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RESEARCH ARTICLE :

An economic issue in biotechnology- the case of Bt cotton in Tamil Nadu

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SUMMARY : A study on the economic analysis of Bt cotton and Non Bt cotton was conducted in Salem and Perambalur districts of Tamil Nadu. The comparative economics of Bt cotton and non Bt cotton showed that that majority of Non Bt farmers (37%) expected yield <10 quintals/acre. But both Bt farmers, (Mahyco Bt farmers) got a yield of >13quintals /acre (49%) and (Rasi Bt farmers yield of >13 quintals/acre (61%). The reason for preferring of Bt cotton by the sample farmers by category wise was found that higher yield and higher productivity was ranked as 1st reason. Non Bt farmers reported that higher pest incidence of American bollworms (23.33%) followed by pink bollworm (31.66%) with more number of sprays for pest and diseases resulted in the high cost of cultivation and need more water requirement and susceptibility to pest and diseases were the major problems reported by the Non Bt farmers. Bt cultivated farmers obtained an additional income of Rs. 34,960.77/acre.

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KEY WORDS :
Bt cotton, Non-Bt cotton, Economic analysis

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BACKGROUND AND OBJECTIVES

Cotton is one of the important commercial crops playing a vital role in the national economy in both rural and the urban sectors and globally, India is the third largest producer of cotton, producing around 2.86 million tones on 9 million ha, representing around 15 per cent of global production. It constitutes nearly 70 per cent of the raw material for the Indian textile industry, which earned about Rs.25000 crores of foreign exchange during 2004-05. Yet areas planted to cotton are on the decline, as the returns to farmers shrink with rising costs of inputs and declining world market prices. Cotton being a relatively long duration crop, with extended squaring, flowering and fruiting stages, had been a paradise for wide range of insect pests. Cotton pest complex includes over 160 species of insects, with 15 recognized as key pests. About 50 per cent of the pesticides used in our country, amounting to Rs.16 billion were sprayed on cotton for controlling various pests during the year 2000. Expenditure on bollworm control alone amounted to Rs.11 billion during 2001.Sivakumar,K.,(2002) In the southern state of Andhra Pradesh many cotton farmers committed suicide due to crop failure and losses and it had become a regular feature in

recent years. Rajack. A.,(2000) Integrated pest management has emerged as an important strategy to minimize the risks and problems associated with various pests and diseases in cotton, a recommended practice for cotton farmers throughout the world. Molecular potency *of Bacillus thuringiencis* (Bt) toxin was higher than other chemical pesticides, *viz.,* 300 times higher than synthetic pyrethroids, 8,00,000 times stronger than organophosphates (Feitelson *et al*., 1992).

According to Dhar (2002), the Bt cotton is an insect resistant transgenic crop with a gene (Cry1a, in the case of the Monsanto/Mahyco application) from the bacterium, *Bacillus thuringiensis*, conferring some degree of resistance to *Lepidopteran* pests of cotton, notably the potentially devastating bollworm. Genetically modified cotton is of growing importance with some 5.3 million ha or 16 per cent of the 34 million ha of cotton worldwide being either round-up ready or Bt or some combination. Much damage derives from *Lepidopteran* pests, notably bollworms, including the American bollworm, *Helicoverpa armigera*, and it is these that are the targets of Bt toxins which act by blocking mid-gut receptors in such insects resulting in loss of appetite and subsequent death. If genetically engineered cotton can reduce such pesticide inputs applied to combat *Lepidopteran* pests, even with a premium being paid for the seed, it is argued, this will have multiple benefits – for the farmers, the agricultural economy and the environment.

This study is precisely an attempt in that direction with the following specific objective of examining the comparative economics of Bt and non-Bt cotton cultivation in cotton growing areas (Salem and Perambalur districts) of Tamil Nadu.

RESOURCES AND METHODS

The districts namely Salem and Perambalur where in the cotton is being cultivated around 18,265 ha and 22,686 ha, respectively were taken to conduct the study on the comparative economics of Bt cotton and Non-Bt cotton farmers because these two districts topped the list of districts ranked according to the total area under Bt cotton cultivation. Three-stage sampling procedure was adopted for the identification of the study area and respondents. The list of Bt cotton farmers were obtained from Bt cotton seed companies *viz.*, Mahyco-Monsanto and Rasi Seeds. Using the village-wise list of farmers obtain from the companies, one village having maximum number of Bt cotton adopters was selected from each of the four taluks. From each of the four villages,19 farmers adopting Bt cotton and 11 farmers cultivating (RCH2, MCU-5, Varalakshmi etc.,) non-Bt cotton varieties were selected so that the final sample contained 76 Bt cotton farmers and 44 non-Bt cotton farmers 120 sample farmers in all.

