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Sustainability analysis of *Bt* cotton and non *Bt* cotton in south India

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ABSTRACT: In this regard, present explanatory study was conducted to examine the economic sustainability of *Bt* cotton in Haveri district of Karnataka state, due to maximum area under cotton. A random sample of 80 *Bt* and non *Bt* cotton growing farmers from 4 randomly selected villages was chosen as respondents of the study. The results showed that *Bt* cotton was more sustainable with a higher and stable sustainability index (0.66) compared to non *Bt* cotton (0.59).

Key words: *Bt* cotton, non *Bt* cotton, sustainability

Cotton is an important fibre crop of global significance, which is, cultivated in tropical and sub tropical regions of more than seventy countries across the world. India is one among the important cotton grower on a global scale and has the unique distinction of cultivating cotton. In India cotton plays a key role in the national economy in terms of generation of direct and indirect employment in the agricultural and industrial sectors. In 2001-2002, cotton cultivated area, production decreased and significant yield losses occurred because of high insect infestation. About 10 per cent of insecticides on global basis and 45 per cent in India are used for control of insects in cotton crop alone (Singh, 2004). Several studies showed that *Bt* crops, which provide resistance to some lepidopteran and coleopteran insect pest species, have helped to reduce chemical pesticide use and increase effective yield (Subramanian and Qaim, 2009). *Bt* cotton is currently the most widely grown *Bt* crop. The largest *Bt* cotton areas are found in India and are heavily dominated by smallholder farmers. The smallholders who benefit from *Bt* technology adoption in terms of higher incomes and lower occupational health hazards associated with pesticide sprays (Kouser and Qaim, 2011). In India, it was also shown that *Bt* cotton contributes to poverty reduction and broader rural development (Subramanian and Qaim, 2010; Ali and Abdulai, 2010; Kranthi, 2012). However, there is still uncertainty with respect to the sustainability of these effects. The objective of sustainability is to maximize the goals in economic, social and environmental systems balancing the trade offs and setting priorities among various goals. The present study is analyzed the economic sustainability of the *Bt* cotton production system *vis-à-vis* non *Bt* cotton production system.

Data pertaining to the crop year 2006-2007 was collected from the selected farmers during the month of January 2007. Two stage simple random sampling procedure was adopted for the study. Haveri district was selected from the 29 districts in Karnataka state, as it was the major *Bt* cotton growing area. Four villages in Haveri district were randomly selected in the first stage and in the second stage 80 farmers were selected, consisting of 40 farmers each cultivating *Bt* and non *Bt* cotton, respectively. Sustainability is one that over a period of time enhances environmental quality and the resource base on which agriculture depends; and provides for basic human food and fibre needs and is economically viable and enhances the quality of life for farmers and society as a whole. Ten indicators were chosen to analyse the sustainability and they are land, seeds, farm yard manure, fertilizers, plant protection chemicals, labour, ratios of cost of commercial pesticides to the total cost of cultivation, cost of chemical fertilizers to the total cost of cultivation, ratio of cost of ecologically non destructive inputs to the total cost of cultivation and ratio of cost of purchased inputs to the total cost of cultivation.

Cobb-Douglas (C-D) type of production function fitted to the pooled data of both *Bt* cotton and non *Bt* cotton farmers was used to compute sustainability indices. The estimated values of regression coefficients represent the elasticity of production, while the marginal product (MP) of the i^{th} input x_i is given by

MP of $x_i = b_i * v/X_i$ .... (1)

v = estimated gross returns from pooled data

X_i= geometric mean level of i^{th} input

Since both the dependent and independent variables except land are expressed in value terms (rupees) in the current study, the MP was also represented in value terms (rupees) and represents the value of marginal product (VMP). The VMP of six inputs i.e land, seeds, farm yard manure, fertilizers, plant protection chemicals and labour was computed using the above mentioned method. Ratios of cost of commercial pesticides to the total cost of cultivation, cost of chemical fertilizers to the total cost of cultivation, ratio of cost of ecologically non-destructive inputs to the total cost of cultivation and ratio of cost of purchased inputs to the total cost of cultivation respectively are computed by taking ratios.

