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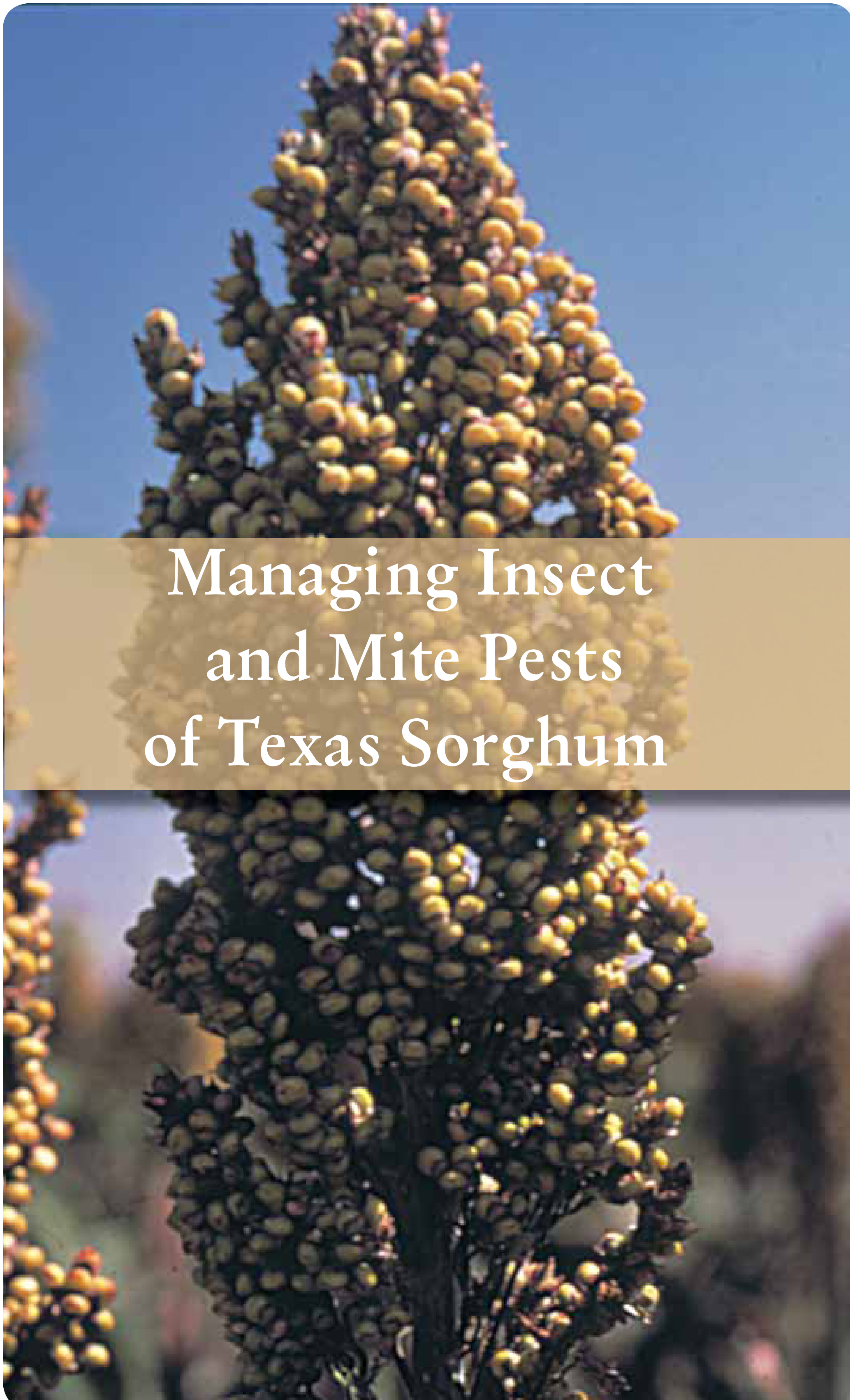
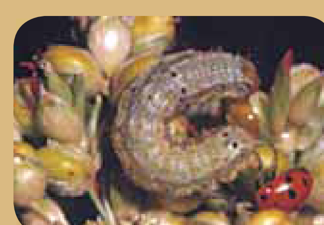
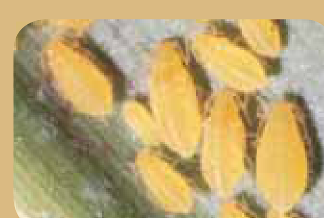


Managing Insect and Mite Pests of Texas Sorghum





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Managing Insect and Mite Pests of Texas Sorghum

Greg Cronholm, Allen Knutson, Roy Parker and Bonnie Pendleton*

An integrated approach to managing insect and mite pests can help Texas sorghum growers and crop protection specialists:

- prevent damaging insect pest infestations;
- diagnose the presence and severity of an insect pest infestation; and
- control an infestation with insecticides when preventive methods are not fully effective and sampling justifies the need for insecticide.

Sorghum has an advantage over other grain crops because it can withstand relatively harsh, hot, dry climates, but responds well to favorable production conditions and irrigation. The crop adds important agricultural diversity in a production region. Beneficial insects associated with sorghum often help reduce the severity of insect and mites in sorghum and in other crops such as cotton. Sorghum is an important rotation crop with cotton and soybeans, and rotation helps manage some weeds, diseases and insect pests.

Some insect and mite pests can reach damaging levels throughout the growing season. Others can cause damage only at a specific plant growth stage. Figure 1 illustrates the probability of various insect and mite pests occurring at each plant development stage.

Most insect pests of sorghum are occasional pests, meaning they cause economic damage in localized areas or only during certain years. Usually only one or two key insect pests are in any sorghum-growing area in Texas. These insects occur most years and dominate control practices. Examples of key insect pests of sorghum are greenbug and sorghum midge.

Some pests, such as Banks grass mite, are induced. These are present in sorghum fields or surrounding areas, but usually in nondamaging numbers. They increase to economically important levels after changes in cultural practices or crop varieties, or when insecticides are used for other insect pests.

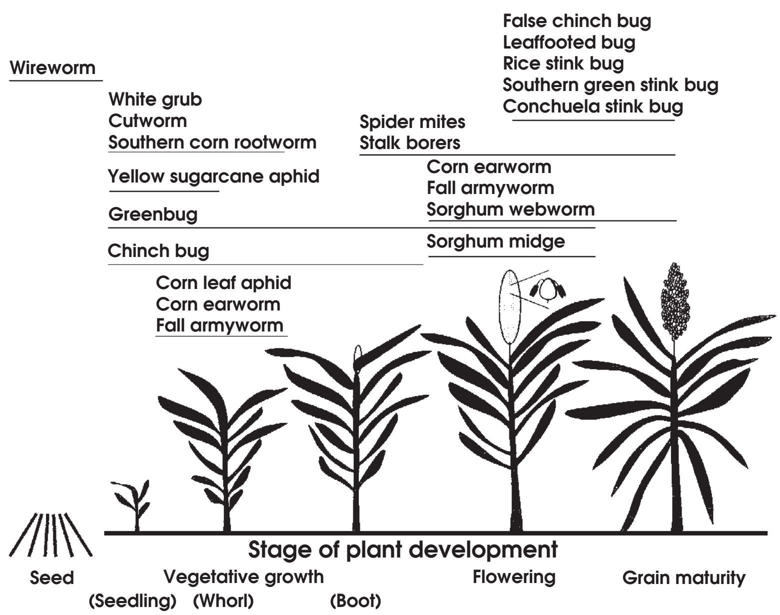

Figure 1. Sorghum insect pest occurrence.

Methods of preventing insect pest infestations

Managing insect and mite pests of sorghum involves actions that prevent pests from increasing to high enough numbers to cause economic damage. These practices help avoid pests, reduce their abundance, slow their rate of increase, lengthen the time it takes them to reach damaging levels, and/or increase the plant's tolerance to the insect pest.

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Cultural management methods

Cultural management methods involve using crop production practices to reduce pest abundance or damage.

Crop rotation involves successive use of host and non-host crops. Sorghum benefits most when rotated with a broad-leaf or tap-rooted crop such as cotton or soybeans. Growing sorghum in a field planted to a different crop the previous year significantly reduces the potential for problems from some insect pests, diseases and weeds.

Crop rotation is especially effective against insect pests with a limited host range, long life cycle (one or fewer generations a year) and limited ability to move from one field to another. For example, wireworms, white grubs and some cutworms have only one generation a year, must have a grass-type crop to develop and reproduce, and cannot move during the damaging larval stage from one field to another. Thus, growing a crop such as cotton or soybeans in the field before growing sorghum helps reduce the abundance of these soil-inhabiting pests. Sorghum growers should rotate crops regularly.

Destroying the previous crop, volunteer and alternate host plants eliminates breeding and/or overwintering habitats to reduce insect pest abundance and damage. This involves mechanically or chemically destroying sorghum plants soon after harvest to kill or expose insect pests and remove their food supply. This method also includes destroying volunteer crop and alternate host plants within and outside a field.

Where conservation tillage practices are used, herbicides can be applied post-harvest to kill crop, volunteer and alternate host plants. Herbicides stop crop growth effectively and are compatible with cultural management practices to reduce insect pest abundance. However, where conservation tillage is practiced certain pests, especially stalk borers, may be more abundant.

Destroying previous crop, volunteer and alternate host plants reduces insect pest abundance the following year. This practice is particularly important in reducing the abundance of southern corn rootworm, cutworms, sorghum webworm, sorghum midge and stalk-boring insects. Johnsongrass is a non-cultivated host of many sorghum insect pests, including greenbug, yellow sugarcane aphid and sorghum midge. Destroying this weed is very helpful in managing insect pests.

Seed selection, seedbed preparation and seed treatment are important in reducing the effects of sorghum insect pests. When deciding on a sorghum hybrid to plant, consider how well the hybrid is adapted to the locale and its susceptibility to insect pests and diseases.

Use sorghum hybrids that tolerate greenbugs. Sorghum hybrids with loose (open) rather than tight (compact) grain heads are less infested with larvae of corn earworm, fall armyworm and sorghum webworm, all of which feed on developing kernels. Also, sorghum with open grain heads is less likely to show the effects of grain deterioration from weather, grain head-infesting bugs and pathogens. Early, uniform hybrids avoid infestation by several insect pests, including sorghum midge, corn earworm and fall armyworm, in addition to avoiding late-season weather problems.

Sorghum hybrids resistant to pathogens and with good standability also reduce the detrimental effects of insect pests. Insect pests add to the stress on sorghum plants during the growing season, and, combined with pathogen infection, increase plant lodging. Some insect pests, such as greenbug and corn leaf aphid, transmit maize dwarf mosaic virus and other sorghum diseases. This problem is best dealt with by using disease-resistant sorghum.

Good seedbed preparation promotes rapid seed germination and seedling growth, which are essential to avoiding damage by wireworms, red imported fire ant and yellow sugarcane aphid. Rapidly growing seedlings are more tolerant of damage.

Fungicide- and insecticide-treated seed protects against some diseases and seed-feeding insects. Seed pre-treated with the systemic insecticides imidacloprid (Gaucho®), thiamethoxam (Cruiser®), or clothianidin (Poncho®) is protected against seed-feeding insects and those such as aphids and chinch bug that attack sorghum during the seedling stage. However, this systemic insecticide also suppresses corn leaf aphids that attract beneficial arthropods needed for natural control of greenbug and other insect pests.

Planting time should be as early as practical, but not when temperatures are too cool for rapid seed germination and seedling growth. In dryland areas of the state, early planting usually takes advantage of seasonal rainfall patterns.

Early planting avoids infestation and damage by some sorghum insect pests because plants grow beyond a vulnerable stage before these insect pests are present. Also, young plants can reach a more tolerant stage before insect pests are present, be susceptible for a shorter period of time or mature before an insect pest becomes abundant enough to cause serious damage. Early-planted sorghum generally avoids damaging numbers of sorghum midge, corn earworm, fall armyworm, sorghum webworm, stalk borers and grain head-infesting bugs.

