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Full Length Research Paper

Economics of Bt cotton in India

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Since the introduction of Bt cotton in India, there has been a serious debate going on its impact on cost, returns and productivity. Andhra Pradesh continue to be the largest cultivator of Bt cotton in India and it occupies third position among Indian cotton growing states both in terms of area as well as outturn. In this context, it would be appropriate to analyze the output and efficiency of inputs used in cotton cultivation in Andhra Pradesh state of India. The study is based on a sample survey of selected farmer households in cotton cultivating villages in Andhra Pradesh of India. The study used Multi-stage stratified random sampling method to select the respondents from among the farm households. A detailed structured questionnaire was used to conduct face-to-face interviews with the farmer households. The sample households among the cotton cultivating households who have cultivated non-Bt cotton during last year or last two years have been taken up to study the impact of the presence of technology. In order to ensure the accuracy of the data related to the previous year, care is taken in selection of farm households, those households who have maintained records. The data on input and output variables like cost of seed, cost of labor, cost of irrigation, cost of fertilizers, cost of pesticides and capital used for the both years were collected for the study. To overcome the conceptual problems in quantifying the impact of technology at two points of time, the value of inputs used and output produced was estimated at constant prices based on survey year's price. Also, it is considered the two periods used for the comparison are normal in terms of agro-climatic variables. The Cobb-Douglas production and decomposition analysis techniques were used to estimate the influence of factors and Bt technology on output change. The results of the estimated production functions reveal that seeds and fertilizer is the most important input to which output is highly responsive in both Bt and non-Bt cotton crop situations. The output elasticity of pesticide is higher in non-Bt cotton cultivation than that in Bt cotton cultivation. The decomposition revealed that the net impact of Bt technology alone is estimated to have increased the output by 10.88%. The adoption of Bt technology enabled the farmers to save inputs significantly. And the value of extra output produced per acre with adoption of Bt technology.

Key words: Bt technology, Bt cotton, decomposition of output change, non Bt cotton production function, resource use efficiency, input and output.

INTRODUCTION

India with its 13% share of world's cotton production ranks the third largest producer of cotton in the world (Cotton Corporation of India (CCI) 2008). Although, India has the world's largest average of cotton, its productivity is among the lowest in the world (F.A.O, 2008). One of the main factors showing impact on the productivity is the fact that the cost on pesticides accounts for major portion of total cost of cultivation. Cotton is highly at risk to insects which impacts cotton production. In fact, cotton alone accounts for more than half of the money spent on pesticides in India (Jamail and Kaushik, 2007). These pests have developed high level resistance against the chemicals used. Such a high level of resistance requires repeated application of pesticides leading to expenditure and crop failures. Andhra Pradesh continue to be the largest cultivator of Bt cotton in India and it occupies third position among Indian cotton growing states both in terms of area as well as outturn. The area under cotton in the state accounts for 10.63% of total area and 12.86% of total production in the country. Nearly 85% of total area under cotton cultivation in the state is under Bt cotton (ISAAA, 2007). Thus, cotton farmers in the state provide livelihood and wage employment to about one tenth of rural population. The living standards of rural people will be effected by the performance of cotton cultivation which is a matter of serious concern (Mahendra and Chandrasekhara., 2007).

With this back drop, the present study is proposed to assess the effect of Bt cotton technology on output and efficiency of inputs used in cotton cultivation in Andhra Pradesh state of India during 2007 to 2008. An attempt is made in this paper to asses the impact of Bt cotton technology on cotton output empirically.

Objectives

The objectives of the study are:

1) To assess the resource use efficiency in Bt cotton vis-à-vis non Bt cotton cultivation.
2) To decompose the influence of factors and Bt technology on output change. And;
3) To estimate value of inputs saved and extra output produced.

