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Productivity and Profitability Impact of Genetically Modified Crops – An Economic Analysis of Bt Cotton Cultivation in Tamil Nadu

R. Loganathan, R. Balasubramanian, K. Mani and S. Gurunathan*
Department of Agricultural Economics, Tamil Nadu Agricultural University, Coimbatore - 641 003, Tamil Nadu

Abstract

Cotton production in India is at cross roads for the past few years. Till recently it was the hybrid that was at the focus but the era of genetically modified cotton has arrived. There has been lot of hue and cry regarding the commercialization of Bt cotton in India since Genetic Engineering Approval Committee (GEAC) has approved the use of Bt cotton seeds. This study has analysed the economic impact of biotechnologically engineered cotton cultivation in Tamil Nadu and the factors affecting the adoption of Bt cotton varieties. The study is based on a sample size of 76 Bt cotton farmers and 44 non-Bt cotton farmers from Salem and Perambalur districts. The results have indicated that only about one-third of the non-Bt cotton farmers are not aware about Bt cotton. Higher yield and higher profitability and lower pest problems have been cited as the important factors behind preference for Bt cotton. The less number of pesticide sprays in Bt cotton is likely to have lot of environmental and health benefits to both farmers and labourers. However, high cost of seeds and incidence of pests and diseases other than bollworm have been reported to be the major bottlenecks in Bt cotton cultivation. The study has made some suggestions to disseminate Bt cotton technology on a wider scale.

Introduction

Plant biotechnology has become a source of agricultural innovation, providing new solutions to age-old problems like overcoming yield and quality constraints. However, the impact of biotechnology is one of the most vigorously contested issues in the recent history of impact of technologies on human society. Economic impact apart, the effect of genetically modified crops on human and animal health, environment, and biodiversity also form part of the discourse. Given the vast array of issues and the diversity of interest groups involved, the debate is likely to last longer than expected. This paper is an attempt to inform this debate through a case study on the productivity and profitability impacts of Bt cotton in the selected regions of Tamil Nadu state. The rationale for selecting Bt cotton is straight forward—Bt cotton is the only genetically modified crop which is under commercial cultivation in India. Further, cotton is one of the important commercial crops cultivated in India and the problem of pest control has always remained a challenge in it. This is borne out by the fact that 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. Being a cash crop, farmers are highly sensitive to pest incidence and resort to indiscriminate and excessive application of recommended and non-recommended pesticides, which in turn lead to the elimination of beneficial parasites and predators. Indiscriminate use of synthetic pyrethroids has led to whitefly resurgence in many parts of the country. Both the financial and environmental costs of heavy pesticide applications to cotton are widely recognized. Therefore, finding a sustainable and easily practicable alternative for controlling major pests

* Author for correspondence,
Email: gurunath007@email.com

in cotton has been a major challenge faced by cotton breeders and entomologists.

Genetically Modified (GM) plants were developed with emphasis on resistance to pest and diseases. A soil bacterium, called *Bacillus thuringiensis* (Bt) has been identified to possess significant potential for use as a bio-pesticide. The toxicity of Bt toxin was higher than other chemical pesticides, viz. 300-times higher than of synthetic pyrethroids and 8,00,000-times stronger than of organophosphates. The US agrichemical giant, Monsanto introduced the Cry 1 Ac gene into the cotton variety, Coker 312. Then, by crossing this strain with elite cotton varieties, it created hybrids, which carried the Bt gene, thus heralding a new era in biological pest control that has implications for a wide range of crops and for the agricultural economy as a whole. Genetically modified Bt cotton has been introduced in India a few years ago as a technological solution to tackle the bollworm problem and its area under cultivation is on the increase. Some of the studies based on data collected from experimental plots have revealed substantial benefits to Bt cotton over non-Bt cotton varieties (Qaim and Zilberman, 2003; and Qaim, 2003).