Fertilizer and irrigation applied to sorghum can both help and harm efforts against insect pests. Using too much fertilizer and irrigation can cause sorghum plants to be succulent and attractive to sorghum insect pests and extend the time to maturity. On the other hand, healthy, vigorously growing plants better tolerate insect pest infestation and other plant stresses. In areas with alkaline soils where iron-deficiency is a problem, applying iron is important for production of healthy sorghum.

Chinch bugs and spider mites favor hot, dry conditions and stressed plants. Dense stands of vigorously growing sorghum are less susceptible to chinch bugs. Rainfall tends to reduce greenbug and spider mite numbers. For most leaf-feeding insect pests, the potential to reduce yield depends partially on plant condition.

Biological management methods

Biological management methods reduce insect pest abundance by using natural enemies — predators, parasites and pathogens that kill insect pests. Natural enemies can be used in three ways:

- ✦ Conservation, or enhancing numbers of already existing natural enemies. Conserving natural enemies is the most applicable biological management method to suppress the abundance of sorghum insect pests.
- ✦ Augmentation, the mass culturing and periodic release of a natural enemy.
- ✦ Importation, the introduction of non-native natural enemies.

Conservation of natural enemies involves protecting existing natural enemies so they are abundant enough to suppress the insect pests they attack. Sorghum hosts an abundance of natural enemies, primarily because of aphid infestations. The corn leaf aphid, usually non-injurious to sorghum, often becomes very abundant. Corn leaf aphids attract many different natural enemies that attack aphid and caterpillar pests.

Natural enemies allowed to increase can hold some insect and mite pests below damaging levels. Insecticides often destroy natural enemies, because most insecticides used in sorghum are broad spectrum, killing insect pests as well as natural enemies. The fact that insecticides kill natural enemies is a primary reason for making sure insecticides are needed before applying them. Once natural enemies have been destroyed, there is no natural (biological) protection against insect pests. This can cause a resurgence of the treated pest or an increase of a secondary pest such as corn earworm or spider mites.

Sorghum pests most affected by natural enemies are greenbug, corn earworm, fall armyworm, sorghum webworm and spider mites. Important natural enemies include spiders, ladybird beetles, lacewing larvae, syrphid fly larvae, minute pirate bug, insidious flower bug, damsel bug, big-eyed bug and parasitic wasps. Predators affect abundance and rate of increase of greenbugs, often preventing them from causing damage. This is particularly true when greenbug-resistant hybrids are used. Parasites often terminate a greenbug infestation. Predators are important in suppressing the abundance of corn earworms and fall armyworms that infest sorghum grain heads. Although several parasites attack sorghum midge, their effect is minimal. Several pathogens, mostly fungi, infect some aphids, chinch bug and caterpillars.

Augmentation is the purchase and periodic release of natural enemies not normally occurring in sufficient numbers to control pests. Commercially available natural enemies sold for pest control in sorghum include convergent lady beetles, lacewing flies and the greenbug parasite *Lysiphlebus testaceipes.*

Naturally occurring convergent lady beetles help control greenbug infestations in sorghum. Convergent lady beetles also can be purchased. These are collected from natural hibernating sites and stored in refrigerators. When released in the field, they quickly fly away or feed at low and ineffective rates without reproducing.

The effectiveness of augmenting other natural enemies for control of sorghum pests is unknown. Because definitive information on augmentation (when to apply, how many to apply, etc.) is lacking, entomologists with Texas Cooperative Extension cannot provide guidelines for augmentation as a management tool in sorghum.

Importation is the identification, collection and release of natural enemies in areas where they do not occur naturally. This method has been effective where an exotic pest has entered Texas without the natural enemies that help control the pest in its native country. Certain species of parasitic wasps and lady beetles that feed on the greenbug have been imported and released in Texas.

Diagnosing insect pest infestations

Sampling

Sampling insects and mites in sorghum is critical to determining the severity of an infestation and the need for insecticide application. Insect pest numbers in sorghum fields can change rapidly. Inspect sorghum at least once a week, especially during critical times when insect pests are likely to be present, to determine the pests present, their abundance and damage. Growers may need to inspect flowering sorghum daily when assessing the abundance of sorghum midge. Record the information collected during each field inspection for future reference to determine changes in insect abundance and plant damage.

The number of samples needed depends on the size of the sorghum field, uniformity, plant growth stage and severity of the insect infestation. Seldom are insect pests distributed evenly in a sorghum field. Examine plants from all parts of a field. Avoid examining only field borders.

Growers can estimate the abundance of most insects in sorghum by visually inspecting the plants and plant parts. Some insects, especially those infesting sorghum grain heads, are effectively sampled by using the "beat-bucket" method. Insect pests that live in the soil are hard to detect and most need to be sampled before the crop is planted.

Soil-dwelling insects, such as white grubs and cutworms, can be found by searching through the soil. Wireworms are difficult to detect in soil. A grain-baited trap can be used to attract them. (See wireworm section on page 9 for details.)

For visual examination, randomly select and carefully inspect plants to detect insects and associated damage. During inspection, consider other factors such as predators, parasitized aphids, plant growth stage and condition. Visual examination is used most often to sample aphids, chinch bug, spider mites and sorghum midge.

The beat-bucket technique is the best way to estimate the number of corn earworm, fall armyworm, sorghum webworm and bugs in sorghum grain heads. Shake sorghum grain heads vigorously into a 2.5- to 5-gallon plastic bucket. Then count the caterpillars and bugs in the bucket. Because adult bugs can fly, take care to count those flying from the bucket or sampled plant.

Economic injury level

The economic injury level is the abundance of an insect pest or amount of plant damage that justifies applying insecticide. Although economic injury levels provided in this publication are based on research, consider them only guidelines, because environmental and crop conditions vary from year to year and region to region.

In some cases, an insecticide is applied when pest abundance is less than the economic injury level to prevent the pest from causing economic loss and to allow time to apply the treatment. This lower threshold is called the economic threshold or action level.

Economic injury levels for most insect pests are provided in tables that consider differences in insecticide and application costs and in the value (per 100 pounds) of the sorghum. To determine if the abundance of insect pests justifies applying insecticide, first estimate the expected market value per 100 pounds at harvest. Then determine the per-acre cost of control including the insecticide and application. Read down the first column for the cost of control and across the table columns for the market value of the crop. The abundance of the insect pest at that point in the table warrants the cost of control.

Chemical management methods

Insecticides are chemicals that kill insects and other arthropods. They are powerful tools and have several advantages. The major advantage is they are often the only practical control for insect pests at or near damaging levels. The key disadvantages of insecticides are cost and broad toxicity. They can harm nontarget organisms in the crop and nearby areas. From a sorghum insect management standpoint, cost of insecticide and killing natural enemies should be considered when making control decisions.

Use an insecticide in the proper amount and only when necessary to prevent economic loss. The cost of achieving full crop potential can exceed potential benefits. Apply insecticides only when insect pests are becoming more abundant and economic crop loss is expected. When deciding whether to apply an insecticide, consider the cost of insecticide applications, prevailing market conditions, expected yield, insect pest abundance, insect age and duration of attack, and stage and condition of the plants attacked.

Indiscriminate insecticide use can lead to pest resistance, resurgence of the treated pest and outbreaks of secondary pests. Selective insecticide use by application method, choice of product or dosage can greatly reduce the occurrence of these problems. Treating insect pests in sorghum can affect the abundance of beneficial and pest insects in adjacent crops.

Seed insecticide treatments

Seed treated with Gaucho® or Cruiser® can be purchased to control wireworms, fire ant, greenbug, yellow sugarcane aphid and chinch bug. Use of treated seed is discussed in the sections on these pests. Contact your seed dealer to buy treated seed.

Planting seed sometimes is treated with insecticides such as malathion, chlorpyrifos or pirimiphos-methyl to control stored-grain pests. These treatments do not control seed-feeding insect pests once seed is planted.

Soil insecticide treatments

Insecticides for controlling some soil-inhabiting insect pests must be applied before the crop is planted or at planting time. Granular or liquid formulations may be used. The formulation selected depends on available equipment and the target insect. Several application techniques are used to treat soil: preplant row treatment, row band at planting and in-furrow at planting.

Preplant row treatment requires special equipment to incorporate insecticide to a depth of 2 to 4 inches. Row treatments must be made after or during bed formation because further cultivation or bed shaping changes the position of insecticide in the row. For best control, treat a band of soil 7 to 10 inches wide and 2 to 4 inches deep, and place seed in the center of the band.

Row band and in-furrow applications may be used to apply insecticide to soil at planting. The technique chosen depends on the pest insect and how a particular insecticide is labeled. Mount the granular applicator spout or spray nozzle just behind the opening plow or disc opener and in front of the covering shovels or press wheel. Adjust spouts or nozzles to make the treatment band 6 to 8 inches wide, treating the seed furrow as well as the covering soil. Incorporating insecticide with the covering shovels is adequate. An insecticide also can be incorporated with short parallel chains, loop chains, press wheels, finger tines or other suitable devices. Do not apply insecticides directly on seed unless the label clearly describes that use, because doing so usually results in poor seed germination. In-furrow insecticide application for other insect pests does not adequately control white grubs when they are abundant.

Some insecticides (e.g., aldicarb, carbofuran, phorate, terbufos) are systemic and can be applied at planting. Applied to soil, these chemicals are absorbed into the young growing sorghum plant and control or suppress such early-season insect pests as greenbug, corn leaf aphid, yellow sugarcane aphid and chinch bug.

Certain insecticides, besides being systemic, are effective against some soil-inhabiting insect pests, such as wireworms and corn rootworms. The duration of systemic activity varies with insecticide and rate, but insect pests are usually suppressed for 2 to 6 weeks after application.

Foliar and grain head insecticide treatments

Aircraft or ground machines may be used to apply insecticides to sorghum foliage and grain heads. Aerial applications work best when insecticide swaths meet or overlap. Insecticide sprays are more effective and hazards minimized when wind velocity is less than 10 miles per hour.

Nozzle size and number, ground speed and pressure influence the rate of insecticide spray output per acre by a ground machine. Calibrate the sprayer carefully to ensure the recommended amount of insecticide is applied. One nozzle per row usually is adequate for young sorghum planted in rows. Two to three nozzles may be needed to adequately cover larger plants and broadcast-planted sorghum. Optimal pump pressure depends on the kind of nozzle used.

Some insecticides discolor foliage of certain sorghum hybrids. Yield losses may occur from extensive leaf damage after these chemicals are used on susceptible hybrids. Review the label carefully before using an insecticide. If you do not know whether the sorghum is susceptible to insecticide, consult the insecticide manufacturer and/or seed company. Carefully follow instructions on the label of an insecticide container to avoid hazards to the applicator, wildlife and the environment.

Endangered Species Act

The Endangered Species Act is designed to protect and to assist in the recovery of animals and plants that are in danger of becoming extinct. In response to the Endangered Species Act, many pesticide lebels now carry restrictions limiting the use of products or application methods in designated biologically sensitive areas. These restrictions are subject to change. Refer to the environmental Hazards or Endangered Species discussion sections on product labels and/or call your county Extension agent or Fish and Wildlife Service personnel to determine what restrictions apply to your area. Regardless of the law, pesticide users can be good neighbors by being aware of how their actions may affect people and the natural environment.

Bees and other pollinators

Protect bees and other pollinators from insecticides. Pollination by bees is important in producing such crops as alfalfa, clover, vetch and cucurbits. Sorghum is an important source of pollen for honey bees in many parts of Texas. However, sorghum is wind- or self-pollinated and does not require insect pollinators.

Take care to minimize bee losses by:

- ✦ Applying insecticides, if practical, before bees move into fields or adjacent crops. When bees are present in the field or vicinity, make applications during the evening after bees have left the field.
- ✦ Using materials least toxic to bees and notifying beekeepers so they can protect bees.

✦ Preventing insecticide spray from drifting directly onto bee colonies.

