PINK BOLLWORM ERADICATION - REPORT OF THE PROGRAM IN WEST TEXAS

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Abstract

The Texas Pink Bollworm (PBW) Suppression/Eradication program has been operating under the supervision of the Texas Boll Weevil Eradication Foundation (TBWEF) to suppress/eradicate this damaging pest of western cotton for six years in the El Paso/Trans Pecos (EP/TP) zone. The program has been highly successful. However a reproducing PBW population was detected in 2007 in a few cotton fields near the Rio Grande River during July. The population was eliminated or greatly reduced on the <40 acres involved by October 2007.

Overall, PBW was suppressed to below economically damaging levels throughout the zone at the end of 2001, the first year of program treatments. As of the end of 2007, PBW moth populations have been suppressed by over 99.92 percent from 1999 population levels. Larval boll infestations have been reduced by over 99.5 percent since 2001.

Introduction

The PBW was first found in the U.S., in Robertson County, TX about 1917. It quickly became the key cotton pest in western areas of the U.S. Cotton Belt. The National Cotton Council estimates pink bollworm has cost cotton producers in the western U.S. approximately $21.6 million annually in prevention, control and yield losses. In Texas, crop damage from PBW has been seen in the Rio Grande River Valley near El Paso and in cotton fields along and west of the Pecos River. Periodic infestations have occurred in southern areas of the Texas High and Rolling Plains. Prior to 1996 cotton producers west of the Pecos River were relied on an insecticide based strategy to limit PBW damage. This strategy required intensive management, it was expensive and it was in danger of being lost to insecticide resistance. To make matters worse, the insecticide based control strategy sometimes led to outbreaks of secondary pests such as aphids or whiteflies. When Bt cotton became available after 1996, growers had an additional tool for controlling PBW populations and damage. The Bt toxin has been a very effective control measure against PBW. But using Bt technology is costly. Most significantly, the technology is not available in the Pima varieties preferred by many of the growers in the region. Acreage of high value, highly PBW susceptible, Pima cotton has increased since the PBW suppression/eradication program began.

Before growers in the EP/TP zone initiated the program, the lack of an area-wide approach to the problem allowed PBW infestations to persist and often worsen. Multiple insecticide applications were required to prevent extensive crop damage. The advent of Bt transgenic cotton allowed producers to stabilize their cost of controlling PBW and this technology provided excellent control, but Bt technology had to be purchased each year. Bt cotton resistance management requirements along with grower decisions to plant Pima and other non-Bt varieties assured that Bt technology would not be used on all the cotton acres in the region and that Bt technology alone would not be used to eradicate PBW. The grower level insecticide/Bt cotton based PBW control program was more robust than the earlier insecticide based strategy because of the two of the two complimentary control technologies, but it was limited because growers approached PBW control on a field by field basis, not an area-wide basis. Some growers worked diligently to control PBW populations on their farms and others did not. Without a consistent area-wide program on all farms, growers in the region could not lower PBW populations year after year and move toward a PBW free production system. The lack of an area-wide detection and control approach to population suppression/eradication allowed PBW populations to persist as a threat to the cotton industry in the region.

The concept of areawide PBW suppression was developed in a successful program conducted in Parker Valley, Arizona from 1990-95 (Antilla et al. 1996). The Arizona program including mapping, trap triggers, pheromone mating disruption technology, and insecticide applications. It differed from the early years of the Texas program in that it did not have Bt transgenic technology available and it had area-wide treatments made by the program in the spring but relied on grower treatments for PBW control in the fall. In the later years of the program in Texas sterile moth technology became available and has been used.

In March of 1999, cotton producers in the El Paso/Trans Pecos (EP/TP) zone passed, with an 80 percent favorable vote, a referendum to begin boll weevil eradication and PBW suppression/eradication in the fall of that year. Conducted by the Texas Boll Weevil Eradication Foundation (TBWEF), the program in the EP/TP zone began with two years of a boll weevil eradication program and with a PBW trapping program. The treatment phase of the PBW program began on 46,621 acres of cotton in 2001. The program was improved and continued on the zone's 41,652 acres of cotton in 2002 and on 37,962 acres of cotton in the zone in 2003. In March of 2003 a retention referendum was held and 89 percent of the growers voted to continue the program. In 2004 and 2005 program operations continued on 42,134 and 43,405 acres of cotton, respectively. In June 2005 a referendum was held to continue boll weevil eradication, move from a PBW suppression program to a PBW eradication program and extend the number of years an assessment can be collected to pay for the program. The referendum passed by with over 95 percent of the growers voting in favor of the changes. In 2006 and 2007 the program operated with 42,290 and 39,312 acres, respectively.

