BOLL WEEVIL ERADICATION UPDATE - TEXAS, 1996

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Abstract

The boll weevil eradication program in Texas was initiated in 1994 in an effort to rid the state of the cotton boll weevil, *Anthonomus grandis* Bohman. The cotton growing area in the state was divided into nine zones, each encompassing between 150,000 and 3.9 million acres of cotton. The plan is to sequentially implement the program in each of the nine zones to achieve statewide eradication within 10 years.

The program was first initiated in the Southern Rolling Plains (SRP) Zone on 220,000 acres of cotton in September of 1994 with the diapause phase. All cotton fields received a single application of Fyfanon® ULV (malathion) during the week of September 26, and every week thereafter; however, the last treatment was applied on a 10-day interval. Treatments continued until all hostable plants and food supply were eliminated by harvesting, stalk destruction or a killing freeze.

The first season-long phase of the program was initiated in the SRP during the spring of 1995. Boll weevil traps were placed at planting around all cotton fields at a density of one trap per five acres and were inspected on a weekly basis. A single Fyfanon® ULV application was made to fields that had reached the treatment criteria (action threshold). The threshold was a trap catch of two adult boll weevils per field at matchhead square. The action threshold was increased to eight adults per field beginning August 7 in an effort to reduce the use of insecticide during mid-season, and decreased to five adults per field beginning September 18 for the remainder of the season.

In the spring of 1996, the second season-long phase of the program in the SRP included some modifications that were requested by growers as a precautionary measure to avoid compounding possible secondary pest problems. The modifications included the use of Vydate® C-LV (oxamyl) insecticide for control of the overwintered populations and Phaser® 3EC (endosulfan) insecticide for the mid-season populations. Additionally, the action threshold for mid-season (July 5 - August 10) was increased to 10 adult weevils per field (40 acre field size) per week. Fyfanon® ULV insecticide was used to control the late- season populations.

The overall mean number of boll weevils captured per trap during the fall of 1996 was significantly less than 1994. The 1996 mean was 4.9 whereas the 1994 mean was 50.6, a reduction rate of 90.3%. The season-long mean number of adult weevils per trap in 1996 was also significantly less than in 1995. The 1996 mean was 2.11 whereas the 1995 mean was 8.21, a reduction rate of 74.3%. Despite the unseasonably dry conditions experienced early in the growing season, 1996 ginning records for 40 randomly selected farms indicate approximately an 18% increase in the yield for the dryland and a 29% increase for the irrigated cotton as compared to the historical five-year average.

In 1996, the program was also initiated with the diapause phase in the South Texas/Winter Garden (ST/WG) and the Rolling Plains Central (RPC) zones on approximately 500,000 acres each. Fields in both zones received weekly applications of Fyfanon® ULV beginning at the open boll crop phenology. The exception to the seven-day regimen occurred only during the last two applications in the RPC, where applications were on ten-day intervals. Treatments continued until all hostable plants and food supply were eliminated by harvesting, stalk destruction or a killing freeze.

Since 1996 was the first year of the program in the ST/WG and RPC, no program trapping data was collected the previous year for comparison, as was the case in the SRP. However, in ST/WG the overall mean number of boll weevil adults during the month of September (peak fall populations) in traps placed around 220 randomly selected fields was higher than the overall mean number of boll weevil adults per trap during the month of April (peak emergence of overwintering populations) by less than one-fold. Typical population trends under individual grower control in the Lower Gulf Coast of Texas, according to a six-year study, averaged an 84-fold increase when the same type of analysis was applied (Segers et al., 1987). Similar results were observed in the RPC. Definite conclusions may

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not be made in either ST/WG or RPC until comparative data is collected in 1997.

These results demonstrate that the area-wide eradication approach, utilizing pheromone traps with sound cultural, mechanical and chemical controls, represents an effective strategy in reducing the boll weevil populations as planned, subsequently eliminating the most destructive cotton pest in the state.