Inbred lines for hybrid seed production

Inbred lines used for sorghum hybrid seed production are often more susceptible than hybrids to insect pest damage and insecticide phytotoxicity. The increased susceptibility to insecticides and higher crop value of sorghum for hybrid seed production generally require lower economic injury levels for insect pests. Also, insect pests that influence seed quality and germination are more important in hybrid seed production.

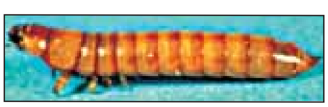
Monitor hybrid seed production fields regularly and consider the increased susceptibility to insect pests and insecticide phytotoxicity. Before applying an insecticide, check the insecticide label carefully and consult the manufacturer and seed company about possible phytotoxic effects.

Seed and root insect pests

Wireworms

Elateridae (wireworm) and
Tenebrionidae (false wireworm)

Wireworm



False wireworm

True and false wireworms are immature stages of click and darkling beetles, respectively. Wireworms generally are shiny, slender, cylindrical and hard-bodied. Their color ranges from yellow to brown.

Wireworms feed on planted sorghum seed, preventing germination. To a lesser degree, they feed on seedling plant roots, reducing plant stands and vigor.

Cultural practices that reduce abundance of and damage by wireworms include:

✦ Preparing good seedbeds and planting when soil moisture and temperature are adequate to promote rapid seed germination;

✦ Cultivating to reduce noncrop plant material; and

✦ Planting sorghum in a field where a taprooted crop such as cotton was grown the previous year.

Sample fields before planting to determine the need to use insecticide-treated seed or to apply insecticide at planting. Soil examination and bait traps can be used to sample for the presence of wireworms.

To build a bait trap, place 6 to 12 ounces of nontreated sorghum seed in a 4-inch-wide by 6- to 8-inch-deep hole. Cover the hole with soil, and mark the trap with a stake. Covering the trap location with a 4- by 4-foot sheet of black plastic warms the soil and makes trapping more effective. At least 2 weeks before planting, install one trap for each 10 to 20 acres. Two weeks later, examine the grain in the trap and count the wireworms. Also, growers may thoroughly examine soil samples 1 foot square by 4 inches deep. *If you find one wireworm larva per square foot or two or more larvae per bait trap, treat either seed or soil with insecticide.*

Information on seed treatment procedures is in the section on seed treatment. Seed treated with Gaucho® or Cruiser® also is labeled for wireworms.

Table 1. Suggested insecticides for control of wireworms.

Insecticide	Application rate	Days from last application to: Harvest	Graze
Seed treatments			
Imidacloprid (Gaucho® 480)	8 fl oz/100 lbs seed commercially applied	See remarks	
Thiamethoxam (Cruiser® 5FS)	5.1 fl oz/100 lbs seed commercially applied	—	—
At planting			
Terbufos (Counter® 15G)	7 oz/1,000 ft of row	See remarks 50	50

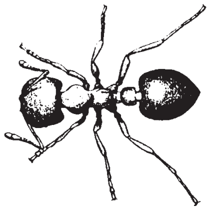
Remarks

Imidacloprid. Do not graze or feed livestock on treated areas for 45 days after planting.

Terbufos. Do not place granules in direct contact with seed because seed may be injured.

Red imported fire ant

Solenopsis invicta



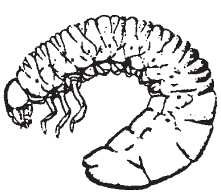
Red imported fire ant

Under certain conditions in the eastern and southern parts of the state, red imported fire ants feed on planted seed. Worker ants chew through the thin seed coat and remove the embryo (germ). They rarely consume the endosperm (starch) of the seed. They prefer water-soaked or germinating seeds, but also damage dry seeds.

Cultural management practices that reduce damage by wireworms to planted sorghum seed also reduce damage by red imported fire ant. Use seed with good vigor and plant into a well-prepared seedbed when soil temperature and moisture are adequate for rapid seed germination. Firmly pack covering soil to prevent easy access of fire ants to planted seed and thus reduce damage by fire ants. Insecticide-treated seed as described for wireworms is effective against red imported fire ants. Planting seed treated with Gaucho® or Cruiser® or in-furrow, at-planting application of insecticide may provide effective control.

White grubs

Phyllophaga crinita and others



White grub

White grubs are the larvae of May or June beetles. White grubs are characteristically "C-shaped" with white bodies and tan to brown heads and legs. Because the last abdominal segment is transparent, dark-colored digested material can be seen in the larva. Larvae vary in size according to age and species.

Rarely are white grubs serious pests of sorghum. However, because they can be present in a field at planting and cannot be controlled once sorghum is planted, their presence must be determined before planting. Grubs damage sorghum by feeding on the roots. They may kill small seedlings, resulting in stand loss. Severely pruned roots of larger plants result in plant stunting and lodging and increased susceptibility to drought and stalk rot organisms.

Table 2. Suggested insecticides for suppressing white grubs.

Insecticide	Application rate	Days from last application to: Harvest	Graze
Commercially treated seed			
Clothianidin (Poncho® 600)	5.1-6.4 fl oz/100 lbs seed	—	—
At planting			
Terbufos (Counter® 15G)	7 oz/1,000 ft of row	See remarks 100	50
Remarks			

Terbuos. Do not place granules in direct contact with seed because seed may be injured.

Planting sorghum in a field where a nongrass crop was grown the previous year is the most important cultural management tactic against white grubs.

To determine the abundance of white grubs before planting, examine 1 square foot of soil in each 5 to 10 acres. *If more than two white grubs are found per square foot, severe damage to sorghum could result.* No insecticides for white grubs are currently labeled for broadcast, incorporated application. *If white grubs average one per square foot, growers can adequately suppress them with a band application of terbufos.*

Southern corn rootworm

Diabrotica undecimpunctata howardi

Southern corn rootworm is the larval stage of the spotted cucumber beetle. Rootworms are small, brown-headed and creamy white, with wrinkled skin. They burrow into germinating seeds, roots and crowns of sorghum plants.

Symptoms of rootworm damage include reduced stands, lower plant vigor, and the occurrence of "dead heart" in young plants. Later in the season, maturity may be delayed, weeds may increase in abundance because of a nonuniform plant stand, and plants may lodge. Damage by southern corn rootworms is most likely to occur in the area of Texas shaded on the map (Figure 2).

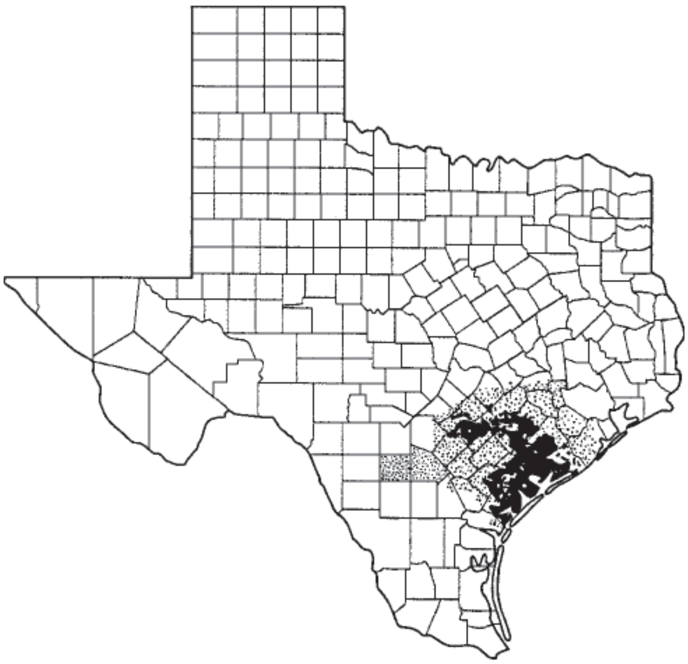


Figure 2. Areas of potentially economically damaging southern corn rootworm infestations in Texas.

Table 3. Suggested insecticides for controlling southern corn rootworm.

Insecticide	Application rate	Days from last application to: Harvest	Graze
Commercially treated seed			
Clothianidin (Poncho® 600)	5.1-6.4 fl oz/100 lbs seed	—	—
At planting			
Carbofuran (Furadan® 4F)	24-32 oz/13,000 linear ft	See remarks 75	75
Chlorpyrifos (Lorsban® 15G)	8 oz/1,000 ft of row	See remarks	
Terbufos (Counter® 15G)	4-7 oz/1,000 ft of row	See remarks 100	50

Remarks

Carbofuran. Apply in seed furrow or 7-inch band and incorporate.

Chlorpyrifos. Apply once per season in a 6- to 7-inch band, behind the planter shoe and in front of the press wheel.

Terbufos. Apply once per season in a 5- to 7-inch band directly behind the planter shoe in front of the press wheel, and not in direct contact with seed.

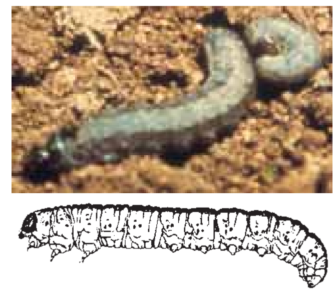
NOTE: Lower rates of insecticides listed have been shown to provide most favorable economic returns; however, where severe infestations consistently occur, use the higher insecticide rate.

Granular or liquid formulations of several insecticides are labeled for in-furrow or row band application for controlling rootworm. Base the need for insecticide treatment on a field history of previous damage by rootworms. Rotating insecticides decreases the possibility of rootworms developing resistance. Seed treatment with Gaucho® or Cruiser® helps control rootworms.

Stem and leaf insect pests

Cutworms

Agrotis and *Euxoa* spp.



Cutworm

Cutworms of several species can damage sorghum. Cutworms are immature stages of moths that are active at night. Cutworm moths prefer to lay eggs in grassy and weedy fields. Eggs are laid on stems or leaves of sorghum or grassy weeds or in the soil, and hatch in 2 to 14 days.

The typical cutworm larva attacking sorghum is plump and curls into a "C" shape when disturbed. Larvae vary in color from grayish white to grayish black or brown depending on species. Fully grown larvae are 1 to 2 inches long. Some species pass the winter in the soil as pupae and others as adults; most overwinter as small larvae in cells in the soil, under trash, or in clumps of grass. They start feeding in spring and continue growing until early summer, when they pupate in the soil. Larvae of most species remain underground during the day and feed at night.

The most common cutworms in sorghum (surface-feeding cutworms) cut plants off at, slightly below or above the surface of the soil. Some (climbing or army cutworms) feed on above-ground plant parts; others are subterranean and feed on underground plant parts including roots of seedlings.

Cultural controls for cutworms include plowing under or using herbicides to control vegetation in late summer or early fall, destroying weeds, and thoroughly preparing the seedbed at least 4 to 6 weeks before planting. Cutworms are more severe in weedy fields.

The presence of cutworms in sorghum is determined by visible damage to plants. For surface-feeding and subterranean cutworms, determine the number of severed or dead and dying plants per foot of row. Base your decision to apply insecticide on the degree to which an adequate stand is threatened. For cutworms that feed on above-ground plant parts, significant losses occur when more than 30 percent of the leaf tissue has been eaten.

Insecticide sprayed as a broadcast treatment on the ground and plants usually protects against cutworms. However, cutworms spend the day hidden in the soil. Late-afternoon applications sometimes are more effective. Insecticidal baits are effective against some cutworms, but are expensive. Insecticide applied at planting controls subterranean cutworms. Apply the insecticide in a 6- to 7-inch band and incorporate it into the top 1 to 2 inches of soil.

Aerial or ground application of approved insecticide is effective in controlling cutworms in an established sorghum stand. However, insecticide is more effective on climbing than on subterranean cutworms. See Table 4 for insecticides suggested for cutworm control. Certain insecticides that control southern corn rootworms also help control cutworms.

Table 4. Suggested insecticides for controlling cutworms.

