COMPARISON OF COSTS AND RETURNS ASSOCIATED WITH *HELIOTHIS* RESISTANT *Bt* COTTON TO NON-RESISTANT VARIETIES

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Abstract

In Mississippi, tobacco budworm, *Heliothis virescens*, and bollworm, *Helicoverpa zea*, destroyed more bales of cotton than any other insect in 1995. Mississippi cotton producers, especially in the hills (eastern) area of Mississippi, suffered an unusual amount of budworm/ bollworm damage. In 1995, cotton producers in the hills of Mississippi suffered yield reductions of 23.27 percent or 101,503 bales due to budworm/ bollworm. Producers in Mississippi as a whole had yield reductions of 8.03 percent or 144,413 bales due to budworm/bollworms (Layton et al., 1996). *Bt* cotton gives producers an option to help reduce the risk of budworm/bollworm damage. Therefore, complete economic analysis must be performed to determine the viability of *Bt* as a risk management tool.

Introduction

Over 15 years ago, several companies joined a concerted effort to develop a variety of cotton capable of producing its own insecticide. The result of their effort is *Bt* cotton. Beginning in 1996, producers have the opportunity to purchase *Bt* cotton seed and commercially produce transgenic *Bt* cotton. Monsanto is the first company to register and market *Bt* cotton. Monsanto received government registration for *Bt* cotton in 1995 after six years of extensive field trials. Monsanto markets *Bt* cotton under the trade name of Bollgard™ (Deaton, 1996).

Although *Bt* cotton has proven effective as a means of controlling tobacco budworm and bollworm, producers are concerned about the costs and returns of *Bt* in relation to non-*Bt* varieties. Many estimates have been made as to how much *Bt* cotton will save producers in insecticide costs by controlling budworm and bollworm. One *Bt* cotton field trial in Tallahatchie and Washington counties in Mississippi found savings in insecticide costs to be $82.25 per acre in Washington county and $73.63 per acre in Tallahatchie county (Davis et al., 1995). Another study concluded *Bt* cotton could increase profits by $12.53, $41.01, or $79.12 per acre given low, normal, or high budworm/bollworm infestation levels (Shaunak, 1995). However, spraying for late season pests such as budworm and bollworm also inadvertently controls other pests such as boll weevil and plant bugs (Layton, 1996). Therefore, complete economic analysis of *Bt* cotton is necessary to determine the true economic benefit, if any, to producers. Previous research has focused only on the reduced costs of insecticide applications and the savings provided therein. In contrast, this research encompasses all practices involved in producing cotton including tillage, insecticide and herbicide applications, harvest cost, and labor costs. Also, this study includes any yield advantages *Bt* cotton may offer.

Objective

The general objective of this study is to determine the total economic benefit of *Bt* cotton in relation to non-*Bt* cotton to Mississippi cotton producers. Specific objectives include determining the reduction in total production cost associated with *Bt* cotton, production cost differences between *Bt* and non-*Bt* cotton, and a comparison of total costs and returns of *Bt* and non-*Bt* cotton. In 1995, the research focused on field trials located throughout the state. In 1996, the research focused on the hill section of Mississippi, east of U.S. Interstate 55.

Data Sources and Methods

In 1995, entomologists from Mississippi State University Entomology Department and Mississippi State Delta Research Station conducted experiments at five locations (Madison, Yazoo, Leflore, Lee, and Tallahatchie Counties) to examine the effectiveness of several different insect management practices, of which, one option was *Bt* cotton. After the 1995 harvest, complete production data was gathered on a total of nine *Bt* cotton plots and 24 non-*Bt* cotton plots. All *Bt* plots were treated for insects as prescribed in the Mississippi Cotton Insect Control Guide. Non-*Bt* plots were treated for insects in one of four ways: plots were sprayed as prescribed in the Mississippi Cotton Insect Control Guide; plots were sprayed early with a pyrethroid for plant bugs and thereafter according to the Mississippi Cotton Insect Control Guide; plots were treated for plant bugs with an early application of Orthene and thereafter according to the Mississippi Cotton Insect Control Guide; or insect control measures were prescribed by a consultant. Varieties compared in the study were Nucotn 33 (*Bt* cotton), Delta & Pine Land 5415, and grower chosen varieties which included Suregrow 125, Stoneville 132, Hartz 1244, LA887, and Delta & Pine Land 50. Production and yield data for all plots were collected and entered into Mississippi State Budget Generator computer software to develop complete enterprise budgets for each field in the study. Budget data was then entered into a spreadsheet format for analysis.

