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Managing Insect *and* Mite Pests *of* Texas Corn

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Preface

This edition of *Managing Insect and Mite Pests of Texas Corn* is a departure from all past versions; it assumes that transgenic technology is now the most common form of insect control for major pests, and that most other pest control decisions will be made for fields of transgenic corn. However, this edition does not deemphasize non-transgenic corn; it includes as much information on managing pests of non-transgenic corn as in the past.

Insect-protected transgenic corn and its associated seed treatments have fundamentally changed the way we practice insect pest management for many key pests. These technologies are deployed before the insects arrive rather than after they begin threatening economic loss.

As with traditional insecticides, we must not use these new technologies carelessly. The pest numbers may not justify the cost of control, and it would promote insect resistance through widespread and continuous selection.

However, these technologies do allow greater flexibility in designing pest management plans. They usually enable growers to avoid using insecticides for key pests, such as caterpillars, which in turn will reduce the threat of the secondary pest outbreaks that often result from pesticide use.

Introduction

Corn is subject to insect attack throughout the growing season. Some insects may reach damaging levels in spite of natural predators and parasites, and the pests may require chemical control. However, insect numbers do not always relate directly to plant damage. Equally important are other factors such as crop rotation, growth stage, moisture conditions, plant vigor, time of year, and parasite and predator abundance. Therefore, apply chemicals only after careful evaluation of economic and natural control factors.

To use insecticides wisely, producers must inspect their crops often to determine whether insect or mite pests have risen to damaging numbers. See the individual insect sections in this publication for methods of determining insect numbers and guides for determining the need for pesticides.

Seed-corn production fields and sweet corn are more susceptible to insect damage than is field corn. Certain pests must be controlled at lower levels for seed corn and sweet corn because they are more susceptible to insect attack and the kernels have higher value. Insect control recommendations in this publication refer primarily to insect and mite control on field corn.

A few insect and mite pests attacking corn in Texas show some resistance to once-effective pesticides. Generally, the more extensively a pesticide is used, the more rapidly that resistance develops. Even insecticides with different trade names may have the same active ingredient(s), and alternating between insecticides with the same active ingredients does no good in delaying resistance.

The suggested insecticides tables contain a column titled *IRAC group*. This is the formal mode of action group recognized by the International Resistance Action Committee. To delay the development of resistance, rotate insecticides from different IRAC groups; never apply insecticides from the same IRAC group sequentially.

This publication complements *Texas Corn Production Emphasizing Pest Management and Irrigation* (B-6177, 2005), which is available from the Texas A&M AgriLife Extension Bookstore (http://www.agrilifebookstore.org) for $5 per copy. *Texas Corn Production* provides details on each corn pest and discusses scouting and economic thresholds.

Policy statement for making pest management suggestions

This publication does not list all of the products registered for corn or all uses for the products mentioned. The insecticides and suggested use patterns were determined by a consensus of Extension and research entomologists based on field tests. Products listed must meet specific performance standards and avoid undue environmental harm.

The suggested insecticides have been tested to make sure that they provide adequate control in field situations. However, it is impossible to eliminate all risks. Unforeseen or unexpected conditions or circumstances may lead to less-than-satisfactory results. The Texas A&M AgriLife Extension Service assumes no responsibility for such risks; the user of this publication shall assume that responsibility.

Suggested pesticides must be registered and labeled by the U.S. Environmental Protection Agency (EPA) and the Texas Department of Agriculture. The status of pesticide label clearances is subject to change and may have changed since this publication was printed. The user is always responsible for the effects of pesticide residues on livestock and crops, as well as for problems that arise from drift or movement of the pesticide.

Always carefully follow the instructions on the product label. Pay particular attention to the practices that ensure worker safety.

For more information, contact your county Extension staff or contact the Extension Entomologist at the Department of Entomology, Texas A&M University, College Station, TX 77843-2475, or call (979) 845-7026.

Disclaimer

The information given herein is for educational purposes only. Reference to commercial products or trade names is made with the understanding that no discrimination is intended and no endorsement by Texas A&M AgriLife Extension is implied.

Biological control

Biological control is the use of living organisms such as parasites, predators, and disease-causing organisms (pathogens) to control pests. Insect and mite populations are often held below damaging levels by weather, lack of food, and natural enemies (including diseases, predators, and parasites). Recognize the impact of these natural control factors and, where possible, encourage their action.

Biological control includes the conservation, augmentation, and importation of natural enemies:

- **Conservation** involves protecting populations of natural enemies by minimizing insecticide applications and by using insecticides that are more toxic to the target pest than to the natural enemy.
- **Augmentation** entails the periodic purchase and release of natural enemies.
- **Classical biological control** is the importation of natural enemies from other countries.

Seasonal progression of pests

This guide discusses insect and mite pests in the approximate seasonal order that they damage corn: pre-emergence, seedling to tassel, and tassel to hard dough. Many pest species cause economic damage for only a short time during the growing season. However, some pests remain a threat for much longer periods.

Table 1 lists the stages of corn and associated pests that may be of economic consequence at a particular growth stage.

Table 1. Seasonal progression of insect pests

Pest	Seed/ seedling	Whorl to pretassel	Tassel/ silk	Grain filling
Wireworm	×			
White grub	×			
Fire ant	×			
Seedcorn beetle	×			
Seedcorn maggot	×			
Lesser cornstalk borer	×	×		
Flea beetle	×			
Chinch bug	×	×		
Corn leaf aphid	×	×	×	
English grain aphid	×	×	×	
Cutworms	×			
Fall armyworm	×	×	×	×
Armyworm	×	×	×	×
Western corn rootworm	×	×	×	
Mexican corn rootworm	×	×	×	
Southern corn rootworm	×	×		
Spider mites	×	×	×	×
Southwestern corn borer		×	×	×
European corn borer		×	×	×
Mexican rice borer		×	×	×
Sugarcane borer		×	×	×
Neotropical borer		×	×	×
Western bean cutworm		×	×	×
Corn earworm		×	×	×
Grasshoppers		×	×	×

Transgenic corn for insect control

Modern insect-protected transgenic corn combines several toxins, all of which derive from the bacterium *Bacillus thuringiensis (Bt)*. This is why we use the term Bt corn. However, newer technology that does not rely on Bt is on the horizon.

Genes from the *Bacillus thuringiensis* bacterium have been placed into the corn. The genes code for the production of proteins from the Bt bacteria that are toxic to insects. When a susceptible insect eats these proteins, they break down into smaller subunits, some of which bind on the wall of the insect's gut. This binding eventually causes a small hole to form in the gut wall, and the bacteria in the gut then move in to the insect's body. Death is caused not by the Bt protein crystals, but by bacterial septicemia from the natural bacteria in the insect gut.

Susceptibility to Bt toxins ranges widely among broad insect groups (such as beetles, caterpillars, and flies) and among even closely related insects within a small group (caterpillars). The acidity of the insect gut is key—the wrong acidity prevents the crystal subunits from forming. The insects must also have the right type of receptors on the gut wall for the protein subunits to bind, and many insect species lack the appropriate receptors for the Bt toxins.

Table 2 lists the Bt toxins that are registered against corn insects.

This varying activity by Bt proteins on different, even closely related, insect species explains why some Bt toxins work better on some pests than on others. For example, the toxin Cry1Ab affects fall armyworm relatively less than does the toxin Cry1F. However, some stalk borers—the southwestern and European corn borers—are extremely susceptible to both toxins, so much so that farmers have reduced their populations just by planting Bt corn.

Table 2. Currently registered Bt toxins active against insects

Target pests	Toxin
Lepidoptera (caterpillars)	Cry1Ab, Cry1F, Vip3a, Cry1A.105, Cry2Ab2
Corn rootworm	mCry3a, eCry3.1Ab, Cry3Bb1, Cry34/35Ab1

Multiple toxins in modern transgenic corn

Traits in modern insect-protected Bt hybrids fall into two main categories: *stacked* and *pyramid*.

Stacked traits are combinations of toxins that act against very different groups of insects. An example is a corn hybrid that has one toxin (Cry1F) to kill caterpillar pests and a different toxin (Cry34/35) to kill corn rootworm larvae. Cry1F has no effect on corn rootworm, and Cry34/35 has no effect on caterpillars, but the combination protects against both types of pests. Similarly, herbicide-tolerant genes are also added to the mix of traits, which makes this a three-way stack of traits.

Pyramid traits are combinations of two or more types of Bt toxins that act on the same group of pests. A simple example is the combination of Cry1F and Cry1Ab, both of which target caterpillars. This type of corn has no toxins for corn rootworm but is pyramided for toxins to protect against caterpillars.

Stacked pyramids are currently the highest evolution of Bt technology: They are stacked for toxins that target very different types of insects; and they are pyramided for two or more toxins that target a particular type of insect or pest group.

An example is a hybrid containing three toxins targeted at caterpillars (Cry1F, Cry1A.105 and Cry2Ab2). It is a pyramid toxin plant for caterpillars; it also has two toxins directed specifically at corn rootworm larvae (Cry3Bb1 and Cry34/35), making it pyramided against rootworms as well. (Technically speaking, Cry34/35 is a binary toxin, but it acts as a single toxin because both components are always present.) The hybrid also has genes that make it tolerant to two types of herbicides.

The seed/technology companies have begun to cross-license Bt toxins from each other to build multi-toxin pyramids for caterpillar pests and corn rootworm. These multi-toxin pyramids control the target pests better than would a single toxin; they also help prevent insect resistance.

Pyramids are critical for delaying the development of resistance. Some insects have become able to survive some individual toxins in hybrids if the pests encounter them one at a time. For example, fall armyworm is resistant to Cry1F in Puerto Rico and parts of the U.S. South, where continuing to use Cry1F (only) corn will make a larger and larger percentage of the population resistant each year.

One answer to the problem is to add a second or even third toxin so that the insects with genes to live through Cry1F will most probably not have the genes to live through the second and third toxin. This effectively removes the Cry1F-resistant insects from the population and prevents the continued development of Cry1F resistance.

Pyramid Bt corn enables farmers to avoid most significant economic losses to direct feeding by caterpillars. Don't expect the pyramid Bt corn to be damage-free, but know that the damage is less—often far less—than would be the case with non-Bt corn.

Growers whose fields have heavy caterpillar infestations year after year should consider pyramid Bt corn for caterpillars. Corn earworm and fall armyworm usually infest late-planted corn more heavily than corn planted in the normal window. In this situation, the value of Bt toxins for caterpillars often increases.

Because of the complexity involved in choosing Bt corn, consult with seed dealers before making a decision.

Note: Bt corn offers no protection against spider mites, which can threaten any type of Bt or non-Bt corn in Texas.

Insect resistance management and transgenic corn

The EPA requires all companies that register hybrid corn with plant-incorporated protectants to have a resistance management plan. These plans are based on several factors, including scientific studies on the pests, their survival on a particular toxin, and their movements before and after mating. The purpose of the plans is to prevent resistance from developing for a certain number of years—not forever. That goal is not practical.

Because the EPA will not grant permission for a company to sell Bt corn without a resistance management plan in place, the seed companies require growers to sign stewardship agreements each year. Each agreement is based on the EPA resistance management plan for the particular set of Bt toxins in the hybrids. Following the stewardship agreements is vital because it delays the development of resistance to the corn toxins.

All current resistance management plans in corn rely on a “refuge,” a certain percentage of the corn seed that does not contain the Bt toxins. The idea is to let some insects develop on non-Bt corn, where they are not selected for resistance; these will then mate with selected insects and dilute the resistance alleles, or alternate forms of genes, in the next generation.

Seed companies must report compliance data to the EPA each year. Compliance is the number of growers who are following the stewardship guidelines and the number who are not. In recent years, the EPA has noted a slip in compliance, especially in the South (cotton zone), and it has turned up the heat on companies to increase compliance. The seed companies also know that a lack of compliance means that resistance to their Bt toxins is more likely to develop. For these reasons, corn growers can expect visits from seed company representatives to ensure that they comply with the stewardship agreement(s).

Resistance development can cause two serious problems:

- The EPA could remove certain Bt technologies from the market. This has already happened in Puerto Rico.
- The Bt hybrids could stop working, and growers would once again lose money to the pests that have developed resistance.

Growers in the Midwest with resistant corn rootworms are now paying the technology fee for rootworm Bt corn (with the highest levels of seed treatment available), paying for soil-applied insecticides to put on top of it, and paying again to spray adult rootworm beetles in the summer, all the while losing yield to corn rootworm. Resistance means vastly increased costs and lower farm profits.