Introduction

The boll weevil, *Anthonomus grandis* Bohman, a native of Mexico and Central America, was first introduced into the United States, near Brownsville, Texas, about 1892 (Hunter et al., 1905). By 1922, the pest had spread into cotton growing areas of the United States from the eastern two-thirds of Texas and Oklahoma to the Atlantic Ocean. Northern and western portions of Texas were colonized by the boll weevil during a subsequent range expansion that occurred between 1953 and 1966 (Newsom and Brazzel, 1968). In 1903 the Texas Legislature offered a $50,000 cash reward for a practical way to control the boll weevil.

Yield losses attributed to the boll weevil, the cost of insecticide control, environmental considerations, infestation of secondary insect pests and insect resistance have all resulted in an aggressive effort to develop a beltwide strategy for controlling the boll weevil in the United States.

Although most growers judiciously apply control measures to boll weevil infested acreage in almost all such areas, 5 to 20 percent of the infested acreage may receive inadequate or no control treatments (Knipling, 1979). This uncontrolled acreage harbors populations capable of reinfesting neighboring areas. Models developed by Knipling (1979) demonstrate that if only 10 percent of a population remains untreated, that portion of the population can develop normally and redistribute throughout the entire area after only four generations, or in less than one growing season. Also, judicious application of control measures cannot protect against reinfestation from neighboring areas the following season. Thus, growers who treat their acreage are faced with a continuing need to reapply insecticide to control reinfestations.

Approximately $70 million is spent annually for boll weevil control, and the pest still causes an estimated $200 million in crop losses each year (Knipling, 1964). In recent years, these figures may have increased by 50% (Hedin et al., 1976). It is generally agreed that cotton cannot be profitably grown in areas where the insect cannot be controlled and other control strategies are imperative.

In view of the economic and environmental problems posed by the boll weevil and in recognition of the technical advances developed over almost 100 years, a cooperative boll weevil eradication experiment was initiated in 1971 in southern Mississippi and parts of Louisiana and Alabama. This experiment used an integrated control approach including chemical treatment, releases of sterile males, mass trapping, and cultural control. Based on this experiment, a special study committee of the National Cotton Council of America concluded that it was technically and operationally feasible to eliminate the boll weevil. The success of the 3-year boll weevil eradication trial, initiated in 1978 on 32,500 acres in North Carolina and Virginia, led to the Southwestern and Southeastern boll weevil eradication programs (USDA, 1991).

In 1993, the Texas Boll Weevil Eradication Foundation was established by the Texas Legislature to govern and oversee the implementation of the boll weevil eradication program in Texas. The Foundation divided the cotton growing area in the state into nine eradication zones each encompassing approximately 150,000 to 3.9 million acres. In March of 1994, the cotton producers and landowners in the SRP passed a referendum with a majority vote of 84% to initiate the first eradication program in the state. The program started in the SRP with the diapause phase in the fall of 1994 on approximately 220,000 acres. In October of 1994, the producers and landowners in the Lower Rio Grande Valley (LRGV) zone passed a referendum with a majority vote of 73% to initiate the eradication program. The program started in the LRGV in the spring of 1995 with the season-long phase on approximately 360,000 acres. In January of 1996, the LRGV growers opted to discontinue the program. In 1996, the program began in South Texas/Winter Garden (ST/WG) zone on approximately 500,000 acres after a majority vote of 73% in February of 1995. In 1996, the program also began in the Rolling Plains Central (RPC) zone on approximately 500,000 acres after a majority vote of 85% in December of 1994. Both zones began the program with the diapause phase of the eradication process. In September of 1996, producers and landowners in the St. Lawrence (St.L) zone also passed a referendum with a majority vote of 75% to start the program with the diapause phase in the fall of 1997.

Materials and Methods

The cotton growing area in Texas which encompasses approximately 7 million acres, has been divided into nine eradication zones as follows:
1. Southern Rolling Plains (SRP), (220,000 acres).
2. Lower Rio Grande Valley (LRGV), (360,000 acres).
3. South Texas/Winter Garden (STWG), (600,000 acres).
4. Rolling Plains Central (RPC), (750,000 acres).
5. St. Lawrence (St.L), (150,000 acres).
6. Northern Rolling Plains (NRP), (700,000 acres).
7. Blacklands, (300,000 acres).
8. High Plains (HP), (3.9 million acres).
9. El Paso/Trans Pecos (EPTP), (60,000 acres). (Figure 1)

Mapping

Mapping is one of the first phases of operation in any eradication zone. The purpose of mapping is to identify the exact location of each cotton field and determine the surrounding environment. The program continued to utilize the numbering system that was designed to identify each cotton field in the state with a unique number (El-Lissy et al., 1996).