Method of data collection and analysis :

A structured, pre-tested questionnaire was used for collection of data from both Bt and non-Bt farmers. All the data were collected by personnel interview with the respondents. The data collected from the sample cotton growers included the general particulars like age, education level, farming experience, awareness about different Bt and non-Bt cotton farmers, sources of information on Bt cotton, reasons for cultivating Bt cotton, farmers opinion about the performance of Bt cotton and problems faced in cultivation of Bt cotton. Detailed data on various inputs used in cotton cultivation and their costs were also collected for the agricultural year 2004-05. As a prelude to the interview, the sample farmers were briefed about the scope and importance of this study, so as to get maximum possible realistic data.

Production functional analysis :

Production function analysis was employed to analyze the yield differences between Bt and non-Bt cotton varieties in a more systematic manner. It is also useful to estimate the yield responses of Bt and non-Bt cotton varieties to various factors of production. Due to its wide usage in the analysis of agricultural production systems and the simple and straight forward manner in which the elasticities of production could be obtained, the Cobb-Douglas type of production function has been used in this study. The particular form of the estimated equation is given below:

$$\ln Y = {}_0 + {}_1 \ln X_1 + {}_2 \ln X_2 + {}_3 \ln X_3 + {}_4 \ln X_4 + {}_5 \ln X_5 + {}_6 D_1 \ln {}_7 D_2 + \text{error}$$

where,

Y = Cotton yield (kg/ha)

β_o, $\beta_{1,....}$ β_7 = Regression co-efficients to be estimated

X_1 = Human labour used (mandays/ha)

X_2 = Machine hours used (hours/ha)

X_3 = Quantity of potassic fertilizer used (kg/ha)

X_4 = Plant protection chemicals used (litres/ha)

X_5 = Number of irrigations

D_1 = Dummy for Monsanto Bt, which takes a value of 1, if the variety is Monsanto Bt ,and 0 otherwise

D_2 = Dummy for Rasi Bt which takes a value of 1, if the variety is Rasi Bt, and 0 otherwise.

OBSERVATIONS AND ANALYSIS

The results obtained from the present study as well as discussions have been summarized under following heads :

Pest and disease control :

The results of the pest and disease control for Bt and non Bt cotton (Table.1) showed that majority of the farmers sprayed less than eight times during the winter season and less than six times during summer season. Number of spraying was much lower in Bt cotton than in non-Bt cotton. Close to 70 per cent of the Bt cotton farmers had less than eight sprays while more than 70 per cent of their non-Bt counterparts sprayed more than 13 times during winter. Number of sprayings was comparatively lower among Rasi Bt farmers than the Mahyco Bt farmers.

On the whole, majority of the farmers applied less than six sprays in summer. More than 50 per cent of the Mahyco Bt farmers and more than 60 per cent of the Rasi Bt farmers applied six sprayings during summer. However, about 70 per cent of the non-Bt farmers sprayed for more than 11 times during the summer season. The wide variation in number of sprays during different seasons could be attributed to the variation in intensity of pest and diseases between seasons.

Expenditure on pest and disease control :

The amount spent by the farmers for spraying various chemicals in the study area were obtained and analyzed. The results are presented in Table 2.

There is a perceptible difference between the non-Bt and Bt cotton farmers in respect to the expenditure on pest and disease control measures. More than 90 per cent of the Bt cotton growers spent an amount of less than Rs.1250 on pest and disease control whereas about

Table 1 : Frequency distribution of farmers with different number of pesticide sprays

