CULTURAL CONTROL OF THE BOLL WEEVIL - A FOUR SEASON APPROACH

J. E. Slosser, Entomologist
Texas Agricultural Experiment Station
Vernon, TX

Abstract

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, delayed, uniform planting between late May and early June forms the basis for cultural control of the boll weevil. During 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, which kill larvae inside the squares. 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 reduce winter survival. Complete elimination of winter habitat or modification of the habitat by destroying only the leaf litter where boll weevils overwinter are two options.

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.

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.

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. Each recommended cultural control strategy enhances efforts undertaken during the preceeding and succeeding seasons of the year. The recommendations reviewed in this report are based on 20 years of research conducted by the author from 1975 to 1994. The reference section provides the refereed journal sources for each recommendation, and additional supporting documentation, based on reports by other researchers, is provided also.

Reprinted from the *Proceedings of the Beltwide Cotton Conference*
Volume 2:800-804 (1996)
National Cotton Council, Memphis TN

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. 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, 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.

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. 1). 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. Lint yields are reduced with each delay in planting from late April to late May to late June (middle graph, Fig. 1). However, net returns are highest when cotton is planted in late May (bottom graph, Fig. 1). 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. 2). 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. 2). However, net returns are highest when cotton is planted in late May (bottom graph, Fig. 2). 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. When planting is delayed until late May in irrigated cotton production, net returns are increased.

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

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 condititions less favorable for boll weevil population growth. The length of the growing season (biological, or biotic, environment) can be shortened by planting in late May. 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. 3). 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 (Figs. 1 & 2), primarily because insecticide use was reduced.

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. 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. 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. 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 thoughout 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. 4). As a result, yields were increased about 25 percent in the east-west rows (Fig. 4). Producers can plant on beds, or they can use a rolling cultivator after stand establishment to form a sloped bed.

Planting date influences the timing of the blooming period during the summer. 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.

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. 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.

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. 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 quarters during October. Elimination of the food supply by late September would greatly reduce the numbers of boll weevils that were capable of surviving the winter.

The rate of diapause development and the probability of surviving the winter 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. 5). Boll weevil damage was reduced 94 percent in plots receiving ethephon and arsenic acid.

When compared to yields in untreated plots, one application of ethephon or arsenic acid in late September did not lower yields. 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 a large geographic area, harvest-aid chemicals could reduce total control costs and other adverse aspects associated with using insecticides.

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. 6). 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. 6). 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.

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. It is important to eliminate squares and small bolls by late summer because successful overwintering is dependent upon availability of a food supply during early fall.

Winter Cultural Control

Cultural control objectives during the winter months are designed to deprive the boll weevil of suitable overwintering habitats. There are many types of 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 fencerows overgrown with woody vegetation. These favorable overwintering sites can be small in total area, but they can harbor large numbers of boll weevils. 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 tebutiuron-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. 7). 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.

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. The remaining tree rows provided an effective windbreak.

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. 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% reduction of the overwintering population as compared to that in unmanaged plots.

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. 8). 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.

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. Overwinter habitats can be avoided. The delayed, uniform planting strategy generally allows cotton to avoid boll weevils that overwinter in mesquite.

Summary

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, 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

Some financial support for research on overwinter habitat management was provided by grants from Cotton Incorporated (Research Agreement 79-440), Howard County Cotton Producers Association, and Martin County Insect Control Association.

References

1. Bevers, S. J. and J. E. Slosser. 1992. Assessing cost effectiveness of planting dates and insecticide chemicals in Texas dryland cotton production. J. Prod. Agric. 5: 374-377.

2. Boring, E. P., III. 1972. Studies on overwintering habitat, spring movement, and population dynamics of the boll weevil in the Rolling Plains area of Texas. M.S. thesis, Texas A&M Univ., College Station.

3. Clark, L. E., H. T. Wiedemann, C. J. Gerard and J. R. Martin. 1991. A reduced tillage system with furrow diking for cotton production. Trans. Amer. Soc. Agric. Eng. 34: 1597-1603.

