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## CONTENTS

Sr. No.	TITLE & NAME OF THE AUTHOR (S)	Page No.
<u>1</u>	<b>Democracy And Governance: A Revisitational Discourse.</b> S. T. Akindele, PhD and O. O. Adeyemi	<u>1-47</u>
<u>2</u>	<b>Leadership: A New Synthesis.</b> Akindele, S.T., PhD. and Adeyemi, O. O.	<u>48-93</u>
<u>3</u>	<b>Cells involved in wear-mediated osteolysis.</b> Mrinal K.Musib, Ph.D.	<u>94-107</u>
<u>4</u>	<b>The Leadership and the Retention of Employees That Work for Nongovernmental Organization (NGOs) in Thailand.</b> Matchakarn Ya-anan	<u>108-122</u>
<u>5</u>	<b>A Review On Extent Of Sustainability Of Educational Projects: A Case Of Strengthening Of Mathematics And Science In Secondary Education (Smasse) Project In Kenya.</b> Henry Onderi and Getrude Malala	<u>123-144</u>
<u>6</u>	<b>Improving the educational decision –making system –from the viewpoint of members of education faculties settled in Tehran and staff managers and Specialists in the Ministry of Education.</b> Armin Mahmoudi	<u>145-158</u>
<u>7</u>	<b>Econometric Analysis of Income of Nomads In Irrigated Areas Of Cholistan Desert.</b> Mariam Abbas Soharwardi, Karamat Ali and Jamal Abdul Nasir	<u>159-176</u>
<u>8</u>	<b>Distance Education and Conventional Education; A Case Study through Review of Literature.</b> Ms. Iffat Beg	<u>177-197</u>
<u>9</u>	<b>‘Bt’ Cotton: Resource Use Efficiency in India.</b> Dr. A. Balakrishna	<u>198-216</u>
<u>10</u>	<b>Simone De Beauvoir’s Contribution To Feminism With Reference To The Second Sex.</b> Sachin Vaman Londhe	<u>217-232</u>
<u>11</u>	<b>Identification Of Decision Parameters Influencing Destination Choices Of Indian Domestic Tourists.</b> Harikrishna M. and Rajat Rastogi	<u>233-263</u>
<u>12</u>	<b>Customers Perception Towards Mobile Number Portability.</b> Mrs. Dhanya. J. S	<u>264-282</u>
<u>13</u>	<b>A Case Study On Employee Motivational Practices At Airport Authority Of India Limited With Special Reference To Chennai Airport.</b> Simeon S. Simon, S. Jacob Pratabaraj and Sneha George	<u>283-301</u>
<u>14</u>	<b>Recruitment Policies In Indian Railways–Case Study Of South Western Railway, Hubli.</b> Dr. C. P. Manohar	<u>302-317</u>
<u>15</u>	<b>A Study on Challenges and Opportunities for Agricultural Development in India.</b> Dr. V. J. R. Emerson Moses	<u>318-332</u>
<u>16</u>	<b>Emotional Intelligence Of Students In A B-School.</b> A. K. Mohapatra and Deepak Pattnaik	<u>333-353</u>
<u>17</u>	<b>World Economy And Terrorism: An Over View.</b> Dr. Bhuvnender Chaudhary, Amit Sarkar and Nikhil Monga	<u>354-379</u>

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**Title**

**'BT' COTTON: RESOURCE USE EFFICIENCY IN INDIA**

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**Abstract:**

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 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 of 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 %. It is necessary to motivate the farmers for cultivation of Bt cotton with appropriate extension strategies and policy measures.

**Key Words:** Bt technology, Bt cotton, Decomposition of output change, Non Bt cotton Production function, Resource use efficiency.

**Introduction:**

India with its 13 % share of world's cotton production ranks the third largest producer of cotton in the world (CABI, 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 susceptible to insects which impacts cotton production. Nearly fifty % of the pesticides consumed in India is used only for cotton crop. The chemical control to eliminate these pests have developed high level resistance for the most of chemicals used to control the pest. Such a high level of resistance requires repeated application of pesticides leading to expenditure and crop failures (Jagmail Singh et al, 2007). 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 matter of serious concern (Mahendra Dev S., et al, 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 2007-08.

An attempt is made in this paper to asses the impact of Bt cotton technology on cotton output empirically. The objectives of the study are: (i) To assess the resource use efficiency in Bt cotton vis-à-vis Non Bt cotton cultivation and (ii) To decompose the influence of factors and Bt technology on output change.

### **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 %age 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 - January 2008.



