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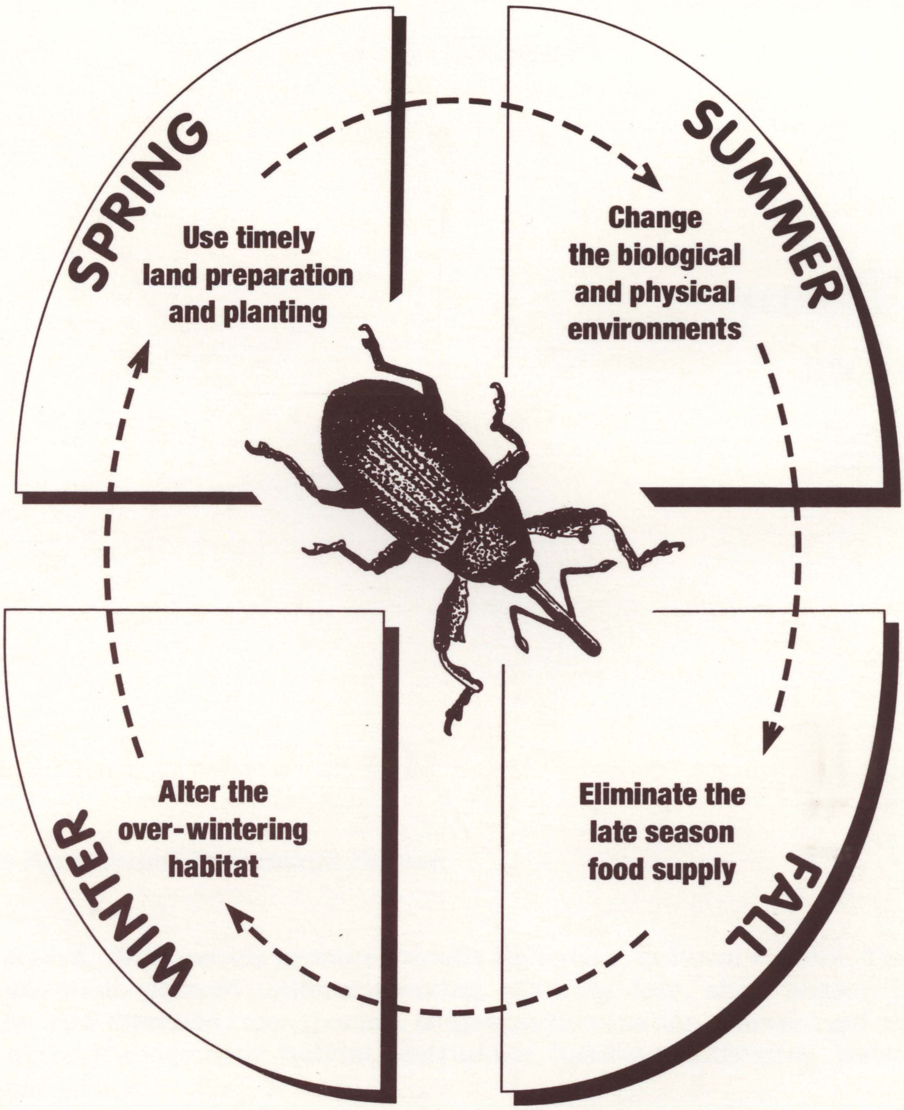
Cultural Control of the Boll Weevil

A Four Season Approach - Texas Rolling Plains



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Cultural Control of the Boll Weevil

A Four Season Approach - Texas Rolling Plains

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Key Words: boll weevil, *Anthonomus grandis grandis* Boheman, cultural control, Texas Rolling Plains, cotton, land preparation, delayed uniform planting, planting date, short season production, cotton variety, bed shape, row direction, row spacing, irrigation termination, harvest-aid chemicals, overwintering habitat, habitat management, habitat destruction, habitat modification, habitat avoidance, diapause, suicidal emergence

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SUMMARY

Cultural control strategies to manage the boll weevil, *Anthonomus grandis grandis* Boheman, can be implemented during each season of the year to enhance cotton production in the Texas Rolling Plains.

In the spring, the land should be prepared for planting by using a reduced tillage system and furrow diking. This system has consistently provided adequate soil moisture for planting in late May. Delayed, uniform planting between late May and early June forms the basis for cultural control of the boll weevil. This planting time reduces effective emergence of overwintered boll weevils, delays development of high population densities until late July, and concentrates square production in July and early August, which reduces the boll weevil population during the fall.

During the summer, cultural control can be used to alter both the physical and biological environments to make conditions less favorable for boll weevil population growth. The length of the growing season (biological environment) is reduced by about one week by planting in late May, as compared to planting in late April to early May. This delayed planting results in lower population densities late in the season. When cotton is planted in late May, initial boll weevil populations are forced to develop during the hottest part of the summer. Planting cotton on sloped beds, in an east-west row direction, can be used to increase exposure of fallen squares to high soil temperatures (physical environment), which kill larvae inside the squares.

In the fall, cultural control objectives are to eliminate squares and small bolls that allow boll weevils to build fat reserves and enter diapause. Cotton should be planted by early June and irrigations should be terminated by late August to reduce square production in the fall. Harvest-aid chemicals can be used to abscise squares and small bolls by late September. This reduces the proportion of the boll weevil population that enters diapause, and fewer boll weevils survive the winter.

During the winter, cultural control strategies are designed to manage the overwintering habitat. Elimination of winter habitat is one option. A second option is to modify the habitat by destroying only the leaf litter where boll weevils overwinter. Elimination of leaf litter, while preserving the associated trees, effectively reduces overwintering boll weevil populations. A third option is to avoid planting cotton adjacent to overwintering habitat.

Cultural control strategies for reducing boll weevil damage during the growing season can be used throughout the year. The recommended practices are known to reduce damage and to increase yield potential, particularly in dryland cotton production. These techniques can be used by a single grower to attain boll weevil suppression on an individual farm, or the strategies can be used on an areawide basis by many growers to achieve maximum population suppression.

INTRODUCTION

Cultural control of the boll weevil, *Anthonomus grandis grandis* Boheman, is a topic as timely today as it was 100 years ago. Cultural control is the manipulation of normal farming practices to reduce pest damage, and it offers an environmentally-sound strategy for managing cotton insect pests. Additionally, the manipulation of some farming operations does not increase costs. Before the advent of modern pest control techniques, such as using insecticides, cultural control offered the only hope for reducing the ravages of the boll weevil. In recent times, environmental concerns and pest resistance to insecticides have again focused attention on cultural management of insect pests.

Detailed research data are not reported in this review, but published technical articles on each recommended management strategy can be obtained by contacting the author. The recommendations reviewed in this report are based on 20 years of research conducted by the author from 1975 to 1994. These strategies were developed specifically for the Texas Rolling Plains.