STUDY AREA AND SAMPLING PROCEDURE

The study used multi-stage stratified random sampling method to select the respondents from among the farm households. The study is based on sample survey of selected farm households in six villages of Warangal and Guntur districts of the Andhra Pradesh state in India. It was decided to select a sample of 408 farm households. Taking district as a unit, the sample size of farm households for a district was kept at 204. Thus, in the sample, there is one village each for the 12 Mandals in the two districts. After selecting villages, a census survey of farm households was conducted to prepare a comprehensive list of all farm households cultivating cotton in each village, irrespective of the extent of area cultivated and ownership of land. The size of the sample for each village was fixed in proportion to the peerage of the cotton farmers in that village. Once the sample size was fixed for the village, the sample size for each stratum was determined in a proportionate manner. From each stratum, sample respondents were selected by following the systematic sampling method using a random start.

A detailed structured questionnaire was used to elicit the information from the farm households. The data collection has done during December 2007 to January 2008.

DATA ANALYSIS

The measurement of the impact of technology can be done in two ways, cross section comparison of farms with presence and absence of technology. The reference period for such a type of study is one agricultural year. The other way is comparison of changes before and after adoption of technology. There is limitation for cross section comparison that it is difficulty to select a sample of farm households that are homogeneous in all resects. Farm households who have used Bt seeds and farm households who have used non-Bt seeds differ in respect of type of seed, farm size, crops and other inputs etc. The difference also can be observed in quality of management of these two categories of farms. Because of these dissimilarities among farm households who have used Bt seeds and who have not used Bt seeds, the cross section comparison studies face conceptual problem in identification and quantification of the impact of Bt (biotechnology) in cotton cultivation. Comparison of change before and after adoption of technology, though does not suffer from the deficiencies arising out of heterogeneity in the farm holdings, encounter different types of problems. The reliability of the information relating to the period before adoption of technology depends on the ability of the farmers to recollect and report necessary details with accuracy, or depends on maintenance of records by the farm house holdings. In order to overcome this difficulty, the sample households among the cotton cultivating households who have cultivated non-Bt cotton during last year or last two years have been taken up to study the impact of the presence of technology. In order to ensure the accuracy of the data related to the previous year, care is taken in selection of farm households, those households who have maintained records.

The data on input and output variables like cost of seed, cost of labor, cost of irrigation, cost of fertilizers, cost of pesticides and capital used for the both years were collected for the study. To overcome the conceptual problems in quantifying the impact of technology at two points of time, the value of inputs used and output produced was estimated at constant prices based on survey year's price. Also, it is considered the two periods used for the comparison are normal in terms of agro-climatic variables.

Analytical techniques

In most of the cases, tabular analysis comprising of averages, frequencies, percentages and cross section comparisons are used for the study. Regression analysis is used to examine the classic economic controversies. Cobb-Douglas production function is used to identify determinants of productivity.

MODELS AND METHODS USED

It can be observed from the earlier studies that introduction of technology triggered a process by which the land productivity is increased significantly. These are only preliminary inferences about the complex relationship between farm productivity and technology. It is expected that the use of Bt seeds will result in changes in the input pattern which inturn effect land productivity. Thus, it can be inferred that increase in land productivity under Bt cotton cultivation is not only through the use of Bt cotton seeds but also by the changes in the use of other factors in production. Therefore, it is essential to decompose the total increase in production per acre into increase due to Bt cotton seeds and increase due to the changes in the use of other inputs. The total change in output per acre after the introduction of Bt cotton has been calculated by comparing output in Bt cotton and non-Bt cotton crop situations. From the analysis of previous studies, it is assumed that production conditions of both Bt cotton and non Bt cotton cultivation is characterized by constant returns to scale (Mahendra and Chandrasekhara, 2007). This may imply that scale effects are eliminated and farm level Cob Douglass production function can be expressed in terms of an acre. Further, it is observed that use of Bt cotton in the study area has brought about a structural change in general and the technological parameters of the production function with Bt cotton cultivation are different from those of non-Bt cotton cultivation. The efficiency of the technology can be measured in terms of productivity per unit of input used.