### **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 in turn 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 Dev S., et al, 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 rises 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.

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

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

$Y_B$  = 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

$\alpha_1, \alpha_2, \alpha_3, \alpha_4$  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 equation-1 and equation-2 and adding some terms subtracting the same terms.

$$\ln Y_B - \ln Y_{NB} = (\ln A_B - \ln A_{NB})$$

$$+ (\alpha_1 \ln X_{B1} - \beta_1 \ln X_{NB1} + \alpha_1 \ln X_{NB1} - \alpha_1 \ln X_{NB1})$$

$$\begin{aligned}
 &+ (\alpha_2 \ln X_{B2} - \beta_2 \ln X_{NB2} + \alpha_2 \ln X_{NB2} - \alpha_2 \ln X_{NB2}) \\
 &+ (\alpha_3 \ln X_{B3} - \beta_3 \ln X_{NB3} + \alpha_3 \ln X_{NB3} - \alpha_3 \ln X_{NB3}) \\
 &+ (\alpha_4 \ln X_{B4} - \beta_4 \ln X_{NB4} + \alpha_4 \ln X_{NB4} - \alpha_4 \ln X_{NB4}) \quad \text{(Equation- 3)}
 \end{aligned}$$

Rearranging the terms in equation-3

$$\begin{aligned}
 &(\ln Y_B - \ln Y_{NB}) = (\ln A_B - \ln A_{NB}) \\
 &+ [\alpha_1 - \beta_1] \ln X_{NB1} + (\alpha_2 - \beta_2) \ln X_{NB2} + (\alpha_3 - \beta_3) \ln X_{NB3} + (\alpha_4 - \beta_4) \ln X_{NB4} + \\
 &[\alpha_1 (\ln X_{NB1} - \ln X_{NB1}) + \alpha_2 (\ln X_{B2} - \ln X_{NB2}) + \alpha_3 (\ln X_{B3} - \ln X_{NB3}) + \alpha_4 (\ln X_{B4} - \ln X_{NB4})] \quad \text{(Equation- 4)}
 \end{aligned}$$

### Decomposition Model:

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

$$\begin{aligned}
 \ln \left[ \frac{Y_B}{Y_{NB}} \right] &= \ln \left( \frac{A_M}{A_N} \right) + \\
 &[\alpha_1 - \beta_1] \ln X_{NB1} + (\alpha_2 - \beta_2) \ln X_{NB2} + (\alpha_3 - \beta_3) \ln X_{NB3} + (\alpha_4 - \beta_4) \ln X_{NB4} + \\
 &[\alpha_1 \ln (X_{B1} / X_{NB1}) + \alpha_2 \ln (X_{B2} / X_{NB2}) + \alpha_3 \ln (X_{B3} / X_{NB3}) + \alpha_4 \ln (X_{B4} / X_{NB4})] \quad \text{(Equation- 5)}
 \end{aligned}$$

The above 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 % change in output per acre with the introduction of Biotechnology.

The impact of Biotechnology can be observed by looking 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 above 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

$$\Delta Y = Y_B - Y_{NB} = \text{Total change in output per acre}$$

$r \Delta Y$  = Value of extra output produced per acre due to the access to Bt technology.

## **RESULTS AND DISCUSSIONS:**

### **Resource Use Efficiency:**

The estimated production function appears to be best fit 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 respect 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 %age change in value of output has been decomposed into %age change in output due to Bt technology and % 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 the 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 %.

### **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 above 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 of 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 coefficient of output with respect 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 of 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.

**Table-1**

**Per acre OLS estimates of the Production function**

Variable	Parameter	Estimated value	t- value	R <sup>2</sup>
<b>Bt cotton</b>				
Constant	Log A <sub>B</sub>	10.97	11.89	0.78
Seed	$\alpha_1$	0.186*	5.76	
Fertilizer	$\alpha_2$	0.271*	9.38	
Pesticide	$\alpha_3$	0.076	0.87	



Human Labour	$\alpha_4$	0.487**	2.33	
<b>Non-Bt cotton</b>				
Constant	Log A <sub>NB</sub>	8.76	13.33	
Seed	$\beta_1$	0.165	2.68	
Fertilizer	$\beta_2$	0.261*	6.33	0.82
Pesticide	$\beta_3$	0.116*	3.05	
Human Labour	$\beta_4$	0.461**	2.93	

**Note:** The dependent variable is the value of output (in Rs.) per acre.

\* Significant at one % level

\*\* Significant at five % level

**Table-2**

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

	<b>Item</b>	<b>%age attributable</b>
	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

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