Across the United States, there are two zones with different refuge requirements in Bt corn. The Corn Zone includes the northern Texas Panhandle and all of the traditional Corn Belt. The Cotton Zone comprises the areas where cotton is traditionally a significant crop. The refuges required for Bt corn are larger in the Cotton Zone than in the Corn Zone.

The different types of Bt corn have varying refuge requirements, depending on where the corn is grown. Texas is split in to two zones: Counties north of the line in Figure 1 follow the refuge requirements for the Corn Belt. Counties south of the line must have larger refuges because of the dominance of Bt cotton that contains some toxins similar to those found in Bt corn.

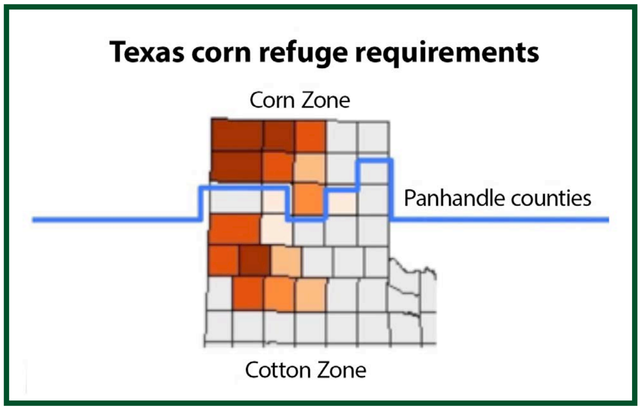


Figure 1. Texas Panhandle and the line dividing the two refuge zones.

All corn grown in Texas south of the line in Figure 1 have a mandated 20 percent or 50 percent caterpillar refuge, depending on whether the corn has pyramid toxins (20 percent) or a single toxin (50 percent) and whether it is active against corn rootworms, caterpillar pests, or both.

All refuges in the Cotton Zone must be “structured,” meaning that the non-Bt refuge corn must be either in a 4-row or wider strip or in a block planting in part of the field or in a field next to it (with restrictions depending on the Bt traits).

Seed blend refuges, sometimes referred to as “refuge in the bag,” are mixes by the seed companies of non-Bt seeds with Bt seeds at the right ratio to give the minimum refuge stated in the stewardship agreement. (It is illegal for growers to blend their own seeds.)

Seed blend refuges may be sold in both the Corn Zone and Cotton Zone, but if they are planted in the

Cotton Zone then an appropriate structured refuge must be planted as well. In the Cotton Zone, none of the refuge corn in the seed blends counts toward the block or strip refuge that must be planted.

It can be very difficult to keep up with the proper stewardship practices required for the many types of Bt corn on the market today. As a response to this problem, the seed companies have partnered with the National Corn Growers Association to publish the stewardship practices for any type of Bt corn grown anywhere in the country. A web-based tool is posted at http://www.ncga.com/for-farmers/issue-briefs-ipm/irm-refuge-calculator, which also links to downloadable apps for iPhone and Android devices.

Also, each year, Michigan State University produces *The Handy Bt Trait Table,* an excellent, concise, two-page summary of the toxins in Bt corn, the pests controlled, and the refuge requirements.

Two versions of the publication are published, one for the Corn Zone and one for the Cotton Zone. They are posted at http://www.texasinsects.org/corn.html.

Pre-emergence insect control

Soil-inhabiting pests

The most common soil insects attacking corn in Texas are corn rootworms, cutworms, seedcorn beetles, seedcorn maggots, sod webworms, white grubs, and wireworms. Cultural practices are vital for reducing damage by these soil pests.

Growing corn on the same land year after year increases the damage done by some soil insects. Crop rotation can reduce that damage. For example, you may reduce and sometimes eliminate losses from corn rootworms by a crop rotation scheme including soybeans or other crops that the rootworms do not feed on. In most areas of Texas, corn has been rotated successfully with sorghum without damage from the Mexican corn rootworm and western corn rootworm. However, the Mexican corn rootworm has damaged corn following sorghum in parts of South Central Texas, but this is rare.

Another cultural practice that reduces soil insect pests is to maintain weed-free fields throughout the year, because weeds serve as host plants for some soil insects.

Sample your fields for cutworms, white grubs, and wireworms before bed formation. If they need chemical treatment, use soil- or seed-treatment methods. One method may be more effective for a particular soil pest than another.

Seed treatment

Almost all hybrid seed corn comes pretreated in the bag. Clothianidin (Poncho), imidacloprid (Gaucho), and thiamethoxam (Cruiser) or thiamethoxam+abamectin (Avicta) are commonly used for this purpose. Where commercially treated seeds are unavailable, growers may have to use direct-seed treatment or planter-box treatments.

To treat light populations of seedcorn beetles, seed-feeding ants, seedcorn maggots, and wireworms, treat the seeds with planter-box products. The insecticide should coat each seed evenly:

- Use a concrete mixer, commercial seed applicator or homemade seed applicator to treat seeds.
- Sprinkle 1 pint of water on each 100 pounds of seed and mix them to coat the seed with moisture.
- While mixing the seed, slowly add the correct amount of insecticide, and mix it thoroughly until the insecticide is distributed evenly on all the seeds.
- Plant the seeds within 20 days of treatment, because long exposure to the chemical will affect germination in some hybrids.

Do not use treated seed for human consumption or livestock feed.

Some insecticides are applied to seed in the planter box. This method is effective only against low populations of seedcorn beetles, seed-feeding ants, seedcorn maggots, and wireworms. Use as directed on the insecticide label.

Soil treatment

For some soil pests, you must apply the insecticide before the crop is planted or at planting time. Use granular or liquid formulations, depending on the target insect and your equipment. Granular forms of insecticide are generally safer.

Three application techniques are available to treat the soil: preplant broadcast, row band or T-band, and in-furrow at planting.

Preplant insecticide application: A **broadcast application** generally protects against soil insects best and is the only way to control heavy infestations of white grubs. But broadcast applications are usually not recommended because they require more insecticide and are more expensive than are row band or in-furrow treatments.

When broadcast applications are necessary, apply the insecticide uniformly to the field and incorporate it to a depth of 3 to 5 inches immediately after application.

Because of label changes in recent years, fewer products are approved for preplant broadcast application.

Corn planted on a bed requires special equipment to incorporate the insecticide to 3 to 5 inches deep. This is called **row treatment.** For best control, treat a band of soil 7 to 10 inches wide and 3 to 5 inches deep, and place the seed in the center of the band.

Row treatments must be made during or after bed formation. Further cultivation or bed shaping will alter the position of the insecticide in the row.

Insecticide application at planting: Techniques for applying insecticides to the soil at planting time include row band, T-band, or in-furrow applications. Choose the technique according to the pest species and the insecticide label.

Some insecticides applied at planting for corn rootworm control will suppress some early-season pests such as chinch bugs, flea beetles, and fire ants on seed or seedling plants. Depending on the insecticide, the pests may be suppressed for 2 to 4 weeks.

Follow these guidelines when applying granular insecticides:

- Mount the application equipment on the planter with the spout just behind the opening plow or disc opener and in front of the covering shovels or press wheel.
- Adjust the spouts so that the treatment band is about 6 to 8 inches wide and the seed furrow and covering soil are treated.
- Incorporate the insecticide by covering shovels, short parallel chains, loop chains, press wheels, finger tines, or other suitable devices.
- *Do not* apply insecticide directly on the seed unless this use is specifically listed on the label; doing so can reduce seed germination. Some insecticides are labeled only for band application behind the seed-covering devices. Poor control usually results from in-furrow application where populations of white grubs are large.

White grubs and cutworms

White grubs are the larval stage of May and June beetles. The larvae damage the plant by feeding on the roots. Small damaged plants often are killed, and large plants are stunted and may lodge before harvest.


White grubs

To determine the need for white grub control before planting, examine a 1-square-foot soil sample for each 5 to 10 acres. An average of one white grub per square foot is enough to decrease stands significantly.

If the field has an average of about one white grub per square foot, a planting time in-furrow or band treatment will provide adequate suppression (Table A1 in the Appendix).

For surface cutworms, incorporate the insecticide into the top 1 to 2 inches of soil. See Table A8 in the Appendix for cutworm control on seedling corn.

Wireworms, seedcorn maggots, and seedcorn beetles

Insecticidal seed treatments often control wireworms (Table A2), seedcorn maggots, and seedcorn beetles. Check your soil closely during land preparation to determine whether seed treatment or soil applications are needed to control these pests. If the wireworm populations are large, follow the recommendations listed on appropriate insecticide labels.


False wireworm


Wireworm larva

Mexican and western corn rootworm

Corn rootworm can be a significant pest anywhere in Texas, and the best defense against it is crop rotation. (The exceptions are in the Coastal Bend and South Texas, where this insect is common; crop rotation does not always control it there.)


Mexican corn rootworm adult

However, many growers cannot rotate out of corn; they grow corn year after year in the same field. Laboratory studies have shown that corn rootworm can develop resistance to any of our current rootworm Bt toxins in as little as 4 years of continuous use.


Western corn rootworm adult

In parts of the Midwest, western corn rootworm has become resistant to Cry3Bb1 and mCry3A. The first confirmed cases of resistance were in fields that were in continuous corn planted to Cry3Bb1 for 4 or more years. Unlike the caterpillar toxins that are relatively toxic to their target pests, corn rootworm toxins are relatively less toxic overall, and the natural populations of corn rootworms have the genes to survive the current toxins, Cry3Bb1, Cry34/35, mCry3A, and eCry3.1Ab. There is some cross-resistance between Cry3Bb1 and mCry3A so that insects that become resistant to one of these toxins will have partial resistance to the other.

The keys to preventing resistance to corn rootworm toxins are to rotate crops where possible and to rotate corn rootworm toxins where crop rotation is not possible. Never use the same rootworm technology in the same field for more than 3 years, and fewer years than 3 is better.

Although you may have to buy seed from a different company, it is vital that you observe this 3-year limit to delay resistance on your farm. Corn rootworm adults tend to lay eggs in the same field where they fed on roots as larvae, and most corn rootworm resistance can be traced back to a specific field where the toxins were not rotated.

In the Coastal Bend and southern part of Texas (Fig. 2), even rotated corn may need protection from southern corn rootworm. All Bt corn comes with an insecticidal and fungicidal seed treatment. However, even the best seed treatments cannot control corn rootworms at moderate and high infestation levels.

Mexican and western corn rootworm beetles lay eggs in the soil during the summer and fall, shortly after silking time. The eggs are usually laid in a cornfield in the upper 2 to 8 inches of the soil, where they remain until they hatch the following year.

Although the hatching time depends somewhat on soil temperature, the eggs usually begin to hatch about mid-April in South Texas and about mid-May in the High Plains. They continue hatching for several weeks.

If the newly hatched corn rootworms have no corn roots to feed on, they will die. Because Mexican and western corn rootworm have only one generation per year, *the best way to control these two subspecies is to rotate corn with any other crop.*

In continuous corn production fields, an average of one or more beetles per plant on any sampling date during the growing season indicates the need for a soil insecticide, a transgenic Bt hybrid, or crop rotation the next spring (Tables A3, A4, and A5).

Corn rootworms usually damage crops from mid-April through mid-May in South Texas and in June in the High Plains. Extensive damage to the brace roots and fibrous roots may cause the plants to lodge. A "goose necking" appearance occurs when the lodged plants continue to grow.

In parts of the Midwest, western corn rootworm is resistant to Cry3Bb1 and mCry3A, and there is cross-resistance between the two toxins. As of early 2016, resistance had not been documented in either western or Mexican corn rootworm in Texas.

Southern corn rootworm

Corn rootworm larvae

Southern corn rootworm adult

Because the southern corn rootworm lays eggs in the soil after the corn is in the seedling stage, rotating crops will not control this insect adequately. Unlike the Mexican and western corn rootworms, southern corn rootworm can have more than one generation per year.

In most areas of Texas, the southern corn rootworm is a minor pest if the corn is planted in fields that were not grassy or weedy during the previous year. However, in the Gulf Coast region (Fig. 2), it has been a significant pest.