The initial objective of the program was to reduce PBW populations and damage across the zone to below levels at which economic damage occurred. This objective was reached in 2001, the first year of program treatments. With the first objective met, neighboring areas of New Mexico and Chihuahua, Mexico became interested in the program and the objective changed to continuing and intensifying the suppression program in the EP/TP Texas zone and working with cotton producers in adjacent areas to expand the program throughout the region. In 2002 producers in the state of Chihuahua, Mexico, and in south central New Mexico initiated programs similar to the Texas program. With the entry of Chihuahua and New Mexico into the program, the regional effort had three separate programs working together to eliminate PBW. These programs were mutually supportive and shared information and technology. They provided cost reductions through controlling populations and suppressing PBW migration into neighboring program areas. In 2004, the Texas program began receiving limited sterile PBW moths for release in the Pecos work unit. In 2005, 2006 and 2007 sterile moths were supplied by USDA-APHIS in sufficient quantity to become the first level of suppression used by the programs in the EP/TP zone, the South Central New Mexico program and the program in the Juarez region Chihuahua, Mexico. In 2006 and 2007 program expansion into Arizona and parts of Sonora, Mexico increased the cotton acreage in the Southwestern Region under PBW eradication.

Methods and Materials

El-Lissy et al. (1997) provided a detailed description of the boll weevil eradication methods from which the methods used in this program were adapted.

Mapping

Use of Bt transgenic cotton varieties was encouraged in the Texas program (and subsequently in other programs) by reducing the assessment cost to growers on acres planted to Bt varieties. Immediately after seedling emergence, all cotton fields were mapped using differentially corrected GPS technology (Geo II and III GPS units and Pathfinder Software, Trimble Navigation). The presence or absence of the Bt toxin was determined by randomly selecting seedlings from all cotton fields in the El Paso/Trans Pecos zone and testing them using ELISA test procedures (AgDia Inc.) for the presence of Bt toxin. Field maps were constructed using Map Info software. Field maps were color coded to indicate Bt transgenic cotton, non-Bt cotton, and sensitive site fields (those near houses, schools, etc.). Producer data, field numbers, and other information were electronically associated with each field.

Detection

Delta sticky traps (Scentry Biologicals) baited with gossyplure (pink bollworm sex pheromone) were deployed around all fields at a density of approximately 1 trap per 10 acres (minimum of 2 traps per field) between seedling emergence and the appearance of pinhead squares. Each trap was bar coded which allowed the trap data to be electronically associated with a physical location on the map. From deployment to the time fields were harvested and no longer hostable, traps were checked weekly and replaced at least every two weeks (every week in most areas). Trap capture information, crop stage and other data were recorded weekly. Traps with pink bollworm captures were removed weekly and replaced with new traps and pheromone lure. The traps were taken to the office/laboratory where the adult moths were inspected to determine if they were red dyed sterile moths or undyed native moths. All moths were counted and the data was entered into the PBW data collection/handling system.

Control

Several PBW control technologies were used. Plant testing for the presence of the Bt toxin in 2007 showed that 13,302 acres of the zone's 39,312 acres, or 34 percent, was Bt cotton. This was down from 9,231 acres of Bt cotton in the zone (or 23 percent Bt cotton in 2006). Since the inception of the program Bt cotton acreage has averaged 37 percent of the cotton acreage in the zone. Bt cotton percentages varied in each work unit. In the Pecos work unit the percentage of cotton acreage planted to Bt cotton was 79 percent in 2007, up from 49 percent in 2006. In the Fort Hancock work unit 24 percent of the cotton planted in 2007 was Bt cotton, up from 19 percent in 2006. A similar trend was seen in the El Paso work unit where 11 percent of the cotton acres were planted to Bt transgenic varieties, up from 5 percent in 2006. Bt and non-Bt acres were treated only as needed and in compliance with U.S.E.P.A.'s Bt cotton refuge requirements.