In 1996, cotton producer lists were obtained from county extension agents for counties to be surveyed. Counties to be surveyed were those counties that are in the hill area of Mississippi, the area generally east of Interstate 55. These lists were sorted by the county agents according to

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producers who grew *Bt* cotton and those who did not. The number of surveys taken in each county was determined by the percentage of cotton acres in each county (as a percentage of total cotton acres in the 1995 boll weevil eradication zone or outside of the erad zone depending on the location of the county). Producers were contacted and interviewed individually to collect their production data for a *Bt* cotton field and a non-*Bt*, or refuge, field depending on the percentage of the farm planted to *Bt* cotton. For farms that chose the refuge option of planting 4 acres of non-*Bt* cotton for each 100 acres of *Bt* cotton, only a refuge field that was not treated for bollworm/budworm was available for surveying. Like the data collected in 1995, the survey data was entered into the Mississippi State Budget Generator to develop complete enterprise budgets for each field. The budget data was converted to a spreadsheet format for analysis.

Results

Since the two data sets were obtained by different methods, test plot data and survey data, results will not be compared between the two years. However, the results of both data sets show *Bt* cotton has an economic advantage over non-*Bt* cotton. Returns above total specified expenses for *Bt* cotton were higher than those of non-*Bt* cotton for both years. Although there was not much difference in the total cost of production of *Bt* versus non-*Bt* cotton, higher yields from *Bt* cotton produced significant differences in net returns from *Bt* and non- *Bt* cotton. Table 1 and Table 2 show a summary of estimated per acre costs and returns for *Bt* and non-*Bt* cotton respectively for 1995. Tables 3, 4, and 5 show a summary of estimated per acre costs and returns for *Bt*, non-*Bt* cotton treated for budworm/bollworm, and non-*Bt* cotton not treated for bollworm respectively for 1996. Throughout the following discussion of results, "net returns" refers to returns to land, equipment, and general farm overhead.

1995 Field Test Plots

Economic analysis of *Bt* cotton and non-*Bt* cotton budgets generated from 1995 field test plot data showed net returns above total specified expenses (net returns), to vary widely from field to field. In the 1995 research field test plots, net returns for *Bt* plots varied from a low of $27.05 per acre to a high of $270.07 per acre. The average net return for the 1995 *Bt* test plots was $156.81 per acre. Per acre net returns on non-*Bt* fields ranged from -$212.20 to a positive return of $236.82 in 1995 test plots. The average net return per acre for non-*Bt* plots was $61.98. The difference between average net returns was $94.83 per acre more for *Bt* plots versus non-*Bt* plots in 1995. Yields for *Bt* were 118 pounds of lint per acre better than the average yield of the non-*Bt* fields. *Bt* plots yielded an average of 845 pounds of lint per acre in 1995 while non-*Bt* plots averaged 727 pounds of lint per acre. The higher yields increased revenue from *Bt* plots by an average of $79.20 per acre over non-*Bt* plots. The average total income per acre, including revenue from seed, was $567.09 for *Bt* and $487.89 for other varieties.

The economic advantage *Bt* cotton has over other varieties is rooted in the technology it possesses which enables *Bt* cotton to control insects, namely the tobacco budworm and bollworm, and thus increase yields by better managing pests. However, there is a charge for the technology of transgenic cotton. Producers are required to pay $32 per acre to Monsanto for *Bt* technology. In an ideal situation for the producer, this charge is less than the cost of controlling budworms and bollworms without *Bt*. If, however, the charge is equal to or slightly greater than insecticide savings, yield improvements may supplement per acre revenue to the point that there is still an advantage to plant *Bt* cotton.

