpkin. 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, which cause the plants to wilt and die. Injured leaves become riddled with holes, giving them a "lacy" appearance. Sunflowers are most sensitive to palestriped flea beetle injury from seedling emergence (VE) through the four-leaf stage (V4). Significant stand losses may result from heavy feeding injury by palestriped flea beetles.

Scouting Method: Surveys may be accomplished by using yellow sticky cards placed in between the rows and close to the ground. 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. 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. Research has shown that insecticide seed treatments may provide up to 75 percent control of adults.

Sunflower Beetle (Coleoptera: Chrysomelidae)

Species: *Zygogramma exclamationis* (Fabricius)

Description: The sunflower beetle is associated exclusively with sunflowers. Adults closely resemble adult Colorado potato beetles and may be confused with this species. However, sunflower beetles are smaller and do not feed on potatoes, and Colorado potato beetles do not feed on sunflowers. The head of the adult (Figure 20) 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 1/4 to 1/2 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 creamy yellow. Sunflower beetle larvae (Figure 21) are yellowish green with a brown head capsule and are 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 5/16 to 13/32 inch (8 to 10 mm) when fully mature.

Life Cycle: Adults overwinter in the soil and emerge in late May or early June at about the same time sunflower seedlings emerge. Adults feed on the true leaves of young plants but seldom on the cotyledons. Adults feed during the day, whereas larvae are nocturnal feeders and congregate among the bracts of the flower bud and in the leaf axils during the day. 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 from 200 to 2,000 eggs. Larvae emerge in about one week. Larvae have four instars, which feed and are present in fields for about six weeks. When mature, larvae enter the soil to pupate in earthen cells. The pupal stage lasts from 10 days to two weeks. The late-summer population of adults 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.

Figure 19. Palestriped flea beetle adult - *Systena blanda* (Melsheimer) *(F. Peairs, Colorado State University, Bugwood.org)*

Figure 20. Sunflower beetle adults - *Zygogramma exclamationis* (Fabricius) *(P. Beauzay, NDSU)*

Figure 21. Sunflower beetle larvae - *Zygogramma exclamationis* (Fabricius) *(L. Charlet, USDA-ARS)*

The sunflower beetle has one generation per year in the northern Great Plains.

Damage: Both adults and larvae defoliate plants and will feed on both cultivated sunflowers and native *Helianthus* species. Adult sunflower beetles damage plants soon after they emerge from overwintering. Damage to cotyledons is generally light, but the first true leaves may be severely damaged or completely consumed. Fields may be severely defoliated if beetles are numerous. Adults feed predominantly on leaf margins, while larvae feed on the entire leaf surface. When larvae are numerous, damaged leaves take on a lacy appearance. If larval feeding is severe, defoliation can reduce yield due to poor seed set or fill.

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 the economic threshold in a field. Insecticides are effective in preventing economic loss when applied to actively feeding adults and/or larvae. A standardized scouting protocol mentioned earlier is recommended. 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 economic threshold is 10 to 15 larvae per plant, or when approximately 25 percent defoliation occurs on the upper eight to 12 leaves. Management normally is advised if defoliation reaches the 25 to 30 percent level at the late vegetative and early bud stages and more defoliation (based on larval size of less than ¼ inch or 6 mm) likely will occur on the actively growing part of the plants. However, if defoliation is 25 percent and the majority of larvae are about 1/3 inch (8 mm) long, they have reached maturity and will stop feeding soon. Then management is not warranted. Adult and larval populations of sunflower beetle decrease as planting date is delayed. Defoliation also is lower at 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 late-season insects, such as red sunflower seed weevil. Spring or fall cultivation does not reduce overwintering populations of sunflower beetle adults or influence the pattern of emergence from the soil during spring and summer. Natural enemies include parasitoids that attack 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 sunflower beetle.

Thistle Caterpillar (Painted Lady Butterfly) (Lepidoptera: Nymphalidae)

Species: *Vanessa cardui* (L.)

Description: The only member of the order Lepidoptera that potentially can cause extensive defoliation to sunflowers is the painted lady butterfly, or thistle caterpillar. Larvae feed on more than 100 plant species, including thistle, sunflower and burdock, and also have been noted feeding on crops such as canola and soybeans. The body of the adult (Figure 22) is about 1 inch (25 mm) long with a wingspan of about 2 inches (50 mm). 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 eyespots. Eggs are small, spherical and white. Larvae or caterpillars (Figure 23) are brown to black and spiny, with a pale yellow stripe on each side. When mature, the larvae are 1¼ to 1½ inches (32 to 38 mm) long. The chrysalis, or pupa, is molten gold and about 1 inch (25 mm) long.