Several pheromone mating disruption products were used in the PBW Eradication Program in the EP/TP zone. High dose, hand applied gossyplure dispensers (PB-ROPE L, Pacific Biocontrol Corporation) were used at an application rate of approximately 200 dispensers per acre on 2,736 acres of cotton in 2007. All of the acres treated with rope were in the Fort Hancock work unit. Seventy-two percent fewer acres were treated with rope in 2007 than in 2006 when 9,686 acres were treated. Compared with 2003 when rope usage was at its highest level and 23,551 acres were treated, treated acres have declined by over 88 percent. Local labor contractors were hired to apply the pheromone rope dispensers. In 2001 rope was used on those fields that were difficult to treat with aircraft. In subsequent years the effectiveness and lower cost of rope compared with season-long fiber treatment brought about increased use of rope. After 2005, when sufficient sterile insects became available for application season-long on all EP/TP cotton acres, fields targeted for rope applications were those in which wild-type moths had been caught and/or those identified with larval infestations the previous year. No rope was used in the Pecos work unit in 2006 or 2007. High dose rope dispensers have provided suppression almost all season from a single application.

Checkmate MEC (Suterra Inc.) was the sprayable mating disruptant product used in 2007. It was applied either alone or tank mixed with insecticides. Sprayable pheromone treatments were initiated at pinhead square stage. These treatments were reapplied when traps around a field caught native PBW moths. Positive trap catches of native moths around a field indicated the presence of native PBW moths and low concentration of pheromone and/or sterile moths in the field. Such fields had potential to allow mating of native moths. For the year, 2,989 cumulative cotton acres were treated with sprayable pheromone mating disruption products. This was down 61 percent from the 7,597 acres were treated with sprayable pheromone in 2006. The peak year for sprayable pheromone use was 2001 when 142,842 cumulative acre treatments were made. Sprayable pheromone usage in 2007 was down 98 percent from 2001.

Fields in which more than one moth was caught per week received applications of insecticides. Lock-On 2E, Tombstone (Loveland Products, Inc.) or Battery 2.5 EC (Agriliance, LLC.) were applied at mid-label rates. These treatments were applied with and without sprayable pheromone (dual treatments). Cumulatively, 4,313 acres were treated with insecticides and 1,479 acres received dual treatments. The program treated 88 percent fewer acres in 2007 than were treated in 2001, the peak year for insecticide use.

Sterile moths were released from aircraft over all EP/TP cotton acreage for the first time in 2005. Sterile moth releases in 2007 were initiated the first week of May and continued through the week ending October 15 (168 days). For the year, 1,309,878,641 sterile moths were released. Sterile moth releases in 2006 and 2005 were conducted over periods of 175 and 154 days, respectively. And 1,127,587,232 and 1,335,830,385 moths were released during those years, respectively. The average number of sterile insects released per acre per day during the release period was 198 in 2007 compared with 152 in 2006 and 200 in 2005. The moths were reared in the California Department of Food and Agriculture (CDFA)/USDA-APHIS PBW rearing facility in Phoenix, AZ. They were put on commercial aircraft in the afternoon or evening and delivered to El Paso that night for release the next day. They were shipped in specially designed cooler shipping/distribution boxes (USDA-APHIS) which were held overnight in a refrigerated cooler. The following morning, the distribution boxes were mounted directly into a Cessna 206 aircraft fitted with release equipment (USDA-APHIS). The sterile PBW moths were then metered onto cotton fields from a height of about 500 feet. The goal was to maintain a ratio of at least 60 sterile moths captured for each native moth captured on each program field each week. Fields that did not maintain the 60:1 ratio were treated with additional sterile moths, pheromone, insecticide or a combination of treatments. Average recapture data for the zone showed the 60:1 ratio was reached after the first week of May and maintained season-long. Only 141 fields were treated, 12 percent of the fields in the zone. Treatments were applied because a field failed to achieve the 60:1 ratio

or where native moths were being caught, as a buffer to protect nearby non-Bt cotton. The majority of treatments were triggered to provide a protective buffer around the "hot spot" area. In a number of cases insecticide use reduced the ratio of native to sterile insects, triggering a program treatment. The average ratio of sterile moths to native moths was 1:2,370 season-long.