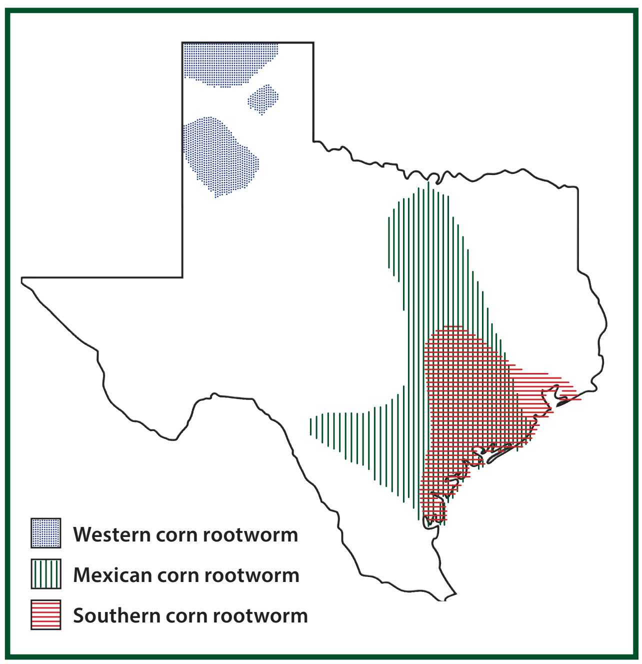


Figure 2. Areas where rootworms have damaged corn in recent years.

Consider seed treatments or an in-furrow or band pesticide application if infestations have reduced plant stands previously (Tables A6 and A7). Seed treatments provide good control, even better as rates increase. The Bt hybrids are relatively ineffective at controlling southern corn rootworm.

For most fields, research has shown that applying in-furrow insecticides at one-half the maximum rate in Table A7 provides the most favorable economic returns for control of southern corn rootworm. Where heavy infestations occur each year, use the higher rates.

Seedling to tassel stage insect control

Corn leaf aphid

Fields in the seedling stage rarely need to be treated for corn leaf aphid. Yield losses have occurred only where the pest has reduced stands of seedling plants. Pre-tassel and later growth stages can tolerate large numbers of aphids without economic damage.

Aphid mummies

Corn leaf aphids

Soil cutworms

Cutworms are dingy, grayish-black, smooth “worms” that are the larval stages of several moth species. Most cutworms are active at night, when they damage seedling corn by cutting the stalk just above ground level. Grassy or weedy areas may harbor large numbers of cutworms. Most species hide in the soil during the day and are not visible on the plants.

Cutworm

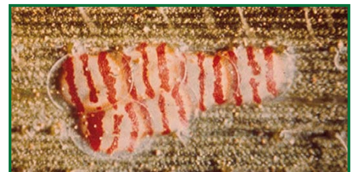
When cutworms are damaging plant stands, applying insecticide by ground will usually give adequate control (Table A8). For best results, apply the insecticides in the late afternoon. If the soil is dry, cloddy, or crusty at the time of treatment, control may not be as effective as in moist soil.

Southwestern corn borer

All types of Bt corn with toxins targeted at caterpillars will control southwestern corn borer effectively; they do not need an insecticide for southwestern corn borer control (Table A9). However, as of this writing in late 2015, there is evidence that southwestern corn borer may be resistant to Cry1F in Arizona and New Mexico, so the use of a two-toxin (pyramid) Bt corn is recommended in case that resistance has spread to Texas.

Southwestern corn borer moths emerge from corn stubble in the spring to lay eggs on whorl-stage corn. More larvae typically feed in the whorl on the corn that is near unplowed stubble.

Eggs are laid on the upper and lower surfaces of expanded leaves in the whorl. Freshly laid eggs are creamy white; after about 24 hours, three red bands appear on each egg.



Southwestern corn borer eggs

Small larvae hatch from the eggs in about 5 days and begin feeding in the whorl. As the leaves unfold, they will reveal the typical rows of holes across the leaf surface associated with whorl feeders.

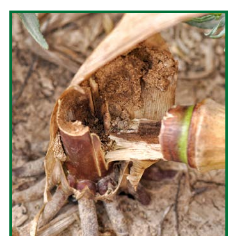
Southwestern corn borer larva

Another leaf symptom commonly associated with southwestern corn borer feeding in the whorl is long, transparent areas (the windowpane effect) on the leaf where the young larvae feed only partially through the leaf tissue.

Southwestern corn borer adult

After the larva has fed in the whorl, it crawls down the plant and bores into the stalk. Corn borer larvae reach 1 to 1½ inches long. They have a regular pattern of raised black dots on a creamy white body.

First-generation eggs and larvae are difficult to detect because they rarely infest more than 5 percent of the plants. However, if infestations are large enough to warrant treatment, apply insecticide (Table A10) before the borers leave the whorl and enter the stalk.



Southwestern corn borer girdle

European corn borer

European corn borer was first discovered in Texas High Plains corn in 1978. Since then, the widespread planting of Bt corn has reduced populations drastically. European corn borer is effectively controlled with all types of Bt corn that have one or more toxins targeting caterpillars (Table A11). Economic infestations affect most corn-growing areas of the Texas Panhandle.


European corn borer

Borers overwinter as full-grown larvae in corncobs, weed stems, or other cornfield debris. They pupate in May, and the first generation of moths emerges in late spring. The moths are first attracted to the dense vegetation around corn; they remain there for a few days while they mate.

Mated females return to the cornfields to lay eggs. They are attracted to the tallest fields (at least 22- to 35-inch extended leaf height). The eggs, 15 to 30 in a mass, overlap like fish scales and are normally deposited near the midribs on the undersides of the leaves.

The eggs hatch in 3 to 7 days. The larvae move to the whorl to feed before entering the stalk to continue feeding.

To determine whether you need to apply insecticide to control first-generation European corn borers, examine five random samples of 20 consecutive plants each. An insecticide application is justified if 50 percent of the plants are infested with an average of at least one live larva per plant (Table A12).

Lesser cornstalk borer

The lesser cornstalk borer occasionally attacks seedling corn. The small, slender larva remains in a silken tube in the soil; it injures plants by feeding on the crown area at the soil line.

These insects may occur in damaging numbers on sandy soils, and populations increase in dry conditions. Because rainfall and irrigation will kill many larvae, the timing and amount of irrigation will influence control. Insecticides applied at planting for corn rootworms may control other soil pests such as lesser cornstalk borer (Table A13).


Lesser cornstalk borer larva

Applications of terbufos (Counter CR) for corn rootworms have suppressed lesser cornstalk borer. During the seedling stage, carefully inspect areas where this insect has been a problem. Base the treatments on plant damage and the presence of larvae. This insect does not usually affect larger corn plants.

Other borers

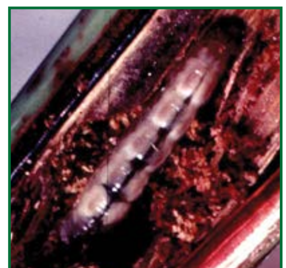
In recent years, most borer damage to corn in the Lower Rio Grande Valley and along the Gulf Coast has been caused by the Mexican rice borer, sugarcane borer, and the neotropical borer (Fig. 3).

These borers typically attack corn before and after tassel. They feed on the leaves for a short time before boring into the stalks.

Sugarcane borer can cause whorl damage, stalk tunnels, shank damage, and grain-feeding injury. Yield losses are usually minor unless the stalk lodges. Sugarcane borer damage to kernels may cause a red coloration that makes the grain unmarketable for some purposes.

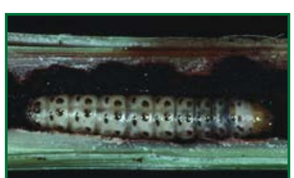
Bored stalks fall most often during ear filling or ear maturation, and lodging is often associated with high winds. The stalks may break at any point but not usually near the soil level as with southwestern corn borer infestations.

Transgenic Bt corn hybrids control these borers well. Conventional insecticidal control is most successful if you scout the fields closely and treat before the larvae bore into the stalks.


Mexican rice borer larva


Sugarcane borer larva


Sugarcane borer adult


Neotropical borer larva


Neotropical borer adult

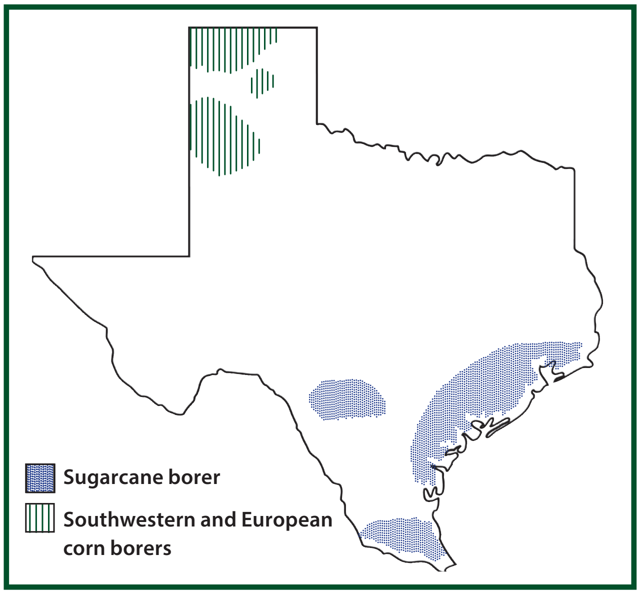


Figure 3. Areas where borers have damaged corn in recent years.

Corn earworm and fall armyworm

Corn earworm and fall armyworm moths deposit eggs on leaves. Newly hatched larvae begin to feed in the whorl. Although larval feeding will cause the leaves to appear ragged, *insecticide treatments of whorl stage corn seldom achieve economical control.*

Corn earworm larva

Corn earworm adult

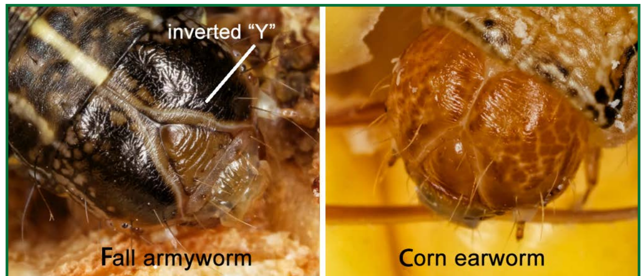
Fall armyworm egg mass

Fall armyworms hatching

Fall armyworm larva

Fall armyworm adult

Difference between fall armyworm (top) and corn earworm (bottom). Upper front view at left; side view at right



Difference between fall armyworm and corn earworm

Flea beetles

Flea beetles are very tiny, shiny black or greenish black insects that jump when disturbed. They range from a little smaller than a pinhead to several times larger.

Flea beetles feed on the leaves of corn plants. Damaged leaves have a whitened, bleached appearance. Plant growth slows as the leaves wilt and hang limp. Flea beetles are more likely to damage later-maturing corn.

Flea beetle

Fields kept clean of weeds the previous season seldom suffer significant flea beetle injury. When enough flea beetles are damaging corn, an insecticide application may be necessary (Table A14).

Flea beetles and damage

Chinch bug

Adult chinch bugs are about ⅙ inch long with black bodies and reddish-yellow legs. When fully developed, the white wings develop a triangular black spot near the middle of the back on the outer wing margin. When viewed from above, the insect appears to have a white X or a white hourglass on the back.

Adult and immature chinch bugs suck plant juices and cause the leaves to redden. Damage by chinch bugs normally occurs from seedling emergence until the plants are 18 inches tall.

Chinch bugs

Large numbers of chinch bugs can move into a cornfield by crawling or flying from wild bunch grasses or small grains. Once in the field, they congregate and feed behind the leaf sheaths of the corn plant and below the ground line on the plant roots and crowns.

In fields with a history of early-season, economically damaging chinch bug populations (Fig. 4), seed treatments or at-plant, soil-incorporated insecticides can suppress the insect. Granular formulations may protect corn for 2 to 3 weeks if enough rain falls after the application to wash the insecticide off the granules.

Closely monitor young plants for chinch bugs and feeding damage after germination, particularly during dry periods, even when you use seed treatments or at-plant insecticides (Tables A15 and A16).