All cotton fields were mapped using the differentially corrected Global Positioning System (GPS). The GPS is based on a system of satellites developed by the U.S. Department of Defense. Now fully operational, the system has 24 satellites orbiting the Earth at an altitude of 11,000 miles. Program personnel used hand-held receivers (Scout Master, Trimble Navigation) capable of receiving satellite signals and calculating the precise reference points to triangulate a location (latitude / longitude). By measuring the travel time of signals transmitted from each satellite, the receiver computes its distance from that satellite. With distance measurements from at least three satellites, the hand held units can calculate the latitude / longitude within 100 meters (error range) from the exact location. Accompanying the hand-held GPS unit, program personnel used a real time FM hand-held differential correction receiver (DCI 3000®) in the SRP, and ACCQPOINT™ in ST/WG and the RPC. The FM receiver was connected to each of the GPS units to calculate and reduce the error (100 meters) to 1-5 meters. The GPS works anywhere on Earth, 24 hours a day and in any weather condition. Using the GPS hand-held units, latitude and longitude readings were taken at every corner (point) around each field. Points were stored in the GPS hand held units, taken to the office, and downloaded into MapInfo Professional™ version 4.0 (mapping software) via a specially written in-house computer routine that was designed to sort and connect the points. MapInfo is then capable of taking the readings, drawing the exact shape and location, then superimposing each field in layers of the maps. Each layer provides a detailed map of counties, streets, rivers and other major or permanent fixtures, producing comprehensive maps. These maps indicate the exact location of each field with an error range of one to five meters, as well as the exact number of acres within each field. Field maps are stored in the computer and used for trapping and insecticide applications, as well as other program activities.

Trapping

Boll weevil traps were baited with one-inch square laminated polyvinyl chloride dispensers impregnated with 10 mg of grandlure. In the SRP, traps were placed at planting around all cotton fields at a density of one per five acres and inspected weekly in the same manner as in 1995 (El-Lissy et al., 1996). In order to collect historical data relative to boll weevil population densities in 1996, traps were placed around the periphery of 220 and 167 randomly selected fields in ST/WG and RPC, respectively. Traps were placed shortly after planting at the rate of one per five acres and were inspected on a weekly basis.

Bar Code System: Beginning in 1996, the Bar Code System was utilized in the SRP as a tool to assist field personnel in collecting all trapping information in an efficient and timely manner before treatment decisions were made. Each trapper was provided with a 4.1" X 2.6" X 0.6" hand held bar code scanner (TimeWand® II) equipped with a built-in real time clock to record the time as scanning (trapping) took place. The bar code scanner weighs about 4.9 ounces, and is fabricated with a special circuitry that allows scanning in complete darkness and direct sunlight. The scanner also features a 2-line X 16-character liquid crystal display (LCD) window, and an alphanumeric keypad. The scanner is powered by a rechargeable (overnight) nickel-cadmium battery, and equipped with a 320K RAM memory chip allowing it to retain as much as five full days of trapping information. The hand-held scanner was designed to tolerate high temperatures (122°F), and humidity (95%), and is built with a durable metal casing to withstand the rigors of field activities. The scanner tip is partially infrared and partially a visible beam that is able to search through dust or contaminates to read the bar code. The bar code (BarCode Labeler™ II) is made of a polyester/vinyl label with smudge proof, carbon-based ink able to withstand the sun as well as multiple scans.