Sr. No.	Number of spray	Mahyco Bt	Rasi Bt	All Bt	Non-Bt
	Winter				
1.	< 8	20 (60.60)	32 (74.41)	52 (68.42)	2 (4.54)
2.	8-10	6 (18.18)	6 (13.95)	12 (15.79)	3 (6.81)
3.	11-13	5 (15.15)	4 (9.30)	9 (11.84)	7 (15.90)
4.	>13	2 (6.06)	1 (2.32)	3 (3.95)	32 (72.72)
5.	Average number of sprays	8.39	5.32	14.65	15.13
	Total number of farmers	33 (100)	43 (100)	76 (100)	44 (100)
	Summer				
1.	<6	17 (51.51)	26 (60.45)	43 (56.58)	1 (2.27)
2.	6-8	9 (27.27)	12 (27.90)	21 (27.63)	3 (6.81)
3.	9-11	4 (12.12)	4 (9.30)	8 (10.53)	9 (20.45)
4.	>11	3 (9.09)	1 (2.32)	4 (5.26)	31(70.45)
5.	Average number of sprays	6.75	5.13	11.88	12.63
	Total number of farmers	33 (100)	43 (100)	76 (100)	44 (100)

Figures in parentheses indicate percentage to the total

Table 2 : Frequency distribution of farmers based on cost of chemical spraying for pest and disease control

Sr. No.	Average expenditure on pesticides (Rs./ha)	Mahyco Bt	Rasi Bt	All Bt	Non Bt
1.	< 1250	29 (87.88)	37(86.04)	71 (93.42)	0 (0.00)
2.	1250-2500	4 (12.12)	6 (13.95)	5 (6.58)	5 (11.36)
3.	2500-5000	0 (0)	0 (0)	0 (0)	29 (65.90)
4.	> 5000	0 (0)	0 (0)	0 (0)	10 (22.72)
5.	Average cost of pest control	1052	1655	1396	6340
	Total number of farmers	33 (100.00)	43 (100.00)	76 (100.00)	44 (100.00)

Figures in parentheses indicate percentage to the total

two-third of non-Bt cotton growers spent Rs.2500 to Rs.5000 on pest control, and about 23 per cent of the non-Bt farmers spent more than Rs.5000 per ha.

Yield performance of Bt and non-Bt cotton :

The yield performance of Bt cotton and non-Bt cotton were analysed and the results are presented in Table 3.

It could be observed from Table 3 that majority of non-Bt farmers (98 %) obtained less than 25 quintals/ha of kapas yield. Majority of the Mahyco Bt and Rasi Bt farmers a kapas yield of more than 33 quintals/ha. However, a higher proportion of Rasi Bt farmers obtained yield of more than 33 quintals/ ha (60 %) as compared to Mahyco Bt farmers (42 %).

Overall performance of Bt cotton – Feedback from the field :

Feedback is a basic component of self-regulating system. Feedback enables the system or the producer of a particular product to correct for its own malfunctioning or for changing the product features. The farmers will adopt a new technology only after observing its performance in field conditions and hence their opinion about Bt cotton was collected and the details are presented in Table 4.

It could be inferred from Table 4 that less bollworm attack emerged as important trait that was most preferred by the sample farmers. Since bollworm incidence was the major problem faced by farmers cultivating cotton, it could attract the attention of the farmers immediately. This advantage can be projected while promoting the product. Besides less incidence of bollworm and the consequent reduction in cost of pest control, more yield and higher profitability were ranked as second and third important features of Bt cotton.

Economics of Bt versus non-Bt cotton :

The costs and returns of Bt and non-Bt cotton cultivation are provided in Table. The information provided in the table reveal that human labour was the major component of cost of inputs applied for cotton production. Its share in total costs was about 45 per cent in Bt cotton and 40 per cent in non-Bt cotton. This is followed by fertilizers accounting for about 18 per cent of the total cost of cotton cultivation. Cost of machinery used for field operations accounted for about 10 per cent in all categories of farms. Cost of pesticides has shown a significant difference between Bt and non-Bt farmers in terms of absolute amount spent on pest control as well as in terms of its relative share in total cost of all inputs. The actual expenditure on pesticides was Rs. 1400 for Bt cotton while it was more than 300 per cent higher at Rs. 6350 for non-Bt cotton. The share of pesticides in total cost was less than five per cent in Bt cotton, while it was close to one-fifth of total costs of inputs used for non-Bt cotton.

