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Managing Insect and Mite Pests of Texas Small Grains

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Managing Insect and Mite Pests of Texas Small Grains

Integrated pest management (IPM) is the use of multifaceted techniques that are the most economical and ecologically sound to control insect and mite pests efficiently and effectively. IPM includes:

- **Cultural practices,** such as crop rotation, fertilization, and variety and planting date selection
- **Biological control,** including the use of pests' natural enemies
- **Chemical control,** aiming to use selected insecticides and rates judiciously to keep pest numbers below economically damaging levels

The best pest-control strategy is prevention—using good agronomic practices and cultural methods to keep the plants healthy. Apply insecticides only when the pest population or plant damage reaches levels that can cause crop losses greater than the cost of treatment. These levels are called the *economic threshold* or *action level*.

For insect and mite pests of wheat and other small grains, IPM includes sound cultural practices, grazing management, biological control, and, if necessary, insecticide applications.

Cultural Practices

Several cultural practices can reduce pest numbers—choosing resistant varieties, maintaining plant health, rotating crops, and planting later in the season. Reduced tillage has produced mixed results on pest populations, decreasing some pests and increasing others.

Varietal selection

Some wheat cultivars are resistant to pests such as the greenbug, Hessian fly, and Russian wheat aphid (Fig. 1). However, these pests can develop new biotypes that overcome the resistant genes in these cultivars. Plant breeders continually work to develop new lines that are resistant to these new biotypes and to improve yield and grain quality.

The practice of catching seed at harvest and planting it the next season can result in the deterioration of seed quality, plant vigor, and plant resistance. Wheat variety trials at multiple locations over several years have identified the varieties that are best suited for local growing conditions. The varieties have been proven to maximize yield, quality, maturity, winter hardiness, and disease and insect resistance in specific regions of Texas.

Plant health

Factors that affect a small grains plant will also affect the insects and mites that feed on it. The healthier, larger, and more vigorously growing the plant, the more pests it can tolerate without significant loss. Thus, optimum planting date, soil fertility, and irrigation will increase a crop's pest tolerance. Research has demonstrated this increase for crops attacked by the bird cherry-oat aphid, greenbug, Hessian fly, and winter grain mite.

Crop rotation

Crop rotation is particularly useful in managing pests that have a limited dispersal range, such as the Hessian fly, white grubs, winter grain mites, and wireworms. To increase the effects of rotation, destroy the crop residue soon after harvest and eliminate volunteer host plants (a practice called *summer host termination*) and, where possible, avoid planting next to neighboring crops that are hosts to insect pests of small grains.

Figure 1. Insects for which wheat cultivars have been developed to be resistant to (from left): greenbug, Russian wheat aphid, and Hessian fly

Planting date

The planting date will be influenced by the planned use of the small grains—whether for livestock grazing or for producing grain. Small grains are cool-season plants and do not grow well when daytime temperatures are in the upper 90s. When planting early for grazing, producers should understand that the field is at higher risk for disease and arthropod problems if there is a period when both summer host plants and seedling small grains are growing next to each other. This allows arthropods and diseases to move from the summer host to the seedling small grains. To minimize this risk, plant later in the season and use resistant varieties. The timing varies within production regions; check with the local Texas A&M AgriLife Extension Service office for the optimum planting dates in your area. Producers can also plant another small grain. For example, oats are not a host of Hessian fly and can be planted where Hessian fly is a threat. In many regions, producers interested only in grain production can delay the planting date until after mid-October to early November. Delayed planting allows wheat and barley to miss at least part of the first generation of Hessian flies. It also leaves less time for greenbugs, Russian wheat aphids, and bird cherry-oat aphids to establish populations. Destroying volunteer small-grain plants before planting the small grains crop can reduce infestations of wheat curl mite.

Tillage

Tillage has long been recognized as an important practice for insect control. It not only destroys host plants, but it also may bury some insects too deep for survival or physically kill shallow soil-borne or overwintering pests. Plowing under stubble and volunteer wheat reduces the Hessian fly and some of the other pests that remain in and around fields.

Reduced tillage leaves more crop residue on the soil surface, reduces soil temperatures, and increases soil moisture. Research shows that reduced tillage may encourage certain diseases and insects, particularly soil dwelling insects and pupae. For example, the wheat curl mite is a particular problem in the Texas Panhandle, where reduced tillage allows it to survive between crops on volunteer wheat, native grasses, and corn. Winter grain and brown wheat mites increase where there is crop residue. However, other research indicates that reduced tillage decreases aphid numbers. Intensified pest management may be needed to prevent crop losses in a reduced tillage program.

Reducing small grains stubble and controlling volunteer wheat plants and summer weeds will help reduce the number of aphids, Hessian flies, and wheat curl mites that can move into wheat fields.

Grazing Management

Growers plant wheat on more than 6 million acres in Texas each year. About 40 percent of the wheat acreage is grazed to some extent, and about 30 percent is used only for forage. Barley, oats, rye, and triticale are also used for livestock forage. Small-grains pastures are often seeded in late summer or early fall to take advantage of soil moisture and to give the plants time to establish strong root systems that can support heavy grazing by an average freeze date.

Grazing of small grains suppresses infestations of aphids and winter grain mites. However, if the aphid populations rise above the economic threshold after the small grains are well established, producers may opt to move livestock on part of the pasture and treat the remainder. After the reentry interval for grazing (specified on the insecticide label), the livestock can be turned into the treated part of the pasture. Once livestock return to the treated area, inspect the untreated area to determine whether aphid control is still needed there. In a heavily grazed field, aphid infestations are unlikely to be above the economic threshold.

Grazing can reduce aphid numbers 3- to 10-fold over fields not grazed. However, the difference will be less when aphid infestations are very light and many of the aphids are winged. In general, the heavier the grazing, the more an aphid infestation is reduced. When livestock are taken off the pastures, the aphids will increase. Livestock are generally removed from wheat pastures just before the wheat begins jointing and rapidly growing. At that point, damaging numbers of aphids are less likely to develop because the plants are large and vigorous and the pests' natural enemies are more active in warm, spring weather.

Biological Control

Factors that often hold insect and mite infestations below damaging levels include weather, inadequate food, and natural enemies. Recognize the effect of these natural control factors and, where possible, encourage them. Biological control uses living organisms— such as parasites (which live in or on the host and may kill it), predators (feed on the pests), and pathogens (cause diseases in pests) to reduce pest numbers. The primary natural enemies of insects and mites attacking wheat are several kinds of lacewings, lady beetles, and parasitic wasps. Other predators include big-eyed bugs, damsel bugs, spiders, and syrphid flies. Pathogenic fungi may control aphids occasionally. For more information on the natural enemies of wheat pests, see the AgriLife Extension publication *Biological Control of Insect Pests of Wheat,* which is available online at agrilifebookstore.org.

Biological control is most effective when used with other compatible pest control practices in an integrated pest management program. These practices include cultural control, host plant resistance, and the selective use of insecticides when other practices fail to keep pest numbers below economic levels. Methods of biological control are conservation, importation, and augmentation of natural enemies.

Conservation involves protecting existing populations of natural enemies. To prevent the development of economically damaging pest infestations, avoid using insecticides until they are needed. When you do apply an insecticide, minimize the effects by using those that are selective—that is, more toxic to the target pest than to the natural enemy.

Importation is the release of natural enemies into 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. For example, several species of natural enemies have been imported into Texas to control the Russian wheat aphid.

Augmentation is the periodic release of natural enemies that occur naturally but not in sufficient numbers to provide pest control. This practice can be effective in greenhouses. However, because little definitive information is available on the effectiveness of releasing natural enemies in wheat (such as when and how many to release), Extension entomologists cannot provide guidelines for augmentation as a management tool in wheat.

Insecticide use

Insecticides are a key component of IPM because they can reduce a pest population rapidly to avoid crop loss. However, they should be used only as a last resort to prevent economic loss from pests. Apply insecticides when pest density or plant damage approaches the economic threshold. Inspect the fields once or twice a week to determine crop growth, damage levels, and the pest and beneficial insect population levels. This information is necessary to determine if the pest is at the economic threshold or action threshold and if an insecticide treatment is needed to prevent economic loss. Unfortunately, economic thresholds have not been developed for all pests. When using insecticides, always read and follow the label directions.

Because pests are active at different times of the growing season, knowing when specific pests are likely to be present can help you anticipate pest infestations. Figure 2 compares the stages of small grain development. Table 1 shows the periods of plant development when pests are likely to attack.

The occurrence and development of different small grains pests are usually related to plant development and various environmental factors. Although the severity of insect problems cannot be predicted, the pest occurrence profile in Table 1 indicates the insect and mite pests that may attack small grains in various seasons and stages of development. Inspect the fields carefully to determine the presence and damage potential of each pest.

Soil pests

The most common soil insect pests of Texas small grains are white grubs, wireworms, false wireworms and cutworms. Weeds are important food sources for these pests. Key methods of reducing these soil pests include controlling weeds by summer fallowing, tillage, and using herbicides to reduce crop residues and kill weeds.

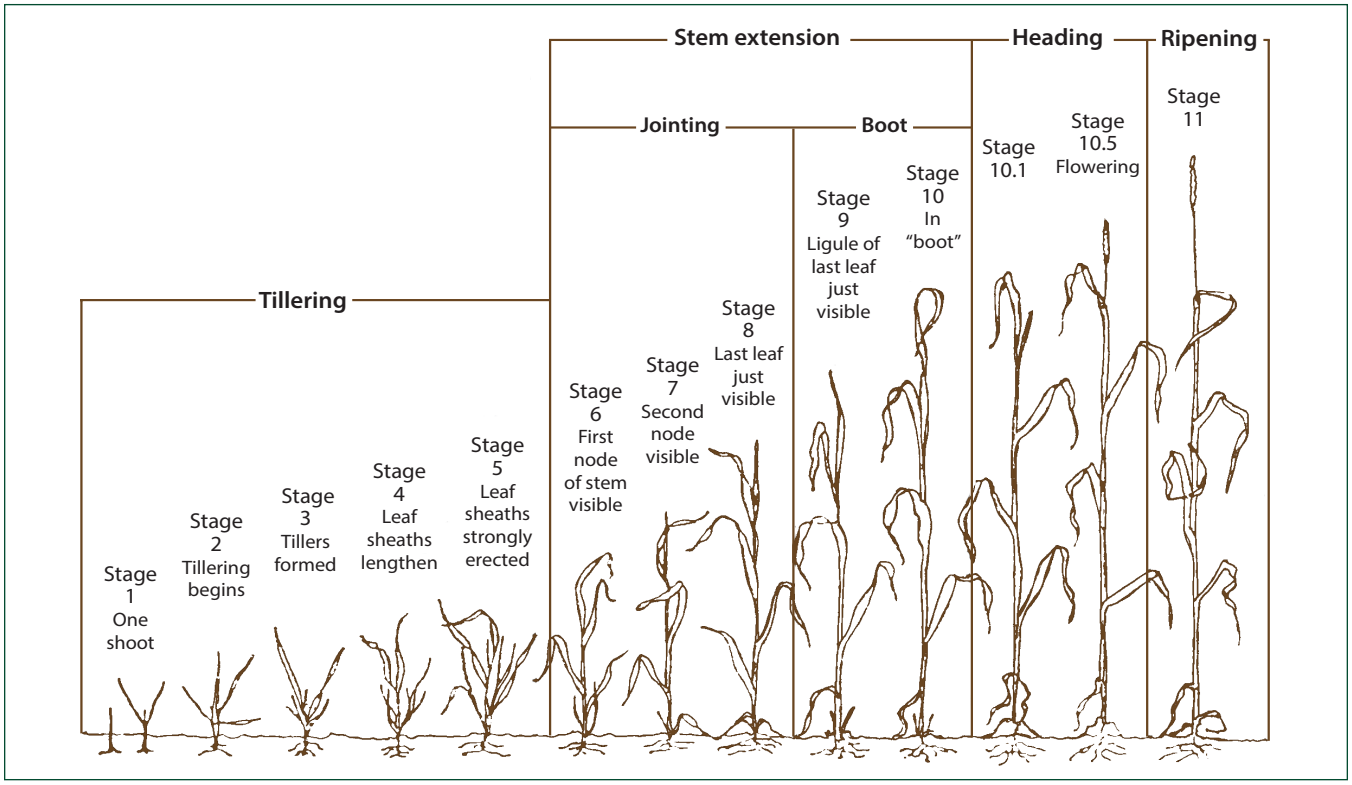

Figure 2. Feekes scale of small grain development

Table 1. Seasonal pest profile—the seasons and stages of plant development when various insect and mite pests may infest small grains

	Pest occurrence											
	Planting and crop establishment								----------Harvest----------			
Insect pest	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**
Army cutworm												
Bird cherry-oat aphid												
Brown wheat mite												
English grain aphid												
Fall armyworm												
Flea beetles												
Grasshopper												
Greenbug												
Hessian fly												
Russian wheat aphid												
Soil insects												
True armyworm												
Wheat curl mite												
Winter grain mite												

Insect presence
Possible damaging insect infestations

It is important to prepare the seedbed properly and inspect the soil for these pests before planting. There are no effective methods of treating soil pests with insecticides once the crop has been planted and seedlings have emerged. No insecticides are labeled for preplant soil application to small grains fields. Some insecticides can be applied to the seed before planting to control certain soil pests if damaging numbers of these pests are detected before planting or if the field has a history of pest damage.