Above mentioned ten indicators were ranked by ten experts from various fields of agricultural sciences and were assigned relative weights by Garrett ranking technique to get the scale value (S_i) of each indicator.

Garrett's formula for converting ranks into percent was given by

Per cent position=100*(Rij-0.5)/Nj................. (2)

Where Rij= rank given for I^{th} factor by j^{th} individual

Nj= number of factors ranked by j^{th} individual

The present position of each rank then converted into scores referring to the Garette ranking table. For each factor, the scores of individual respondents were added together and divided the total number of the respondents for whom scores were added. These mean scores for all the factors were arranged in descending order, ranks were given and most important factors were identified. The ranks of the sustainability indicators are given in Table 1. To develop the sustainability index, the values of sustainability indicators which were in different units were made into unit values using the equation (4) for all indicators except for the ratios of cost commercial pesticides, chemical fertilizers, ecologically non destructive inputs and purchased inputs to the total cost of cultivation, for which equation (5) was used as lower value was desirable for this indicator.

$$U_{ik} = \frac{Y_{ik} - \text{Min } Y_i}{\text{Max } Y_i - \text{Min } Y_i} \quad \text{................................(3)}$$

$$U_{ik} = \frac{\text{Max } y_i - Y_{ik}}{\text{Max } Y_i - \text{Min } Y_i} \quad \text{.....................................(4)}$$

Where, U_{ik} is the unit value of the i^{th} indicator for the k^{th} farmer, Y_{ik} is the value of the i^{th} indicator for the k^{th} farmer, Max Y_i is the maximum value of the i^{th} indicator, and Min Y_i is the minimum value of the i^{th} indicator.

The sustainability index for each farmer was then calculated using the equation,

$$SI_k = \frac{\sum_{k=1}^{n} (U_{ik} x S_i)}{\sum_{i=1}^{8} S_i} \quad \text{.................................(5)}$$

Where, SI_k is the sustainability index of the k^{th} farmer, U_{ik} is the unit value of the i^{th} indicator for the k^{th} farmer; S_i is the scale value of the i^{th} indicator.

The significance of the difference between the two mean sustainability indices of *Bt* cotton and non *Bt* cotton was tested using the two sample t test for means with the t statistic.

$$t = \frac{(\overline{x}_1) - (\overline{x}_2)}{\sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}}} \quad \text{...................................(6)}$$

Where,

$\overline{x}_1$= Mean of sample 1,

$\overline{x}_2$= Mean of sample 2,

σ_1^2 = Variance of sample 1,

σ_2^2 = Variance of sample 2,

n_1 = Number of observations in sample 1

n_2 = Number of observations in sample 2.

The farmers were then classified into different sustainability groups based on the deviation of their sustainability index from mean value as follows. Farmers having Sustainability Index (SI) < Mean SI - ½ SD were classified as low sustainability group. Those having SI > Mean SI +½ SD were classified as high sustainability group. Those farmers having sustainability index in between Mean SI +½ SD and Mean SI - ½ SD were classified as medium sustainability group.

Ten experts from different faculties of agricultural sciences ranked 10 sustainability indicators as presented in Table 1. Garret ranking technique was used to assign relative weights for each of these indicators. For each indicator, the scores of individual experts were added together and divided the total number of the respondents for whom scores were added. These mean scores (scale value) for all the factors were arranged in descending order, ranks were given and most important factors were identified. The scale value for each indicator and their respective ranks are presented. The indicator, which is ranked a prime importance, was seeds in case of *Bt* cotton with the highest scale value of 78 this might be due to getting high yield from the seeds. Qaim (2003) and Qaim and Zilberman (2003) came to similar findings. Further sustainability indicators were ranked as farm yard manure, land, fertilizer; plant protection chemicals and labour. The ratio of ecologically non destructive inputs to total cost of cultivation, ratio of cost of commercial pesticides to total cost of cultivation and ratio of chemical fertilizers to the total cost of cultivation occupied seventh, eighth and ninth ranks, respectively. Ratio of purchased inputs to the total cost of cultivation with the lowest scale value of 29.65 was ranked last.