The share of seed cost to total input costs was about 14 per cent in the case of Bt cotton whereas it was less than seven per cent in the case of non-Bt cotton. However, the savings in pesticide costs for Bt cotton has been found to more than offset the higher seed cost for Bt cotton. Hence, the total cost of all inputs used in non-Bt cotton was about 10 per cent higher (Rs. 33686)

Table 3 : Frequency distribution of farmers based on yield of Bt cotton and non-Bt cotton

Sr. No.	Yield of cotton (Quintals per ha)	Mahyco Bt	Rasi Bt	Non Bt
1.	< 25	0 (0.00)	1 (2.32)	43 (97.72)
2.	25-30	3 (9.09)	6 (13.95)	1 (2.27)
3.	30-33	14 (42.42)	10 (23.25)	0 (0.00)
4.	> 33.00	16 (48.48)	26 (60.46)	0 (0.00)
5.	Average yield	33.44	33.62	20.33
	Total	33 (100)	43 (100)	44 (100)

Figures in parentheses indicate percentage to total

Table 4 : Farmers' opinion on Bt cotton

Sr. No.	Opinion	Numbers	Percentage
1.	Less bollworm attack	74	97.36
2.	More yield	72	94.73
3.	Require less number of spray	62	81.57
4.	Germination percentage is more	34	44.73

than the total cost of inputs used in Bt cotton cultivation (Rs. 30895). The average kapas yield of Bt cotton was much higher at 33 quintals per ha as compared to non-Bt cotton which recorded an yield of only 20 quintals per ha. Hence, cultivation of Bt cotton has resulted in win-win situation for the farmers with low pest incidence and low cost of pest control together with higher yield and better quality of the output. Because of better quality of the kapas the Bt cotton fetched a higher price in the market than non-Bt cotton. Consequently, the gross return from Bt cultivation was almost twice that from non-Bt cotton and the gross margin from Bt cotton cultivation (about Rs.45000) was more than six times higher than the gross margin from non-Bt cotton (about Rs.7000).

Production function analysis :

To capture the yield response of cotton and the yield effect due to Bt seed more precisely, production function analysis was carried out. Following the convention and the straightforward way in which the elasticities of production could be obtained, the Cobb-Douglas production has been used in the present study and the results are presented in Table 6.

Except irrigation all the variables included in the analysis were found to be statistically significant in explaining the yield variability of cotton. Irrigation was not significant probably because all the farmers irrigated to the recommended level and there was not much variation in number of irrigation across farms. Plant protection chemicals had negative effect on yield probably

Table 5 : Cost and returns of Bt and non-Bt cotton cultivation by sample farmers (Rs/ha)

Sr. No.	Particulars	Rasi Bt (43)	Mahyco Bt (33)	All Bt (76)	Non Bt (44)
1.	Human labour	12743 (43.36)	15914 (48.46)	14121 (45.71)	13182 (39.13)
2.	Bullock labour	121 (0.41)	269 (0.82)	185 (0.60)	385 (1.14)
3.	Machine labour	3110 (10.58)	3149 (9.59)	3127 (10.12)	2996 (8.89)
4.	Seeds	4219 (14.36)	4448 (13.54)	4320 (13.98)	2223 (6.60)
5.	Manures	1601(5.45)	1460 (4.45)	1539 (4.98)	1991 (5.91)
6.	Fertilizer nutrients	5404 (18.39)	5965 (18.16)	5649 (18.28)	6089 (18.08)
7.	Plant protection chemicals	1655 (5.63)	1052 (3.20)	1396 (4.52)	6340 (18.82)
8.	Irrigation cost	536 (1.82)	585 (1.78)	558 (1.81)	479 (1.42)
10.	Total cost (Rs.)	29388 (100)	32844 (100)	30895 (100)	33686 (100)
11.	Total yield (quintal)	33.62	33.44	33.52	20.33
12.	Price (Rs./quintal)	2205	2345	2284	1993
13.	Gross return (Rs.)	74125	78426	76555	40514
14.	Gross margin (Rs.)	44737	45582	45660	6828

Figures in parentheses indicate percentage to total

Table 6 : Results of cobb-douglas production function analysis for cotton

Variable	Estimated co-efficient	Standard error	t-values
Constant	0.6434	0.4575	1.407
Human labour	0.3672***	0.0955	3.846
Machine labour	0.0955 ***	0.0395	4.954
Fertilizer-Potash	0.0374**	0.0817	2.007
Plant protection chemicals	- 0.0422***	0.00689	6.116
Irrigation	0.0409	0.0261	1.569
Dummy for Rasi Bt cotton	0.1063**	0.0595	1.786
Dummy for Mahyco Bt cotton	0.3089***	0.385	8.029
R^2	0.9412		
Adjusted R^2	0.9376		
F-value	256.20		
N	120		