The cultural control studies were undertaken to increase our understanding of the ecological relationships between the boll weevil and its environment and to enhance the value of delayed, uniform planting for boll weevil management. An historical perspective of delayed, uniform planting is presented in the Acknowledgments Section of this bulletin. As studies progressed over the years, it became evident that many aspects of the seasonal ecology of the boll weevil could be manipulated by planting in late May (delayed, uniform planting). For example, the role of bed shape during the summer and the use of chemicals to terminate the crop in the fall are enhanced by a late May planting. But these studies also revealed that the type of overwintering habitat influenced boll weevil spring emergence patterns. The reason that delayed, uniform planting is so effective is a result of early termination of spring emergence from mesquite, the most abundant overwintering habitat for boll weevils in the Rolling Plains. As the intertwined relationships between the ecology of the boll weevil and dryland cotton culture in the Rolling Plains were unravelled, it became apparent that an interrelated system of seasonal cultural control practices could be developed. Each recommended cultural control strategy enhances efforts undertaken during the preceding and succeeding seasons of the year.

Many of the cultural management strategies reduce costs associated with areawide boll weevil management programs, such as fall diapause control or eradication. Clearly, elimination of the boll weevil will be considerably easier if populations are reduced with cultural controls before areawide management efforts begin. Eradication, once accomplished, will be easier to maintain in future years by using many of the techniques outlined in this bulletin.

The objectives of this report are to discuss a sequence of cultural control strategies that can be implemented throughout the year for management of the boll weevil. Cotton production in the Texas Rolling Plains serves as the focal point for the options discussed. Some of the strategies, such as delayed, uniform planting, are specific for the Texas Rolling Plains; other options, such as management of the overwintering habitat, are applicable to many cotton producing areas.

SPRING CULTURAL CONTROL

Crop establishment is an important part of an insect control program. Timely planting is critical to managing the boll weevil in the Texas Rolling Plains.

Prepare the Land for Planting

To meet the target planting date, the land must have been properly prepared, including destruction of last year's stalks, establishment of beds and perhaps furrow dikes, and application of fertilizer and herbicides. When these preparations have been made early in the year, water from spring rains can be stored in the beds (Fig. 1), and adequate soil moisture is then available for planting in late May. When planting time arrives, the grower is in a position to plant cotton rather than having to prepare the land and then planting at a later, less optimum time. Planting in late May forms the basis for boll weevil management in the Texas Rolling Plains.

Utilize Delayed Planting

The concept behind delayed planting is to reduce effective emergence of the boll weevil (Fig. 2), which is that proportion of the overwintering population that emerges after squares become available for feeding and oviposition sites. Delayed planting reduces the availability of squares at the end of the boll weevil spring emergence period. Boll weevils that emerge from overwintering habitat before squares are present die; this is termed "suicidal emergence." When cotton is planted in late April, squares are present by mid-June (top graph, Fig. 2), but when cotton is planted in late May, squares do not appear until early July (bottom graph, Fig. 2). As compared with late-April planting, the late-May planting reduces effective emergence, resulting in a lower boll weevil infestation at the time of first squares.

Figure 1. Cotton planted on beds with furrow-diking adjacent to cotton on beds without furrow-diking illustrating conservation of rainfall. Chillicothe, Texas. July 1986.

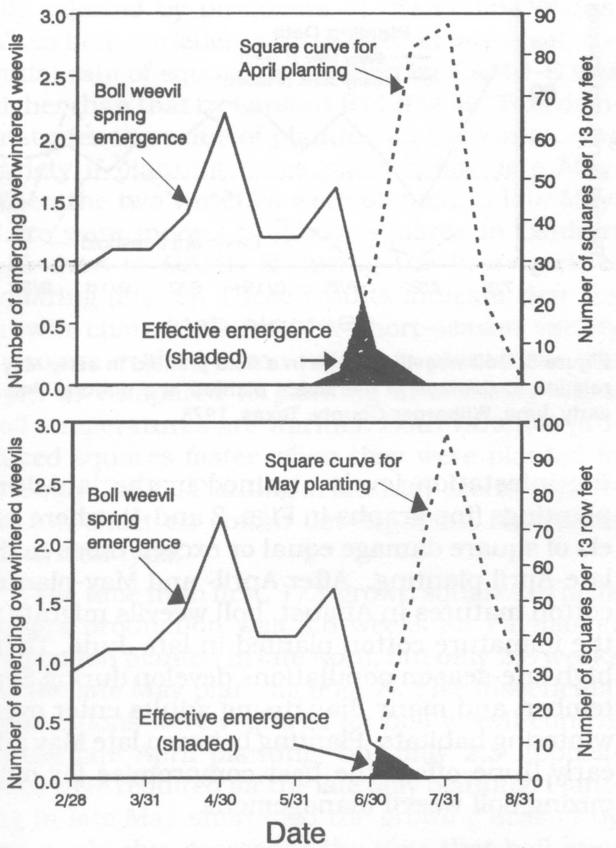


Figure 2. Comparison of effective boll weevil emergence for cotton planted in late April versus planted in late May.

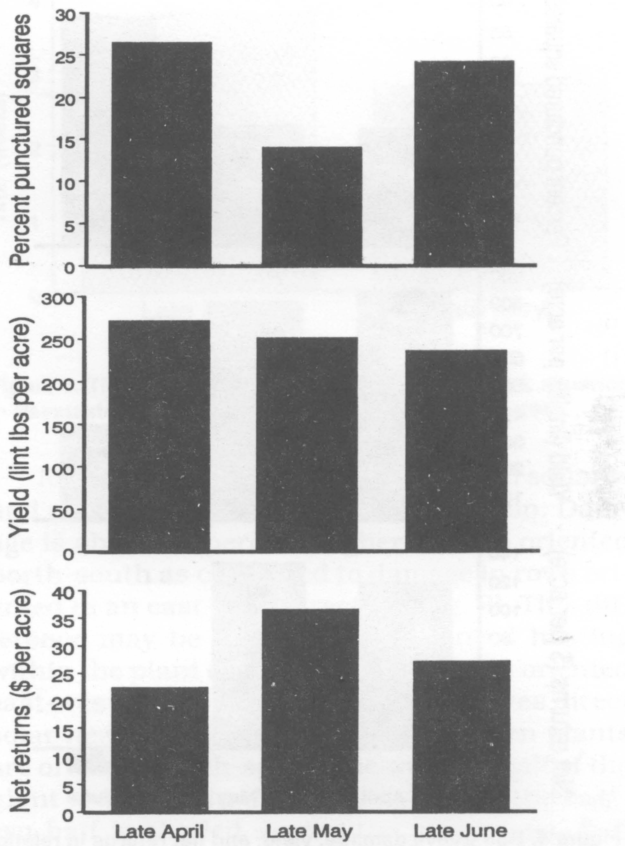


Figure 3. Boll weevil damage, yield, and net returns in relation to late April, late May, and late June planting dates in dryland cotton. Chillicothe, Texas. 1986-1989.