It is expected that the use of Bt seeds reduce the cost of pesticides and the cost of labour used to apply the pesticide which in turn enable the farmers to intensify the use of other basic inputs. Thus, the high intensity of appropriate mix of basic inputs raises output. The upward shift in the production functions makes it possible to obtain additional output per unit of land. With the same amount of other inputs or in other words with lesser amount of inputs, it becomes possible to get the same level of output per acre.

Production function modal

The Cob Douglass production function expressed in per acre term for both Bt cotton and non Bt cotton cultivation can be expressed in the following forms:

$$In Y_B = In A_B + \alpha_1 In X_{B1} + \alpha_2 In X_{B2} + \alpha_3 In X_{B3} + \alpha_4 In X_{B4} \quad (1)$$

$$In Y_{NB} = In A_{NB} + \beta_1 In X_{NB1} + \beta_2 In X_{NB2} + \beta_3 In X_{NB3} + \beta_4 In X_{NB4} \quad (2)$$

Y_B = Output per acre in Bt cotton cultivation, Y_{NB} = output per acre in non-Bt cotton cultivation, X_{B1} = value of seed used per acre in Bt cultivation, X_{B2} = value of fertilizer used per acre in Bt cultivation, X_{B3} = value of pesticides used per acre in Bt cultivation, X_{B4} = value of human labour per acre in Bt cultivation, X_{NB1} = value of seed used per acre in non Bt cultivation, X_{NB2} = value of fertilizer used per acre in non-Bt cultivation, X_{NB3} = value of pesticides used per acre in non-Bt cultivation, X_{NB4} = value of human labour used per acre in non-Bt cultivation, α_1, α_2, α_3, α_4 are the output elasticity co-efficients of seeds, fertilizer, pesticides and human labour in Bt cultivation where as $\beta_1, \beta_2, \beta_3, \beta_4$ are the corresponding elasticity coefficient for the non-Bt cultivation.

Taking the difference between the Equations-1 and 2 and adding some terms subtracting the same terms:

$$In\ Y_B - In\ Y_{NB} = (In\ A_B - In\ A_{NB}) + (\alpha_1\ In\ X_{B1} - \beta_1\ In\ X_{NB1} + \alpha_1\ In\ X_{NB1} - \alpha_1\ In\ X_{NB1}) + (\alpha_2\ In\ X_{B2} - \beta_2\ In\ X_{NB2} + \alpha_2\ In\ X_{NB2} - \alpha_2\ In\ X_{NB2}) + (\alpha_3\ In\ X_{B3} - \beta_3\ In\ X_{NB3} + \alpha_3\ In\ X_{NB3} - \alpha_3\ In\ X_{NB3}) + (\alpha_4\ In\ X_B^4 - \beta_4\ In\ X_{NB4} + \alpha_4\ In\ X_{NB4} - \alpha_4\ In\ X_{NB4}) \quad (3)$$

Rearranging the terms in Equation-3:

$$(In\ Y_B - In\ Y_{NB}) = (In\ A_B - In\ A_{NB}) + \left[(\alpha_1 - \beta_1) In\ X_{NB1} + (\alpha_2 - \beta_2) In X_{NB2} + (\alpha_3 - \beta_3) In X_{NB3} + (\alpha_4 - \beta_4) In X_{NB4}\right] + \left[\alpha_1 (In X_{NB1} - In X_{NB1}) + \alpha_2 (In X_{B2} - In X_{NB2} + \alpha_3 (In X_{B3} - In X_{NB3}) + \alpha_4 (In X_{B4} - In X_{NB4})\right] \quad (4)$$

Decomposition model

The following log linear estimable forms of equations were used for examining the structural break in production relation (Bisaliah, 1977):

$$In \left[Y_B / Y_{NB}\right] = \left[In (A_M / A_N)\right] + \left[(\alpha_1 - \beta_1) In X_{NB1} + (\alpha_2 - \beta_2) In X_{NB2} + (\alpha_3 - \beta_3) In X_{NB3} + (\alpha_4 - \beta_4) In X_{NB4}\right] + \left[(\alpha_1 In (X_{B1} / X_{NB1}) + \alpha_2 In (X_{B2} / X_{NB2}) + \alpha_3 In (X_{B1} / X_{NB3}) + \alpha_4 In (X_{B4} / X_{NB4})\right] \quad (5)$$