In case of non *Bt* cotton plant protection chemicals was ranked first with the highest scale value of 67.75 this is due to the more incidences of pest and diseases. Followed by land, seeds, fertilizers, farm yard manure, labour, ratio of chemical fertilizers to the total cost of cultivation, ratio of cost of commercial pesticides to total cost of cultivation, and ratio of purchased inputs to the total cost of cultivation. Ratio of ecologically non destructive inputs to total cost of cultivation with the lowest scale value of 32.1 was ranked last, this is because it replenishes the production system and enhances its ability to sustain itself.

The weighted average of 10 sustainability indicators was worked out to represent the composite sustainability index separately for each farm. The mean composite sustainability indices of *Bt* and non-*Bt* cotton farmer are presented in Table 2. It could be observed that the mean sustainability index of *Bt* cotton was 0.66, whereas it was 0.59 in case of non *Bt* cotton. The difference between the two mean sustainability indices was found to be significant indicating that, *Bt* cotton is more sustainable compared to non *Bt* cotton. The co efficient of variation of sustainability index in case of *Bt* cotton was 2.88 per cent as against 6.45 in non-*Bt* cotton.

The two different categories of farmers *viz.*, *Bt* cotton farmers and non *Bt* cotton farmers were classified into three sustainability groups *viz.*, low, medium and high, based on their

Table 1. Ranking of sustainability indicators of *Bt* and non *Bt* cotton farming

Indicators	*Bt* cotton		Non *Bt* cotton	
	Scale value	Ranks	Scale value	Ranks
Land (ac)	64.21	3	65.25	2
Seed (Rs)	78.12	1	63.22	3
Farm yard manure (Rs)	67.75	2	59.54	5
Fertilizer (Rs)	56.50	4	60.75	4
Plant protection chemicals (Rs)	53.21	5	67.75	1
Labour (Rs)	50.95	6	49.95	6
Ratio of ecologically non destructive inputs to total cost	42.15	7	32.15	10
Ratio of chemical fertilizers to total cost	37.15	9	41.65	7
Ratio of commercial pesticides to total cost	38.15	8	40.65	8
Ratio of purchased inputs to total cost	29.65	10	36.9	9

Table 2. Sustainability index of *Bt* and non *Bt* cotton farming

Particulars	Mean	Variance	SD	CV	Observations	t statistic
Bt cotton	0.66	0.0004	0.02	2.89	40	13.12 *
Non *Bt* cotton	0.59	0.0016	0.04	6.46	40	

Note: * Significant at 5 per cent, SD: Standard Deviation, CV: Coefficient of Variation

Table 3. Classification of sample farmers according to the sustainability index

Sustainablity grops	Category of farmers		Farmers in each group	Chi-Square
	Non *Bt* cotton farmers	*Bt* cotton farmers		
Low	10(25)	7(17.5)	20	0.52*
Medium	21(52.5)	20(50)	34	
High	9(22.5)	13(32.5)	26	
Sample size	40	40	80	

Note: Figures in parentheses represent percentage to the respective sample size; *Significant at 5 per cent

sustainability index and the results are presented in Table 3. It could be observed that only 17.5 per cent of *Bt* cotton farmers in the low sustainability group, where as 25 per cent of the non *Bt* cotton farmers were in this group. 50 per cent of *Bt* farmers were in the medium sustainability group where as only 52.5 per cent of the Non *Bt* farmers were in this group. 32.5 per cent of the *Bt* farmers were in high sustainability group where as only 22.5 per cent of non-*Bt* farmers were in this group. The chi-square found to be significant, indicates a significant difference in the distribution of the two groups that is farmer cultivating *Bt* cotton were significantly more skewed towards higher sustainability to non *Bt* cotton farmers. Similar results were observed by Qaim and Subramanian 2006 indicate that *Bt* cotton farmers are more sustainable where they were benefiting from higher yields and reduced pesticide expenses in comparison with non-*Bt* cotton farmers.

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