BT AND CONVENTIONAL COTTON IN THE HILLS AND DELTA OF MISSISSIPPI: 5 YEARS OF COMPARISON

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Abstract

Results of research initiated in 1995 that utilized field size units of approximately 25 acres to evaluate Bt-transgenic cotton and conventional, non-Bt cotton grown in major regions of Mississippi are discussed. Insect populations identified by 5 years of sampling are graphically examined. A general shift of heliothine egg lay earlier in the season is identified. Tarnished plant bug infestations in the hills are considerably less than those in the delta of Mississippi, and in this study populations tended to be about the same on Bt-cotton and non-Bt cotton. Heliothine egg deposition does not differ between Bt and non-Bt cotton, but population characteristics are different between the hill and delta regions. Aphid populations appear to be similar in Bt and non-Bt cottons, and appear to be higher in the hills than the delta.

Introduction

Introduction of transgenic cotton expressing the Bt protein designated Cry1A, created a need to evaluate the technology in comparison with conventional cotton in different regions in Mississippi. It soon became apparent that management of non-heliothine insect pests of Bt-transgenic cotton (Bt-cotton) would also require research and observation. With the assistance of funding from the special research initiative program in Mississippi, a research program was begun to evaluate the new technology and ascertain its economic advantage, if any, in Mississippi.

Field-sized research plots, approximately 25 acres or more in size, were initiated in 1995 as part of a research project to evaluate the then new technology of transgenic (Bt) cotton in comparison with conventional, non-Bt cotton. Five locations were originally chosen, two in the hill region and three in the delta region of Mississippi. The treatments were replicated eight times during the first two years and four times during the last three years. Additional fields of Bt-transgenic cotton were planted to allow the addition of other insect control strategies, such as aggressive early season tarnished plant bug and heliothine management in Bt cotton. Results of the peripheral studies were discussed by Stewart et al. (1998). This research project incorporated the first field-sized plantings of Bt-cotton for research by university or other non-industry groups.

During the 5 year interim since the beginning of the project, acreage planted to Bt cotton has risen from the seed-increase acreage of 1995 to nearly 70% of the cotton acreage in Mississippi in 1999. Bt-cotton plants are nearly totally lethal to tobacco budworm [*Heliothis virescens* (F.)] and provides significant control of corn ear worm [*Helicoverpa zea* (Bodie)]. The impact of such a large Bt-cotton crop on these insect populations is largely unknown. However, it would be expected that some effect may be discernable in large populations if sufficient data were available to identify trends. Stewart et al. (1998) reported that statistical differences in pest or beneficial arthropod numbers did result between Bt and non-Bt cotton in the first three years of this research for numbers of heliothine larvae, boll weevil punctures, tarnished plant bugs, lady beetles and ants. The effect on beneficial insects was probably related to the reduced necessity to manage heliothine larvae in Bt-cotton. Thus, one would expect to observe different population parameters for non-heliothine pests in Bt-cotton as compared with conventional cotton. It is the purpose of this paper to briefly state the economic results of 1999, and to graphically sketch aspects of the large data base resulting from this research project. It will focus only on the Bt and non-Bt cotton managed in the study according to the annually published Mississippi Cotton Insect Control Guide.

Materials and Methods

The database used for this project includes twice-weekly sampling of 25 terminals, 25 squares and bolls (if present), a drop cloth sample, and 25 sweeps with a sweep net in each of four sectors of each field (i.e. four samples per field). Aphids were rated on the basis of 0 to 3 (none to dense). Sweep net and drop-cloth samples were used for both tarnished plant bug counts and counts of beneficial arthropods. Grower cooperators were used to insure that region-specific agronomic practices would be used. Growers were responsible for planting the fields and for insecticide applications after our recommendations were made. Scouts were provided by the researcher and were under the jurisdiction of the research establishment. Harvest was measured by either picking a measured area of each field and weighing the cotton in a cotton trailer or boll buggy by use of truck scales, or by building a module from a known area and recording the information obtained from the gin. Cost of insect control measures used in each field was computed based on current cotton planning budgets published annually by the Department of Agricultural Economics, Mississippi State University and included the $32.00 per acre technology fee for transgenic cotton and $22.00 per acre for boll weevil eradication. Total cost of insecticide applications include

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direct and associated costs such as labor and interest loans computed according to a standard formula. Insecticide prices are based on a state-wide survey.

Fields were located in two hill region counties, one in the north and one in the southern area of cotton production, and in at least two delta counties. These were located as follows for each respective year. 1995: Lee, Madison, Leflore (four replicates), Tallahatchie and Yazoo. 1996: Itawamba, Madison, Leflore (four replicates), Tallahatchie and Yazoo. 1997: Itawamba, Madison, Leflore, and Tallahatchie. 1998: Itawamba, Hinds, Tallahatchie and Leflore. 1999: Itawamba, Hinds, Tallahatchie and Coahoma. Thus during the first two years, eight replicates of the major treatments (Bt-cotton and non-Bt cotton) were available, but only four replicates in subsequent years.

