STATUS REPORT OF PINK BOLLWORM ERADICATION IN TEXAS

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Abstract

The Texas Pink Bollworm (PBW) Eradication Program has been operating under the supervision of the Texas Boll Weevil Eradication Foundation (TBWEF) to eradicate this damaging pest in the El Paso/Trans Pecos (EPTP) zone since 1999. A total of 1,001,359,900 red-dyed, sterile moths were released in 2011. Of those 2,093,320 were recaptured in traps along with 60 native moths. Of the 60 native moths captured, one was captured in the Pecos district and 59 were captured in an area around the Tornillo district. The native moth captures in 2011 represent an increase of 44 moths over 2010. PBW were suppressed to below economically damaging levels in the EPTP zone at the end of 2001, the first year program treatments began. As of the end of 2011, PBW moth populations have been suppressed by over 99.99 percent from 1999 population levels.

Introduction

The PBW was first found in the United States in Robertson County, Texas, about 1917. It quickly became the key cotton pest in western areas of the U.S. Cotton Belt. The National Cotton Council estimates the pink bollworm has cost cotton producers in the western United States approximately $21.6 million annually in prevention, control and yield losses. In Texas, crop damage from PBW was seen annually in the Rio Grande River Valley near El Paso and in cotton fields along and west of the Pecos River. However, periodic infestations have occurred in southern areas of the Texas High and Rolling Plains, as well. Prior to 1996 cotton producers west of the Pecos River relied on an insecticide-based strategy to limit PBW damage. This approach required intensive management, was expensive and continually in danger of failure due to insecticide resistance. In addition, the insecticide-based control strategy made the crop more vulnerable to outbreaks of secondary pests such as aphids and whiteflies.

When Bt cotton became available in 1996, growers began to utilize the technology to control PBW populations and damage. The Bt toxin has been a very effective control measure against PBW; however, using the Bt technology adds to production costs and the technology is not available in the Pima varieties preferred by many of the growers in the region. The grower level insecticide/Bt cotton-based PBW control program, which developed after 1996, was more robust than the earlier insecticide-based strategy because two complimentary control technologies were used. It was, however, 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 but others did not. Without a consistent area-wide program on all farms, growers in the region could not sustain PBW population reductions year after year and move to a PBW-free production system. The lack of a unified, area-wide approach for detection and control allowed PBW populations to persist as a threat to the cotton industry in the region.

The concept of area-wide PBW suppression was developed in a successful program conducted in Parker Valley, Ariz., 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 use Bt cotton and it had area-wide treatments made by the program in the spring but relied on grower treatments for PBW control in the fall. Sterile PBW moth releases further strengthened the Texas program after 2005. Sterile moths were not used in the 1990-95 Arizona program.

In March of 1999, cotton producers in the EPTP 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 EPTP zone began with a boll weevil eradication program and a 2-year 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 could be collected to pay for the program. The referendum passed with over 95 percent of the growers voting in favor of the changes. Planted acreage for 2006, 2007, and 2008, were 42,034, 39,533, and 33,029 respectfully. A subsequent referendum was held in May of 2009 with 95 percent voting to continue the eradication program. In 2009 and 2010 the program operated with 34,081 and 38,851 acres, respectively. The acreage expanded in 2011 to approximately 49,853 land acres.

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 suppression operations. 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 EPTP 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 to cotton growers 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. From 2005 through 2011 sterile moths were supplied by USDA/APHIS in sufficient quantity to become the first level of suppression used by the programs in the EPTP zone, the South Central New Mexico program and the program in the Juarez region of the state of Chihuahua, Mexico**.**

Methods and Materials

Mapping

Use of Bt transgenic cotton varieties was encouraged in the Texas program (and subsequently in other programs) through reduced assessment costs to growers on acres planted to Bt varieties. Immediately after seedling emergence, all cotton fields were mapped using differentially corrected GPS technology (Geo XT and III 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 EPTP zone and testing them using ELISA test procedures 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 variable density of approximately one trap per 10 acres (minimum of two 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 database.