Quality control of sterile moths was monitored by assessing the longevity of the moths, the response of sterile males to pheromone traps, moth weight, by tracking the temperature of the shipping containers and by other means. This information was used to improve the quality of the sterile insects being applied to the cotton fields.

The primary technologies used to suppress/eradicate the PBW in the EP/TP zone have changed as the program as progressed. In 2001, the initial year of the program, the main technologies used were Bt cotton and sprayable pheromone mating disruption products. Long duration, hand applied pheromone mating disruption rope and insecticide treatments were also used. In 2002 and 2003, Bt cotton remained a primary control component, but pheromone rope was used in lieu of sprayable mating disruption on many acres. Sprayable mating disruption and insecticides were used on a few acres. In 2004, sterile insect application was introduced to the program, joining Bt cotton and pheromone rope as the primary control technologies. Sterile insect availability was limited, however and only the Pecos work unit received season-long sterile moth applications. Sprayable mating disruption pheromone and insecticides were used on a small number of acres in 2004. In 2005 sterile moths and Bt cotton were the primary technologies relied upon. Long duration rope was used on limited acreage. Use of sprayable pheromone mating disruption and insecticides were the least used of the technologies. Growers in the EP/TP zone planted fewer acres of Bt cotton in 2006. Sterile insect releases were the primary control technology used in 2006; and rope, sprayable pheromone and insecticide were used at similar levels as were used in 2005. In 2007 Bt cotton and sterile insects were the primary controls used over most of the zone, but hand applied and aerially applied mating disruption products and insecticides were used heavily on a relatively small, hot spot area which developed near the Rio Grande at Acala, TX.

PBW Population Monitoring

Two methods of monitoring PBW populations were used. Trap data has been collected since the fall of 1999 when the program began in the EP/TP zone**.** The 1999 and 2000 trap catch information provided a baseline against which populations in later years have been compared. Sterile moth recapture provided information about the numbers and responsiveness of the sterile insects. The ratio of sterile to native insects captured provided the basis for triggering fields for other treatments. Field personnel collected PBW infested traps and returned them to the field offices where moths were identified, separated as sterile or native and counted. To facilitate this process the sterile insects were marked with dye placed in their diet in the USDA-APHIS rearing facility at Phoenix, Arizona. Trapping information was used to direct sterile moth drops so that at least, a ratio of 60:1 sterile to native moths could be maintained on fields.

Since 2001, 25 blooms and later 25 bolls were sampled in each of four quadrants of 20 randomly selected fields in each of 3 work units each week. The 60 fields chosen for sampling stayed constant during the year and locations have remained constant from year to year.

Results

Sterile Moth Quality

The response of sterile moths to pheromone traps is an indicator of their competitiveness with native moths. The ratio of recaptured moths to released moths each year 2005 -2007 is shown in Figure 1. The 2x recapture rate obtained in 2007 indicated that the program was benefiting by improved quality in the sterile moths being released. Sterile moths in 2007 were larger than in past years and had improved longevity in temperature control cabinets.

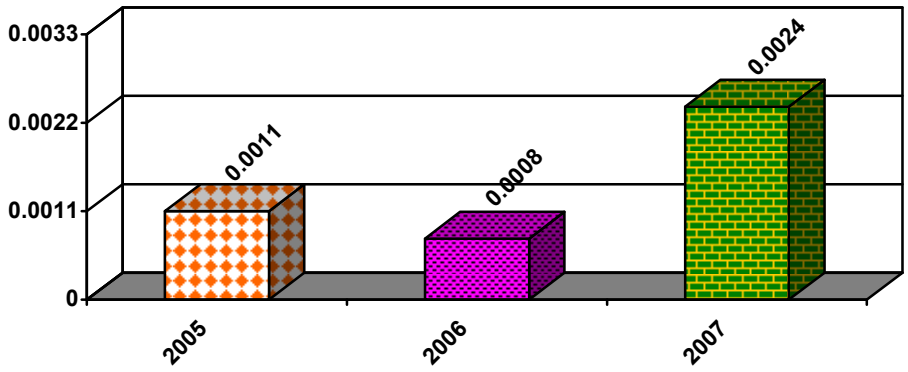

Figure 1. Ratio of sterile PBW moths captured in pheromone traps to sterile moths released.