When dryland cotton is planted in late May, square damage is reduced about 50 percent as compared with damage in cotton that is planted in late April (top graph, Fig. 3). Boll weevil damage is lower in late-May cotton for two reasons: effective emergence is reduced and population development is hindered by high temperatures during July (refer to the Summary in Summer Cultural Control). Lint yields are reduced with each delay in planting from late April to late May to late June (middle graph, Fig. 3). However, net returns are highest when cotton is planted in late May (bottom graph, Fig. 3). Insecticide control costs are lowest for cotton planted in late May, and this accounts for the higher net return. Thus, when dryland cotton is planted in late May, boll weevil damage is reduced and net returns are increased.

Boll weevil damage to squares is similar in irrigated cotton planted in late April and late May (top graph, Fig. 4). This is different from the case in dryland cotton; irrigation produces more luxuriant cotton plants which moderate the harsh July temperature conditions, and boll weevil populations are not suppressed during July. Lint yields are reduced with each delay in planting from late April to late May to late June (middle graph, Fig. 4). However, net returns are highest when cotton is planted in late May (bottom graph, Fig. 4). As in the case for dryland cotton, insecticide control costs are reduced when cotton is planted in late May, which accounts for higher net returns. Thus, when planting is delayed until late May in irrigated cotton production, net returns are increased.

Use Uniform Planting

Cotton can be grown successfully when planted over a 65-day period from late April to late June. In the Rolling Plains, cotton planted in late April frequently has to be replanted because spring storms prevent stand establishment, wash the seed out of the ground, or destroy seedling plants. Uniform early planting could not be achieved across a broad geographical area because up to 25 percent of the crop might have to be replanted in a typical year. Uniform late planting in June generally results

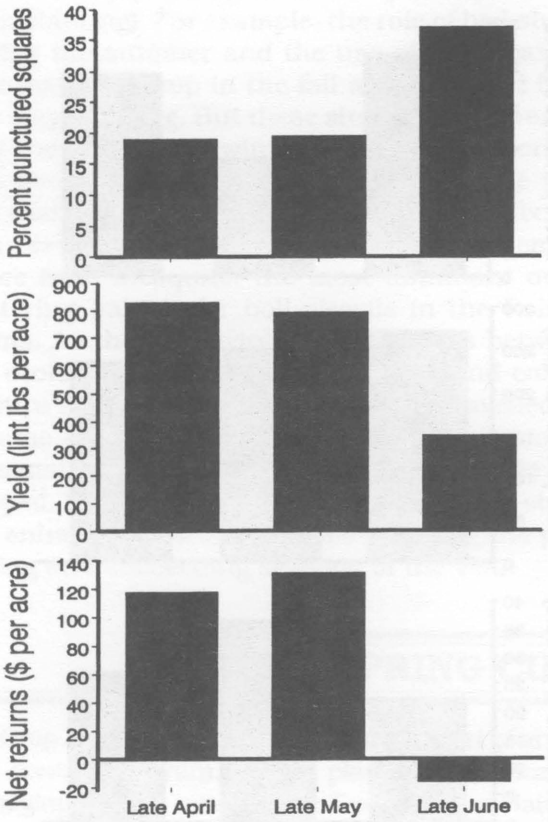


Figure 4. Boll weevil damage, yield, and net returns in relation to late April, late May, and late June planting dates in irrigated cotton. Munday, Texas. 1986 - 1989.

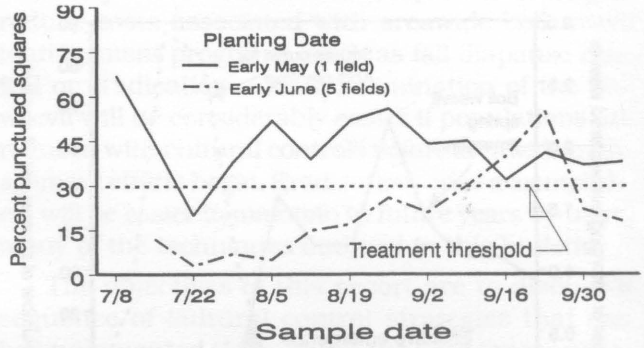


Figure 5. Boll weevil damage in a field planted in early May in relation to damage in five fields planted at a uniform time in early June. Wilbarger County, Texas. 1975.

in reduced yields and net returns because the growing season is too short.

When a field is planted earlier than adjacent fields, boll weevil damage stays above the treatment threshold throughout the growing season, if the field is left untreated (Fig. 5). An early planted field intensifies the boll weevil problem within a production region where growers are attempting to use a delayed, uniform planting program. The value of a uniform planting period is apparent by the infestation levels attained in the late-June plantings (top graphs in Figs. 3 and 4), where levels of square damage equal or exceed those in the late-April planting. After April- and May-planted cotton matures in August, boll weevils migrate to the immature cotton planted in late June. Then, high late-season populations develop during September, and many diapausing adults enter overwintering habitats. Planting between late May and early June offers the best compromise for optimizing boll weevil management.

Summary

Delayed, uniform planting between late May and early June is a strategy that reduces initial boll weevil populations that infest cotton. Delayed, uniform planting restricts population development to a short time period during July and August, thus preventing high populations during September. This cultural management technique enhances other cultural controls that can be implemented during the summer and fall months, and it reduces the importance of some overwintering habitats, particularly mesquite.

SUMMER CULTURAL CONTROL

During the summer, the goal of cultural control is to alter the physical and biological environments to make conditions less favorable for boll weevil population growth.

Shorten the Growing Season

The length of the growing season (biological, or biotic, environment) can be shortened by planting in late May or by planting an early-maturing cotton variety. Early-maturing cottons escape high, late-season boll weevil damage, because the bolls mature and become unsuitable for food and oviposition sites before boll weevil populations reach damaging levels. However, cotton variety and planting date interact to influence rate of plant development. For example, TAMCOT CAMD-E is an early-maturing, short-season variety, while Lankart 611 is a medium maturity variety. These two varieties represent the maturity range generally selected by producers in the Rolling Plains. When both varieties were planted in late April, the initial rate of square production by CAMD-E was higher than that by Lankart 611 (Fig. 6). This demonstrates the value of planting an early-maturing variety if planting takes place before late May. When the two varieties were planted in late May, there were more 1/3-grown squares in Lankart 611 than in CAMD-E during the first week of squaring (Fig. 6). These results indicate that the growth characteristics of a short-season variety are more evident when cotton is planted in late April as compared to planting in late May when soil temperatures are warmer. Both varieties produced squares faster when they were planted in late May (Fig. 6). Planting in late May exerts a short-season effect on cotton development, regardless of varietal type.

The time from first, 1/3-grown squares to peak square production was 3.8 weeks for Paymaster 145 cotton planted in late April, but only 2.8 weeks for the late May planting (Fig. 7). Five insecticidal applications were required for boll weevil control in the late April planting, but only 2.3 applications were required for the late May planting. Planting in late May shortened the growing season by one week; this decreased the time that boll weevils could develop on the plants thereby reducing the number of insecticide applications. Net returns were highest in cotton planted in late May (Fig. 4), primarily because insecticide use was reduced.