Life Cycle: The painted lady butterfly overwinters in tropical and subtropical areas and migrates north annually to the northern Great Plains. 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 sunflowers, and many other host plants. Hatching occurs in about one week. Larvae feed on sunflowers 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 chrysalis and have two or more generation a year.

Damage: Larvae feed on the leaves and, when numerous, may defoliate plants. Larvae produce 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 sunflower yield is similar to that described for sunflower beetle larvae.

Figure 22. Thistle caterpillar (Painted lady butterfly) adult - *Vanessa cardui* (L.) *(Extension Entomology)*

Figure 23. Thistle caterpillar (Painted lady butterfly) larva - *Vanessa cardui* (L.) *(J. Knodel, NDSU)*

Management: Insecticide use generally has not been warranted for control of larvae. However, instances of high localized infestations can occur within certain fields and spot treating may be necessary. Disease outbreaks, indicated by dying larvae present on leaves, often occur when large populations are present. Sampling sites should be at least 75 to 100 feet (23 to 31 meters, or 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 economic threshold for the thistle caterpillar is 25 percent defoliation, provided that most of the larvae are still less than 1¼ inch (32 mm) long. If the majority of the larvae are 1¼ to 1½ inches (32 to 38 mm) long, most of the feeding damage already will have occurred and treatment is not advised.

Lygus Bug (Hemiptera: Miridae)

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

Description: The most common species of *Lygus* bug occurring in sunflower fields is the tarnished plant bug *(Lygus lineolaris)*. It attacks at least 385 different plant species and occurs in 39 U.S. states and five Canadian provinces. They probably follow a seasonal pattern based on crop development, moving to a crop as it reaches the reproductive stage and leaving as it senesces. Adults (Figure 24) are small, cryptically colored insects with a distinctive yellow triangle or "V" on the wings, and are about 3/16 inch (4 to 5 mm) in length. They vary from pale green to dark brown. The immature stages or nymphs (Figure 25) are similar in appearance to the adults but lack wings and are usually green.

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

Damage: Oilseed sunflowers are not thought to be at risk of damage from *Lygus* feeding. The presence of scarring on confection or nonoilseed sunflowers, known as kernel brown spot, is caused by *Lygus* bugs feeding on developing seeds, which causes 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. The quality issue is significant because processors discount the finished product with only 0.5 percent damage.

Management: 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. *Lygus* can be treated at the same time confection sunflowers are treated for other insects, such as red sunflower seed weevil and banded sunflower moth. Research indicates that two insecticide applications separated by a one-week interval were more efficacious than one insecticide application alone.

Figure 24. Tarnished plant bug adult - *Lygus lineolaris* (Palisot de Beauvois) *(S. Bauer, USDA Agricultural Research Service, Bugwood.org)*

Figure 25. Tarnished plant bug larva - *Lygus lineolaris* (Palisot de Beauvois) *(S. Bauer, USDA Agricultural Research Service, Bugwood.org)*

Head and Seed Feeders

Sunflower Headclipping Weevil
(Coleoptera: Attelabidae)

Species: *Haplorhynchites aeneus* (Boheman)

Description: The sunflower headclipping weevil adult (Figure 26) is shiny black. The weevil is about 5/16 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, prolonged head and snout. Larvae (Figure 27) are cream-colored, somewhat C-shaped and grublike and are 3/16 to 1/4 inch (4 to 6 mm) long.

Life Cycle: Adults emerge in mid-July and are active for a two- to three-week period. 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 line of feeding weakens the stem at this point to the extent that the weight of the maturing head eventually severs the head from the top of the stalk. Larvae feed on the severed head and later move into the soil to overwinter.

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

Management: If the adults are encountered only periodically through scouting, controls should not be necessary, and to date no economic threshold has been established.

Figure 26. Sunflower headclipping weevil adult - *Haplorhynchites aeneus* (Boheman) *(Extension Entomology)*

Figure 27. Sunflower headclipping weevil larva - *Haplorhynchites aeneus* (Boheman) *(Extension Entomology)*

Red Sunflower Seed Weevil
(Coleoptera: Curculionidae)

Species: *Smicronyx fulvus* LeConte

Description: The red sunflower seed weevil occurs from the Appalachian Mountains westward through the Great Plains and to the Pacific Northwest. Red sunflower seed weevil adults (Figure 28) are 7/16 to 1/8 inch (2.5 to 3.1 mm) long and are covered with reddish-orange, oval scales. As the weevils age, the scales rub off and the weevils become darker in appearance. Eggs are white and average 0.28 mm wide and 0.70 mm long. Larvae (Figure 29) are small, 7/64 inch (2.54 mm) long, cream-colored, legless and C-shaped.