The 1995 test plots being analyzed in this study showed a savings in the cost of insecticide applications including the $32 charge for *Bt* technology. Plus, the added benefit of increased yields was observed. Total insect control costs for *Bt* cotton averaged $32.58 per acre. Non-*Bt* plots averaged $91.13 per acre for total insect control costs, a difference of $58.55 per acre in favor of *Bt*. Since *Bt* technology is an insect control measure and $32 is charged to producers specifically for *Bt* technology, it is necessary to include the technology charge in analysis of insect control costs. The true savings in insect control cost was $26.55 per acre in 1995 test plots when the technology charge is included.

1996 Survey Results

Results of the 1996 survey showed *Bt* cotton to hold an economic advantage over other varieties. However, some of the savings in insecticide costs observed in the 1995 field test plots were not observed from the 1996 survey. Per acre net returns from surveyed 1996 *Bt* fields ranged from -$7.81 to $561.83 per acre. The average net return for surveyed *Bt* fields was $246.30 per acre in 1996. Per acre net returns for surveyed non-*Bt* fields ranged from a loss of $53.38 to a positive return of $628.87 in 1996. The average net return per acre of surveyed non-*Bt* fields was $230.08 for 1996. In 1996, average net returns for *Bt* cotton were $16.23 per acre higher than non-*Bt* fields. The 1996 survey average total income per acre for *Bt* cotton was $686.95 and $653.65 per acre for non-*Bt* varieties, $33.30 per acre less than *Bt*.

Data from the 1996 survey showed per acre insect control cost in *Bt* cotton averaged $31.13. The per acre average insect control cost for surveyed non-*Bt* fields in 1996 was $49.29, $18.16 per acre more than *Bt* fields. The non-*Bt* average insect control cost excludes those fields that were refuge acres that could not be sprayed for budworm or bollworm. When the charge for technology is added to the average insect control cost for *Bt* cotton in 1996, the total cost for insect control is $63.13 per acre, which is $13.84 per acre more than insect control costs for non-*Bt* varieties.

However, this increased cost is compensated for by increased yields in *Bt* cotton. Surveyed non-*Bt* fields had an average yield of 948 pounds of lint per acre. Surveyed 1996 *Bt* fields had an average yield of 995 pounds on lint per acre, 47 pounds of lint more than non-*Bt* fields. On average, higher yields from *Bt* cotton in the 1996 survey increased per acre revenue of *Bt* cotton by $28.20.

Refuge

The costs represented in Table 3 do not represent the total economic costs of growing *Bt* cotton. Producers who grew *Bt* cotton had two refuge options in 1996. One option required producers to plant 20 acres of non-*Bt* cotton for every 100 acres of *Bt* cotton planted. This refuge may be sprayed for budworm and/or bollworm with any insecticide besides a *Bt* foliar spray. The other option was to plant 4 acres of non-*Bt* cotton for every 100 acres of *Bt* cotton planted. This refuge could not be sprayed with any insecticide targeted at budworm or bollworm (Monsanto, 1996). Therefore, the cost and returns for producing either an additional .2 acres of non-*Bt* cotton or .04 acres of non-*Bt* cotton, depending on the refuge option chosen, must be included in a complete budget for an acre of *Bt* cotton. Therefore, if the first refuge option listed above were chosen, for each acre of *Bt* cotton planted, .2 acres of non-*Bt* cotton must be planted for a total of 83⅓% of one acre in *Bt* cotton and 16⅔% of an acre in another variety. If the refuge option which does not allow for control of budworm/bollworm is chosen, for each acre of *Bt* cotton planted, an additional .04 acres of another variety must be planted. This refuge option allows for 96.2% of a producers total cotton acreage to be planted to *Bt* cotton and 3.8% planted in some other variety. Since a refuge for the test plots was not required in 1995, the costs and returns for refuge acres were not available to be used in adjusting the research test plot results.

