

Factors Influencing the Adoption of Bt Cotton in the Punjab, Pakistan

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ABSTRACT

Based on farm-level-data collected in the main cotton growing district of the Punjab Pakistan, analysis showed that farmers were very eager to adopt Bt cotton, but its poor performance in some areas damaged the confidence of farmers. The main aim of this survey study was to examine the factors influencing the farmers' adoption of Bt cotton. Results indicated that there were many reasons for the non-adoption of Bt cotton, but the main ones were the higher irrigation and fertilizer requirements of the Bt cotton cultivars. Most reasons given by the farmers related to agronomic and management practices, which were may have been due to a lack of knowledge and information on the genetically modified insect resistance of Bt cotton. The higher seed cost was also a main factor in the non-adoption of Bt cotton. The findings of this study may have important implications for the adoption and agronomic practices for insect-resistant Bt cotton.

Key Words: Factors; Non-adoption; Bt cotton; Pakistan

INTRODUCTION

Every new technology has its benefits and risks. The benefits associated with the use of transgenic crops are a dramatic decrease in the use of conventional and broad-spectrum insecticides, target pest specificity, improved yield, lower production costs and compatibility with other biological control agents. As an example, the growing of transgenically modified cotton that expresses insecticidal protein derived from *Bacillus thuringiensis* Berliner (Bt) is revolutionizing cotton production on a global scale (Head *et al.*, 2005). Some risks are also associated with transgenic crops, including out-crossing by the transfer of pollen to non-transgenic plants, food safety concerns, development of resistance in target pests and effects on non-target organisms and biodiversity (Cannon, 2000; Wolfenbarger & Phifer, 2000; Edge *et al.*, 2001; Shelton *et al.*, 2002; Naranjo, 2005).

Agriculture plays a pivotal role in the economy of Pakistan. It contributes about 24% to national GDP and employs 44% of the total labor force. Cotton (*Gossypium hirsutum* L.) is the main cash crop and is known as "White Gold". Pakistan is the fourth largest producer of cotton after China, the USA and India (Abro *et al.*, 2004). The 2.16% population growth rate of Pakistan demands an increasing trend in productivity using less available resources, water and pesticides and with less labour engaged in agriculture (Hayee, 2005). To achieve these objectives, a substantial amount of financial resources and manpower have been committed by the government of Pakistan to the development of genetically modified local cotton varieties with the collaboration of the Center of Excellence in Molecular Biology (CEMB), Lahore and National Institute

for Biotechnology and Genetic Engineering (NIBGE) in Faisalabad, Pakistan.

The Punjab, with 80% of the total area, is the main producer of cotton in Pakistan. In the year 2005-06, it is estimated that Bt cotton was grown on half a million acres in Pakistan, of which 0.23 million acres were in the Punjab Province. Farmers are using US\$300 million worth of pesticides annually, out of which more than 75% is used on cotton crops to control pests, especially bollworms (Rao, 2007). Bollworms are serious pests of cotton in Pakistan. They cause heavy damage, which may vary in extent from year to year but generally cause 30-40% yield reduction (Abro *et al.*, 2004). However due to the development and introduction of Bt cotton, the number of spray operations per crop (cotton) has been reduced (Men *et al.*, 2003).

Global adoption of Bt cotton has risen dramatically from 1.90 million acres in its introductory period in 1996 to 19.40 million acres in 2005. It is remarkable that in the 2005 cotton growing season, 54% of cotton crops grown in the USA, 76% in China and 80% in Australia were with single or multiple Bt genes. Bt cotton, the first transgenic non-food crop has provided a specific, safe and most effective tool for the control of most pests. Farmers' adoption of Bt cotton has increased to an area of 2.4 million hectares in China (Wu *et al.*, 2002; Yang *et al.*, 2005). Bt plants are a very cost effective and environmentally safe way to control pests (Shelton *et al.*, 2002). Field studies in China have shown that by adopting Bt cotton, farmers have reduced pesticide and labour costs, and there is less exposure to toxic insecticides (Xia *et al.*, 1998; Pray *et al.*, 2001, 02).