Life Cycle: Red sunflower seed weevil emergence occurs in late June and early July. Newly emerged adults feed on sunflower buds or floral tissues. Once pollen is available, adults include pollen in their diet. Females need to feed on sunflower pollen for several days prior to egg laying. Weevil populations are highest on plants at 50 percent anthesis. Adults leave plants that have completed anthesis and move to other plants that still are shedding pollen. Adult longevity is about 53 days. Adult weevils do not readily fly and remain hidden among the disk florets. Eggs are deposited within developing seeds. The egg-laying pattern follows seed fill, which progresses from the periphery to the center of the head. Usually an infested seed contains a single larva, although 8 to 12 percent of the seeds may contain several eggs. Egg laying lasts about 20 days. Larvae emerge in the developing kernel and develop through five instars. An infested seed usually contains a single larva, which consumes approximately one-third of the kernel. In late August, fifth-instar larvae chew an exit hole in the seed, drop to the ground directly beneath the sunflower head and overwinter in the soil. Larvae continue to emerge from the seeds for about 30 days. Pupation occurs in the soil during early June through early July of the following season.

Damage: While the kernel of some seeds may be totally eaten, most seeds are only partially consumed. Larval feeding

Figure 28. Red sunflower seed weevil adult - *Smicronyx fulvus* LeConte *(Extension Entomology)*

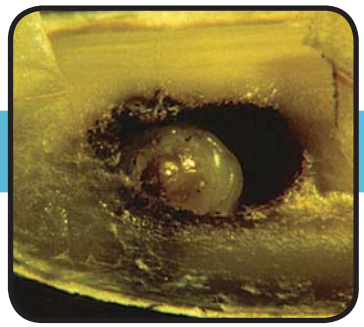

Figure 29. Red sunflower seed weevil larva - *Smicronyx fulvus* LeConte *(Extension Entomology)*

reduces seed weight and oil. Oil concentration loss is attributed to larvae feeding on the seed and not on the hull. Oil loss from damage to the hull is insignificant. Adult feeding on the bracts of developing sunflower does not cause economic damage. 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. Producers 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 grain storage bin. Larvae that are still in the seed at bin filling are done feeding and can cause heat 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. The most advantageous time to initiate control of seed weevil is in the field when adult weevils are active, but prior to egg laying. The ET varies with differences in plant population, the cost of insecticide applications and the market price of sunflowers.

Economic Threshold =

$$\frac{\text{Cost of Insecticide Treatment}}{(\text{Market Price} \times 21.5)\,(0.000022 \times \text{Plant Population} + 0.18)}$$

Currently, an infestation level of five to eight seed weevil adults per head in oil sunflowers or one seed weevil per head in confectionery sunflowers 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 (R5.1 to R5.4) and the ET has been reached. If spray application is delayed past the time when more than four out of 10 plants are at stage R5.4, many eggs already will be laid in the developing seeds and those eggs and larvae cannot be controlled. If fields are sprayed too early, reinfestation may occur in areas with a high weevil population. After spraying, fields should be rechecked periodically to determine if reinfestation is reaching the ET. Continue monitoring until most of the heads in the field have reached the R5.7 stage. At that stage, most eggs will have been laid and most seeds will be too mature to be suitable for further red seed weevil egg laying.

To sample for red sunflower seed weevil, 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: 1) stop sampling; no action is needed, 2) stop sampling and treat or 3) take more samples because a decision cannot be reached. When populations are low or high, sequential sampling allows for a quick decision with few samples. If populations are near the ET, more precision is needed to make an accurate determination and more samples are required. To more precisely check individual sunflower heads for red sunflower seed weevils, the faces 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 so they can be counted more accurately. Consult the most recent NDSU Extension sunflower seed weevil publication (E-817) for a table to convert visual counts to the absolute number of weevils (both counted and uncounted).

Several registered insecticides are available for control of sunflower seed weevils in the U.S. and Canada. Early planting of sunflowers reduces seed damage caused by red sunflower seed weevil without causing a measurable reduction in oil content and seed weight. Surrounding a sunflower field with a ring of early blooming sunflowers can effectively 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. Although larvae of both red and gray sunflower seed weevils have been reported as hosts for a number of parasitoid species, biological control is generally not effective in controlling weevils during the current field season.