Trap Data

The results of the PBW trapping are shown in Figures 2. and 3. From 2000 forward 80,000 to 110,000 traps were inspected in the zone each year. Captures of native PBW moths have declined each year since the treatment phase began in 2001. Figure 2. shows the native moths captured per trap inspection since 1999. Using a native moths per trap inspection as a standard for comparison, PBW populations have declined 99.92 percent from 1999 to 2007. And since 2005, native moth captures per trap inspected have declined 82 percent.

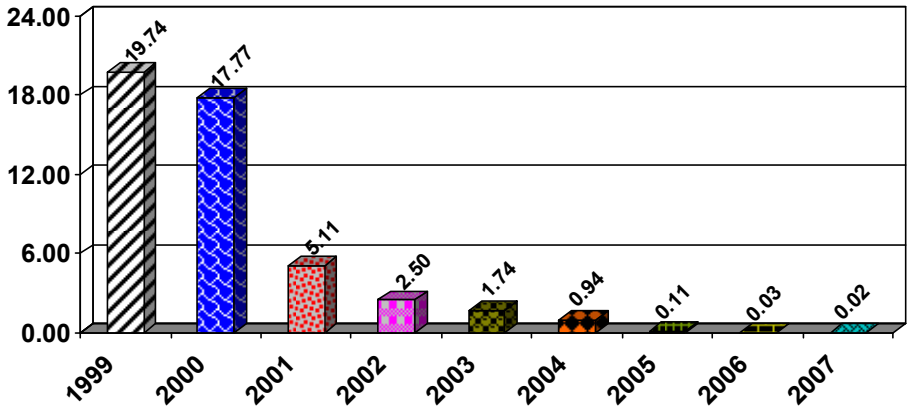

Figure 2. Year-end average number of native pink bollworm moths captured per trap inspection.

Shown in Figure 3 are the totals of the native moths captured each year since 2000. Comparison of the total native moths caught data from 2000 to 2007 indicates a population reduction of 99.90 percent. The change in total native moth captures from 2005 to 2007 indicates a population reduction of 88.6 percent.

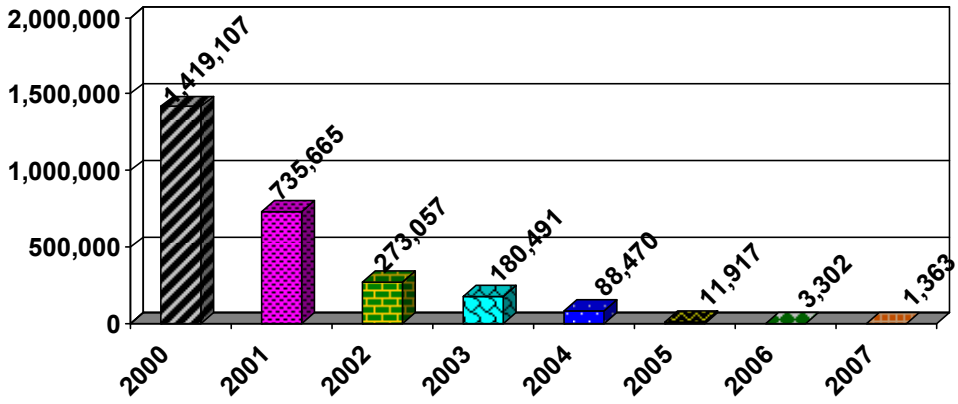

Figure 3. Year-end totals of native moths captured in pheromone baited, delta sticky traps operated by the PBW eradication program in the El Paso/Trans Pecos zone.

Approximately 80 percent of the native moths captured in 2007 came from the small area “hot spot” area near the Rio Grande River south of Acala, TX.

