

## Can Genetically-Engineered Cotton Help Farmers? – A Case Study from Pakistan

**Cotton is an important cash crop that makes a significant contribution to the economy of Pakistan. However, in recent years, Pakistani cotton growers have experienced significant increases in production costs alongside stagnating yields. To help find an answer to these problems, a new SANDEE study has assessed the costs and benefits of adopting genetically-modified Bt cotton seeds. This study, which is the work of Khuda Bakhsh from Institute of Agricultural and Resource Economics, University of Agriculture, Faisalabad, Pakistan, assesses the effects of Bt cotton on short-run profits, yields and farm inputs for farmers in Pakistani Punjab.**



Figure 1: Map of Punjab province and study location

The study finds that, on average, farmers that adopt Bt cotton obtain higher yields per hectare and significantly reduce their use of pesticides than farmers growing normal varieties of cotton. This means that they generally achieve higher returns from their farms. The study concludes that allowing more Bt cotton varieties (if the availability of quality Bt cotton seeds in the market is ensured) is likely to improve the livelihoods of farmers. However, it also highlights that such a move would raise legitimate concerns about irrigation water availability and biodiversity loss.

use of pesticides in Pakistan raises environmental concerns and also makes Pakistani cotton less competitive in the world market.

The adoption of *Bacillus thuringiensis* (Bt) cotton is seen as a potential

### The Cotton Pesticide Challenge

The problems confronting cotton production in Pakistan are caused by a rising incidence of disease and insect attacks. Small farms, which dominate Pakistan's agriculture, are particularly vulnerable to pest infestation, because of their inability to bear any form of financial risks. Because of this, pesticides are a very important input in the country's cotton production process and currently account for about 33% of input costs. To supply Pakistani farmers with the chemicals they need, huge amounts of pesticide are imported and produced domestically. The increased



Pest scouting of Bt cotton field by the farmer

## The Adoption of Bt Cotton

Farmers can reduce the amount of pesticide they use on cotton crops in many ways. These include biological control methods, mechanical controls, integrated pest management and the selection of cotton varieties with a resistance against pests. Most of these options require continued research and development. Their introduction also requires a good deal of effort to introduce, motivate and train targeted farmers. This must be done in order to convince the farmers of the benefits they might obtain from adopting a new farming technique. However, with genetically modified (GM) cotton seeds, little investment is required in disseminating the technology as long as the Bt seed is available in the market.

GM seeds, first adopted in developed countries, are expensive. Nonetheless, the use of the Bt cotton seed, in particular, has spread widely in developing countries in recent years. The main reasons for this are the many private benefits of Bt cotton that have been identified. Multiple studies suggest that Bt cotton use reduces pesticide sprays and increases seed cost and yields. Research also provides evidence that planting Bt cotton not only significantly decreases spraying against the pest cotton bollworm, but can also reduce the prevalence of cotton bollworm on other crops.

Another important benefit of Bt cotton to farms, as identified by its proponents, is a reduction in health costs from pesticide exposure. The human health impacts of pesticide use are generally difficult to measure. However, a few studies have shown that a greater percentage (around 22%) of cotton farmers who do not grow Bt cotton report health problems linked to pesticide than farmers planting only Bt cotton (5-8%). Other researchers also argue that Bt cotton has led to a notable decline in acute pesticide poisoning cases among cotton growers in India.

The view on Bt cotton, however, is not always totally positive. There are some studies that find that Bt cotton does not significantly increase yields and income and that bollworms continue to grow in the crop. These studies identify a variety of factors for the failure of Bt cotton such as: farmers' limited knowledge on how to use the technology, the prevalence of a black market for un-improved Bt cotton varieties and climatic variations and other disasters.