At the beginning of the season, each trap had a unique bar code affixed on the inside wall of the trap body (cup) prior to initial placement in the field. At planting, field personnel scanned each trap being deployed and entered the work unit, field and trap number using the keypad. The scanner automatically recorded the time and date of trap deployment for each trap; information was then stored in the hand-held scanner. At the end of the day, each scanner was placed in a downloader / charger station at the office. Each station was linked to the office computer (PC) with an RJ-11 male connector. The trap information was then transmitted within two minutes per scanner to a database specially designed to match each of the unique bar codes with its designated trap. This process (trap deployment) was designed to establish a permanent record for each trap before the weekly trap inspection began.

At the beginning of each trapping day, field personnel signed in by scanning their assigned personal identification (ID) number, and then scanning the bar code affixed to their assigned vehicle before leaving the office. This documented time for payroll purposes as well as vehicle usage. After the sign-in process was complete, the hand-held scanner was then ready to interpret trap bar codes. As each trap bar code was scanned, a series of questions appeared on the LCD window. Each question was answered either by scanning a specially configured bar code, or by using the keypad. The questions started by asking to identify the task (i.e., deployment, inspection, or removal), and then the number of weevils in that trap, crop phenology, lure and insecticide strip replacement. Additional questions pertained to trap condition, i.e., trap function, missing or replaced trap, or trap not inspected due to wet conditions. Field personnel scanned an end-of-day bar code and placed the scanners in downloader/charger station at the end of the workday. Trapping information was then transmitted to the data management program for data manipulation and decision making-process (El-Lissy et al., 1996).

In addition to field trapping information, the bar code scanners served as a viable method of quality control to verify that all traps were inspected by automatically stamping the actual time of inspection and the exact amount of time spent between traps. Further, the bar code system was also utilized in recording information pertaining to the aerial application of insecticides, i.e., aircraft take-off and landing, insecticide usage, and chemical inventory.

Quality Control: Quality control was implemented to ensure that program guidelines for boll weevil trapping were being followed. Quality control was conducted throughout the season by randomly selecting a minimum of 15 percent of all fields in each work unit on a weekly basis. Quality control includes: (1.) Visual Inspection - Trapping density, trap position, trap condition, lure and insecticide strip replacement, and crop phenology were evaluated; (2.) Planting weevils (Spiking) - The quality control supervisor planted a known number of weevils and/or tokens in a percentage of traps around the fields selected for quality control that week. Information gathered by the quality control supervisor was compared with the daily trapping report submitted by the trapper. This comparison was made to verify accurate trapping information.

Control

The control part of the eradication program consists of cultural, mechanical and chemical control:

(1.) Cultural Control: Windows for uniform cotton planting and harvesting, as organized by growers in each zone, are key components of cultural control by providing the necessary host-free period. In the SRP and RPC, most growers started to plant on or about May 15, and beginning February 15 in the ST/WG. In zones with mandatory stalk destruction rules and regulations, such as the ST/WG zone in which temperate climates may induce regrowth during the winter months (off-season), program personnel assisted the Texas Department of Agriculture (TDA) in maintaining a host-free period during the off-season months. Program personnel provided TDA with information to identify fields that were out of compliance with plow-up regulations before the stalk destruction date. Additionally, to encourage cultural control, the Foundation compensated growers with $2.50 per acre (with a $7.50 maximum) for each week fields were in compliance with the stalk destruction rules prior to the date established by TDA.

(2.) Mechanical Control: While the primary function of the trap was to measure the adult boll weevil population densities and identify their locations, another key benefit was removing segments of these populations in the process. In the SRP, traps removed a total of 3,144,161 adult boll weevils during the 1995 season and 1,122,457 during 1996.

(3.) Chemical Control: In the spring of 1996, the second season-long phase of the program in SRP included some modifications that were requested by growers in the SRP as a precautionary measure to avoid compounding possible secondary pest problems. Vydate® C-LV insecticide (8.5 fl oz/ac, 0.25 lb [AI]/ac) was used for control of overwintered boll weevil populations prior to July 4. Phaser® 3EC insecticide (22.0 fl oz/ac, 0.51 lb [AI]/ac) was used for the mid-season control (July 5 - August 17). Both insecticides were diluted in water (pH = 7.0) to total volume of a 1gal/ac of finished material. Fyfanon® ULV insecticide (12.0 fl oz/ac, 0.92 lb [AI]/ac) was used for the late season applications. Fyfanon® ULV was also used to control populations season long in fields that were located within close proximity (0.25 mile) to designated environmentally sensitive sites, i.e., schools, residences, child care centers, wildlife refuge, and rivers. The action threshold remained the same as 1995, except for the mid-season (July 5- August 10) ten adult weevils per field (40 acres or less) per week. All cotton fields in both ST/WG and the RPC received single applications of Fyfanon® ULV (12.0 fl oz/ac, 0.92 lb [AI]/ac) on a weekly basis. Except in the RPC, as temperatures began to decline, the last two applications were employed on ten-day intervals. Applications commenced at the first open boll crop phenology in both ST/WG (July 7) and in RPC (September 10).