White grub

White grubs are the larval stage of May and June beetles (*Phyllophaga* spp. and *Cyclocephala* spp.). The larvae are C-shaped with white bodies and tan to brown heads (Fig. 3). The last abdominal segment is transparent, making the dark, digested material inside visible. The larvae vary in size according to age and species. The grubs feed on plant roots and can kill small seedlings and reduce stands. Larger plants with severely pruned roots may be stunted and become more susceptible to drought. As the soil cools in the fall, white grub feeding decreases and the larvae migrate deeper into the soil. Delayed planting may improve stand establishment. Although no insecticides are registered to control white grubs in wheat, limited field tests suggest that insecticide seed treatments may suppress light infestations.

Figure 3. White grubs

True wireworm and false wireworm

True wireworm (Elateridae family) and false wireworm (Tenebrionidae family) larvae are similar looking, but the adult true wireworm is a click beetle, and the adult false wireworm is a darkling beetle (Figs. 4 and 5). Both feed on planted seeds and seedling roots and can reduce stands and plant vigor. Noticeable stand losses are evidence of wireworm damage. Damage increases when dry weather in the fall delays germination, providing more time for wireworms to feed on the seed.

Figure 4. True wireworms

Figure 5. False wireworm

Cultural controls are the same for both types of wireworms:

- Killing weeds in fields
- Rotating to warm-season crops
- Rotating to crops that can be treated with a pre-plant soil insecticide

Some species of wireworms are abundant only in poorly drained soils. Proper drainage of such soils will help prevent damage.

Sample fields for wireworms: Fields can be sampled for wireworms using solar bait stations placed in the field about 3 weeks before planting. To make a wireworm bait station:

1. Dig a hole about 3 to 4 inches deep and 6 to 9 inches wide.
2. Place ½ cup of wheat in the bottom of the hole.
3. Backfill the baited area and mound soil over it.
4. Cover the mound with an 18-inch square of black plastic and a 1-yard-square sheet of clear plastic.
5. Put soil on the plastic edges to hold the sheets down.
6. Set about a dozen bait stations per 40 to 50 acres.

After 2 weeks, dig up the bait and count the wireworm larvae. If the stations average one or more wireworms, consider treating the wheat seed with an insecticide. The reliability of this method depends on soil temperature, soil moisture levels to initiate seed germination, and the population size and distribution of wireworms in the soil profile. To decide whether to treat seeds or implement other practices to reduce wireworm problems, know how to recognize wireworm damage, keep good records of wireworm problems in the field, and know each field's history of wireworm problems.

Imported fire ant

Imported fire ants, *Solenopsis invicta* Buren, feed on wheat seeds along field margins where colonies are concentrated (Fig. 6). Feeding may cause stand loss extending 10 to 15 feet into the field. Damage is most common during dry, warm weather that delays germination and gives ants more time to feed. Loose, dry soil gives ants easy access to the seed.

Figure 6. Imported fire ants

Aboveground pests

Army cutworm and other cutworms

Cutworms are the immature stages of drab, brownish moths that are most active at night. Several species can damage small grains. Cutworm moths lay eggs in grassy, weedy fields; army cutworm moths lay eggs even on bare soil. Newly hatched cutworms are brown to black and feed on small grain seedlings. The older larvae look shiny or greasy (Fig. 7). The larvae clip the aboveground part of the plant from the root system at or below the soil surface (Fig. 8). Infested fields look as if they have been closely grazed, and the damage may be "clumped" in spots in the field.

Figure 7. Army cutworm

Figure 8. Army cutworms and damage in wheat

In Texas, the most common cutworm species attacking small grains is the army cutworm (*Euxoa auxiliarias*). Although it is a true cutworm, it feeds much like an armyworm. The caterpillars are surface feeders and move to above ground at night and on cloudy days to feed. They cut off small plants at or near the soil surface. During the day, the larvae hide under soil clods and debris close to the base of the plant. The army cutworm has one generation per year. During late summer and early fall, the female moth lays 1,000 to 2,000 eggs as it migrates through an area. The eggs hatch in a few days, and the larvae feed periodically through the fall and winter on warmer days. By mid- to late winter, the larvae in small grains can be ⅜ to 1½ inches long. Large populations can cause considerable damage by defoliating plants and reducing stands, especially in February and March as the grains begin to green up. Particularly vulnerable to the army cutworm are thin, late-planted, or poorly tillering stands.

In outbreak years, fields can have 10 to 20 cutworms per square foot. On sunny days, they will be under debris or slightly below the soil surface. Consider applying insecticide when infestations reach four to five cutworms per square foot. The larvae pupate in the soil in early spring and emerge as moths about 3 to 4 weeks later. These moths are attracted to lights and can become a nuisance around homes and buildings. The moths migrate from the Great Plains to the Rocky Mountains to escape the summer heat, returning in late summer and early fall to begin the cycle again. To minimize cutworm numbers, reduce weeds and crop residues in fallowed fields, and delay planting until the fields have been clean-plowed.

Fall armyworm

Caterpillars of the fall armyworm (*Spodoptera frugiperda* (J. E. Smith)) feed on seedlings in the fall, thinning stands and reducing the production of early-season forage. The larvae are most consistently shades of brown but may also be greenish to nearly black (Figs. 9 and 10). They have a white inverted "Y" between the eyes (Fig. 11) and four distinct black spots on top of the eighth abdominal segment. Mature larvae are 1½ inches long. In addition to small grains, fall armyworms feed

Figure 9. Fall armyworm larva showing the four distinct black spots on the eighth abdominal segment

Figure 10. Larvae of fall armyworm hatching

Figure 11. White inverted "Y"of a fall armyworm

on alfalfa, corn, cotton, cowpeas, peanuts, grain sorghum, and sorghum-grass hybrids.

Early planting of small grains greatly increases the risk of fall armyworm infestations. The moths may deposit egg masses (Fig. 12) on the leaves of seedling small grains. Small larvae feed on the leaf tissue, creating tiny "windowpanes" in the leaves. Larger larvae consume entire leaves and are more difficult to control. On seedlings, consider applying insecticide if fall armyworms are present and reducing the stand. Once plants are established, control is suggested when there are 4 or more larvae 1 inch or longer per square foot and when their damage threatens the stand. Delaying planting can reduce damage when other host crops have large infestations or when dry conditions limit the attractiveness of other hosts. Under these conditions, large numbers of armyworm may infest newly planted wheat.

Figure 12. Mass of fall armyworm eggs

True armyworm

The larvae of the true armyworm (*Pseudaletia unipuncta* (Haworth)) can attack small grains in large numbers, devouring all material in their path. Outbreaks are favored by cool, damp weather from late March through June. When fully grown, the larvae are 1½ inches long and green to brown with light stripes on their sides and back (Fig. 13). A brown or dark band is on the outer side of each proleg (small, fleshy leg on the abdomen). The head, which has a pattern of narrow lines that looks like a net, lacks the white inverted "Y" of the fall armyworm.

Figure 13. True armyworm

Armyworm larvae do not develop well once daytime highs average 88°F. The heat causes their numbers to decrease dramatically. Infestations often begin in areas where the small grains are the tallest and thickest or near the edge of fields, where weeds provide a favorable environment. During the day, armyworms hide at the bases of the plants; they move up the plants to feed late in the afternoon, at night, and during cloudy weather. They can cause extensive damage below the crop canopy before they are detected. Early armyworm detection is important because small larvae are easier to control. Also, the larger the larvae, the more they consume. Signs of damage include defoliation and beard and head clipping. It is important to protect the flag leaf and grain head from armyworm damage. Control measures are suggested when four to five larvae per square foot are found in combination with evidence of extensive feeding on lower leaves.

Wheat head armyworm

Although wheat head armyworms are a minor pest of wheat, they appear each year as a late-season wheat pest in the Texas High Plains. There are 13 known species of wheat head armyworms in the genus *Dargida* (synonym *Faronta*) and all of the larvae and moths look similar. The moths have a wingspan of about 1¼ to 1½ inches. Moths are yellow-brown with a lengthwise brown stripe on each forewing. They emerge to lay eggs in the spring, and the first generation of larvae emerges in late May and June. Infestations often occur along field margins.

The larvae are slender and greenish to light tan, depending on the maturity of the grain (Fig. 14). They can be up to 1½ inches long. Yellow, white, and brown stripes run lengthwise on each side of the body. The larvae feed in the wheat heads and damage the kernels, primarily those in the soft

Figure 14. Wheat head armyworm armyworm

dough stage. Infestations are heavier in dryland fields and on the edges of irrigated fields. Feeding damage is most often evident after harvest, when hollowed out kernels become apparent. No thresholds have been established for treatment. Plus, the pre-harvest intervals (PHIs) for most available insecticides make it difficult to treat when the larvae are causing damage. Most products labeled for other armyworms have a 14- to 35-day PHI for grain. Insecticides with the active ingredients malathion and chlorantraniliprole have PHIs of 7 days and 1 day, respectively.

Greenbug

Greenbugs (S*chizaphis graminum* (Rondani)) are pale green aphids that usually have a dark green stripe on the back (Fig. 15). They are about 1/16 inch long. Greenbugs suck plant juices and inject toxins into wheat plants, causing the leaves to yellow and die. They also are an important vector of the barley yellow dwarf virus and possibly more plant diseases.

Figure 15. Greenbugs

Under favorable conditions—temperatures between 55 and 95°F—greenbugs reproduce rapidly, develop in large numbers (Fig. 16), and can cause economic losses. Their natural enemies, however, reproduce slowly at temperatures below 65°F. Consequently, greenbugs may increase to enormous numbers in cool weather, while their natural enemies are multiplying slowly.

Figure 16. Greenbug colony

In winter, 99 percent of the greenbugs can be killed when temperatures average below 20°F for at least 1 week. The population also must be without protection from snow cover. Greenbugs can infest spots in fields or entire fields. As the populations increase, areas in the field may turn yellow from aphid feeding. Heavy, uncontrolled infestations may kill the plants. Greenbugs cause more damage when small grains lack moisture during a mild winter and cool spring. The damage may be confused with moisture stress, nitrogen deficiency, or dryland root rot (foot rot).

Estimating greenbug infestations: The Glance 'n Go greenbug sampling system calculates treatment thresholds based on the potential crop value, cost of control, and time of year. This method is quicker and simpler than counting greenbugs. The system was developed by wheat researchers of Oklahoma State University and USDA–ARS at Stillwater, Oklahoma. For Glance 'n Go information and scouting forms, visit http://entoplp.okstate.edu/gbweb/index3.htm.

Producers still wanting to count greenbugs can walk diagonally across the field, making at least five random counts per 20 acres of field area. Each count should consist of 1 linear foot of row. Greenbugs can be counted while they are on small plants. For larger plants, slap the plant against the ground or a clipboard to jar the insects loose for counting. If the greenbugs are numerous, estimate the number of insects present. Sample greenbugs during the warmest part of the day, when they are most likely to be exposed on the aboveground parts of the plants. During cool, dry weather, the insects may congregate in loose soil at the bases of plants, which makes detection and chemical control difficult.

