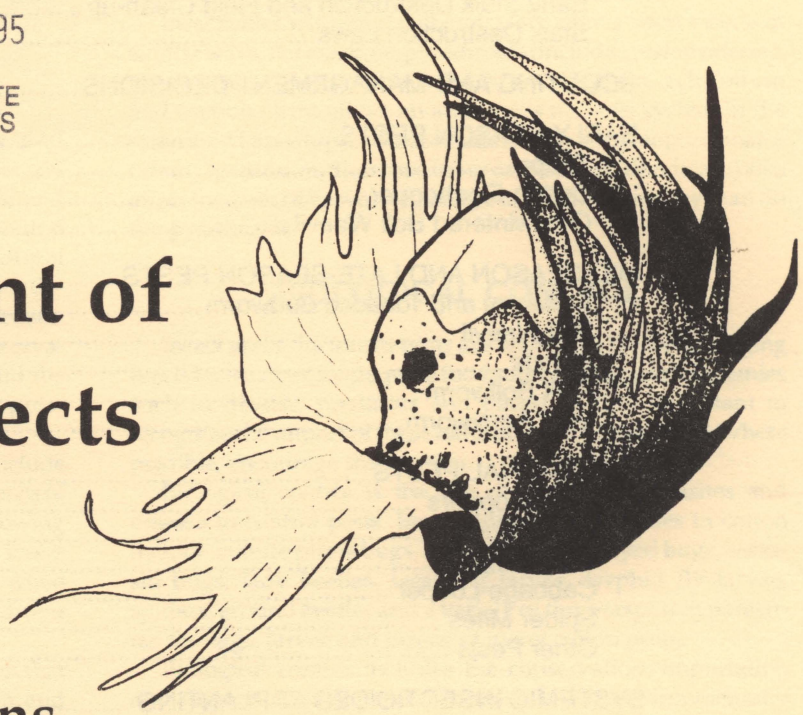
B-1209

Texas Agricultural Extension Service
The Texas A&M University System



Management of Cotton Insects

in the High Plains, Rolling Plains and Trans Pecos Areas of Texas

1995-1996

For recommended insecticides refer to B-1209A, "Suggested Insecticides for Managing Cotton Insects in the High Plains, Rolling Plains and Trans Pecos Areas of Texas, 1995."

Texas Agricultural Extension Service • Zerle L. Carpenter, Director • The Texas A&M University System • College Station, Texas

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Management of Cotton Insects in the High Plains, Rolling Plains and Trans-Pecos Areas of Texas

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A committee of state and federal research personnel and Extension specialists meets annually to review cotton pest management research and management guidelines. These guidelines are directed toward maximizing profits for the Texas cotton producer by optimizing inputs and production.

PEST MANAGEMENT PRINCIPLES

The term "pest management" applies to a philosophy used in the design of insect, mite, disease and weed pest control programs. It encourages the use of the most compatible and ecologically sound combination of available pest suppression techniques. These management techniques include: cultural control, such as manipulation of planting dates and stalk destruction; crop management practices, such as variety selection and timing of irrigation; biological control, involving conservation of existing natural enemies; host plant resistance; and the wise use of selective insecticides and rates to keep pest populations below economically damaging levels.

Major factors to be considered when using insecticides include protecting natural enemies of cotton pests, possible resurgence of primary pests, increased numbers of secondary pests following applications and pest resistance to insecticides. Therefore, insecticides should be applied at the proper rates and used only when necessary, as determined by frequent field inspections, to prevent economic losses from damaging pests.

The pest management concept rests on the assumption that pests will be present to some degree in a production system, and that at some levels they may not cause significant losses in production. The first line of defense against pests is prevention through the use of good agronomic practices or cultural methods which are unfavorable for the development of pest problems (discussed below). Properly selected control measures should be taken only when pest populations reach levels at which crop damage suffered could result in losses greater than the cost of the treatment. This potentially injurious population or plant damage level, determined through regular field scouting activities, is called an **economic threshold or action level**. Precise timing and execution of each production operation is essential. In short, pest management strives to optimize rather than maximize pest control efforts.

INSECTICIDE RESISTANCE MANAGEMENT

Experience has shown that reliance on a single group of insecticides that act the same way may cause pests to develop resistance to the entire group of insecticides. A good strategy to help avoid pest resistance is to rotate the use of insecticide groups, taking advantage of different modes of action. Such insecticide management should delay the development of resistance and also provide better overall insect control.

Insecticides with similar chemical structures affect insects in similar ways. For example, pyrethroids (including esfenvalerate, permethrin, cypermethrin, bifenthrin, cyfluthrin, cyhalothrin and tralomethrin) all act on an insect's nervous system in the same way. Other types of insecticides such as organophosphates (methyl parathion, dicrotophos) or carbamates (thiodicarb) also affect the insect's nervous system, but in a different way than do the pyrethroids.

BIOLOGICAL CONTROL

Insect and mite infestations are often held below damaging levels by weather, inadequate food sources and natural enemies such as disease, predators and parasites. It is important to recognize the impact of these natural control factors and, where possible, encourage their action.

Biological control is the use of predators, parasites and disease to control pests. Important natural enemies in cotton include minute pirate bugs, damsel bugs, big-eyed bugs, assassin bugs, lady beetles, lacewing larvae, syrphid fly larvae, spiders, ground beetles and a variety of tiny wasps that parasitize the eggs, larvae and pupae of many cotton pests.

Biological control includes the conservation, importation and augmentation of natural enemies. It is an environmentally safe method of pest control and is a component of integrated pest management programs in cotton. The Texas A&M University System is fully committed to the development of pest management tactics which use biological control.

Existing populations of natural enemies are conserved by avoiding the use of insecticides until they are needed to prevent the development of economically damaging pest infestations. Insecticide impact can also be minimized by using insecticides that are more toxic to the target pest than to the natural enemy. Classical biological control is the importation of natural enemies from other countries. This method has been effective where an exotic pest has entered Texas without its incumbent natural enemies, or to augment existent natural enemies of native pests.

Augmentation involves the purchase and release of natural enemies on a periodic basis. The most notable commercially available natural enemies include the egg parasite, *Trichogramma*, and the predators, lady beetles and lacewings. Although the control of both bollworms and tobacco budworms by the release of commercially reared *Trichogramma* wasps is theoretically possible, researchers have not been able to consistently achieve the level of parasitism necessary to reduce infestations below

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economically damaging levels. Multiple *Trichogramma* releases at high rates ranging from 50,000 to 150,000 parasitized eggs per acre were utilized in these studies. There are currently no economic thresholds established for augmentative releases of *Trichogramma* for bollworm/budworm control in cotton. Furthermore, parasite mortality from insecticides used to control other pests in or around parasite release areas would be a major factor adversely affecting the success of augmentative releases.

Research studies have shown that releasing large numbers of lacewing larvae (30,000 and more per acre) can reduce bollworm infestations below damaging levels. However, these release rates are currently cost prohibitive because of high production costs for rearing lacewings. The release of lace-wing eggs has been less successful and there is little information on the efficacy of releasing adult lacewings in cotton. There is even less information pertaining to the utility of releasing either lady beetles or lacewings for the control of economically damaging infestations of aphids.

Because definitive information on the application of augmentation (when to apply, what density should be applied, etc.) is lacking, entomologists with the Texas Agricultural Extension Service can not provide guidelines for the application of augmentation as a management tool in cotton.

CROP MANAGEMENT

Irrigated Production

Plan and conduct production practices to achieve early crop maturity in order to escape late-season insect attack and population buildup of insect pests. Production inputs should be directed toward maximum crop profit instead of maximum crop yield.

Crop management practices that have an impact on insect pest numbers and crop damage are:

- Varietal selection (short-season or full-season varieties). Short-season varieties usually mature earlier and escape late-season pest problems which often occur on late-season varieties.
- Uniform planting dates. Allow fields in an area to mature together. Pest infestations are prevented from developing in earlier planted fields and moving into later planted fields.
- Plant population on irrigated cotton should range from 4 to 7 plants/row foot (50,000 to 90,000 plants per acre) in most areas. Higher plant populations can cause delayed crop maturity due to competition for water, nutrients and sunlight. Overcrowding may also contribute to undesirable stalk growth.
- Amount of nitrogen fertilizer used and application timing — Excessive or late nitrogen applications delay crop maturity, particularly when coupled with late irrigation, and subject the crop to intensified and prolonged attack by cotton bollworms, tobacco budworms, boll weevils and pink bollworms.
- Weed control — Weeds limit yield by competing directly with cotton plants for water and nutrients; they also attract various insect pests into cotton fields.
- Amount and timing of crop irrigations — Timing of irrigations often is more important than the total amount of water applied. Water use by the cotton plant is very low during the 35- to 40-day period from seed emergence to the appearance of the first square. Water use increases rapidly with the appearance of the first square. Maximum water use is reached during peak bloom. As the plant progresses toward maturity, water demands are reduced.

Flowering is the period of most rapid plant growth and development, when more than half of the total water is used. Excessive irrigation during this period may make plants more attractive to cotton bollworm and tobacco budworm moths because of additional vegetative growth. Excessive vegetative growth can be checked by allowing sufficient depletion of available water before each irrigation. Excessive water will delay crop maturity, thus increasing crop susceptibility to attack from bollworms, tobacco budworms, boll weevils and pink bollworms.

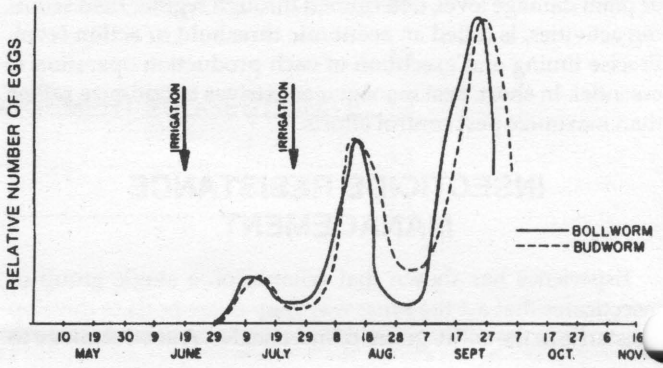
The final irrigation should be timed to provide enough moisture to mature the bolls set during the first 4 weeks of boll production in upland and acala cotton, and to mature the bolls set during the first 6 weeks in Pima cotton. Fruit produced as a result of late irrigations not only adds little to final yield, but also delays the opening of mature bolls, increases crop susceptibility to insects, induces boll rot and contributes to defoliation problems. Late set bolls normally have a poor probability of producing fiber and the lint produced from these bolls is generally of poorer quality because of immature fibers and insect damage.