World Scenario in Bt Cotton

Initial skepticisms not withstanding, Bt cotton has reached millions of hectares of cotton area. Over the past few years transgenic cotton has attracted the attention of researchers and farming community in view of the high positive reports emulating from USA, China, Australia and other countries where Bt cotton has been under commercial cultivation. The size of the transgenic crop seeds market has expanded to US$ 3.044 billion over a period of 5 years, from 1995 to 2000. The market is estimated to grow to US$ 25 billion by 2010. Globally, 39.9 million hectares were under cultivation of transgenic crops in 1999 and it increased to 52.6 million ha in 2002. In terms of distribution by traits, 71 per cent of this area was under insect-resistant transgenic crops, primarily corn and cotton that expressed the δ-endotoxin coding genes of *Bacillus thuringiensis*. Since the first release in 1966, there has been substantial increase in area under transgenic Bt crops from about 11.8 Mha in 1999 to 90 Mha in 2005. It testifies the economic advantage (besides a substantially lower application of synthetic pesticides) that farmers have experienced. Nevertheless, commercial cultivation of Bt crops has been limited to the mainland USA and southern parts of Australia and China.

Indian Scenario

Cotton production in India is at cross roads for the past few years. Till recently it was hybrid, which was at the focus, but the era of genetically modified cotton has arrived. There was a lot of hue and cry regarding the commercialization of Bt cotton in India since Genetic Engineering Approval Committee (GEAC) approved the use of Bt cotton seeds. It is high time that seed companies must have information on preliminary aspects, and preferences of farmers, etc. so as to come up with suitable market-mix for increasing the sales of Bt cotton seeds. It is also essential to build up a wide ranging literature on various economic issues surrounding the cultivation of Bt cotton. It is essential to answer many of the questions raised about the economic and environmental implications of Bt cotton cultivation. The public, researchers and policymakers need to be supplied with adequate information on the pros and cons of Bt cotton, vis-à-vis the claims made by the private biotechnology and seed industries. Hence, there was an urgent need to take up a study on the economic impact of biotechnologically engineered cotton cultivation in Tamil Nadu and the factors affecting the adoption of Bt cotton varieties. This study is precisely an attempt in that direction.

Methodology

Selection of Study Area

Three-stage sampling procedure was adopted for the study. In the first stage, Salem and Perambalur districts were purposively selected because these two districts topped the list of districts ranked according to the total area under Bt cotton cultivation. In the second stage, Attur and Gangavalli taluks from the Salem district, and Veppanthattai and Kunnam taluks from the Perambalur district were selected based on the taluk-wise area under Bt cotton cultivation.

The lists of Bt cotton farmers were obtained from Bt cotton seed companies, viz. Mahyco-Monsanto and Rasi Seeds. Using the village-wise list of farmers, 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 non-Bt cotton were selected so

that the final sample contained 76 Bt cotton farmers and 44 non-Bt cotton farmers and 120 farmers in all.

Data Collection

Data were collected by personnel interview with the respondents using structured and pre-tested questionnaires. Data on various inputs used in the cotton cultivation and their costs were also collected for the agricultural year 2004-05.

Analytical Framework

Garrett's Ranking Technique

Garrett ranking technique was used to rank the sources of information, reasons for cultivation and problems faced by the farmers in Bt cotton cultivation. In the Garrett's rank scoring technique, the respondents were asked to rank the factors or problems and these ranks were converted into per cent position by using Equation (1):

$$Percent\ Posittition = \frac{100(R_{ij} - 0.5)}{N_j} \qquad \ldots(1)$$

where,

R_{ij} = Rank given to the i^{th} attribute by the j^{th} individual, and

N_j = Number of attributes ranked by the j^{th} individual.

By referring to the Garrett's table, the estimated per cent positions were converted into scores. Thus for each factor, the scores of various respondents were added and the mean score was estimated. The means thus obtained for each of the attributes were arranged in a descending order.