When to treat greenbugs: Table 2 provides a general guide for determining the need for treatment when counting greenbugs. It is impractical to specify all the conditions under which to apply insecticides for greenbug control. Some of the factors are the number of greenbugs present, the size and vigor of the plants, air temperature, time of year, moisture conditions, plant growth stage, and effectiveness of parasites and predators. However, low temperatures slow the activity and effectiveness of most insecticides. It may take twice as long for an insecticide to kill at 45°F as it would at 70°F. For best results, apply insecticides when temperatures are above 50°F. If you must spray at lower temperatures, use the highest rate recommended.

Irrigated small grains can withstand larger greenbug populations. The presence of yellow or brown plants caused by greenbug feeding in spots in the field may indicate a need to estimate infestation levels. Occasionally, treating very young plants

Table 2. Treatment thresholds for greenbugs in small grains

Plant height (inches)	Number of greenbugs per linear foot
3–6	100–300
4–8	200–400
6–16	300–800

may be warranted when greenbug populations average 25 to 50 aphids per foot of drill row.

Heavy, rapidly increasing greenbug infestations can cause excessive damage. However, when the weather is warm, lady beetles and parasitic wasps can reduce greenbug populations. Where there are one to two lady beetles (adults and larvae) per foot of row, or 15 to 20 percent of the greenbugs are mummies from being parasitized, delay control measures until you can determine whether the greenbug population is continuing to increase. Other important predators include spiders, damsel bugs, lacewing larvae, and syrphid fly larvae. When weather conditions are favorable for predators and parasites, they will significantly reduce greenbug populations within a week. More information is available in the Texas A&M AgriLife Extension publication *Biological Control of Insect Pests of Wheat*, which is available online at agrilifebookstore.org.

Insecticide-resistant greenbugs: In 1990, surveys conducted in sorghum fields in counties north of Amarillo found greenbugs that were resistant to some registered insecticides. And, a resistant population was again found in the western Panhandle in 2014. Resistant greenbugs may be mixed with susceptible greenbugs and be detected only after an insecticide application for greenbugs or Russian wheat aphids. To delay greenbug resistance to pesticides, apply insecticide only to fields where economic thresholds have been exceeded.

Host plant resistance: In 1996, TAM-110 was the first wheat variety to carry resistance to all current greenbug biotypes (E, I, and K). In 2005, TAM-112, which had the same greenbug resistance genes as TAM 110, was released with improved yield and milling characteristics. In some years, planting wheat varieties with resistance to disease may be equally or more important than planting varieties with resistance to insects.

Russian wheat aphid

The Russian wheat aphid (RWA) first appeared in the United States in March 1986 in the Texas High Plains. It has since spread throughout the Great Plains, into Canada, and to the West Coast. This aphid (*Diuraphis noxia* (Mordviko)) is lime green, spindle shaped, and about 1/16 inch long. It has short antennae and a projection above the cauda, or tail. The projection gives the insect a "double tailed" appearance (Figs. 17 and 18).

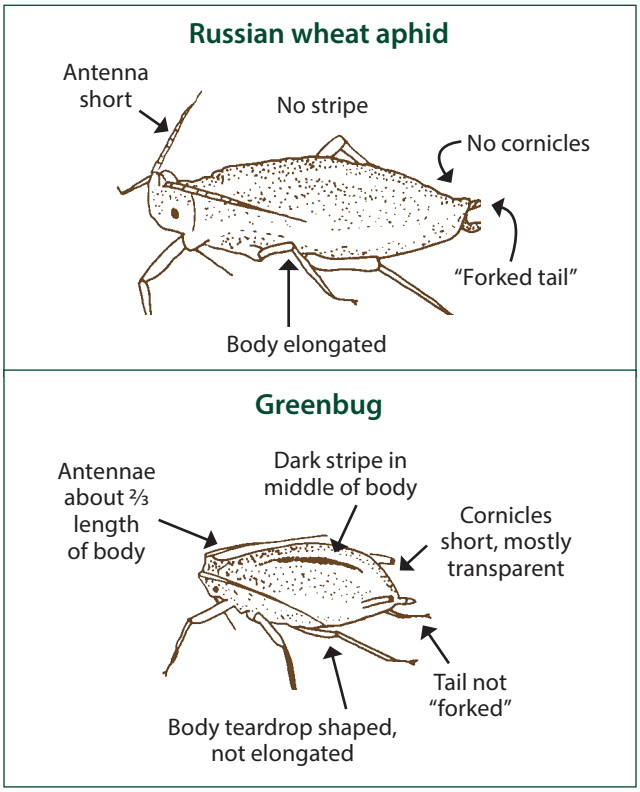

Figure 17. Comparison of Russian wheat aphid (top) and greenbug

Russian wheat aphids lack prominent cornicles. While feeding, Russian wheat aphids inject a toxin that causes white and purple streaks running lengthwise on the leaves. Tillers of heavily infested plants appear flattened, and leaf edges roll inward,

Figure 18. Russian wheat aphids

giving the entire leaf a tubelike appearance (Fig. 19). Russian wheat aphids prefer feeding on the younger, uppermost leaves of a plant. Unlike the greenbug and bird cherry-oat aphid, the Russian wheat aphid does not spread the barley yellow dwarf virus.

Figure 19. Russian wheat aphids feeding

Because these aphids cause the most damage when small grains are moisture stressed, use cultural practices that reduce crop stress. Destroying volunteer wheat and planting later will delay the initial infestation.

Predators and parasites are also important in reducing Russian wheat aphid populations. Many of the natural enemies that attack greenbugs also attack Russian wheat aphids. To help conserve these natural enemies, use insecticide judiciously.

For hosts, the Russian wheat aphid prefers wheat and barley to oats, rye, and triticale. They are occasionally observed on corn and sorghum but are not known to cause any damage.

In 2003, a Russian wheat aphid biotype was detected that had developed resistance to all previously resistant Russian wheat varieties with the *Dn4* resistant gene. This aphid biotype, RWA2, was first found in Colorado. The formerly resistant wheat varieties are Ankor, Halt, Prairie Red, Prowers, and Stanton. Although adapted to the Texas High Plains, they were used primarily in Colorado and Western Kansas. A survey across the Great Plains in 2005 found that 88 percent of the Russian wheat aphids sampled from the Texas High Plains were the resistant RWA2 biotype. However, surveys in 2010 to 2013 indicated that the aphid had shifted to biotypes that were not resistant (90 percent) to the *Dn4* resistant gene. These changes in RWA biotypes indicate that to help protect against RWA damage, producers need to plant wheat varieties with the latest resistance to RWA. Also, scout the fields routinely for unexpected infestations and damage.

RWA populations are largest and, consequently, the most damaging in the High Plains (Fig. 20).

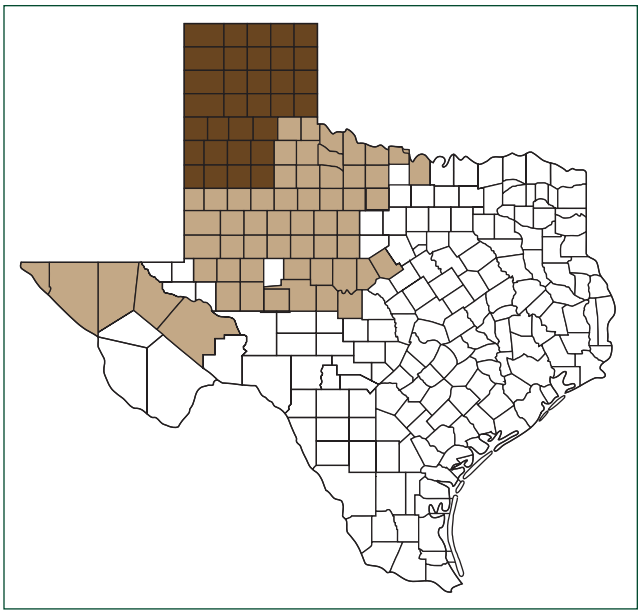

Figure 20. Texas counties where Russian wheat aphids have been found. (Dark brown indicates area where Russian wheat aphids are most damaging.)

Although the aphid occurs in the Rolling Plains, it is not an important pest because it cannot survive the summer (*over-summer*) there. In the High Plains, RWA can over-summer on warm-season grasses such as buffalo grass, green sprangletop, and several species of grama grass. Cool-season grasses that are wild hosts of the Russian wheat aphid include various brome grasses, jointed goat grass, and several species of wheat grasses. Insecticides applied to the seed can control early-season infestations of RWA. Once the crop has reached soft dough, an insecticide application may not be justified.

Sampling and economic thresholds for RWA: Sampling involves walking across a field and randomly selecting 100 tillers, each from a different site. To prevent bias, reach down and grab the tillers without looking at them. Then carefully examine each tiller and record the number of tillers that are infested. Consider any tiller with one or more Russian wheat aphids as infested. Determine the percentage of tillers that are infested. Then use Table 3 to decide whether treatment is justified. For example, if the market value of the crop is projected to be $50 per acre and control costs are $9 per acre, the treatment threshold is 36 percent infested tillers. The thresholds in Table 3 are for Russian wheat aphids infesting wheat in late winter

Table 3. Russian wheat aphid economic threshold using percent infested wheat tillers as the sampling unit

Control cost per acre $	Market value of crop ($) per acre					
	50	100	150	200	250	300
	Percent infested tillers					
4	16	8	5	4	3	3
5	20	10	7	5	4	3
6	24	12	8	6	5	4
7	28	14	9	7	6	5
8	32	16	11	8	6	5
9	36	18	12	9	7	6
10	40	20	13	10	8	7
11	44	22	15	11	9	7
12	48	24	16	12	10	8

and spring. The thresholds are based on the cost of control and the market value of wheat. For every 1 percent of the tillers infested, yield drops by 0.5 percent.

A formula for calculating when to treat can be used instead of the table. The formula for determining the economic threshold level is based on the percentage of tillers infested before flowering:

$$\text{\% tillers infested to treat} = \frac{\text{Cost of control/acre} \times 200}{\text{Expected yield/acre} \times \text{Market value per bushel}}$$

To calculate the threshold during and after flowering, substitute 500 for 200 in the formula.

Bird cherry-oat aphid

Bird cherry-oat aphids feed on various grains and grasses and are particularly abundant on small grains. These aphids (*Rhopalosiphum padi* (L.)) are yellowish green, dark green, or black and have a reddish-orange area around the base of the cornicles (Fig. 21). Because bird cherry-oat aphids do not inject a toxin while feeding (unlike the greenbug), they are less damaging. Control measures for the bird cherry-oat aphid are rarely needed to prevent damage from direct feeding. However, an insecticide treatment may be necessary when this aphid is very abundant and the crop is under moisture stress. Like the greenbug, the bird cherry-oat aphid is an important vector of the barley yellow dwarf virus and possibly other diseases. Seed treatments to control early-season infestations of greenbugs and bird cherry-oat aphids may reduce the potential spread of barley yellow dwarf virus by these aphids.

Figure 21. Bird cherry-oat aphid

English grain aphid

English grain aphids (*Macrosiphum* (Sitobion) *avenae* (F.)) are about 1/10 inch long and larger than other cereal aphids. They are light green to brown and have long, black antennae, cornicles, and legs (Fig. 22). These aphids can be a concern in the spring, when they feed on stems during flowering and on developing kernels in the wheat heads. Their feeding can result in shrunken grain and lower test weight. Because many of the same predators and parasites that help control the greenbug also control English grain aphids, they seldom cause yield losses. They are a vectors of barley yellow dwarf virus. Treatment thresholds for English grain aphid have not been developed for Texas. Until more information is available, the thresholds used on winter wheat in Nebraska can serve as a guide for managing English grain aphid in Texas.

Figure 22. English grain aphid

To use these thresholds:

1. Count the English grain aphids on each stem and each head at several sites across the field.
2. Calculate the average number of aphids per stem (including those on the head).
3. Consider applying insecticide if infestations across the field average
   - 5 or more aphids per stem during the flowering stage
   - 10 or more per stem during the milk stage of grain development
   - More than 10 aphids per stem during the milk to medium dough stage

Rice root aphid

The rice root aphid (*Rhopalosiphum rufiabdominalis* (Sasaki)) feeds on plant roots in spots within wheat fields. Stunted plants may be the first indication of its presence, with only a small percentage of plants infested. These aphids are olive or dark green and up to 1/10 inch long (Fig. 23). They usually have a reddish area at the rear between and around the base of the cornicles. Rice root aphids vector barley yellow dwarf virus. Insecticidal control measures have not been developed for this insect. Its primary hosts are peaches and plums. Secondary host plants include rice, wheat, and other small grains.