Insecticide	Application rate	Days from last application to: Harvest	Graze
Chlorpyrifos		See remarks	
(Lorsban® 4E)	16-32 oz/acre	30-60	30-60
(Lorsban® 15G)	8 oz/1,000 ft of row	—	—
(NuFos® 4E)	16-32 oz/acre	—	—
(NuFos® 15G)	8 oz/1,000 ft of row	—	—
Cyfluthrin		See remarks	
(Baythroid® 2E)	1.0-1.3 oz/acre		14
Cyhalothrin		See remarks	
(Karate® 1E)	1.92-2.56 oz/acre		
(Warrior® 1E)	1.92-2.56 oz/acre		
Zeta-cypermethrin			
(Mustang Max®)	1.28-4.0 oz/acre	14	45

Remark

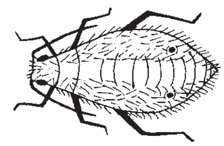
Chlorpyrifos. *4E* - To minimize insecticidal injury, do not apply to drought-stressed plants or within 3 days after irrigation or rain except where insecticide is applied in irrigation water. The waiting period from last application to harvest or grazing is 30 days for the 16-oz rate and 60 days for the 32-oz rate.

Cyfluthrin. If applied once or twice, green forage may be fed or grazed on the day of treatment. For three applications, allow at least 14 days between last application and grazing.

Cyhalothrin. Do not graze livestock in treated area or harvest for fodder, silage or hay.

Yellow sugarcane aphid

Sipha flava



Yellow sugarcane aphid

Yellow sugarcane aphids usually are lemon-yellow, but under some conditions are pale green. They are covered with small spines and have two double rows of dark spots on the back. Both winged and wingless forms live in the colony. This aphid feeds on many different grasses, including johnsongrass and dallisgrass. Females give birth for 28 days to living young, averaging two nymphs a day by each female. Nymphs mature in 13 to 19 days; adults live for 25 to 30 days.

Yellow sugarcane aphids feed on sorghum and inject toxin into leaves of seedlings and older plants. Aphids feeding on seedling plants turn the leaves purple and stunt growth. On more mature plants, leaves turn yellow. By the time discoloration symptoms are visible, plants have been injured significantly. Damage often leads to delayed maturity and plant lodging that may be worsened by associated stalk rots.

The presence of yellow sugarcane aphids must be determined soon after sorghum plants emerge. The presence of purple-colored seedling plants is an indication of a yellow sugarcane aphid infestation. Scout sorghum by inspecting plants beginning the first week of plant emergence and twice weekly until plants have at least five true leaves. As plants grow larger, they become more tolerant of aphid feeding. Very small seedling sorghum plants (one to three true leaves) often are significantly damaged after being infested for a week or less.

Discoloration symptoms may be useful in assessing yield losses, and may be used in a decision to replant. Information in Table 5 describes plant damage and corresponding percentage yield loss associated with levels of damage. Do not consider the first two "seed leaves" when estimating damage.

Economic injury levels presented in Tables 6 to 8 are based on the percentage of yellow sugarcane aphid-infested plants at the 1, 2 or 3 true-leaf stage. Do not count the two seed leaves that appear first.

Many predators feed on yellow sugarcane aphids, but the aphids are rarely parasitized. Insecticides are currently the only way to manage yellow sugarcane aphids in sorghum. Seed treated with Gaucho® or Cruiser® or insecticide applied at planting (carbofuran or phorate) reduces the severity of yellow sugarcane aphid infestations (Table 9).

Table 5. Estimated yield loss based on damage by yellow sugarcane aphids to three true-leaf stage sorghum plants.

Description	% Loss/plant
No discoloration	0
Localized discoloration	8
Less than one entire leaf discolored	11
One entire leaf discolored	31
More than one leaf discolored	54
More than two leaves discolored	77
Dying/dead plant	100

Table 6. Economic injury levels for yellow sugarcane aphid based on percentage of seedling plants infested at the one true-leaf stage.

Control cost ($) per acre	Crop market value ($) per acre 100	150	200	250	300	400	500	600
	Percent infested plants							
6	15	10	8	6	5	4	3	3
8	20	13	10	8	7	5	4	4
10	25	17	12	10	9	6	5	5
12	30	21	14	12	10	7	6	5

Table 7. Economic injury levels for yellow sugarcane aphid based on percentage of seedling plants infested at the two true-leaf stage.

Control cost ($) per acre	Crop market value ($) per acre 100	150	200	250	300	400	500	600
	Percent infested plants							
6	26	18	13	11	10	7	6	5
8	35	24	17	14	13	9	7	7
10	43	29	22	17	16	11	9	8
12	51	35	26	20	18	13	10	9

Table 8. Economic injury levels for yellow sugarcane aphid based on percentage of seedling plants infested at the three true-leaf stage.

Control cost ($) per acre	Crop market value ($) per acre 100	150	200	250	300	400	500	600
	Percent infested plants							
6	67	44	33	27	24	17	14	12
8	89	60	44	36	32	22	18	16
10	*	76	55	44	39	28	22	20
12	*	92	66	53	44	33	27	22

*Do not treat.

Table 9. Suggested insecticides for yellow sugacane aphid.

Insecticide	Application rate	Days from last application to: Harvest	Graze
Commercially treated seed			
Clothianidin (Poncho® 600)	5.1-6.4 fl oz/100 lbs seed	—	—
Imidacloprid (Gaucho® 480)	8 oz/cwt	—	45
Thiamethoxam (Cruiser® 5FS)	5.1 oz/cwt	—	—
Applied post-emergence			
Carbofuran (Furadan® 4F)	8-16 oz/acre	See remarks 75	75
Dimethoate		See remarks	
(4E)	8-16 oz/acre	28	28
(5E)	6.4-12.8 oz/acre	28	28

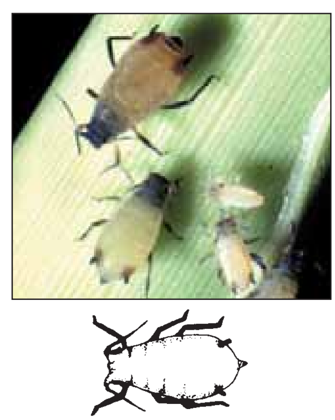
Remarks

Carbofuran. Applicator must use proper protective equipment when applying this highly toxic insecticide. Do not apply to foliage more than twice per season. Do not apply after heads emerge from the boot.

Dimethoate. Do not apply more than three times per season. Do not apply after heads emerge from the boot.

Corn leaf aphid

Rhopalosiphum maidis



Corn leaf aphid

Corn leaf aphids often infest the whorl and undersides of sorghum leaves in great numbers. This dark bluish-green aphid is oval-shaped, with black legs, cornicles and antennae. There are winged and wingless forms.

Corn leaf aphids are found most frequently deep in the whorl of the middle leaf of preboot sorghum, but also occur on the undersides of leaves, on stems or in grain heads.

When feeding, corn leaf aphids suck plant juices but do not inject toxin as do greenbugs and yellow sugarcane aphids. The most apparent feeding damage is yellow mottling of leaves that unfold from the whorl.

This insect rarely causes economic loss to sorghum. In fact, they can be considered helpful. Beneficial insects such as lady beetles are often attracted to feed on corn leaf aphids. When corn leaf aphid numbers rapidly decline at sorghum heading, the beneficial insects are present to suppress greenbug and other insect pests. These beneficial insects also are believed to move to adjacent crops, such as cotton, and help manage insect pests in those crops.

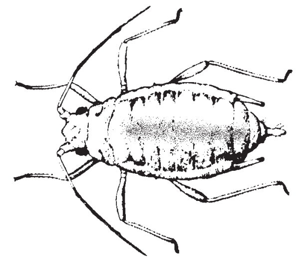
When abundant, corn leaf aphids are easily seen within the whorl of sorghum plants. The whorl leaf can be pulled from the plant and unrolled to detect aphids when numbers of aphids are low. Occasionally, corn leaf aphids will become so abundant on a few plants in a field that grain head exertion and development are hindered. Moisture-stressed sorghum plants are more likely than non-stressed plants to be damaged by corn leaf aphids. Although very rare, infestations on seedling sorghum might cause stand loss, and grain head infestations might cause harvesting problems.

Because corn leaf aphids prefer to live and feed in the whorl of sorghum, aphid numbers normally decline rapidly after the grain head exerts (emerges) from the boot. Sometimes molds grow on the honeydew that corn leaf aphids produce. Honeydew on sorghum grain heads has been associated with harvesting problems. The aphid also transmits maize dwarf mosaic virus.

Although insecticide is rarely justified, corn leaf aphids can be controlled with the insecticides used for greenbugs. Seed treated with Gaucho® or Cruiser® or the application of carbofuran, phorate or terbufos at planting are effective in controlling corn leaf aphids. However, corn leaf aphids do not inject toxin as they feed and very rarely damage sorghum. Because it is rarely a pest, sampling procedures and damage assessment information are unavailable.

Greenbug

Schizaphis graminum



Greenbug

The greenbug is an aphid that sucks plant juices and injects toxin into sorghum plants. The adult greenbug is light green, approximately 1/16 inch long, with a characteristic darker green stripe down the back. Usually, the tips of the cornicles and leg segments farthest from the body are black. Winged and wingless forms may be present in the same colony.

Females produce living young (nymphs) without mating. Under optimum conditions, the life cycle is completed in 7 days. Each female produces about 80 offspring during a 25-day period.

Greenbugs usually feed in colonies on the undersides of leaves and produce much honeydew. The greenbug may be a pest during the seedling stage and in the boot or heading stage. Infestations may be detected by the appearance of reddish leaf spots caused by the toxin greenbugs inject into the plant. The reddened areas enlarge as the number of greenbugs and injury increase. Damaged leaves begin to die, turning yellow then brown. Damage at the seedling stage may result in stand loss.

Larger sorghum plants tolerate more greenbugs. Yield reductions during boot, flowering and grain-development stages depend on greenbug numbers, length of time greenbugs have infested the plants, and general plant health. Many greenbugs on booting and older plants can reduce yields and weaken plants that may later lodge.

Scouting sorghum for greenbugs is easy. Examine a minimum of 40 randomly selected plants per field each week. Greenbugs are seldom distributed evenly in a field, so examine plants from all parts of the field; avoid examining only field borders. In fields larger than 80 acres, or if making a control decision is difficult, examine more than 40 plants.

When deciding whether to control greenbugs, consider the amount of leaf damage, number of greenbugs per plant, percentage of parasitized greenbugs (mummies), numbers of greenbug predators (lady beetles) per plant, moisture conditions, plant size, stage of plant growth and overall condition of the crop. It is important to know from week to week whether greenbug numbers are increasing or decreasing. For example, insecticide treatment would not be justified if the recommended treatment level (based on leaf damage) had been reached but greenbug numbers had declined substantially from previous observations.

In seedling sorghum (less than 6 inches tall), greenbugs may be found on any part of the plant including the whorl or in the soil at the base of the plant. When scouting seedling sorghum, examine the entire plant and the soil around the base of the plant. Note the presence or absence of greenbugs and any damage to plants (yellowing, death of tissue). Refer to Table 10 for economic thresholds for greenbugs on different plant growth stages.

Plants can tolerate about 30 percent leaf loss before yield is reduced. Greenbug infestations after sorghum flowering and before the hard-dough stage should be controlled before they kill more than two normal-sized leaves on 20 percent of the plants. In the Texas Blacklands, insecticide application is suggested when greenbugs are colonizing the upper leaves of booting sorghum and causing red spotting or yellowing of leaves.

These guidelines are based on the assumption that greenbugs are increasing so rapidly that control by beneficial insects is ineffective. However, when more than 20 percent of the greenbugs appear brown and swollen from being parasitized, an insecticide treatment is usually unnecessary. Also, plants showing drought or other stress cannot tolerate as much greenbug damage without suffering reduction in yield.

Greenbug colonies usually begin on the undersides of lower leaves and move up the plant. On most sorghum hybrids, only the undersides of lower leaves need to be examined, although in some cases greenbug colonies may be found first on the undersides of upper leaves. Do not confuse greenbugs with the bluish-green corn leaf aphid, often found with greenbugs in the plant whorl.