Gray Sunflower Seed Weevil
(Coleoptera: Curculionidae)

Species: *Smicronyx sordidus* LeConte

Description: The gray sunflower seed weevil is found on sunflowers from Mexico to the Canadian provinces of Manitoba and Saskatchewan. It is more common in southern regions than the red sunflower seed weevil. Adults of the gray sunflower seed weevil (Figure 30) are slightly larger (9/64 inch

Figure 30. Gray sunflower seed weevil adult - *Smicronyx sordidus* LeConte
(Extension Entomology)

Figure 31. Gray sunflower seed weevil larva - *Smicronyx sordidus* LeConte
(Extension Entomology)

or 3.6 mm long) than the red sunflower seed weevil and are gray instead of red. The gray sunflower seed weevil is covered with gray scales, but old adults may be black because of the loss of scales. Eggs are nearly elliptical, with one end distinctly larger than the other. Egg length averages 0.7 mm, with widths at the two opposite ends being 0.2 and 0.3 mm. Except for the width differences in the two ends of the egg, the shape and size of gray sunflower seed weevil eggs resemble that of the red sunflower seed weevil. Larvae (Figure 31) are small, 1/8 inch long (3 mm), cream-colored, legless and C-shaped. Larvae resemble red sunflower seed weevil larvae in color and shape but are larger. They are internal seed feeders and usually are found near the bottom of the developing seed.

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. Newly emerged adults feed on floral buds. Unlike the red sunflower seed weevil, which oviposits internally in the seed and occurs on plants during anthesis, gray sunflower seed weevil oviposition is external and occurs while the plant is in the bud stage. Eggs are placed in the tips of immature disk florets and larvae move through the corolla tube to reach the developing ovary. Larvae then migrate to the base of the ovary to feed. Larvae pass through four instars. Once the plant reaches anthesis, it is no longer attractive to gray sunflower seed weevil and weevils will leave the plant. Seeds infested by larvae of the gray sunflower seed weevil enlarge, protrude above surrounding seeds. Enlarged seeds are apparent at 16 days after egg laying and may be a type of gall. At maturity, larvae chew an exit hole in the pericarp and drop to the ground. Larval emergence begins about 46 days after egg laying. The majority of larvae drop to the ground from mid-August through September and overwinter 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 gray sunflower seed weevil may be sufficiently high to warrant treatment at the late bud stage (R3 to R4). As with the red sunflower seed weevil, larvae normally drop from the head to the soil after completing development. Larvae that do not emerge will present the grower with the same problem as unemerged red sunflower seed weevil larvae.

Management: Several insecticides are registered for control of sunflower seed weevils. If fields need to be treated with insecticides for the gray sunflower seed weevil, they should be sprayed while the plants are still in early bud stage. By late bud stage, most oviposition already will have occurred. The treatment strategy for control of the red sunflower seed weevil during early flowering will not control the gray sunflower seed weevil. 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 R2 and continue until plants are blooming. Even in confection fields, seed likely will not be rejected because of gray sunflower seed weevil damage because infested seeds often are removed during the threshing and seed cleaning process.

Banded Sunflower Moth
(Lepidoptera: Tortricidae)

Species: *Cochylis hospes* Walsingham

Description: The banded sunflower moth has a widespread distribution and probably occurs wherever wild *Helianthus* species grow. The adult moth (Figure 32) measures 1/4 inch (6 mm). Light tan body scales cover the body. A distinct, dark brown triangular scale patch covers the midportion of the forewings, and the edges of the forewings have a small, brown patch of scales. The wingspan is about 1/2 inch (13 mm). Eggs are 0.45 mm long and 0.29 mm wide. Early instar larvae are off-white, and late instar larvae (Figure 33) are pinkish to red and finally turn green with a brown head capsule. Larvae are about 7/16 inch (11 mm) at maturity.

Life Cycle: Banded sunflower moths begin to emerge from the soil about mid-July and are present in the field until mid-August. Moths spend much of their time in vegetation along field margins during the day. At twilight, females move into the fields to lay eggs. Within a week after emergence, they begin

Figure 32. Banded sunflower moth adult and eggs (circle) - *Cochylis hospes* Walsingham *(Extension Entomology)*

Figure 33. Banded sunflower moth larva - *Cochylis hospes* Walsingham *(Extension Entomology)*

to lay eggs on the outside of the bracts of the sunflower head. Moths flutter from plant to plant but do not feed. The average lifespan of adults is seven to 10 days. Moth flight lasts two months. Egg laying begins during early July and continues for approximately six weeks. Females lay more eggs on pre-bloom heads than on early bud or post-bloom heads. Most eggs are laid on the outer whorl of the involucral bracts, but some eggs are laid on the underside of the sunflower head. The incubation period of the eggs is approximately seven days. Eggs may be found through early August and hatch in five to eight days.