4. DeMichele, D. W., G. L. Curry, P. J. H. Sharpe, and C. S. Barfield. 1976. Cotton bud drying: a theoretical model. Environ. Entomol. 8: 1011-1016.

5. Masud, S. M., R. D. Lacewell, E. P. Boring, III and T. W. Fuchs. 1985. Economic implications of a regional uniform planting date cotton production system: Texas Rolling Plains. J. Econ. Entomol. 78: 535-541.

6. Montandon, R., J. E. Slosser, and L. E. Clark. 1994. Late-season termination effects on cotton fruiting, yield, and boll weevil (Coleoptera: Curculionidae) damage in Texas dryland cotton. J. Econ. Entomol. 87: 1647-1652.

7. Rummel, D. R. and S. C. Carroll. 1983. Winter survival and effective emergence of boll weevil cohorts entering winter habitats at different times. Southwest. Entomol. 8: 101-106.

8. Rummel, D. R. and S. C. Carroll. 1985. Longevity of overwintered boll weevils (Coleoptera: Curculionidae) following emergence in spring and early summer. Environ. Entomol. 14: 127-130.

9. Slosser, J. E. 1981. Cultural control of the boll weevil: influence of bed shape. J. Econ. Entomol. 74: 561-565.

10. Slosser, J. E. 1993. Influence of planting date and insecticide treatment on insect pest abundance and damage in dryland cotton. J. Econ. Entomol. 4: 86: 1213-1222.

11. Slosser, J. E. 1995. Cultural control of the boll weevil: A four season approach - Texas Rolling Plains. Tex. Agric. Exp. Stn. Bull. 1721.

12. Slosser, J. E. and T. W. Fuchs. 1991. Overwinter survival of boll weevils (Coleoptera: Curculionidae) in the Texas Rolling Plains. Environ. Entomol. 20: 877-881.

13. Slosser, J. E., P. W. Jacoby, and J. R. Price. 1985. Management of sand shinnery oak for control of the boll weevil (Coleoptera: Curculionidae) in the Texas Rolling Plains. J. Econ. Entomol. 78: 383-389.

14. Slosser, J. E., G. J. Puterka, and J. R. Price. 1986. Cultural control of the boll weevil (Coleoptera: Curculionidae): effects of narrow-row spacing and row direction. J. Econ. Entomol. 79: 378-383.

15. Slosser, J. E., D. G. Bordovsky, and S. J. Bevers. 1994. Damage and costs associated with insect management options in irrigated cotton. J. Econ. Entomol. 87: 436-445.

16. Slosser, J. E., R. J. Fewin, J. R. Price, L. J. Meinke, and J. R. Bryson. 1984. Potential of shelterbelt management for boll weevil (Coleoptera: Curculionidae) control in the Texas Rolling Plains. J. Econ. Entomol. 77: 377-385.

17. Sterling, W. L. and P. L. Adkisson. 1974. Seasonal incidence of diapause and reproduction in boll weevils inhabiting the High and Rolling Plains of Texas. Tex. Agric. Exp. Sta. Misc. Pub. 1145.

18. White, J. R. and D. R. Rummel. 1978. Emergence profile of overwintered boll weevils and entry into cotton. Environ. Entomol. 7: 7-14.