Crop irrigation should terminate at least 10 days prior to a predicted peak in bollworm egg-laying. This will reduce plant attractiveness to bollworm and budworm moths, lower field humidity to suppress egg hatch and limit the amount of young, tender growth available for newly hatched worms to feed on.

Dryland Production

The primary factor limiting dryland cotton production is the lack of adequate moisture prior to and during the growing season. Due to the lack of moisture or the formation of hardpan, cotton plants may be unable to develop an adequate root system. Dry conditions and moisture stress after cotton begins to fruit will cause the cotton plants to abort squares and small bolls, often reducing or completely negating any potential yield increase obtained from pest control. The amount of moisture in the soil profile at planting appears to be the most accurate predictor of potential yield. Each insecticidal control decision must be made based on the anticipated yield. Because the yield potential of dryland cotton is generally moderate to low, insecticides and other inputs such as fertilizers should be based on realistic yield goals.

IRRIGATION TIMING IN RELATION TO HYPOTHETICAL BOLLWORM/BUDWORM EGG-LAY PATTERN*



*The dates of peak egg-lay vary each year

The yield potential of cotton planted after June 20 is greatly reduced; average yields can be expected only in those years when warm conditions extend well into October. Because of the limited yield potential, additional benefits from the management of insects are also limited. An insecticidal application can be expected to result in a positive economic return only when expected damage equals or exceeds the insecticide and application cost.

Information on cotton varieties that perform best under dryland conditions can be obtained from county Extension agents who annually conduct cotton variety demonstrations. Short-season cottons fruit and mature more rapidly than Delta-type varieties; consequently, the short-season varieties are subject to insect damage for a shorter period of time and may escape the development of large late-season insect populations.

Fertilization of dryland cotton should be based on a soil test.

Plant dryland cotton so that there are 26,000 to 53,000 plants per acre (two to four plants per foot on 40-inch rows). Higher plant populations cause greater competition between plants for moisture and nutrients and can lead to increased pest damage.

Severe bollworm problems can occur in either wet or dry years; however, wet conditions, which favor succulent growth, are generally more favorable for bollworm survival. Bollworms and aphids may become a problem following an insecticide application which destroys beneficials. Insecticides should be applied only when necessary, as determined by frequent field inspection.

Uniform Optimal Planting Date

In areas where boll weevils are present, producers should plant cotton after mid-May. Producer committees in most Rolling Plains counties set a county-wide planting date. This uniform optimal planting date (also known as the uniform planting date or delayed uniform planting date) works by delaying the appearance of squares necessary for boll weevil survival and development until most overwintered weevils have emerged and died from starvation.

The peak period of boll weevil emergence from overwintering sites is typically the last week of May and the first two weeks of June. However, significant emergence can continue into early July in some years. These weevils live for 10 to 22 days following emergence. When cotton is planted after mid-May, the appearance of 1/3-grown squares is delayed until the first week of July or later. Research has shown that very few emerging overwintered weevils survive until 1/3-grown squares are available for oviposition in July. Squares smaller than 1/3-grown do not provide sufficient food for boll weevil larvae to complete development.

Early planting may result in the production of a complete boll weevil generation before later planted cotton begins to square. By using rapid-maturing, short-season cotton varieties and a uniform optimal planting date, the cotton crop is subject to insect damage over a shorter period of time. This often reduces the number of insecticide applications that may be necessary.

Monitoring Cotton Growth

Early fruiting is desirable and facilitates early crop maturity. Frequent monitoring gives a good indication of crop set. Problem fields often can be detected early if growth and fruiting habits are accurately monitored, although the cause of a problem may not be immediately evident.

Cotton development by calendar days and heat units.

Growth interval	Calendar days Mean	Calendar days Range	Accumulated heat units (DD60's from planting required*)
Planting to:			
Stand establishment	7	5 - 13	78
First true leaf	16	11 - 25	
Squaring	36	29 - 41	526
1/3-grown square	44	36 - 49	
First bloom	61	45 - 81	1064
Peak bloom	79	59 - 102	
First open boll	96	88 - 106	1641
95% mature bolls	146	129 - 163	2271
Boll development:			
Fiber length established	First 18-45 days		
Fiber micronaire and strength determined	Next 20-60 days		

*Calculated by the formula:

$$DD\ 60 = \frac{\text{High daily temperature} + \text{low daily temperature}}{2} - 60$$

For each day in which the result is a positive number, heat units are accumulated. For example, if the high for the day is 90 and the low 60, then 90 + 60 = 150 ÷ 2 = 75; 75 - 60 = 15; so 15 heat units would be accumulated for the day. This total would be added to those accumulated each day since planting to get accumulated heat units.

To monitor fruiting levels, mark a point on a row of plants and count 100 consecutive 1/3-grown (1/4 inch in diameter) or larger green squares; record the number of row feet required to gain that count. Record also the number of bolls observed. Later in the season, when bolls are more numerous, count 100 consecutive bolls, both green and open, and record the number of row feet required to make the count. To estimate the number of squares or bolls present per acre, divide the number of row feet recorded to gain a count of 100 consecutive squares or bolls into the number of row feet per acre (13,068 for 40-inch rows and 13,756 for 38-inch rows) and multiply by 100:

$$\text{Bolls and/or squares per acre} = \frac{13{,}068 \text{ or } 13{,}756}{\text{No. row feet recorded for 100 consecutive bolls or squares}} \times 100$$

To monitor the squaring rate, count fruiting sites and all squares on at least ten plants from each of four representative areas in the field. Fruiting usually begins on nodes 6 to 9 depending on variety and environmental conditions. Node 1 is the cotyledonary node (seed leaves). To calculate percent square set, divide the number of small squares counted by the number of fruiting sites recorded and multiply by 100. In normal fields, 75 percent or more of the small squares are retained during the first 3 to 4 weeks of squaring.

Early Stalk Destruction and Field Clean-Up

Early harvest and stalk destruction are among the most effective cultural and mechanical practices for managing overwintering boll weevils if done on an areawide basis. These practices reduce habitat and food available to the boll weevil,

pink bollworm, bollworm and tobacco budworm. When cotton is not harvested until frost, stalks may be left standing in the field except in areas where the pink bollworm is a problem. Stalks should be shredded and plowed under to a depth of 6 inches in areas of pink bollworm infestation. Green or cracked bolls left at the ends of rows should be destroyed to reduce pink bollworm populations. Where cotton is harvested before a killing frost, plants should be shredded to prevent regrowth which can provide squares for weevils to feed on and allow them to successfully overwinter.

The addition of 0.5 lb. methyl parathion or 0.25 lb. azinphosmethyl (Guthion®) to phosphate-type defoliants has proven effective in reducing overwintered boll weevils. Do not add methyl parathion or azinphosmethyl to chlorate-type defoliants because of the potential fire hazard.

Stalk Destruction Laws

Upon request and petition of Texas Cotton Producers, the Texas Legislature passed the Boll Weevil Control Law and the Pink Bollworm Quarantine Law in an effort to combat the two destructive cotton pests. These two laws, which are enforced by the Texas Department of Agriculture, require producers in a regulated county to culturally manage pest populations using habitat manipulation by planting and destroying cotton within an authorized time period. Appointed producers, who are members of local pest management zone committees, have established a series of cotton planting and stalk destruction deadlines for all producers in each regulated county.

The battle against pink bollworms has been extremely successful. Because farmers have adhered to authorized planting and stalk destruction deadlines over the past years, pink bollworm populations in most of the state have been reduced to levels that don't cause major economic damage. Boll weevil population control through stalk destruction efforts has been significant but progress has been slower. Strict adherence to the established deadlines is critical to success of boll weevil management.

SCOUTING AND MANAGEMENT DECISIONS

Regular field scouting is a vital part of any pest management program because it is the only way reliable information can be obtained to determine if and when pest numbers reach the economic threshold. Scouting involves more than just "checking bugs." It determines the insect density and damage level through the use of standardized, repeatable sampling methods. It is also a reliable way to monitor plant growth, fruiting, beneficial insect activity, weeds, diseases and the effects of implemented pest suppression practices.

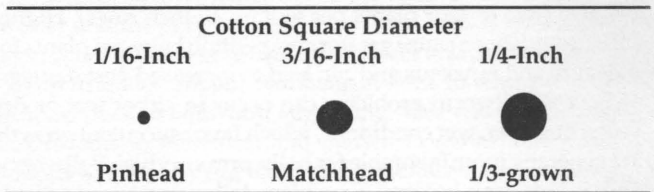
Control measures are needed when a pest population reaches a level at which further increases would result in excessive yield or quality losses. This level is known as the "economic threshold" or treatment level. The relationship between pest level, amount of damage and ability of the cotton plant to compensate for damage is greatly influenced by crop phenology and seasonal weather. The economic threshold is not constant but varies with factors such as price of cotton, cost of control and stage of plant development.

Field inspections should be made every 3 to 7 days using the scouting procedures described in this guide. When a cotton field is properly scouted, accurate and timely decisions can be made to optimize control efforts while minimizing risk.

The following general discussion briefly reviews the insect pests of cotton (for more detail see B-933, "Cotton Insects"). The insect pests are discussed as they normally would occur throughout the cotton production season.

EARLY-SEASON PESTS

The period from plant emergence to first 1/3-grown squares requires about 5 to 6 weeks. The 1/3-grown square is approximately 1/4 inch in diameter. Major pests during this crop development period include thrips, cotton fleahoppers and overwintered boll weevils.



Thrips

Thrips are slender, straw colored insects about 1/15 inch long, with rasping and sucking mouthparts. Adults are winged and capable of drifting long distances in the wind. Thrips attack leaves, leaf buds and very small squares and may cause a silvering of the lower leaf surface, deformed or blackened leaves, terminal loss and square loss. Under some conditions, heavy infestations may reduce stands, stunt plants and delay fruiting and maturity. Thrips damage is most evident during cool, wet periods when small cotton is growing slowly. Thrips damage often is further compounded by plant damage resulting from rain, wind, blowing sand and diseases. Under favorable growing conditions, cotton can sometimes recover completely from early thrips damage. In many areas thrips are considered minor cotton pests. Thrips problems are more prevalent in areas with large winter wheat acreages and where producers plant prior to late May or early June. Research has demonstrated that cotton varieties with hairy leaves are less injured by thrips than smooth-leaf varieties.