Greenbugs in a field can increase 20-fold per week, but the seasonal average is a 5- to 6-fold increase each week. Rain and predators suppress aphid abundance early in the season, although the increase of natural enemies has a lag time of 1 to 2 weeks. A common parasitoid usually is responsible for a rapid decline in aphid abundance late in the season.

Sorghum hybrids resistant to greenbug are available commercially. However, greenbug biotypes have consistently occurred and new resistant hybrids have had to be developed. Hybrids resistant to greenbug biotypes C, E, I and K have been or are being developed. Using greenbug-resistant hybrids is suggested. Resistance mainly is tolerance, and therefore resistant hybrids will not be free of greenbugs. Damage thresholds for resistant sorghums are the same as for susceptible sorghums because thresholds are based on plant damage.

When deciding on insecticide treatment, consider the previously listed factors and consult the recommended treatment levels in Table 10. When estimating leaf damage, consider any leaf to be dead if more than 75 percent of its surface is red, yellow or brown. Do not mistake for greenbug damage the natural senescence of the small bottom leaves. Estimate an average leaf damage level for the entire field unless it is feasible to spot treat areas of the field.

The greenbug usually is susceptible to labeled insecticides (Table 11), but resistance to organophosphorous insecticides exists in several counties in the Texas Panhandle.

Table 10. Economic threshold levels for greenbug on sorghum at different plant growth stages.

Plant size	When to treat
Emergence to about 6 inches	20% of plants visibly damaged (beginning to yellow), with greenbugs on plants
Larger plant to boot	Greenbug colonies causing red spotting or yellowing of leaves and before any entire leaves on 20% of plants are killed
Boot to heading	At death of one functional leaf on 20% of plants
Heading to hard dough	When greenbug numbers are sufficient to cause death of two normal-sized leaves on 20% of plants

Continued extensive use of certain insecticides could expand the resistance problem. Where resistance exists in an area, apply the initial insecticide at the higher labeled dosage rate and increased application volume to ensure complete coverage.

Table11. Suggested insecticides for controlling greenbug.

Insecticide	Application rate	Days from last application to: Harvest	Graze
Commercially treated seed			
Clothianidin (Poncho® 600)	5.1-6.4 fl oz/100 lbs seed	—	—
Imidacloprid (Gaucho® 480)	8 oz/cwt	—	45
Thiamethoxam (Cruiser® 5FS)	5.1 oz/cwt	—	—
Applied at planting			
Aldicarb (Temik® 15G)	7 lb/acre	See remarks 90	
Carbofuran (Furadan® 4F)	24-32 oz/13,000 linear ft	See remarks 75	75
Chlorpyrifos (Lorsban® 15G	8 oz/1,000 ft of row	See remarks	
Phorate (Thimet® 20G)	6 oz/1,000 ft of row	See remarks 30	30
Terbufos (Counter® 15G)	7 oz/1,000 ft of row	See remarks 100	50
Applied post-emergence			
Carbofuran (Furadan® 4F)	24-32 oz/acre	See remarks 75	75
Chlorpyrifos (Lorsban® 4E) (NuFos® 4E)	8-32 oz/acre	See remarks 30-60	30-60
Dimethoate (4E) (5E)	8-16 oz/acre 6.4-12.8 oz/acre	See remarks 28 28	28 28
Malathion (57EC)	24 oz/acre	See remarks 7	—
Phorate (Thimet® 20G)	4.5-6.0 oz/1,000 ft of row	See remarks 30	30

Remarks

Aldicarb. Do not feed green forage to livestock.

Carbofuran. Applicator must use proper protective equipment when applying this highly toxic insecticide. Do not apply to foliage more than twice per season. Do not apply after heads emerge from the boot.

Chlorpyrifos. Do not exceed three applications. The waiting period from last application to harvest or grazing is 30 days for the 16-oz rate and 60 days for higher rates.

Dimethoate. Do not apply more than three times per season. Do not apply after heads emerge from the boot.

Malathion. Do not graze or feed treated foliage.

Phorate. Do not place in contact with seed. Do not feed foliage before grain harvest.

Terbufos. May be knifed in at bedding, or banded (except in West Texas) or knifed in at planting (see label for dosage differences). Do not place granules in direct contact with seed. For early-season control of light to moderate infestations.

Chinch bug

Blissus leucopterus leucopterus

Chinch bug

Chinch bugs are sporadic pests of sorghum in Texas. Adult chinch bugs are black, with reddish yellow legs and with conspicuous, fully developed white forewings, each of which has a black triangular spot at the middle of the outer margin. Immature chinch bugs resemble adults in shape but lack wings. Young nymphs are yellowish, later turning reddish with a white or pale yellow band across the front part of the abdomen. Older nymphs are black and gray with a conspicuous white spot on the back between the wing pads.

Eggs are laid behind the lower leaf sheaths of sorghum plants, on roots or in the ground near the host plant. The life cycle is completed in 30 to 40 days, and there are at least two generations a year. Chinch bugs overwinter as adults in bunch grass. They begin moving to sorghum when temperatures reach 70 degrees F.

Adult and immature chinch bugs suck juices from stems, leaves or underground plant parts. Young plants are highly susceptible. Older plants withstand attack better, but they, too, become reddened, weakened and stunted. Chinch bugs are favored by hot, dry weather, and large numbers of adult and immature bugs often migrate from wild bunch grasses or small grains into sorghum.

To find chinch bugs, carefully examine plants and surrounding soil. Make at least five random checks per field.

Cultural practices that stimulate dense, vigorous plant stands are recommended because these conditions are less favored by chinch bugs, and injury usually is reduced. Plant sorghum as early as practical.

Apply insecticide when two or more chinch bugs are found on 20 percent of seedling plants less than 6 inches tall. On taller plants, insecticide often is justified when chinch bugs infest 75 percent of the plants. Generally, one chinch bug per seedling sorghum plant reduces grain yield by 2 percent.

Table12. Suggested insecticides for controlling chinch bugs.

Insecticide	Application rate	Days from last application to: Harvest	Graze
Commercially treated seed			
Clothianidin (Poncho® 600)	5.1-6.4 fl oz/100 lbs seed	—	—
Imidacloprid (Gaucho® 480)	8 oz/cwt	—	45
Thiamethoxam (Cruiser® 5FS)	5.1 oz/cwt	—	—
Applied at planting			
Aldicarb		See remarks	
(Temik® 15G)	7.5 oz/1,000 ft of row	90	
Chlorpyrifos		See remarks	
(Lorsban® 15G)	8 oz/1,000 ft of row	30	3
Terbufos		See remarks	
(Counter® 15G)	7 oz/1,000 ft of row	100	50
Applied post-emergence			
Carbaryl		See remarks	
(Sevin®)			
(4F)	32-64 oz/acre	21	14
(80S or 80WSP)	1.25-2.5 lb/acre	21	14
(4XLR+)	32-64 oz/acre	21	14
Carbofuran		See remarks	
(Furadan® 4F)	8-16 oz/acre	75	75
Chlorpyrifos		See remarks	
(Lorsban® 4E) (NuFos® 15G)	16-32 oz/acre	30-60	30-60
Cyfluthrin		See remarks	
(Baythroid® 2E)	1.3-2.8 oz/acre		14
Cyhalothrin		See remarks	
(Karate® 1F) (Warrior® 1E)	3.84 oz/acre		

Remarks

Aldicarb. Apply granules in furrow and cover with soil. Do not feed green forage to livestock.

Carbaryl. Use high-gallonage ground application directed at bases of plants.

Carbofuran. Ground application only. Use 20-30 gallons of water per acre. Do not apply more than twice per season. Do not apply after heads emerge from the boot.

Chlorpyrifos. Apply with enough water to ensure a minimum spray volume of 20-40 gallons per acre. Use ground equipment to direct spray toward bases of plants. The waiting period from last application to harvest or grazing is 30 days for the 16-oz rate and 60 days for more than 16 oz. Do not apply more than 48 oz per acre per season. Do not treat sweet sorghum.

Cyfluthrin. If one or two applications are made, green forage may be fed or grazed on the day of treatment. If three applications are made, allow at least 14 days between last application and grazing. Direct applications at the basal portion of the plant.

Cyhalothrin. Do not graze livestock in treated area or harvest for fodder, silage or hay.

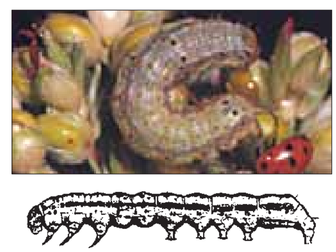
Terbufos. Apply in 5- to 7-inch band over the row in front of or behind press wheel and lightly incorporate into soil. Do not place granules in direct contact with seed. For early-season control of light to moderate infestations.

Chinch bugs sometimes are difficult to control with insecticides. In fields with a history of economically damaging infestations of chinch bug, at-planting, soil-incorporated insecticides or Gaucho®, Cruiser® or Poncho® treated seed may be justified. Granular insecticides must receive about one-half inch of rainfall after application to effectively suppress early-season chinch bug infestations.

If infestations reach the economic threshold after plant emergence, apply post-emergence insecticide using at least 20 gallons of water per acre through nozzles directed at the bases of plants. Control is seldom satisfactory on plants in the boot stage or later. Aerial insecticide application is seldom effective and not suggested.

Corn earworm and fall armyworm (whorlworms)

Helicoverpa zea and *Spodoptera frugiperda*



Corn earworm

Fall armyworm

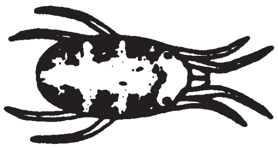
Corn earworm and fall armyworm infest the whorls and grain heads of sorghum plants. Larvae hatching from eggs laid on sorghum leaves before grain heads are available migrate to and feed on tender, folded leaves in the whorl.

To find larvae in sorghum whorls, pull the whorl leaf from the plant and unfold it. Frass, or larval excrement, is present where larvae feed within the whorl. Damaged leaves unfolding from the whorl are ragged with "shot holes." Although this may look dramatic, leaf damage usually does not reduce yields greatly, and control of larvae during the whorl stage is seldom economically justified. Also, larvae within the whorl are somewhat protected from insecticide.

Insecticide application may be justified if larval feeding reduces leaf area by more than 30 percent or is damaging the developing grain head or growing point within the whorl. See page 22 for information on these insects as pests of sorghum grain heads.

Banks grass mite

Oligonychus pratensis



Banks grass mite

Large numbers of Banks grass mites sometimes occur on sorghum, especially in more arid areas of Texas. These mites are very small; females are larger than males. After feeding, mites turn deep green, except for the mouthparts and first two pairs of legs that remain light salmon colored. Eggs (about 50 per female) are laid in webbing on the undersides of sorghum leaves. Eggs are pearly white, spherical, one-fourth the size of the adults, and hatch in 3 to 4 days. The life cycle requires about 11 days under favorable conditions.

Spider mites suck juices from the undersides of sorghum leaves. Mite infestations begin along the midrib of the lower leaves. Infested areas become pale yellow initially and later become reddish on the top surface. The entire leaf may turn brown. As spider mites become more abundant on the lower leaves, the infestation spreads upward through the plant. The undersides of heavily infested leaves have a dense deposit of fine webbing spun by the spider mites.

Increases in spider mite abundance generally occur after sorghum grain heads emerge. Large numbers of spider mites occurring early in kernel development can reduce the ability of sorghum plants to make and fill grain. After kernels reach hard dough, grain is not affected. However, if spider mites are very abundant sorghum plants may lodge, resulting in harvest losses.

Inspect the undersides of lower leaves carefully. Mites occur in colonies, first along midribs of leaves. Later they spread away from the midrib and up the plant to higher leaves. Webbing indicates the presence of mites. Mite infestations commonly begin along field borders, and may spread quickly throughout a field.