Change the Microclimate

Temperature is one aspect of the physical, or abiotic, environment which influences mortality of boll weevil larvae and seasonal population dynamics. During the summer, cultural control techniques are used to enhance the severity of the high soil temperature conditions experienced by developing larvae in fallen cotton squares.

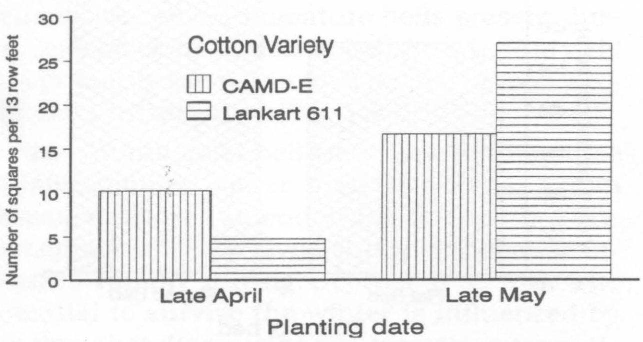


Figure 6. Average number of 1/3-grown squares in two cotton varieties during first week of squaring. Munday, Texas. 1986 - 1989.

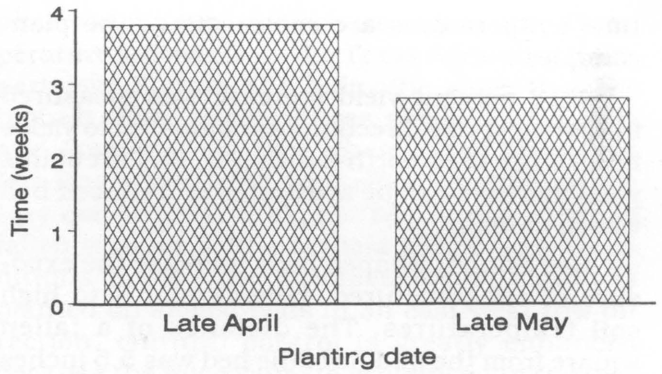


Figure 7. Time from first, 1/3-grown squares to peak squaring in Paymaster 145 cotton. Chillicothe, Texas. 1986 - 1989.

Row Direction. Boll weevil damage to squares and soft bolls is affected by row direction. Damage is about 28 percent higher in rows oriented north-south as compared to damage in rows oriented in an east-west direction (Fig. 8). This difference may be caused by differential heating within the plant canopy. When rows are oriented east-west, the total plant canopy receives direct solar heating throughout the day. When plants are oriented north-south, the western half of the plant is shaded in the mornings while the eastern half is shaded during the afternoons. Boll weevils may tend to concentrate in cotton planted in a north-south direction because day-

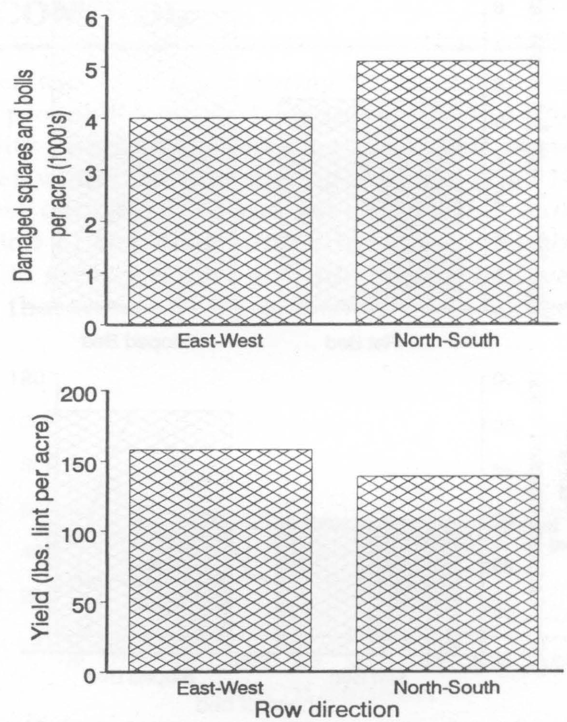


Figure 8. Influence of row direction on boll weevil damage and yield in cotton grown on flat beds. Chillicothe, Texas. 1981 - 1983.

time temperatures are cooler within the plant canopies.

A 13 percent yield increase was measured in east-west row directions as compared to yields in rows oriented north-south (Fig. 8). Part of this yield increase can be attributed to reduced boll weevil damage.

Bed Shape. Shaped beds increase the exposure of egg-punctured, fallen squares to high soil temperatures. The distance of a fallen square from the middle of the bed was 5.5 inches on flat beds, but this distance increased to 7.8 inches on sloped (shaped) beds (Fig. 9). Squares that fell from cotton grown on sloped beds rolled out from under the protective shading of the plant canopy. On flat beds only 29 percent of the fallen squares were exposed to direct solar radiation, while 52 percent of the squares were exposed when cotton was grown on sloped beds (Fig. 9). Fallen squares that are exposed to high temperatures rapidly desiccate causing thermal death of the larva inside the square.

When cotton is planted in an east-west row direction, sloped beds can be used to reduce boll weevil damage in about 50 percent of the years. Sloped beds provide an effective cultural control technique in years with average temperature and rainfall conditions (years with moderate climatic conditions) because furrows are exposed to direct sunlight throughout the day. In years with extremely high temperatures and low rainfall, sloped beds do not enhance boll weevil mortality.

Sloped beds do not reduce the amount of damage in north-south row directions in any year. Plants shade the furrows in mornings and afternoons, which protects the larvae in fallen squares.

In two of four years, boll weevil damage to squares in rows oriented east-west was reduced an average of 28 percent in sloped beds as compared to amount of damage in flat beds (Fig. 10). As a result, yields were increased about 25 percent in the east-west rows (Fig. 10). Producers can plant on beds, or they can use a rolling cultivator after stand establishment to form a sloped bed.

Row Spacing. Narrow row spacing cannot be used to reduce boll weevil damage in the Rolling Plains. As row spacing decreased from 40 inches to 27 inches to 20 inches, amount of boll weevil damage increased (Fig. 11). Boll weevil damage was 46 percent higher in 20 inch rows as compared to the amount of damage in 40 inch rows. Although yields were about 13 percent higher in the 20 inch rows as compared to yields in 40 inch rows, narrow rows could actually intensify boll weevil problems in some areas. In-

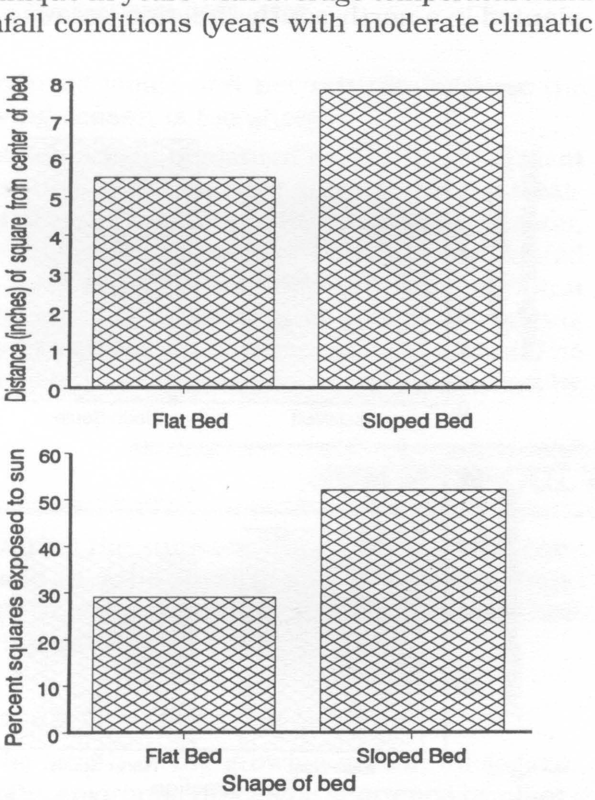


Figure 9. Effect of bed shape on exposure of fallen, boll weevil-damaged squares to sunlight. Chillicothe, Texas. 1976.