Boll Sampling Data

Boll infestation data are not available for the years prior to the start of the treatment phase of the program. Prior to the inception of the program, larval infestations of from 20 to 50 percent of late set bolls were common in fields in that did not receive several well-timed insecticide applications to suppress them. Even with treatment, PBW typically infested 10-20 percent or more of the top bolls. Boll infestations the first year of the program dropped to 4.5 percent. Since then, the percentage of PBW infested bolls season-long has to been reduced 99.5 percent (Fig 4). In 2007, infested bolls were found only in the small Acala "hot spot" area.

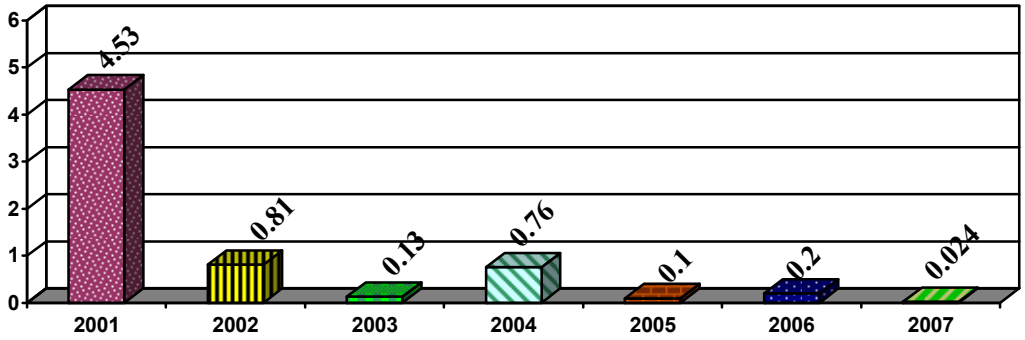

Figure 4. Average number of larvae per boll from randomly selected "historical fields" by year.

During the course of the program, Bt cotton strongly reduced PBW larval infestations. Though three small larvae were discovered in the 14,985 Bt cotton blooms and bolls sampled in 2004, larval sampling in Bt cotton fields in since that time has not resulted in the discovery of a single live larvae in Bt cotton.

Conclusions

The treatment phase of the PBW program in the EP/TP zone was initiated in the spring of 2001 and has been conducted successfully since that time. An aggressive monitoring and treatment protocol has been used. Control technologies have been used in a timely manner in accordance with the established protocol. The need for grower treatments for PBW control was eliminated in 2001 and none have been made since that time.

Native moth trap catches have been reduced each year of the program and captures have been reduced by 99.9 percent since the program began.

Extensive boll sampling indicated that larval infestations and boll damage were reduced to very low levels in 2007. Remaining populations of PBW have been reduced to about 40 acres, 0.1 percent of the cotton acreage in the zone.

In 2002 neighboring cotton producing areas in Chihuahua, Mexico and in the Mesilla Valley of New Mexico began pink bollworm eradication programs. Impressive PBW population reductions have been reported from these areas as well. This cohesive multi-national and multi-state effort has been effective in reducing PBW populations and is working toward elimination of PBW in the region. In 2006 and 2007 the PBW eradication program expanded into Arizona with strong population reductions reported there.

Programs built on a foundation of thorough pheromone trapping and use of the available control technologies have produced very promising results. Bt cotton, long duration pheromone rope, sprayable pheromone mating disruption products, insecticides and sterile moths used in programs of this type can provide PBW suppression reaching levels far below those attainable through conventional means. Implementation of a coordinated program of this type in PBW infested cotton growing areas can result in elimination of the pest as an economic concern, a high degree of population suppression and these programs have the potential to achieve eradication of the PBW from large areas where cotton is produced.

Movement of PBW moths into the EP/TP eradication zone from neighboring zones not currently in eradication or suppression programs is a concern. Continued program expansion reduces this threat. The availability of sterile moths to complete eradication is critical. Elimination of reproducing PBW populations will allow necessary program cost reductions. Continued trapping programs to detect immigrating native PBW moths, continued availability and use of Bt cotton and continued availability of sterile moths are needed, along with other control methods, to insure that immigrating native PBW moths do not develop reproducing populations in the zone after PBW eradication has been completed.

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