Management and decision making. In areas with a history of frequent, heavy thrips infestations, the use of systemic insecticides should be seriously considered. Research has shown that the application of foliar sprays after significant thrips damage has occurred generally does not result in increased yields. Where postemergence sprays are to be used, fields should be scouted as often as twice a week as cotton emerges. Thrips can migrate in heavy numbers from adjacent weeds or crops, especially small grains, and cause significant damage within a few days and prior to the appearance of true leaves. Significant damage to plants rarely occurs after the 4- to 6-true-leaf stage.

Although no research-based economic threshold has been established for this pest, field observations have indicated that **control may be justified when an average of one to five thrips per plant is found**. The number of thrips per plant to use as a treatment guideline increases as plants add more leaves.

Cotton Fleahopper

Adult fleahoppers are about 1/8 inch long and pale green. Nymphs resemble adults but lack wings and are light green. They move very rapidly when disturbed. Adults move into cotton from weed hosts when cotton begins to square. Both adults and nymphs suck sap from the tender portion of the plant, including small squares. Pinhead size and smaller squares are most susceptible to damage.

Management and decision making. The decision to apply insecticide should be based on the number of fleahoppers present, the squaring rate and the percent square set. **During the first 3 weeks of squaring, the economic threshold is 25 to 30 fleahoppers per 100 terminals combined with less than 75 percent square set.**

In cotton planted after May 15, treatment decisions should be made during the first week of squaring, if possible, to avoid a potential bollworm outbreak resulting from the destruction of beneficial insects and spiders. As plants increase in size and fruit load, larger fleahopper populations can be tolerated without yield reduction. In most years treatment is rarely justified after first bloom. However, occasionally, when cotton plants do not set an adequate square load during the first 3 weeks of squaring, fleahoppers can prevent the square set that is needed for an adequate crop.

Overwintered Boll Weevil

Emerging overwintered boll weevils usually move relatively short distances from hibernation sites and usually are confined to small areas in fields adjacent to good overwintering habitat. Overwintered weevil emergence begins during early spring and generally peaks during late May and early June. However, significant emergence can continue into early July in some years. The adult weevil is about 1/4 inch long, grayish brown, and has a prolonged snout with chewing mouthparts at its tip. The presence of two distinct spurs on the lower part of the first segment of the front leg will distinguish the boll weevil from other weevils with which it might be confused.

Weevil colonization in cotton is closely related to the fruiting of the plant, with the greatest numbers of overwintered weevils entering cotton fields after squares are present. Therefore, the extent of overwintered weevil infestation depends on the size of the emerging weevil population and the availability of squaring cotton. Thus, early-planted cotton and fields adjacent to ideal overwintering habitat are much more likely to have significant weevil infestation than cotton planted later in the season or fields farther away from good overwintering habitat. In areas where a uniform delayed planting date is recommended, volunteer cotton should be destroyed as early as possible.

Management and decision making. In weevil infested areas, uniform planting of cotton on a community-wide basis after mid-May will often significantly reduce weevil infestations. When fruiting cotton is not available for feeding, the life span of newly-emerged weevils is relatively short. Therefore, delayed, uniform planting of cotton increases suicidal emergence of overwintered weevils.

The need for insecticide applications to suppress overwintered boll weevils can be determined by: 1) pheromone trap collections (Trap Index Method); 2) Field Inspection Method; or 3) a combination of both methods.

Trap Index Method. Boll weevil pheromone traps should be placed along field margins near favorable overwintering habitat or near areas of the field with a history of early infestations. For fields up to 100 acres in size, at least four to five traps should be used. Pheromone traps should be in operation several weeks before the first squares appear in cotton. The treatment decision is based on the "Trap Index" and scouting information. Inspect traps weekly and determine the average number of weevils caught per trap each week for each field monitored. Record numbers for future reference. Weevils entering fields shortly before and during early squaring are the most important from the standpoint of potential infestation. Determine the average number of weevils captured for the week that the first squares (pinhead to matchhead size) appear. This will be the Trap Index. The number of weevils captured in traps prior to and during the early squaring indicates the size of the overwintering population and the need for one or more insecticide applications.

Trap Index	Decision
One or fewer weevils per trap per week	**Do not treat.**
More than one, but fewer than four weevils per trap per week	**Treatment may or may not be justified. Do not treat unless field inspection at pinhead to 1/3-grown-square stage indicates presence of a damaging weevil infestation (see field inspection method) or unless the number of weevils caught per trap for the week previous to pinhead square exceeds 10.**
More than four weevils per trap per week.	**Treatment is probably justified.**

Pheromone traps must be kept operational and inspected regularly to be reliable. Rain, windy conditions and cool temperatures will reduce weevil response to pheromone traps. Therefore, if adverse weather conditions are present during the week of first square, the average trap catch for the previous week should be considered in determining the need to treat.

Pheromone trap data may not be reliable after 25 percent or more of the cotton in an area has begun to square or after 1/3-grown squares are present in a field around which the traps are located. Trap data are most reliable in areas using uniform planting dates.

Field inspection method. Fields should be observed very closely when pinhead size squares begin to appear. Inspect at least 100 plants for adult boll weevils. **If one or more weevils are found per 100 plants checked or four weevils per 100 feet of row monitored (about 530 weevils per acre) in cotton which was planted after mid-May, apply insecticide just prior to or when first squares reach 1/3-grown stage.**

Overwintered boll weevil control is designed to destroy adult weevils in the field before they deposit eggs in squares. It is also designed to keep the F_1 (first in-season) weevil generation below the treatment level, thereby avoiding the treatments at a time when bollworm outbreaks are more likely to occur (late July to early August). If field or trap inspections indicate that weevils are still entering the field following the first insecticide application, an additional one or two applications may be needed. The first application should be made just before the earliest squares are 1/3-grown with additional applications following at 5-day intervals.

Applications should be terminated as soon as possible after the first 1/3-grown square stage to allow beneficial insects and spiders time to reestablish. There is always a risk of increased bollworm activity where these treatments are made within 10 days of bloom.

MID-SEASON AND LATE-SEASON PESTS

Mid-season is the 6-week fruiting period following the appearance of the first 1/3-grown squares. Proper crop management and frequent field inspection of pests and beneficials will eliminate unnecessary insecticide applications during this period. The major concern during this period is ensuring adequate fruit set and preserving beneficial insect populations.

Late-season is the remainder of the production season when the major concern is boll protection. Monitoring boll set may aid in making spray decisions in the late-season period. Boll protection is of primary concern as long as bolls which will be harvested are immature.

Bollworm and Tobacco Budworm

Bollworm and tobacco budworm larvae are similar in appearance and cause similar damage. Full-grown larvae are about 1 1/2 inches long and vary in color from pale green, pink or brownish to black, with longitudinal stripes along the back.

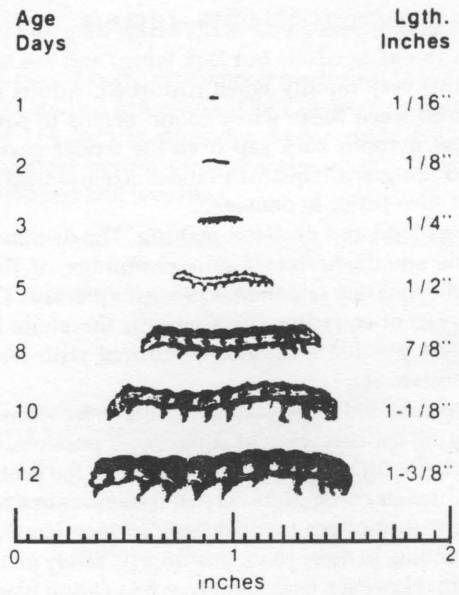
Tobacco budworm and bollworm moths are attracted to and lay eggs readily in cotton that is producing an abundance of new growth. Moths usually lay single eggs on the tops of young, tender terminal leaves in the upper third of the plant. Eggs are pearly white to cream color and about half the size of a pinhead. These should not be confused with looper eggs, which are flatter and usually laid singly on the undersides of leaves. Eggs hatch in 3 to 4 days, turning light brown before hatching. Young worms usually feed for a day or two on tender leaves, leaf buds and small squares in the plant terminal before moving down the plant to attack larger squares and bolls. When small worms are in the upper third of the plant, they are most vulnerable to control by insecticides and beneficial insects and spiders.

Sometimes moths deposit eggs on squares, bolls, stems and, in general, lower parts of the plant. This may occur when cotton plants are stressed and making little new growth, or during periods of high temperature and low humidity. Detection and control of eggs and small worms are more difficult when eggs are deposited in these locations.

Budworms are more resistant to insecticides than bollworms. Budworms are less numerous than bollworms until mid-August or early September, and rarely reach damaging levels. Once certain kinds of conventional insecticides are used to control bollworms and budworms, the percentage of budworms in the infestation increases with each additional application because of selection pressure. Aphid and other secondary pest infestations may increase following bollworm/budworm sprays, especially when pyrethroids are used.

BOLLWORM IDENTIFICATION

Actual size of Heliothis larvae of known age



Management and decision making. Cotton fields should be scouted carefully every 3 to 5 days during periods of predicted moth egg-laying activity. In fields with fewer than five squares per row foot (approximately 67,000 per acre), bollworm populations often collapse and cease to be a problem.

Eggs and newly hatched worms are usually found in the plant terminals and indicate possible outbreaks. Natural mortality agents such as weather and predators frequently control these pests before any damage occurs. Once worms have grown to larger than 1/2 inch long, natural and insecticidal control are less effective. Insecticides applied to control 1/2-inch-long worms are only moderately effective.

Frequently, examination of the upper third of the plant (leaves, stems, squares, blooms and bolls) is all that is needed to make a sound management decision. However, when eggs are being laid all over the plants or when 60 percent or more of the bolls are mature, whole plant counts should be used. Mature, unopened bolls are firm, cannot be dented when pressed between the thumb and forefinger, and cannot be cut easily with a sharp knife.

Before bloom. The decision to apply conventional insecticides (as opposed to microbial insecticides, ovicides or no treatment) for bollworm and budworm control during this period should be made very carefully. Conventional insecticides often kill beneficial insects and spiders, thus allowing a rapid increase in bollworm numbers. Avoid making conventional insecticide treatments on the basis of egg numbers or first signs of crop damage. Under most conditions, do not use conventional insecticides before blooms are observed in the field. **Treatment may be warranted where 15 to 25 percent of**

the green squares examined are worm damaged and small worms are present. Consider using a microbial insecticide to preserve beneficial insects and spiders. Microbial insecticide use is discussed further on page 12.