In the 1996 survey, data were collected for refuge fields in addition to *Bt* fields. The average per acre net return for surveyed refuge fields that could be sprayed for budworm/bollworm was $230.08. For surveyed refuge acres that could not be sprayed for bollworm/budworm, the average per acre net return was $120.60. If these returns from refuge acres are incorporated into the total returns for *Bt* cotton, the average per acre total net returns for a producer who chose the 20 acre refuge for 100 acres of *Bt* cotton is $241.24 per acre. For the other refuge option (4 acres of refuge for 100 acres of *Bt* cotton), the average total net returns per acre is $241.52. Both of these adjusted average net returns are lower than the per acre average net return for *Bt* cotton alone, $246.30. However, the adjusted values which incorporate the costs and returns of the required refuge acres are a more accurate reflection of the actual net returns of *Bt* cotton. With the costs and returns for the refuge acres included, *Bt* cotton had net returns about $11.17 per acre more than non-*Bt* varieties. These results are evidence that no matter the refuge option chosen, *Bt* cotton will improve net returns to producers. According to the data gathered from the survey, there is only $.28 per acre difference between the two refuge options.

Conclusions

Economic analysis of complete enterprise budgets for *Bt* cotton and non-*Bt* cotton indicate, for crop years 1995 and 1996, *Bt* cotton had higher returns per acre than non-*Bt* cotton. The actual savings for *Bt* cotton will vary from year to year depending on the level of insect infestation and the number of sprays required in a given year. In 1995, budworm/bollworm infestations were relatively heavy while in 1996, infestations tended to be light. Varying levels of infestation will affect the amount of potential savings from *Bt* cotton. Producers should view *Bt* cotton and the charge for transgenic technology as a risk management option. Although savings from *Bt* cotton will vary depending on the level of insect infestation in a given year, *Bt* cotton appears to protect yields in the event of insect infestation. It is important to note at this point, only two years of data is available for this study and the two data sets are from different sources making it difficult to compare the results. However, with the data that is available, *Bt* cotton appears to produce higher net returns for producers than the average of other varieties.

References

Davis, M. K., M.B. Layton, J. D. Verner, and Greg Little. "Field Evaluation of *Bt*-Transgenic Cotton in the Mississippi Delta." 1995 Proceedings Beltwide Cotton Conferences. Volume 2. National Cotton Council, Memphis, TN. pp 771-775.

Deaton, W. R. 1996. Background and Performance - Bt Cotton. Proceedings Beltwide Cotton Conferences. 157.

Layton, Blake. 1996. Anticipated Changes in Mid-South Insect Management Resulting From Adoption of Bt-Transgenic Cotton. Proceedings Beltwide Cotton Conferences. 160-161.

Layton, Blake. 1996. Cotton Insect Losses 1995. Proceedings Beltwide Cotton Conference. 670-689.

Monsanto. "1996 License For Monsanto Gene Technology in Cotton (Section II Part B)."

Shaunak, Raj K. Economic Implications of Adopting Genetically Engineered Heliothis Resistant *Bt* Cotton Cultivars in Mississippi. Doctoral dissertation. Mississippi State University. September 1995.

Table 1. Summary of average costs and returns for *Bt* plots in 1995.

Item	*Bt* cotton
	$ per acre
INCOME	
Cotton Seed	60.35
Cotton Lint	506.73
TOTAL INCOME*	567.08
DIRECT EXPENSES	
Custom	82.94
Harvest Aid	14.55
Fertilizer	32.09
Herbicide	33.26
Insecticide	32.58
Fungicide	10.46
Haul	16.89
Seed	8.93
Other (per acre *Bt* technology charge)	32.00
Growth Regulator	9.61
Operator Labor	12.68
Hand Labor	1.02
Unallocated Labor	11.41
Diesel Fuel	10.34
Repair & Maintenance	31.14
Interest on Op. Cap.	11.49
TOTAL DIRECT EXPENSES*	344.42
RETURNS ABOVE DIRECT EXPENSES*	222.67
TOTAL FIXED EXPENSES*	65.86
TOTAL SPECIFIED EXPENSES*	410.27
RETURNS ABOVE TOTAL SPECIFIED EXPENSES*	156.81

* Does not include costs and returns for refuge acres.

Table 2. Summary of average costs and returns for non-*Bt* plots in 1995.