Make at least five random checks in the field. *Apply insecticide when two or more adult chinch bugs infest 20 percent of the seedlings that are less than 6 inches tall. On taller plants, apply insecticides when immature and adult bugs infest 75 percent of the plants.*

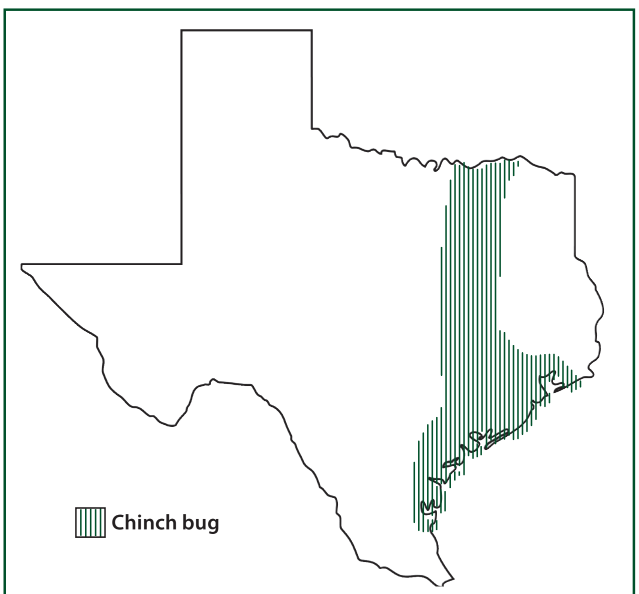


Figure 4. Areas where chinch bugs have damaged corn in recent years.

Tassel to hard dough stage insect control

Corn earworm

Corn earworm moths begin laying eggs on leaves and silks soon after tassel emergence. They begin laying eggs on emerging silks before pollination.

After hatching, the larvae tunnel into the silk channel to feed. Because the damaged silks have usually completed pollination, a loss of pollination is generally not a problem.

Later instar larvae feed on the kernels at the tip of the ear. Ear damage is usually minor, although an occasional field may have excessive damage.

Corn earworm control is difficult because the eggs are laid throughout the silking period and after pollination (brown silk stage). Because the untreated silks are exposed daily as they lengthen, insecticides must be applied often. Control efforts are usually costly and inconsistent. Currently, control strategies are not suggested in commercial field corn.

Southwestern corn borer

Although the southwestern corn borer has been a major corn pest on the High Plains (Fig. 3), the widespread planting of Bt corn has reduced its populations. It also occurs in Far West and Northeast Texas but is not economically important in these regions.

The larvae cause damage by tunneling in the stalk and later girdling the plant, which then lodges. In the spring, moths emerge from corn stubble and weed hosts to lay first-generation eggs on whorl-stage corn.

On the High Plains, first-generation larvae mature and pupate in the stalk in July. Moths begin emerging about mid-July and lay eggs of the second generation, usually after tasseling has occurred. (See Fig. 3 for distribution).

About three-fourths of the second-generation eggs are laid on the upper surfaces of the middle seven leaves—the ear leaf and the two leaves above and four leaves below it. The eggs are laid singly or in masses of two, three, or more. The eggs overlap like fish scales or shingles. Freshly laid eggs are creamy white; 1 day later, three red bands appear across each egg.

The eggs hatch in about 5 days. Small larvae feed behind leaf collars and ears and beneath the shucks of the primary ear. Older larvae bore into the stalk and continue feeding. Mature corn borer larvae reach 1 to 1½ inches long. They are dull white and have a regular pattern of raised black dots over the body (photos on page 11).

As the plant reaches maturity, the larvae prepare to overwinter in the base of the stalk by girdling the plant from 1 to 6 inches above the ground. Wind can easily lodge girdled plants. Lodged plants are difficult to harvest, and yields are reduced.

Southwestern corn borer larvae overwinter in the stalk base or root crown. They are insulated by a frass (excrement) plug in the stalk and by the surrounding soil.

One of the most effective ways to control borers is to destroy this winter habitat to reduce spring moth emergence. A single tandem disc cultivation or shredding will expose the larvae to cold and dry winter conditions while leaving enough residue to prevent soil erosion. Set the shredder to cut the stalks at the soil surface, which removes the protective frass plug.

Shredding is particularly compatible with grazing and minimum tillage operations because it does not bury the plant materials but does expose the corn borer larvae. Also, the stalks can be shredded even when the soil is frozen.

Double disking and deep plowing are effective methods if soil erosion is not a problem. Cultivating or shredding before mid-January will kill many larvae. Timely stubble destruction will reduce local infestations of first-generation larvae. However, to effectively reduce southwestern corn borer populations areawide, every producer must cooperate by destroying stubble.

Early-planted corn is less susceptible to lodging caused by corn borers. Plants with large, healthy stalks, combined with proper fertilization and adequate irrigation, will help prevent this lodging.

To reduce losses, rotate crops, use early-maturing varieties, and harvest early with equipment designed to pick up lodged stalks. All of the Bt hybrids with toxins targeted at caterpillars provide excellent control of the southwestern corn borer (Table A9). However, as of early 2016, there is evidence that southwestern corn borer may be resistant to Cry1F in Arizona and New Mexico, so the use of a two-toxin (pyramid) Bt corn is recommended in case that resistance has spread to Texas.

Insecticide treatments usually are directed toward second-generation larvae (Table A10). *Apply the insecticide when the eggs or newly hatched larvae infest 20 to 25 percent of the plants.* Check for egg masses to determine the potential infestation and the correct timing of insecticide application.

European corn borer

All of the Bt hybrids with toxins targeted at caterpillars provide excellent control of European corn borer (Table A11). In non-Bt corn, yield losses from second-generation European corn borer are usually higher than are those from the first generation. Second-generation moths that emerge in mid-summer are attracted to dense vegetation around cornfields, primarily for mating.

Mated females return to recently tasseled corn to lay eggs on the undersides of the ear leaf and the leaves nearest to it. The eggs are white, with a black dot (the head of the young larva) appearing just before hatching. The eggs hatch in 3 to 5 days.

After hatching, about 75 percent of the small larvae move to the leaf axils; the remaining 25 percent move to the ear sheath and collar tissue. They reduce yield by larval tunneling, ear droppage, and direct kernel feeding.

To determine the need for an insecticide application, examine a minimum of five random samples of 20 consecutive plants each. (Table A12). *An insecticide application is justified if you find an average of 10 to 20 hatched and unhatched egg masses per 100 plants.* Two applications may be necessary to control European corn borer satisfactorily.

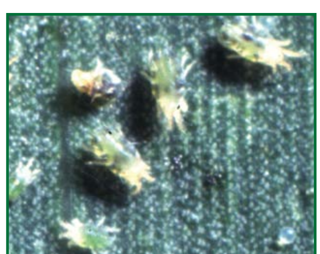
Spider mites

Economic infestations of spider mites occur on corn primarily in the Texas High Plains; they occasionally occur in the Winter Garden region and the Rio Grande Valley.

Large numbers of spider mites may occur on corn after the tassels appear. Mites first appear on the lower leaves, but they may move upward until they kill all the leaves (and in extreme cases, the entire plant).

Yield losses from mite feeding occur during the grain-filling growth stages (tassel to soft dough). Once the corn reaches the fully dent growth stage, the mites do not reduce yield directly. Heavy infestations cause extensive webbing on the leaves and may be associated with stalk rot and lodging.

Mite populations increase rapidly in hot, dry weather. An important factor triggering mite increases is the use of insecticide to control other pests. Insecticides may kill the beneficial arthropods that usually



Banks grass mites

Banks grass mite colony

keep spider mite numbers low. Because mite numbers may increase when excessive amounts of fertilizer are used, test the soil and apply only the amount of fertilizer needed.

Twospotted spider mite

Proper irrigation timing will help the plants withstand mite-feeding damage. The most important time to prevent water stress is during tassel and early grain filling.

Both the Banks grass mite and twospotted spider mite can occur on corn in Texas. The Banks grass mite is the predominant species in early and mid-season, and it is distributed more widely than is the twospotted spider mite. A few fields, however, will have large numbers of twospotted spider mites or mixed populations of both species.

To distinguish between the species, note the pattern of pigmentation spots on the body. (Fig. 5). The adult twospotted spider mite has a well-defined spot on each side of the front half of the abdomen. The spots on the adult Banks grass mite extend all the way down both sides of the body, sometimes almost touching at the rear of the body. Also, twospotted spider mites produce more webbing than do Banks grass mites.

All of the modern miticides take from a few to several days to begin controlling spider mite populations, and the action thresholds have changed from in the past when we had fast-acting miticides. Therefore, base your control decisions on earlier damage levels from spider mite feeding than in the past.

Scout the fields at least once a week to determine whether predators are keeping mite populations and their damage in check. If so, the mite densities and damage will not increase from week to week.

To estimate when to begin applications for spider mite control, use the rating scale in Table 3. It can help you estimate the damage to individual plants as well as the average damage to several plants in an area. Use the average from several locations to make control decisions.

Field trials of the modern miticides (Tables 3, A17, and A18) have shown that mite control works best on tasseled corn before the mites become aggressively active, when they move up the plant rapidly and damage the ear leaf (damage rating 5).

When the mites have caused damage ratings of 6 and above, they have already reduced yields significantly, and miticides will not control the infestations effectively. Begin applying miticides at damage rating 3, when the mite populations are becoming increasingly active but enough time remains to spray the field.

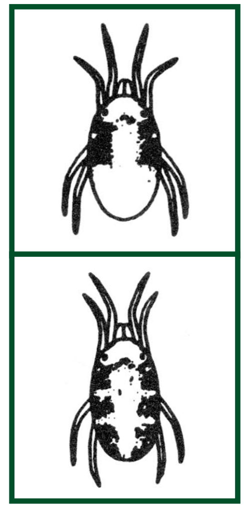


Figure 5. Twospotted spider mite (top) and Banks grass mite (bottom).

Table 3. Mite damage rating scale for estimating spider mite feeding damage on corn

Rating	% leaf area damage per plant	Damage
1	1–10	A few small mite colonies and associated damage (chlorotic spots) along the midrib of the lowest leaves.
2	11–20	Mite colonies and damage spread along the midribs on the plant's lowest leaves.
3	**21–30**	**Mite colonies and damage spread out from the midrib on the lowest leaves. Small colonies may occur on leaves up to the ear. Action threshold.**
4	31–40	Mites and damage cover most of the leaf area on the 1 or 2 lowest leaves, and the mite colonies and damage extend along the midrib to the ear leaf.
5	41–50	Mites have killed 1 leaf, heavily infested and damaged 2 or 3 green leaves, and infested 1 or 2 leaves above the ear.
6	51–60	Mites have killed or nearly killed the bottom 2 leaves; colonies and damage extend beyond the midribs on 2 leaves above the ear.
7	61–70	Mites have killed or nearly killed the bottom 3 leaves, significantly damaged all leaves up to the ear, and infested and damaged most to all the leaves on the plant.
8	71–80	Mites have killed or nearly killed all the leaves up to the ear; mites and damage occur on most to all leaves on the plant.
9	81–90	Mite feeding has killed most leaves on the plant; only those in upper third of the plant are alive.
10	91–100	The plant has very little green area left, or the plant is dead.

Archer et al., 1989. "Techniques for screening maize for resistance to mites." In: T*oward Insect Resistant Maize for the Third World: Proceedings of the International Symposium on Methodologies for Developing Host Plant Resistance to Maize Insects.* (Ed: Mihm, J. A.) CIMMYT, Mexico D.F., pp. 178-183.

Adult corn rootworm beetles (Mexican and western corn rootworm)

Although adult rootworm beetles feed on leaves, pollen, and tassels, they prefer silks. When adults are numerous (8 to 10 per plant) during the green silk stage and *the silks are chewed back to within ½ inch of the shuck, poor pollination may cause poorly filled ears. When this amount of feeding occurs, or if excessive leaf damage occurs, it is profitable to control the beetles.*

Controlling adult beetles usually reduces the number of eggs laid in a field. However, insecticides can cause an outbreak of spider mites by destroying their predators. Because spider mites can greatly damage corn and are difficult to control, do not use a synthetic pyrethroid to control adult corn rootworm beetles. Apply insecticide to control adult beetles only when necessary (Table A19).

Insecticide baits consisting of carbaryl and a feeding attractant from cucurbits are labeled for control of adult corn rootworms. Corn rootworm beetles feed on these baits, which do not destroy as many beneficial insects and predatory mites. Therefore, these baits present less risk of outbreaks of spider mites after application than do many other conventional insecticides.

Fall armyworm

The fall armyworm is a sporadic pest of corn but has become a more consistent pest in recent years. It migrates north during the growing season from overwintering sites in South Texas and northern Mexico. Recent research from Mississippi indicates that significant whorl damage can decrease yield, but as of early 2016, the final scientific paper has not been published.