The aforementioned equation permits us to decompose the total difference in output per acre in between Bt cotton cultivation and non Bt cotton cultivation into Bt technology component and other input components. It decomposes the natural logarithm of the ratio of per acre output in non-Bt cotton cultivation which is approximately an aggregate percentage change in output per acre with the introduction of biotechnology. The impact of biotechnology can be observed by locking at the changes in intercept term and slope parameters. The first two bracketed expressions in Equation-5 measures the changes in output per acre due to change in the intercept term and change in the slope parameters as a result of use of Bt cotton seed. The second bracketed expression, sum of arithmetic change in output elasticities weighed by the logarithm of value of that input used is a measure of change in output due to shift in slope parameters of the production function. The third bracketed expression is the sum of logarithms of the ratios for each input of Bt cotton cultivation to non-Bt cotton cultivation, each weighed by the output elasticity of that input. This expression is a measure of change in output due to difference in the per acre values of seed fertilizers, pesticides, and human labour input used and the given output elasticity of these inputs under Bt cotton production technology.

The estimated values of least square regression coefficient elasticities for Bt cotton and non-Bt cotton cultivation is presented in Table 1.

Models to estimate value of inputs saved and extra output produced

To estimate the value of inputs saved and the quantity of extra output produced with introduction of Bt cotton seeds, the following method is adopted:

Y_B = value of output per acre in Bt cotton cultivation, Y_{NB} = value of output per acre in non-Bt cotton cultivation, R_B = value of seeds per acre, fertilizers, pesticides and human labour required to produce Y_B Bt cotton cultivation, R_{NB} = value of seeds, fertilizers, pesticides and human labour required to produce Y_{NB} non- Bt cotton cultivation, r = %age change in output per acre with Bt technology but with input use level of seeds, fertilizers, pesticides and human labour of non-Bt cotton cultivation, S_R = value (in Rupees) per acre of seeds, fertilizers, pesticides and human labour saved with Bt technology.

From the aforementioned definition:

R_{NB} = (1-r/100) R_B

$S_R = R_B - R_{NB}$ = (r/100) R_B

The value of extra output produced with the introduction of Bt technology can also be calculated using the input levels of non- Bt cotton cultivation in the following manner. Let:

▲Y = $Y_B - Y_{NB}$ = total change in output per acre.
r▲Y = value of extra output produced per acre due to the access to Bt technology.

RESULTS AND DISCUSSION

Resource use efficiency

The estimated production function appears to be best fit

Table 1. Per acre OLS estimates of the production function.

Variable	Parameter	Estimated value	t- value	R^2
		Bt cotton		
Constant	Log A_B	10.97	11.89	
Seed	α_1	0.186*	5.76	
Fertilizer	α_2	0.271*	9.38	0.78
Pesticide	α_3	0.076	0.87	
Human labour	α_4	0.487**	2.33	
		Non-Bt cotton		
Constant	Log A_{NB}	8.76	13.33	
Seed	β_1	0.165	2.68	
Fertilizer	β_2	0.261*	6.33	0.82
Pesticide	β_3	0.116*	3.05	
Human labour	β_4	0.461**	2.93	

Note: The dependent variable is the value of output (in Rs.) per acre. *Significant at 1% level and **Significant at 5% level.

