ALTERNATIVE INFIELD REFUGE STRATEGIES FOR CONTROL OF PINK BOLLWORM IN Bt TRANSGENIC COTTON

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Abstract

Large scale commercial tests of three infield refuge planting scenarios were conducted in 1998 on 2,500 acres of cotton near Vicksburg, Arizona to compare the development of pink bollworm infestation levels. Season long trapping monitored population dynamics. Single rows of conventional cotton were systematically planted within separate Bt-transgenic fields at the rates of one non-Bt row in four, six and eight rows of Bt cotton respectively. Each treatment was replicated six times.

Eighteen hundred (1,800) bolls collected on October 1 and 22 from non-Bt rows were incubated in boll boxes and third instar or larger larvae were counted. Results demonstrated that no differences exist between the medians of the three refuge treatments. A 36,000 boll sample collected from Bt replicates produced no larvae. Yield throughout the test area was well above the state average.

A second, non replicated test was conducted on Youngker and Youngker Farms in an area of much greater pink bollworm pressure in Buckeye, Arizona. This study suggested that crop losses incurred on an infield refuge of 25% non-Bt cotton produced less negative economic impact than chemical control costs on a nearby full field non-Bt external refuge crop.

Introduction

The pink bollworm *Pectinophora gossypiella* (Saunders) has been a major pest of cotton in the desert southwest for more than 30 years. During this time pesticide use documents confirm that cotton growers in Arizona and southern California have treated more than 14 million acre equivalents with harsh pesticides in an attempt to control the insect. This represents direct expenditures of more than 1.25 billion dollars. Monitary losses from uncontrolled PBW populations may easily range from $85 - $170 per acre.

The development and commercialization of transgenic cottons that express insect control protein genes from *Bacillus thuringensis* (Bt) were shown to be highly effective in controlling pink bollworm (PBW) damage (Wilson et. al. 1995). Studies conducted by Watson in Yuma, Arizona in 1994 concluded that mixtures of Bt and non-Bt seed were exceptionally resistant to PBW attack. Research carried out by Mallet and Porter 1992 suggested that the ability of tobacco budworm and cotton bollworm larvae to move from plant to plant may accelerate selection for resistant insects under certain conditions. As a result the seed mixture strategy was ultimately abandoned in favor of the current licensing agreement allowing a treatable 80:20 or non treatable 96:4 ratio of Bt to non-Bt planting. (Luttrell and Caprio, 1996). Multi year studies designed to evaluate a variety of Bt cotton deployment strategies for efficacy specifically against pink bollworm have been initiated in Arizona (Simmons, Dennehy and Tabashnik, 1997). Initial results of these experiments suggest that in-field refuges of one row of non Bt cotton for each five rows of Bt cotton showed great promise as an alternative to external refuge strategies. Due to physical limitations in planting equipment, not all growers can effectively follow the one in six scenario demonstrated by Simmons, et. al. 1997. Because of this it was speculated that other planting ratios, such as one in four and eight, might have similar suppressive effects. In an effort to address this issue and to examine the infield single row non-Bt refuge approach in a large relatively isolated block of cotton, the following study was conducted.

Results and Discussion

Historically cotton in the Vicksburg area has a heavy late season buildup of PBW in the top crop of any non-Bt plantings. However, 1998 provided only light to moderate PBW pressure statewide. Despite relatively low numbers both infield and desert line trapping data suggested that PBW populations were initially migratory in nature. As evidence of this, desert traps in line with the prevailing winds west of Vicksburg showed sizable increases fully two weeks prior to the majority of infield traps.

Pink bollworm infestation rates at the end of the season represented the principal means of project evaluation. A combined total of 1,800 bolls were collected on October 1 and 22 from the non-Bt rows in each replicate. Totals in Table 1 are the sums of equal to or greater than third instar PBW larvae from the bolls collected on both dates. A much larger sample of 36,000 Bt bolls was concurrently harvested from the replicates. No third instar or greater PBW larvae were recovered from this sample, all bolls of which were incubated in 12 X 7 X 3.5 inch plastic boll boxes and were additionally cracked and inspected for larvae. Data analysis was accomplished with a Moods Median Test, a non

Reprinted from the *Proceedings of the Beltwide Cotton Conference*
Volume 2:1241-1243 (1999)
National Cotton Council, Memphis TN

parametric equivalent to the parametric one-way analysis of variance. Results of the test were that no differences exist between the medians of the three refuge treatments (Figure 1).

Throughout the season growers in Vicksburg made no chemical applications for PBW control, one treatment for whitefly and two for lygus. First pick yields range from 1,552 - 1,739 pounds of lint per acre (3.2 - 3.6 bales), significantly higher than the state average.

A second non replicated test was conducted on Youngker and Youngker Farms in Buckeye, Arizona, an area of considerably higher PBW pressure than Vicksburg. Two fields approximately one mile apart were compared. One had 25% infield refugia in the form of two adjacent non-Bt rows (DPL 5415) next to six Bt rows (DPL 33B). The second field was 100% non-Bt (DPL 5415), PBW being controlled with conventional chemical tactics. Lack of replications precluded statistical analysis of this test but several critical data elements provided valuable information namely: 1) Adjacent non-Bt refuge rows were able to be harvested separately with a two row picker for comparative yield data; 2) High PBW levels established a worst case control scenario; and 3) Clearly delineated control cost records provided the ability to calculate economic benefits between the two compared strategies. The results are as follows. Despite a top boll infestation rate of 40% in samples from early October the infield non-Bt refuge averaged 3.23 bales per acre versus 3.49 for adjacent Bt, a difference of 0.26 bales. This represents a 125 pound reduction in yield for the non-Bt field component. Based on an estimate of 70 cents value per pound and prorated over 25% of the field the net loss to the grower was $21.87 per acre. No chemical treatments were made on this field for PBW control.

Correspondingly the full field non-Bt external refuge was chemically treated sixteen (16) times for PBW control at a cost of $146.41 per acre. Yields from this field averaged 3.06 bales per acre with infestation levels averaging 12.6%.

In conclusion the results from both the Vicksburg and Youngker tests strongly suggest that growers may gain a variety of benefits by considering infield refuge strategies in their farming operations and that flexibility exists in the type of non-Bt planting pattern selected.

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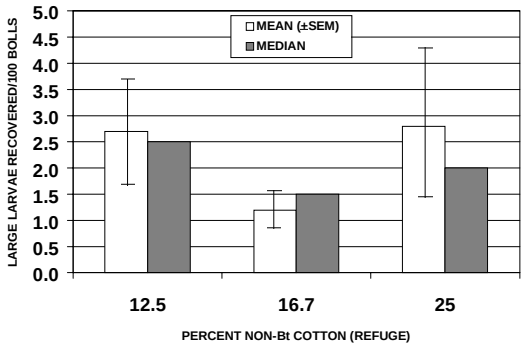
Table 1. Pink bollworm infestation ratio for three infield refuge types.

% Refuges	12.5	16.7	25.0
Larvae Found	16.0	7.0	17.0
Mean	2.67	1.17	2.83
Median	2.5	1.5	2.0
Std Deviation	2.4	0.98	3.7
Std Error	0.98	0.4	1.5



No significant difference between treatments
(Mood Median Test, p=0.79).

Figure 1. In-field refuge: PBW damage, 1998, Vicksburg, AZ