Newly emerged larvae move from the bracts to the disk flowers of the sunflower head, where they enter open disk florets. Larvae feed on disk florets, unfertilized seeds, and developing and mature seeds. Consumption of disk florets may affect yield in sunflowers adversely. Studies simulating damage by disk-floret removal showed that heads did not compensate for lost disk florets during seed filling. Third-instar larvae tunnel through the disk florets and feed on young, developing seeds. As the seeds mature and harden, larvae chew into the seeds. After feeding on the kernel of a mature seed, the larva moves to a new seed. Each larva consumes five to seven seeds.

Larvae develop through five instars and are present in sunflower heads from mid-July to mid-September. At maturity, larvae drop to the ground and spin cocoons in the soil to overwinter. Pupation takes place in late June or early July of the following year. The pupal period lasts about 12 days.

Damage: 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 (R5). Larvae feed in the florets until the third instar. During later stages of development, larvae tunnel through the bases of the florets and into the seed. 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. Small areas of silken webbing on mature sunflower heads indicate the presence of banded sunflower moth larvae within the head.

Banded sunflower moth larval damage to the seed is similar to damage caused by the red sunflower seed weevil. The banded sunflower moth larva normally consumes the entire kernel, and the red sunflower seed weevil larva consumes a third of the kernel. The exit hole in the seed created by banded moth larva is slightly larger than the exit hole created by the red sunflower seed weevil larva.

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 producers practicing conservation tillage. Research in North Dakota has demonstrated that delaying planting of sunflowers until late May or early June helps reduce infestation levels of the banded sunflower moth. Parasitic wasps attack eggs and larvae. Predators also consume eggs and larvae. Field scouting and use of economic thresholds will minimize the negative impacts of insecticides on these beneficial insects.

The use of insecticides to manage the banded sunflower moth is warranted when populations are at or exceed the EIL. Two distinct and separate procedures can be used to develop an EIL for the banded sunflower moth: egg scouting and adult moth scouting.

Although sampling is done for eggs or moths, chemical treatment is directed at the larval stage, which is the actual damaging stage. Once the decision to treat has been made, timing the spray application correctly is critical to get maximum control. The optimal sunflower plant stage to treat is the R5.1 growth stage, or when pollen shed is just beginning. This is the time when banded sunflower moth eggs have hatched and larvae are present, but before the head has seeds forming. At this time, the larvae are beginning to feed on the disk flowers, are exposed on the head and are susceptible to the insecticide treatment. On older plants where the seeds have started maturing, most larvae will be feeding within the seeds or under the protection of the florets and will be protected from the insecticide. By then, much of the feeding damage already has occurred. Insecticides should be applied early in the morning or late in the day to minimize adverse effects on bees and other pollinators.

The procedure for egg sampling is simpler and quicker than sampling for moths and the method allows more time to react if a treatment is needed. However, if the correct time to sample for eggs is missed, the adult sampling procedure should be used to determine the potential for economic damage.

Egg Scouting Method and Economic Threshold: The potential for banded sunflower moth damage is determined by counting eggs on floral bracts in the field. Because the eggs are very small, a magnifier is needed to count eggs accurately (Figure 32). We recommend using a head-mounted 3.5X magnifier to leave both hands free for manipulating the bud being observed. Egg counts should be made when most of the plants in the field are at plant stage R3 (distinct bud elongated 3/4 inch (19.1 mm) above the nearest leaf, yellow ray petals not visible). However, to avoid sampling bias, buds should be selected randomly without regard to plant stage.

Sampling for banded sunflower moth egg populations in commercial fields should be conducted as follows:

1. Divide each side of the field into two sections.
2. Sample the center of each section at 20 feet from the field edge.
3. Randomly select five buds.
4. From each bud, randomly select six bracts from the outer whorl and count the eggs on each bract.
5. Average the egg counts from the five buds and then map the average egg counts from each sample site to a diagram of the field.

Next, compare the average egg density ***at each sampling site*** to the calculated economic injury level.

Economic Injury Level (EIL). The economic injury level (EIL) is the number of eggs per six bracts and considers treatment cost ($/acre), market price ($/lb) and plant population per acre.

$$\text{EIL} = \frac{C}{V \times PP \times 0.00078}$$

V = Market value per pound
PP = Plant population per acre
C = Treatment cost

Example: C = $8, V = $0.13 and PP = 16,000
The EIL is 4.9 eggs per six bracts.

Adult Moth Sampling During Day and Economic Threshold: Sampling sites should be at least 75 to 100 feet in from the field margins. When sampling a field, use the X pattern, 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 (R-3), usually during mid- to late July.