Aerial applications were made by airplanes equipped with a spray system designed and calibrated to deliver ultra-low volume when Fyfanon® was used (El-Lissy et al., 1996). Calibration adjustments were made to the aircraft to deliver one gallon per acre when Vydate® and Phaser® were used for control. Aerial application in 1996 required 105, 74 and 10 aircraft in ST/WG, RPC, and SRP, respectively.

Each aircraft was equipped with a differentially corrected Global Positioning System (GPS) unit. This technology is similar to the one used in mapping, and is used in the aerial application as a method of quality control and documentation. At the end of each day, the aerial contractor provided program personnel (field supervisor) with information for each flight on a standard 3.5" high density computer diskette or on a Memory Card (PCMCIA). The field supervisor then displayed every flight on a computer screen to verify the quality of application by examining the exact position of aircraft, flight pattern, time and date of application, speed, swath width, spray on/off and flight time for each field as well as total flight time for each airplane. Four different GPS systems were utilized in the aerial applications during the 1996 spray operations, including Satloc (MapStar™) version 2.09, Del-Norte (Landnav®), Precision Electronic Guidance System (PEGS) version 1.6, and WAG Flagger.

Fields that were located within close proximity to some of the designated environmentally sensitive sites or near permanent obstacles were treated with high clearance ground sprayers. Mistblowers mounted on pickup trucks were also used to provide accurate placement of insecticide on corners and edges of fields and under power lines or other obstacles where airplanes had less accessibility (El-Lissy et al., 1996).

Results and Discussion

In the SRP, preliminary analyses indicate that the overall mean number of adult weevils captured per trap during the spring emergence (June 2 to July 21) in 1996 was significantly less than 1995. The mean in 1996 was 0.5 and in 1995 was 21.0, a reduction rate of 97.6%. The mean number of trap catches of the mid-season generations (July 22 to September 15) was also less in 1996 as compared to 1995. The 1996 mean was 0.4 and in 1995 was 0.7, a reduction rate of 43%. However, the mean number of weevil catches in the traps during the late-season period (September 16 to December 8) was slightly higher in 1996 when compared to 1995. The 1996 mean was 6.4 and in 1995 was 5.2, an increase rate of 23%. The reduction rate of late season populations in 1995 was 90% and was 88% in 1996 when compared to 1994 (Figure 2). The slight increase in trap catches during the late-season of 1996 may have been attributed to the short term efficacy (24h) provided by Phaser® (England et al., in press) during mid-season applications, the increased action threshold (ten weevils per field) during the same time frame, and late-season rainfall preventing timely insecticide applications.

In 1996, the cumulative number of acres treated in SRP for overwintered population control was 28,576 acres, averaging 0.16 application per acre, and in 1995 was 430,181 acres, averaging 2.0 applications per acre, a reduction rate of 92%. The cumulative acres treated for mid-season control in 1996 was 296,017, averaging 1.6 applications per acre, and in the 1995 was 479,954, averaging 2.2 applications per acre, a reduction rate of 27.3%. For late-season control, the cumulative number of acres treated in 1996 was 785,546 averaging 4.3 applications per acre and in 1995 was 1,970,259, averaging 9.0 applications per acre, a reduction rate of 52.2%. The season-long average number of insecticide applications per acre in 1996 was 4.3 and in 1995 was 8.6, a reduction rate of 50% (Figure 3).