Production Functional Analysis

The production function analysis was employed to analyse the yield differences between Bt and non-Bt cotton varieties. 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 way in which the elasticities of production could be obtained, the Cobb-Douglas type of production function was used. The particular form of the estimated equation is given below [Equation (2)]:

$$\ln Y = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + \beta_6 D_1 + \beta_7 D_2 + Error\ term \qquad \ldots(2)$$

where,

Y = Cotton yield (kg/ha),

$\beta_0, \beta_1, \ldots \beta_7$ = Regression coefficients to be estimated,

X_1 = Human labour used (humandays/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 Mahyco Bt, which takes the value 1, if the variety is Mahyco Bt, 0 otherwise, and

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

Results and Discussions

Land Ownership by the Farmers

The extent of land-owned is a major determinant of farm household income, standard of living, employment status, etc. Through its impact on farm income and access to capital and labour, land has important implications for adoption of modern technologies in agriculture.

The average area of wetland and garden land owned by the farmers has shown very little variation across different farm categories. Both the wetland and garden land owned per farmer was around one ha per farmer (Table 1). The average extent of dryland owned was comparatively higher among Rasi-Bt farmers with an average of 1.55 ha, while the Mahyco-Bt farmers and non-Bt farmers owned around one ha of dryland. The total area of land owned was 2.87 ha per household in the case of Rasi-Bt farmers, 2.13 ha per family among Mahyco-Bt growers and 2.50 ha per family among non-Bt farmers.

Table 1. Average area of land owned (ha) and land value (Rs)

Sl No.	Particulars	Mahyco-Bt	Rasi-Bt	Total-Bt	Non-Bt	Grand total
1	Wetland area	1.31	1.20	1.25	1.06	1.18
2	Garden land area	1.11	1.05	1.07	1.00	1.05
3	Dryland area	0.92	1.55	1.15	1.19	1.21
4	Total land area	2.13	2.87	2.55	2.49	2.53

Cropping Pattern of Sample Farmers

Analysis of cropping pattern of the sample farms would be of great help in understanding the potential demand for Bt seeds and relevant details have been furnished in Table 2.

The sample farms have shown a fairly high degree of crop diversification. About 40 per cent of the area was under cotton cultivation in both the categories of farms, viz. Bt and non-Bt cotton farms, although Bt cotton farmers allocated a slightly higher proportion of area for cotton cultivation than their non-Bt counterparts. Paddy was the second major crop in farms growing both Bt and non-Bt cotton with about 15 per cent to 20 per cent share in total area cultivated. Maize and tapioca were the other major crops occupying more than 10 per cent of the total cultivated area in the sample farms. Sugarcane, banana, turmeric, and groundnut were some of the other crops grown in the study villages.

Awareness about Bt Cotton among Sample Farmers

Farmers' awareness about Bt cotton was analysed and the results have been presented Table 3.

It is evident from Table 3 that almost 50 per cent of the Mahyco-Bt farmers became aware about Bt cotton from the representatives of the company, while about 70 per cent of the Rasi-Bt farmers acquired awareness about Bt cotton from seed dealers. It was possibly due to the fact that the Rasi seeds are located close to the study region and have long presence in the region with strong support from the local leaders who were instrumental in popularizing it. The state agricultural department has been a source of awareness to less than one-fifth of the Bt cotton farmers and about

Table 2. Cropping pattern of the sample farmers

(area in ha)

Sl No.	Crops	Mahyco-Bt	Rasi-Bt	All-Bt	Non-Bt	Overall
1	Cotton	23.18	56.38	79.55	43.93	123.48
		(34.38)	(48.23)	(43.16)	(39.93)	(41.95)
2	Paddy	19.53	9.92	29.45	22.47	51.92
		(28.98)	(8.48)	(15.98)	(20.42)	(17.64)
3	Maize	6.48	21.96	28.44	12.15	40.59
		(9.61)	(18.79)	(15.43)	(11.04)	(13.79)
4	Tapioca	8.50	11.34	19.84	13.36	33.20
		(12.61)	(9.70)	(10.76)	(12.14)	(11.28)
5	Sugarcane	4.45	5.06	9.51	6.88	16.40
		(6.61)	(4.33)	(5.16)	(6.26)	(5.57)
6	Turmeric	4.45	2.94	7.39	4.05	11.44
		(6.61)	(2.51)	(4.01)	(3.68)	(3.89)
7	Banana	0.00	4.05	4.05	4.05	8.10
		(0)	(3.46)	(2.20)	(3.68)	(2.75)
8	Groundnut	0.81	5.26	6.07	3.14	9.21
		(1.20)	(4.50)	(3.29)	(2.85)	(3.13)
	Total	67.41	116.90	184.31	110.02	110.02
		(100)	(100)	(100)	(100)	(100)