Control

Several PBW control technologies have been used. Plant testing for the presence of the Bt toxin in 2011 showed that 26,038 acres of the zone's 49,853 acres, or 52 percent, was Bt cotton. This was up from 19,340 acres of Bt cotton in the zone (or 50 percent Bt cotton) in 2010. Since the inception of the program, Bt cotton acreage has averaged 40 percent of the cotton acreage in the zone, however, Bt cotton percentages have been varied in each work unit. A label for 100 percent planting of Bollgard II and Widestrike cotton in a pink bollworm eradication program was granted for the El Paso Trans Pecos Zone for 2011. In the Pecos work unit, the percentage of cotton acreage planted to Bt cotton was 92.5 percent in 2011, down from 96 percent in 2010. In the Fort Hancock work unit 45 percent of the cotton planted in 2011 was Bt cotton, up from 40 percent in 2010. The trend seen in the El Paso work unit where 28 percent of the cotton acres were planted to Bt transgenic varieties in 2011, is up slightly from 24 percent in 2010.

Several pheromone mating disruption products were used in the PBW Eradication Program in the EPTP zone. High dose, hand-applied gossyplure dispensers (PB-ROPE L, Pacific Biocontrol Corporation) were used at an application rate of 100-200 dispensers per acre on 8,050 acres of cotton in 2010. The use of long duration pheromone rope was up 478 percent from the 1,682 acres were treated with rope in 2009. The increased number of acres was in response to the accidental non-sterile releases due to a lab error that occurred in 2009. It was also down 66 percent from 2003, the peak year for rope use in the zone. Local labor contractors were hired to apply the pheromone rope dispensers. There were no applications made with hand-applied gossyplure dispensers in 2011.

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 were justification for increased use of rope. After 2005, when sufficient sterile insects became available for application season-long on all EPTP 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 from 2006 through 2011. High dose rope dispensers have provided PBW population suppression almost season-long from a single application.

No sprayable mating disruption treatments were applied in 2011. Checkmate MEC (Suterra Inc.) was used in 2007 and No-Mate Fiber was used in previous years, 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. These fields had potential to develop larval PBW populations. The peak year for sprayable pheromone use was 2001 when 142,842 cumulative acre treatments were made.

No insecticide applications were made in 2011. In previous years, 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). In 2001, 47,897 acres were treated, the peak year for insecticide use.

Sterile moths were released from aircraft over all EPTP cotton acreage for the first time in 2005. Sterile moth releases in 2011 were initiated on May 2nd and continued through the week ending Oct. 15th. For the year, 1,001,359,900 sterile moths were released. The moths were reared in the USDA-APHIS PBW rearing facility in Phoenix, Ariz. They were put on commercial aircraft the afternoon of each scheduled shipping day 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 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 average ratio of sterile moths recaptured to native moths captured season-long in 2011 was 34,888:1, compared to 65,657:1 in 2010, 911:1 in 2009 and 161,134:1 in 2008.

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 applied to the cotton fields. Although trap spiking has always been a part of the Texas quality control protocol, another quality control mechanism was introduced in 2011 with the spiking of traps for the detection of native moths conducted by personnel outside the EPTP zone (non-employees of the Foundation). This will continue in the 2012 season. Spiking (the placing of sterile, non- dyed moths in the traps) allows the Foundation to monitor personnel and assure that all moths are counted. Adjustments were also made in Phoenix at the PBW rearing lab in 2010. These changes resulted in more oversight at the lab to decrease the chance of repeating the accidental 2009 release.

The primary technologies used to suppress/eradicate the PBW in the EPTP zone have changed as the program as progressed. In the initial year of the program (2001), 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 also used. 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 EPTP zone planted fewer acres of Bt cotton in 2006. Sterile insect releases and Bt cotton were the primary control technologies used in 2006, but 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, Texas. In 2008, 2009, and 2010, pheromone rope and sterile moths were the only control technologies used. In 2011, the dropping of sterile moths became the only method of PBW control.

PBW Population Monitoring

PBW populations were monitored by trapping and bloom/boll inspection. Trapping data has been collected since the fall of 1999. 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. Sterile insects were marked with dye placed in their diet in the USDA-APHIS rearing facility at Phoenix, Arizona. Trap information was used to direct sterile moth drops on fields.