Discussion

Yield from 1999 plots were as follows for Bt- and non-Bt cotton respectively. Lb lint, 706, 630; Cost of insecticide, $72.60, $57.94; Total insect control costs, $79.24, $68.10; Based on 52 cent cotton, the technology benefit (return for Bt-cotton minus return for non-Bt cotton) for insecticide costs only, $24.86; Return based on total insect control costs, $28.38. Compared with the $53.26 five year average technology benefit based on insecticide costs only, the 1999 results are quite low. The 1999 season was characterized by very low heliothine populations across the state, making the transgenic-Bt technology less valuable than in years of high heliothine populations. The data suggest that even at low larval populations, the Bt-cotton benefits from control of populations that would be considered sub-threshold on non-Bt cotton.

Three dimensional spline graphs with years and weeks as axes describing two dimensions of time (trend over the 5 year period and seasonal trend) are useful for describing the insect populations in this study. Figure one indicates an obvious decline in seasonal heliothine egg deposition over the five-year span of the study, as well as shortening of the egg deposition period and a shift of the peak egg lay to earlier in the season. This suggests that forces acting upon the heliothine population strongly affect not only moth numbers, but perhaps species composition of the moth population as well. Budworm moths normally occur early in the season, followed by bollworm moths from corn during mid season, and finally by mostly budworm or a mixture of the two species during late season. During 1999, the late budworm population failed to materialize at least in the hills of Mississippi, and the overall budworm population was extremely low. This may be a direct effect of the large acreage of Bt-cotton throughout the state. The trend is strongest in the hill section where typically more Bt-cotton is grown in relation to non-Bt cotton (Fig. 2). The trend towards earlier and lower populations during later years of the study may also reflect the acceptance during later years of the need for spraying Bt-cotton for heavy bollworm infestations. The number of eggs laid in non-Bt and Bt-cotton appear to be similar, indicating equal attractancy of the two cottons (Fig. 3). It also indicates uniform dispersal of moths since larvae essentially do not mature in Bt-cotton and moths in those fields during mid- to late season must come from other sources.

Tarnished plant bug populations increase during late season (Fig. 4). Populations on cotton are higher in the delta than in the hills (Fig. 5). Contrary to results reported in 1998 using data not restricted to fields managed according to the cotton insect control guide, plant bugs did not appear to be heavier on Bt-cotton than on non-Bt cotton (Fig. 6).

Aphid populations as indicated by ratings from 0-3, are fairly evenly distributed across years in the hills and delta regions (Fig. 7). However, the aphid infestations tend to be longer within season for the hill area, possibly because boll weevil eradication sprays began in portions of the hill area prior to introduction of eradication in the delta. These findings concur with of that Layton et al. (1999) who identified boll weevil sprays of malathion as a cause of flared aphid populations in Mississippi. Aphid ratings are somewhat higher on Bt-cotton than on non-Bt and appear to increase later in the season in later years as compared to the first years of the project (Fig. 8). This trend may be exaggerated by aphid populations in 1999 since they occurred and peaked considerably later than normal in 1999.

The distribution of lady beetles was essentially the same on non-Bt and Bt-cotton (Fig. 9). Total beneficial counts (including lady beeltes, big-eyed bugs, nabids, minute pirate bugs, spiders and ants) tended to follow the general distribution of the aphid population. Lady beetles made up a high percentage of the population of beneficial insects.

Summary

A general shift of heliothine egg lay on both non-Bt and Bt-cotton earlier in the season is identified over the 5 year period of the study. Tarnished plant bug infestations in the hills are considerably less than those in the delta of Mississippi, but populations restricted to the plots receiving management according to the Mississippi Cotton Insect Control guide are about the same in Bt-cotton and non-Bt cotton. Heliothine egg deposition does not differ between Bt and non-Bt cotton, but population characteristics are different between the hills and delta regions. Aphid populations appear to be similar in Bt and non-Bt cottons, and appear to be higher in the hills than the delta, possibly as a result of the effect of the boll weevil eradication program which has been in effect longer in the hills than in the delta.

References

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Stewart, S., J. T. Reed, R. G. Luttrell and A. Harris. 1998. Cotton insect control strategy project: comparing BT and conventional cotton management and plant bug control strategies at five locations in Mississippi, 1995-1997. Proc. Beltwide Cotton Conf. 2:1199-1203.