The Pakistan Atomic Energy Commission (PAEC) provided 40,000.0 kg seed of the Bt cotton cultivars "IR-FH-901, IR-NIBGE-2, IR-CIM-448 and IR-CIM-443" in

May 2005. These cultivars were grown over an area of 8,000 acres during the 2005-2006 cotton seasons. The encouraging outcomes have surprised everyone from seed companies to farmers due to less bollworm damage and less use of pesticide. Pakistan is among the largest cotton producers in the world but its production per acre is very low as compared to China and India (Abro *et al.*, 2004). Therefore, new technologies are urgently required to increase output and decrease inputs in the alarming context of shrinking land and water resources. Due to different pest problems in various crops under different ecological conditions and cropping systems, there may be different interaction (responses) of transgenic crops, which ultimately affect their performance. There is a need for researchers to conduct surveys and do field trials so that a complete model is developed for the long-term persistence of Bt cotton. The present study was therefore undertaken to identify the factors that are influencing the adoption of Bt cotton in Pakistan, keeping in mind the benefits and constraints of the development and introduction of Bt cotton.

MATERIALS AND METHODS

The survey was conducted from May to November 2006 in the main cotton growing districts of the Punjab in Pakistan, where Bt cotton has been grown for 4-5 years. A total of 65 farmers from the different districts of Punjab were interviewed. A preliminary survey was done in the 2005 cotton season to develop a questionnaire. The questionnaire aimed to identify the factors that influence the adoption of Bt cotton. The questionnaire was completed during face-to-face interviews in the field and multiple responses were allowed. Each questionnaire took 30 min with the individual farmer. Survey data encoding and statistical analysis were accomplished using SPSS statistical software.

RESULTS AND DISCUSSION

Socio-economic characteristics of the respondents. Age is an important demographic characteristic affecting the adoption of technology by farmers (Hussain, 1987). The data from 65-farmers indicated that most of the farmers (44.6%) were in the middle age category (31-45 years), while 38.5% belonged to age category of above 45 years and 16.9% of the respondents were up to 30 years of age. Of the surveyed farmers, 43.0% were illiterate. Among the literate group, 37.0% were primary to middle school educated, while 20.0% of the respondents had matriculation or higher education. The survey indicated that most (43.1%) of the farmers have large (>25 acres) land holdings, while 33.8% of respondents had land holdings of 11-25 acres and 23.1% belonged to the small (up to 10 acre) category of land holding (Table I).

Factors influencing the adoption of Bt cotton. The survey study indicated that transgenic Bt/IR cotton has been grown

Table I. Socio-economic characteristics of the respondents (n=65)

Category of farmers	No. (%) respondents
Age	
Young (up to 30 years)	11(16.9)
Middle (31-45 years)	29(44.6)
Old (Above 45 years)	25(38.5)
Education	
Illiterate	28(43.0)
Primary to middle school (8 years)	24(37.0)
Matriculation & higher (above 8 years)	13(20.0)
Land holding	
Small (up to 10- acres)	15(23.1)
Medium (11-25 acres)	22(33.8)
Large (> 25 acres)	28(43.1)

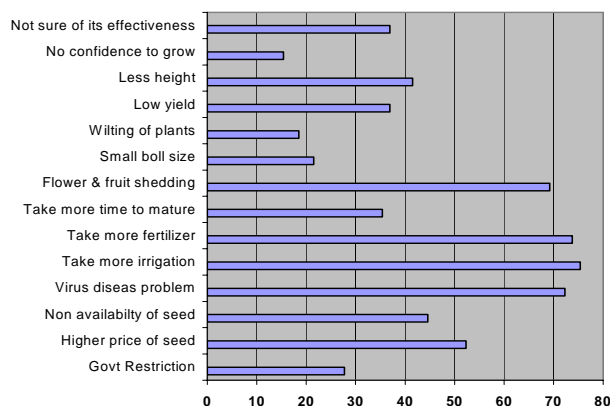
since the 2002-2003 cotton season in the Punjab, Pakistan. Farmers are very eager to adopt these new cultivars, but this adoption behaviour is influenced by several factors (Fig. 1). Adoption can be measured in two ways: the number of adopters (i.e., proportion of farmers growing Bt cotton) and the crop area (proportion of cotton area planted to Bt cotton). There was a variation between the farmers for the adoption of Bt cotton. The larger farmers have sufficient resources to manage crops and this resulted in the adoption of Bt cotton, but this early adoption of Bt cotton was reduced in the case of small farmers by limited resources. The main reasons for the discontinuation of Bt cotton growing are given in the Table II and Fig. 1. An important factor was the irrigation and fertilizer applications; the majority of the farmers, 75.4% and 73.8%, respectively mentioned that Bt cotton cultivars required more irrigation and fertilizer applications. These results were consistent with the results of a survey conducted in the Sindh, Pakistan (Hayee, 2005) that showed that Bt cotton requires more irrigation and that the price of Bt seed is higher than for non-Bt cotton varieties.