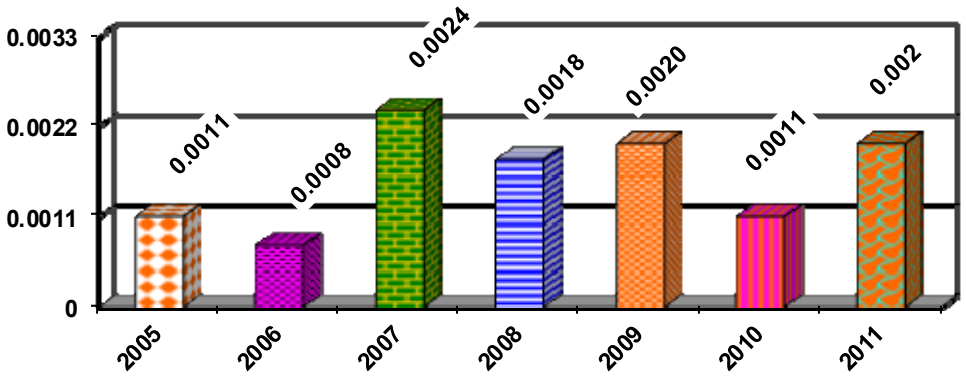
Since 2001, 25 blooms and later 25 bolls were sampled in each of four quadrants of 20 randomly selected fields in each of three work units each week. The 60 fields chosen for sampling stayed constant during the year and locations have remained constant from year to year.

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 -2011 is shown in Figure 1.

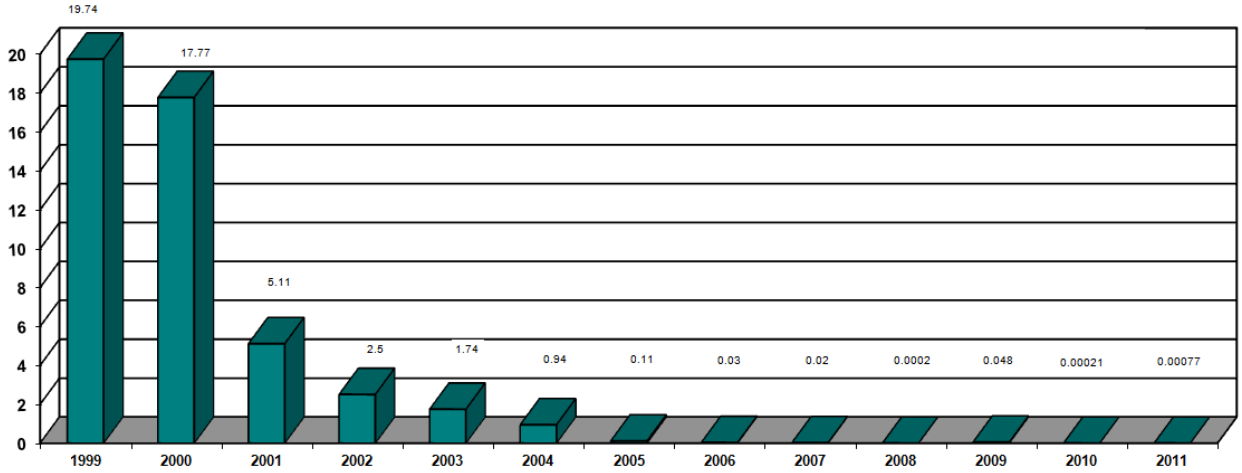
Figure 1. Ratio of sterile PBW moths captured in pheromone traps to sterile moths released.



Trap Data

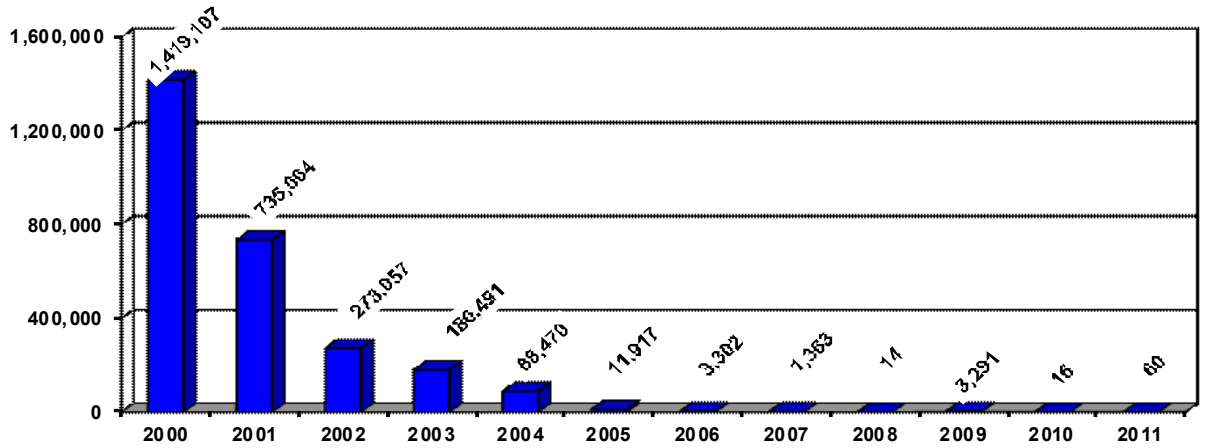
The results of the PBW trapping are shown in Figures 2 and 3. From 2000 forward, 65,000 to 142,000 traps were inspected in the zone each year. Captures of native PBW moths have declined each year since the treatment phase began in 2001 with the exception of 2009 and 2011. Using native moths per trap inspection as a standard for comparison, PBW populations have declined 99.99 percent from 1999 to 2011. Figure 2 shows the average number of native moths captured per trap inspection since 1999.