The majority of the cotton growing area in the SRP zone experienced unseasonably dry weather conditions during May, June and July of 1996 (National Oceanographic and Atmospheric Administration), a critical period of the growing season for the crop development (Figure 4). Despite the unusually dry and hot conditions, the 1996 ginning records for 40 randomly selected farms indicate an 21% increase in yield for the dryland cotton and 42% for irrigated as compared to the historical annual average (excluding 1995) (Figure 5).

In the ST/WG, the cumulative number of acres treated for diapause control was 3,406,980 acres, averaging 7.2 applications per acre. The heavy rain experienced during September and October in the upper coast (42% of the acreage) prevented growers from harvesting and resulted in prolonging the need for insecticide applications. There was no program trapping data collected from the previous year for comparison as there was in the SRP. In 1996 (first year of the program), the overall mean number of boll weevil adults per trap during the month of September (peak fall populations), was higher than the overall mean number of boll weevil adults per trap during the month of April (peak emergence of overwintering populations) by less than one-fold (Figure 6). Typical population trends under individual grower control in the Lower Gulf Coast of Texas, according to a six-year study, averaged an 84-fold increase when the same type of analysis was applied (Segers et al., 1987).

In the RPC, the cumulative number of acres treated for the diapause control was 2,907,750, averaging 5.8 applications per acre. The overall mean number of adult boll weevils per trap during the month of November (peak fall populations) was 57% less than that of the month of June (peak emergence of overwintering populations) (Figure 7). A definite conclusion relative to the impact of the diapause phase of the program on the boll weevil populations in ST/WG and RPC may not be made until comparative data is collected in 1997.

Based on the above, we conclude that the outcome after the second season long phase of the area-wide boll weevil eradication program in the SRP has been successful. The boll weevil numbers have been significantly reduced, insecticide applications for boll weevil control have also been significantly reduced, and the cotton yield increased, in spite of the unseasonably dry and hot conditions experienced early in the growing season of 1996. In ST/WG and RPC zones the trapping data suggest that the diapause phase of the program was successful in reducing the late-season boll weevil populations.

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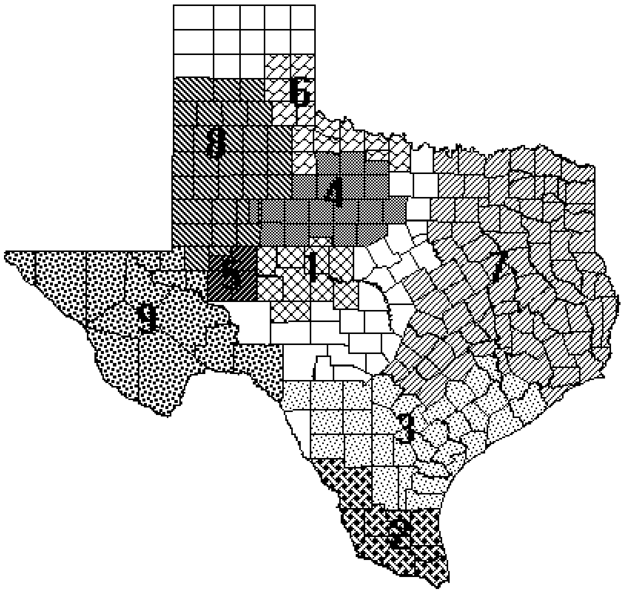

Figure 1: Boll weevil eradication zones in Texas

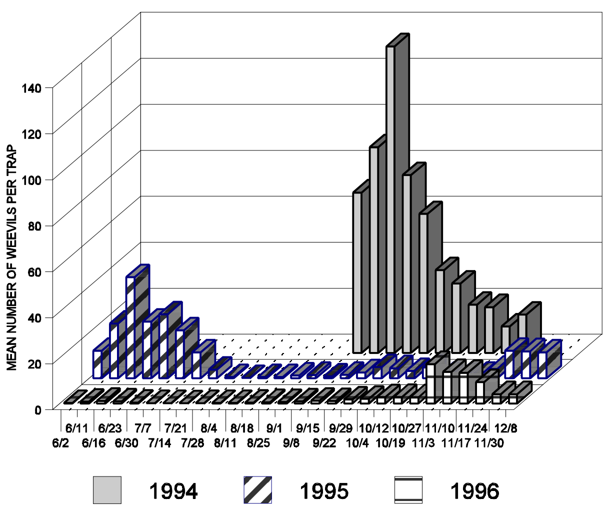

Figure 2. Mean number of adult boll weevils captured per trap per week in the Southern Rolling Plains (SRP), Texas, 1994, 1995, and 1996.