Figure 23. Rice root aphid

Winter grain mite

The winter grain mite (*Penthaleus major* (Dugés)) feeds on the leaves of barley, oats, and wheat. Feeding turns the leaf tips brown, stunts the plants, and causes them to appear silvery gray. These mites range from 1/32 inch to 1/16 inch long. The adult has four pairs of reddish-orange legs, and the body is dark brown to black (Fig. 24). Winter grain mites feed primarily at night and remain around the base of the plant during the day. They are less active in hot, dry weather. The most significant damage occurs in winter and early spring. It is usually more severe in fields where small grains were planted in previous years. To reduce infestations, rotate with other kinds of crops. The appearance of feeding symptoms and the presence of mites indicate the need for control.

Figure 24. Winter grain mite

Brown wheat mite

The brown wheat mite (*Petrobia latens* (Müller)) is about the size of the period at the end of this sentence and is considerably smaller than the winter grain mite. Its rounded body is metallic dark brown with a few short hairs on the back. The front legs are about twice as long as the other three pairs of legs (Fig. 25). This mite occurs throughout the High Plains and Rolling Plains. Brown wheat mites are most prevalent in dry weather (Fig. 26), and populations increase when wheat suffers from deficient moisture. Miticides are often not warranted if the crop is so drought stressed that it cannot respond.

Figure 25. Brown wheat mite

Figure 26. Brown wheat mite damage

Wheat curl mite

The wheat curl mite (*Aceria tosichella* Keifer) is white, sausage shaped, and about 1/100 inch long (Fig. 27). It has four small legs on the front. This mite vectors wheat streak mosaic, triticum mosaic, and wheat mosaic virus (formerly called High Plains virus) but causes very little damage otherwise. Mite feeding alone causes the leaves to roll and take on an onion leaf appearance. If the virus is present, the leaves become mottled and

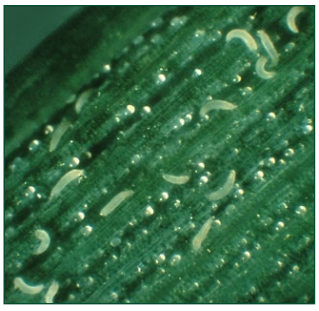

Figure 27. Wheat curl mites

streaked with yellow. Wheat curl mites reproduce fastest at 75 to 80°F. They crawl very slowly and depend almost entirely on wind for dispersal. The mite is most active during warm weather and moves mostly on warm, southwesterly winds. Consequently, most symptoms of the wheat streak mosaic virus develop from southwest to northeast across a field. The mites over-summer on grass-type hosts and volunteer wheat. Volunteer wheat is the most important host for the mite as well as for the wheat mosaic virus, wheat streak mosaic virus, and possibly the triticum mosaic virus.

Populations of wheat curl mites are likely to be highest when:

- Mites migrate to early volunteer wheat after hail damages wheat that is nearing maturity.
- July rains produce good stands of volunteer wheat.
- Volunteer wheat is not destroyed, or not destroyed until after the planted wheat is up.
- Wheat is planted early.
- Summers are cool.
- Autumn is warm and dry, the optimum conditions for mite reproduction and movement.

There are no remedial control options once a wheat plant is infected with the wheat streak mosaic virus or wheat mosaic viruses. Chemicals do not control the mites or prevent disease infections. Therefore, the most effective control strategies are avoiding infection and choosing plant resistant varieties. Research has shown that TAM112 has resistance but not immunity to both the mite and the viral diseases.

Prevent the wheat curl mite from transmitting viruses by breaking the "green bridge" from one wheat crop to the next by using these management practices:

- Eliminate grass weeds and volunteer wheat around your fields and neighboring properties.
- Delay plantings near properties under the Conservation Reserve Program (CRP) or native stands of grasses until the grasses have senesced.
- Destroy grass weeds and volunteer wheat by tillage or a burn-down herbicide at least 21 days before planting wheat.

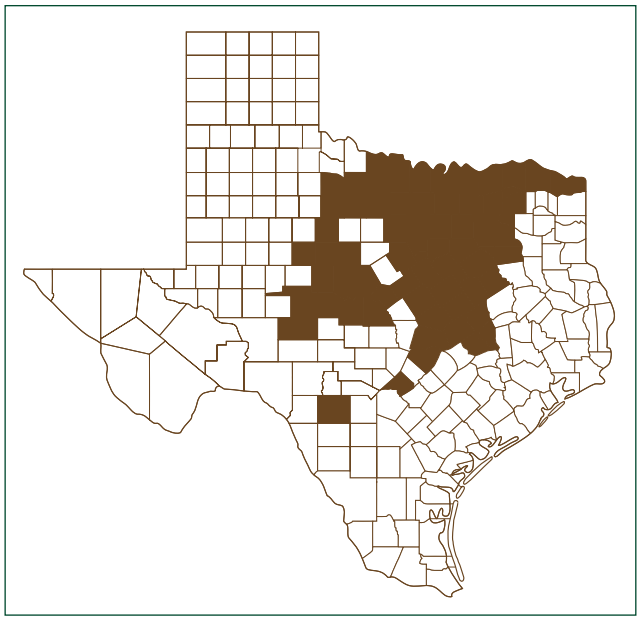

Figure 28. Counties in which the Hessian fly has been recorded

Hessian fly

The Hessian fly (*Mayetiola destructor* (Say)) infests wheat in the Central Rolling Plains and central and southwest Texas (Fig. 28). The mosquito-like Hessian fly adult is ⅒ inch long and has dark wings, a black thorax, and a dark red abdomen. Females deposit an average of 200 eggs in clusters of 5 to 12 glossy red eggs in the grooves on the upper leaf surface. They prefer to lay eggs on younger plants and leaves. After hatching, the larvae move down the leaf grooves and under the leaf sheath, coming to rest just above the plant crown or just above a node. As they develop, the larvae suck plant juices and form a shallow depression in the stem. Newly hatched larvae are red but turn lighter in a few days. Fully developed larvae are white with a semitransparent green stripe down the middle of the back (Fig. 29). At maturity, the larva forms rigid, dark brown, outer case, or puparium. This period is known as the "flaxseed" stage because the puparium resembles a flax seed (Fig. 30). The Hessian fly survives the summer as a

Figure 29. Hessian fly larvae

dormant, fully developed larva inside the *puparium*. The adult fly emerges from the puparium (Fig. 31). It will live no more than 3 days.

Figure 30. Hessian fly larvae in the "flaxseed" stage

Figure 31. Hessian fly adult

The larvae injure wheat by feeding on stem tissue at the crown of young plants or just above the nodes on jointed wheat. They cause more damage to newly emerged and younger seedlings than to older, established plants. In the fall and early winter, feeding stunts infested tillers, and the leaves become somewhat broader and darker green. Stunted tillers, particularly in younger plants, usually wither and die. Consequently, stands are thin in the fall, less forage is produced, and more plants succumb to winterkill. If the infested tillers survive, their growth and yield will decrease. Hessian fly infestations in the spring also stunt tiller growth and cause uneven plant height. Larval feeding at the nodes weakens the stem at the feeding site and may cause significant lodging or stem breakage, making harvest more difficult. During kernel formation, feeding can also interfere with nutrient flow to the head, reducing grain quantity and quality. Expect significant grain losses when fall infestations exceed 5 to 8 percent or when spring infestations exceed 20 percent of the stems.

Although the preferred host is wheat, infestations have been seen on barley, emmer, rye, spelt, and triticale. Oats are not a host for the Hessian fly. It has occasionally been found on wild grasses such as little barley, goatgrass, quackgrass, timothy, and western wheatgrass. There are likely other grass hosts in Texas.

Management strategies

To reduce economic losses, adopt the following cultural practices:

- Grow adapted wheat varieties with resistance to Hessian fly. Information about these varieties for your area is available from your county Extension agent and wheat seed dealer.
- Plant later in the fall to reduce the potential for a fall generation.
- Destroy volunteer wheat, which serves as an early-season host.
- Bury crop residue 4 to 6 inches deep.
- Rotate to crops other than wheat or barley to suppress the fly population.
- Avoid moving infested straw to a non-infested area.

Resistant varieties: Some wheat varieties are resistant to certain populations of the Hessian fly but susceptible to other populations of this pest. These unique populations of Hessian flies are called *biotypes.* They result from genetic changes that allow the flies to feed and survive on different varieties of wheat.

Some biotypes cannot survive on wheat varieties that have specific genes for resistance. This is why planting Hessian fly-resistant varieties usually works well to prevent losses.

However, Hessian flies can overcome resistance in wheat just as rust fungi develop new races. Over time, the widespread planting of one or two resistant varieties can favor biotypes that survive on the resistant varieties. This new, virulent biotype eventually can become so common that the formerly resistant varieties begin to suffer damage.

The *Texas Wheat Variety Trial Results* lists the resistance of hard red winter varieties to Hessian fly each year. The report is posted under "Wheat Variety Results – State Wide, at http://varietytesting.tamu.edu/wheat/#varietytrials. It includes a table, "Hard Red Winter Wheat Characteristics," that lists the susceptibility or resistance of these varieties.

Delayed planting: Postponing planting minimizes the damage from the Hessian fly and reduces the number of fall generations.

A date in late fall after which flies do not emerge is called the *fly-free date.* In central Oklahoma and farther north in the wheat belt, planting after this date has effectively reduced or prevented Hessian fly infestations and damage. This practice has proved to be of limited value in Texas, where intermittent periods of warm weather allow the adults to emerge, mate, and lay eggs well into December.

If you must plant wheat early for grazing livestock, minimize the risk of Hessian fly infestation by planting a variety that is resistant to the fly, or consider treating the seed with insecticide for fields with a history of Hessian fly damage.

Destroying volunteer wheat: Controlling volunteer wheat is a useful management tool for many wheat pests, including aphids, Hessian flies, and wheat curl mites. The lack of wheat deprives the first-generation adults of a place to deposit their eggs.

Reducing crop residue: Plowing under old wheat stubble 4 to 6 inches deep in August greatly reduces adult emergence from buried plant residue. However, soil erosion and moisture-retention problems in some areas can dictate that residue burial be limited to conform to conservation practices.

Rotating crops: Although crop rotation helps reduce Hessian flies in a given field, they can remain in the old wheat residue for 2 years, and wind can carry the adults to nearby fields. Burning the straw kills the exposed pupae and larvae in the stems but not the pupae at the soil surface or below the soil line.

Containing infested straw: Avoid moving infested straw or hay to a non-infested area. When buying or selling wheat hay or straw, look for brown pupae behind the leaf sheaths at the nodes to make sure the material is not infested with live Hessian flies.

Applying pesticide: Insecticide seed treatments labeled for control of Hessian fly can suppress light infestations in seedling wheat in the fall. These treatments may not protect the seedling wheat from damage when large numbers of Hessian fly infest the crop.

Occasional pests

Stinkbugs

Several species of stinkbugs feed on and damage wheat during flowering and grain fill, including the rice stinkbug, southern green stinkbug, several species of brown stinkbugs, and in West Texas, the conchuela stinkbug (Fig. 32). Stinkbugs have piercing-sucking mouthparts that penetrate the developing kernel. The insects' feeding on immature grain can reduce germination, kernel weight, and baking quality. The periods most susceptible to stinkbug feeding and damage are the flowering and milk stages. Once the grain is in the soft dough stage, it is less susceptible to damage from stinkbugs.

Figure 32. Stinkbugs that occasionally feed on and damage wheat during flowering and grain fill (from left): Conchuela, rice, and southern green stinkbugs

In a research study, one rice stinkbug per 10 wheat heads (spikes) during the milk stage significantly reduced germination and kernel weight. During the soft dough stage, no significant reduction in germination or kernel weight was found until at least three rice stinkbugs per 10 heads were present. Similar results were observed for southern green stinkbug. These results suggest that if rice or green stinkbugs average one or more per 10 heads during the flowering or milk stage, apply an insecticide to protect the crop from damage. During the soft dough stage, consider treatment if infestations average 3 or more per 10 heads. An infestation of 1 stinkbug per 10 heads is a high infestation. Stinkbugs are usually not distributed uniformly within a field. Instead, they are often more abundant in local areas, often near field margins. To accurately assess the infestation before deciding on treatment, scout several areas of the field.