Infestations occurring from the tassel to dough stage can damage corn greatly. The larvae feed on the ears and ear shanks and behind the leaf collars. Research on the High Plains has shown that when boring through the side of an ear, one fall armyworm larva reduces yield by an average of 0.20 pound through direct kernel injury and the damage by associated fungi. Fall armyworm damage may also cause mycotoxin levels to increase in grain.

Heavy infestations may reduce yields substantially because the larvae feed directly on the ear. Additional losses can occur when shank feeding causes the ears to drop and when stalks lodge because of feeding damage to the nodes.

The larvae range from a light tan to a dark green or black. Light and dark stripes run lengthwise on the body. Dark spots or bumps occur in a pattern over the body, especially when viewed from the top. The head has a prominent inverted Y in a light color that contrasts with the dark head capsule.

Scouting for fall armyworms can be difficult. Check corn leaves and grasses in the furrow for egg masses. Each mass may have 50 to 100 eggs. Check also for small larvae behind the leaf collars, in ear tips and at the bases of primary and secondary ears.

Unlike small larvae, late-instar larvae are pale tan and have a small black spot on each side toward the head. This will help distinguish them from corn earworm and southwestern corn borer larvae.

Texas does not have an established economic threshold for this pest. If control is necessary, target the small larvae before they enter the primary ear. The newer, multiple-toxin Bt corn hybrids provide good to excellent control of fall armyworm (Table A20). Recent research has shown that insecticides targeted at ear protection should be applied in the period from 2 days before pollen shed to 4 days after (Table A21). Later applications will be less effective in ear protection.

True armyworm


Yellowstriped armyworm

True armyworms occasionally damage corn heavily. The most damage usually occurs in fields that have junglerice (watergrass) and Johnsongrass in the furrows or in fields that have hail-damaged leaves.

True armyworms may go unnoticed as populations build up on the weeds in the furrows. Then, when the weeds are consumed and the larvae grow, they begin feeding on the corn leaves. Large larvae can defoliate corn plants rapidly. Excessive defoliation will reduce yield, and premature drying of the stalk may lead to lodging problems. *Apply chemical treatments when larval feeding destroys an average of three leaves per plant* (Table A22).

Western bean cutworm


Western bean cutworm larva

Economic damage from western bean cutworm is restricted to the extreme northwest corner of the Texas Panhandle.

Moth activity begins in early July, with egg lay following shortly thereafter. The moths lay eggs on the upper surfaces of the corn leaves in masses of 5 to 200. They turn from a pearly white at egg lay to bluish black at hatching time.

Western bean cutworm egg mass

At hatching, the young cutworms feed on the eggshell and then move to one of two sites on the corn plant, depending on the stage of corn development. If the corn has not tasseled, they will feed in the whorl on the developing tassel. If it has tasseled, they will move to the developing ear and feed on the silk. As the larvae mature, they begin feeding on the developing grain.

Pale western cutworm

There is strong evidence that western bean cutworm is becoming resistant to the Bt toxin Cry1F, and the toxin Cry1Ac never was very effective. Transgenic corn with these toxins can still be effective, but only if it is pyramided with additional toxins.

Apply insecticide when 14 percent of the plants are infested with eggs or larvae and the corn is 95 percent tasseled (Tables A23 and A24).

Grasshoppers

Grasshoppers occasionally damage corn. Control damaging infestations early while the grasshoppers are small and still in the crop border areas. *Ten or more grasshoppers per square yard in the crop margins warrant control measures* (Table A25).

Sap beetles

Corn sap beetles, or picnic beetles, are attracted to decaying vegetable matter and often invade corn ears damaged by insects. They are not attracted to healthy ears.

Sap beetle

These beetles are small (⅓ inch) and black or brown. They sometimes have orange or yellow spots on their wing covers.

Insecticide application methods

Ground machines or aircraft may be used to apply most insecticides. Spray applications are more effective and drift is reduced when wind does not exceed 10 miles per hour. Avoid spraying when the plants are wet.

Because pressure, ground speed, and nozzle size and number influence the rate of spray solution output per acre, calibrate the sprayer carefully and often to make sure you are applying the recommended amounts of insecticide. Usually one nozzle per row is adequate for young row crops; for larger plants, two or three nozzles per row may be needed.

Some insecticides and miticides applied with irrigation water (chemigation) through center pivot and stationary irrigation systems can effectively control some corn pests. Chemigation can reduce application costs and may require less insecticide because it covers the crop more thoroughly than do conventional application methods. Chemigation requires an initial investment in chemical injection equipment and additional management time.

Safety features and practices are necessary for safe and effective chemigation. Of key importance is preventing groundwater contamination. *For some insecticides, chemigation is prohibited* because they are either highly toxic to mammals or are ineffective when applied in irrigation water.

Refer to the pesticide label to determine whether chemigation is approved. If so, follow the safety equipment and procedures that are required by federal law and are listed on the product label.

The label also may provide instructions for mixing, diluting, and agitating the product; state the amount of irrigation water to apply during chemigation; and recommend specific adjuvants to increase pesticide efficacy by reducing washoff.

During windy weather, do not use irrigation systems with nozzles positioned above the crop canopy for chemigation because they may cause pesticide drift from the treated field. Also, shut off the endguns during chemigation. Wear personal safety equipment while mixing and loading the insecticide. Avoid contaminating the site with spilled pesticide, and dispose of the pesticide containers properly.

Carefully maintain and calibrate the pesticide injection pump unit to apply the insecticide uniformly at the desired rate in the irrigation water. Inaccurate calibration can result in under application, which reduces insecticide effectiveness, or over application, which increases costs and may contaminate the crop and the environment.

Endangered species regulations

The Endangered Species Act protects and helps the recovery of animals and plants that are in danger of becoming extinct. In response to this act, many pesticide labels now carry restrictions limiting the use of products or application methods in designated biologically sensitive areas.

These restrictions are subject to change. To determine which restrictions apply to your area, look on the product label for an Environmental Hazards or Endangered Species discussion section and/or call your local county Extension agent or U.S. Fish and Wildlife Service personnel.

Regardless of the law, pesticide users can be good neighbors by knowing how their actions can affect people and the environment, and taking steps to prevent undue harm.

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 use any type of pesticide on that crop, WPS applies to you.

The WPS requires that you provide to your employees three types of protection from pesticide exposure. You must: 1) inform the employees about exposure; 2) protect them from exposure; and 3) mitigate any pesticide exposures that they might receive.

The WPS requirements appear in the "Direction for Use" part of the pesticide label. For more information, see the EPA Worker Protection Standard website at http://www.epa.gov/pesticides/health/worker.htm. You may also call the Texas Department of Agriculture Pesticide Worker Protection Program at (512) 463-7622 or (800) 835-5832.

Protecting bees and other pollinators from insecticides

Pollination is vital for producing many seed crops, particularly for legumes such as alfalfa, clovers, and vetch. In contrast, most grass-type plants are wind or self-pollinated and do not require insect pollinators.

Where pollen-collecting insects are required for flower fertilization, the producer, insecticide applicator, and beekeeper should cooperate closely to minimize bee losses:

- If practical, apply insecticides before the bees are moved into the fields for pollination.
- Where insecticides are needed, use materials that are the least toxic to bees (Table A26).
- Make all applications when the bees are away from the field. Evening or early-morning treatments between 7 p.m. and 6 a.m. are generally best. Evening applications after the bees have left the field are less hazardous than are early-morning applications.
- Use spray or granular formulations rather than dusts.
- When possible, use an insecticide in groups 3 or 4 in Table A28.
- Notify the beekeeper so that he or she can make arrangements to protect the bees.
- Avoid drifting or spraying any insecticide directly on colonies. Heavy losses generally occur in these situations. On hot evenings, bees often cluster on the fronts of the hives. Pesticide drift or direct spray at this time will kill many bees.

Appendix

Table A1. Suggested insecticides for controlling white grubs

Insecticide (listed alphabetically)	Amount per 1,000 feet of row	Amount per acre on 40-inch row spacing	IRAC group
Chlorethoxyfos +			1B
bifenthrin			3A
(SmartChoice 5G)	3.0–3.5 oz	2.6–3.0 lb	
(SmartChoice HC)	1.0–1.67 oz	0.8–1.4 lb	
Chlorpyrifos			1B
(Lorsban® 15G)	8.0 oz	6.5 lb	
(Nufos® 15G)	8.0 oz	6.5 lb	
Tefluthrin			3A
(Force® 3G)	4–5 oz	3.3–4.1 lb	
Terbufos			1B
(Counter® 20G)	6.0 oz	4.9 lb	
(Counter® 15G)	8.0 oz	6.5 lb	

Remarks

Chlorethoxyfos + bifenthrin: Apply in furrow only, not banded.
Chlorpyrifos: Chlorpyrifos 15G is not labeled for band application. Must be in-furrow or T-band.
Tefluthrin: Apply as banded, T-band, or in-furrow.
Terbufos: Read the supplemental label for information on potential crop damage if used in combination with some herbicides. Banded or in-furrow application only.

Table A2. Suggested insecticides for controlling wireworms

Insecticide (listed alphabetically)	Amount per 1,000 feet of row	Amount per acre on 40-inch row spacing	IRAC group
Chlorethoxyfos +			1B
bifenthrin			3A
(SmartChoice 5G)	3.0–3.5 oz	2.6–3.0 lb	
(SmartChoice HC)	1.0–1.67 oz	0.8–1.4 lb	
Chlorpyrifos			1B
(Lorsban® 15G)	8.0 oz	6.5 lb	
(Nufos® 15G)	8.0 oz	6.5 lb	
Tefluthrin			3A
(Force® 3G)	4–5 oz	3.3–4.1 lb	
Terbufos			1B
(Counter® 20G)	6.0 oz	4.9 lb	
(Counter® 15G)	8.0 oz	6.5 lb	

Remarks

Chlorethoxyfos + bifenthrin: Apply only in furrow, not banded.
Chlorpyrifos: Chlorpyrifos 15G is not labeled for band application. Must be in-furrow or T-band. For best control of wireworms, apply as an in-furrow treatment. Consider using an insecticidal seed treatment with T-band applications.
Tefluthrin: Apply as banded, T-band, or in-furrow.
Terbufos: Read the supplemental label for information on potential crop damage if used in combination with some herbicides.

Table A3. Suggested Bt technology for controlling Mexican and western corn rootworms		
Technology	**Rootworm toxin(s)**	**Caterpillar toxin(s)**
Agrisure 3000GT, 3011A	mCry3A	Cry1Ab
Agrisure Viptera 3111	mCry3A	Cry1Ab + Vip3A
Agrisure 3122	mCry3A + Cry34/35Ab1	Cry1Ab + Cry1F
Agrisure Duracade 5122	mCry3A + eCry3.1Ab	Cry1Ab + Cry1F
Agrisure Duracade 5222	mCry3A + eCry3.1Ab	Cry1Ab + Cry1F + Vip3A
Herculex RW (HXRW)	Cry34/35Ab1	none
Herculex XTRA (HXX)	Cry34/35Ab1	Cry1F
Optimum TRIsect	mCry3A	Cry1F
Optimum Intrasect XTra	Cry34/35Ab1	Cry1F + Cry1Ab
Optimum Intrasect XTreme	mCry3A + Cry34/35Ab1	Cry1F + Cry1Ab
Optimum AcreMax RW	Cry34/35Ab1	none
Optimum AcreMax1 (AM1)	Cry34/35/Ab1	Cry1F
Optimum AcreMax TRIsect	mCry3A	Cry1F + Cry1Ab
Optimum AcreMax Xtra	Cry34/35Ab1	Cry1F + Cry1Ab
Optimum AcreMaxXTrem	mCry3A + Cry34/35Ab1	Cry1F + Cry1Ab
YieldGard VT Rootworm	Cry3Bb1	none
YieldGard VT Triple	Cry3Bb1	Cry1Ab
Genuity VT Triple PRO	Cry3Bb1	Cry1A.105 + Cry2Ab2
Genuity SmartStax	Cry3Bb1 + Cry34/35Ab1	Cry1A.105 + Cry2Ab2 + Cry1F
Mycogen SmartStax	Cry3Bb1 + Cry34/35Ab1	Cry1A.105 + Cry2Ab2 + Cry1F

Table A4. Suggested seed treatments for controlling Mexican and western corn rootworms		
Seed treatment	**Application rate**	**IRAC group**
Clothianidin (Poncho 600 at the 1.25 mg ai/seed rate of Poncho 600)	Apply 1.25 mg ai/seed or 5.64 fl. oz per 80,000 unit of seed	4A
Imidacloprid (Gaucho 600)	For Gaucho 600 apply 1.34 mg ai/seed or 6.0 oz per 80,000 unit of seed.	4A
Thiamethoxam (Cruiser 5FS)	Apply 1.25 mg of active ingredient per kernel. Each fluid ounce contains 17.7 grams of active ingredient.	4A
Thiamethoxam + abamectin (Avicta Complete Corn 250 and 500; Avicta Duo and Dou 250 Corn)	For corn rootworm, must be tank mixed with Cruiser 5FS. See label for rates. Must be applied only in Syngenta-certified seed treatment facilities.	4A 6

Note: Shat seed treatments are insufficient to control heavy rootworm populations.