Note: Figures within the parentheses are percentages to total cultivated area

Table 3. Awareness about Bt cotton among sample farmers

Awareness source	Mahyco-Bt	Rasi-Bt	All-Bt	Non-Bt
Bt cotton seed company	16	5	21	2
	(48.48)	(11.63)	(27.63)	(4.55)
Agricultural Department	5	8	13	2
	(15.15)	(18.60)	(17.11)	(4.55)
Seed dealer	5	30	35	14
	(15.15)	(69.77)	(46.05)	(31.82)
Neighbour	6	0	6	12
	(18.18)	(0)	(7.89)	(27.27)
Media, Newspaper	1	0	1	0
	(3.03)	(0)	(1.32)	(0)
Not aware about Bt cotton	-	-	-	14
				(31.82)
Total	33	43	76	44
	(100)	(100)	(100)	(100)

Note: Figures within the parentheses indicate percentages to total

five per cent of non-Bt farmers. Media such as television and radio played no role while newspapers were the only source of awareness generation about Bt cotton but for a very small fraction of farmers. About 70 per cent of the non-Bt growers were also aware about Bt cotton, for whom seed dealers and neighbours were the major sources of awareness.

Area under Cotton Cultivation

The area under cotton and reasons for its increase or decrease are presented in this section. Allocation of area for cultivation of cotton by the sample farmers would help to understand the demand for Bt cotton seeds in the study area, hence the same was analysed and has been presented in Table 4. It could be observed from Table 4 that about two-third of both Bt and non-Bt cotton growers had less than one hectare of land under cotton cultivation, while about 20 to 25 per cent of them had one to two hectares of land under cotton. A little above one-tenth of the farmers had more than two hectares under cultivation. A breakup of Bt farmers between Mahyco and Rasi Bt cotton would reveal that close to one-fourth of the Rasi Bt cotton growers cultivated more than two hectares of their land with Bt cotton crop.

Reasons for Preference to Bt Cotton

Farmers were asked to rank the reasons for preferring a Bt cotton variety and the same were analysed using Garret's ranking technique. The results

Table 4. Area under cotton in sample farms

(in ha)

Area under cotton	Mahyco-Bt	Rasi-Bt	All-Bt	Non-Bt	Overall
< 1.0	25	24	49	28	77
	(75.75)	(55.81)	(64.47)	(63.63)	(64.16)
1.01-2.0	8	9	17	11	28
	(24.24)	(20.93)	(22.34)	(25)	(23.33)
> 2.0	0	10	10	5	15
	(0.00)	(23.25)	(13.16)	(11.36)	(12.50)
Average	1.78	3.53	2.77	2.31	2.60
Total	33	43	76	44	120
	(100)	(100)	(100)	(100)	(100)

Note: Figures within the parentheses indicate percentages to total

Table 5. Reasons for preferring Bt cotton by using Garret's ranking (N=120)

Particulars	Garret Score	Rank
Higher yield and higher profitability	71.66	I
Less pest problems and low pesticide requirement	56.60	II
Quality of lint is good	37.15	III
Easy marketability of the produce	34.08	IV