Beet armyworm

Fully developed beet armyworm larvae (*Spodoptera exigua* (Hübner)) are 1¼ inches long. They are light green with a conspicuous black spot on each side of the thorax above the second pair of thoracic legs (Fig. 33). Damaging populations are most likely to occur in late summer or early fall when hot, dry conditions inhibit the growth of preferred hosts, forcing the moths to deposit egg masses on young, small grains. Compared to other caterpillar pests, beet armyworms are more difficult to control with

Figure 33. Beet armyworm

insecticides. Choose an insecticide that lists *beet armyworm* on the label. Fields planted after mid-October usually escape beet armyworm infestation.

Chinch bug and false chinch bug

Adult chinch bugs (*Blissus leucopterus leucopterus* (Say)) are about ⅛ inch long. The body is black, but the wings are mostly white with black triangular spots at the middle of the outer margin (Fig. 34). Young chinch bugs are shaped like the adults. They are red at first but turn darker as they mature. They have a white band across the abdomen (Fig. 34).

Figure 34. Chinchbugs

In early spring, chinch bugs move into small grains from bunch grass, where they overwinter. Young and adult chinch bugs feed on small grains, and very heavily infested plants may be stunted or killed. Infestations are usually confined to small, well-defined spots. When a damaging infestation occurs on the field border, prompt treatment may prevent infestation of the entire field.

Adult false chinch bugs (*Nysius raphanus* (Howard) are ⅛ inch long, narrow, and a dull yellowish gray (Fig. 35). The wing tips are transparent and extend beyond the end of the abdomen. These insects often increase in the spring on weedy plants in the Mustard family and then migrate in large numbers to other crops, including small grains.

Figure 35. False chinchbugs

False chinch bugs suck sap from the stems and heads of small grains. This feeding may cause poorly filled heads and shriveled grain, but the extent of their damage is not well documented.

Before applying insecticide, consider the percentage of the field infested and make sure that these bugs are feeding on the small grains and not just migrating through.

Grasshoppers

Several species of grasshoppers are occasional problems in Texas small grains (Fig. 36). Most damage occurs in the fall when these pests migrate into fields.

Before planting, check the areas around the wheat fields for heavy infestations. Treat them before the planted wheat emerges. Some insecticides applied as seed treatments are labeled for grasshopper control.

Flea beetles

Flea beetles (*Phyllotreta cruciferae* (Goeze)) are black, shiny, and about the size of a pinhead (Fig. 37). They jump readily when approached. In the fall, these beetles may infest the borders of a field and gradually move across it, feeding on and killing plants as they go. They skeletonize the leaves, giving injured plants a bleached appearance before they wilt and die.

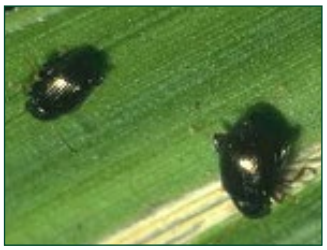

Figure 37. Flea beetles

Fields and field borders that have been kept clean of weeds during the previous season are less subject to flea beetle damage.

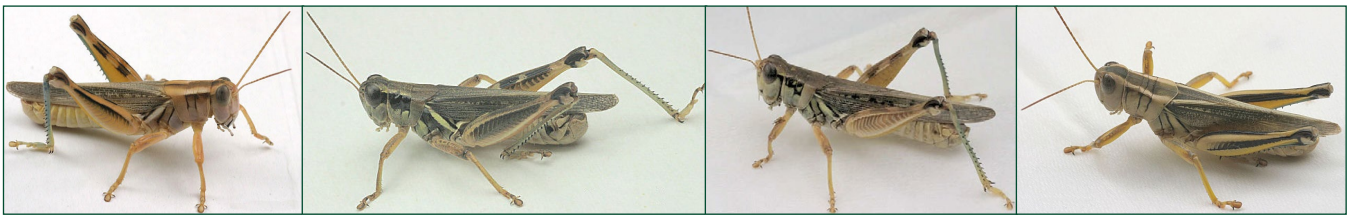

Figure 36. Grasshoppers that occasionally cause problems in Texas small grains (from left): Packard, red-legged, migratory, and two-striped grasshoppers

Wheat stem maggot

The second-generation wheat stem maggot (*Meromyza americana* Fitch) produces adult flies that emerge in the spring and lay eggs on the leaves of barley, oats, rye, wheat, and other grass hosts.

The developing larvae, or maggots, feed on the stem just above the last stem joint, cutting the flow of moisture and nutrients to the head (Fig. 38). The head turns from green to tan to white, but the leaf sheath and stem below where the maggots have tunneled remain green. These white heads are easily pulled from the plant.

Because the infested tillers seldom exceed 1 percent of the wheat, insecticide treatments are rarely, if ever, necessary.

Figure 38. Wheat stem maggots (left) and damage

Pale western cutworm

The pale western cutworm (*Agrotis orthogonia* Morr.) is a subterranean cutworm that feeds almost entirely on the stems of the wheat crown just below the soil surface. The larvae prefer loose, sandy, dry, or dusty soil.

Evidence of caterpillar feeding includes wilted leaves, thinning stands, and dead tillers (Fig. 39). When the infestation is severe, the larvae can destroy a field in a matter of days.

In late summer and fall, the adult moths emerge and deposit up to 300 eggs per female in cultivated soil. Although some eggs may hatch in the fall, most hatch in late winter or early spring. After developing in the spring, the mature larvae (Fig. 40) burrow into the soil to transform into a pre-pupa. This stage over-summers until pupating in August. Because dry weather favors the survival of pale western cutworms, outbreaks may follow dry springs.

Figure 39. Pale western cutworm damage

Figure 40. Pale western cutworm

Consider treating if you find one larva per square foot when the potential for yield is good, and 2 larvae per square foot when the potential for yield is low.

Leafhopper

Sometimes during dry weather in late fall, the aster leafhopper and other leafhopper species migrate in large numbers into fields of small grains. These pests apparently increase on wild hosts and move into small grains to feed on succulent plants. Leafhoppers suck sap from the leaves. When infestations are large, the fields can look silver. Infestations often decline after freezing temperatures. Insecticide recommendations have not been developed for leafhoppers infesting wheat.

Policy statement for making pest management suggestions

The information and suggestions in this publication reflect the opinions of Extension entomologists based on field tests and experience. The recommendations are a product of research and are believed to be reliable.

However, it is impossible to eliminate all risk. Unforeseen or unexpected conditions or circum-

stances may result in less-than-satisfactory results, even when these suggestions are used. The Texas AgriLife Extension Service will not assume responsibility for risks. Such risks shall be assumed by the user of this publication.

Pesticides must be registered and labeled for use by the U.S. 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.

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 the instructions on the container label carefully.

Endangered species regulations

The Endangered Species Act is designed to protect and help the recovery of animals and plants that are in danger of becoming extinct. In response to the Endangered Species Act, many pesticide labels now carry restrictions limiting the use of products or application methods in areas that have been designated as biologically sensitive.

These restrictions are subject to change. To determine what restrictions apply to your area, refer to the Environmental Hazards or Endangered Species discussion sections on the product labels or call your county Extension agent or Fish and Wildlife Service personnel.

Regardless of the law, pesticide users can be good neighbors by being aware of how their actions may affect people and the natural environment.

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 that you protect your employees from pesticide exposure.

You must protect employees from exposure, inform them about exposure, and mitigate pesticide exposures that they may receive. WPS requirements appear in the "Directions for Use" part of the pesticide label. For more information, see Agricultural Worker Protection Standard (WPS), 40 CFR Part 170, or call the Texas Department of Agriculture, Pesticide Program, (800) 835-5832.

Quick reference guide for wheat pests with established thresholds

True armyworm, *Pseudaletia unipucta* (Haworth): Control measures are suggested when 4 to 5 larvae per square foot are found in combination with evidence of extensive feeding on lower leaves.

Fall armyworm, *Spodoptera frugiperda* (J. E. Smith): Once the plants are established, control is suggested when there are 4 or more larvae 1 inch or longer per square foot and when their damage is threatening the stand.

Pale western cutworm, *Agrotis orthogonia* Morr.: Consider treating when there is 1 larva per square foot and the potential for yield is good, or 2 larvae per square foot when the potential for yield is low.

Greenbugs, *Schizaphis graminum* (Rondani): There are two methods for determining when to consider beginning control methods. Use either a) Table 2 or b) the Glance 'n Go scouting forms and information, which are posted at http://entoplp.okstate.edu/gbweb/index3.htm.

Table 2. Treatment thresholds for greenbugs in small grains

Plant height (inches)	Number of greenbugs per linear foot
3–6	100–300
4–8	200–400
6–16	300–800

Russian wheat aphid: See Table 3 and the formula for calculating threshold levels.

Table 3. Russian wheat aphid economic threshold using percent infested wheat tillers as the sampling unit

Control cost per acre $	Market value of crop ($) per acre					
	50	100	150	200	250	300
	Percent infested tillers					
4	16	8	5	4	3	3
5	20	10	7	5	4	3
6	24	12	8	6	5	4
7	28	14	9	7	6	5
8	32	16	11	8	6	5
9	36	18	12	9	7	6
10	40	20	13	10	8	7
11	44	22	15	11	9	7
12	48	24	16	12	10	8

Formula for calculating threshold levels

$$\text{\% infested tillers to treat} = \frac{\text{Cost of control/acre} \times 200}{\text{Expected yield/acre} \times \text{Market value/bushel}}$$

Note: To calculate the threshold during and after flowering, substitute 500 for 200 in the formula

Stinkbugs: If rice or green stinkbugs average 1 or more per 10 heads during the flowering or milk stage, apply an insecticide to protect the crop from stinkbug damage. During the soft dough stage, consider treatment if infestations average 3 or more per 10 heads.

Seed treatments containing pesticides labeled for use on small grains

Crop	Trade name company	Common/ chemical name	% active ingredient	Rate/cwt of seed	Pests	Additional information
Barley, oat, rye, triticale, wheat	Cruiser 5FS Syngenta	thiamethoxam	47.6%	0.75–1.33 fl oz/cwt	**Insects:** Aphids, Hessian fly[1]	Provides early-season protection of seedlings against injury by aphids (including bird cherry-oat, English grain, greenbug, and Russian wheat aphid) [1]Oats are not a host of Hessian fly. Although no insecticides are registered for white grub control in wheat, limited field tests suggest that Cruiser® seed treatments are effective.
				0.19–0.50 fl oz/cwt	**Insects:** Wireworms	
Barley, triticale	CruiserMaxx Cereals Syngenta	thiamethoxam mefenoxam difenoconazole	2.80% 0.56% 3.36%	5.0 fl oz/cwt	**Insects:** Aphids, wireworms **Diseases controlled:** Common and dwarf bunt, damping-off caused by seed- and soil-borne *Fusarium* and soil-borne *Pythium*, general seed rots, loose smut, root rot, seedling blight **Diseases suppressed:** Common root rot (*Cochliobolus* spp.), early-season *Rhizoctonia* root rot, *Fusarium* crown and foot rot, take-all	To protect against aphids, mix an additional amount of Cruiser 5FS with CruiserMaxx Cereal. Mix 5.0 fl oz Cruiser Maxx Cereal with 0.48–1.0 fl oz Cruiser 5FS/100 lb seed. Cruiser Maxx Cereals suppresses wireworm activity; however, if wireworm pressure is high, mix 5.0 fl oz Cruiser Maxx Cereal with 0.25 fl oz Cruiser 5FS/100 lb seed. Although no insecticides are registered for white grub control in wheat, limited field tests suggest that Cruiser® seed treatments will suppress white grub populations. Do not apply a neonicotinoid insecticide–any crop that has been grown from seed treated by Cruiser Maxx Cereals.
Wheat (winter and spring)	CruiserMaxx Cereals Syngenta	thiamethoxa mefenoxam difenoconazole	2.80% 0.56% 3.36%	5.0 fl oz/cwt	**Insects:** Aphids, Hessian fly, wireworms **Diseases controlled:** Common and dwarf bunt; damping-off caused by seed- and soil-borne *Fusarium* and soil-borne *Pythium*; general seed rots; loose smut; root rot; seedling blight **Diseases suppressed:** Common root rot (*Cochliobolus* spp.), early-season *Rhizoctonia* root rot, foot rot, *Fusarium* crown rot, take-all	To protect against aphids, an additional amount of Cruiser 5FS must be mixed with CruiserMaxx Cereal. Mix 5.0 fl oz Cruiser Maxx Cereal with 0.48–1.0 fl oz Cruiser 5FS/100 lb seed. Cruiser Maxx Cereals suppresses wireworm activity; however, if wireworm pressure is high, mix 5.0 fl oz Cruiser Maxx Cereal with 0.25 fl oz Cruiser 5FS/100 lb seed. Although no insecticides are registered for white grub control in wheat, limited field tests suggest that Cruiser® seed treatments will suppress white grub populations. Do not apply a neonicotinoid insecticide—any crop that has been grown from Cruiser Maxx Cereals treated seed.