Hot, dry weather may favor a rapid increase in mites. Also, mites in sorghum may respond as induced (secondary) pests after an insecticide application for a key insect pest such as greenbug. A rapid increase in spider mites after insecticide application is thought to be caused by the tolerance of mites to some insecticides, the destruction of beneficial insects, and the dispersal of mites from colonies.

Natural enemies do not always control spider mites adequately. Because spider mites increase more rapidly on moisture-stressed plants, irrigation, where available, should be timed to prevent plant stress. Also, spider mites may move from small grains, especially wheat, to sorghum. To avoid this, plant sorghum away from small grains.

Insecticides produce varying degrees of success. Historically, insecticidal control of mites in sorghum has been erratic. *Insecticide application may be justified when 30 percent of the leaf area of most sorghum plants in a field show some damage symptoms from mite feeding.* Thorough coverage is required; apply at least 3 to 5 gallons of spray mixture per acre. Banks grass mites are often resistant to insecticides.

Table 13. Suggested miticides for controlling Banks grass mite.

Miticide	Concentrate/ unit area	Days from last application to: Harvest	Graze
Dimethoate		See remarks	
(4E)	16 oz	28	28
(5E)	12.8 oz	28	28
Phorate		See remarks	
(Thimet® 20G)	4.9 lb	30	
Propargite		See remarks	
(Comite® 6.55E)	24-36 oz	60	30

Remarks

Dimethoate Ground application: Apply in 25-40 gallons of water. Do not apply more than three times per season. Do not apply after heads emerge from the boot. Do not use in the Trans-Pecos area.

Phorate Broadcast into whorl of plant. Do not use in the Trans-Pecos area. Do not feed foliage before harvest.

Propargite. Do not apply more than once per season. Slight phytotoxicity may occur on some sorghum hybrids.

Grain head insect pests

Sorghum midge

Stenodiplosis sorghicola

Sorghum midge

The sorghum midge is one of the most damaging insects to sorghum in Texas, especially in the southern half of the state. The adult sorghum midge is a small, fragile-looking, orange-red fly with a yellow head, brown antennae and legs and gray, membranous wings.

During the single day of adult life, each female lays about 50 yellowish-white eggs in flowering spikelets of sorghum. Eggs hatch in 2 to 3 days. Larvae are colorless at first, but when fully grown, are dark orange. Larvae complete development in 9 to 11 days and pupate between the spikelet glumes. Shortly before adult emergence, the pupa works its way toward the upper tip of the spikelet. After the adult emerges, the clear or white pupal skin remains at the tip of the spikelet.

A generation is completed in 14 to 16 days under favorable conditions. Sorghum midge numbers increase rapidly because of multiple generations during a season and when sorghum flowering times are extended by a range of planting dates or sorghum maturities.

Sorghum midges overwinter as larvae in cocoons in spikelets of sorghum or johnsongrass. Johnsongrass spikelets containing diapausing larvae fall to the ground and become covered with litter. When sorghum is shredded, spikelets containing larvae fall to the ground and are disked into the soil. Sorghum midges emerging in spring do so before flowering sorghum is available, and these adults infest johnsongrass. Sorghum midges developing in johnsongrass disperse to fields of sorghum when it flowers.

Early-season infestations in sorghum are usually below damaging levels. As the season progresses, sorghum midge abundance increases, especially when flowering sorghum is available in the area. Numbers often drop late in the season.

A sorghum midge damages sorghum when the larva feeds on a newly fertilized ovary, preventing normal kernel development. Grain loss can be extremely high. Glumes of a sorghum midge-infested spikelet fit tightly together because no kernel develops. Typically, a sorghum grain head infested by sorghum midges has various proportions of normal kernels scattered among non-kernel-bearing spikelets, depending on the degree of damage.

Effective control of sorghum midge requires the integration of several practices that reduce sorghum midge abundance and their potential to cause crop damage. The most effective cultural management method for avoiding damage is early, uniform planting of sorghum in an area so flowering occurs before sorghum midges reach damaging levels. Planting hybrids of uniform maturity early enough to avoid late flowering of grain heads is extremely important. This practice allows sorghum to complete flowering before sorghum midges increase to damaging levels.

Cultural practices that promote uniform heading and flowering in a field are also important in deciding on treatment and in achieving acceptable levels of insecticidal control. To reduce sorghum midge abun-

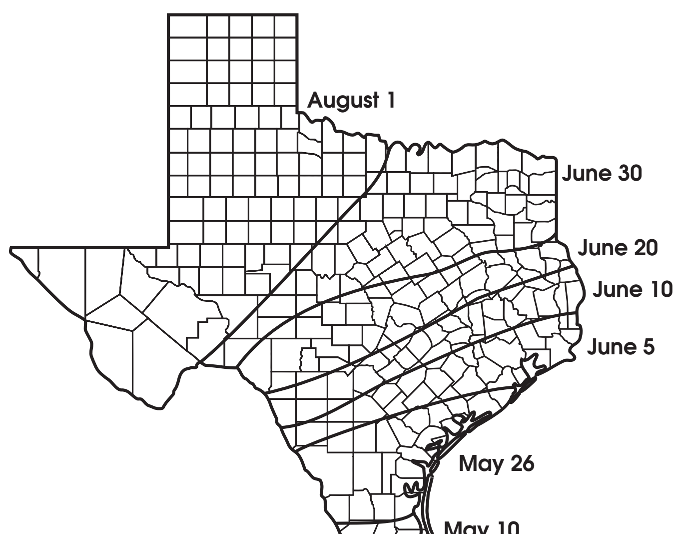


Figure 3. Estimated latest sorghum flowering dates most likely to escape significant damage by sorghum midge.

dance, use cultivation and/or herbicides to eliminate johnsongrass inside and outside the field. Where practical, disk and deep plow the previous year's sorghum crop to destroy overwintering sorghum midges.

Multiple insecticide applications are used to kill adults before they lay eggs. Sorghum planted and flowering late is especially vulnerable to sorghum midge. To determine whether insecticides are needed, evaluate crop development, yield potential and sorghum midge abundance daily during sorghum flowering. Because sorghum midges lay eggs in flowering sorghum grain heads (yellow anthers exposed on individual spikelets), they can cause damage until the entire grain head or field of sorghum has flowered. The period of susceptibility to sorghum midge may last from 7 to 9 days (individual grain head) to 2 to 3 weeks (individual field), depending on the uniformity of flowering.

To determine if adult sorghum midges are in a sorghum field, check at mid-morning when the temperature warms to approximately 85 degrees F. Sorghum midge adults are most abundant then on flowering sorghum grain heads. Because adult sorghum midges live less than 1 day, each day a new brood of adults emerges. Sampling must be done almost daily during the time sorghum grain heads are flowering. Sorghum midge adults can be seen crawling on or flying about flowering sorghum grain heads.

The simplest and most efficient way to detect and count sorghum midges is to inspect carefully and at close range all sides of randomly selected flowering grain heads. Handle grain heads carefully during inspection to avoid disturbing adult sorghum midges. Other sampling methods can be used, such as placing a clear plastic bag or jar over the sorghum grain head to trap adults.

Because they are relatively weak fliers and rely on wind currents to aid their dispersal, adult sorghum midges usually are most abundant along edges of sorghum fields. For this reason, inspect plants along field borders first, particularly those downwind of earlier flowering sorghum or johnsongrass. If no or few sorghum midges are found on sorghum grain heads along field edges, there should be little need to sample the entire field.

However, if you find more than one sorghum midge per flowering grain head in border areas of a sorghum field, inspect the rest of the field. Sample at least 20 flowering grain heads for every 20 acres in a field. For fields smaller than 20 acres, sample 40 flowering grain heads. Flowering heads are those with yellow blooms. Avoid plants within 150 feet of field borders. Record the number of sorghum midges for each flowering head sampled and then calculate the average number of midges per flowering head. Almost all of the sorghum midges seen on flowering sorghum heads are female.

Next, calculate the number of flowering heads (yellow blooms present) per acre. Record the number of flowering heads along a length of row equal to 1/1000 of an acre. As an example, for a row spacing of 40 inches, 13.1 row feet is equal to 1/1000 of an acre. Make counts in at least four areas of the field. If flowering (plant maturity) is highly variable across the field, additional sites should be sampled. Average all counts and multiply by 1000 to estimate the number of flowering heads per acre. If there is only one head per plant, then the number of flowering heads per acre is equal to the percent heads in bloom multiplied by the number of plants per acre.

Sorghum midge density per acre is then calculated as the mean number of midges per flowering head x number of flowering heads per acre. For example, if there are 30,000 flowering heads per acre and scouting records show an average of 0.5 sorghum midge per flowering head, then there are an estimated 15,000 sorghum midges per acre (0.5 sorghum midge per head x 30,000 flowering heads per acre). The percentage of flowering heads changes rapidly during bloom and should be determined each time the field is sampled.

Studies have shown that the larvae from a single female sorghum midge will destroy an average of 45 grain sorghum kernels. The seed weight of sorghum hybrids averages 15,000 seeds per pound (range of 12,000 to

18,000, depending on the hybrid). A loss of 45 kernels per midge, therefore, represents 0.0030 pounds (1.364 grams) of grain.

The economic injury level for sorghum midge can be calculated from the following equation:

$$\text{Number of sorghum midges per flowering head} = \frac{\text{(Cost of control as \$ per acre)} \times 33256}{\text{(Value of grain as \$ per cwt)} \times \text{(Number of flowering heads}}$$

In the equation above, the control cost is the total cost of applying an insecticide for sorghum midge control and the grain value is the expected price at harvest as dollars per 100 pounds. The value 33256 is a constant and results from solving the economic injury equation. The number of flowering heads per acre is determined as described above.

For example, assume field scouting yields an average of 1.1 sorghum midges per flowering head and field sampling shows the number of flowering heads is 18,000 per acre. (This is equal to a plant population of 90,000 with 20 percent of the heads flowering and one head per plant.) If the value of the crop is estimated to be $4.00 per 100 pounds and the cost of control is $5.00 per acre, the above equation yields the injury level as:

$$\frac{\$5.00 \times 33256}{\$4.00 \times 18{,}000} = \text{2.3 sorghum midges per flowering head}$$

In this example, the field density of 1.1 sorghum midges per flowering head is below the injury level and treatment would not be justified. If the field is scouted 2 days later and the sorghum midge density is again 1.1 midges per flowering head, but now the number of flowering heads has increased to 45,000 per acre (50 percent of the plants now have a flowering grain head in a plant density of 90,000 per acre and one head per plant), the injury level is now:

$$\frac{\$5.00 \times 33256}{\$4.00 \times 45{,}000} = \text{0.9 sorghum midge per flowering head}$$

In this example, the field density of 1.1 sorghum midges is now above the economic injury level of 0.9 per flowering head and treatment would be justified. This shows the importance of considering the number of flowering heads (grain susceptible to midge damage) in estimating the economic injury level.

Economic injury levels, as determined from the above equation, are shown in Table 14 for a range of typical treatment costs per acre, market values per 100 pounds of grain, and numbers of flowering heads per acre. Use the equation for estimating injury levels for your actual control costs, crop value and number of flowering heads per acre.

Insecticide residues should effectively suppress sorghum midge egg laying 1 to 2 days after treatment. However, if adults still are present 3 to 5 days after the first application of insecticide, immediately apply a second insecticide treatment. Several insecticide applications at 3-day intervals may be justified if yield potential is high and sorghum midges exceed the economic injury level.

Table 14. Estimated economic injury levels for sorghum midge for a range of factors. (This table is only a guide. Use the equation in the text to estimate the economic injury level in your field.)

		Economic injury level—mean number of midges/flowering head		
Control cost, $/acre	**Crop value, $100 lbs**	**Flowering heads = 18,000/acre**	**Flowering heads = 45,000/acre**	**Flowering heads= 67,500/acre**
5	6	1.6	0.6	0.4
5	7	1.3	0.5	0.34
5	8	1.2	0.5	0.3
6	6	1.9	0.8	0.5
6	7	1.6	0.7	0.4
6	8	1.4	0.6	0.35
7	6	2.2	0.85	0.6
7	7	1.9	0.75	0.5
7	8	1.6	0.65	0.45

Table 15. Suggested insecticides for controlling sorghum midge.