After bolls are present. Divide the cotton field into four or more manageable sections depending upon field size. Make whole plant inspections of five randomly chosen sets of three adjacent cotton plants in each section.

Count the number of eggs, worms and key predators encountered and estimate the number of eggs, worms or key predators per acre using the following formula:

$$\text{Worms, eggs or key predators per acre} = \frac{\text{No. eggs, worms or key predators counted}}{\text{No. of whole plants checked}} \times \text{No. of plants per acre}$$

The number of plants per cotton acre is calculated from counts of plants on at least 10 feet of row in four locations in the field:

$$\text{Plants per acre} = \frac{\text{Row feet per acre}}{\text{Row feet examined}} \times \text{Plants counted}$$

$$\text{Row feet per acre} = \frac{522{,}720}{\text{Row spacing in inches}}$$

Treatment may be justified when counts average 5,000 or more small worms per acre. However, if two or more key predators are found for each small worm, control measures may not be needed or a microbial insecticide may be used (see Microbial Insecticides page 12). The actual treatment level will vary according to the ability of the individual scout to locate small larvae, the age structure of the infestation, maturity of the crop and crop value.

Boll Weevil

Recently emerged adults feed on squares or bolls for 4 to 8 days before mating and laying eggs. Adult weevils puncture squares or bolls both for feeding and egg laying. Egg laying punctures can be distinguished from feeding punctures by the presence of a wart-like plug which the female places over the feeding site after she has deposited an egg in the cavity. The female deposits an average of 100 eggs during her life span of about 30 days.

Eggs hatch into larvae, or grubs, within 3 to 5 days under mid-summer conditions. Grubs transform into pupae within the square or boll in approximately 7 to 11 days. Adults emerge 3 to 5 days later. The time required for development from egg to adult under summer field conditions averages 17 days, with a complete generation occurring in 21 to 25 days.

Punctured squares flare open and usually fall to the ground within a week. Small bolls that are punctured may also fall to the ground, but larger bolls remain on the plant.

When direct sunlight and hot, dry conditions cause fallen squares to dry out rapidly, large numbers of weevil larvae do not survive.

Boll weevil damage reaches its highest level late in the growing season. As cotton plants mature and the number of squares is reduced, the percentage of boll weevil-damaged squares becomes an unrealistic indicator of damage because boll weevils are competing for squares. As square numbers decrease, boll weevils may cause more damage to small bolls.

Boll protection should be the primary concern as long as there is a significant number of immature bolls which can be expected to mature before the average frost date or before the crop is terminated by a desiccant or defoliant. Where economic weevil infestations are encountered, protect bolls until the last bolls expected to be harvested are 12 to 15 days old.

One or more insecticide applications made at weekly intervals may be required to control moderate weevil infestations. For heavy infestations, it may be necessary to make several applications at 3- to 5-day intervals.

Management and decision making. Monitor cotton until the last bolls expected to be harvested are at least 12 to 15 days old. Examine 100 squares, at least 1/3-grown, taking 25 squares from each of four representative locations in the field and from various positions on the plants. **When 30 percent of the squares are weevil damaged and adult weevils are readily found, control measures are suggested.** As cotton plants mature and the number of squares is reduced, base treatment decisions on the amount of small boll damage.

Aphids

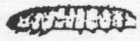
Three species of aphids, or plant lice, feed on cotton plants: the cotton aphid, the black cowpea aphid and the green peach aphid. Cowpea aphids are shiny black with white patches on the legs and can be common on seedling plants. Aphid infestations can occur from plant emergence to open bolls. Aphids usually are found on the undersides of leaves, on stems, in terminals and sometimes on fruit. Heavy and prolonged infestations can cause leaves to curl downward, older leaves to turn yellow and shed, squares and small bolls to shed and bolls to be reduced in size, resulting in incomplete fiber development.

Honeydew excreted by aphids can drop on fibers of open bolls. A black, sooty fungus sometimes develops on the honeydew deposits during wet periods. Fiber from such bolls is stained, sticky and of lower quality, resulting in difficult harvest, ginning and yarn spinning.

Natural control by unfavorable weather, predators, parasites and pathogens can be effective in holding populations below damaging levels. Sometimes aphid numbers increase to moderate or heavy levels and then decline for no apparent reason.

Management and decision making. Insecticide treatment may be necessary if infestations are approaching heavy levels in large areas of the field and natural control has not been sufficient to limit aphid buildup. Refer to the latest Cotton Aphid Task Force Suggestions for further management information for insecticide resistant cotton aphids. These are available at the county Extension agent's office.

Pink Bollworm



Pink bollworms are primarily late-season insect pests. Larvae will feed on squares in the early season without economic damage to the crop. But once bolls are present, they become the preferred food supply. Pink bollworm larvae prefer 15- to 20-day-old upland cotton bolls. Pima cotton bolls remain susceptible to damage until they are 35-40 days old. It is essential that

bolls set during the first 4 weeks of the boll-setting period be protected from pink bollworm damage. In Pima cotton it is important to protect the crop even longer, since it matures more slowly. To provide this protection normally requires continued scouting and treatments if necessary until mid-September for upland and the first of October on Pima.

Management and decision making. Pink bollworm pheromone traps should be placed in fields at seedling emergence and monitored at least weekly until the 4- to 5- leaf stage, then daily until the 1/3-grown square stage. **If more than 5 moths are caught per trap per night at the pinhead square stage, insecticides or pheromone mating disruption products or a combination should be applied.** Subsequent treatments may be needed if indicated by the trap catches. Terminate treatments prior to the 1/3-grown square stage.

In areas where moths are captured in pheromone traps, field inspections for rosetted blooms should be made after the crop is in the second week of bloom. Since rosetted blooms caused by pink bollworms do not result in economic damage, the rosetted bloom counts and pheromone trap data should be used for detection of infested fields and to time pheromone mating disruption sprays for population suppression. Generally, insecticide applications should be reserved for later in the season.

Where rosetted blooms are detected in a field, inspections of 40 to 50 quarter-sized bolls should be made twice weekly. Collect bolls when walking diagonally across the field. Bolls should be cracked or cut and examined for the presence of pink bollworms. Examine the inside of the carpel wall for the entrance wart or mines made by small larvae, and the lint and seed for evidence of feeding or larvae. Pheromone traps can be helpful in identifying infested fields and timing insecticide applications, but should not be used without boll inspections as a decision-making tool. **Oil trap catches of 60 to 100 moths per trap per night for 3 nights are a strong indicator that an adult flight is underway and treatment may be needed.**

When weekly boll counts indicate a 10 to 15 percent infestation during the first 6 weeks of boll set in upland cotton, or 5 to 10 percent in Pima cotton, insecticide treatments are warranted. Apply insecticide treatments using pheromone trap catches as a timing indicator or apply on a 5-day schedule. Where infestations occur late in September, 40 to 50 percent of the top-crop bolls may be infested without economic loss in upland cotton.

Termination of insecticide treatments. Terminate insecticide treatments in upland cotton when the last bolls expected to be harvested are 30 days old. Bolls of this age are "rock hard" in firmness. Newly hatched pink bollworm larvae have difficulty entering the more mature bolls and surviving in the dry fibers. In Pima cotton, treatments should be continued until 70 percent of the bolls are open.

Cultural control is the most desirable, satisfactory and economical method of controlling pink bollworms. Farming practices should be planned and conducted for early crop maturity and to permit crop termination by mid-September. The pink bollworm is seldom a problem in the High and Rolling Plains areas. Cotton should be harvested as early as possible. Stalks should be shredded and plowed (preferably with a moldboard) to a depth of at least 6 inches. Plowing should be completed as early as possible. By law, they must be plowed by February 1.

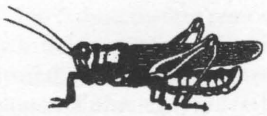
Beet Armyworm

Beet armyworm eggs are laid on both leaf surfaces in masses covered by a whitish, velvety material. Young beet armyworms "web up" and feed together on leaves, but eventually disperse and become more solitary in their feeding habits. Early-season infestations feed on leaves and terminal areas. Occasionally they destroy the terminal, causing extensive lateral branch development and delayed maturity. Early- season insecticide applications may be warranted when plants with undamaged terminals approach the lower optimal plant stand limits of two plants/row foot for dryland production and four plants per foot of row in irrigated production. Larvae skeletonize leaves rather than chewing large holes in them. Damaging infestations sometimes develop late in the season when beet armyworms also feed on terminals, squares, blooms and bolls. When beet armyworms begin to damage the fruit, control may be justified. Infestations usually are spotty within a field, and careful scouting is necessary to determine the need for, and field area requiring, control. Beet armyworms longer than 1/2 inch may be difficult to control.

Management and decision making. Scout the field by using the Whole Plant Inspection Method described in the bollworm and tobacco budworm section beginning on page 8. **When small worm counts exceed 20,000 per acre and at least 10 percent of the plants examined are infested, control may be warranted.**

OCCASIONAL PESTS

Grasshoppers



The lubber (Jumbo) grasshopper is a large, brown, clumsy grasshopper without fully developed wings. It cannot fly but its hind legs are greatly enlarged and it is a strong hopper. It can be extremely damaging to seedling cotton. Large numbers are capable of completely destroying stands, especially around field margins.

Management and decision making. Although no economic threshold has been established for this species, **field observations have indicated that populations of one per 3 row feet in the field or two per square yard in vegetation around the field may be capable of causing economic damage.**

Other species. A number of other grasshopper species are occasional cotton pests. They generally move into fields from adjacent fence rows, ditch banks or field margins.

Management and decision making. Damaging infestations need to be controlled early while grasshoppers are small and still in crop border areas. **Twenty or more grasshoppers per square yard in crop margins or ten or more per 3 row feet in the field are suggested treatment levels.**

Lygus Bugs

Several species of lygus attack cotton. Adults are winged, vary in color from greenish to brown and are about 1/4 inch long. They prefer legumes to cotton and usually are found in large numbers in areas of alfalfa production. Lygus bugs are attracted to succulent growth; their feeding results in shedding of squares and small bolls, stunted growth and boll deformation. Damage shows up in white blooms as black anthers and puckered areas in petals.

Management and decision making. The need for lygus bug control is determined by their abundance in relation to the fruiting condition of the cotton plants. Fields should be inspected for lygus bugs at 4- to 5-day intervals. **Before peak bloom, insecticide treatments should be considered when ten lygus bugs (count each nymph as two) are present per 50 sweeps on two successive sampling dates.** Make sweeps (with a standard size sweep net) at several locations in the field by sweeping across the top of one row only in such a way that the top 10 inches of the plants are struck.