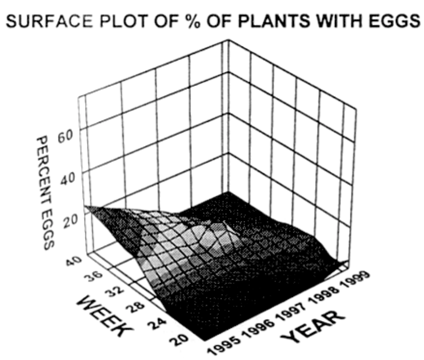

Figure 1. Spline graph of percent of terminals with heliothine eggs representing both seasonal and long term egg population trend towards fewer and early egg deposition. Data include both non-Bt and Bt-cotton.

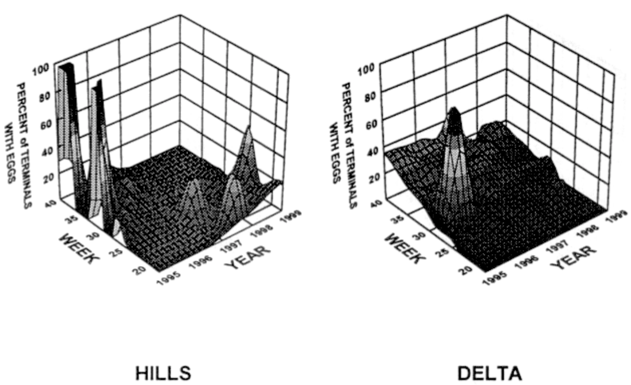

Figure 2. Spline graph of percent of terminals with heliothine eggs representing both seasonal and long term egg population trend towards fewer and early egg deposition, particularly in the hill section of Mississippi. The budworm epizootic of 1995 is clearly evident and is a source of bias for interpretation of trends including that date. Data include both non-Bt and Bt-cotton.

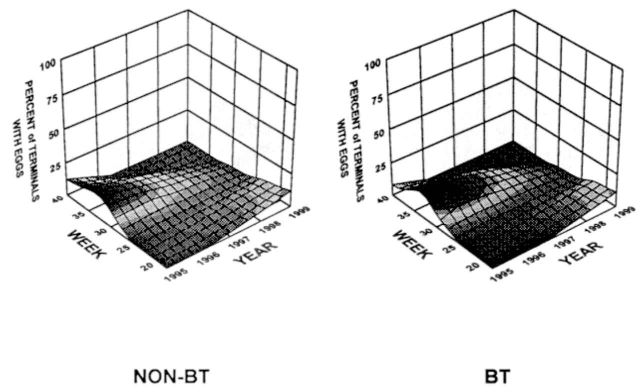

Figure 3. Spline graphs of percent of terminals with heliothine eggs representing both seasonal and long term egg population on non-Bt and Bt-cotton from all locations of the study. Distribution appears nearly identical within and throughout the study.

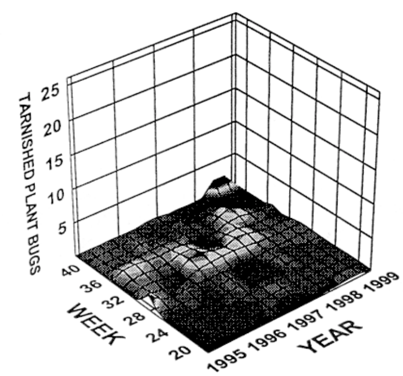

Figure 4. Spline graph of mean sample results for tarnished plant bug. Tarnished plant bug is primarily a mid- to late-season pest in this study. Data include both non-Bt and Bt-cotton and all locations in the study.

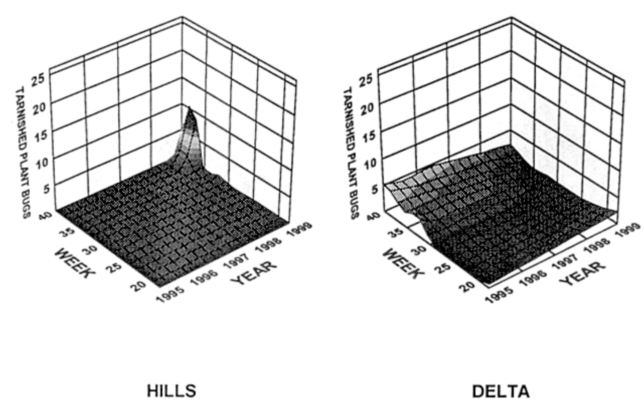

Figure 5. Spline graph of tarnished plant bug sampling results representing both seasonal and long term distribution in the hills and delta of Mississippi. Data include both non-Bt and Bt-cotton.