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 2011 indicates a population reduction of 99.99 percent. In 2009, there was a large increase in the number of natives over 2008 but the reduction of native moths from 2000 to 2011 stood at 99.99 percent.

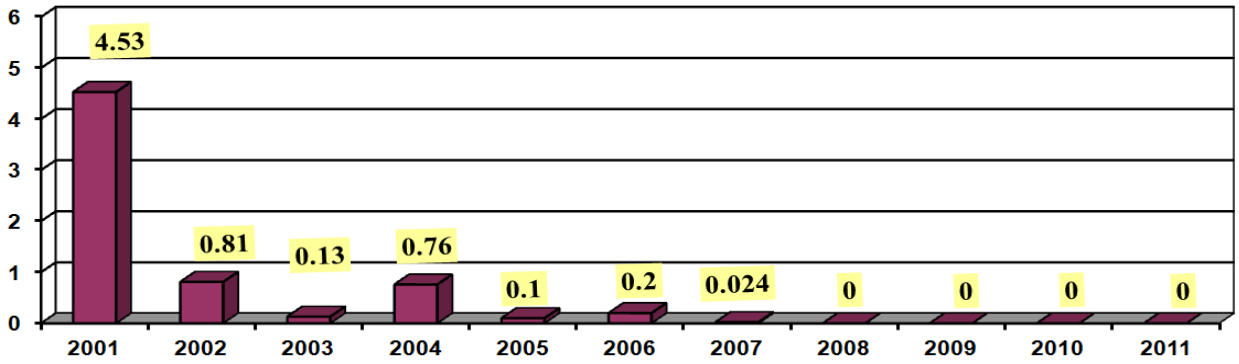
Figure 3. Year-end totals of native moths captured in pheromone baited, delta sticky traps operated by the PBW eradication program in the El Paso/Trans Pecos zone.



Boll Sampling Data

Boll infestation data is not available for the years prior to the start of the treatment phase of the program. However, prior to the inception of the program, larval infestations of from 20 to 50 percent were commonly seen in late set bolls. Even with timely treatment, PBW larvae typically infested 10-20 percent or more of the top bolls. Boll infestations the first year of the program dropped to 4.5 percent, in part, due to area-wide boll weevil eradication applications of malathion. Since then, PBW infested bolls season-long has to been reduced to undetectable levels (Figure 4). In 2007, infested bolls were found only in the small "hot spot" area near Acala, Texas. In 2008, no pink bollworm larvae were detected in over 35,000 fruit inspections, and in 2009, no pink bollworm larvae were detected in over 67,000 fruit inspections. With increased native moth activity primarily in the Clint/Fabens area during 2009, a larger number of inspections were conducted late in the season. Most of the native moth captures were at the open boll stage of growth near season end. There were 35,615 bloom and boll inspections in 2010 and 16,519 bloom and boll inspections in 2011 with no larvae found in any of the inspections.

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. In the early years of the program there was some concern that the intensive pressure on PBW populations during eradication might trigger Bt resistance in PBW. Three small PBW larvae were discovered in Bt cotton blooms and bolls in 2004 (14,985 Bt cotton blooms and bolls sampled that year). Larval sampling in Bt cotton fields since that time have not resulted in the discovery of a single PBW larvae in Bt cotton.

Conclusions

The treatment phase of the PBW program in the EPTP zone was initiated in the spring of 2001 and has been conducted successfully since that time. Aggressive monitoring and treatment protocols have been used. The need for grower treatments for PBW control was eliminated in 2001 and none have been made since that time.

In 2002, neighboring cotton producing areas in Chihuahua, Mexico, and in the Mesilla Valley of New Mexico, began pink bollworm eradication programs. The cohesive multi-national and multi-state pink bollworm eradication effort has virtually eliminated PBW populations from the region. Program expansion has brought all southwestern United States and all northwestern Mexico production into the program. Only cotton in Durango and Coahuilla states in Mexico (the Laguna area near Torreon) and cotton production in southeast New Mexico and the generally sub-economic populations in southern areas of the Texas High and Rolling Plains remain outside the program. It is notable, however, that very low, but detectable PBW populations have been documented from many other areas of Texas as well. In 2011, a detectable low population was trapped in Midland County, Texas outside the El Paso Trans Pecos Zone. This area is approximately 100 miles due east of cotton planted in the EPTP zone.

There were two distinct areas of infestation in 2009. The Pecos area infestation occurred in late September after a northern cold front blew into the area. Of the 6,023 acres planted in the Pecos district, less than 30 acres were non-Bt. The 669 native moths in the Pecos district were captured over a five week period beginning on Sept. 28. Earlier in the 2009 season, PBW had been detected in Gaines County on the High Plains of Texas. The native moths detected in the Clint/ Fabens area began on Oct. 19, and were concentrated in this small area over a six week period ending Nov. 23. Trap captures that occurred in the Clint, Texas area were atypical of a normal infestation or migration. With the assistance of Bob Staten, a mitigation plan was developed for 2010 that necessitated the tying of approximately 8,050 acres of cotton in the Fabens area.

Native moth trap catches have been reduced each year of the program with the exception of 2009 and 2011 and captures have been reduced by 99.99 percent since the program began. In 2011, native moth captures were scattered throughout the Tornillo district beginning in August (Figure 5). A single native moth was captured in the Coyanosa area of the Pecos district in October.

Figure 5 2011 Native Trap Captures near El Paso

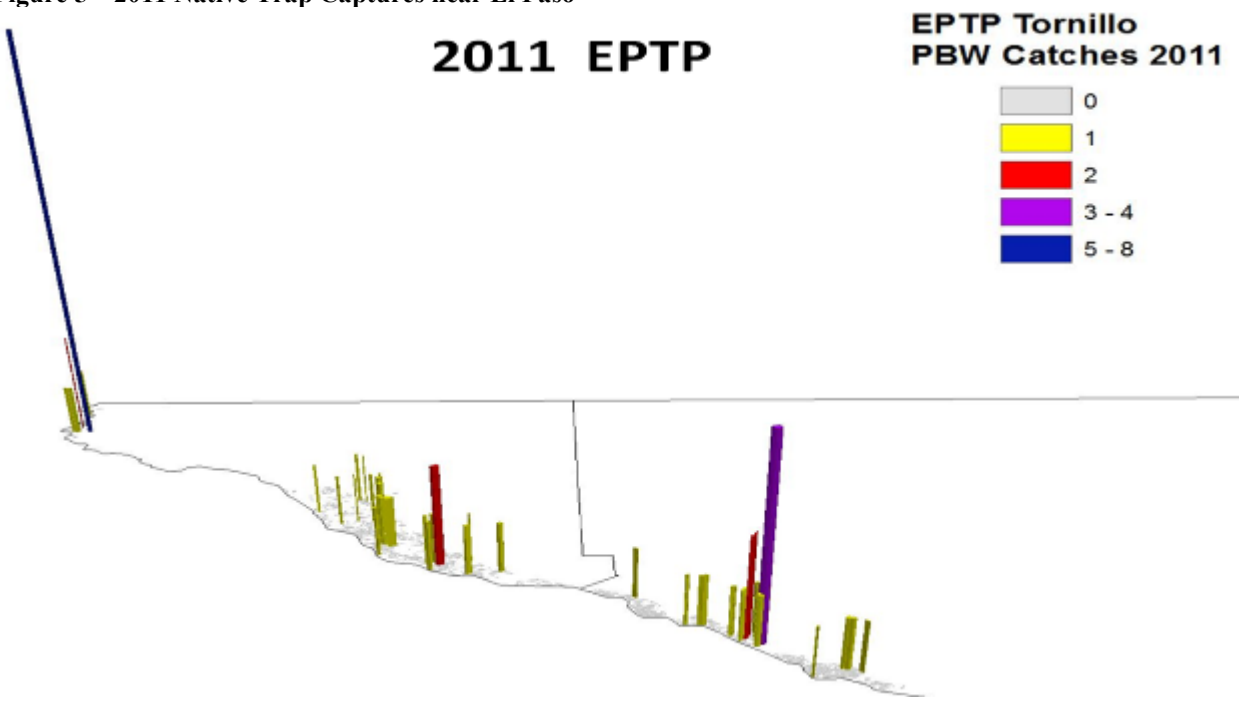
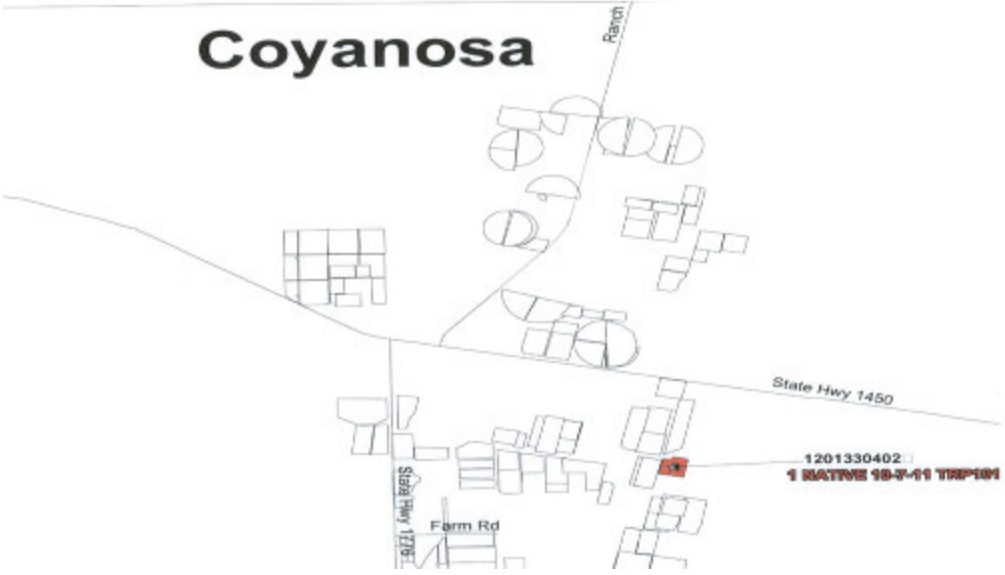


Figure 6 2011 Native Trap Capture near Pecos, Texas



Pink bollworm eradication programs built on a foundation of thorough pheromone trapping and using multiple 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 achieve eradication of well entrenched pink bollworm populations.

Movement of PBW moths into the EPTP eradication zone from neighboring zones (in Texas and eastern New Mexico) not currently in eradication or suppression programs is a concern. Program expansion into these areas would eliminate this threat. However, it is difficult to justify the cost in areas in which PBW is sporadic pest. The availability of sterile moths to complete eradication and maintain areas free from reproducing PBW populations post eradication is critical. Elimination of reproducing PBW populations will greatly reduce treatment costs and allow trap density reductions. This will result in program cost reductions. Trapping programs to detect immigrating native PBW moths, continued availability of Bt cotton and continued availability of sterile moths are needed. These and other detection/control technologies will be needed to insure that immigrating native PBW moths do not develop reproducing populations in eradicated zones. The most pressing need for pink bollworm eradication is the use of an additional marker to verify that questionable moths captured are either color depleted sterile moths or native pink bollworm moths. There is a question of whether some of the moths captured in 2011, may be sterile moths with their color depleted which would necessitate identifying them as a native moth.

Acknowledgments

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We recognize and appreciate the contributions of Mr. Larry Turnbough to Texas eradication programs. Mr. Turnbough served as a member of the EPTP Steering Committee, the TBWEF Board of Directors and the National Cotton Council Pink Bollworm Action Committee. He has spent countless hours in support of boll weevil and pink bollworm eradication in Texas. We thank Bob Staten for his assistance during the season. Also we thank USDA-APHIS for their critical support of the program. APHIS has provided sterile PBW rearing and shipment, funds administration and technical program support.

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