Dependent variable: Cotton yield (quintals / ha)
*, ** and *** indicate significance of values at P=0.1, 0.05 and 0.01, respectively

because farmers used excessive quantities of pesticides than the recommended levels. It is a common practice to observe farmers, especially those who cultivate cotton under irrigated conditions, using pesticides at regular intervals rather than going for need-based application. Dumping of pesticides has been resorted to by many farmers especially those cultivating non-Bt cotton without considering pest thresholds. Interestingly, the dummy for both Mahyco Bt and Rasi Bt were statistically highly significant indicating that they have significant positive yield effects as compared to the non-Bt cotton. The adjusted R-squared value of the estimated production function was 0.9376 indicating that about 94 per cent of the yield variability in cotton could be explained by the variables considered in the analysis.

Summary and Conclusion :

Reasons for preferring Bt cotton and problems in Bt cotton :

The Garret's ranking techniques revealed that higher yield and higher profitability were reported to be the top most reasons for choosing to grow Bt cotton variety followed by less pest problems and low pesticide requirement. Quality of lint and buyers' preference were ranked third and fourth important reasons, respectively for the adoption of Bt cotton.

Susceptibility to pests and diseases and the consequent requirement of high doses of pesticides were cited as main constraints by non-Bt cotton growers. Higher cost of cultivation was yet another major problem faced by cotton growers. Uncertainty in yield, and price risk were the other minor problems encountered by non-Bt cotton growers in the study region. The problems faced by Bt cotton growers are much different from non-Bt cotton growers. It could be observed from Table 3.4 that the high cost of Bt cotton seeds was the most important problem faced by the Bt cotton farmers. The cost of the non-Bt cotton seeds were less by 40-60 per cent when compare to the cost of Bt cotton seeds. Poor germination percentage and the higher incidence of pests other than boll worms were ranked as the second and third major problems in Bt cotton. The germination percentage of the Bt seeds was reported to be poor (mean score 62.25). Incidence of pests other than bollworm is high in Bt cotton (mean score 50.00).

Pest and disease control :

Number of sprays was much lower in Bt cotton than in non-Bt cotton. Close to 70 per cent of the Bt cotton farmers had less than eight sprays while more than 70 per cent of their non-Bt counterparts sprayed more than 13 times during winter. Number of sprayings was comparatively lower among Rasi Bt farmers than the Mahyco Bt farmers. On the whole, majority of the farmers applied less than six sprays in summer. More than 50 per cent of the Mahyco Bt farmers and more than 60 per cent of the Rasi Bt farmers applied six sprayings during summer. However, about 70 per cent of the non-Bt farmers sprayed for more than 11 times during the summer season. The wide variation in number of sprays during different seasons could be attributed to the variation in intensity of pest and diseases between seasons.

There has been a perceptible difference between the non-Bt and Bt cotton farmers in respect of the expenditure on pest and disease control measures. More than 90 per cent of the Bt cotton growers spent an amount of less than Rs.1250 on pest and disease control whereas about two-third of non-Bt cotton growers spent Rs.2500 to Rs.5000 on pest control, and about 23 per cent of the non-Bt farmers spent more than Rs.5000 per ha.

Yield performance of Bt and non-Bt cotton :

Majority of non-Bt farmers (98 %) obtained less than 25 quintals/ha of kapas yield. Majority of the Mahyco Bt and Rasi Bt farmers a kapas yield of more than 33 quintals/ha. However, a higher proportion of Rasi Bt farmers obtained yield of more than 33 quintals/ ha (60 %) as compared to Mahyco Bt farmers (42 %).

Economics of Bt versus non-Bt cotton :

The information provided in the table reveal that human labour was the major component of cost of inputs applied for cotton production. Its share in total costs was about 45 per cent in Bt cotton and 40 per cent in non-Bt cotton. This is followed by fertilizers accounting for about 18 per cent of the total cost of cotton cultivation. Cost of machinery used for field operations accounted for about 10 per cent in all categories of farms. Cost of pesticides has shown a significant difference between Bt and non-Bt farmers in terms of absolute amount spent on pest control as well as in terms of its relative share in total cost of all inputs. The actual expenditure on pesticides was Rs.1400 for Bt cotton while it was more than 300 per cent higher at Rs. 6350 for non-Bt cotton. The share of pesticides in total cost was less than five per cent in

Bt cotton, while it was close to one-fifth of total costs of inputs used for non-Bt cotton.