Lygus bugs can continue to damage the late-season crop. Use the same sampling techniques and chemical control suggestions given in the previous section. **After peak bloom, begin treatment of late-season lygus bug infestations when counts exceed 20 to 30 per 50 sweeps (count nymphs as two) in fields where plants failed to retain squares and set bolls normally during the first 4 to 5 weeks of fruiting.**

Stink Bugs

Several species of stink bugs feed on squares and bolls. Feeding on bolls may cause boll shed and/or seed damage and lint staining. Stink bugs may move into cotton when grain sorghum in the area starts to mature.

Management and decision making. Examine 10 row feet of cotton in several locations in the field. **When there is an average of five or more stink bugs per 10 feet of row, feeding can cause excessive loss of squares and small bolls and may stain lint.** Stink bugs often are clumped near field margins. Spot treatment provides effective control when this situation exists.

Cabbage Looper

Cabbage looper eggs are laid singly, mainly on the lower surfaces of leaves. Larval feeding damage is characterized by leaf ragging or large holes in the leaves. Looper larvae often are killed by a disease before economic foliage loss occurs.

Management and decision making. No economic threshold has been established for this pest. **Insecticide treatments generally are not recommended.**

Spider Mites

Spider mites infest the undersides of leaves, where they remove the sap from the plant and cause the leaves to discolor. They may also infest bracts of squares and bolls, causing the bracts to desiccate and squares or small bolls to shed. Severe infestations can defoliate the cotton plant. Mite infestations most often occur in spots and in field margins. Increased spider mite populations usually follow multiple applications of insecticides for other pests, since insecticides destroy natural spider mite predators.

Management and decision making. Treat when mites begin to cause noticeable leaf damage. Spot treatment of fields is encouraged when infestations are restricted to small areas.

Other Pests

Early season. Garden webworms, beet armyworms, yellowstriped armyworms, saltmarsh caterpillars and cotton square borers are occasional pests of cotton in this area. Cutworms can cause damage during the seedling stage. Keep fields as weed-free as possible 3 weeks before planting to avoid cutworm problems. Garden webworms can be a problem on seedling to 6-leaf-stage cotton. High numbers of beet armyworms, yellowstriped armyworms and saltmarsh caterpillars can reduce plant stands. Treatment of isolated areas within a field or along field borders can be effective in controlling these pests and reducing their spread across the field.

Late season. Fall armyworms, yellowstriped armyworms and saltmarsh caterpillars rarely cause economic damage when they feed only on leaves of cotton late in the season. Whiteflies can sometimes reach high numbers in September and October.

Management and decision making. Economic thresholds have not been established for these pests. **Control is a matter of judgment.** Insecticides are most effective if applied when worms are small.

SYSTEMIC INSECTICIDES AT PLANTING

In areas where early-season thrips infestations consistently damage young cotton each year, preventative systemic insecticide treatments have proved more effective than postemergence spray applications. In choosing either approach to early-season thrips control, key factors to consider include the abundance of thrips on other host plants at cotton planting time, the variety planted, the acreage planted, the planting date, available equipment and labor, drought tendencies, and the probability of having to replant. Limitations and advantages of both systemics used at planting and postemergence spray applications should be evaluated carefully before making a choice.

Limitations of Systemics

- The decision to invest in systemics must be made before the severity of the thrips problem can be assessed; therefore, the net economic return is uncertain.
- If replanting is necessary, the initial systemic treatment is lost and a new treatment at additional expense may be required.
- Under unfavorable conditions for plant emergence (such as poor seed quality, planting too deeply, seedling disease, asochyta blight or cool, wet weather), some systemics may contribute to further stand reduction.
- In areas where producers typically plant late (such as the Uniform Optimal Planting Date in the Rolling Plains) or where planting is delayed until late May or early June, the likelihood of having thrips problems is lessened significantly and the probability of economic returns from the use of systemics is diminished considerably.
- Heavy rains may leach systemics from the root zone, thus shortening the effective control period and necessitating a foliar spray for additional control.

Advantages of Systemics

- Systemics are effective when inclement weather or field conditions prevent sprayer operation.
- The activity of systemics within the plant is relatively unaffected by rain and weathering during their normal period of effectiveness.
- The use of systemics reduces pesticide drift to non-target sites and organisms and provides longer residual control than foliar sprays.
- Under certain conditions, some systemics often stimulate more rapid early growth and sometimes increase yields which apparently cannot be attributed to early-season pest control alone.
- Use of systemics at planting will prevent significant thrips damage when high thrips numbers infest plants as they emerge.
- Protection from early-season thrips damage can result in earlier maturity, which may be important during years of deficient moisture, early crop termination, or pest buildups during late-season.
- At this time there is no research-based economic threshold for thrips control using postemergence applications. Therefore, the current foliar application suggestions may be inappropriate.

OVICIDES

These insecticides effectively reduce numbers of bollworm and tobacco budworm eggs. Because large numbers of eggs often fail to produce economically damaging worm infestations, **insecticidal control of eggs alone is not recommended.** Environmental factors such as hot, dry weather can significantly reduce field levels of eggs. Some other important natural control factors include predacious insects and spiders and parasitic wasps. Natural egg control can vary greatly between fields and times of the season. Often, high numbers of sterile eggs are found. If larval infestations exceed suggested treatment levels and large numbers of eggs are present, the addition of an ovicide to the larvicide may be justified to enhance overall control.

MICROBIAL INSECTICIDES

Microbial products which are natural pathogens of the bollworm and tobacco budworm are commercially available as preparations of *Bacillus thuringiensis* (*B.t.*). Field studies indicate that microbials are best suited for square protection. They are slow acting and should be used against infestations of worms during the squaring period through the first 10 days of blooming. They are not suggested for use after that point.

Microbials are effective against worm numbers up to 6,000 per acre. They do not destroy beneficial arthropods (predators and parasites), a characteristic which sets them apart from conventional insecticides. When beneficial arthropod populations are absent, other insecticides provide more consistent control.

Treat fields in which most larvae are not more than 1/4-inch long. Infestations of larger worms should not be treated with microbials. Maximum effectiveness with *B.t.* requires precise sampling of cotton plants during the fruiting period. Sampling should be conducted at least twice a week while squares are developing. Apply microbials with ground equipment at the rate of 5 to 15 gallons of liquid per acre, or by air using 2 to 5 gallons per acre.

Registered *Bacillus thuringiensis* products and labeled rates for controlling bollworm and tobacco budworm.

Product	Rate per acre (formulated material)
Biocot XL	0.33-2.33 pts.
Biocot XLP	0.5-3.5 pts.
Condor	0.5-1.67 qts.
Dipel 2X	0.5-2.0 lbs.
Dipel ES	1.0-2.5 pts.
Dipel ES-NT	1.0-2.5 pts.
Design	1.0-2.0 lbs.
Javelin	0.25-1.5 lbs.
MVP	2.0 qts.

DIAPAUSING BOLL WEEVIL CONTROL

To pass the winter, weevils must be in a state of reduced activity known as diapause. To reduce the spring population of boll weevils in cotton fields, weevils should be suppressed before they leave the field for hibernation sites. The more infested acreage properly treated in an area, the less chance there is of damaging weevil numbers emerging early the next season. To effectively reduce diapausing weevils in the fall, apply insecticides at 10-day intervals from the period of October 1 to 15 until crop termination. Where regrowth occurs, additional insecticide applications may be warranted as long as weevils are present.

PROTECTING BEES FROM INSECTICIDES

Pollination is extremely important in producing many seed crops such as alfalfa, clover and vetch. Honey bee pollination also is critical in the production of cucurbits throughout the state, and supplements native pollinators. The role of honey bees and wild pollinators in contributing to increased yields and fiber length of cotton is unclear. The importance of insect pollinators in the production of hybrid cotton is well recognized, however.

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

1. Apply insecticides, if practical, before bees are moved into fields or adjacent crops for pollination. When bees are in the vicinity, evening applications after bees have left the field are less hazardous than early morning applications.
2. Where insecticides are needed, consider their toxicity. "Highly toxic" insecticides include materials that kill bees on contact during application or for several days following application. Insecticides categorized as "moderately toxic" or "relatively nontoxic" should be applied in late evening or early morning when bees are not foraging. For information on hazards of insecticides to honey bees, refer to the table in B-1209A, "Suggested Insecticides for Management of Cotton Insects in the High Plains, Rolling Plains and Trans Pecos Areas of Texas."
3. To prevent heavy losses of bees, do not spray any insecticide directly on colonies and avoid insecticide drifting. Bees often cluster on the fronts of their hives on hot evenings. Pesticide drift or direct spray at this time generally results in high levels of mortality.

ADDITIONAL REFERENCES

Number	Title
B-933	Cotton Insects ($5.00)
B-1204	Management of Cotton Insects in the Southern, Eastern and Blackland Areas of Texas
B-1204 A	Suggested Insecticides for Management of Cotton Insects in the Southern, Eastern and Blackland Areas of Texas
B-1210	Management of Cotton Insects in the Lower Rio Grande Valley
B-1210A	Suggested Insecticides for Management of Cotton Insects in the Lower Rio Grande Valley
B-1593	Cotton Harvest-Aid Chemicals

These publications can be obtained through your county Extension office or ordered from the Texas Agricultural Extension Service, Distribution and Supply, P. O. Box 1209, Bryan, Texas 77806.

POLICY STATEMENT FOR MAKING PEST MANAGEMENT SUGGESTIONS

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

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

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

For additional information, contact your county Extension staff or write the Extension Entomologist, Entomology Department, Texas A&M University, College Station, Texas, 77843-2475, (409) 845-7026.

ENDANGERED SPECIES REGULATIONS

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

WORKER PROTECTION STANDARD

The Worker Protection Standard (WPS) is a set of new federal regulations that applies to all pesticides used in agricultural plant production. If you employ any person to produce a plant or plant produce for sale and apply any type of pesticide to that crop, WPS applies to you. Beginning January 1, 1995, you must comply with all WPS regulations. The WPS requires you to protect your employees from pesticide exposure. It requires you to provide three basic types of protection for your employees: you must inform employees about exposure, protect employees from exposure, and mitigate pesticide exposures that employees might receive. In 1995 all agricultural pesticides will bear a Worker Protection Standard statement on the label. It will appear in the "DIRECTIONS FOR USE" part of the label. For more detailed information, consult EPA publication 735-B-93-001 (GPO #055-000-0442-1) *The Worker Protection Standard for Agricultural Pesticides -- How to Comply: What Employers Need to Know*, or call Texas Department of Agriculture, Pesticide Worker Protection Program, (512) 463-7717.

