INFLUENCE OF Bt COTTON ON BENEFICIAL ARTHROPOD POPULATIONS

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Abstract

Studies were conducted on paired farm fields and in large research plots in 1996 and 1997 to determine the impact of Bt cotton on beneficial arthropod populations. Sweep samples were taken to determine relative numbers of beneficials, and terminal evaluations were used to detect Heliothine pressure. Squares were removed for evaluation of Heliothine feeding and boll weevil feeding/oviposition. Insecticide sprays were applied to on-farm fields in response to plant bug, Heliothine complex, and boll weevil in 1996. In 1997, Dimilin was used to reduce boll weevil oviposition, but one on-farm site was sprayed with methyl parathion to control weevil populations. Total numbers of beneficial arthropods were greatly reduced in 1996, due to insecticide effects, when compared to 1997. Beneficial arthropod populations rarely differed significantly between Bt and non-Bt sites in either year. In 1996, there were significant differences in the number of larvae greater than 1/4 inch found on terminals and in the number of Heliothine damaged squares in Bt and non-Bt varieties.

Introduction

Early-season insecticide sprays on cotton for boll weevil (*Anthonomus grandus* Boheman) and plant bug (*Lygus spp*.) have a disruptive effect on beneficial arthropod populations (Lambert et al. 1996, Turnipseed and Sullivan 1997), but the use of selective and short residual insecticides may allow populations to rebound to pre-treatment levels and maintain those levels throughout mid- to late-season. The efficacy of Bt cotton against the tobacco budworm is well established (Mascarenhas et al. 1994, Jenkins et al. 1993, 1997), but control of bollworm is variable (Mahaffey et al. 1995, Jenkins et al. 1997). The primary Lepidopteran pests of cotton in Tennessee are the tobacco budworm (*Heliothis virescens* F) and the bollworm (*Helicoverpa zea* Boddie), collectively called the Heliothine complex (**HC**). In Tennessee, HC begins to appear and increase from late June through September.

An important benefit resulting from the use of Bt cotton is the reduction in insecticide sprays to control HC (Benedict 1996, Layton 1996). The reduction in the input of chemical insecticides afforded by the use of Bt cotton not only decreases crop production costs and selection pressure for the development of insecticide resistance by tobacco budworm, but also decreases insecticide induced disruption of natural enemies that prey on HC. The conservation of these natural control forces may impact pest management strategies used by growers and may allow the potential of biological control to be fully utilized (Herzog 1995).

The full effect of transgenic Bt on non-target insect populations will not be known until large acreages have been planted over several seasons (Meredith 1995). If beneficial insect numbers are not reduced by sprays to control HC, several questions may be raised (Benedict 1996). Are there differences in the kinds of beneficial arthropods found in Bt and conventional cotton varieties? Does Bt cotton influence beneficial insect numbers? What insects will fill the void left from using Bt and removing lepidopteran pests from the field (Meredith 1995)? In the absence of insecticide treatments for HC, will secondary pest populations increase (Layton 1996)? Will predatory arthropod numbers be great enough to impact secondary pest populations (Bacheler 1996, Layton 1996)? Studies were conducted in 1996 and 1997 on farm fields and in large research plots to answer these questions and to add to our understanding of the effects of Bt cotton on predatory arthropods.

Methods

All **sites** consisted of two treatments: **Bt** cotton and a non-Bt/conventional cotton (**CC**) variety. Each on-farm field (**OFF**) site included one Bt field and one CC field. Each field was divided into approximately equal quadrants. Large research plot sites consisted of a Bt and CC plot each replicated three times in a randomized complete block design.

In **1996**, six sites, five paired OFFs and one large plot trial, were evaluated for beneficial arthropod numbers and HC pressure. Sites 1-5 were paired OFFs planted in 40-inch rows, and Site 6 was a large plot trial containing 6 plots each 1.1 acre. Cotton was planted over a three-week period beginning May 6 using standard planting practices. At-planting insecticides or Gaucho-treated seed were used at all locations to control early-season insects.

Sites 1-3 were located in northeast Madison County, centrally located in western Tennessee. Site 1 was 27 acres of NuCOTN 33B and 65 acres of DPL 5409; Site 2 was 87 acres of NuCOTN 33B and 29 acres of STV 495; Site 3 was 35 acres of Paymaster H1220 BG and 8 acres of DPL 5409. Sites 4-6 were located in Fayette County, in southwestern Tennessee. Site 4 was 32 acres of Nu COTN 33B and 14 acres of DPL 50; Site 5 was 39 acres of NuCOTN 33B and 34 acres of DPL 50; Site 6 was planted with NuCOTN 33B and DPL 5415.