Remarks

Seed treatments protect roots adequately if the infestations are light or moderate. However, granular insecticides and Bt transgenic hybrids control large rootworm infestations better.

Clothianidin: For use in commercially available equipment designed for seed treatment only. Not for use in hopper-box, slurry box, or similar seed treatment applications used at planting.

Imidacloprid: May be applied by commercial seed treatment facilities, end use at agricultural establishments, or immediately before planting.

Thiamethoxam: Consult your Syngenta seed treatment representative for recommendations on slurry additives to use during applications of Cruiser 5FS. Follow the planter manufacturer's recommendations for using talc, graphite, or other hopper box additives at planting.

Table A5. Suggested granular and liquid insecticides for controlling Mexican and western corn rootworm larvae

Insecticide (listed alphabetically)	Amount per 1,000 feet of row	Amount per acre on 40-inch row spacing	IRAC group
Chlorethoxyfos +			1B
bifenthrin			3A
(SmartChoice 5G)	4.5–5.0 oz	3.9–4.3 lb	
(SmartChoice HC)	1.5–1.67	1.2–1.4 lb	
Chlorpyrifos			1B
(Lorsban® 15G)	8.0 oz	6.5 lb	
(Nufos® 15G)	8.0 oz	6.5 lb	
(Lorsban® 4E or Advanced)	—	2 pt per acre	
(Nufos 4E)	—	2.0 pt per acre	
Tefluthrin			3A
(Force® 3G)	4.0–5.0 oz	3.3–4.1 lb	
Terbufos			1B
(Counter® 20G)	6.0 oz	4.9 lb	
(Counter® 15G)	8.0 oz	6.5 lb	

Remarks

Chlorethoxyfos + bifenthrin: Apply only in furrow, not banded.

Chlorpyrifos: Chlorpyrifos is not effective on Mexican corn rootworm in high-pH soils in South Texas. Nufos 15G and 4E do not list Mexican corn rootworm as a pest controlled. Granules are not labeled for band application. Must be in-furrow or T-band. Liquid formulation must be applied by T-band application only. Applications made using a band width less than 5–6 inches may cause phytotoxicity under certain environmental conditions such as cool temperatures, wet conditions, and light soils. Lorsban 4E and Nufos can be chemigated to control corn rootworm larvae.

Tefluthrin: See the label for application and timing instructions.

Terbufos: Read the supplemental label for information on potential crop damage if used in combination with some herbicides.

PRECAUTION: Certain sulfonylurea herbicides and organophosphate insecticides used in the same crop year on corn may injure the crop severely. Please read pesticide labels carefully.

IMPORTANT: Using the same soil insecticides year after year in the same field is not a good practice. For best results, rotate organophosphate (chlorpyrifos, terbufos) with other (tefluthrin) soil insecticides each year.

For all band applications, apply in a 6- to 8-inch band just behind seed drop and in front of covering shovels and press wheel or chain drag. Soil incorporation to about 1 inch deep is important.

Table A6. Suggested seed treatments for controlling southern corn rootworm		
Seed treatment	**Application rate**	**IRAC group**
Clothianidin (Poncho 600 and Poncho 1250, the 1.25 mg ai/seed rate of Poncho 600)	For Poncho 600, apply 1.25 mg ai/seed or 5.64 fl oz per 80,000 unit of seed.	4A
Imidacloprid (Gaucho 600)	For Gaucho 600 apply 1.34 mg ai/seed or 6.0 oz per 80,000 unit of seed.	4A
Thiamethoxam (Cruiser 5FS)	Apply 1.25 mg of active ingredient per kernel. Each fluid ounce contains 17.7 grams of active ingredient.	4A
Thiamethoxam + Abamectin (Avicta Complete Corn 250 and 500; Avicta Duo and Dou 250 Corn)	For corn rootworm, must be tank mixed with Cruiser 5FS. See label for rates. Must be applied only in Syngenta-certified seed-treatment facilities.	4A 6

Note: Seed treatments are insufficient to control heavy rootworm populations.

Remarks

Seed treatments protect the roots adequately if the infestations are light or moderate. However, granular insecticides and Bt transgenic hybrids control under high rootworm infestations better.
Clothianidin: For use in commercially available equipment designed for seed treatment only. Not for use in hopper-box, slurry box, or similar seed treatment applications used at planting.
Imidacloprid: May be applied by commercial seed treatment facilities, for end use at agricultural establishments, or immediately before planting.
Thiamethoxam: Consult your Syngenta seed treatment representative for recommendations on slurry additives to use when applying Cruiser 5FS. Follow planter manufacturer recommendations for using talc, graphite, or other hopper box additives at planting.

Table A7. Suggested insecticides applied at planting for controlling southern corn rootworm			
Insecticide (listed alphabetically)	**Amount per 1,000 feet of row**	**Amount per acre on 40-inch row spacing**	**IRAC group**
Chlorethoxyfos + bifenthrin (SmartChoice 5G) (SmartChoice HC)	 4.5–5.0 oz 1.5–1.67	 3.9–4.3 lb 1.2–1.4 lb	1B 3A
Chlorpyrifos (Lorsban® 15G) (Nufos® 15G)	 8.0 oz 8.0 oz	 6.5 lb 6.5 lb	1B
Tefluthrin (Force® 3G)	 4–5 oz	 3.3–4.1 lb	3A
Terbufos (Counter® 20G) (Counter® 15G)	 6.0 oz 8.0 oz	 4.9 lb 6.5 lb	1B

Remarks

Chlorethoxyfos + bifenthrin: Apply only in furrow, not banded.
Chlopyifos: Chlorpyrifos 15G is not labeled for band application. Must be in-furrow or T-band. The maximum application rate for at-plant application is 8.0 oz per 1,000 feet of row.
Terbufos: Read the supplemental label for information on potential crop damage if used in combination with some herbicides.
Tefluthrin: See the label for application and timing instructions.
PRECAUTION: Some sulfonylurea herbicides and organophosphate insecticides may injure the crop severely if they are used in the same crop year on corn. Please read the pesticide labels carefully.
IMPORTANT: Using the same soil insecticide year after year in the same field is not a good practice. Rotate organophosphate (chlorpyrifos, terbufos) with other (tefluthrin) soil insecticides each year.
For all band applications, apply in a 6- to 8-inch band just behind seed drop and in front of covering shovels and press wheel or chain drag. Incorporate into the soil to about 1 inch deep.

Table A8. Suggested insecticides for controlling cutworms

Insecticide (listed alphabetically)	Amount per acre	Days from last application to		IRAC group
		Harvest	Grazing	
Chlorpyrifos				1B
(Lorsban® 4E or Advanced)	1–2 pt	21	0	
(Nufos® 4E)	1–2 pt	21	0	
Esfenvalerate				3A
(Asana® XL 0.66E)	5.8–9.6 oz	21	See label	
Permethrin				3A
(Ambush®)	6.4–12.8 oz	30	0	
(Arctic® 3.2EC)	4.0–6.0 oz	30	0	
(Pounce® 1.5G)	6.7–10.0 lb	30	0	
Lambda-cyhalothrin				3A
(Warrior® II)	0.96–1.6 oz	21	1	

Remarks

Chlorpyrifos: It is preferable to apply chlorpyrifos when the soil is moist and the cutworms are active on or near the soil surface.

Permethrin: Pre-emergent use—in the period from 5 days before planting until crop emergence, apply as a broadcast spray in at least 20 gallons of finished spray/acre with ground equipment. Foliar use—apply by ground before ear formation.

Table A9. Suggested Bt technology for controlling southwestern corn borer

Technology	Rootworm toxin(s)	Caterpillar toxin(s)
Agrisure GT/CB/LL, 3010A	None	Cry1Ab
Agrisure 3000GT, 3011A	mCry3A	Cry1Ab
Agrisure Viptera 3110	None	Cry1Ab + Vip3A
Agrisure Viptera 3111	mCry3A	Cry1Ab + Vip3A
Agrisure 3122	mCry3A + Cry34/35Ab1	Cry1Ab + Cry1F
Agrisure Duracade 5122	mCry3A + eCry3.1Ab	Cry1Ab + Cry1F
Agrisure Duracade 5222	mCry3A + eCry3.1Ab	Cry1Ab + Cry1F + Vip3A
Herculex (HX1)	None	Cry1F
Herculex XTRA	Cry34/35Ab1	Cry1F
Optimum TRIsect	mCry3A	Cry1F
Optimum Intrasect	None	Cry1F + Cry1Ab
Optimum Intrasect Leptra	None	Cry1F + Cry1Ab + Vip3A
Optimum Intrasect XTra	Cry34/35Ab1	Cry1F + Cry1Ab
Optimum Intrasect XTreme	mCry3A + Cry34/35Ab1	Cry1F + Cry1Ab
Optimum AcreMax (AM)	None	Cry1F + Cry1Ab
Optimum AcreMax1	Cry34/35/Ab1	Cry1F
Optimum AcreMax TRIsect	mCry3A	Cry1F + Cry1Ab
Optimum AcreMax Xtra	Cry34/35Ab1	Cry1F + Cry1Ab
Optimum AcreMaxXTrem	mCry3A + Cry34/35Ab1	Cry1F + Cry1Ab
Yieldgard CB (YGCB)	None	Cry1Ab
YieldGard VT Triple	Cry3Bb1	Cry1Ab
Genuity VT Double Pro	None	Cry1A.105 + Cry2Ab2
Genuity VT Triple PRO	Cry3Bb1	Cry1A.105 + Cry2Ab2
Genuity SmartStax	Cry3Bb1 + Cry34/35Ab1	Cry1A.105 + Cry2Ab2 + Cry1F
Mycogen SmartStax	Cry3Bb1 + Cry34/35Ab1	Cry1A.105 + Cry2Ab2 + Cry1F

Note: All Bt hybrids targeting southwestern corn borer have provided excellent control. However, as of this writing in 2016, there is evidence that populations in Arizona and New Mexico may be less susceptible to Cry1F than in the past.

Table A10. Suggested insecticides for controlling southwestern corn borer				
Insecticide (listed alphabetically)	**Amount per acre**	**Days from last application to**		**IRAC group**
		Harvest	**Grazing**	
Bifenthrin				3A
(Brigade® 2EC)	2.1–6.4 oz	30	30	
Bifenthrin + Zeta-cypermethrin				3A
(Hero®)	4–10.3 oz	30	30	
Carbaryl				1A
(Sevin® XLR Plus 4 lb)	1–2 qt	48	14	
Chlorantraniliprole*	14–20 oz	14		
(Prevathon)				
Chlorpyrifos				1B
(Lorsban® 4E or Advanced)	1.5–2 pt	21	0	
(Nufos® 4E)	1.5–2 pt	21	0	
(Lorsbsan® 15G)'	3.5–8 oz; see footnote	21	See label	
(Nufos® 15G)	3.5–8 oz; see footnote	21	See label	
Esfenvalerate				3A
(Asana XL® 0.66E)	5.8–9.6 oz	21	See label	
Flubendiamide*				28
(Belt SC)	2–3 oz	28	See label	
Lambda-cyhalothrin				3A
(Warrior® II)	1.28–1.92 oz	21	1	
Lambda-cyhalothrin +				3A
chlorantraniliprole				28
(Besiege)	6–10 oz	21	See label	
Methoxyfenozide*				18
(Intrepid 2F)	6–16 oz	21	See label	
Permethrin				3A
(Ambush®)	6.4–12.8 oz	30	0	
(Arctic® 3.2EC)	4–6 oz	30	0	
(Pounce® 1.5G)	6.7–10.0 lb	30	0	
Spinosad*				5
(Tracer 4EC)	2–3 oz	28	See label	
Spinetoram*				5
(Radiant SC)	3–6 oz	28	See label	

* We anticipate that chlorantraniliprole, flubendiamide, methoxyfenozide, spinosad, and spinetoram will control southwestern corn borer effectively, but populations have been too low in the recent past to allow us to conduct the necessary research trials.