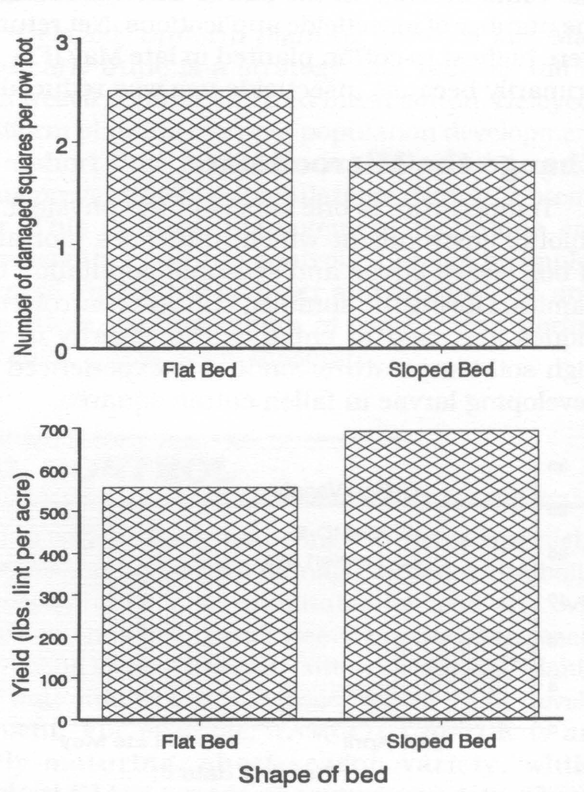


Figure 10. Influence of bed shape on boll weevil damage and yield in rows oriented east-west. Chillicothe, Texas. 1977 and 1979.

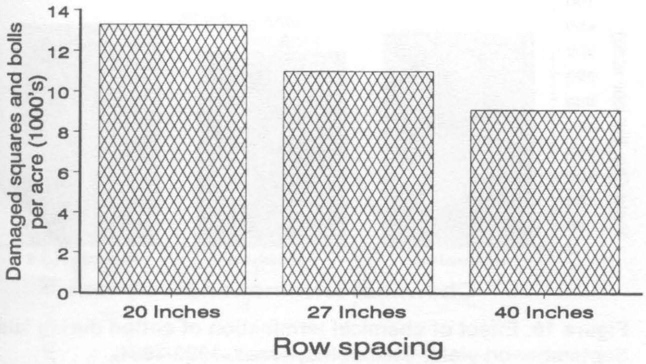


Figure 11. Influence of row spacing on boll weevil damage in cotton planted on flat beds. Chillicothe, Texas. 1981 - 1983.

creased damage in narrow rows was associated with higher levels of square production, on a per acre basis. Apparently, boll weevils were congregating in areas with more abundant food, or perhaps they spent less time searching for squares and were able to damage more because squares were more abundant.

Summary

Planting date influences the timing of the blooming period during the summer (Fig. 12). When cotton is planted in late May, blooms are produced from mid-July to late August, and the peak blooming period occurs in late July. Temperature records from the Texas Agricultural Experiment Station at Chillicothe show that the highest daily temperatures occur during July and August at the time when cotton planted in late May is blooming. Therefore, planting in late May can be used to expose boll weevil larvae in fallen squares to the highest temperature conditions during the summer. When cotton is planted on sloped beds in an east-west row direction, cultural control is greatly enhanced because the microclimate is changed to the detriment of the boll weevil.

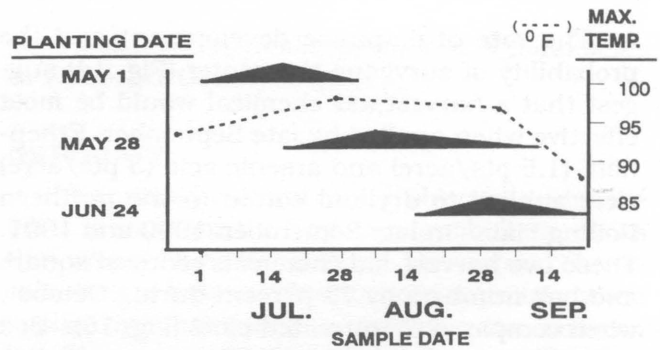


Figure 12. Blooming period (▲) in relation to planting date and maximum air temperatures. Chillicothe, Texas.

FALL CULTURAL CONTROL

During the fall, a cultural control objective is to eliminate squares and small bolls; these serve as food and allow boll weevils to build fat reserves for the winter.

Utilize Harvest-Aid Chemicals

When cotton is planted in late May, squares formed between early July and late August contribute over 95 percent of the final yield. The squares and small, immature bolls present during September and October contribute little to yield and primarily serve as a food source for boll weevils entering diapause (Fig. 13).

Low numbers of boll weevils enter diapause in late summer. Fewer than 30 percent are in diapause before the end of September, but the percentage of boll weevils entering diapause increases rapidly during October (Fig. 14). The potential to survive the winter is influenced by the time that diapausing boll weevils enter suitable overwintering habitat. Boll weevils that enter winter habitat during September have a low probability of surviving the winter, but probability of survival increases when boll weevils enter winter habitat during October (Fig. 14). These data (Figs. 13 and 14) suggest that elimination of the food supply by late September would greatly reduce the numbers of boll weevils that were capable of surviving the winter.

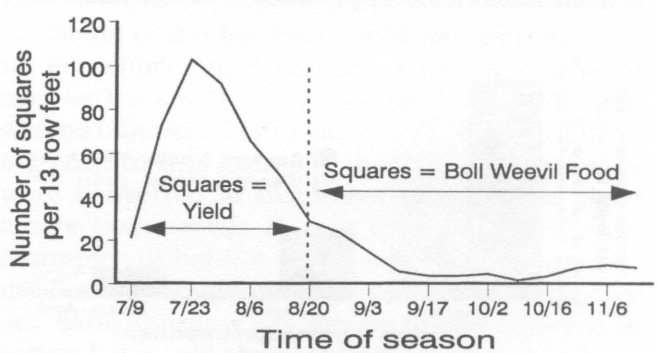


Figure 13. Typical square production curve for dryland cotton in the Texas Rolling Plains. Chillicothe, Texas.