Both Bt and CC at sites 1-3 received two to three 10-inch band pinhead square applications of Vydate C-LV, Provado, or Vydate/ Provado tank mixes to control plant bug and

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emerging boll weevils from Jun14 - Jul 5. From Jul 27 - Aug 21, all sites except Bt cotton at Site 2 received one to three broadcast insecticide applications to control HC, boll weevil, and/or stinkbug. Sites 4 and 5 received one broadcast pinhead square application of methyl parathion and dimethoate to control boll weevil and plant bug from Jun 19 - Jun 27 on Bt and CC. At Site 4 and 5, Orthene 90S was applied on Jun 19 to both Bt and CC to control plant bug. Boll weevil pressure reached economic threshold in mid-July and three to five applications of methyl parathion were applied from Jul 12 - Aug 14 on Bt and CC to control this pest. The CC received one to two applications of Curacron 8 and/or a pyrethroid to control HC from Jul 3 - Aug 14. Both varieties at Site 6 were treated with pinhead square applications of Vydate C-LV on Jun 22 and 27 to control plant bug and boll weevil; received seven applications of methyl parathion or Vydate C-LV between Jul 12 and Aug 28 for boll weevil; and received one application of Asana XL 0.66 to control HC on Aug 21.

Sweep samples consisting of 100-sweeps/treatment were taken to determine relative beneficial arthropod numbers. For the purpose of this paper beneficial arthropod numbers include: lady beetle (Coleoptera: Coccinellidae) adults and larvae, big-eyed bug (*Geocoris spp*.) adults and nymphs, insidious flower bug (*Orius spp*.) adults and nymphs, lacewing (Neuroptera: Chrysopidae and Hemerobiidae) adults and larvae, and spiders (Araneae). Secondary pests observed were aphids (Homoptera: Aphididae), plant bugs (*Lygus spp*.), and stink bugs (Pentatomidae). One hundred terminals per treatment were examined in the field to detect HC eggs, small larvae less than ¼ inch, large larvae greater than ¼ inch, and feeding damage; and one hundred squares per treatment were removed and examined in the laboratory to evaluate efficacy of Bt in controlling HC larval feeding and to monitor boll weevil (*Anthonomus grandis* Boheman) feeding and oviposition.

Sites 1 and 2 were evaluated on Jul 9, 18, 26, and Aug 1, 7, and 14; Site 3 on Jul 9, 18, 26, and Aug 1, 7, 14, and 21. Sites 4, 5, and 6 were evaluated on Jul 16, 23, and Aug 5, 13, and 19.

In **1997**, three sites, one paired OFF (Site 1) and two large plot trials (Sites 2 and 3) were studied. Cotton was planted over a 10-day period beginning May 4. At-planting insecticides or Gaucho-treated seed were used at all locations, and standard planting practices were used.

Sites 1 and 3 were located in western Madison County. Site 2 was located in Fayette County, in southwestern Tennessee. Site 1 was an OFF with 12 acres of DPL 50BG and 15.5 acres of DPL 5409. Site 2 was a large plot trial consisting of six 1.1 acre plots. The Bt was NuCOTN 33B, and the CC was DPL 50. Site 3 was also a large plot trial consisting of six 0.26-acre plots planted to Paymaster H1215 BG and PM H1215.

The Bt field at Site 1 was sprayed with Vydate-CLV on Jul 16 in response to plant bug and boll weevil numbers and with methyl parathion on Aug 15 and 23 to control boll weevil. The CC at Site 1 was sprayed on Aug 5, 15, and 23 with methyl parathion to control boll weevil. Site 2 was sprayed with dimethoate on Jun 4 and with Bidrin 8 on Jun 19 to control thrips. Dimilin 2L was applied in response to boll weevil pressure on Aug 1, 6, and 15. Site 3 was sprayed with Dimilin 2L on Jul 30, Aug 6 and 15 to control boll weevil.

In 1997, changes in data collection methods were made based on site size. Sweep sample methods were intensified by increasing to 200 sweeps/quadrant the number of sweeps taken at Site 1; 200 sweeps/plot at Site 2; and 100 sweeps/plot at Site 3. Terminal evaluations were the same as in 1996 except damaged square evaluations were dropped, and damaged boll data were added. At Site 1, 25 terminals/quadrant were examined; while at Sites 2 and 3, 25 terminals/plot were examined. The number of squares removed and examined from all sites were the same as in 1996. Three-ft. drop cloth samples (**DCS**) were taken once/week for a 3-week period beginning at pin-head squaring to determine plant bug and boll weevil numbers. Ten DCS/quadrant or plot were taken at Sites 1 and 3 and five DCS/plot at Site 2.

Site 1 was evaluated on Jun 23; Jul 1, 7, 14, 21, and 28; and Aug 4, 11, and 18. Data were collected from Site 2 on Jun 25; Jul 2, 9, 16, 22, 30; Aug 6, 14, 21, and 26; and Sept 4 and 11; and Site 3 was evaluated on Jun 20; Jul 1, 8, 14, 22, and 28; and Aug 5, 11, 19, and 25.