continued on next page

Seed treatments containing pesticides labeled for use on small grains continued

Crop	Trade name company	Common/ chemical name	% active ingredient	Rate/cwt of seed	Pests	Additional information
Barley, oat, rye	CruiserMaxx Vibrance Cereals Syngenta	thiamethoxam mefenoxam difenoconazole sedaxane	2.78% 0.86% 3.34% 0.72%	5.0–10 fl oz/cwt	**Insects:** European chafer, wireworms **Diseases controlled:** Common and dwarf bunt; damping-off caused by seed- and soil-borne *Fusarium* spp. or Rhizoctonia spp.; general seed rots; root rot; seed-borne septoria; seedling blight; soil-borne *Pythium* spp. **Diseases suppressed:** Common root rot (*Cochliobolus* spp.), *Fusarium* crown and foot rot, take-all	The 5 fl oz/cwt rate of CruiserMaxx Vibrance Cereals suppresses wireworm activity. If pressure is moderate or high or control is required, use the higher rate of CruiserMaxx Vibrance Cereals. To control European chafer activity, use the higher rate of CruiserMaxx Vibrance Cereals.
Triticale, wheat (winter and spring)	CruiserMaxx Vibrance Cereals Syngenta	thiamethoxam mefenoxam difenoconazol sedaxane	2.78% 0.86% 3.34% 0.72%	5.0–10 fl oz/cwt	**Insects:** Wireworms, European chafer **Diseases controlled:** Common and dwarf bunt; flag bunt[1]; *Fusarium* seed scab; general seed rots; karnal bunt; loose smut; seed-borne septoria; seedling blight, root rot, and damping-off caused by seed- and soil-borne *Fusarium* spp. or Rhizoctonia spp., and soil-borne *Pythium* spp.; septoria leaf blotch[1] **Diseases suppressed:** Common root rot (*Cochliobolus* spp.), *Fusarium* crown and foot rot, take-all	The 5.0 fl oz/cwt rate of CruiserMaxx Vibrance Cereals suppresses wireworm activity. If pressure is moderate or high or control is required, use the higher rate of CruiserMaxx Vibrance Cereals. To control European chafer activity, use the higher rate of CruiserMaxx Vibrance Cereals. [1] Control of these diseases is listed for winter wheat and triticale, not for spring wheat.
Barley, oat, rye	CruiserMaxx Vibrance Quattro Syngenta Seed Shield Cereals Helena Warden Cereals WRII Windfield United	thiamethoxam mefenoxam difenoconazole sedaxane fludioxonil	5.75% 0.86% 3.45% 1.44% 0.72%	5.0 fl oz/cwt	**Insects:** Aphids, European chafer, wireworms **Diseases controlled:** Common bunt; covered smut; dwarf bunt[2]; false loose smut[1]; general seed rots; seed-borne septoria; seedling blight, root rot, and damping-off caused by seed- and soil-borne *Fusarium* spp. or Rhizoctonia spp., and soil-borne *Pythium* spp.; true loose smut **Diseases suppressed:** Common root rot (*Cochliobolus* spp.)[3], foot rot, *Fusarium* crown rot, take-all	The 5 fl oz/cwt rate of Cruiser Vibrance Quattro suppresses wireworm activity and aphids. If pressure is moderate or high or control is required, apply up to 0.8 fl oz additional Cruiser 5FS [1]For control in barley [2]For control in rye [3]For suppression in oat

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Seed treatments containing pesticides labeled for use on small grains continued

Crop	Trade name company	Common/ chemical name	% active ingredient	Rate/cwt of seed	Pests	Additional information
Triticale, wheat (winter and spring)	CruiserMaxx Vibrance Quattro Syngenta Seed Shield Cereals Helena Warden Cereals WRII Windfield United	thiamethoxam mefenoxam difenoconazole sedaxane fludioxonil	5.75% 0.86% 3.45% 1.44% 0.72%	5.0 fl oz/cwt	**Insects:** Aphids, European chafer, wireworms **Diseases controlled:** Common bunt, damping-off caused by seed- and soil-borne *Fusarium* spp. or Rhizoctonia spp., dwarf bunt[1], flag bunt[1], *Fusarium* seed scab, general seed rots, karnal bunt, loose smut, root rot, seed-borne septoria, seedling blight, septoria leaf blotch[1], soil-borne *Pythium* spp. **Diseases suppressed:** Common root rot (*Cochliobolus* spp.), *Fusarium* crown and foot rot, take-all	The 5 fl oz/cwt rate of Cruiser Vibrance Quattro suppresses wireworm activity and aphids. If pressure is moderate or high or control is required, apply up to 0.8 fl oz additional Cruiser 5FS. [1]Control of these diseases is listed for winter wheat and triticale, not for spring wheat.
Barley, oat, rye, triticale, wheat	Attendant 480 FS Arysta U.S.A. Macho 480 ST Albaugh, LLC/ Agri Star Nitro Sheild IV Windfield United	imidacloprid imidacloprid	40.23% 40.7%	1.0–3.0 fl oz/ cwt 0.16–0.32 fl oz/cwt 1.5–3.0 fl oz/cwt	**Insects:** Aphids, Hessian fly[1] **Insects:** Wireworms **Insects:** Grasshoppers	[1]Oats are not a host of Hessian fly. Provides early-season protection of seedlings against injury by aphids (including bird cherry-oat, English grain, greenbug, and Russian wheat aphid) Suppresses wireworm activity on seed and young seedlings only Treated seed may be planted as a 50–60-foot border around the perimeter of the field to help minimize early-season damage from grasshoppers. Do not graze or feed livestock on treated areas for 45 days after planting.

For end-use application at agricultural establishments: Always mix product thoroughly before using. Apply using equipment such as a total slurry treater (TST), farmer-applied seed treater (F.A.S.T.) or other on-farm seed treating equipment capable of accurately applying low rates of each product. Apply 1.0–3.0 fl oz per hundredweight (cwt) of seed as a slurry treatment before planting. Each product must be combined with a fungicide product for seed and seedling protection against fungal pathogens, as well as the listed insects. Depending on the fungicide product used, dilution with water may be necessary for optimum coverage. Products may also be applied on farm seed previously treated with a fungicide. In this case, dilution is necessary.

For commercial seed treatment: Each product may be applied with mechanical, slurry, or mist-type seed treating equipment, provided that the equipment is calibrated to accurately and uniformly apply the product to seed. For maximum effectiveness, seed must be treated uniformly and covered thoroughly.

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Seed treatments containing pesticides labeled for use on small grains continued

Crop	Trade name company	Common/ chemical name	% active ingredient	Rate/cwt of seed	Pests	Additional information
Barley, oat, rye, triticale, wheat	Axcess BASF Dyna-Shield Imidacloprid 5 Loveland Products, Inc. Gaucho 600 Flowable Bayer CropScience Macho 600 ST Albaugh, LLC/ Agri Star	imidacloprid	48.7%	0.8–2.4 fl oz/cwt	**Insects:** Aphids, Hessian fly[1]	Provides early-season protection of seedlings against injury by aphids (including bird cherry-oat, English grain, greenbug, and Russian wheat aphid) [1]Oats are not a host of Hessian fly. Low use rate for "wireworm-only" protection for suppression of wireworm activity on seed and young seedlings To reduce early-season damage caused by grasshoppers, plant treated seed as a 50–60-foot border around the edges of the field. Do not graze or feed livestock on treated areas for 45 days after planting.
				0.13 to 0.26 fl oz/cwt	**Insects:** Wireworms	
				1.2–2.4 fl oz/ cw	**Insects:** Grasshoppers	—
Barley, oat, rye, triticale, wheat	Nitro Shield Windfield United Senator 600 FS Nufarm Agricultural Products Sharda Imidacloprid 5SC Sharda USA Startup IMIDA United Phosphorus	imidacloprid	48.7%	0.8–2.4 fl oz/cwt	**Insects:** Aphids, Hessian fly[1]	Provides early-season protection of seedlings against injury by aphids (including bird cherry-oat, English grain, greenbug, and Russian wheat aphid) Oats are not a host of Hessian fly[1]. Low use rate for "wireworm-only" protection for suppression of wireworm activity on seed and young seedlings To reduce early-season damage caused by grasshopper plant treated seed as a 50–60-foot border around the edges of the field. Do not graze or feed livestock on treated areas for 45 days after planting.
				0.13 to 0.26 fl oz/cwt	**Insects:** Wireworms	
				1.2–2.4 fl oz/cwt	**Insects:** Grasshoppers	
For end-use application at agricultural establishments: Apply using a total slurry treater (TST), farmer applied seed treater (F.A.S.T.), air pressure system or other on-farm seed treating equipment to deliver accurate rates of the product to achieve optimum product performance. Apply 0.8–2.4 fl oz/cwt seed. Each product should be combined with a fungicide product for seed and seedling protection against fungal pathogens, as well as insect pests. Dilution with water may be necessary depending on fungicide formulation used. Products may also be applied on-farm as an over-treatment–seed pretreated with a fungicide. In this case, dilution is necessary.						
Barley, oat, wheat	Enhance AW Arysta U.S.A.	imidacloprid Captan-related derivatives carboxin	20.0% 19.55% 0.45% 20.0%	4 oz/cwt	Insects: Aphids, Hessian fly[1], wireworm **Diseases controlled:** Common bunt, stinking smut. Protects seed from seed- and soil-borne fungi that cause seed decay, damping-off, and seedling blights (including *Fusarium, Cochliobolus sativus, Rhizoctonia* and *Pythium*) for all labeled crops	Provides early-season protection of seedlings against injury by aphids (including bird cherry-oat, English grain, greenbug, Russian wheat aphid) Suppresses early-season Hessian fly damage [1]Oats are not a host of Hessian fly. Suppresses wireworm activity on seed and young seedlings Do not graze or feed livestock on treated areas for 45 days after planting.

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Seed treatments containing pesticides labeled for use on small grains continued

Crop	Trade name company	Common/ chemical name	% active ingredient	Rate/cwt of seed	Pests	Additional information
Barley, wheat	Dyna-Shield Foothold Extra Loveland Products, Inc. Sativa IM Max Nufarm Agricultural Products	imidacloprid metalaxyl tebuconazole	11.37% 0.60% 0.45%	3.4–5.0 fl oz/cwt	**Insects:** Aphids, Hessian fly, wireworms **Diseases controlled:** Common root rot, covered smut, flag smut[1], *Fusarium* foot rot, loose smut, *Pythium* damping-off, Rhizoctonia root rot, septoria disease complex[1], stinking smut[1] **Diseases suppressed:** Barley leaf rust, barley stripe, powdery mildew, wheat leaf rust	Early-season protection of seedlings against injury by aphids (including bird cherry-oat, English grain, greenbug, and Russian wheat aphid) and wireworms Although no insecticides are registered for white grub control in wheat, limited field tests suggest that imidacloprid seed treatments are effective. [1]Also listed for wheat Do not graze or feed livestock on treated areas for 45 days after planting.
Barley, wheat	Dyna-Shield Foothold Virock Loveland Products, Inc. Sativa IMF Max Nufarm Agricultural Products	imidacloprid metalaxyl tebuconazole fludioxonil	11.16% 0.60% 0.45% 0.36%	3.4–5.0 fl oz/cwt	**Insects:** Aphids, Hessian fly, wireworms **Diseases controlled:** Common root rot, covered smut; flag smut[1]; *Fusarium* foot rot; loose smut; *Pythium* damping-off; Rhizoctonia root rot; seed decay caused by *Aspergillus, Penicillium,* and other species; septoria disease complex[2]; stinking smut[2] **Diseases suppressed:** Barley leaf rust, barley stripe, powdery mildew, wheat leaf rust	Early-season protection of seedlings against injury by aphids (including bird cherry-oat, English grain, greenbug, and Russian wheat aphid) [1]Also listed for wheat disease control Do not graze or feed livestock on treated areas for 45 days after planting.
Barley, oat, wheat	Gaucho XT Flowable Bayer CropScience	imidacloprid metalaxyl tebuconazole	12.7% 0.82% 0.62%	3.4–4.5 fl oz/cwt	**Insects:** Aphids, Hessian fly[1], wireworms **Diseases controlled:** Common root rot, covered smut, flag smut[2], *Fusarium* foot rot, loose smut, *Pythium* damping-off, *Rhizoctonia* root rot, *septoria* disease complex[2], stinking smut[2] **Diseases suppressed:** Barley leaf rust, barley stripe, powdery mildew, wheat leaf rust	[1]Oats are not a host of Hessian fly. Early-season protection of seedlings against injury by aphids (including bird cherry-oat, English grain, greenbug, Russian wheat aphid) [2]Also listed for oat and wheat disease control Do not graze or feed livestock on treated areas for 45 days after planting.