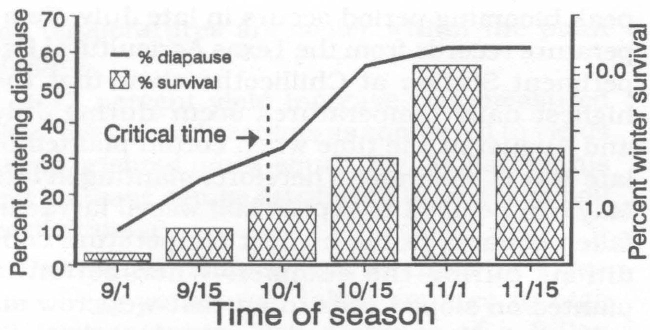


Figure 14. Percent of boll weevil population entering diapause and percent overwinter survival versus time of entry into habitat. (Data adapted from Bottrell & Almand 1970, Sterling & Adkisson 1974, Rummel & Carroll 1983.)

The rate of diapause development and the probability of surviving the winter (Fig. 14) suggest that a harvest-aid chemical would be most effective when applied by late September. Ethephon (1.5 pts/acre) and arsenic acid (3 pts/acre) were applied to dryland cotton in the northern Rolling Plains in late September, 1990 and 1991. These two harvest-aid chemicals reduced square and boll numbers by 72 percent during October, when compared to untreated plots (Fig. 15). Boll weevil damage was reduced 94 percent in plots receiving ethephon and arsenic acid (Fig. 15).

When compared to yields in untreated plots, one application of ethephon or arsenic acid in late September did not lower yields (Fig. 16). Harvest-aid chemicals are not commonly used in dryland cotton in the northern Rolling Plains, so the decision to use them in late September would have to be based on their potential for boll weevil management, not yield enhancement.

Harvest-aid chemicals could be used effectively in an eradication program or in community diapause control programs to reduce overwintering boll weevil populations. This approach might reduce the need for multiple early season and in-season insecticide applications. When used over

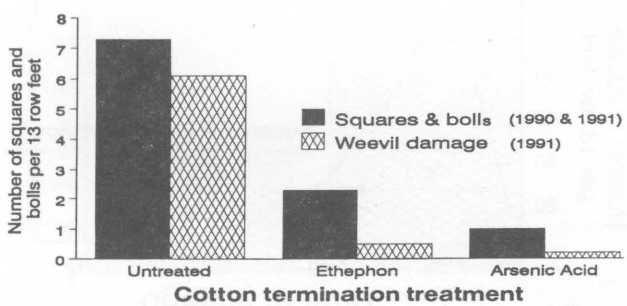


Figure 15. Effect of chemical terminaton on availability of squares and bolls and on boll weevil damage during October. Chillicothe, Texas.

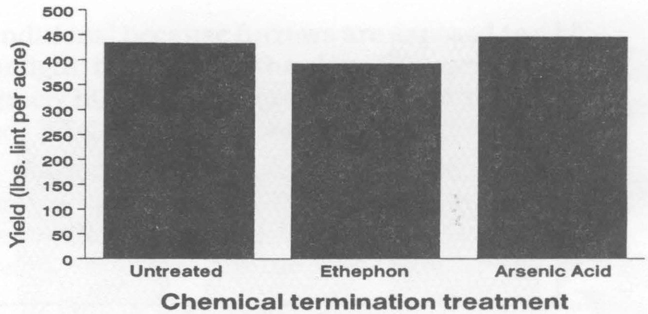


Figure 16. Effect of chemical termination of cotton during late September on yield. Chillicothe, Texas. 1990-1991.

a large geographic area, harvest-aid chemicals could reduce total control costs and other adverse aspects associated with using insecticides.

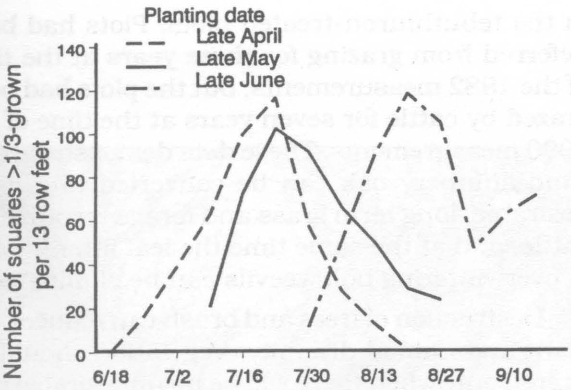
Role of Planting Date

It is very important to limit the availability of 1/3-grown squares during late summer and early fall. Planting cotton in late May restricts the primary period of 1/3-grown square production to July and August, but when cotton is planted in late June, 1/3-grown squares are produced in high numbers during August and September (Fig. 17). When high numbers of squares are present in fields during September, as occurs when cotton is planted in late June, boll weevil population numbers become very high during the fall (Fig. 17). Planting between late May and early June is a cultural strategy that can be used to reduce numbers of late season squares and bolls, thereby limiting boll weevil population growth during the fall.

Terminate Irrigations in August

Large numbers of diapausing boll weevils often develop in irrigated cotton fields in September and October. For example, there can be three times as many squares and small bolls in irrigated fields during the fall as compared to numbers in dryland fields (compare the dryland and irrigated fields in Wilbarger County in Fig. 18). Excessive numbers of squares and bolls in irrigated fields allow development of high populations of diapausing boll weevils.

Management of irrigated fields during the summer is necessary to reduce boll weevil problems the following year. Irrigation termination in August is an effective cultural technique for reducing pest populations and their food supply during the fall. This cultural strategy has effectively eliminated overwintering populations of pink bollworms, *Pectino-phora gossypiella* (Saunders), in



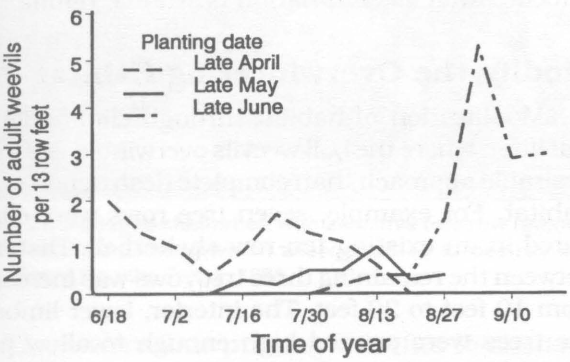


Figure 17. Influence of three planting dates on timing of square production (top) and on boll weevil population development (bottom) in dryland cotton. Chillicothe, Texas.