Insecticide	Application rate	Days from last application to: Harvest	Graze
Chlorpyrifos (Lorsban® 4E)	8 oz	30	30
Cyfluthrin (Baythroid® 2E)	1.0-1.3 oz	See remarks	14
Cyhalothrin (Karate® 1E) (Warrior® 1E)	1.92-2.56 oz	See remarks	
Esfenvalerate (Asana® XL)	2.9-5.8 fl oz	21	—
Malathion (Fyanon® ULV)	8-12 oz	7	7
Methomyl (Lannate®) (2.4LV)	12-24 oz	14	14
(90WSP)	4-8 oz	14	14
Zeta-cypermethrin (Mustang Max®)	1.28-4.0 fl oz	14	45

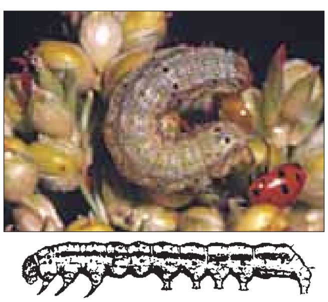
Remarks

Cyfluthrin. If one or two applications are made, green forage may be fed or grazed on the day of treatment. If three applications are made, allow at least 14 days between last application and grazing.

Cyhalothrin. Do not graze livestock in treated area or harvest for fodder, silage or hay.

Corn earworm and fall armyworm (headworms)

Helicoverpa zea and *Spodoptera frugiperda*



Corn earworm

Fall armyworm

Corn earworm and fall armyworm moths lay eggs on leaves or grain heads of sorghum. Newly hatched corn earworm larvae are pale in color and only 1/16 inch long. They grow rapidly and become variously colored, ranging from pink, green or yellow to almost black. Many are conspicuously striped. Down the side is a pale stripe edged above with a dark stripe. Down the middle of the back is a dark stripe divided by a narrow white line that makes the dark stripe appear doubled. Fully grown larvae are robust and 1 ½ to 2 inches long.

Young fall armyworm larvae are greenish and have black heads. Mature larvae vary from greenish to grayish brown and have a light-colored, inverted, Y-shaped suture on the front of the head and dorsal lines lengthwise on the body.

Corn earworm and fall armyworm larvae feed on developing grain. Small larvae feed on flowering parts of the grain head at first, then hollow out kernels. Larger larvae consume more kernels and cause the most damage. The last two larval stages cause about 80 percent of the damage. Frass is common in infested grain heads, on tops of upper leaves and on the ground under plants.

Natural mortality of small corn earworm and fall armyworm larvae is normally very high. Both corn earworm and fall armyworm moths can lay several hundred eggs on sorghum grain heads before or during flowering, but only a few larvae survive. Natural factors suppressing these insects include predators, parasites, pathogens and cannibalism among larvae.

Infestations occur less often in early- than late-planted sorghum. An important management tactic is to use sorghum hybrids with loose (open) grain heads. Early-planted sorghum and hybrids with open grain heads usually are less infested.

Begin sampling for headworms soon after the field finishes flowering and continue at 5-day intervals until the hard dough stage. To sample headworms, grasp the stalk just below the sorghum head, bend the head into a clean, white, 5-gallon bucket, and vigorously beat the head against the side of the bucket. Headworms will fall into the bucket where they can be seen and counted. Sample at least 30 grain heads, selected at random from across the field. In fields larger than 40 acres, sample at least one grain head per acre. Record the number of small (less than ¼ inch long), medium (¼ to ½ inch long) and large (longer than ½ inch) headworms found in the samples. Divide the total number of medium or large headworms by the number of heads sampled to get the average number of headworms per head. Then multiply the average number of headworms per head by the number of heads per acre to calculate the number of headworms per acre. (To estimate the number of plants or heads per acre for various row spacings, see page 20.)

Studies have shown that a corn earworm larva will consume about 0.010252 pounds (4.65 grams) of grain during its development in the sorghum head. However, estimating the economic injury level for headworms is complicated because the potential yield loss varies with the size of the larvae. That is why it is necessary to record the number of small, medium-size and large headworms.

Small larvae (up to ¼ inch) consume very little grain (about 10 percent of the total) and about 80 percent of them die in this stage. Therefore, small larvae should not be considered in determining the economic injury level. If most headworms are this size, sample the field again in 3 to 4 days. If most of the larvae are larger than ¼ inch at that later time, determine which size (medium-size or large) is most common and use the corresponding equation below to calculate the economic injury level.

If the infestation consists of about equal numbers of medium-size and large headworms, use this equation:

$$\text{Potential loss (as lbs/acre)} = (\text{no. of large larvae/acre} \times 0.010252) + (\text{no. of medium-size larvae/acre} \times 0.19 \times 0.010252)$$

Treatment would be economically justified if the value of the potential loss (loss in pounds per acre x dollars per pound of grain) exceeded the treatment cost per acre.

Most corn earworm larvae larger than ½ inch will survive to complete development, and these large larvae are most damaging; they consume 83 percent of the total grain consumed during larval development. About 19 percent of medium-size larvae (¼ to ½ inch long) survive beyond this stage. Thus, the potential grain loss from medium-size larvae is only 19 percent of the potential loss from large larvae.

Two ways to determine the economic injury level are presented. Both use the same factors and yield the same results. The first method uses the equations below to present the threshold as the number of larvae per head, while the second method shows the results in table format as the number of larvae per acre. The number of larvae per acre can be divided by the number of heads per acre to yield the mean number of larvae per head as an economic injury level.

Economic injury level for large larvae:

$$\text{Number of large larvae per head} = \frac{\text{Cost of control as \$ per acre} \times 9754}{\text{Grain value as \$ per cwt} \times \text{heads per acre}}$$

Economic injury level for medium-size larvae:

$$\text{Number of medium-size larvae per head} = \frac{\text{Cost of control as \$ per acre} \times 9754}{\text{Grain value as \$ per cwt} \times \text{heads per acre} \times 0.19}$$

Table 16. Economic injury level for large (longer than ½ inch) corn earworm larvae shown as the number of larvae per acre. When the number of larvae per acre exceeds the number in the table at a given cost of control and value of grain per cwt, the value of the protected grain exceeds the cost of control.[1]

Control cost	Grain value $/100 lbs			
$/acre	6.00	7.00	8.00	10.00
6	9,750	8,500	7,250	5,750
8	13,000	11,000	9,750	7,750
10	16,250	14,000	12,250	9,750
12	19,500	16,750	14,750	11,750

[1] This threshold table assumes all larvae will survive and complete development.

Table 17. Economic injury level for medium-size (¼ to ½ inch) corn earworm larvae shown as the number of larvae per acre. When the number of larvae per acre exceeds the number in the table at a given cost of control and value of grain per cwt, the value of the protected grain exceeds the cost of control.[1]

Control cost	Grain value $/100 lbs			
$/acre	6.00	7.00	8.00	10.00
6	51,500	44,750	38,250	31,250
8	68,500	58,000	51,500	41,750
10	87,750	73,750	64,500	51,500
12	102,750	88,250	77,750	62,000

[1] This table assumes 81 % of the medium-size larvae will die in that stage and not contribute to additional yield loss.

Table 18. Suggested insecticides for controlling corn earworm and fall armyworm in sorghum.

Insecticide	Concentrate/ unit area	Days from last application to: Harvest	Graze
Carbaryl			
(Sevin®)			
(4F)	32-64 oz	21	14
(80S or 80WSP)	1.25-1.8 lb	21	14
(4XLR+)	32-64 oz	21	14
Cyfluthrin		See remarks	
(Baythroid® 2E)	1.3-2.8 oz		14
Cyhalothrin		See remarks	
(Karate® 1E)	2.56-3.84 oz		
(Warrior® 1E)	2.56-3.84 oz		
Esfenvalerate			
(Asana® XL)	5.8-9.6 fl oz	21	—
Methomyl			
(Lannate®)			
(2.4LV)	12-24 oz.	14	14
(90WSP)	4-8 oz.	14	14
Zeta-cypermethrin			
(Mustang Max®)	1.75 to 4.0 fl oz	14	45

Remarks

Cyfluthrin. If one or two applications are made, green forage may be fed or grazed on the day of treatment. If three applications are made, allow at least 14 days between last application and grazing.

Cyhalothrin. Do not graze livestock in treated area or harvest for fodder, silage or hay.

Sorghum webworm

Nola sorghiella

Sorghum webworm

Sorghum webworms occasionally infest grain heads of sorghum planted 2 to 3 weeks later than normal. This insect occurs primarily in the more humid eastern half of Texas.

Adults are small, white moths active at night. They lay about 100 eggs singly but fastened rather securely to flowering parts or kernels of sorghum. Eggs are round to broadly oval and are flattened from top to bottom.

Webworm larvae are somewhat flattened, yellowish or greenish brown and marked with four lengthwise reddish to black dorsal stripes. When mature, larvae are about ½ inch long and covered with many spines and much hair. Pupae within a cocoon are reddish brown, slender and sub-cylindrical. A generation requires 1 month; as many as six generations may develop in a year. The larva overwinters in a cocoon on the host plant.

Many sorghum webworms may be found in grain heads of late-planted sorghum. Young larvae feed on developing flower parts. Older larvae gnaw circular holes in and feed on the starchy contents of maturing kernels, which usually are only partly consumed. Each larva may eat more than 12 kernels in 24 hours. Larvae do not spin webs (as the name might imply) over the sorghum grain head but, when disturbed, young larvae often suspend themselves by spinning a thin silken thread.

Inspect for sorghum webworms when grain heads begin to flower; continue at 5-day intervals until kernels are in the hard-dough stage. To examine grain heads for sorghum webworms, shake grain heads vigorously into a 2.5- to 5-gallon plastic bucket, where even small larvae can be seen and counted

Table 19. Suggested insecticides for controlling sorghum webworm.

Insecticide	Concentrate/ unit area	Days from last application to: Harvest	Graze
Carbaryl			
(Sevin®)			
(4F)	32-64 oz.	21	14
(80S or 80WSP)	1.25-2.5 lb	21	14
(4XLR+)	32-64 oz	21	14
Cyfluthrin		See remarks	
(Baythroid® 2E)	1.3-2.8 oz		14
Cyhalothrin		See remarks	
(Karate® 1E)	2.56-3.84 oz		
(Warrior® 1E)	2.56-3.84 oz		
Methomyl			
(Lannate®)			
(2.4LV)	24 oz	14	14
(90WSP)	8 oz	14	14

Remarks

Cyfluthrin. If one or two applications are made, green forage may be fed or grazed on the day of treatment. If three applications are made, allow at least 14 days between last application and grazing.

Cyhalothrin. Do not graze livestock in treated area or harvest for fodder, silage or hay.

easily. Inspect at least 30 plants from a field to ensure that sample estimates are reasonably reliable. Sample at least one grain head per acre in fields larger than 40 acres.

Insecticide application is economically justified when grain heads are infested with an average of five or more small larvae. Cultural practices to reduce sorghum webworm abundance include plowing sorghum residues after harvest to destroy overwintering pupae, planting as early as practical, and using sorghum hybrids with loose (open) grain heads.

Grain head-feeding bugs

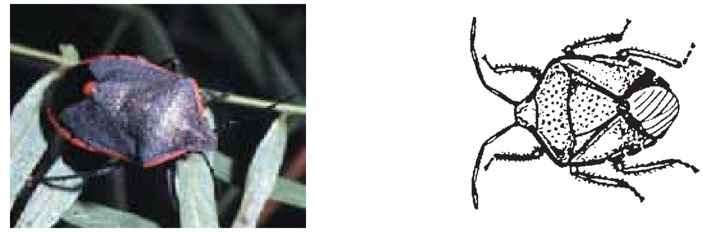
Several species of true bugs, primarily stink bugs, may move in relatively large numbers from alternate host plants into sorghum during kernel development. Bugs infesting sorghum in Texas include rice stink bug, southern green stink bug, conchuela stink bug, brown stink bug (*Euschistus servus*), red-shouldered stink bug (*Thyanta accerra*), leaffooted bug and false chinch bug.