Remarks

Research data demonstrate that using cabaryl, chlorpyrifos, and certain pyrethroids (esfenvalerate, lambda-cyhalothrin, lambda-cyhalothrin + chlorantraniliprole, permethrin) can cause increases in spider mites on corn. For information about mite resistance to bifenthrin, see the Table A18 footnotes.

Bifenthrin + zeta-cypermethrin: Do not apply more than 0.4 lb active ingredient per acre per season for foliar application.

Chlorpyrifos: The 15G formulation is labeled as post-plant application only for corn borers.

Lambda-cyhalothrin + chlorantraniliprole: Do not apply more than 10 oz per acre after corn has reached the milk stage.

Methoxyfenozide: Texas research trials have shown the 4.0 oz rate to be effective on low to moderate populations, but 6.0 to 8.0 oz rates are recommended for populations that significantly exceed the economic threshold. Do not apply through irrigation systems.

Permethrin: Do not apply after the silks begin to turn brown.

Spinosad and spinetoram: Time the applications to coincide with peak egg hatch. Treat large populations with the high rate. Spinosad is suggested for the first generation only.

Table A11. Suggested Bt technology for controlling European corn borer		
Technology	**Rootworm toxin(s)**	**Caterpillar toxin(s)**
Agrisure GT/CB/LL, 3010A	None	Cry1Ab
Agrisure 3000GT, 3011A	mCry3A	Cry1Ab
Agrisure Viptera 3110	None	Cry1Ab + Vip3A
Agrisure Viptera 3111	mCry3A	Cry1Ab + Vip3A
Agrisure 3122	mCry3A + Cry34/35Ab1	Cry1Ab + Cry1F
Agrisure Duracade 5122	mCry3A + eCry3.1Ab	Cry1Ab + Cry1F
Agrisure Duracade 5222	mCry3A + eCry3.1Ab	Cry1Ab + Cry1F + Vip3A
Herculex (HX1)	None	Cry1F
Herculex XTRA	Cry34/35Ab1	Cry1F
Optimum TRIsect	mCry3A	Cry1F
Optimum Intrasect	None	Cry1F + Cry1Ab
Optimum Intrasect Leptra	None	Cry1F + Cry1Ab + Vip3A
Optimum Intrasect XTra	Cry34/35Ab1	Cry1F + Cry1Ab
Optimum Intrasect XTreme	mCry3A + Cry34/35Ab1	Cry1F + Cry1Ab
Optimum AcreMax (AM)	None	Cry1F + Cry1Ab
Optimum AcreMax1	Cry34/35/Ab1	Cry1F
Optimum AcreMax TRIsect	mCry3A	Cry1F + Cry1Ab
Optimum AcreMax Xtra	Cry34/35Ab1	Cry1F + Cry1Ab
Optimum AcreMaxXTrem	mCry3A + Cry34/35Ab1	Cry1F + Cry1Ab
Yieldgard CB (YGCB)	None	Cry1Ab
YieldGard VT Triple	Cry3Bb1	Cry1Ab
Genuity VT Double Pro	None	Cry1A.105 + Cry2Ab2
Genuity VT Triple PRO	Cry3Bb1	Cry1A.105 + Cry2Ab2
Genuity SmartStax	Cry3Bb1 + Cry34/35Ab1	Cry1A.105 + Cry2Ab2 + Cry1F
Mycogen SmartStax	Cry3Bb1 + Cry34/35Ab1	Cry1A.105 + Cry2Ab2 + Cry1F

Note: All Bt hybrids targeting European corn borer provide excellent control.

Table A12. Suggested insecticides for controlling European corn borer				
Insecticide (listed alphabetically)	**Amount per acre**	**Days from last application to**		**IRAC group**
		Harvest	**Grazing**	
Bacillus thuringiensis (Dipel® ES)	1.5–2.5 pt	0	0	11A
Bifenthrin (Brigade® 2EC and generic formulations)	2.1–6.4 oz	30	30	3A
Bifenthrin + zeta-cypermethrin (Hero®)	4–10.3 oz	30	30	3A
Chlorantraniliprole* (Prevathon)	14–20 oz	14	1	28
Chlorpyrifos				1B
(Lorsban® 4E or Advanced)	1–2 pt	21	See label	
(Nufos® 4E)	1–2 pt	21	See label	
(Lorsbsan® 15G)	3.5–8 oz; see footnote	21	See label	
(Nufos® 15G)	3.5–8 oz; see footnote	21	See label	
Esfenvalerate (Asana® XL 0.66E)	7.8–9.6 oz	21	See label	3A
Flubendiamide* (Belt SC)	2–3 oz	28	See label	28
Lambda-cyhalothrin (Warrior® II)	1.28–1.92 oz	21	1	3A
Lambda-cyhalothrin + chlorantraniliprole (Besiege)	6–10 oz	21	See label	3A 28
Methoxyfenozide* (Intrepid 2F)	6–16 oz	21	See label	18
Permethrin				3A
(Ambush®)	6.4–12.8 oz	30	0	
(Arctic® 3.2EC)	4–6 oz	30	0	
(Pounce® 1.5G)	6.7–10.0 lb	30	0	
Spinosad* (Tracer® 4SC)	2–3 oz	28	See label	5
Spinetoram* (Radiant SC)	3–6 oz	28	See label	5

* We anticipate that chlorantraniliprole, flubendiamide, methoxyfenozide, spinosad and spinetoram will effectively control European corn borer, but populations have been too low recently to allow us to conduct the necessary research trials.

Remarks

Research data demonstrate that using cabaryl, chlorpyrifos, and certain pyrethroids (esfenvalerate, lambda-cyhalothrin, lambda-cyhalothrin + chlorantraniliprole, permethrin) can cause increases in spider mite densities on corn. For information about mite resistance to bifenthrin, see the footnotes for Table A18.

Bacillus thuringiensis: Ground application only for the first generation.

Bifenthrin + zeta-cypermethrin: Do not apply more than 0.4 lb active ingredient per acre per season for foliar application.

Chlorpyrifos: The 15G formulation is labeled as post-plant application only for corn borers. For chlorpyrifos 4E, the lowest rate for aerial or ground application is 1.5 pt/acre. The 1.0 pt rate is for chemigation only.

Lambda-cyhalothrin + chlorantraniliprole: Do not apply more than 10 oz/ac after corn has reached the milk stage.

Permethrin: Apply before the brown silk stage.

Spinosad: Suggested for first generation only. Time the applications to coincide with peak egg hatch.

Table A13. Suggested insecticides for controlling lesser cornstalk borer				
Insecticide (listed alphabetically)	**Amount per acre**	**Days from last application to**		**IRAC group**
		Harvest	**Grazing**	
Chlorpyrifos				1B
(Lorsban® 15G)	8 oz/1,000 row ft	21	See label	
(Nufos® 15G)	8 oz/1,000 row ft	21	See label	
(Lorsban® 4E or Advanced)	2 pt/acre	21	0	
(Nufos 4E)	2 pt/acre	21	0	

Remarks

Chlorpyrifos: Chlotpyrifos 15G for lesser cornstalk borer control is labeled for T-band application only, not in-furrow.

Table A14. Suggested insecticides for controlling flea beetles				
Insecticide (listed alphabetically)	**Amount per acre**	**Days from last application to**		**IRAC group**
		Harvest	**Grazing**	
Carbaryl				1A
(Sevin® XLR Plus 4 lb)	1–2 qt	48	14	
Esfenvalerate				3A
(Asana® XL 0.66EC)	5.8–9.6 oz	21	See label	

Table A15. Suggested seed treatments for controlling chinch bugs		
Seed treatments	**Seed treatment rate**	**IRAC**
Clothianidin (Poncho® 250, the 0.25 mg rate of Poncho 600)	For Poncho 600, apply 0.25–0.50 mg ai/seed or 1.13 fl oz per 80,000 unit of seed.	4A
Imidacloprid (Gaucho 600)	For Gaucho 600 apply 1.34 mg ai/seed or 6.0 oz per 80,000 units of seed.	4A
Thiamethoxam (Cruiser 5FS)	Apply 0.25 to 0.80 mg of active ingredient per kernel. Each fluid ounce contains 17.7 g of active ingredient.	4A
Thiamethoxam + abamectin (Avicta Complete Corn 250 and 500; Avicta Duo and Dou 250 Corn)	Must be applied only in Syngenta-certified seed treatment facilities	4A 6

Remarks

Clothianidin: This is a commercial seed treatment, and growers cannot buy clothianidin to treat their own seed. For use in commercially available equipment designed for seed treatment only. Not for use in hopper-box, slurry box, or similar seed treatment applications used at planting.
Imidacloprid: May be applied by commercial seed treatment facilities, for end use at agricultural establishments, or immediately before planting.
Thiamethoxam: This is a commercial seed treatment, and growers cannot buy clothianidin to treat their own seed. Consult your Syngenta Seed Treatment representative for recommendations on slurry additives to use during applications of Cruiser 5FS. Follow planter manufacturer recommendations for using talc, graphite, or other hopper box additives at planting.

Table A16. Suggested insecticides for controlling chinch bugs				
Liquid or granular insecticides (listed alphabetically)	**Amount per acre**	**Days from last application to**		**IRAC group**
		Harvest	**Grazing**	
At-plant				
Chlorpyrifos				1B
(Lorsban® 15G)	8 oz/1,000 row ft	21	See label	
(Nufos® 15G)	8 oz /1,000 row ft	21	See label	
Terbufos				1B
(Counter® 20CR)	6 oz/1,000 row ft	30	30	
(Counter® 15G)	8 oz/1,000 row ft	30	30	
Post-plant				
Carbaryl				1A
(Sevin® XLR Plus 4 lb)	1.0–2.0 qt	48	14	
Chlorpyrifos				1B
(Lorsban® 4E or Advanced)	1–2 pt	21	0	
(Nufos® 4E)	1–2 pt	21	0	
Lambda-cyhalothrin				3A
(Warrior® II)	1.92 oz	21	1	
Karate (sweet corn only)	3.20–5.12 oz	21	See label	

Remarks

For post-plant application, use only ground application equipment, and direct the spray nozzles at the infested portions of the plants. Control is difficult on larger plants.

Carbaryl: For optimum control, apply 20 gallons of water per acre by ground and direct the spray toward the bases of the stalks to provide thorough coverage.

Chlorpyrifos: For Chlorpryfos 15G, a T-band is more effective than an in-furrow application. Consider in-furrow applications as suppression only. Apply the 4E formulation with enough water to ensure a minimum spray volume of 20–40 gallons per acre using ground equipment.

Terbufos: Apply at planting time in-furrow, placing the granules directly in the seed furrow behind the planting shoe. Terbufos is for early-season control of light to moderate infestations.

Table A17. Suggested miticides for controlling twospotted spider mites				
Miticides (listed alphabetically)	**Amount per acre**	**Days from last application to**		**IRAC group**
		Harvest	**Grazing**	
Etoxazole				10B
(Zeal)	1.5–3.0 oz	21	See label	
Fenpyroximate				21A
(Portal)	1.5–2.0 pt	14	See label	
(Portal XLO)	2.0 pt			
Hexythiazox				10A
(Onager 1E)	10–16 oz	30	30	
Propargite				12C
(Comite® II 6 lb)	Early: 18 oz Later: 48–54 oz	30	30	
Spiromesifen				23
(Oberon 4SC)	Pre-tassel: 4.0–8.0 oz Post-tassel: 5.0–8.0 oz	30	See label remarks	
Sulfur				UN
(6 lb flowable)	6 qt	0	0	

Remarks

Etoxazole: The 2.0 oz rate will provide more consistent control than the 1.5 oz rate. Maximum of 2 applications at least 14 days apart.
Fenpyroximate: Maximum of 2 applications at least 14 days apart.
Hexythiazox: Do not make more than one application per year or apply more than 24 oz per year.
Propargite: Two applications can be made per year but must be separated by at least 21 days. Do not exceed 54 oz per year.
Spiromesifen: Do not use more than 8.5 oz/ac per season or exceed two applications per crop per season. Allow at least 14 days between applications.
Sulfur: Thorough plant coverage is required.