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B-1209A

Texas Agricultural Extension Service
The Texas A&M University System

Suggested Insecticides for

Management of Cotton Insects

in the High Plains, Rolling Plains and Trans Pecos Areas of Texas

1996

This insert is to be used with B-1209, "Management of Cotton Insects in the High Plains, Rolling Plains and Trans Pecos Areas of Texas, 1995-1996."

Texas Agricultural Extension Service • Zerle L. Carpenter, Director • The Texas A&M University System • College Station, Texas

Suggested Insecticides for Management of Cotton Insects

in the High Plains, Rolling Plains and Trans Pecos Areas of Texas

Charles T. Allen, Emory P. Boring III, James F. Leser, and Thomas W. Fuchs*

A committee of state and federal research scientists and Extension specialists meets annually to review cotton pest management research and management guidelines. Guidelines are revised at this meeting to reflect the latest proven techniques for maximizing profits for the Texas cotton producer by optimizing inputs and production.

Management of Cotton Pests

The proper management of cotton pests is dependent upon the use of pest management principles. Pest management does not rely solely on insecticides. Therefore, the USER of this insert is strongly encouraged to refer to B-1209 for discussion of pest biology, scouting techniques, economic thresholds, insecticide resistance management, conservation of existing natural control agents, overall crop management practices which do not promote pest problems, ovicide use, microbial insecticide use, and guidelines for protecting bees from insecticides. If the insecticide recommendations in this insert are followed without regard to the other management techniques listed in B-1209, there is a risk of misusing insecticides, resulting in adverse economic and environmental consequences.

Policy Statement for Making Insecticide Use Recommendations

This is not a complete listing of all products registered for cotton or their uses. The insecticides and their suggested use patterns included in this publication reflect a consensus of opinion of Extension entomologists based on field tests. The data from these field tests met the minimum requirements as outlined in the Guidelines for the Annual Entomology Research Review and Extension Guide Revision Conference. Products listed must conform to our performance standards and avoid undue environmental consequences.

Suggested insecticide use rates have exhibited sufficient efficacy in tests to be effective in providing adequate control in field situations. However, it is impossible to eliminate all risks. Conditions or circumstances which are unforeseen or unexpected may result in less than satisfactory results. The Texas Agricultural Extension Service will not assume responsibility for such risks. Such responsibility shall be assumed by the user of this publication.

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

The **USER** is always responsible for the effects of pesticide residues on his livestock and crops as well as problems that could arise from drift or movement of the pesticide. Always read and follow carefully the instructions on the container label. Pay particular attention to those practices which insure worker safety.

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Extension entomologists, The Texas A&M University System.

Table 1. Insecticide suggestion table.

Pest	Insecticides (listed alphabetically)	Insecticide class[1]	Pounds active ingredient per acre[2]	Formulated amount per acre	Precaution status[3]	Re-entry interval (hrs)[4]	Honey bee hazard[5]
Thrips							
Seed	Acephate (Orthene® 80S)	OP (treated at delinting plant)					
Planter box	Acephate (Orthene® 90S)	OP	0.188	3.34 oz	C	*	**
In-furrow	Acephate (Payload 15G)	OP	0.5-1.0	3.33-6.67 lbs	C	*	**
	Aldicarb (Temik® 15G)	C	0.3-0.45	2-3 lbs	D	*	**
	Disulfoton (Di-syston® 15G)	OP	0.6	4 lbs	D	*	**
	Phorate (Thimet® 20G)	OP	0.5	2.5 lbs	D	*	**
Foliar	Acephate (Orthene® 90S)	OP	0.09-0.188	1.67-3.34 oz	C	24	H
	Azinphosmethyl (Guthion® 2L)	OP	0.125	8 oz	D	48***	H
	Carbaryl (Sevin® 80S)	C	0.5	10 oz	W	12	H
	Dicrotophos (Bidrin® 8E)	OP	0.05-0.1	0.8-1.6 oz	D	48***	H
	Dimethoate	OP					
	(Cygon® 4E)		0.11-0.25	3.5-8.0 oz	W	12	H
	(Dimate® 2.67E)		0.11-0.22	5.3-10.5 oz	W	12	H
	(Dimethoate® 2.67E)		0.11	5.3-10.5 oz	W	12	H
	Methyl Parathion (4E)	OP	0.12-0.225-0.25	4-8 oz	D	48***	H
	Methyl Parathion (7.5E)		0.125-0.25	2.1-4.3 oz	D	48***	H
Fleahoppers	Acephate (Orthene® 90S)	OP	0.188-0.25	3.34-4.44 oz	C	24	H
	Carbaryl (Sevin®)	C					
	(80S)		0.5-1.0	0.6-1.25 lbs	C	12	H
	(XLR Plus 4)		0.5-1.0	1-2 pts	C	12	H
	(50W)		0.5-1.0	1-2 lbs	C	12	H
	(4F)		0.5-1.0	1-2 pts	C	12	H
	Chlorpyrifos (Lorsban® 4E)	OP	0.19-0.5	6-16 oz	W	24	H
	Dicrotophos (Bidrin® 8E)	OP	0.05-0.2	0.8-1.6 oz	D	48***	H
	Dimethoate	OP					
	(Cygon® 4E)		0.11-0.25	3.5-8 oz	W	12	H
	(Dimate® 2.67E)		0.11-0.22	5.3-10.5 oz	W	12	H
	(Dimethoate® 2.67E)		0.11-0.22	5.3-10.5 oz	W	12	H
	Methomyl (Lannate® 2.4LV)	C	0.113-0.225	6-12 oz	D	72	H
	Methyl Parathion (4E)	OP	0.1	3.2 oz	D	48***	H
	Methyl Parathion (7.5E)		0.1	1.7 oz	D	48***	H
	Oxamyl	C					
	(Vydate® 2L)		0.25	1 pt	D	48	H
	(Vydate® 3.76C-LV)		0.25	8.5 oz	D	48	H
	Oxydemetonmethyl (Metasystox-R® 2E)	OP	0.25	1 pt	W	48***	M
Boll Weevils							
Overwintered	Azinphosmethyl	OP					
	(Guthion® 2L)		0.25	1 pt	D	48***	H
	(Guthion® 3F)		0.25	0.67 pt	D	48***	H
	Carbaryl (Sevin® 80S)	C	1.25-1.5	1.56-1.87 lbs	W	12	H
	Endosulfan	CD					
	(Phaser® 3E)		0.375-1.5	1-4 pts	D	48	M
	(Thiodan® 3E)		0.375-1.5	1-4 pts	D	48	M
	(Thiodan® 2CO)		0.375-1.5	1.5-6 pts	D	48	M
	Malathion (91% ULV 9.33 lb)	OP	0.58-0.88	8-12 oz	C	12	H
	Methyl Parathion (4E)	OP	0.25-0.5	8-16 oz	D	48***	H
	Methyl Parathion (7.5E)		0.25-0.5	4.3-8.5 oz	D	48***	H
	Methyl Parathion encapsulated (Penncap M® 2F)	OP	0.25	1 pt	W	48	H
	Oxamyl	C					
	(Vydate® 2L)		0.25	1 pt	D	48	H
	(Vydate® 3.76C-LV)		0.25	8.5 oz	D	48	H

*Refer to federal label for specific field re-entry instructions.
**These products are applied to the seed or to the soil and pose no hazard to honey bees.
***Re-entry interval is 72 hours in areas where the average annual rainfall is less than 25 inches.

(continued)

Table 1. Insecticide suggestion table. ***(Continued)***

Pest	Insecticides (listed alphabetically)	Insecticide class[1]	Pounds active ingredient per acre[2]	Formulated amount per acre	Precaution status[3]	Re-entry interval (hrs)[4]	Honey bee hazard[5]
Grasshoppers	Carbaryl	C					
	(Sevin ®)						
	(80S)		0.5-1.5	10-30 oz	W	12	H
	(5% Bait)		1.5	30 lbs	C	*	H
	(20% Bait)		1.5	7.5 lbs	C	*	H
	(XLR Plus 4)		0.5-1.5	1-3 pts	C	12	H
	Malathion	OP					
	(91% ULV 9.33 lb)		0.58	8 oz	C	12	H
Beet Armyworms	Chlorpyrifos	OP					
	(Lorsban ® 4E)		1.0	2 pts	W	24	H
	Diflubenzuron	IGR					
	(Dimilin® 2F)		0.0625-0.125	4-8 oz	C	12	R
	Methomyl	C					
	(Lannate ® 2.4LV)		0.45	1.5 pts	D	72	H
	Profenofos	OP					
	(Curacron ® 8E)		0.75-1.0	12-16 oz	W	12	H
	Sulprofos	OP					
	(Bolstar ® 6E)		0.75-1.5	1-2 pts	W	48***	H
	Thiodicarb	C					
	(Larvin ® 3.2F)		0.6-0.9	1.5-2.25 pts	W	12	M
Saltmarsh Caterpillars	Carbaryl	C					
	(Sevin ® 80S)		1.25-2.0	1.5-2.5 lbs	W	12	H
	Methyl Parathion (4E)	OP	0.5-1.0	1-2 pts	D	48***	H
	Methyl Parathion (7.5E)		0.5-1.0	8.5-17.1 oz	D	48***	H
	Parathion (4E)	OP	0.5-1.0	1-2 pts	D	7 days	H
	Parathion (8E)		0.5-1.0	8-16 oz	D	7 days	H
	Trichlorfon	OP					
	(Dylox ® 80SP)		1.0-1.5	1.25-1.875 lbs	W	12	M
Lygus Bugs	Carbaryl	C					
	(Sevin ® 80S)		1.0-2.0	1.25-2.5 lbs	W	12	H
	Dimethoate	OP					
	(Cygon ® 4E)		0.25	8 oz	W	12	H
	(Dimate ® 2.67E)		0.22	10.5 oz	W	12	H
	(Dimethoate ® 2.67E)		0.22	10.5 oz	W	12	H
	Methomyl	C					
	(Lannate ® 2.4LV)		0.225	12 oz	D	72	H
	Methyl Parathion (4E)	OP	0.5	1 pt	D	48***	H
	Methyl Parathion (7.5E)		0.5	8.5 oz	D	48***	H
	Parathion (4E)	OP	0.5	1 pt	D	7 days	H
	Parathion (8E)		0.5	8 oz	D	7 days	H
Bollworms & Tobacco Budworms							
	Eggs*(Use only with a larvicide. See "Ovicides" section, B-1209.)*						
	Amitraz	T					
	(Ovasyn ® 1.5EC		0.125-0.25	0.67-1.33 pts	W	24	R
	Methomyl	C					
	(Lannate ® 2.4LV)		0.113-0.225	6-12 oz	D	72	H
	Profenofos	OP					
	(Curacron ® 8E)		0.125-0.25	2-4 oz	W	12	H
	Thiocarb	C					
	(Larvin ® 3.2F)		0.125-0.25	5-10 oz	W	12	M
	Larvae						
	Acephate	OP					
	(Orthene ® 90S)		1	1.11 lbs	C	12	H
	Bacillus thuringiensis (See listing in Table 2. See "Microbial Insecticides" section in, B-1209.)						
	Bifenthrin****	SP					
	(Capture ® 2E)		0.04-0.1	2.6-6.4 oz	W	12	H
	Cyfluthrin****	SP					
	(Baythroid ® 2E)		0.025-0.05	1.6-3.2 oz	D	12	H
	Cyhalothrin****	SP					
	(Karate ® 1E)		0.025-0.04	3.2-5.1 oz	D	24	H
	Cypermethrin****	SP					
	(Ammo ® 2.5E)		0.04-0.1	2-5 oz	C	12	H
	Esfenvalerate****	SP					
	(Asana XL ® 0.66E)		0.03-0.05	5.8-9.6 oz	W	12	H
	Methomyl	C					
	(Lannate ® 2.4LV)		0.45	1.5 pts	D	72	H
	Methyl Parathion (4E)	OP	1.25-2.0	2.5-4 pts	D	48***	H
	Methyl Parathion (7.5E)		1.25-2.0	1.3-2.0 pts	D	48***	H