There is also a lot of concern about the impact of Bt cotton on the earnings of small farmers, who may be forced to buy seeds for every crop from foreign monopolies. Some researchers have found that small farmers who adopt Bt cotton hoping to lower costs may actually incur higher costs because of the high costs of seeds and the need for more fertilizers and irrigation.

solution to the pest-related challenges facing Pakistani cotton farmers. The Bt cotton seed includes a genetically engineered modified soil bacterium gene, *Bacillus thuringiensis*. This gene has a natural toxin against several harmful insects, especially bollworms. Thus, Bt Cotton's proponents argue that using this type of cotton seed could lead to reduced pesticide consumption and should have a consequent positive impact on the environment. There is evidence to suggest that this is the case from countries that have allowed the cultivation of Bt cotton at a commercial level. These include the USA, Australia, China, Mexico, Argentina, South Africa and India.

Bt cotton was officially introduced in Pakistan in the year 2010. However, even prior to this, Bt cotton was being grown in large tracts of agricultural land (over 50% of the area under cotton cultivation), using unapproved Bt cotton seed varieties.

## Assessing the Costs and Benefits of Bt cotton

Because of the current importance and future potential of Bt cotton in Pakistan's cotton farming system, the SANDEE study set out to investigate the costs and benefits that its use might bring.

The study was undertaken in the cotton growing area of Southern Punjab, Pakistan. Punjab is divided into irrigated and non-irrigated areas and the research team focused on irrigated farmland in the Southern Punjab, where 90% of cotton farms are concentrated. Three study districts were randomly selected (Multan, R Y Khan and Mianwali) and 96 respondents selected from each district.

The respondents were interviewed during 2009, for two crop seasons-2008 and 2009. The interviews gathered information about the inputs and outputs of cotton cultivation. Information was also obtained on farming practices, the scope of Bt cotton adoption and the socio-economic characteristics of the farmers.

## The Link Between Yields and Profits

In order to understand why farmers decided to adopt Bt cotton the research team looked at the yields that farmers were getting from their cotton crops, assessed the cost of inputs and calculated the average net revenues they were receiving. The revenue of households growing Bt and/or non-Bt cotton was estimated by multiplying the quantity produced by the price received by farmers at the farm gate. Similarly, the total cost of the various inputs the farmers used was computed by multiplying the quantity of inputs by the respective prices paid by the farmers.

The researchers made an assessment of the links between the use of Bt-cotton and farmers' yields and profits. In all their calculations, they were careful to take into account the multiple other variables that could affect yields and profits, such as entrepreneurial skills and the impact of the weather. Specifically a reduced-form panel-data-based random effects (RE) and fixed effects (FE) method was used to address the

problem of selectivity in the adoption of Bt cotton and the issue of endogeneity in the use of pesticides and other inputs.

## 78% of Cotton Land under Bt Cotton

The study found that 78% of the cropped area in the study region had been converted to Bt cotton. Some farmers grew Bt cotton exclusively, some farmers only grew non-Bt cotton and some grew a mixture of the two types of cotton. Overall, there were few major differences in socio-economic characteristics between the farmers who chose to grow Bt, non-Bt cotton or a mixture of both on their farms.

The mean cotton yield in the study sample plots was 2,395 kg per hectare. The mean net revenue was PKR 49,784 (USD 586) per hectare of cotton. The mean amount of NPK fertilisers applied by the farmers was 249 kg per hectare. On average, four litres of pesticides were used per hectare. Labour costs, which included both family labour and hired labour, were, on average, PKR 7754 (USD 91) per hectare.

## Bt Cotton Brings Higher Yields

After controlling for other factors, the researchers found that, on average, farmers who grew Bt cotton had 10% higher yields than farmers who grew non-Bt cotton. The study also found that farmers growing Bt cotton were likely to have higher incomes than farmers using non-Bt seeds. On average, the net revenue or return from Bt cotton use was PKR 53,249 (US\$ 626) per hectare versus a return of PKR 41,833 (US\$ 492) from non-Bt cotton.

The higher returns from Bt cotton were mainly attributable to reductions in pesticide costs. Indeed, it was found that the 78% conversion of cotton growing area to Bt cotton in the study area had resulted in farmers using 22% less pesticides.

