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Economic Profitability and Adoption of Bt Cotton and non-Bt Cotton in North India

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Background and Problem Statement

Cotton is one of the major cash crops in India. India is second largest producer of cotton in the world after China. The cotton was growing near about 9.5 million hectares producing 31 million bales in 2007-08. It is planted by 4 million farmers and involves many more in processing, textile manufacture and trade with 30% contribution in GDP of Indian agriculture. However, yield of cotton in India is low, with an average yield of 553 kg/ha compared to the world average of 780 kg/ha in 2007-08 (Sen, 2008). Main losses in cotton production are due to its susceptibility to about 162 species of insect pests and a number of diseases (Manjunath, 2004). Among the insects, cotton bollworm is the most serious pest of cotton in India causing annual losses of at least US\$300 million per year. This insect has also developed resistance against most of the recommended insecticides which forcing the farmers to apply as much as doses of 10-16 sprays in a single cropping season (Kranthi et al., 2001; Ramasubramanyam, 2004).

So mitigating this yield loss, incorporating the insect resistance gene in cotton has become the prime objective of cotton improvement efforts in India. But painfully no bollworm resistance is available in the germplasm. Thus, in 2002, the efforts got diverted to harness Bt (*Bacillus Thuringiensis*) technology for bollworm resistance in India. Bt is an ubiquitous soil bacterium which provide the resistance power to cotton plant against bollworms. After that the atmosphere of debate on Bt technology is occurred. There are some studies which favour the Bt cotton for example James (2000) observed that in India, 40% higher yield of Bt hybrids (14.64q/ha) over their non-Bt counterparts (10.45q/ha). Naik (2001) analysed that in India, there was 78.8% increase in the value due to yield and 14.7% reduction in pesticides cost with the growing of Bt cotton as compared to non-Bt cotton. The

Qaim and Zilberman (2003), Barwale et al. (2004) reported that on an average, Bt hybrids received three times less spray against boll worm than non-Bt cotton. The general germplasm effect was negligible and the yield gain was largely due to Bt gene itself. In 2008-09, there was more than 80 % area of cotton was under Bt cotton.

On the other hand, even area under Bt cotton is increased, there are some studies which are totally neglect the benefit of Bt technology. For examples, Sahai and Rahman, Shiva and Jafri (2003) found that in India, performance of Bt cotton was worse than non Bt cotton not only in yield as well as in quality also. ISIS, Qayum and Sakkhari (2005) reported that Bt cotton was totally failed in India which was not favourable for small farmers and rain fed areas. It yielded nearly 30% less than non-Bt cotton.

The debate about Bt cotton' profitability and its suitability for region is going on and area under Bt cotton is increasing very rapidly. This study's main objective to clarify this debate and find out the factors which are responsible for adoption of Bt cotton.

Material and Methods

Bt cotton was introduced in 2005 in Northern India therefore Northern India was selected for this study. This study based on primary data which is collected from farmers through personal interviews from Haryana and Punjab states of North India. For collection of data, multi-stage sampling technique was used. From each state 100 farmers were interviewed, thus total 200 farmers were selected for detailed data collection in which 160 Bt farmers and 40 non-Bt cotton farmers for agriculture year 2007-08. For profitability analysis, partial budgeting tool is used which is a method of making a comparative study of costs and returns which results from a change in a part of the farm business. The logit model is used to identify the adoption factors. If $U_i^{Bt} \geq U_i^C$, then he will adopt the Bt cotton If $U_i^{Bt} < U_i^C$, then he will continue with non-Bt cotton.

$$U_i = \sum \beta_i \chi_i$$

Where, χ_i is the variable which determines the choice of individual i.

So $P_i = f(\beta, \chi_i)$

Where, X is explanatory variables related to adoption

$$Y(P = 1 / \chi_i) = \frac{1}{1 + e^{-(\beta + \beta_i \chi_i)}}$$

Y = Adoption of Bt cotton (1, 0)

β_i = Coefficient of explanatory variables

χ_i = Explanatory variables –Expenses on insecticide, cotton revenue, Network dummy, education, experience in cotton, No of information source, family size, annually off-farm income and state dummy.

Result and Discussion

In survey, we found that Bt farmers are younger and have higher income and expenses than non Bt farmers. The result from table 1 shows that Bt cotton seed is very costly than non-Bt seed. But Bt farmers are spending near about half money on spraying. Thus, Bt farmers used less insecticide than non-Bt cotton. It also means that Bt cotton is less environmental hazards on the basis of chemical insecticides. They used more chemical fertilizer which is near about double than non-Bt farmers. Bt cotton needs more water than non-Bt cotton. This thing proved here in this study also. Bt farmers spent more money on picking because Bt cotton had higher yield than non-Bt cotton. In developing countries, cotton picking always have done manually. Thus, in developing countries will be like that more yields more picking cost.

Table 1: Partial Budgeting form of Bt and Non-Bt cotton

a) Increase in costs in Rs./acre	b) Decrease in cost in Rs.
I) Seed cost = 1364.52-256.48=1108.04	Insecticide cost=1690.29-867.28=823.01
II) Fertilizer cost=1739.49-915.13=824.36	Sub total = 823.01
III) Irrigation cost=1256.24-734.45=521.79	
IV) Picking cost = 2468.75-1846.25=622.50	
Sub total =1108.04+824.36+521.79+622.50=3076.69	
c) Decrease in Returns in Rs.: nil	d) Total Increase in Returns in Rs.:
	22328.13 - 14799.25 =7528.88
Comparing Net return with Bt cotton = (b+ d)-(a+c) = (823.01+7528.88) – 3076.69 = 5275.20 Rs.	