(continued)

Table 1. Insecticide suggestion table. ***(Continued)***

Pest	Insecticides (listed alphabetically)	Insecticide class[1]	Pounds active ingredient per acre[2]	Formulated amount per acre	Precaution status[3]	Re-entry interval (hrs)[4]	Honey bee hazard[5]
	Permethrin****	SP					
	(Ambush® 2E)		0.1-0.2	6.4-12.8 oz	W	12	H
	(Pounce® 3.2E)		0.1-0.2	4-8 oz	C	12	H
	Profenofos	OP					
	(Curacron® 8E)		0.5-1.0	8-16 oz	W	12	H
	Sulprofos	OP					
	(Bolstar® 6E)		0.75-1.5	1-2 pts	C	48***	H
	Thiodicarb	C					
	(Larvin® 3.2F)		0.6-0.9	1.5-2.25 pts	W	12	M
	Tralomethrin****	SP					
	(Scout X-tra® 0.9E)		0.018-0.024	2.56-3.41 oz	D	24	H
	Zeta cypermethrin****	SP					
	(Fury® 1.5E)		0.033-0.045	2.82-3.83 oz	W	12	H

****The synthetic pyrethroid insecticides (examples include fenvalerate, bifenthrin, esfenvalerate, cyfluthrin, cyhalothrin, permethrin, tralomethrin and cypermethrin) recommended for control of bollworms and/or tobacco budworms also will provide boll weevil control. However, application intervals similar to those recommended for the traditional phosphate insecticides (3 to 5 days under heavy pressure) are necessary to provide adequate control. When treatments are to be made for a bollworm or budworm-boll weevil complex, a suggested treatment regime is to use a pyrethroid followed 3 to 5 days later by a phosphate boll weevil insecticide.

Since pyrethroids are not more effective than phosphates for boll weevil control, but are more effective for bollworm-budworm control, they should be saved for bollworm-budworm management.

We do not recommend using pyrethroids for boll weevil control alone or for early-season pests because increased use may enhance the opportunity for insects to develop resistance to pyrethroids.

Bifenthrin suppresses spider mites when used for control of bollworms and tobacco budworms.

The use of synthetic pyrethroid insecticides may increase cotton aphid numbers.

Boll Weevils (In-season)	Azinphosmethyl	OP					
	(Guthion® 2L or ULV 2 lb)		0.25	1 pt	D	48***	H
	(Guthion® 3F)		0.25	0.67 pt	D	48***	H
	Carbaryl	C					
	(Sevin® 80S)		1.6-2.0	2.0-2.5 lbs	W	12	H
	Endosulfan	CD					
	(Phaser® 3E)		0.375-1.5	1-4 pts	D	48	M
	(Thiodan® 3E)		0.375-1.5	1-4 pts	D	48	M
	(Thiodan® 2CO)		0.375-1.5	1.5-6 pts	D	48	M
	Malathion	OP					
	(91% ULV 9.33 lb)		0.58-1.17	8-16 oz§	C	12	H
	Methyl Parathion (4E)	OP	0.375-1.0	12-32 oz	D	48***	H
	Methyl Parathion (7.5E)		0.375-1.0	6.4-17.1 oz	D	48***	H
	Methyl Parathion encapsulated	OP					
	(Penncap M® 2F)		0.25	1 pt	W	48	H
	Oxamyl	C					
	(Vydate® 2L)		0.25	1 pt	D	48	H
	(Vydate® 3.76C-LV)		0.25	8.5 oz	D	48	H
Cotton Aphids §§	Acephate	OP					
	(Orthene® 90S)		0.5-1.0	8.89-17.78 oz	C	24	H
	Chlorpyrifos	OP					
	(Lorsban® 4E)		0.25-1.0	8-32 oz	W	24	H
	Dicrotophos	OP					
	(Bidrin® 8E)		0.25-0.5	4-8 oz	D	48***	H
	Dicrotophos	OP + T					
	(Bidrin 8E) +		0.25-0.5 +	4-8 oz +	D + W	48***	H
	Amitraz						
	(Ovasyn 1.5E)		0.125-0.25	0.67-1.33 pt			
	Dicrotophos	OP + OP					
	(Bidrin 8E) +		0.25-0.5 +	4-8 oz +	D + W	48***	H
	Profonofos						
	(Curacron 8E)		0.125-0.25	2-4 oz			
	Dimethoate	OP					
	(Cygon® 4E)		0.125-0.25	4-8 oz	W	12	H
	(Dimate® 2.67E)		0.11-0.22	5.3-10.7 oz	W	12	H
	(Dimethoate® 2.67E)		0.11-0.22	5.3-10.7 oz	W	12	H
	Disulfoton	OP					
	(Di-syston® 8E)		0.1-0.2	1.6-3.2 oz	D	48***	M
	Methomyl	C					
	(Lannate® 2.4LV)		0.225	12 oz	D	72	H

(continued)

§16 oz rate restricted to fall diapause applications.

§§Difficulty in controlling cotton aphids has been encountered in some areas of Texas. Poor or erratic control can be expected in the High Plains, Trans Pecos, Rolling Plains and Wintergarden areas. Resistance exists to most registered materials and continued excessive use of certain insecticides is apt to expand the resistance problem. Where resistance exists in an area, the initial insecticide application should be made at the higher labeled rate. Poorest control has occurred during periods of rapid population growth. Contact the county Extension agent in your area for the latest information on aphid control.

Table 1. Insecticide suggestion table. ***(Continued)***

Pest	Insecticides (listed alphabetically)	Insecticide class[1]	Pounds active ingredient per acre[2]	Formulated amount per acre	Precaution status[3]	Re-entry interval (hrs)[4]	Honey bee hazard[5]
	Methyl Parathion (4E)	OP	0.17-0.25	5.4-8.0 oz	D	48***	H
	Methyl Parathion (7.5E)		0.17-0.25	2.9-4.3 oz	D	48***	H
	Oxydemetonmethyl (Metasystox-R® 2E)	OP	0.125-0.25	0.5-1.0 pt	W	48	M
	Parathion (4E)	OP	0.25-0.37	8-12 oz	D	7 days	H
	Parathion (8E)		0.25-0.37	4-6 oz	D	7 days	H
	Profenofos (Curacron® 8E)	OP	0.5	8 oz	W	12	H
Stink Bugs	Carbaryl (Sevin® 80S)	C	1.33-2.0	1.67-2.5 lbs	W	12	H
	Methyl Parathion (4E)	OP	0.5-1.0	1-2 pts	D	48***	H
	Methyl Parathion (7.5E)		0.5-1.0	8.5-17.1 oz	D	48***	H
	Parathion (4E)	OP	0.5-0.75	1-1.5 pts	D	7 days	H
	Parathion (8E)		0.5-0.75	8-12 oz	D	7 days	H
Pink Bollworms	Carbaryl (Sevin® 80S)	C	2.0-2.4	2.5-3.0 lbs	W	12	H
	Chlorpyrifos (Lorsban® 4E)	OP	0.75-1.0	1.5-2.0 pts	W	24	H
	Cyfluthrin**** (Baythroid 2E)	SP	0.025-0.05	1.6-3.2oz	D	12	H
	Cyhalothrin**** (Karate 1E)	SP	0.02-0.03	2.56-3.84 oz	D	24	H
	Esfenvalerate**** (Asana XL® 0.66E)	SP	0.03-0.05	5.8-9.6 oz	W	12	H
	Methyl Parathion (4E)	OP	0.5-1.0	1-2 pts	D	48***	H
	Methyl Parathion (7.5E)		0.47-0.94	0.5-1 oz	D	48***	H
	Methyl Parathion encapsulated (Penncap M® 2F)		0.5-1	2-4 pts	W	48	H
	Permethrin**** (Ambush® 2E)	SP	0.1-0.2	6.4-12.8 oz	W	12	H
	(Pounce® 3.2E)		0.1-0.2	4-8 oz	C	12	H
	Tralomethrin**** (Scout X-TRA 0.9E)	SP	0.018-0.024	2.56-3.41 oz	D	24	H
	Zeta cypermethrin**** (Fury® 1.5E)	SP	0.033-0.045	2.82-3.83 oz	W	12	H
Cabbage Loopers	*Bacillus thuringiensis*	*(see "Microbial Insecticides" section in B-1209)*					
Spider Mites	Avermectin B_1 (Zephyr® 0.15E)		0.01-0.02	8-16 oz	W	48	H
	Dicofol (Kelthane® MF)	CH	1.0-1.5	1-1.5 qts	C	12	R
	Methyl Parathion (4E)	OP	0.25-0.33	8.0-10.6 oz	D	48***	H
	Parathion (4E)	OP	0.25	8 oz	D	7 days	H
	Parathion (8E)		0.25	4 oz	D	7 days	H
	Profenofos (Curacron® 8E)	OP	0.5-0.75	8-12 oz	W	12	H
	Propargite (Comite® 6.55E)	CD	0.8-1.6	1-2 pts	D	24	R

[1] C=carbamate; OP=organophosphate; SP=synthetic pyrethroid; CD=cyclodiene; CH=chlorinated hydrocarbon; T=triazapentadiene; IGR=insect growth regulator.