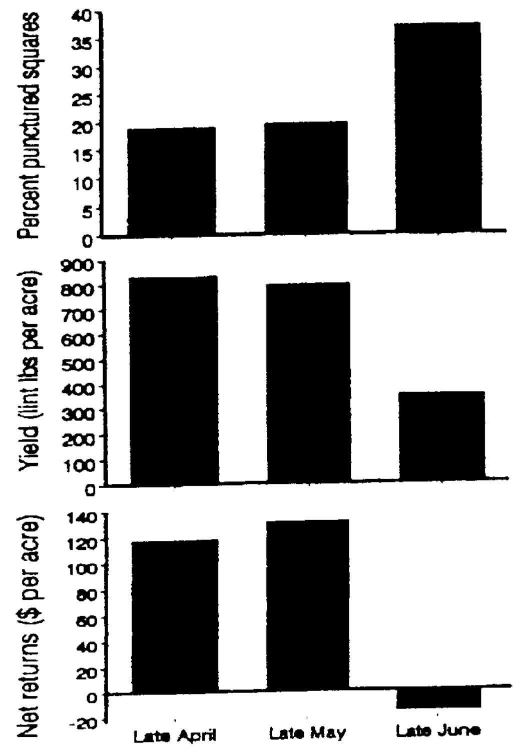

Fig. 2. Boll weevil damage, yield, and net returns in relation to late April, late May, and late June planting dates in irrigated cotton. Munday, Texas. 1986-1989.

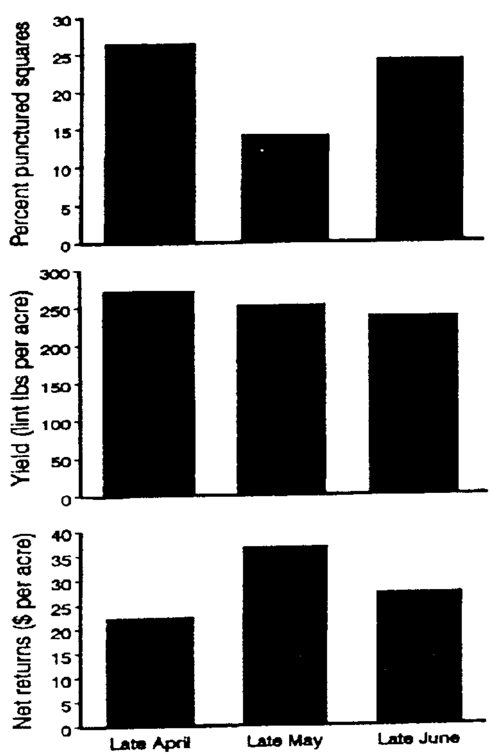

Fig. 1. Boll weevil damage, yield, and net returns in relation to late April, late May, and late June planting dates in dryland cotton. Chillicothe, Texas. 1986-1989.

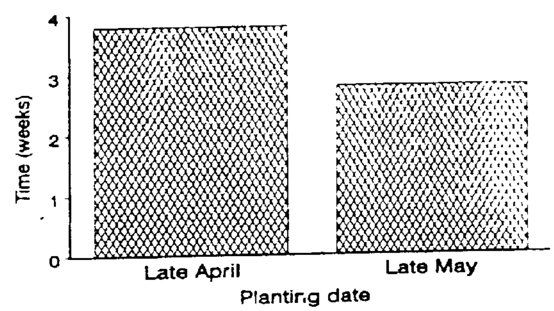

Fig. 3. Time from first, 1/3-grown squares to peak squaring in Paymaster 145 cotton. Chillicothe, Texas. 1986-1989.

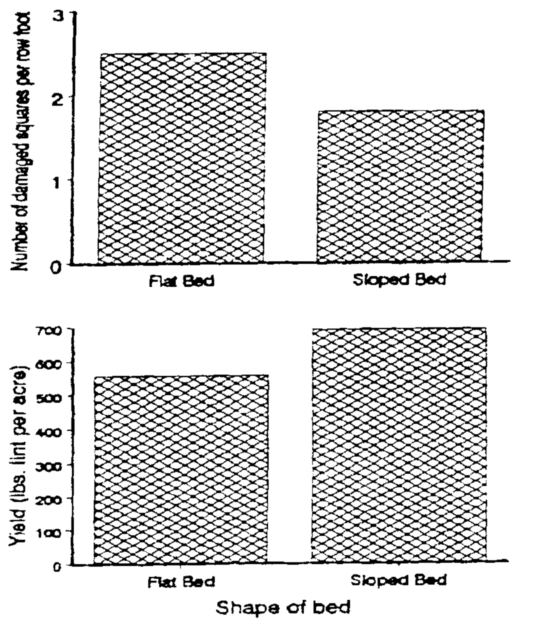

Figure 4. Influence of bed shape on boll weevil damage and yield in rows oriented east-west. Chillicothe, Texas 1977 and 1979.