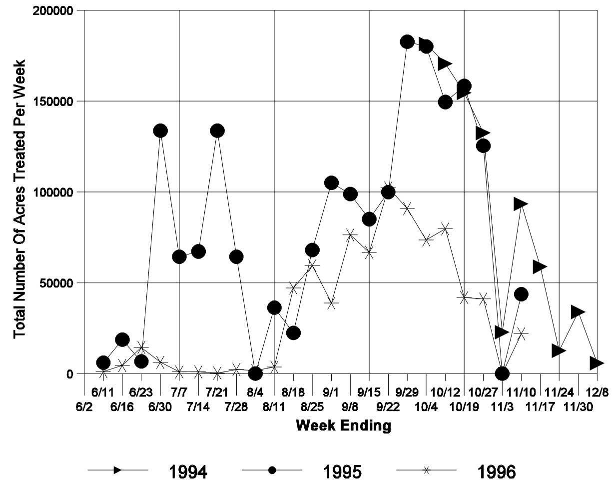

Figure 3. Weekly insecticide applications for boll weevil control, Southern Rolling Plains, Texas, 1994, 1995, and 1996.

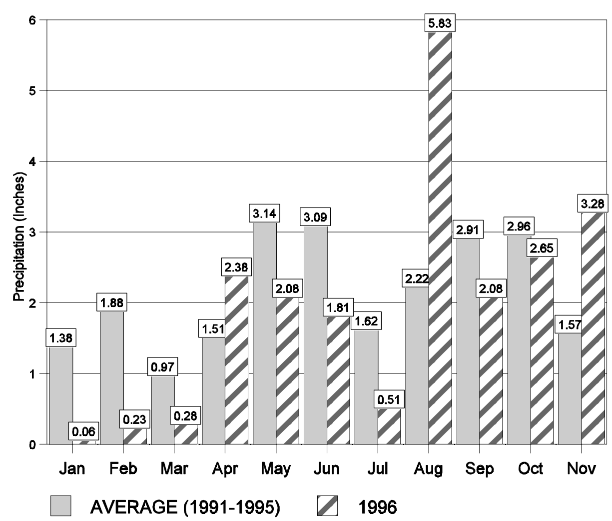

Figure 4. Monthly average precipitation in inches, San Angelo, Texas, 1996

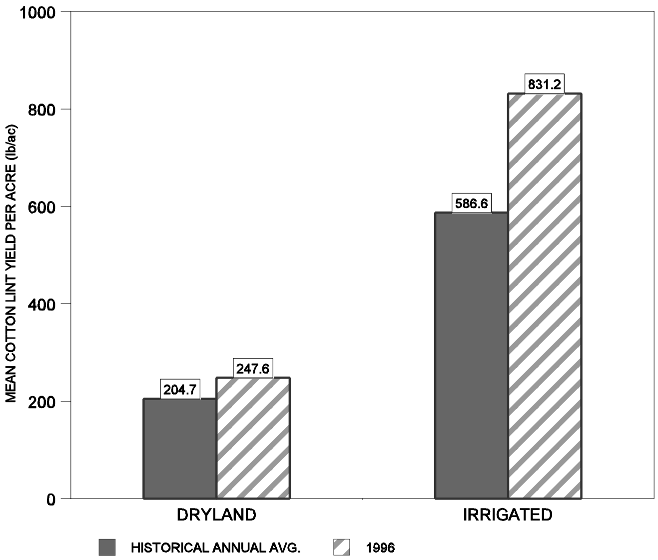

Figure 5. Mean cotton lint yield per acre (40 farms) in 1996 and the historical annual averages in the Southern Rolling Plains, Texas.