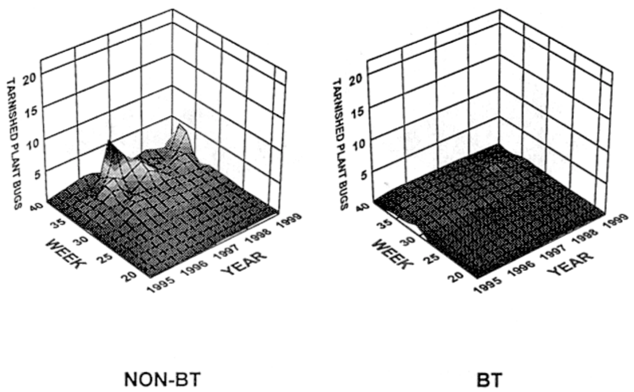

Figure 6. Spline graph of tarnished plant bug sampling results representing both seasonal and long term distribution in the delta of Mississippi on non-Bt and Bt-cotton.

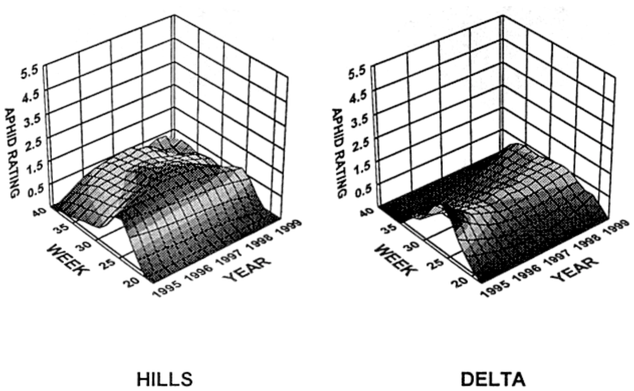

Figure 7. Spline graphs of aphid ratings combining results from non-Bt and Bt-cotton in the hills and delta of Mississippi.

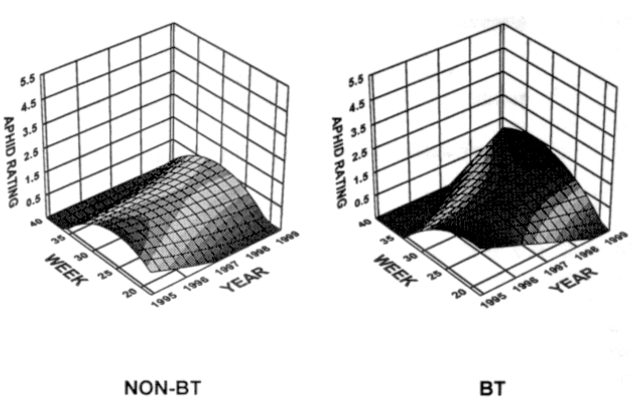

Figure 8. Spline graphs of aphid ratings combining results from all locations in the study from non-Bt and Bt cotton.

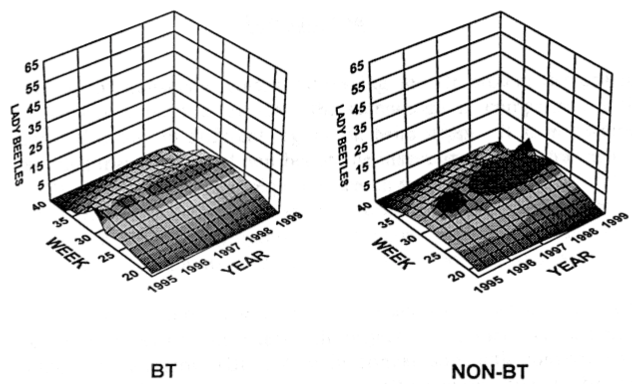

Figure 9. Spline graphs of lady beetle distribution over seasonal and annual time on non-Bt and Bt-cotton utilizing combined results from all locations in the study.

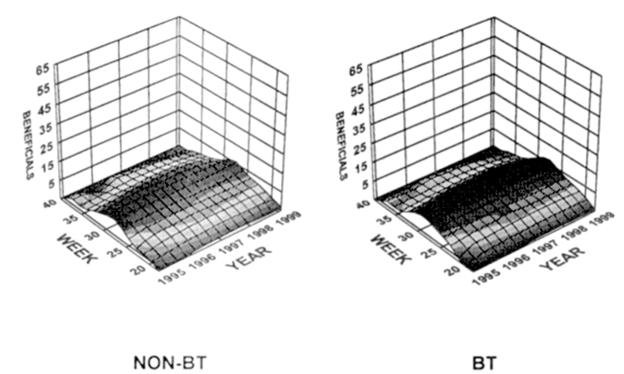

Figure 10. Spline graphs of combined beneficial insect distribution over seasonal and annual time.