as the variation explained in yield by different farm inputs varies between 0.78 and 1.82% in Bt and non-Bt cotton crop situations. It is further observed that most of the elasticity coefficients of inputs have registered the expected signs with a prior economic logic and found to be significant at probability levels ranging from 5 to 10%. The results of the estimated production functions reveal that fertilizer is the most important input to which output is highly responsive in both Bt and non-Bt cotton crop situations. The elasticity of output with respect to fertilizer is found to be positive and significant at 5% probability level in both Bt and non-Bt crop situations. From the analysis of the results, it is found that expenditure on seeds is another important input to which output is highly responsive in both cotton crop situations. The coefficients associated with expenditure on seed is found to be positive and significant at 5% probability level of significance in both categories of farms. On the other hand, it is observed that elasticity coefficient of output with respective to pesticides is higher in non Bt cotton cultivation as compared to Bt cotton cultivation. That is, output elasticity of pesticide is higher in non Bt cotton cultivation than that of in Bt cotton cultivation which reveals that an increase in expenditure on pesticides resulted in increased output in non- Bt cotton cultivation when compared to Bt cotton cultivation. The elasticity coefficient of pesticides though found to be positive in Bt cotton cultivation, it is not significant. The elasticity coefficient of pesticides is found to be positive and significant in non Bt cotton crop situation. It could be observed that the elasticity coefficient with respect to human labour is positive and significant in both Bt cotton and non-Bt cotton crop situations. Farther, it is observed that output elasticity of human labour is found to be higher in Bt cotton cultivation when compared to non-Bt cotton crop situation.

The elasticity coefficient with respect to human labour is positive and significant in both Bt cotton and non-Bt cotton crop situations. The output elasticity of human labour is higher in Bt cotton cultivation when compared to non- Bt cotton crop situation.

Decomposition analysis

In order to evaluate the net impact of Bt technology and other inputs on cotton productivity, the results of the decomposition analysis is presented in Table 2. The percentage change in value of output has been decomposed into percentage change in output due to Bt technology and percentage change in output due to change in per acre use of other inputs. The total estimated change in the value output with an access to use of Bt cotton seed worked out to 26.56%, which is marginally higher than observed change in output. The difference between the observed and estimated changes in output in both forms may be because of the non inclusion of certain factors, either due to the problem of quantification or due to non- availability of data. The net impact of Bt technology in cotton crop can be captured by adding the first two bracketed expressions of Equation-2. Bt technology alone is estimated to have increased the output by 10.88%. This could reveal that with some level of use of seeds, fertilizers, pesticides and human labour, the farmers have obtained 10.88% more output per acre by using Bt cotton seeds when compared to those who have used non-Bt cotton seeds. The differences in the use of seed, fertilizer, pesticide and human labour have increased the output per acre by 8.15, 0.61, 1.68 and 5.21% respectively. Changes in the use of all these inputs put together have been increased by about 15.65%.

Table 2. Decomposition analysis of total difference in output (Value in Rs.) per acre between Bt cotton and non- Bt cotton cultivation.

	Item	Percentage attributable
	Total observe difference in output	24.50
1.	Bt technology	10.88
2.	Changes in inputs	
a)	Seed	8.15
b)	Fertilizer	0.61
c)	Pesticide	1.68
d)	Human labour	5.21
	All inputs	15.65
	Total estimated change due to all sources	26.53

Table 3. Value of inputs (Rs) saved per acre due to Bt technology.

Item	Amount
R_B	10424
R_{NB}	12445
R	24.5
S	2021.0

Table 4. Value of extra output (Rs) produced per acre due to Bt technology.

Item	Amount
Y_B	20750
Y_{NB}	16295
$\blacktriangle Y=Y_B-Y_{NB}$	4455
R	24.5
S	1091.48

Value of the inputs saved and extra output produced

The value (in Rupees) of inputs saved per acre with the adoption of Bt technology is given in Table 3 adoption of Bt technology alone has saved about Rs.2,021/- per acre when compared with non Bt cotton. Thus, adoption of Bt technology enabled the farmers to save inputs significantly. From the aforementioned analysis, it is clearly evident that optimum utilization of resources is higher in Bt cotton than that of non-Bt cotton. The value of extra output produced per acre with adoption of Bt technology is reported in Table 4. The additional revenue from adoption of Bt cotton is Rs.4,455/- per acre which is higher when compared to non- Bt cotton cultivation. It is a clear evident that by adopting Bt technology, cotton farmers are benefited significantly. The optimum utilization of resources is higher in Bt cotton than that in non-Bt cotton. The value (in Rupees) of inputs saved per acre with the adoption of Bt technology is Rs.2,021/- per acre when compared with non Bt cotton. The adoption of Bt technology enabled the farmers to save inputs significantly. The value of extra output produced per acre with adoption of Bt technology is Rs.4,455/- per acre which is higher when compared to non- Bt cotton cultivation.