Table A18. Suggested miticides for controlling Banks grass mites				
Miticides (listed alphabetically)	**Amount per acre**	**Days from last application to**		**IRAC group**
		Harvest	**Grazing**	
Bifenthrin (Brigade® 2EC and generic products) See footnotes for resistance caution statement	5.12–6.4 oz	30	30	3A
Bifenthrin + zeta-cypermethrin (Hero®)	10.3 oz	30	30	3A
Dimethoate				1B
(Dimethoate 4 E)	0.67–1 pt	28	14	
(Dimethoate 5 lb)	8.4–12.8 oz	14	14	
(Dimethoate 400)	0.6–1 pt	28	14	
Etoxazole (Zeal)	1.5–3.0 oz	21	See label	10B
Fenpyroximate				21A
(Portal)	1.5–2.0 pt	14	See label	
(Portal XLO)	2.0 pt			
Hexythiazox (Onager 1E)	10–16 oz	30	30	10A
Propargite (Comite® II 6 lb)	Early: 18 oz Later: 48–54 oz	30	30	12C
Spiromesifen (Oberon 4SC)	4.0–8.0 oz	30	See label	23
Sulfur (6 lb flowable)	6 qt	0	0	UN

Remarks

Bifenthrin: Research has indicated that spider mites in some areas of Texas are resistant to bifenthrin, especially in the High Plains. Bifenthrin will not control resistant populations. ULV applications are prohibited. Bifenthrin is often used in combination with dimethoate.
Bifenthrin + zeta-cypermethrin: Apply for Banks grass mite control when colonies first form before they damage or discolor leaves and before the disperse above the bottom third of the plant. Research has indicated that spider mites in some areas of Texas are resistant to bifenthrin, especially in the High Plains. Bifenthrin will not control resistant populations.
Dimethoate: It is not labeled for the Trans-Pecos area of Texas. This product has often been combined with pyrethroids to control mites. There is no demonstrated advantage to mixing dimethoate with propargite. Heavy infestations may require an alternate chemical.
Etoxazole: The 2.0 oz rate will provide more consistent control than the 1.5 oz rate. Maximum of 2 applications at least 14 days apart.
Fenpyroximate: Maximum of 2 applications at least 14 days apart.
Hexythiazox: Do not make more than one application per year or apply more than 24 oz per year.
Propargite: Two applications can be made per year but must be separated by at least 21 days. Do not exceed 54 oz per year.
Spiromesifen: Do not use more than 8.5 oz/acre per season or exceed two applications per season. Allow at least 14 days between applications.
Sulfur: This is the only material that has been partially effective in the Trans-Pecos area of Texas. The plants must be covered thoroughly.

Table A19. Suggested insecticides for controlling Mexican and western corn rootworm beetles

Insecticides (listed alphabetically)	Amount per acre	Days from last application to		IRAC group
		Harvest	Grazing	
Carbaryl (Sevin® XLR Plus 4 lb)	1.0–2.0 qt	48	14	1A
Malathion (Fyfanon® ULV 9.9 lb)	4.0 oz	5	no	1B

Remarks

Research data demonstrate that use of cabaryl, chlorpyrifos, and pyrethroid (esfenvalerate, lambda-cyhalothrin, bifenthrin, permethrin) insecticides can cause increases in spider mite densities on corn.

Note: Applying the insecticides listed above during pollen shed will destroy foraging honeybees.

Table A20. Suggested Bt technology for controlling fall armyworm

Technology	Rootworm toxin(s)	Caterpillar toxin(s)
Agrisure Viptera 3110	None	Cry1Ab + Vip3A
Agrisure Viptera 3111	mCry3A	Cry1Ab + Vip3A
Agrisure 3122	mCry3A + Cry34/35Ab1	Cry1Ab + Cry1F
Agrisure Duracade 5122	mCry3A + eCry3.1Ab	Cry1Ab + Cry1F
Agrisure Duracade 5222	mCry3A + eCry3.1Ab	Cry1Ab + Cry1F + Vip3A
Optimum Intrasect	None	Cry1F + Cry1Ab
Optimum Intrasect Leptra	None	Cry1F + Cry1Ab + Vip3A
Optimum Intrasect XTra	Cry34/35Ab1	Cry1F + Cry1Ab
Optimum Intrasect XTreme	mCry3A + Cry34/35Ab1	Cry1F + Cry1Ab
Optimum AcreMax (AM)	None	Cry1F + Cry1Ab
Optimum AcreMax TRIsect	mCry3A	Cry1F + Cry1Ab
Optimum AcreMax Xtra	Cry34/35Ab1	Cry1F + Cry1Ab
Optimum AcreMaxXTrem	mCry3A + Cry34/35Ab1	Cry1F + Cry1Ab
Genuity VT Double Pro	None	Cry1A.105 + Cry2Ab2
Genuity VT Triple PRO	Cry3Bb1	Cry1A.105 + Cry2Ab2
Genuity SmartStax	Cry3Bb1 + Cry34/35Ab1	Cry1A.105 + Cry2Ab2 + Cry1F
Mycogen SmartStax	Cry3Bb1 + Cry34/35Ab1	Cry1A.105 + Cry2Ab2 + Cry1F

Table A21. Suggested insecticides for controlling fall armyworm

Insecticides (listed alphabetically)	Amount per acre	Days from last application to		IRAC group
		Harvest	Grazing	
Chlorantraniliprole (Prevathon)	14–20 oz	14	1	28
Flubendiamide (Belt SC)	2–3 oz	28	See label	28
Lambda-cyhalothrin + chlorantraniliprole (Besiege)	6–10 oz	21	See label	3A 28

Remarks

Chlorantraniliprole: Minimum interval between applications is 7 days.

Lambda-cyhalothrin + chlorantraniliprole: Do not apply more than 10 oz per acre after the corn has reached the milk stage. Research shows that using pyrethroids such as lambda-cyhalothrin can increase spider mite densities on corn.

Table A22. Suggested insecticides for controlling true armyworm

Insecticides (listed alphabetically)	Amount per acre	Days from last application to		IRAC group
		Harvest	Grazing	
Carbaryl				1A
(Sevin® XLR Plus 4 lb)	1.0–2.0 qt	48	14	
Chlorantraniliprole				28
(Prevathon)	14–20 oz	14	1	
Chlorpyrifos				1B
(Lorsban® 4E or Advanced)	1–2 pt	21	See label	
(Nufos® 4E)	1–2 pt	21	See label	
Esfenvalerate				3A
(Asana® XL 0.66E)	5.8–9.6 oz	21	See label	
Flubendiamide	2–3 oz			28
(Belt SC)		28	See label	
Lambda-cyhalothrin +				3A
chlorantraniliprole				28
(Besiege)	6–10 oz	21	See label	
Methomyl:				1A
(Lannate® 90SP)	0.25–0.5 lb	21	See label	
(Lannate® 2.4LV)	0.75–1.5 pt	21	See label	
Permethrin				3A
(Ambush®)	6.4–12.8 oz	30	0	
(Arctic® 3.2EC)	4.0–6.0 oz	30	0	

Remarks

Research shows that using carbaryl, chlorpyrifos, and pyrethroid (esfenvalerate, lambda-cyhalothrin, permethrin) can increase mite densities on corn.

Lambda-cyhalothrin + chlorantraniliprole: Do not apply more than 10 oz/ac after the corn has reached the milk stage.

Note: Applying the insecticides listed above during pollen shed will destroy foraging honeybees.

Table A23. Suggested Bt technology for controlling western bean cutworm		
Technology	**Rootworm toxin(s)**	**Caterpillar toxin(s)**
Agrisure Viptera 3110	None	Cry1Ab + Vip3A
Agrisure Viptera 3111	mCry3A	Cry1Ab + Vip3A
Agrisure Duracade 5222	mCry3A + eCry3.1Ab	Cry1Ab + Cry1F + Vip3A
Optimum Intrasect Leptra	None	Cry1F + Cry1Ab + Vip3A
Genuity VT Double Pro	None	Cry1A.105 + Cry2Ab2
Genuity VT Triple PRO	Cry3Bb1	Cry1A.105 + Cry2Ab2
Genuity SmartStax	Cry3Bb1 + Cry34/35Ab1	Cry1A.105 + Cry2Ab2 + Cry1F
Mycogen SmartStax	Cry3Bb1 + Cry34/35Ab1	Cry1A.105 + Cry2Ab2 + Cry1F

Table A24. Suggested insecticides for controlling western bean cutworm				
Insecticides (listed alphabetically)	**Amount per acre**	**Days from last application to**		**IRAC group**
		Harvest	**Grazing**	
Bifenthrin (Brigade® 2EC)	2.1–6.4 oz	30	30	3A
Bifenthrin + zeta-cypermethrin (Hero)	2.6–6.1 oz	30	30	3A
Carbaryl (Sevin® XLR Plus 4 lb)	2.0 qt	48	14	1A
Chlorantraniliprole (Prevathon)	14 -20 oz	14	1	28
Esfenvalerate (Asana® XL 0.66E)	2.9–5.8 oz	21	See label	3A
Flubendiamide (Belt SC)	2–3 oz	28	See label	28
Lambda-cyhalothrin + chlorantraniliprole (Besiege)	5–10 oz	21	See label	3A 28

Remarks

Research shows that using carbaryl, chlorpyrifos, and pyrethroid (bifenthrin, esfenvalerate, zeta-cypermethrin, lambda-cyhalothrin,) insecticides can cause increases in mite densities on corn.

Lambda-cyhalothrin + chlorantraniliprole: Do not apply more than 10 oz/ac after the corn has reached the milk stage.

Table A25. Suggested insecticides for controlling grasshoppers				
Insecticides (listed alphabetically)	**Amount per acre**	**Days from last application to**		**IRAC group**
		Harvest	**Grazing**	
Bifenthrin (Brigade® 2EC and generic products)	2.1–6.4 oz	30	30	3A
Bifenthrin + zeta-cypermethrin (Hero®)	2.6–6.1 oz	30	30	3A
Chlorantraniliprole (Prevathon)	8–20	14	1	28
Chlorpyrifos (Lorsban® 4E or Advanced) (Nufos® 4E)	 0.5–1.0 pt 0.5–1.0 pt	 21 21	 0 0	1B
Esfenvalerate	5.8–9.6 oz	21	See label	3A
Lambda-cyhalothrin (Warrior® II)	1.28–1.92 oz	21	1	3A
Lambda-cyhalothrin + chlorantraniliprole (Besiege)	6–10 oz	21	See label	3A 28

Remarks

Lambda-cyhalothrin + chlorantraniliprole: Do not apply more than 10 oz/ac after corn has reached the milk stage.

Table A26. Honey bee hazards	
Insecticides	**Remarks**
Group 1. Highly toxic	
Bifenthrin Carbaryl (Sevin®) Chlorpyrifos (Lorsban® Nufos) Cyfluthrin Cypermethrin Clothianidin (Poncho®) Dimethoate Esfenvalerate (Asana® XL) Imidacloprid (Gaucho®) Lambda-cyhalothrin (Warrior II®) Malathion Methomyl (Lannate®) Methyl parathion (Penncap-M®) Permethrin (Ambush®, Arctic® 3.2EC) Spinosad (Tracer®) Spinetoram (Radiant®) Tefluthrin (Force®) Thiamethoxam (Cruiser®) Zeta-cypermethrin	This group includes materials that kill bees on contact during application or for several days after application. Remove bees from the area if these insecticides are used on plants being visited by the bees (with some exceptions). Malathion occasionally causes heavy bee losses, particularly during periods of extremely high temperatures. Apply malathion in the evening after all the bees have completed foraging. Avoid ultra-low-volume malathion after blooms appear.
Group 2. Moderately toxic	
Malathion (EC) Spiromesifen (Oberon®) Terbufos (Counter®)	Apply in late evening.
Group 3-4. Relatively nontoxic	
Chlorantraniliprole (Prevathon®) Dipel® Etoxazole (Zeal®) Fenpyroximate (Portal®) Flubendiamide (Belt®) Hexythiazox (Onager®) Methoxyfenozide (Intrepid® 2F) Propargite (Comite®) Sulfur	Apply in late evening or early morning when the bees are not foraging.

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