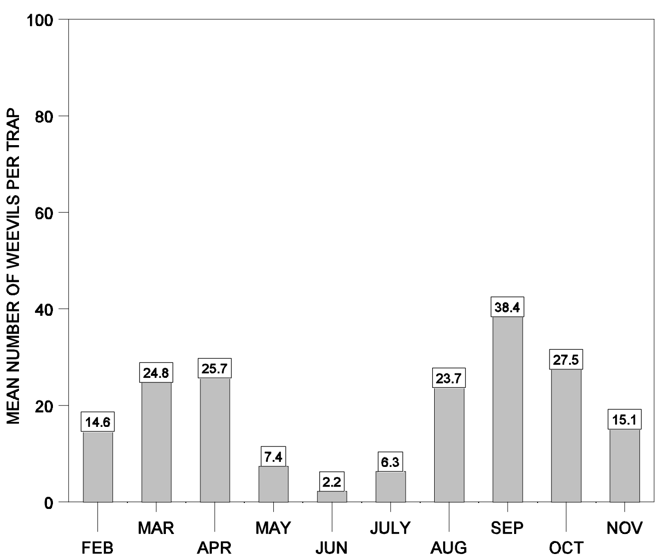

Figure 6. Mean number of adult boll weevils captured per trap per month in the South Texas/Winter Garden (ST/WG) Zone, Texas, 1996.

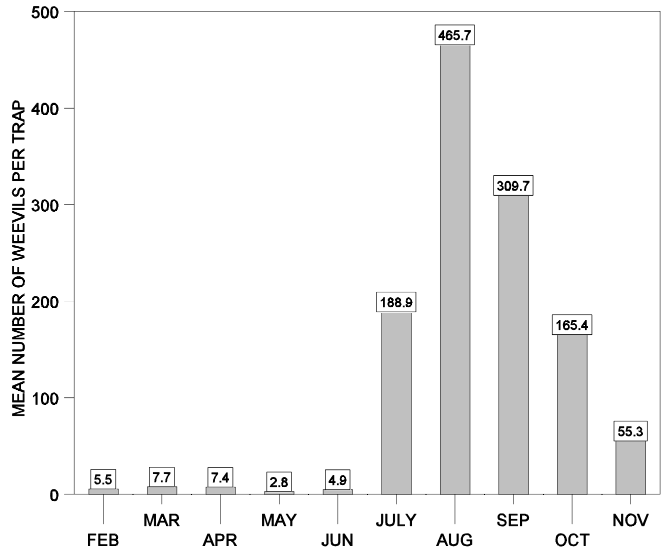

Figure 7. Mean number of adult boll weevils captured per trap per month during a six-year study of seasonal response to pheromone traps on the Lower Gulf Coast of Texas, 1977-1982, (Segers et al., 1987).

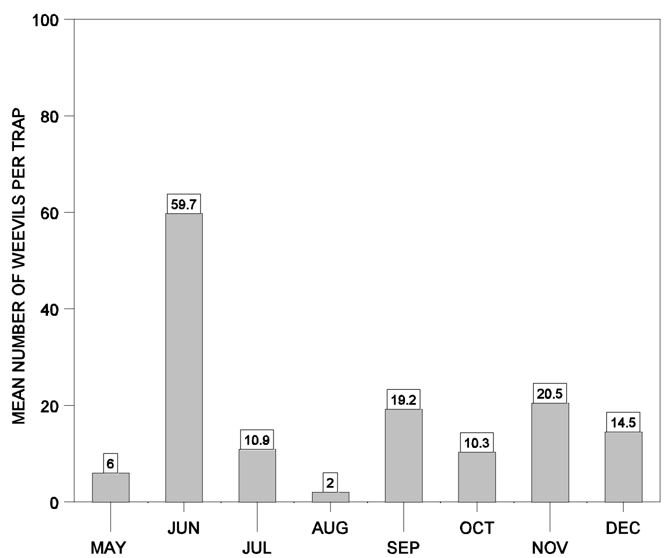

Figure 8. Mean number of adult boll weevils per trap per month in the Rolling Plains Central (RPC) Zone, Texas, 1996.