Arizona. A similar technique holds promise for managing boll weevils in irrigated fields in the Texas Rolling Plains. For example, some irrigated fields in Knox County, Texas, which had irrigations terminated during August, had numbers of

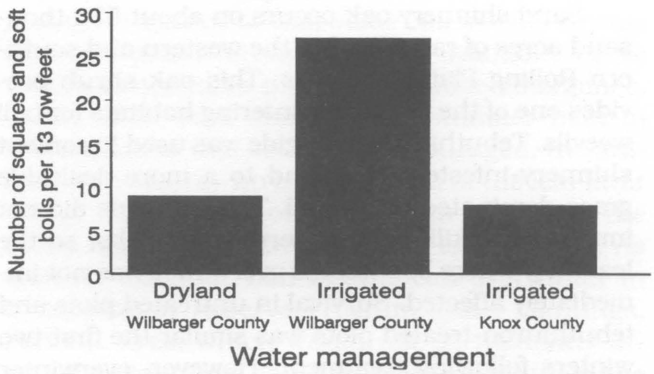


Figure 18. Average number of squares and soft bolls during September and October in dryland and irrigated fields. 1984.

squares and bolls similar to those in dryland fields in Wilbarger County (Fig. 18).

Summary

The primary cultural control objective during the fall is to eliminate the food supply of boll weevils as they prepare for overwintering. Harvest-aid chemicals show promise for this purpose, especially when applied by late September. Planting cotton between late May and early June is another way to effectively reduce numbers of squares and bolls during September and October. A management option in irrigated fields is to terminate irrigations in August; this significantly reduces numbers of squares and bolls during the fall. It is important to eliminate squares and small bolls by late summer because successful overwintering is dependent upon availability of a food supply during the early fall.

WINTER CULTURAL CONTROL

Cultural control objectives during the winter months are designed to deprive the boll weevil of suitable overwintering habitats.

Eliminate the Overwintering Habitat

There are many types of suitable overwintering habitats for boll weevils in the Rolling Plains region including shelterbelts, sand shinnery oak, mottes of western soapberry or hackberry trees, overgrown vegetation around abandoned farmsteads, dense mesquite pastures, and fence rows overgrown with woody vegetation. These favorable overwintering sites can be small in total area, but they can harbor large numbers of boll weevils. The economic costs associated with boll weevil survival in shelterbelts, one type of winter habitat which is generally small in area, were estimated at $54.78 per acre in the adjacent 40-acre cotton field.

Some of the habitats could be destroyed. In an experiment in Arkansas, a five acre wooded area within a 600-acre cotton field was destroyed, and no boll weevil infestation occurred the following year. In this example, the five acres of woods were converted to five acres of cotton, a place where boll weevils do not typically overwinter. Examples of habitat that could be eliminated in the Texas Rolling Plains include western soapberry and sand shinnery oak mottes in and adjacent to cotton fields, old abandoned farm sites that have become overgrown with vegetation, and mesquite-infested rangeland adjacent to cotton.

Sand shinnery oak occurs on about 570 thousand acres of rangeland in the western and southern Rolling Plains of Texas. This oak shrub provides one of the best overwintering habitats for boll weevils. Tebuthiuron herbicide was used to convert shinnery-infested rangeland to a more desirable grass-dominated rangeland. The herbicide did not immediately kill the shinnery oak shrubs, so the leaf litter where boll weevils overwinter was not immediately affected. Survival in untreated plots and tebuthiuron-treated plots was similar the first two winters following treatment. However, overwinter survival was reduced 67 percent during the third winter in the tebuthiuron plots (Fig. 19). It took two years following herbicide treatment for the litter layer to decompose or blow away sufficiently to reduce winter survival of the boll weevil.

Herbicide applications are expensive, so their long-term effects are important. In 1982, two years posttreatment, grass and forb production totaled 360 lbs. per acre in untreated plots and 2670 lbs. per acre in tebuthiuron-treated plots. In 1990, which was ten years posttreatment, total grass and forb production in untreated plots was 360 lbs. per acre while that in the tebuthiuron-treated plots was 890 lbs. per acre (Fig. 20). In 1982 and 1990 there was a 642 percent increase and a 147 percent increase, respectively, in grasses and forbs

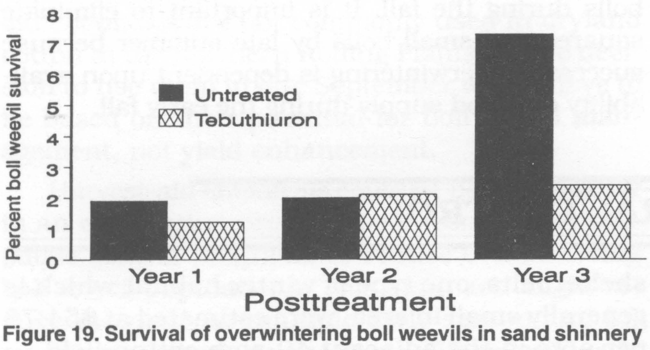


Figure 19. Survival of overwintering boll weevils in sand shinnery oak treated with tebuthiuron herbicide in 1980. Kent County, Texas.

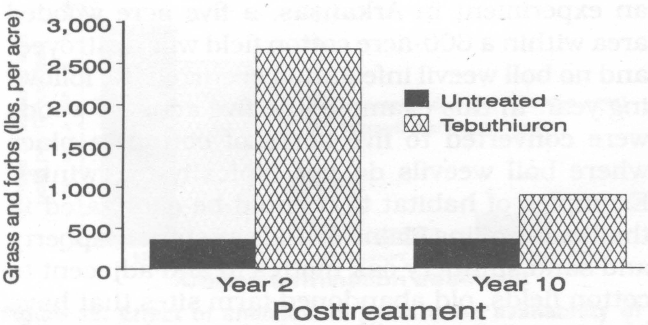


Figure 20. Grass and forb production in sand shinnery oak treated with tebuthiuron herbicide in 1980. Kent County, Texas.

in the tebuthiuron-treated plots. Plots had been deferred from grazing for three years at the time of the 1982 measurements, but the plots had been grazed by cattle for seven years at the time of the 1990 measurements. These data demonstrate that sand shinnery oak can be converted to a more desirable, long term grass and forage resource for cattle, and at the same time the leaf litter habitat of overwintering boll weevils can be eliminated.

Destruction of trees and brush can reduce both plant and animal diversity. Vegetation should be altered only when there will be no undesirable side effects, such as elimination of wildlife habitat.

Modify the Overwintering Habitat

Modification of habitat through elimination of leaf litter, where the boll weevils overwinter, is a more desirable approach than complete destruction of the habitat. For example, seven tree rows were eliminated in an existing ten-row shelterbelt. Distance between the remaining three tree rows was increased from 10 feet to 20 feet. The interior, lower limbs of the trees were pruned high enough to allow passage of a tractor, and the leaf litter could then be destroyed by annual disking. (Fig. 21 shows the shelterbelt and leaf litter before tree row removal, and Fig. 22 shows the shelterbelt after thinning.) The three remaining tree rows still provided an effective windbreak.

Figure 21. Unmanaged shelterbelt with dense tree planting and abundant leaf litter accumulation. Foard County, Texas. 1977.

Figure 22. Managed shelterbelt with selective tree row removal and lower limb pruning which allows disking to destroy leaf litter. Foard County, Texas. 1981.