Another important factor mentioned by the farmers (72.3%) was the incidence of cotton leaf curl virus (CLCV) in Bt cotton (Table II, Fig. 1). This is a very common disease in Pakistan caused by whitefly. With the advent of the 'Green Revolution', cotton production in Pakistan reached 12.82 million bales in the year 1991-92 but after this, production decreased drastically and fell to 8 million bales due to CLCV. A survey in the Sindh, Province (Hayee, 2005) indicated that 60% of Bt cotton growers reported CLCV in Bt cotton. The cotton mealy bug and CLCV shook the confidence of Bt cotton farmers and pesticide companies took advantage of this situation to advise the farmers not to grow Bt cotton. Some of the farmers mentioned wilting of Bt cotton plants, but actually it was not a pathogenic wilt attributable to fungi, bacteria or viruses. The wilting of Bt cotton plants was due to prolonged dry spells, or may have been due to the excessive use of fertilizer and irrigation application, which increased the build-up of *Verticillium* and *Fusarium* wilt. Although CLCV also occurred in the non-Bt cotton cultivars, farmers lacked information about Bt cotton and assumed it to be a

Table II. Reasons given by the farmers for the non adoption of Bt cotton

Category of farmers	No (%) respondents							
	Govt. restrictions	Higher price of seed	Non availability of seed	Virus disease problem	Takes more irrigation	Takes more fertilizer	Takes more time to mature	
Age (Years)								
Young -30 (n=11)	3(27.3)	7(63.6)	7(63.6)	8(72.7)	8(72.7)	4(36.4)	5(45.5)	
Middle 31-45 (n=29)	10(34.5)	14(48.3)	12(41.4)	18(62.1)	21(72.4)	24(82.8)	7(24.1)	
Old > 45 (n=25)	5(20.0)	13(52.0)	10(40.0)	21(84.0)	20(80.0)	20(80.0)	11(44.0)	
Linear-by-linear association	0.52(p=0.47)	0.21(p=0.65)	1.27(p=0.26)	1.23(p=0.26)	0.33(p=0.56)	4.95(p=0.03)	0.14(p=0.70)	
Education								
Illiterate (n=28)	5(17.9)	16(57.1)	16(57.1)	22(78.6)	24(85.7)	22(78.6)	10(35.7)	
Middle (n=24)	9(37.5)	13(54.2)	12(50.0)	15(62.5)	17(70.8)	17(70.8)	9(37.5)	
Matric & higher (n=13)	4(30.8)	5(38.5)	1(7.7)	10(76.9)	8(61.5)	9(69.2)	4(30.8)	
Linear-by-linear association	1.30(p=0.25)	1.05(p=0.30)	7.32(p=0.007)	0.17(p=0.67)	3.11(p=0.78)	0.50(p=0.48)	0.05(p=0.81)	
Total (n=65)	18(27.7)	34(52.3)	29(44.6)	47(72.3)	49(75.4)	48(73.8)	23(35.4)	
Category of farmers	Flower & fruit shedding	Small boll size	Wilting of plants	Low yield	Less height	Lack of confidence to grow	Not sure of its effectiveness	
Age (Years)								
Young -30 (n=11)	8(72.7)	2(18.2)	1(9.1)	3(27.3)	4(36.4)	1(9.1)	3(27.3)	
Middle 31-45 (n=29)	19(65.5)	5(17.2)	5(17.2)	10(34.5)	13(44.8)	4(13.8)	11(37.9)	
Old > 45 (n=25)	18(72.0)	7(28.0)	6(24.0)	11(44.0)	10(44.8)	5(20.0)	10(40.0)	
Linear-by-linear association	0.013(p=0.91)	0.69(p=0.40)	1.16(p=0.28)	1.03(p=0.31)	0.004(p=0.95)	0.78(p=0.38)	0.43(p=0.51)	
Education								
Illiterate (n=28)	19(67.9)	10(35.7)	7(25)	10(35.7)	15(53.6)	7(25)	13(46.4)	
Middle (n=24)	16(66.7)	3(12.5)	3(12.5)	10(41.7)	11(45.8)	1(4.2)	8(33.3)	
Matric & higher (n=13)	10(76.9)	1(7.7)	2(15.4)	4(30.8)	1(7.7)	2(15.4)	3(23.1)	
Linear-by-linear association	0.23(p=0.63)	5.16(p=0.23)	0.87(p=0.35)	0.02(p=0.87)	6.52(p=0.01)	1.46(p=0.23)	2.24(p=0.13)	
Total (n=65)	45(69.2)	14(21.5)	12(18.5)	24(36.9)	27(41.5)	10(15.4)	24(36.9)	