While these estimates of the positive effect of Bt cotton on yield are significant, they are generally lower than similar results from other studies. One reason for these relatively lower yield estimates may be the fact that Bt cotton seed in Pakistan was un-approved at the time of the study. Seed quality may therefore have been adulterated.

The main negative impact of the adoption of Bt cotton was related to an increase in water use. The study estimates that if farmers were to fully convert to Bt cotton in the study area, this would contribute to an 11% increase in the use of irrigation water.

## Concerns About Bt Cotton

While the study shows that Bt cotton can have a positive impact on farmers' livelihoods, the study notes that the research literature on the impact of Bt cotton on small farmers is mixed, and that worries remain about the long term impacts of Bt cotton. Two key problems that have been highlighted are the loss of biodiversity and genetic pollution.

Biodiversity loss may occur as farmers start planting only Bt cotton on their farms. This can result in fewer varieties of cotton being available in the field. Crop diversity is a particular concern. Given the current rapid introduction of Bt cotton into Pakistan it is likely that more research will be focused on Bt cotton, to the detriment of other non-Bt cotton varieties. This may result in the availability of fewer cotton varieties.

Genetic pollution (i.e. genes from Bt cotton escaping into the natural ecosystem) is another major concern because this may result in a decline in the naturally prevalent gene pool.

Overall, the literature on Bt cotton seems to suggest that it offers a range of private benefits to farmers. However, some questions remain about whether small farmers who use Bt cotton are being overly exposed to risks because of the high costs of the seeds. There is also agreement that the potential long-term adverse impacts of Bt cotton use include: the increased use of irrigation water, biodiversity loss, genetic pollution and possible effects on land fertility. (For more background information on the introduction of Bt cotton and its pros and cons see the Side Bar).

## Bt Cotton Cultivation on the Rise

The study concludes that Bt cotton has three important advantages over non-Bt cotton. These are: a decline in pesticide use, an increase in yields and higher net revenues.

The study notes that, since data collection took place, the use of Bt cotton in Punjab has further increased and now dominates cotton production. Farmers are therefore clearly recognizing the benefits of Bt cotton, including the fact that it reduces the costs of pesticide use and the risks of pest attacks.

However, the study warns that, while pesticide costs will likely decline with the conversion from non-Bt to Bt cotton, costs associated with other inputs such as water and labour are likely to increase. The increase in irrigation water use is a particular cause for concern given the huge demands in Pakistan for agricultural water.

## SANDEE

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**Table 1: Socio-economic characteristics of sampled farmers**

Variables	All Farmers	Farmers growing Bt and Non Bt cotton	Farmers growing only Bt cotton
Age of respondent (Years)	44 (12)	44 (12)	44 (12)
Total area under cotton production (hectares)	17 (24)	14 (23)	20 (24)
Farming experience (year)	20 (11)	21 (11)	19 (11)
Cotton growing experience (Years)	15 (12)	19 (11)	12 (12)
Education (schooling years)	4 (2)	4 (2)	4 (2)
No. of parcels or plots	2 (1)	3 (11)	2 (1)
Farmers getting credit (%)	21	24	20
Credit availed (PKR)	211,426 (316291)	220,839 (348717)	201,597 (286633)
Number of observations	573	233	340

Figures in parentheses are standard deviations

## Problems with Supply

One other problem with the use of Bt cotton is that market supply cannot currently meet the huge demand for the seeds. As a result growers are facing problems with the non-availability of quality Bt cotton seeds. This raises the concern that farmers will use the unapproved Bt varieties that are now available in the market and that this may well lead to a reduction in yields. Thus, the study recommends that there is a need to ensure the availability of a high quality supply of seeds - this is particularly important for small farmers who are vulnerable to any form of financial risk.

The researchers also note that the longer-term public implications of Bt cotton use, in terms of biodiversity loss and gene reduction, are largely under-explored. There is an understandable concern that these significant public worries may get overshadowed, given the private returns available to farmers from using Bt cotton. The study therefore recommends that these concerns would make a suitable subject for future research.

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