In both years, sweep sample contents were placed in containers with collection information labels and paper towels moistened with ethyl acetate. The containers were taken to the laboratory where the contents were removed and stored in vials containing 70% ethyl alcohol. Arthropods were later counted using a dissecting microscope. Squares pulled from the plots were placed in bags containing collection information, taken to the laboratory and examined for HC feeding damage and boll weevil damage. OFF data were recorded using quadrants as plots so that each paired OFF consisted of four replications.

All data were analyzed for ANOVA using Gylling's PRM software (P=0.05).

Results

Sweep Samples

In 1996, five instances of significant differences were observed in the number of beneficial arthropods present in sweep samples across all observations and sampling dates at all sites (n=324). Four of those differences occurred at Site 2, and one occurred at Site 4. In all cases, numbers of beneficial arthropods found in Bt cotton were significantly greater than the number found in CC. Site 2 was a paired

OFF, and the conventional field had been sprayed one to three days prior to sampling in three of four instances where significant differences occurred. Significantly greater numbers of a secondary pest, cotton aphid, was found at Site 3 on Aug 21.

In 1997, thirteen occurrences of significant differences were found in the number of beneficial arthropods present in sweep samples across all sampling dates at all sites (n=243). Eleven of the differences were at Site 1. In this OFF situation, the two fields were geographically separated and the Bt cotton had considerably more mid- to late-season vegetative growth than the CC. The CC reached 'cut-out ' by Aug 4, while the Bt not until Aug 18. Adult lady beetles were present in significantly greater numbers in Bt on Aug 4 and 11; more lady beetle larvae were found in CC on Jul 21 and on Aug 11 than on Bt. Three differences in the number of big-eyed bugs occurred. On Jul 21 there were more big-eyed bug adults in CC. More adults were found in Bt on Jul 28, but more nymphs were found in CC on the same date. Spider numbers were significantly higher on Jul 14 and 21 in the CC. Insidious flower bug numbers were significantly different on Jul 21, with greater numbers found in CC. On Aug 11, more insidious flower bug were found in Bt. Two of the differences were at Site 2 where Bt had a greater number of insidious flower bug on Aug 6 and where CC had a greater number of lady beetle larvae on Aug 22. There was only one instance of a significant difference in secondary pests evaluated: significantly greater numbers of plant bug in Bt were found at Site 1 on Aug 11. Once again, this field was more vegetative and was still squaring in the upper 18 inches of the plant.

Field Evaluation of Terminals

In 1996, all sites had significant differences between Bt and CC in the number of HC larvae, eggs, *or* damaged squares found on plant terminals. Site 1 had a greater number of HC eggs in Bt compared to CC on Jul 9, and had a greater number of damaged squares in CC compared to Bt on the same date. On Jul 18, there were greater numbers of eggs and damaged squares in the CC, and on Jul 26 there were significantly greater numbers of eggs in the CC. Site 2 had significantly higher numbers of HC damaged squares in CC compared to Bt on Jul 9. There were more eggs in Bt than CC on Jul 26 at Site 3. On Jul 16 at Site 4, a greater number of large larvae and damaged squares were found in the CC while more eggs were found in Bt. On Jul 23, CC had the greatest number of damaged squares while Bt had the most eggs. On Aug 5, more eggs were found in the Bt, while the greatest square damage was found in the CC. More square damage occurred in CC than on Bt at Site 5 on Jul 16. More small larvae and damaged squares were found in CC than in Bt at Site 5 on July 23. On Aug 5, 13, and 19, a significantly greater number of damaged squares were found in CC than Bt. On the 19th, CC also had a greater number of small larvae. Site 6 had greater numbers of small larvae on Jul 23 and Aug 19 in the CC and also more damaged squares.

In 1997, HC pressure was below threshold levels at all sites in Madison and Fayette counties. There were no significant differences in the number of small or large larvae, the number of damaged bolls, or eggs in the two systems.

Laboratory Evaluation of Square Damage

In 1996, there were no differences between Bt and CC in the number of squares damaged by bollworm and boll weevil at Sites 1,2,3,4, and 6. Site 5 demonstrated differences in the number of *both* bollworm and boll weevil damaged squares in the two systems on Jul 16 and in the number of worm damaged squares on Aug 19. In all three instances, the numbers of damaged squares were greater in the CC.

In 1997, there was only one occurrence of differences in the number of bollworm and boll weevil damaged squares. The number of boll weevil damaged squares at Site 1 on Jul 28 was significantly greater in CC.

1997 Drop Cloth Counts

There were no differences between Bt and CC in the number of plant bugs or boll weevils found at all sites on all dates.

Conclusions

In both years, the number of significant differences of beneficials collected by sweep sampling was extremely low. These data indicate Bt cotton does not influence beneficial arthropod numbers in large plots or grower environments where insecticides are not used. Plant bug numbers did increase in the absence of sprays (1997), but there were no differences in numbers found in CC and Bt cotton. These data indicate that beneficial arthropods did not affect secondary pest numbers in either of the two systems. Bt cotton is an important tool for growers to combat HC, however our data indicate the use of Bt cotton rarely has an impact on beneficial arthropod numbers.

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