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Seed treatments containing pesticides labeled for use on small grains continued

Crop	Trade name company	Common/ chemical name	% active ingredient	Rate/cwt of seed	Pests	Additional information
Barley, oat, rye, triticale, wheat (winter and spring)	Rancona Crest Arysta U.S.A. Warden Cereals HR Windfield United	imidacloprid metalaxyl ipconazole	14.1% 0.562% 0.421%	5.0–8.33 fl oz/cwt	**Insects:** Aphids, Hessian fly[1], grasshoppers, white grubs, wireworms **Diseases controlled:** Common bunt; covered smut[2]; damping-off and seedling blight (seed- and soil- borne *Fusarium, Cochliobolus sativus,* and *Pythium*); false loose smut[2]; general seed rots by *Penicillium* and *Aspergillus;* loose smut; *Rhizoctonia* root rot; seed rot; true loose smut[2] **Diseases suppressed:** Common root rot, *Fusarium* foot rot, leaf stripe[2]	Early-season protection of seedlings against injury by aphids (including bird cherry-oat, English grain, greenbug, and Russian wheat aphid) Suppresses early-season Hessian fly damage [1]Oats are not a host of Hessian fly. Suppresses wireworm activity on seed and young seedlings Early-season protection from damage by white grubs (including European chafer, Japanese beetles, northern masked chafer) Treated seed may be planted as a 50–60-foot border around the perimeter of the field to help minimize early-season damage from grasshoppers. [2]Also listed for barley Do not graze or feed livestock on treated areas for 45 days after planting.
Barley, oat, rye, triticale, wheat (winter and spring)	Rancona Crest WR Arysta U.S.A. Warden Cereals WR Windfield United	imidacloprid metalaxyl ipconazole	2.95% 0.585% 0.439%	5.0–8.33 fl oz/cwt	**Insects:** Wireworm **Diseases controlled:** Common bunt; covered smut[1]; false loose smut[1]; general seed rots by *Penicillium* and *Aspergillus;* loose smut; *Rhizoctonia* root rot, seed rot, damping-off and seedling blight (seed- and soil- borne *Fusarium, Cochliobolus sativus,* and *Pythium*); true loose smut[1] **Diseases suppressed:** Common root rot, *Fusarium* foot rot, leaf stripe[1]	Suppresses wireworm activity on seed and young seedlings [1]Also listed for barley Do not graze or feed livestock on treated areas for 45 days after planting.
Barley, oat, triticale, wheat	Sativa IM RTU Nufarm Agricultural Products TebuStar IM ST Albaugh, LLC/ Agri Star	imidacloprid metalaxyl tebuconazole imidacloprid metalaxyl tebuconazole	1.58% 0.632% 0.474% 1.538% 0.615% 0.461%	5.0 fl oz/cwt	**Insects:** Wireworms **Disease controlled:** Common root rot; flag smut; *Fusarium* foot rot; general seed rots; loose smut; *Pythium* damping-off; *Rhizoctonia* root rot; seedborne *Fusarium* scab; *septoria* disease complex; stinking smut **Diseases suppressed:** Powdery mildew, rust	Suppresses wireworm activity on seed and young seedlings Do not graze or feed livestock on treated areas for 45 days after planting.

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Seed treatments containing pesticides labeled for use on small grains continued

Crop	Trade name company	Common/ chemical name	% active ingredient	Rate/cwt of seed	Pests	Additional information
Barley, oat, triticale, wheat	Sativa IMF RTU Nufarm Agricultural Products	imidacloprid metalaxyl tebuconazole fludioxonil	1.55% 0.62% 0.46% 0.37%	5.0 fl oz/cwt	**Insects:** Wireworms **Diseases controlled:** Common root rot; flag smut, *Fusarium* foot rot, general seed rots; loose smut, *Pythium* damping-off; *Rhizoctonia* root rot; seed decay by *Aspergillus, Penicillium,* and other species; seedborne *Fusarium* scab; stinking smut **Diseases suppressed:** Powdery mildew, rust	Suppresses wireworm activity on seed and young seedlings Do not graze or feed livestock on treated areas for 45 days after planting.
Barley, oat, rye, triticale, wheat	NipsIt Inside[1] Valent U.S.A. LLC Agricultural Products	clothianidin	47.8%	0.25–1.79 fl oz/cwt 0.75–1.79 fl oz/cwt 1.79 fl oz/cwt	**Insects:** Wireworms **Insects:** Aphids **Insect:** Hessian fly[2]	[1]Nipsit Inside can be applied under 2ee regulations to all listed crops for grasshoppers at 1.0–1.79 fl oz/cwt. Treated seed may be planted as a 50–60-foot border around the edges of the crop as a barrier–immature grasshoppers advancing toward the interior of the field. [2]Oats are not a host of Hessian fly.
Barley, oat, wheat	NipsIt Suite Valent U.S.A. LLC Agricultural Products	clothianidin metalaxyl metconazole	2.93% 0.88% 0.44%	5.0–7.5 fl oz/cwt	**Insects:** Wireworms **Diseases controlled:** Common bunt[2], common root rot, covered smut[1], flag smut[2], *Fusarium* seed scab, *Fusarium* seedling dieback, loose smut, *Pythium* seed rot and seedling dieback, Rhizoctonia root rot, seed decay fungi	[1]Additional diseases for barley [2]Additional diseases for wheat

Foliar insecticides labeled for use on small grains

Crop	Common chemical name	Trade name	Rate per acre	Insect pest	Additional label information
Wheat	chlorpyrifos	Chlorpyrifos 4E Ag Govern 4E Hatchet Lorsban 4E Lorsban Advanced Nufos 4E Warhawk Warhawk Clearform Whirlwind Vulcan	0.5–1 pt	Greenbug, Russian wheat aphid, English grain aphid, brown wheat mite, grasshopper spp.	[1]Listed on Govern, Hatchet, Lorsban 4E, Lorsban Advanced, Nufos, Warhawk, Warhawk Clearform, and Whirlwind labels Do not apply within 14 days before harvest of forage and hay or within 30 days before harvest of grain and straw. Do not make more than 2 applications of any products containing chlorpyrifos per season. Do not allow meat or dairy animals to graze or otherwise feed on treated forage within 14 days of application. Do not feed straw from treated wheat within 28 days of application.
			1 pt	Army cutworm; suppression only of other cutworm spp., armyworms[1], cereal leaf beetle[1]	
Wheat	chlorpyrifos + *gamma*-cyhalothrin	Bolton	5–9 fl oz	Greenbug, Russian wheat aphid, bird cherry-oat aphid, English grain aphid, brown wheat mite, grasshopper spp.	Do not apply within 14 days before harvest of forage and hay or within 30 days before harvest of grain and straw. Do not make more than 2 applications of any products containing chlorpyrifos per season. Do not graze treated areas or harvest treated forage within 7 days after last treatment. Do not feed treated straw within 30 days after the last treatment.
			9–18 fl oz	Army cutworm, armyworms, cereal leaf beetle, cutworms, flea beetles	
			13–18 fl oz	Stink bug spp.	
		Cobalt	7–13 fl oz	Greenbug, Russian wheat aphid, oat bird-cherry aphid, English grain aphid, brown wheat mite, grasshopper spp.	
			13–25 fl oz		
			19–25 fl oz		
Wheat	chlorpyrifos + *lambda*-cyhalothrin	Cobalt Advanced	6–13 fl oz	Greenbug, Russian wheat aphid, oat bird-cherry aphid, English grain aphid, brown wheat mite, grasshopper spp.	Do not apply within 14 days before harvest of forage and hay or within 30 days before harvest of grain and straw. Do not make more than 2 applications of products containing chlorpyrifos per season. Do not graze treated areas or harvest treated forage within 7 days after last treatment. Do not feed treated straw within 30 days after the last treatment.
			11–25 fl oz	Army cutworm, armyworms, cereal leaf beetle, cutworms, flea beetles	
			16–25 fl oz	Stink bug spp.	

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Foliar insecticides labeled for use on small grains continued

Crop	Common chemical name	Trade name	Rate per acre	Insect pest	Additional label information
Wheat	chlorpyrifos + *zeta*-cypermethrin	Stallion	3.75–11.75 oz	Cutworm spp. (including army cutworm), painted lady caterpillar	Do not apply within 14 days before harvesting forage and hay or within 28 days before harvest of grain and straw. Do not allow meat or dairy animals to graze in treated areas on forage within 14 days of an application. Do not feed straw within 28 days of application.
			5.0–11.75 oz	Bird cherry-oat aphid, cereal leaf beetle, flea beetle, grasshopper, webworm spp., wheat stem maggot (adult), wheat stem sawfly (adult)	
			9.25–11.75 oz	Fall armyworms, southern armyworm, true armyworm, yellowstriped armyworm, chinch bug, greenbug, Russian wheat aphid, grasshopper spp., stink bug spp.	
Barley, oat, rye, triticale, wheat	chlorantraniliprole	Prevathon[1] Coragen[2]	14.0–20.0 fl oz[1] 3.5–7.5 fl oz[2]	Fall armyworm, true armyworm, beet armyworm	Do not apply more than 60 fl oz of Prevathon or 15.4 fl oz of products containing Coragen per acre per calendar year. Preharvest interval: 1 day
			8.0–20.0 fl oz[1] 2.0–5 fl oz[2]	Grasshopper spp.	
Barley, oat, rye, triticale, wheat, wheat hay	chlorantraniliprole + *lambda*-cyhalothrin	Besiege	5.0–8.0 fl oz	Army cutworm, cutworm spp.	Preharvest interval: 30 days Do not allow livestock to graze in treated areas or harvest treated wheat forage as feed for meat or dairy animals within 7 days after treatment. Do not feed treated straw to meat or dairy animals within 30 days after the last treatment.
			8.0–20.0 fl oz	Armyworm, bird cherry-oat aphid, cereal leaf beetle, English grain aphid, fall armyworm, flea beetle spp., grasshopper spp., Hessian fly, Russian wheat aphid, stink bug spp., Yellowstriped armyworm	
			8.0–10.0 fl oz	Grass sawfly	
			10.0 fl oz	Chinch bug, corn leaf aphid, greenbug, mite spp.	
Barley, oat, rye, triticale, wheat	*beta*-cyfluthrin	Baythroid XL	1.0–1.8 fl oz	Army cutworm, cereal leaf beetle, cutworm spp.	Pre-grazing or foraging interval: 3 days Preharvest interval: 30 days Do not apply more than 4.8 fl oz per acre per season.
			1.8–2.4 fl oz	Armyworms, bird cherry-oat aphid, English grain aphid, Russian wheat aphid, fall armyworms, flea beetles, grasshopper spp., southern armyworm, stink bug spp., yellowstriped armyworm, pale western cutworm	
			2.4 fl oz	Chinch bug	

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Foliar insecticides labeled for use on small grains continued