Item	Non-*Bt* cotton
	$ per acre
INCOME	
Cotton Seed	51.42
Cotton Lint	436.48
TOTAL INCOME	487.89
DIRECT EXPENSES	
Custom	85.85
Harvest Aid	13.03
Fertilizer	23.95
Herbicide	35.60
Insecticide	91.13
Fungicide	2.61
Haul	14.55
Seed	8.97
Other	0
Growth Regulator	11.21
Operator Labor	12.32
Hand Labor	.81
Unallocated Labor	11.09
Diesel Fuel	10.12
Repair & Maintenance	29.85
Interest on Op. Cap.	11.29
TOTAL DIRECT EXPENSES	362.38
RETURNS ABOVE DIRECT EXPENSES	125.51
TOTAL FIXED EXPENSES	63.53
TOTAL SPECIFIED EXPENSES	425.91
RETURNS ABOVE TOTAL SPECIFIED EXPENSES	61.98

Table 3. Summary of average costs and returns for *Bt* cotton fields surveyed in 1996

Item	*Bt* cotton
	$ per acre
INCOME	
Cotton Seed	89.48
Cotton Lint	597.47
TOTAL INCOME*	686.95
DIRECT EXPENSES	
Custom	79.70
Harvest Aid	12.12
Fertilizer	42.94
Herbicide	33.24
Insecticide	31.13
Fungicide	6.00
Haul	14.25
Seed	10.16
Other (*Bt* charge and BWEP)	34.01
Growth Regulator	5.88
Operator Labor	17.36
Hand Labor	3.34
Unallocated Labor	15.62
Diesel Fuel	13.45
Repair & Maintenance	39.59
Interest on Op. Cap.	11.21
TOTAL DIRECT EXPENSES*	358.50
RETURNS ABOVE DIRECT EXPENSES*	328.45
TOTAL FIXED EXPENSES*	82.14
TOTAL SPECIFIED EXPENSES*	440.65
RETURNS ABOVE TOTAL SPECIFIED EXPENSES*	246.30

* Does not include costs and returns for refuge acres

Table 4. Summary of average costs and returns for non-*Bt* cotton fields surveyed in 1996.

Item	*Bt* cotton
	$ per acre
INCOME	
Cotton Seed	84.78
Cotton Lint	568.87
TOTAL INCOME	653.65
DIRECT EXPENSES	
Custom	77.42
Harvest Aid	15.49
Fertilizer	41.91
Herbicide	31.29
Insecticide	49.29
Fungicide	6.41
Haul	11.71
Seed	8.86
Other (*Bt* charge and BWEP)	2.50
Growth Regulator	5.36
Operator Labor	17.50
Hand Labor	3.39
Unallocated Labor	15.75
Diesel Fuel	13.63
Repair & Maintenance	39.24
Interest on Op. Cap.	10.11
TOTAL DIRECT EXPENSES	341.79
RETURNS ABOVE DIRECT EXPENSES	311.86
TOTAL FIXED EXPENSES	81.78
TOTAL SPECIFIED EXPENSES	423.58
RETURNS ABOVE TOTAL SPECIFIED EXPENSES	230.08

Table 5. Summary of average costs and returns for non-*Bt* cotton fields not treated for budworm/bollworm surveyed in 1996.

Item	*Bt* cotton
	$ per acre
INCOME	
Cotton Seed	64.20
Cotton Lint	429.03
TOTAL INCOME	493.24
DIRECT EXPENSES	
Custom	62.44
Harvest Aid	11.14
Fertilizer	39.63
Herbicide	35.84
Insecticide	26.68
Fungicide	5.03
Haul	11.90
Seed	8.60
Other (*Bt* charge and BWEP)	1.07
Growth Regulator	6.21
Operator Labor	16.64
Hand Labor	3.17
Unallocated Labor	14.97
Diesel Fuel	12.72
Repair & Maintenance	37.71
Interest on Op. Cap.	9.18
TOTAL DIRECT EXPENSES	294.85
RETURNS ABOVE DIRECT EXPENSES	198.39
TOTAL FIXED EXPENSES	77.78
TOTAL SPECIFIED EXPENSES	372.64
RETURNS ABOVE TOTAL SPECIFIED EXPENSES	120.60