With Bt cotton, cost mainly increased in seed, fertilizer, irrigation and picking which is Rs. 3076.69 per acre. On the other hand, farmers reduced the insecticide cost which is near about 26 per cent cost of total increased cost with Bt cotton. But Bt farmers had higher yield, thus they had near about 50 per cent more return than non-Bt cotton which compensate all increased cost. Thus with Bt cotton farmers got higher net return i.e. Rs.5275.20 per acre.

In Northern India, Bt cotton was approved for commercial cultivation in 2005. Some of the farmers adopt Bt cotton first year, many other farmers adopted after see the Bt cotton in the farm of their neighbour farmer or village farmers. The following figure 1. shows their adoption pathway. In adopter major group of early majority and another major group is from early adopters. Mostly farmers want to watch the seed variety in their neighbourhood then they will adopt. In northern India, farmers adopted Bt cotton mainly in third year of Bt cotton approval.

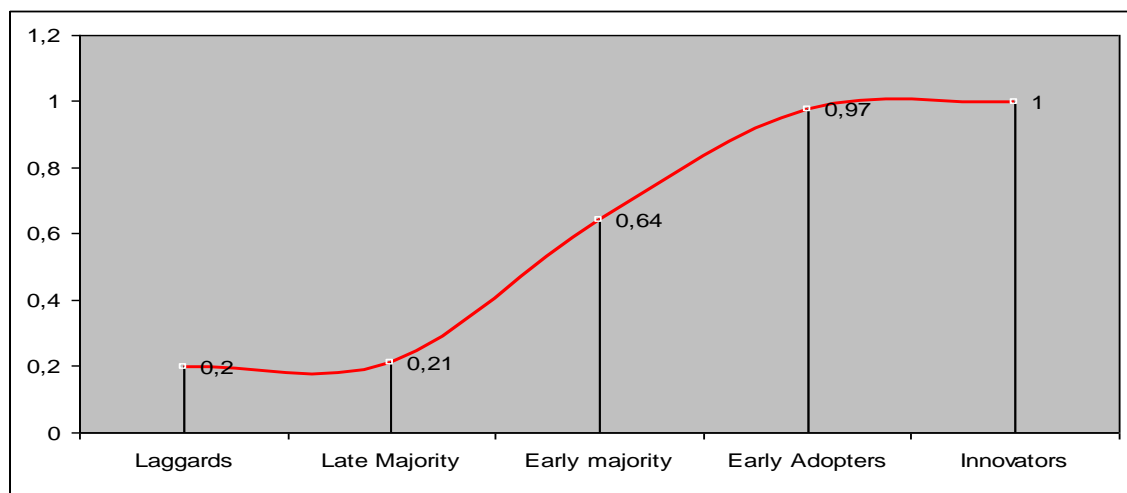


Figure1. Overtime adoption pathway

Table 2 shows that factor which affects the adoption of Bt cotton in Northern India. Thirtle *et. al* (2003) also used the logit model and found that economic factors like farm size, non-farm income and social factors like farmer experience, female labour in family are the main factors for Bt cotton adoption. So we also assumed that farm size is a main factor to adopt a new technology because farmers with large farms are likely to bear more risk than farmers with small farms. The main factors which affects the adoption of Bt cotton are economic factors like insecticide expenses, revenue from cotton, non-farm income and social factors are education level of farmer, farmer's network. If the farmers want to spend less money on insecticide, these farmers would like to adopt a technology which reduces the insecticide use. Farmers get higher cotton revenue, these farmers would like to adopt new technology, new seed etc to improve their return in agriculture. When farmers have good money then they can spend some more money to improve their production.

Table 2: Adoption factors of Bt cotton in Northern India.

Y	Coeff.	S.E.	P> z
Insecticide expenses (Rs./acre)	-4.248	.931	0.000
Total cotton revenue (in Rs.)	2.515	.622	0.000
Annually Non-Farm income (in Rs.)	.026	.061	0.664
Education (in school years)	.886	.365	0.015
Network dummy	2.184	1.158	0.059
Family size	-.032	1.065	0.976
Experience in cotton farming (in yrs.)	-1.328	1.253	0.289
No. of information source	.669	.850	0.432
State dummy (if state Haryana=1)	-2.070	.912	0.023
Constant	5.486	8.628	0.525
Log likelihood	-34.881		
Pseudo R ²	0.652		

Non farm income has the positive sign and largest coefficient which tells its importance as a source of money which farmers can use to buy the expensive Bt cotton seed. Non-farm income has a stronger effect because the farmers are likely to be less risk averse. Educated farmers and other farmers' who are engaged with some famers' club or organisation means having network would like to adopt Bt cotton because these farmers always get information about new technology properly. Here, state dummy has negative impact on adoption of Bt cotton. It means Punjab state farmers are more advanced to adopt Bt cotton than Haryana farmers because they have little bit more resources than Haryana farmers. Here, farming experienced does not have impact on adoption of Bt cotton. If the negative indication on adoption is analysed, then it can be concluded that more experienced farmers would like to stay with their traditional way or conventional cotton. They would not like to adopt new technology or new seed variety so quickly.

Conclusions

After discussion of main results, it can be concluded that Bt cotton is economically profitable than non-Bt cotton. But it requires more irrigation which shows that it is not suitable for dry areas. Bt cotton farmers used more fertilizer than non-Bt cotton farmers. It means that in future, soil fertility of Bt cotton area can be reduced. But on the other hand, Bt reduces the use of insecticide which shows that it is beneficial for the environment. The farmers used Bt cotton due to more yield and reduction in insecticide. Adoption factors will be verified from place to place. In Northern India, the main factor for adoption of Bt cotton are economic factors. Mainly these are insecticide expenses, cotton revenue and non-farm income and others are education and network of farmers. Punjab farmers are more likely to adopt Bt cotton than other farmers in Northern India.

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