Crop	Common chemical name	Trade name	Rate per acre	Insect pest	Additional label information
Wheat	cyfluthrin	Tombstone Tombstone Helios	1.0–1.8 fl oz	Army cutworm, cereal leaf beetle, cutworm spp.	Pre-grazing or foraging interval: 3 days Preharvest interval: 30 days Do not apply more than 4.8 fl oz per acre per season.
			1.8–2.4 fl oz	Armyworms, bird cherry-oat aphid, English grain aphid, Russian wheat aphid, fall armyworms, flea beetles, grasshopper spp., southern armyworm, stink bug spp., yellowstriped armyworm, pale western cutworm	
			2.4 fl oz	Chinch bug	
Triticale, wheat	dimethoate	Dimethoate 4E Dimethoate 4EC Dimethoate 400 Dimethoate LV-4 Dimate 4E	0.5–0.75 pt	Aphids (greenbugs)	Do not apply within 14 days of grazing immature plants. Preharvest interval: 35 days Do not apply more than 1 pt per acre per year.
			0.33–0.5 pt	Brown wheat mite	
			0.75 pt	Grasshopper spp.	
Barley, oat, rye, triticale, wheat	flupyradifurone	Sivanto Prime	7.0–14.0 fl oz	Aphids, leafhoppers	Preharvest interval: 7 days for hay or forage; 21 days for dried grain, stover, or straw Do not apply more than 28 fl oz per acre per calendar year.
Triticale, wheat, wheat hay	*gamma*-cyhalothrin	Proaxis Proaxis-Insecticide	1.92–3.2 fl oz	Army cutworm, cutworm spp.	Do not apply within 30 days of harvest. Do not allow livestock to graze in treated areas or harvest treated wheat forage as feed for meat or dairy animals within 7 days after last treatment. Do not feed treated straw to meat or dairy animals within 30 days after the last treatment. Do not apply more than 0.48 pt per acre per season.
			2.56–3.84 fl oz	Fall armyworms, armyworms, English grain aphid, flea beetles, grasshopper spp., oat bird-cherry aphid, Russian wheat aphid, and stink bug spp., Hessian fly, yellowstriped armyworms	
			3.84 fl oz	Greenbug, mite spp., chinch bug and corn leaf aphid	
Barley, oat, rye, triticale, wheat, wheat hay	*gamma*-cyhalothrin	Declare Insecticide	0.77–1.28 fl oz	Army cutworm, cutworm spp.	Do not apply within 30 days of harvest. Do not allow livestock to graze in treated areas or harvest treated wheat forage as feed for meat or dairy animals within 7 days after last treatment. Do not feed treated straw to meat or dairy animals within 30 days after the last treatment. Do not apply more than 0.19 pt per acre per season.
			1.02–1.54 fl oz	Fall armyworms, armyworms, English grain aphid, flea beetles, grasshopper spp., oat bird-cherry aphid, Russian wheat aphid, Hessian fly, stink bug spp., yellowstriped armyworms	
			1.28-1.54 fl oz	Grass sawfly	
			1.54 fl oz	Greenbug, mite spp., chinch bug, corn leaf aphid	

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Foliar insecticides labeled for use on small grains continued

Crop	Common chemical name	Trade name	Rate per acre	Insect pest	Additional label information
Barley, oat, rye, triticale, wheat, wheat hay	*lambda*-cyhalothrin	Grizzly Z Insecticide[1] Kendo Insecticide Lambda-CY AG Lambda-CY EC Insecticide-RUP Lamcap Lamdec Insecticide[2] LambdaStar Insecticide LambdaStar 1CS Lambda T Paradigm Province Silencer Silencer VXN Willowood Lambda-CY 1EC	1.92–3.2 fl oz	Army cutworm, cutworm spp.	[1]Grizzly labeled for wheat, wheat hay, and triticale [2]Lamdec Insecticide labeled for wheat and wheat hay Do not apply within 30 days of harvest. Do not allow livestock to graze in treated areas or harvest treated wheat forage as feed for meat or dairy animals within 7 days after last treatment. Do not feed treated straw to meat or dairy animals within 30 days after the last treatment. Do not apply more than 7.68 fl oz per acre per season.
			2.56–3.84 fl oz	Fall armyworms, armyworms, English grain aphid, flea beetles, grasshopper spp., oat bird-cherry aphid, Russian wheat aphid, stink bug spp., Hessian fly, yellowstriped armyworms	
			3.20–3.84 fl oz	Grass sawfly	
			3.84 fl oz	Greenbug, mite spp., chinch bug, corn leaf aphid	
Barley, oat, rye, triticale, wheat, wheat hay	*lambda*-cyhalothrin	Karate with Zeon Technology Grizzly Too[1] LambdaStar Plus Insecticide Lamcap II Province II[1] Warrior II with Zeon Technology	0.96–1.92 fl oz 0.96–1.60 fl oz[1]	Army cutworm, cutworm spp.	Do not apply within 30 days of harvest. Do not allow livestock to graze in treated areas or harvest treated wheat forage as feed for meat or dairy animals within 7 days after last treatment. Do not feed treated straw to meat or dairy animals within 30 days after the last treatment. Do not apply more than 3.84 fl oz per acre per season.
			1.28–1.92 fl oz	Fall armyworms, armyworms, English grain aphid, flea beetles, grasshopper spp., oat bird-cherry aphid, Russian wheat aphid, stink bug spp., Hessian fly, yellowstriped armyworms	
			1.60–1.92 fl oz	Grass sawfly	
			1.92 fl oz	Greenbug, mite spp., chinch bug, corn leaf aphid	
Barley[1], oat[2], rye[2], wheat[2] (spring and summer)	malathion	Malathion 57 EC	1.5–2 pt[1] 1.5–1.6 pt[2]	Greenbug, English grain aphid, young grasshopper spp.	[1]Maximum single application rate: 2.0 pt/A [2]Maximum single application rate: 1.6 pt/A Preharvest interval: 7 days
			2 pt[1] 1.6[2]	Armyworms	
Barley[1], oat[2], rye[3], wheat[3] (spring and summer)	malathion	Malathion 5 EC Malathion 57% Fyfanon	1.0–2.0 pt[1]	Greenbug, English grain aphid, grasshopper spp., winter grain mites	[1]Maximum single application rate: 2.0 pt/A [2,3]Maximum single application rate: 1.6 pt/A Preharvest interval: 7 days
			1.5 pt[2,3]		
			1.0–2.0 pt[1] 1.5 pt[2] 1.0–1.5 pt[3]	Cereal leaf beetle	

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Foliar insecticides labeled for use on small grains continued

Crop	Common chemical name	Trade name	Rate per acre	Insect pest	Additional label information
Barley[1], oat[2], rye[2], wheat[2]	malathion	Malathion 5	1.5 pt[1,2]	Greenbug, English grain aphid	Preharvest interval: 7 days
			1.0–1.5 pt[1,2]	Cereal leaf beetle	
		Non ULV application	2.0 pt[2] 1.6 pt[3]	Armyworm	
			1.5–2.0 pt[1] 1.6 pt[2]	Grasshopper spp., aphids, spider mites, leafhopper	
Barley[1], oat[2], rye[2], wheat[2] (spring and summer)	malathion	Malathion 8 Flowable	1.0–1.25 pt[1] 1.0 pt[2]	Armyworms, greenbugs, English grain aphid, grasshopper spp.	[1]Maximum single application rate: 1.25 pt/A [2]Maximum single application rate: 1.0 pt/A Preharvest interval: 7 days
Barley[1], oat[2], rye[3], wheat[1] (spring and summer)	malathion	Fyfanon ULV AG	4–8 fl oz[1,2]	Cereal leaf beetles	Preharvest interval: 7 days ULV application labeled rate: 15.6 fl oz/A for each crop and all listed insects. Use closed mixing and loading system.
			8 fl oz[1,2,3]	Grasshopper spp.	
			6–8 fl oz[1,3]	Grass sawfly, barley and wheat midge, Hessian fly	
Barley[1], oat[1], rye[2], wheat[1] (spring and summer)	malathion	Malathion ULV Concentration	4–8 fl oz[1]	Cereal leaf beetle	Preharvest interval: 7 days
			8 fl oz[1,2]	Grasshopper spp.	
Barley, oat, rye, wheat (spring and summer)	methomyl	Annihilate SP	0.25–0.5 lb	Armyworms (except yellowstriped armyworm, western yellowstriped armyworm), cereal leaf beetle, aphids	Preharvest interval: 7 days
		Annihilate LV	0.75–1.5 pt		
Barley, oat, rye, triticale, wheat	spinetoram	Radiant SC Insecticide	2–6 fl oz	Cereal leaf beetle	Do not apply within 21 days of grain or straw harvest or within 3 days of forage, fodder, or hay harvest.
			3–6 fl oz	Grasshopper spp. (suppression)	

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Foliar insecticides labeled for use on small grains continued

Crop	Common chemical name	Trade name	Rate per acre	Insect pest	Additional label information
Barley, oat, rye, triticale, wheat	spinosad	Tracer Natralyte Insect Control	1.0–3.0 fl oz	Cereal leaf beetle	Do not apply within 21 days of grain or straw harvest or within 3 days of forage, fodder, or hay harvest. Do not allow cattle to graze treated area until spray has dried.
			1.5–3.0 fl oz	Armyworms, grasshopper spp., (suppression), webworms	
		Entrust Natralyte Insect Control	0.5–2.0 fl oz	Cereal leaf beetle	
			1.0–2.0 fl oz	Armyworms, grasshopper spp., (suppression), webworms	
		Entrust SC Natralyte Insect Control	2.0–6.0 fl oz	Cereal leaf beetle	
		SpinTor 2SC Natralyte Insect Control	3.0–6.0 fl oz	Armyworms, grasshopper spp.	
		Blackhawk Naturalyte Insect Control	1.1–3.3 fl oz	Cereal leaf beetle, true armyworm	
			1.7–3.3 fl oz	Armyworms (such as fall, yellowstriped), grasshopper spp., (suppression), webworms	
Barley, triticale, wheat	sulfoxaflor	Transform WG	0.75–1.5 oz	Aphids (including greenbug and Russian wheat aphid)	Do not apply within 14 days of grain or straw harvest or within 7 days of grazing, or forage, fodder, or hay harvest. Do not apply more than a total of 2.8 oz per acre per year.
Triticale, wheat	*alpha*-cypermethrin	Fastac CS insecticide[1] Fastac EC insecticide[2]	1.3–3.8 fl oz[1,2]	Cutworm spp. (including army cutworm), painted lady caterpillar	Preharvest interval: 14 days (grain, forage, and hay)
			1.8–3.8 fl oz[1,2]	Armyworms (southern, true, yellow-striped), cereal leaf beetle, flea beetle, pale western cutworm, webworm spp.	
			3.2–3.8 fl oz[1] 3.2–3.9 fl oz[2]	Aphid spp., beet and fall armyworms, chinch bug, grasshopper spp., greenbug, leafhopper spp., stink bug spp., wheat stem sawfly	
Barley[1], oats[1], rye[1], triticale[2], wheat[2]	*zeta*-cypermethrin	Mustang Maxx[3] Respect Respect EC[3,5] Mustang[4]	1.28–4.0 fl oz[3] 1.4–4.3 fl oz[4]	Cutworm spp. (including army cutworm), painted lady caterpillar	[1, 3, 4]Preharvest interval: 14 days (grain, straw, and hay) [2, 3, 4]Preharvest interval: 14 days (grain, forage, and hay) [5]Respect and Respect EC labeled only for triticale and wheat
			1.76–4.0 fl oz[3] 1.9–4.3 fl oz[4]	Armyworms (southern, true, yellow-striped), cereal leaf beetle, flea beetle, pale western cutworm, webworm spp.	
			3.2–4.0 fl oz[3] 3.4–4.3 fl oz[4]	Aphid spp., beet and fall armyworms, chinch bug, grasshopper spp., greenbug, stink bug spp., wheat stem sawfly	

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Foliar insecticides labeled for use on small grains continued

Crop	Common chemical name	Trade name	Rate per acre	Insect pest	Additional label information
Small grains (barley, oats, rye, wheat, etc.)	*Bacillus thuringiensis*, subsp. *kurstaki* strain	Biobit HP[1] Crymax Bioinsecticide[1] Dipel DF Biological Insecticide[2] Dipel ES Biological Insecticide[3] Deliver Biological Insecticide[4] Javelin WG Biological Insecticide[5]	½–2 lb[1] 1–2 lb[2] 2.0– 4.0 pt[3] 0.5–1.5 lb[4] 1.0–1.5 lb[5]	Armyworms	Combination of Bt product with a contact insecticide recommended for infestations that include 4th and 5th instar larvae
	Subsp. *aizawai* strain	XenTari Biological Insecticide[1]			

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Revision