There were four primary benefits to shelterbelt management using selective tree row removal and disking. First, there was an 84 percent reduction in leaf litter. Therefore, the shelterbelt could not harbor as many overwintering boll weevils because most of the microhabitat (leaf litter) was destroyed. Second, winter temperatures averaged 5.4 °F colder than those in unmanaged plots, and freezing temperatures occurred in managed plots but not in unmanaged plots. Percent overwinter survival was reduced 63 percent in the managed area because of the colder environment. Third, temperatures during the spring averaged 2.2 °F warmer in the managed plots as compared to temperatures in unmanaged areas. As a result of the warmer temperatures, spring emergence terminated from one week to one month earlier in managed plots. Therefore, most spring emergence was suicidal; these boll weevils died before 1/3-grown squares were available as feeding and oviposition sites. And fourth, fewer migrating boll weevils selected the managed area during the fall, which resulted in a 70 percent reduction of the overwintering population as compared to that in unmanaged plots.

Sand shinnery oak mottes are small thickets of tall hybrid oak trees that are intermingled with the low shinnery brush. Mottes are important because cooler litter temperatures during the spring, as compared to temperatures in low brush, delay spring emergence so that some boll weevils emerge after 1/3-grown squares become available. These mottes function to increase effective emergence. Cattle often seek shelter from summer heat in mottes, and if this activity is encouraged, the animals can destroy up to 85 percent of the leaf litter where boll weevils overwinter. In this case the motte is preserved, but the litter is destroyed. As another example, boll weevils can overwinter in Conservation Reserve Program grass plantings. Periodic fires, which would not permanently injure the plantings, could be used to eliminate the grass residues where boll weevils overwinter. These examples show that in selected instances, habitats can be modified without destroying them.

Avoid the Overwintering Habitat

When practical, producers should plant cotton as far from favorable overwintering habitat as possible; this reduces the probability of the field becoming infested during the growing season. Cotton fields within several hundred yards of good winter habitat are the ones most likely to be infested during the growing season.

When cotton is planted in late May, 1/3-grown squares become available for oviposition in late June - early July. Although boll weevils can survive the winter in mesquite, most of these survivors can be avoided by using delayed, uniform planting. For example, in the southern Rolling Plains, the date of last emergence from mesquite litter was June 4, which was 19 days earlier than date of last emergence from pecan litter. In the northern Rolling Plains, date of last emergence from mesquite litter was May 31, which was 34 days earlier than date of last emergence from sand shinnery oak litter (Fig. 23). Although mesquite is not one of the best overwintering habitats, it occupies about 9.6 million acres in the Rolling Plains. Mesquite actually may be the most important overwintering habitat in the region, but delayed, uniform planting decreases the importance of this habitat.

Producers often have some fields that are adjacent to winter habitat and some fields that are isolated from habitat. An alternative in this case is to plant the isolated fields first, in accordance with delayed uniform planting recommendations, and then plant the fields that are closer to favorable winter habitat last. A later planting date for fields adjacent to winter habitat will reduce the level of infestation during the growing season.

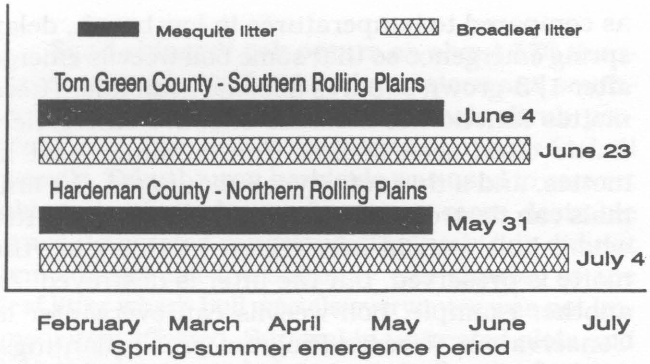


Figure 23. Date of last emerging boll weevils from mesquite and broadleaf litter in the southern and northern Texas Rolling Plains. 1986 - 1988.

Summary

The overwintering habitats of the boll weevil can be destroyed, modified or avoided. Destruction completely eliminates the trees and associated leaf litter, and the area is then planted to a crop or it becomes grass-dominated rangeland or some other vegetation type unsuitable for overwintering boll weevils. The objective of habitat modification is to eliminate the leaf litter while leaving the associated deciduous, broadleaf trees intact. This is the most desirable goal for managing shelterbelts because the windbreak function of the tree plantings must be maintained. Cattle can be used to trample leaf litter in shady groves of trees; this destroys the leaf litter but not the trees. Overwinter habitats can be avoided. The delayed, uniform planting strategy generally allows cotton to avoid boll weevils that overwinter in mesquite. If practical, cotton can be planted as far as possible from winter habitat; this allows the crop to escape those boll weevils that do survive the winter.

CONCLUSIONS

Delayed, uniform planting between late May and early June is a cultural control system that enhances boll weevil management throughout the year. This strategy reduces effective emergence of adults in the spring, increases mortality of larvae in fallen squares during the summer, limits the food supply for diapausing boll weevils during the fall, and enables the cotton crop to avoid those weevils that overwinter in mesquite. Utilization of a short growing season, harvest-aid chemicals, irrigation termination in August, and overwinter habitat management are additional cultural management strategies that effectively reduce population densities and crop damage. Cultural control can be utilized in all seasons of the year to reduce boll weevil damage during the growing season.

ACKNOWLEDGMENTS

There is an important history associated with the development of delayed, uniform planting for boll weevil management in the Texas Rolling Plains. Many people have contributed to the success of this program, but Emory P. Boring, III, with the Texas Agricultural Extension Service at Vernon, has been the key person involved in the implementation of this highly successful Extension program. The value of delayed, uniform planting was first reported by D. R. Rummel (1965) when he noted that development of boll weevil populations was slower at Afton as compared with populations at Spur. He attributed the lower boll weevil populations at Afton to the later planting there, and these observations and subsequent discussions in grower meetings formed the basis for delayed planting in the Rolling Plains. In the early 1970s, E. P. Boring, III began recommending the use of delayed, uniform planting in the Rolling Plains. His recommendation was to plant cotton throughout the region after mid-May (Boring, 1973). This program was subsequently adopted by most cotton producers throughout the Rolling Plains and is recognized by many as being a primary component in the economical management of the boll weevil in dryland cotton. The first research to support delayed, uniform planting was presented by J. E. Slosser (1978). He compared boll weevil damage and population development in an April-planted field with that in early June-planted fields, and he reported that damage and populations were higher and yields were lower in the April-planted field. T. W. Fuchs, Extension Entomologist in the southern Rolling Plains, developed a delayed planting program for that area in the 1980s. Again, this program is recognized as being highly successful. However, producers in the southern area consider

several factors before selecting a specific planting date (Fuchs and England 1989). Lastly, an economic analysis by S. M. Masud and others (1985) showed that net returns in dryland cotton were increased $21.37 per acre in response to delayed, uniform planting. All of these efforts have collectively built confidence in and have led to broad acceptance of delayed, uniform planting in the Texas Rolling Plains.

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