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 is based on comparing the average number of adult moths in the field to the EIL for moths. The EIL is the number of moths per head that will 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 moth EIL for day sampling:

EIL
(moths per 100 plants) =

$$\left[\frac{\text{(Treatment Cost ($)/Market Price)}}{\text{(Plant Population)}} \times 582.9 \right] - 0.7$$

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

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

Insecticide treatment cost = $8/acre
Market price = $0.13/pound
Plant population = 20,000/acre

$$\text{EIL} = \left[\left(\frac{\$8/\$0.13}{20{,}000} \right) \times 582.9 \right] - 0.7$$

= 1.09 moths per 100 plants

For this set of variables, an infestation of about one moth 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 13 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.

Additional information is available in the most recent NDSU Extension banded sunflower moth publication (E-823).

Sunflower Bud Moth (Lepidoptera: Tortricidae)

Species: *Suleima helianthana* (Riley)

Description: The adult sunflower bud moth (Figure 34) has a wingspread of about 5/8 inch (16 to 18 mm). Each gray-brown forewing has two dark transverse bands. One band extends across the middle of the wing and the second band is near the wing tip. The larva (Figure 35) has a dark head capsule with a smooth, cream-colored body and is 5/16 to 7/16 inch (8 to 11 mm) at maturity.

Life Cycle: Two generations of sunflower bud moth are produced per year in the northern Great Plains. Adults emerge from overwintering pupae during the last week of May to mid-June. A few days after adult emergence, eggs can be deposited on buds of immature sunflowers or on the heads of mature sunflowers. Eggs also are deposited in leaf axils. Young larvae penetrate the epidermis and begin feeding in the pith area of either the stalk or receptacle (head). Penetration by first-instar larvae usually occurs in a leaf axil or at a tender area on the back of the receptacle. The initial infestation in mid-June is characterized by an entrance hole surrounded by black frass. Mature larvae pupate within the sunflower plant near 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.

Damage: In early planted sunflowers, 65 to 85 percent of 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. Yield loss is noticeable only when larvae burrow into unopened buds, preventing proper head development. A larva keeps an open burrow and continually pushes frass to its entrance. As the larva grows, frass accumulates at the entrance of its burrow. As the infested plant matures, abnormal plant growth may occur at the site of injury on either the stalk or the receptacle. 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 larvae produces malformations in both the head and stalk.

Management: A field sampling protocol and an ET have not been developed. Insecticide use has not been warranted for control of sunflower bud moth.

Sunflower Moth (Lepidoptera: Pyralidae)

Species: *Homoeosoma electellum* (Hulst)

Description: The sunflower moth has been the most widespread and damaging sunflower insect pest in North America, although infestations in more northerly regions are sporadic. Larval feeding has been reported on more than 40 different composite plant species, including four species of native sunflowers. The adult (Figure 36) is a shiny gray to grayish-tan moth about 3/8 inch (9 mm) long, with a wingspan of about 3/4 inch (19 mm). The fringed hind wings are devoid of markings. 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. However, the wing markings may be faint and difficult to detect. When at rest, the wings are held tightly to the body, giving the moth a somewhat cigar-shaped appearance. The larva (Figure 37) has alternate dark and light-colored longitudinal stripes on a light brown body. The larva is about 3/4 inch (19 mm) long at maturity.

Life Cycle: The seasonal appearance of moths and larvae depends on the latitude of the location. Infestations are seen first in Texas in early May and occur in the northern Great Plains in July and August. The northern limit of the sunflower moth is about 40°N latitude, beyond which it does not overwinter due to the severity of the cold. Moths are highly attracted to sunflowers that are beginning to bloom (R5.1). Individual female moths deposit up to 30 eggs per day on the surface of open sunflower heads. Eggs hatch within 48 to 72 hours, and newly emerged larvae feed on pollen and florets. Larvae begin tunneling into seeds upon reaching the third instar growth stage. Tunneling continues throughout the remainder of larval development. Larval development from emergence to full maturity takes about 15 to 19 days. Larvae spin webs over the face of the sunflower head, which accumulates disk florets and frass. This gives a trashy appearance to the head. Mature larvae move to the ground, where they spin cocoons in which they overwinter.

Damage: First-instars feed primarily on pollen. Second-instar larvae feed on pollen, and larvae may burrow through the corolla to feed on pollen inside disk florets. Larvae in the corollas also feed on anthers and styles. Feeding by third-instars may sever the style and prevent the ovary from being fertilized, resulting in empty seeds. Third-instars also begin feeding on ovaries. Larval feeding results in an average of about 96 damaged disk florets and about 23 damaged ovaries per larva. As they feed, larvae spin webbing over the face of the sunflower head. The accumulated debris in the larval webbing and damage due to larval feeding predispose the head to *Rhizopus* infection. *Rhizopus* further reduces yield and results in rancid oil.