Table 6. Average number of sprayings done by sample farmers

Number of spray	Mahyco-Bt	Rasi-Bt	All-Bt	Non-Bt
		Winter		
< 8	20 (60.60)	32 (74.41)	52 (68.42)	2 (4.54)
8-10	6 (18.18)	6 (13.95)	12 (15.79)	3 (6.81)
11-13	5 (15.15)	4 (9.30)	9(11.84)	7 (15.90)
>13	2 (6.06)	1 (2.32)	3 (3.95)	32 (72.72)
Average number of sprayings	8.39	5.32	7.65	15.13
Total number of farmers	33(100)	43(100)	76(100)	44(100)
		Summer		
< 6	17 (51.51)	26 (60.45)	43 (56.58)	1 (2.27)
6-8	9 (27.27)	12 (27.90)	21 (27.63)	3 (6.81)
9-11	4 (12.12)	4 (9.30)	8 (10.53)	9 (20.45)
>11	3 (9.09)	1 (2.32)	4(5.26)	31 (70.45)
Average number of sprayings	6.75	5.13	11.88	12.63
Total number of farmers	33 (100)	43 (100)	76 (100)	44 (100)

Note: Figures within the parentheses indicate percentages to total

are presented in Table 5. It was revealed that higher yield and higher profitability were the top most reasons for choosing to grow a 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.

Pest and Disease Control in Cotton

Farmers were asked about the number of sprayings normally followed by them for cotton crop and the details are presented in Table 6. It is evident that a majority of the farmers sprayed less than eight times during the winter season and less than six times during the summer season. The number of sprayings 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. The number of sprayings was comparatively lower among Rasi-Bt than Mahyco-Bt farmers. On the whole, a 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 the seasons.

Expenditure on Pest and Disease Control

The analysis of the cost on spraying various chemicals in the study area has been presented in Table 7. A remarkable difference was observed 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 less than Rs 1250/ha on pest and disease control, whereas about two-thirds of non-Bt cotton growers spent Rs 2500 to Rs 5000 on pest control measures, and about

Table 7. Cost on chemical spraying for pest and disease control

Sl. No.	Average expenditure on pesticides (Rs/ha)	Mahyco-Bt	Rasi-Bt	All-Bt	Non-Bt
1	< 1250	29 (87.88)	42 (97.67)	71 (93.42)	0 (0.00)
2	1250-2500	4 (12.12)	1 (2.32)	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	751	570	695	3927
6	Total number of farmers	33(100.00)	43(100.00)	76(100.00)	44(100.00)

Note: Figures within the parentheses indicate percentages to total

Table 8. Frequency distribution yield of Bt cotton and non-Bt cotton

Yield of cotton (q/ha)	Mahyco-Bt	Rasi-Bt	Non-Bt
< 25	0 (0.00)	1 (2.32)	43 (97.72)
25-30	3 (9.09)	6 (13.95)	1 (2.27)
30-33	14 (42.42)	10 (23.25)	0 (0.00)
> 33	16 (48.48)	26 (60.46)	0 (0.00)
Average yield	33.44	33.62	20.33
Total	33 (100)	43 (100)	44 (100)

Note: Figures within the parentheses indicate percentages to total

23 per cent of the non-Bt farmers spent even more than Rs 5000/ha.

Yield Performance of Bt and Non-Bt Cotton

The yield performance of Bt and non-Bt cotton was analysed and the results have been presented in Table 8. It was observed that a majority of non-Bt farmers (98 per cent) obtained less than 25 q/ha of kapas yield. A majority of the Mahyco-Bt and Rasi-Bt farmers obtained the kapas yield of more than 33 q/ha. Between them, a higher proportion of Rasi-Bt farmers obtained yield of more than 33 q/ha (60 per cent) as compared to Mahyco-Bt farmers (42 per cent).

Overall Performance of Bt Cotton — Feedback from the Fields

The feedback from the farmers has been presented in Table 9. It could be inferred that 'less bollworm attack' was ranked as an important trait that was most preferred by the sample farmers. Since bollworm incidence was the major problem in cotton cultivation, it could attract the attention of the farmers immediately. This advantage can be projected in marketing of 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.