Rice stink bug

The rice stink bug (*Oebalus pugnax*) is straw-colored, shield-shaped and ½ inch long. Females lay about 10 to 47 short, cylindrical, light-green eggs in a cluster of two rows. Eggs hatch after 5 days, and nymphs require 15 to 28 days to become adults.

Southern green stink bug

The southern green stink bug (*Nezara viridula*) is about ¾ inch long, green and somewhat shield-shaped. Females deposit 300 to 500 eggs in clusters of about 30. The eggs hatch in about 7 days, reaching the adult stage in about 6 weeks.

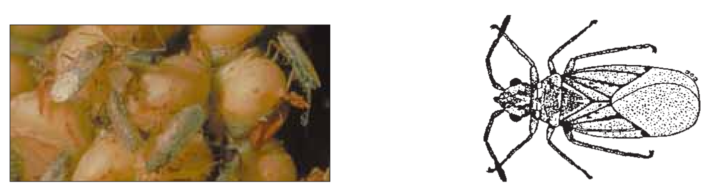


Conchuela stink bug

The conchuela stink bug (*Chlorochroa ligata*) varies in color from dull olive or ash gray to green, purplish pink, or reddish brown. The most characteristic markings are orange-red bands along the lateral margins of the thorax and wings and a spot of the same color on the back at the base of the wings.

Leaffooted bug

The leaffooted bug (*Leptoglossus phyllopus*) is brown, oblong and just longer than ¾ inch. A white band extends across the front wings. The lower part of each hind leg is dilated or leaf-like. Eggs are laid in rows of 15 to 35. Nymphs are reddish.



False chinch bug

The false chinch bug (*Nysius raphanus*) resembles the chinch bug but with more uniform color, ranging from gray to brown. False chinch bugs are 1⁄10 inch long. Large numbers of false chinch bugs occasionally migrate from wild hosts, such as wild mustard, to sorghum, but these insects usually concentrate in small areas of a field.

Bugs suck juices from developing sorghum kernels and, to a lesser extent, from other grain head parts, and may cause economic damage. The extent of damage depends on the number of bugs per grain head, the duration of infestation, and the stage of kernel development when infestation occurs. Bugs cause more damage early during kernel development and less as grain develops to the hard-dough stage. Both nymphs and adults can reduce grain weight, size and seed germination. Fungi often infect damaged kernels, causing them to turn black and further deteriorate in quality. Damaged kernels rarely develop fully and may be lost during harvest.

Grain head-feeding bugs tend to congregate on sorghum grain heads and sometimes within areas of a field. Use the beat-bucket technique to estimate abundance. Shake sorghum grain heads vigorously into a 2.5- to 5-gallon bucket where bugs can be seen and counted more easily. However, adult bugs will fly from the sampled plant or the bucket. Count those that fly from sorghum grain heads or from the bucket and those on plant leaves. Sample at least 30 plants from a field. Take at least one sample per acre in fields larger than 40 acres.

Determine the average number of bugs per sorghum head. Then multiply the average number of bugs per head by the plant density per acre to calculate the number of bugs per acre. Use the table to determine if the rice stink bug population exceeds the economic injury level. *The action level for false chinch bug is 140 bugs per grain head when infestation begins at the milk stage of grain development.*

Not all stink bug species in sorghum are economic pests. Several species, such as the spined soldier bug, prey on harmful insects and thus are beneficial.

Table 20. Economic injury level for rice stink bug as number of bugs per acre at the milk stage.

Control cost	Grain value ($/cwt)			
$/acre	6.00	7.00	8.00	10.00
6	30,500	27,000	23,000	18,500
8	40,500	35,000	30,500	24,500
10	51,000	43,500	38,000	30,500
12	62,000	52,500	46,000	36,500

Table 21. Suggested insecticides for controlling grainhead-feeding bugs.

Insecticide	Concentrate per unit area	Days from last application to: Harvest	Graze
Carbaryl		See remarks	
(Sevin®)			
(4F)	32-64 oz	21	14
(80S or 80WSP)	1.25-2.5 lb	21	14
(4XLR+)	32-64 oz	21	14
Cyfluthrin		See remarks	
(Baythroid® 2E)	1.3-2.8 oz	14	14
Cyhalothrin		See remarks	
(Karate® 1E)	2.56-3.84 oz		
(Warrior® 1E)	2.56-3.84 oz	30	—

Remarks

Carbaryl. Direct spray into heads for optimum control.

Cyfluthrin. If one or two applications are made, green forage may be fed or grazed on the day of treatment. If three applications are made, allow at least 14 days between last application and grazing.

Cyhalothrin. Do not graze livestock in treated area or harvest for fodder, silage or hay.

Stalk-boring insect pests

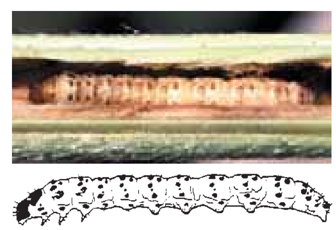
Sugarcane borer
Diatraea saccharalis

Southwestern corn borer
Diatraea grandiosella

European corn borer
Ostrina nubilalis

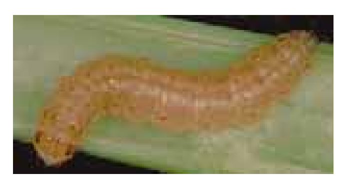
Mexican rice borer
Eoreuma loftini

Neotropical borer
Diatraea lineolata



Sugarcane borer

Southwestern corn borer



European corn borer

Mexican rice borer

Neotropical borer

These closely related insects tunnel in the stalks of sorghum, corn and other crops. The biology of these four species can be generalized: White to buff-colored adult moths lay clusters of elliptical to oval, flattened eggs that overlap like fish scales in shingle-like arrangements on leaves of host plants. Eggs hatch in 3 to 7 days.

The larval stage lasts about 25 days and the pupal stage about 10. There are two to three generations a year. Larvae are creamy white, about 1 inch long when fully grown, and most body segments have conspicuous round brown or black spots. Spots are lighter colored or absent on mature overwintering larvae. Most stem-boring insects pass the winter as fully grown larvae in cells inside stalks that remain after the crop is harvested.

Young larvae feed for a few days on leaves or the leaf axis. Older larvae tunnel into the sorghum stalks. Larvae bore up and down the pith of the stalk. Borer-infested stalks may be reduced in diameter, and lodging of infested plants can result. Boring by larvae in the stem just below the grain head can cause it to break and the grain head to fall. Injury by borers makes the plant more susceptible to stalk rot diseases.

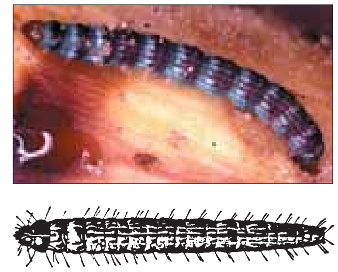
Planting sorghum early is important because borers typically are more abundant in late-planted sorghum. Shredding stalks very close to the ground or plowing and disking stubble destroys overwintering larvae by exposing them to cold temperatures in more northern regions of Texas. This practice reduces borer abundance the next year.

To determine the presence of stem borers, examine the sorghum plants carefully. Small holes near the leaf axis indicate that a larva has entered the stalk. Once larvae have entered the stalk, stalks must be split to see the larvae. Inspect leaves carefully, because eggs are hard to find. Clusters containing 10 to 20 individual eggs may be on the top or undersides of leaves, depending on the borer species. Assess the abundance of eggs and small larvae before larvae bore into stalks. Insecticidal control is effective only if applied before larvae bore into stalks.

Table 22. Suggested insecticides for controlling Southwestern corn borer and European corn borer.

Insecticide	Concentrate/ unit area	Days from last application to: Harvest	Graze
Cyfluthrin (Baythroid® 2E)	1.3-2.8 oz	14	14
Cyhalothrin (Karate® 1E) (Warrior® 1E)	2.56-3.84 oz 2.56-3.84 oz	30	—

Lesser cornstalk borer
Elasmopalpus lignosellus


Lesser cornstalk borer

Larvae of the lesser cornstalk borer attack roots and bore into stalks of sorghum plants. Damaging infestations of this insect rarely occur in sorghum. Larvae are light bluish green with prominent transverse reddish-brown bands. They feed in silken tunnels covered with soil particles. Larvae pupate in silken cocoons under crop debris.

Lesser cornstalk borers usually are more severe during dry periods and in sandy soils. Cultural practices that preserve moisture and increase organic matter in the soil discourage the insect. Early planting and rotation with nonhost crops help avoid damage from lesser cornstalk borer. Insecticidal control rarely is justified, although Warrior®, Karate®, Mustang Max® and Lorsban® are labeled products.

Sugarcane rootstock weevil
Anacentrinus deplanatus


Sugarcane rootstalk weevil

The sugarcane rootstock weevil infests sorghum sporadically, especially during dry years and in fields where johnsongrass is abundant.

The adult weevil is dark brown or black, about $\frac{1}{8}$ inch long and $\frac{1}{16}$ inch wide. The insect overwinters as an adult on ground protected by plant residues. In early spring weevils infest wild grasses, such as johnsongrass, and later move to sorghum. The female uses her mouthparts to make a small puncture at the base of the plant into which the egg is deposited and concealed. About 16 eggs are laid and they hatch in 6 days. Larvae are white, legless grubs about $\frac{1}{5}$ inch long when fully grown. A generation is completed in about 40 days.

Adult weevils feed on young sorghum plants and crowns. This damage is noticeable but not as serious as that caused by larvae. Larvae tunnel into the sorghum stalk just below or above the surface of the soil. Tunnels resemble those made by other borers, except they are much smaller and do not extend up the stalk. Larvae often are found at nodes and near the outer surfaces of the stalk. Their feeding often is responsible for a drought-stressed appearance and lodging of sorghum plants. Exit holes and feeding tunnels provide favorable areas where such pathogens as charcoal rot can enter the plant. Economic thresholds for this pest have not been established and usually control has not been required, although locally damaging populations may occur.

Policy statement for making pest management suggestions

The information and suggestions included in this publication reflect the opinions of Extension entomologists based on field tests, research and experience. However, it is impossible to eliminate all risk. Conditions or circumstances that are unforeseen or unexpected may result in less than satisfactory results even when these suggestions are used. Texas Cooperative Extension will not assume responsibility for risks. Such risks shall be assumed by the user of this publication.

Suggested pesticides must be registered and labeled for use by the Environmental Protection Agency and the Texas Department of Agriculture. The status of pesticide label clearances is subject to change and may have changed since this publication was produced. County Extension agents and appropriate specialists are advised of changes as they occur.

The user is always responsible for the effects of pesticide residues on his livestock and crops, as well as for problems that could arise from drift or movement of the pesticide from his property to that of others. Always read and follow carefully the instructions on the container label.

Worker protection standard

The Worker Protection Standard (WPS) is a set of federal regulations that applies to all pesticides used in agricultural plant production. If you employ any person to produce a plant or plant product for sale and apply any type of pesticide to that crop, WPS applies to you. The regulations require you to protect your employees from pesticide exposure.

You must inform employees about exposure, protect them from exposure and mitigate pesticide exposures that they may receive. WPS requirements will appear in the "Directions for Use" part of the pesticide label. For more detailed information, consult Worker Protection Standard, 40 CFR part 170, or call the Texas Department of Agriculture, Pesticide Worker Protection Program, (512) 463-7622.

Photographs were provided by Greg Cronholm, H.A. Turney, G. T. Bohmfalk, Charles Neeb, Robert Saldana, Bart Drees, Roy Parker, J.W. Stewart, Pat Morrison and Charles Cole.

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