Management: In the central Great Plains, later plantings usually have lower infestations than earlier plantings. However, in other locations, planting dates have to be adjusted for conditions such as moth flight and length of the growing season. When necessary, a number of insecticides are registered for control of the sunflower moth in some regions. Scouting is most accurate in the early morning or late evening, when moths are active. Sampling sites should be at least 75 to 100 feet (23 to 31 m) in 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. The economic threshold for sunflower moth is one to two adults per five plants at the onset of bloom (R5.1) or within seven days of the adult moth's first appearance. Sex pheromone lures are available commercially for monitoring with traps to indicate their arrival and to determine local populations. Insecticide applications should be considered when pheromone trap catches average four moths per trap per day from the R3 through R5 growth stages. Although the sunflower moth has numerous natural enemies, many attack only larvae in native sunflowers or related Asteraceae. Many of the natural enemies are generalists, and their preferred hosts are not associated with sunflowers. The dispersal of the moths over wide distances by wind may play a role in reducing the effectiveness of its parasitoids.

Figure 34. Sunflower bud moth adult - *Suleima helianthana* (Riley) *(J. Gavloski, MAFRI)*

Figure 35. Sunflower bud moth larva - *Suleima helianthana* (Riley) *(Extension Entomology)*

Figure 36. Sunflower moth adult - *Homoeosoma electellum* (Hulst) *(L. Charlet, USDA-ARS)*

Figure 37. Sunflower moth larva - *Homoeosoma electellum* (Hulst) *(Extension Entomology)*

Sunflower Midge (Diptera: Cecidomyiidae)

Species: *Contarinia schulzi* Gagné

Description: Several species of midges are reported from sunflowers, but only the sunflower midge has become an economic pest. Although the sunflower midge is distributed throughout the Great Plains of North America from Manitoba to Texas, its economic impact has been restricted to sunflowers in eastern North Dakota, western Minnesota and Manitoba. The tan body of the adult sunflower midge (Figure 38) is more than 1/16 inch (1.7 mm) long, with a wingspan of about 5/32 inch (4 mm). The wings are transparent with no markings except the veins. Adults are not seen often, but when infestations are high, dead adults may be found on sunflower buds. Eggs are yellow when laid and turn orange when mature. Larvae (Figure 39) attain a length of nearly 3/32 inch (2.4 mm) at maturity and are cream to yellowish orange when mature. They are tapered at the front and rear, with no legs or apparent head capsule.

Life Cycle: The sunflower midge overwinters as a mature larva in a cocoon 2 to 6 inches (5.1 to 15.2 mm) below the soil surface and pupates in June. Adults of the overwintering generation emerge from the soil in early to mid-July, mate and live for about two to three days. Emergence of this generation is 90 percent complete by the last week of July. Females oviposit in sunflower buds, inserting eggs between the bracts or in the center of the head. If emergence occurs before heads are present, eggs may be deposited in the leaf axils of the sunflower plant. Eggs are laid singly or in masses of up to 50. Eggs hatch in three to five days. Larvae develop through three instars in 10 to 14 days. After emergence, larvae move to the bases of bracts and feed, producing necrotic feeding depressions. Second- and third-instars move to the center of the sunflower head. Feeding by these larvae occurs at the bases of developing seeds. Mature larvae drop to the soil and complete development to the adult stage or remain as larvae and overwinter until the following year. Approximately 90 percent of this initial generation of larvae has completed development and moved into the soil by August 4-10. When conditions are suitable, a partial second generation may occur in August. The life cycle of the second generation of sunflower midge takes 31 to 35 days. By late August, 90 percent of the adults of the second generation have emerged from the soil. Eggs are deposited among the seeds. Mature larvae drop to the soil to overwinter, with the majority of mature larvae exiting sunflower heads by mid-September.

Damage: Economic damage may be severe but often is sporadic and localized. Damage usually is restricted to field margins, but in severe infestations, damage is present throughout the field. In some cases, damage has been sufficient to result in fields being abandoned. Growth deformity of sunflower heads that results from sunflower midge infestation is probably due to elevated auxin levels. Newly emerged larvae migrate to the bases of bracts and their feeding produces necrotic feeding depressions between the bracts. These appear as brown scar tissue and are usually the first symptom of a midge infestation. Another early symptom is the loss of ray flowers. Second- and third-instars move to the center of the head and feed at the base of developing seeds, where they may cause seed abortion. If sufficient numbers of larvae are present, head growth is altered. Heavily damaged heads are gnarled and cupped inward, often with a hole or depression in the center, and produce few or no seeds. The extent of damage from second-generation larvae is unknown.

Management: Since plants are susceptible throughout the bud stage, and several emergence events of adult midges occur, correct timing of insecticide for adult midge control is difficult. Testing of both foliar and systemic insecticides has not given adequate control of adults or larvae. 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 in 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 or resistant hybrid.