Fig. 1. Factors influencing the adoption of Bt cotton by farmers (%)



variety totally free from insect pests and diseases. Additionally, most of the farmers (69.2%) mentioned flower and fruit shedding in Bt cotton at high temperatures.

A majority of the farmers (52.3%) cited the higher price of seed as a constraint to adopting Bt cotton technology (Table II, Fig. 1). Similar results were found in a survey conducted in South Africa (Ismael *et al.*, 2001; Morse *et al.*, 2006) that showed the higher cost of seed as the main reason for the non-adoption of Bt cotton. In the authors' view, factors mentioned by the farmers were mainly related to their poor agronomic practices. Among the other reasons mentioned by the farmers for the non-adoption of Bt cotton were: 44.6%-non availability of seed, 41.5%-less height, 36.9%-not sure of its effectiveness and low yield, 35.4%-took more time to mature, 21.5%-small boll size, 18.5%-wilting and 15.4% had no confidence to grow it (Table II, Fig. 1). A significant difference was found among

Table III. Farmers' satisfaction level for Bt cotton

Category of farmers	No (%) respondents		
	Fully satisfied	Partially satisfied	Not satisfied
Age (Years)			
Young -30 (n=11)	3(27.3)	5(45.4)	3(27.3)
Middle 31-45 (n=29)	5(17.2)	14(48.3)	10(34.5)
Old > 45 (n=25)	0.07(p=0.795)	0.15(p=0.702)	0.03(p=0.860)
Education			
Illiterate (n=28)	3(10.7)	15(53.6)	10(35.7)
Middle (n=24)	7(29.2)	10(41.6)	7(29.2)
Matric & higher (n=13)	2(15.4)	7(53.8)	4(30.8)
Linear-by-linear association	0.55(p=0.46)	0.27(p=0.601)	0.003(P=0.96)
Total (n=65)	12(18.5)	32(49.2)	21(32.3)

the education categories for the availability of Bt cotton seed and plant height. A majority of the illiterate farmers (57.1%) mentioned the non-availability of Bt cotton seed, which was mainly due to its non-commercialization or due to lack of social contacts with the researchers and research organizations. Most of the illiterate farmers (53.6%) reported lower plant height in Bt cotton cultivars, which was mainly due to mixing of Bt and non-Bt cotton seeds or due to smuggled Bt cotton seeds not suited to Pakistan agro climatic conditions. A significant difference was found among the age categories for fertilizer applications, as a majority of the experienced old age farmers (80.0%) applied more fertilizer applications to achieve the proper plant height. The responses of the farmers in this study were consistent with a survey conducted in Warangal District, Maharashtra and Andhra Pradesh, India (Qayum & Sakhari, 2003; Sahai & