PROGRAM ADVANCES IN THE ERADICATION OF PINK BOLLWORM PECTINOPHORA GOSSYPIELLA IN ARIZONA COTTON

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Abstract

The year 2007 marked the second season of a multi-phase effort to eradicate pink bollworm, Pectinophora gossypiella (Saunders) from cotton in Arizona beginning with Area 1 including six counties in central and eastern portions of the State. The program, managed by the Arizona Cotton Research and Protection Council, was carried out in accordance with standardized protocols of precise mapping, intensive pheromone detection trapping, and multiple control layers as established by the National Cotton Council Pink Bollworm Action Committee. Average male trap captures demonstrated a 93% reduction through July 29, 2007 in comparison to 2006. Late season migration from neighboring infested areas into the eradication zone decreased the overall trap reduction average to 66% by seasons end. Infested boll data, a more critical measurement of program progress, denoted a 93% reduction in average infestation of non-Bt field samples in 2007 over 2006. Two northwestern Arizona counties entered the eradication program as Area 2 in 2007.

Introduction

Over the past 40 years, PBW has been the most serious cotton pest in Arizona, California and Northwestern Mexico (Henneberry et al 1998). In Arizona alone more than 72 million acre equivalents of harsh pesticides have been applied at an estimated cost of $1.3 billion dollars. In an effort to address this situation, a large scale pilot program to demonstrate the potential for areawide suppression of pink bollworm populations using pheromone technology was carried out in Arizona beginning in 1990 (Antilla et al 1996). The rapid acceptance of transgenic (Bt) cotton varieties since their commercial introduction in 1996 paved the way for serious consideration of the concept of pink bollworm elimination. Given this potential, and the template of a successful active eradication program in west Texas, south central New Mexico and the Mexican state of Chihuahua, the Arizona cotton industry passed a statewide grower referendum in 2004 to enter the eradication effort as soon as adequate control resources were available. Actual program activities began as Area 1 in 2006 in the central and eastern Arizona counties of Maricopa, Pinal, Pima, Graham, Cochise and Greenlee.

Eradication was made possible, primarily due to Bt cotton, the most effective control tool ever known, coupled with the additional complimentary control components of sterile pink bollworm moths, pheromones, cultural controls and limited use of chemical pesticides.

In order to secure the legal authority to enact and manage Pink Bollworm Eradication in Arizona, specific language had to be added to Arizona Cotton Research and Protection Council (ACRPC) enabling legislation. The most critical statutory change limited the amount of time allocated to achieve eradication to four years per region beginning at the time of program initiation (see A.R.S. 3-1086.02). Based on this severe time limit and because maximum utilization of Bt cotton is critical to the timely and efficacious completion of eradication; the ACRPC embarked on an innovative and ambitious effort to scientifically justify a modification in the existing Bt product label to allow individual growers to plant up to 100% Bt. The proposal, submitted to the Arizona State Department of Agriculture, in the form of a 24c Special Local Need request, was contingent on two critical requirements:

1. That the 100% Bt use by grower be allowed only under the jurisdiction of an ongoing sanctioned Pink Bollworm Eradication Program, and

2. That season-long release of sterile pink bollworm moths be made over all such Bt plantings to provide a consistent population of susceptible or non-resistant moths to act in place of the traditional refuge strategy.

The ACRPC 24c proposal was reviewed by an EPA convened Scientific Advisory Panel, approved, and is currently in place through the 2009 crop year.

Methods and Materials

A successful approach to pink bollworm eradication is based on three key components:

1. MAPPING – The location, mapping and identification as to cotton types (Bt vs. non-Bt) of all fields in the eradication zone is an essential first step in program activities. Since the goal of the program is to eliminate all sources of population development, any undetected cotton fields can result in serious consequences to the overall effectiveness of the program. All cotton fields are therefore GPS mapped or confirmed at the beginning of each cotton season and are established in a MapInfo database.

2. TRAPPING – Population monitoring of all fields using gossyplure baited survey traps is vital to program success. Treatment or control triggers are, for the most part, based on trap captures which must be reported on at least a weekly basis to ensure program efficacy. Delta traps on all fields in program areas are deployed prior to the onset of fruiting structures on the cotton plant at the rate of one trap per ten acres of non-Bt cotton and one trap per field or group of contiguous small Bt fields separated only by ditches, field roads or irrigation borders (estimated forty acres) (Leggett et al 1994). Traps are replaced on a weekly basis and counts of both sterile and native moths made and recorded by trained ID personnel. Data is then entered into an information management system for program analysis and action.

3. CONTROL –

a. Bt cotton – No augmentive control is necessary. Multi-year data in Arizona has confirmed virtually no pink bollworm survival beyond second instar larval stage.

b. Pheromone Mating Disruption – High rate pheromone mating disruption systems specifically PB-ROPE L manufactured by ShinEtsu and distributed through Pacific Biocontrol Corporation, and supplemental sprayable pheromone applications are a proven source of control. These systems have no negative environmental effects and do not generate secondary pest problems associated with overuse of conventional insecticides.

Since pheromones do not directly kill pink bollworm life forms and because the activities of the compounds are inversely density dependent, timing of application is vital to maximize efficacy. In early season, pheromone ropes were applied to all non-Bt cotton at or before six true-leaf stage at the rate of 200 ropes per acre on a roughly equidistant grid. Some ropes were twisted on (applied to) individual plants, but the majority were wrapped on the upper one-half of 12" long 1/8" square bamboo splits which were then inserted into the cotton plant row either by hand (labor crews) or mechanically inserted through the use of tractor mounted modified seedling transplanters. The effective control "life" of these rope applications may range as high as 90 days, with trap shutdown serving as the primary measure of mating disruption efficacy.

Late season augmentive pheromone treatments primarily utilized NoMate MEC gossyplure or PB NoMate Fiber (Scentry Biologicals Inc.) mixed with an adhesive sticking agent (Biotac) with the inclusion of a small amount of pyrethroid insecticide to achieve an Attract N Kill mode of action.

c. Sterile Moth Technology – Based on a program that has successfully prevented establishment of pink bollworm in the San Joaquin Valley of California for the past 38 years, sterile moth releases throughout the cotton-growing season interact with all other control systems to prevent the development of pink bollworm populations throughout the eradication zone. Sterile moth releases over Bt cotton also serve to replace traditional refuge strategies as an alternate source of "susceptible" moths. When planting intentions become available to program personnel, the eradication zone is broken up into release areas. Release areas are selected as geographically associated areas with a composite of non-Bt cotton and Bt cotton in amounts correlated to the capacity of the airplane to carry moths, fuel load, and navigation of controlled airspace. In Arizona, ambient heat has a major effect on sterile moth release, release area delineation; scheduling, equipment, operator and moth viability depend on early morning releases when ambient temperatures are at their lowest. Non-Bt cotton receives a minimum treatment equivalent of 250 moths per acre per day via three scheduled releases. Sterile moth releases are scheduled at the maximum interval within seven days to maximize the number of fresh and vigorous moths present in the field to mate with any native populations. Flexibility is incorporated into the system to allow non-Bt release rates to be adjusted as needed to maintain favorable ratios with native moth population levels present in fields. Bt cotton

receives a minimum treatment equivalent to 104 moths per week via two releases spaced to achieve maximum activity over a seven-day period mirroring the technique used for non-Bt cotton. Large blocks of Bt cotton are flown in grid pattern as large contiguous release areas with any outlying singular Bt fields released via individual over flight. Each airplane is equipped with commercial grade GPS navigation equipment, which records the speed, altitude, track and actual release of the sterile moths. The GPS flight data are uploaded to program administration for analysis, quality control and mission planning. The pilot's cockpit display indicates the location of the airplane in relation to the non-Bt and Bt cotton in the release area, and the release of sterile moths. The sterile release rate is pilot controlled by four individual switches providing variable release in flight. Each release machine is calibrated each year upon inception of the release program or any major equipment change. A small camera installed in the release tube allows the pilot to see the moths exiting the airplane.

d. Insecticides – Limited use of insecticides labeled for pink bollworm control may be used for immediate knockdown of pink bollworm numbers should such become excessive in concert with other control strategies listed above. Chlorpyrifos is the principal insecticide utilized.

e. Cotton Plow Down – Enforced destruction of cotton stubble by growers following harvest augments all other control systems as a means of mechanical control of soil based over-wintering populations of pink bollworm. Arizona growers compliance with State mandated plow down regulations exceeds 99% annually.

Results

In 2007, the Arizona Cotton Research and Protection Council completed year two of Area 1 of Pink Bollworm eradication in central and eastern Arizona. Additionally, Pink Bollworm eradication of the River Expansion (Area 2) started in 2007, which included the counties of LaPaz and Mohave. Total fields under eradication in 2007 numbered 4,792 with 181 of those fields being non-Bt cotton. Bt cotton acreage totaled 155,595 acres and non-Bt acreage totaled 6,897 for a total of 162,493 acres of cotton in the Pink Bollworm eradication zones. Three thousand four hundred and eighteen Pink Bollworm traps were deployed at a rate of 1 trap per 40 acres in Bt cotton and 1 trap per 10 acres in non-Bt cotton.

Traps were inspected weekly under magnification for native and sterile pink bollworm. Non-Bt traps were inspected two times per week as required for enhanced coordination of field activities. Native moths collected in traps numbered 415,996 and sterile moths collected in traps numbered 974,876. No trap on any Bt field failed to have sterile captures at least one time during the season (see Figure 1). From July 8 to September 8, 2007 on average 94% of Bt fields reporting native captures also reported sterile captures in the same week. Area wide trapping began in early April and terminated October 13, 2007.

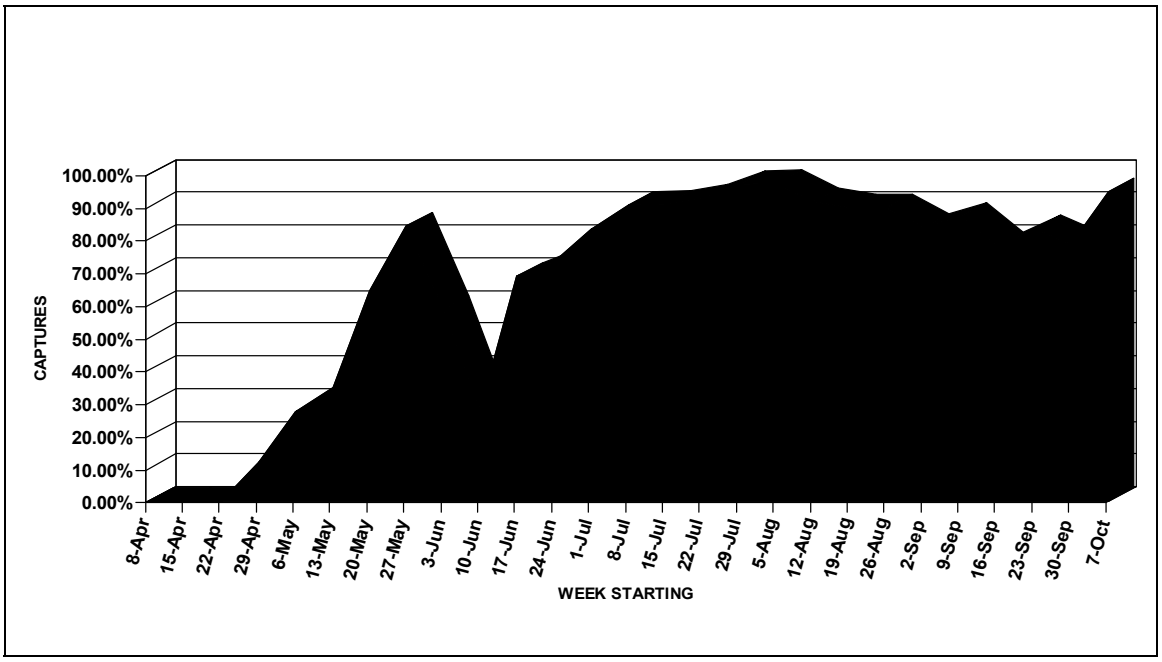

Figure 1. Percent of Bt fields with sterile captures by week in 2007

In central and eastern Arizona, average pink bollworm per trap in 2007 averaged 93% reduction over the same period in 2006 until July 29, when large numbers of migrating moths began to move into the eradication zone (see Figure 2). Season long reduction in pink bollworm per trap was 66% over 2006. When compared with pre-program trapping, pink bollworm per trap reduction is 94.7%. Season long data detailing pink bollworm male moth trap captures per trap per week averaged 42.3; 6.76 and 2.28 for 2005 (pre-program); 2006 and 2007 respectively (see Figure 3).

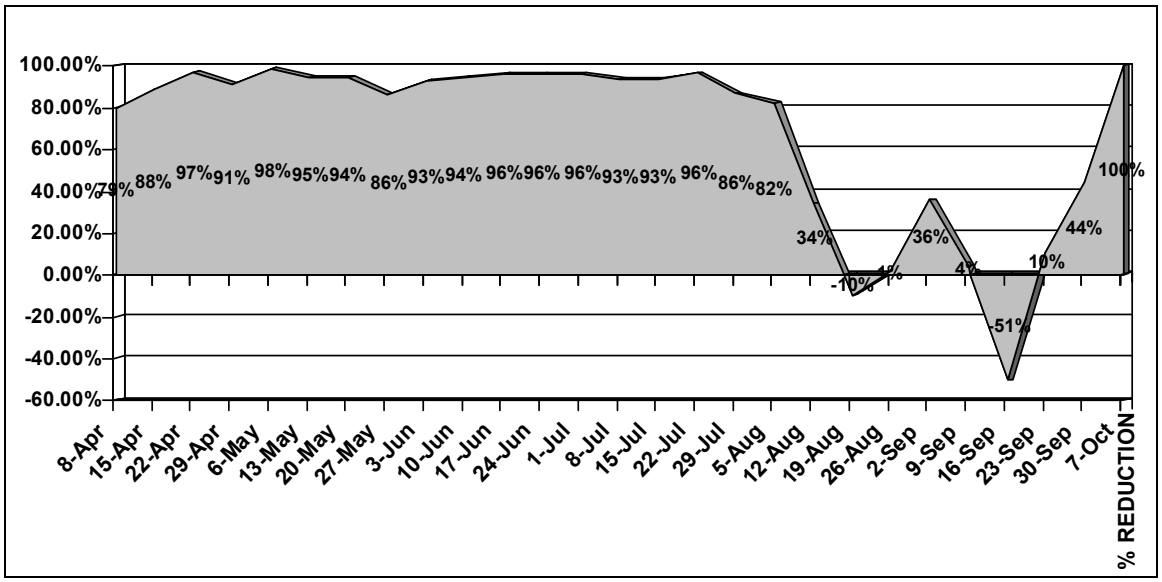

Figure 2. Percent reduction in native PBW per trap from 2006 to 2007

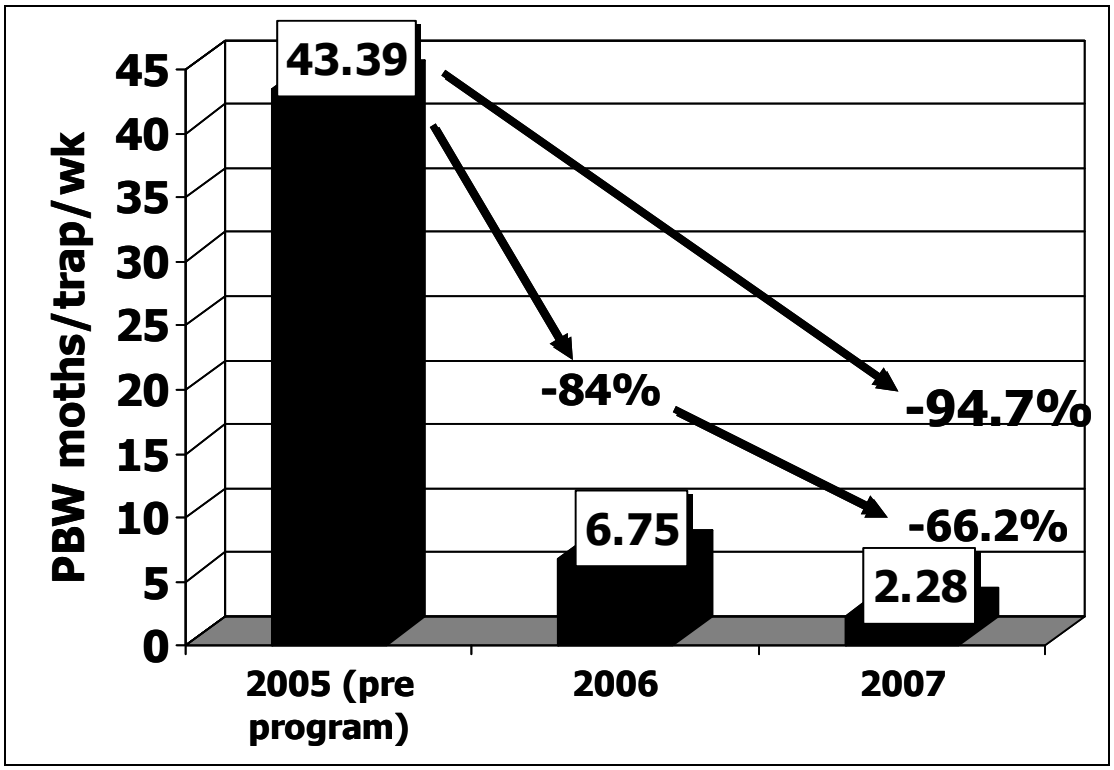

Figure 3. Area 1 season long PBW per trap reductions

Boll survey data represents the most reliable measure of pink bollworm eradication program progress. Based on this, Arizona program field supervisors established a comprehensive boll sampling and inspection effort from early July (when susceptible bolls first become available) through the end of the season. With rare exception, eighty bolls were collected weekly from alternating quadrants on all program non-Bt fields. All bolls sampled were cracked and examined under magnification for all pink bollworm life forms at the ACRPC field offices.

Boll data indicated a 93% reduction in average infestation of non-Bt samples in 2007 over 2006. Arizona pre-program boll infestation levels ranging from 20-40 percent, depending on annual population level severity, were reduced to 2.12 and 0.15 percent season long for 2006 and 2007 respectively (see Figure 4). There were 45,325 bolls inspected from 773 samples in 2007. Boll sampling in the one core highly infested area was reduced to 0% infestation in 2007 from 13.23% infestation in 2006. Six fields in central Arizona produced larvae in boll samples, all larvae were detected after migration from areas outside the eradication zone began. Eastern Arizona samples, which were not subjected to migration pressure from non-program areas, produced zero larvae in 2007. In the river expansion (LaPaz, Mohave counties) seven fields produced larvae in boll samples due to late season migration.

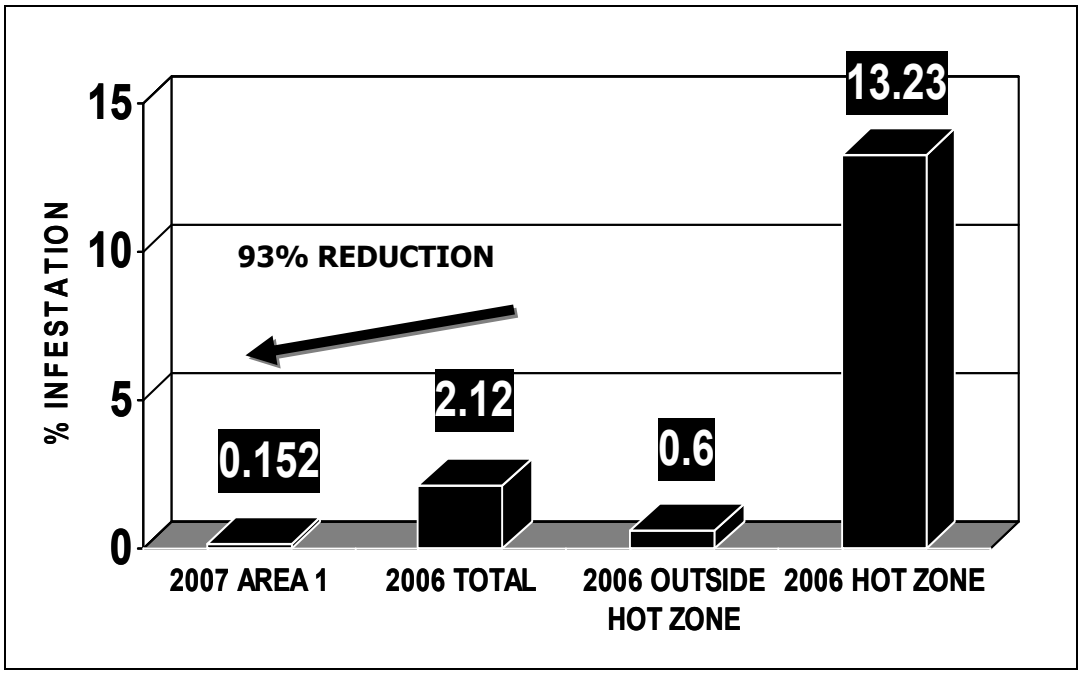

Figure 4. Area 1 reductions in Boll infestations by year.

PB-Rope was applied to 181 non-Bt fields early season. Limited re-treatment with rope was required late season to combat migrating moths on the western edges of the program. In 2007, thirty fields required additional treatments in comparison with two hundred and five in 2006, an 85% reduction. Sterile moth releases were performed 2-3 times per week without interruption from May 1 through October 15, 2007.

Conclusions

Pink bollworm has, since the mid 1960's, seriously affected Arizona cotton agro-ecosystem both economically and environmentally. The advent of transgenic (Bt) cotton varieties alleviated the pink bollworm problem where grown, but preserved base level populations through label required non-transgenic refuges. The addition of complimentary control strategies such as sterile moth release, pheromone mating disruption and limited insecticide use through a coordinated national eradication program sponsored by the National Cotton Council began in 2001 and has proven to be highly successful. Arizona's entry into the program in 2006 provided the opportunity to expand the concept of regional eradication.

Harvest of the 2007 cotton crop in nine central and eastern Arizona counties has successfully completed the second full season of pink bollworm eradication on approximately 146,000 acres. The following second year statistics provide benchmarks for delineating program success.

1. A 94.7% reduction in detection trap captures over pre-program levels.

2. A 93% reduction in boll infestation levels in year two versus year one (2006). Even more dramatic is the 2007 program boll infestation average of slightly more than one-tenth of one percent versus pre-program levels of 20-40%.

3. Use of chemical insecticides in central and eastern Arizona (Area 1) declined by 85% in 2007 versus year one of the program (2006).

Plans in Arizona are to expand into Yuma County in 2008 bringing all cotton acreage in Arizona under eradication. Grower meetings in Yuma have been completed with positive grower feedback and all personnel are in place. Pre-eradication trapping in Yuma revealed a pink bollworm per trap average of 58 natives per trap in non-Bt cotton. Native captures surged in central Arizona in 2007, just after native captures in Yuma began to increase. Spatial

trapping analysis reveals strong movement of natives to the north and east out of Yuma and associated areas late season. Due to migration and statutory time constraints, expansion of the program into Yuma in 2008 is pivotal to overall program success.

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