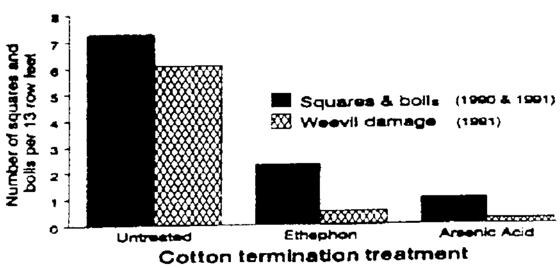

Fig. 5. Effect of chemical termination on availability of squares and bolls and on boll weevil damage during October. Chillicothe, Texas.

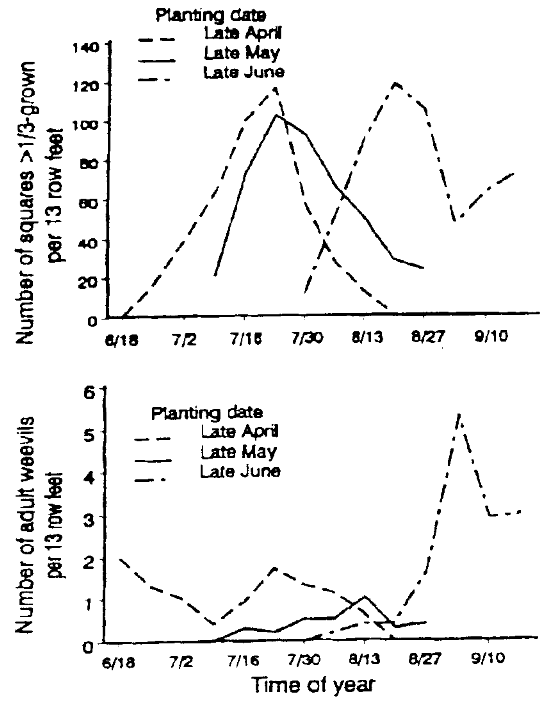

Fig. 6. Influence of three planting dates on timing of square production (top) and on boll weevil population development (bottom) in dryland cotton. Chillicothe, Texas.

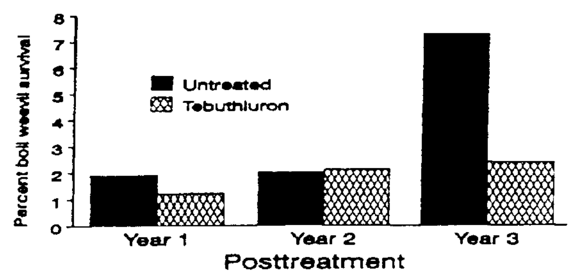

Fig. 7. Survival of overwintering boll weevils in sand shinnery oak treated with tebuthiuron herbicide in 1980. Kent County, Texas.

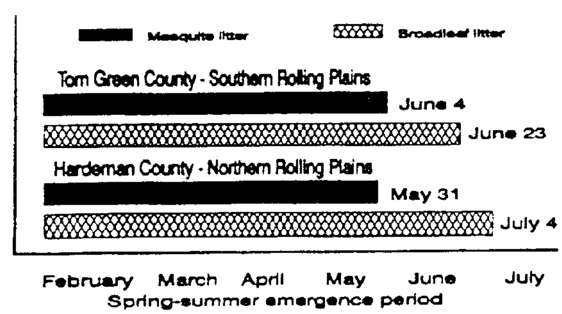

Fig. 8. Date of last emerging boll weevils from mesquite and broadleaf litter in the southern and northern Texas Rolling Plains. 1986-1988.