Table 9. Farmers' opinion on Bt cotton

Opinion	Number	Percentage
Less bollworm attack	74	97.36
More yield	72	94.73
Require less number of sprays	62	81.57
Germination percentage is more	54	71.05

Problems in Cotton Cultivation

Farmers were asked about problems being faced by them in the cultivation of non-Bt and Bt cotton and the same were analyzed using Garret's ranking technique. The results have been presented in Tables 10 and 11, respectively.

Susceptibility to pests and diseases and the consequent requirement of high doses of pesticides were cited as the 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 were much different from those of non-Bt cotton growers. High cost of Bt cotton seeds was the most important problem reported by the Bt cotton farmers. The cost of non-Bt cotton seeds was lower by 40-60 per cent when compared to the cost of Bt cotton seeds. Poor

Table 10. Problems in non-Bt cotton cultivation

Problems	Garret score	Rank
Susceptible to pest and disease	37.36	I
More number of sprays	34.05	II
High cost of cultivation	20.45	III
Uncertainty in yield	12.24	IV
Price risk	8.37	V
High cost of seed	2.27	VI

Table 11. Problems in Bt cotton cultivation

Problems	Garret score	Rank
Higher cost of seed	72.25	I
Poor germination percentage	62.25	II
Higher incidence of pests other than bollworm	50.00	III
Bollworm problem is as severe as in non-Bt cotton	37.62	IV
Non-availability of seed in time	25.37	V

germination percentage and 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 was high in Bt cotton (mean score 50.00).

Economics of Bt vs Non-Bt Cotton

The costs and returns of Bt and non-Bt cotton cultivation have been provided in Table 12. Human labour was the major component of cost on 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. It was 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 the 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 its

Table 12. Cost and returns of Bt and non-Bt cotton cultivation

(Rs/ha)

Sl No.	Particulars	Rasi-Bt (N=43)	Mahyco-Bt (N=33)	All-Bt (N=76)	Non-Bt (N=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	Net return (Rs)	44737	45582	45660	6828

Note: Figures within the parentheses indicate percentages to total

Table 13. Results of Cobb-Douglas production function analysis for cotton

Dependent variable: Cotton yield (q/ha)

Variables	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		

*Note:**, ** and *** denote significance at 10 per cent, 5 per cent and 1 per cent levels, respectively.

relative share in total cost of all inputs. 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 cost of inputs used for non-Bt cotton.

The share of seed cost to total input costs was about 14 per cent in Bt cotton and less than seven per cent in non-Bt cotton. However, the savings in pesticide costs for Bt cotton have been found to more to offset the higher seed cost for Bt cotton. Hence, the total cost of all inputs used was about 10 per cent higher in non-Bt (Rs 33686) than Bt cotton cultivation (Rs 30895). The average kapas yield was much higher for Bt (33 q/ha) than non-Bt (20 q/ha) cotton. Hence, cultivation of Bt cotton has resulted in win-win situation for the farmers with low pest incidence and low cost of pest control with higher yield and better quality of the output. Because of better quality, Bt cotton fetched a higher price in the market than non-Bt cotton. Consequently, net return from Bt cultivation was almost twice than that of 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 13.

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 a negative effect on yield probably because farmers used excessive quantities of pesticides than the recommended levels. 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

The study has revealed that only about one-third of the non-Bt cotton farmers are not aware about Bt cotton. Surprisingly, popular media sources such as television, radio and newspapers have 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, media should be effectively used. Higher yield and higher profitability and lower pest problems have been 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 sprays in Bt cotton is likely to have lot of environmental and health benefits to the farmers and labourers. However, it has been found that farmers are not properly trained in adopting bio-safety measures such as growing refugee crops so as to avoid building-up of the resistance by bollworms against the Bt toxin. Therefore, the non-economic benefits and bio-safety 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 have been cited as major constraints in cultivation of non-Bt cotton. However, high cost of seeds and incidence of pests and diseases other than bollworm have been 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. Human labour and fertilizers/ pesticides application being the major cost items in cotton cultivation, efforts should be made to mechanize field operations. The production function analysis has revealed that application of potash has positive impact on cotton yield and hence application of optimum quantity of potash should be recommended to the farmers.

References

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