The share of seed cost to total input costs was about 14 per cent in the case of Bt cotton whereas it was less than seven per cent in the case of non-Bt cotton. However, the savings in pesticide costs for Bt cotton has been found to more than offset the higher seed cost for Bt cotton. Hence, the total cost of all inputs used in non-Bt cotton was about 10 per cent higher (Rs.33686) than the total cost of inputs used in Bt cotton cultivation (Rs. 30895). The average kapas yield of Bt cotton was much higher at 33 quintals per ha as compared to non-Bt cotton which recorded an yield of only 20 quintals per ha. Hence, cultivation of Bt cotton has resulted in win-win situation for the farmers with low pest incidence and low cost of pest control together with higher yield and better quality of the output. Because of better quality of the kapas the Bt cotton fetched a higher price in the market than non-Bt cotton. Consequently, the gross return from Bt cultivation was almost twice that from non-Bt cotton and the gross margin from Bt cotton cultivation (about Rs.45000) was more than six times higher than the gross margin from non-Bt cotton (about Rs.7000).

Impact of Bt cotton on crop yield: Production function analysis :

To capture the yield response of cotton and the yield effect due to Bt seed more precisely, production function analysis was carried out. The analysis revealed that except irrigation all the variables included in the analysis were found to be statistically significant in explaining the yield variability of cotton. Irrigation was not significant probably because all the farmers irrigated to the recommended level and there was not much variation in number of irrigation across farms. Plant protection chemicals had negative effect on yield probably because farmers used excessive quantities of pesticides than the recommended levels. It is a common practice to observe farmers, especially those who cultivate cotton under irrigated conditions using pesticides at regular intervals rather than going for need-based application. Dumping of pesticides has been resorted to by many farmers especially those cultivating non-Bt cotton without considering pest thresholds. Interestingly, the dummy for both Mahyco Bt and Rasi Bt were statistically highly significant indicating that they have significant positive yield effects as compared to the non-Bt cotton. The adjusted R-squared value of the estimated production function was 0.9376 indicating that about 94 per cent of the yield variability in cotton could be explained by the variables considered in the analysis.

Conclusions and Recommendations :

Only about one third of the non-Bt cotton farmers were not aware of Bt cotton. Surprisingly, popular media sources such as television, radio and newspapers played a very little role in creating awareness about Bt cotton. Hence, to broaden and speed up the reach and adoption of new technologies, especially the genetically modified crop varieties, these media should be effectively used. Regular programmes on the benefits and limitations focusing on their economic and environmental benefits should be carried in the mass media. As higher yield and profitability and low pest problems were cited as important factors behind preferring Bt cotton, these facts should be popularized among the farming community to increase the cotton yield and production in the state. The less number of pesticide spray in Bt cotton is likely to have lot of environmental and health benefits to the farmers and labourers. However, it has been found that almost all the farmers were not properly trained in adopting biosafety measures such as growing refugee crops so as to avoid the resistance build-up by bollworms against the Bt toxin. Therefore, the non-economic benefits and biosafety measures should be given adequate attention in the media coverage and campaigns.

High incidence of pests and disease with attendant application of high doses of chemical pesticides, labour intensive nature of cultivation and high cost of cultivation were cited as major constraints in cultivation of non-Bt cotton cultivation. However, high cost of seeds and incidence of pests and diseases other than bollworm were reported to be the major bottlenecks in Bt cotton cultivation. Therefore, continuous efforts are necessary to evolve pest and disease resistant varieties and to reduce the cost of cultivation. Adequate research attention is necessary to select appropriate cotton germplasm for incorporating Bt gene is very crucial in determining the yield and resistance to pests other than bollworm. Human labour, fertilizers and seeds were the major components of cost of cultivation of Bt cotton while human labour, pesticides and fertilizers were the major cost items in non-Bt cotton cultivation. Therefore, efforts should be made to mechanize the field operations including harvest

as well as to reduce the application of pesticides either through the adoption of integrated pest management strategy or Bt cotton technology. The production function analysis revealed that application of Potash has positive impact on cotton yield and hence application of optimum quantity of potash has to be recommended to the farmers.

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