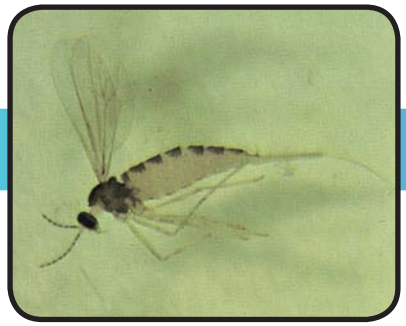

Figure 38. Sunflower midge adult - *Contarinia schulzi* Gagné *(Extension Entomology)*

Figure 39. Sunflower midge larva - *Contarinia schulzi* Gagné *(P. Beauzay, NDSU)*

Sunflower Receptacle Maggot (Diptera: Tephritidae)

Species: *Gymnocarena diffusa* (Snow)

Description: This species is the largest of the three tephritid flies that attack sunflowers, with a body length of about 13/32 inch (10 mm) and a wing span of approximately 3/4 inch (19 mm). The eyes of this species are bright green and the wings have a yellowish-brown and somewhat mottled appearance (Figure 40). Larvae (Figure 41) attain a length of nearly 5/16 inch (8 mm) at maturity. The larvae taper from the front to rear and are yellowish white.

Life cycle: Adults emerge in late June to early July after sunflower buds reach 2 to 4 inches (5 to 10 cm) in diameter. Adults feed on secretions from extrafloral nectaries of native *Helianthus* species before moving to cultivated sunflowers. Females lay eggs from mid-July through August, and eggs are laid between the second and fourth layers of bracts of developing sunflower heads. Larvae tunnel into the spongy tissue of the receptacle. They also may tunnel beneath the receptacle and down some distance into the petiole. Larval development takes about 30 days, after which they form a hole in the back of the sunflower head and drop to the soil to pupate. Overwintering pupae are found about 7½ inches (19 cm) deep in the soil by August or early September. Some larvae will pupate in the sunflower head. One generation per year occurs in North Dakota.

Damage: Larvae feed on the spongy receptacle tissue of the sunflower head and feeding may cause partially deformed heads. Damage to the head is negligible and larvae do not feed on developing seeds.

Management: A field sampling protocol and an ET have not been developed for this insect because it is not of economic significance. Insecticide use has not been warranted for control of this fly.

Sunflower Seed Maggot (Diptera: Tephritidae)

Species: *Neotephritis finalis* (Loew)

Description: This fly is the smallest of the three tephritid species that attack sunflowers, with the adult (Figure 42) having a body length of about 1/4 inch (6 mm) and a wing span of approximately 9/32 inch (7 mm). The wings have a brown lacelike appearance. The larvae (Figure 43) attain a length of 3/16 inch (4.5 mm) at maturity.

Life cycle: Adults emerge during the first week of July and egg laying occurs on the corolla of incompletely opened sunflower inflorescences. The larval stage lasts about 14 days. Larvae feed within undeveloped ovaries of the flowers, often completely consuming the floret before the seed is fertilized. The first generation pupates in the head and the second generation overwinters as pupae in the soil. The small, brown pupae sometimes can be found on the face of sunflower heads, usually surrounded by a small number of damaged florets. Unlike the other two species of sunflower maggots, two complete generations per year of the sunflower seed maggot occur in North Dakota.

Damage: Seed sterility occurs when newly emerged 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. The magnitude of damage to sunflower seeds by sunflower seed maggot larvae depends largely on the stage of larval and seed development.

Management: A field monitoring scheme for this insect has not been developed and an ET has not been established. Insecticide use has not been warranted for control of this fly, although recent injury to sunflowers has been noted in a number of locations in North Dakota. Research is being conducted to determine EIL and the potential for planting date and insecticide use to reduce damage.

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

Figure 41. Sunflower receptacle maggot larva - *Gymnocarena diffusa* (Snow)
(Extension Entomology)

Figure 42. Sunflower seed maggot adult - *Neotephritis finalis* (Loew)
(J. Knodel, NDSU)

Figure 43. Sunflower seed maggot larva - *Neotephritis finalis* (Loew)
(J. Knodel, NDSU)

Integrated Pest Management of Sunflower Insect Pests in the Northern Great Plains

Producers should examine their operations and minimize pest damage by adopting IPM practices based on the use of economic thresholds (when available) and by carefully combining monitoring and various pest management strategies. Significant progress in sunflower pest management has been made and undoubtedly will continue to be made in the future to aid successful sunflower production.

For more information on this and other topics, see: www.ag.ndsu.edu

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