Conclusion

The study revealed that the productivity difference between Bt and non Bt cotton farmers was largely attributable to Bt technology. The results of the estimated production functions reveal that seeds and fertilizer is the most important input to which output is highly responsive in both Bt and non-Bt cotton crop situations. On the other hand, it is observed that elasticity co-efficient of output with respective to pesticides is higher in non Bt cotton cultivation as compared to Bt cotton cultivation. The output elasticity of pesticide is higher in non Bt cotton cultivation than that in Bt cotton cultivation. An increase in expenditure on pesticides resulted in increased output in non Bt cotton cultivation when compared to Bt cotton cultivation. Further, the plant protection chemicals and other inputs were used optimally by Bt cotton farmers as against excessive use by non Bt cotton farmers. Therefore, it is necessary to motivate the farmers for cultivation of Bt cotton with appropriate extension strategies and policy measures. The elasticity coefficient with respect to human labour is positive and significant in both Bt cotton and non-Bt cotton crop situations. The output elasticity of human labour is higher in Bt cotton cultivation when compared to non- Bt cotton crop situation. The results of the decomposition revealed that the net impact of Bt technology alone is estimated to have increased the output by 10.88%. That is with some level of use of seeds, fertilizers, pesticides and human labour, the farmers have obtained 10.88% more output per acre by using Bt cotton seeds when compared to those who have used non-Bt cotton seeds. Changes in the use of all other inputs put together have been increased output by about 15.65%. The adoption of Bt technology enabled the farmers to save inputs significantly. And the value of extra output produced per acre with adoption of Bt technology is Rs.4,455/- per acre which is higher when compared to non- Bt cotton cultivation.

It is a clear evident that by adopting Bt technology cotton farmers are benefited significantly. Therefore, Bt cotton needs to be expanded among all cotton growers to harvest the benefits in terms of higher yield and income.

POLICY IMPLICATIONS AND RECOMMENDATIONS

i) The major policy implications from this study are that availability of Bt seeds should be made available to the farmers at affordable rates to increase the use by small farmers and to increase their profitability. Government should subsidized the cost of Bt technology to encourage the farmers to adopt Bt cotton seeds.

ii) There is an urgent need to develop appropriate package of practices for each Bt cotton hybrid keeping in view agro climatic conditions (rainfed/irrigated) of the States/regions by the state agricultural universities with funding from Government of India.

iii) The appropriate role of government and public sector research system in GM Technology will be highly helpful in solving the current controversial issues regarding Bt cotton which is expected to be utilized for the benefit of farmers. As a long term measure, a role for the public sector in transgenic cotton seed production could be envisaged by activating research and development activities.

REFERENCES

Bisaliah S (1977). “Decomposition analysis of output change under new production technology in wheat farming – some implications to returns on investment”, Indian J. Agric. Econ., 32: 193-201.

Cotton corporation of India(CCI) (2008). National Cotton Scenario and Current Cotton Scenario, www.cotcorp.gov.in

International Service for the Acquisition of Agri-biotech Applications (ISAAA 2007). Global Status of Biotech/GM Crops, http://www.isaaa.org

Jagmail S, Kaushik Sk (2007). “Bt Cotton in India”- Present Scenario and Future Prospects, ‘Indian Farming’, 56(11): 26-28, February 2007.

Mahendra DS, Chandrasekhara RN (2007). “Socio-economic impact of Bt cotton”, CESS Monograph No.3, Centre for Economic and Social Studies, India November-2007, Available at: http//www.cess.ac.in//