[2] Refer to Table 2 for converting pounds active ingredient per gallon to acres per gallon.

[3] C=Caution; W=Warning; D=Danger

[4] Time after application before re-entering fields without protective clothing. The wearing of protective clothing as described on the label may shorten the re-entry interval. In general, no insecticide label will have the statement "allow spray to dry" or "allow dust to settle" as a re-entry interval. However, there may be limited instances where EPA could grant a shorter re-entry interval than the minimum of 12 hours following application. Re-entry intervals are determined by the product's federal label or by Texas Department of Agriculture regulations and are subject to change.

[5] H=highly toxic; M=moderately toxic; R=relatively non-toxic

Table 2. Registered *Bacillus thuringiensis* products and labeled rates for controlling bollworm and tobacco budworm.

Product	Rate per acre (formulated material)
Biocot XL	0.33-2.33 pts
Biocot XLP	0.5-3.5 pts
Condor	0.5-1.67 qts
Dipel 2X	0.5-2.0 lbs
Dipel ES	1.0-2.5 pts
Dipel ES-NT	1.0-2.5 pts
Design	1.0-2.0 lbs
Javelin	0.25-1.5 lbs
MVP II	2.0-4.0 pts

Table 3. Converting pounds active ingredient per gallon to acres per gallon.

Pounds active ingredient needed per acre	Pounds active ingredient per gallon																	
	0.15	0.30	0.66	0.90	1.00	1.80	2.00	2.40	2.50	2.67	3.00	3.20	4.00	6.00	6.55	7.50	8.00	9.33
	Acres per gallon*																	
0.01	15.0	30.0	66.0	90.0	100.0	180.0	200.0	240.0	250.0	267.0	300.0	320.0	400.0	600.0	655.0	750.0	800.0	933.0
0.015	10.0	20.0	44.0	60.0	66.7	120.0	133.3	160.0	166.7	178.0	200.0	213.3	266.7	400.0	436.7	500.0	533.3	622.0
0.019	7.9	15.8	34.7	47.4	52.6	94.7	105.3	126.3	131.6	140.5	157.9	168.4	210.5	315.8	344.7	394.7	421.1	491.1
0.02	7.5	15.0	33.0	45.0	50.0	90.0	100.0	120.0	125.0	133.5	150.0	160.0	200.0	300.0	327.5	375.0	400.0	466.5
0.025	6.0	12.0	26.4	36.0	40.0	72.0	80.0	96.0	100.0	106.8	120.0	128.0	160.0	240.0	262.0	300.0	320.0	373.2
0.03	5.0	10.0	22.0	30.0	33.3	60.0	66.7	80.0	83.3	89.0	100.0	106.7	133.3	200.0	218.3	250.0	266.7	311.0
0.04	3.8	7.5	16.5	22.2	25.0	45.0	50.0	60.0	62.5	66.8	75.0	80.0	100.0	150.0	163.8	187.5	200.0	233.3
0.05	3.0	6.0	13.2	18.0	20.0	36.0	40.0	48.0	50.0	53.4	60.0	64.0	80.0	120.0	131.0	150.0	160.0	186.6
0.0625	2.4	4.8	10.6	14.4	16.0	28.8	32.0	38.4	40.0	42.7	48.0	51.2	64.0	96.0	104.8	120.0	128.0	149.3
0.08	1.9	3.8	8.3	11.3	12.5	22.5	25.0	30.0	31.3	33.4	37.5	40.0	50.0	75.0	81.9	93.8	100.0	116.6
0.1	1.5	3.0	6.6	9.0	10.0	18.0	20.0	24.0	25.0	26.7	30.0	32.0	40.0	60.0	65.5	75.0	80.0	93.3
0.11	1.4	2.7	6.0	8.2	9.1	16.4	18.2	21.8	22.7	24.3	27.3	29.1	36.4	54.5	59.5	68.2	72.7	84.8
0.113	1.3	2.7	5.8	7.9	8.8	15.9	17.7	21.2	22.1	23.6	26.5	28.3	35.4	53.1	58.0	66.4	70.8	82.6
0.125	1.2	2.4	5.3	7.2	8.0	14.4	16.0	19.2	20.0	21.4	24.0	25.6	32.0	48.0	52.4	60.0	64.0	74.6
0.17	0.9	1.8	3.9	5.3	5.9	10.6	11.8	14.1	14.7	15.7	17.6	18.8	23.5	35.3	38.5	44.1	47.1	54.9
0.19	0.8	1.6	3.5	4.7	5.3	9.5	10.5	12.6	13.2	14.1	15.8	16.8	21.1	31.6	34.5	39.5	42.1	49.1
0.2	0.7	1.5	3.3	4.5	5.0	9.0	10.0	12.0	12.5	13.4	15.0	16.0	20.0	30.0	32.8	37.5	40.0	48.7
0.22	0.7	1.4	3.0	4.1	4.5	8.2	9.1	10.9	11.4	12.1	13.6	14.5	18.2	27.3	29.8	34.1	36.4	42.4
0.225	0.6	1.3	2.9	4.0	4.4	8.0	8.9	10.7	11.1	11.9	13.3	14.2	17.8	26.7	29.1	33.3	35.6	41.5
0.25	0.6	1.2	2.6	3.6	4.0	7.2	8.0	9.6	10.0	10.7	12.0	12.8	16.0	24.0	26.2	30.0	32.0	37.3
0.33	0.4	0.9	2.0	2.7	3.0	5.5	6.1	7.3	7.6	8.1	9.1	9.7	12.1	18.2	19.8	22.7	24.2	28.3
0.37	0.4	0.8	1.8	2.5	2.7	4.9	5.4	6.5	6.8	7.2	8.1	8.6	10.8	16.2	17.7	20.3	21.6	25.2
0.375	0.4	0.8	1.8	2.4	2.7	4.8	5.3	6.4	8.7	7.1	8.0	8.5	10.7	16.0	17.5	20.0	21.3	24.9
0.45	0.3	0.7	1.5	2.0	2.2	4.0	4.4	5.3	5.6	5.9	6.7	7.1	8.9	13.3	14.6	16.7	17.8	20.7
0.5	0.3	0.6	1.3	1.8	2.0	3.6	4.0	4.8	5.0	5.3	6.0	6.4	8.0	12.0	13.1	15.0	16.0	18.7
0.55	0.3	0.5	1.2	1.6	1.8	3.3	3.6	4.4	4.5	4.9	5.5	5.8	7.3	10.9	11.9	13.6	14.5	17.0
0.58	0.3	0.5	1.1	1.5	1.7	3.1	3.4	4.1	4.3	4.6	5.2	5.5	6.9	10.3	11.3	12.9	13.8	16.1
0.6	0.2	0.5	1.1	1.5	1.7	3.0	3.3	4.0	4.2	4.5	5.0	5.3	6.7	10.0	10.9	12.5	13.3	15.6
0.675	0.2	0.4	1.0	1.4	1.5	2.7	3.0	3.6	3.7	4.0	4.4	4.7	5.9	8.9	9.7	11.1	11.9	13.8
0.75	0.2	0.4	0.9	1.2	1.3	2.4	2.7	3.2	3.3	3.6	4.0	4.3	5.3	8.0	8.7	10.0	10.7	12.4
0.8	0.2	0.4	0.8	1.2	1.3	2.3	2.5	3.0	3.1	3.3	3.8	4.0	5.0	7.5	8.2	9.4	10.0	11.7
0.88	0.2	0.3	0.8	1.0	1.1	2.0	2.3	2.7	2.8	3.0	3.4	3.6	4.5	6.8	7.4	8.5	9.1	10.6
0.9	0.2	0.3	0.7	1.0	1.1	2.0	2.2	2.7	2.8	3.0	3.3	3.6	4.4	6.7	7.3	8.3	8.9	10.4
1	0.1	0.3	0.7	0.9	1.0	1.8	2.0	2.4	2.5	2.7	3.0	3.2	4.0	6.0	6.6	7.5	8.0	9.3
1.17	0.1	0.3	0.6	0.8	0.9	1.5	1.7	2.1	2.1	2.3	2.6	2.7	3.4	5.1	5.8	6.4	6.8	8.0
1.25	0.1	0.2	0.5	0.7	0.8	1.4	1.6	1.9	2.0	2.1	2.4	2.6	3.2	4.8	5.2	6.0	6.4	7.5
1.5	0.1	0.2	0.4	0.6	0.7	1.2	1.3	1.6	1.7	1.8	2.0	2.1	2.7	4.0	4.4	5.0	5.3	6.2
1.6	0.1	0.2	0.4	0.5	0.6	1.1	1.3	1.5	1.6	1.7	1.9	2.0	2.5	3.8	4.1	4.7	5.0	5.8
2	0.1	0.2	0.3	0.5	0.5	0.9	1.0	1.2	1.3	1.3	1.5	1.6	2.0	3.0	3.3	3.8	4.0	4.7

*See Table 1 for specific rates of insecticides for each insect or mite pest.

Table 4. Converting percent active ingredient of dry insecticides to formulated insecticide per acre.

Pounds active ingredient needed per acre	Percent active ingredient					
	5	15	20	50	80	90
	Pounds formulation per acre*					
0.09	1.80	0.60	0.45	0.18	0.11	0.10
0.188	3.76	1.25	0.04	0.38	0.24	0.21
0.25	5.00	1.67	1.25	0.50	0.31	0.28
0.3	6.00	2.00	1.50	0.60	0.38	0.33
0.45	9.00	3.00	2.25	0.90	0.56	0.50
0.5	10.00	3.33	2.50	1.00	0.63	0.56
0.6	12.00	4.00	3.00	1.20	0.75	0.67
0.75	15.00	5.00	3.75	1.50	0.94	0.83
1.0	20.00	6.67	5.00	2.00	1.25	1.11
1.25	25.00	8.33	6.25	2.50	1.56	1.39
1.33	26.60	8.87	6.65	2.66	1.66	1.48
1.5	30.00	10.00	7.50	3.00	1.88	1.67
1.6	32.00	10.67	8.00	3.20	2.00	1.78
2.0	40.00	13.33	10.00	4.00	2.50	2.22
2.4	48.00	16.00	12.00	4.80	3.00	2.67

*See Table 1 for specific rates of insecticides for each insect or mite pest.

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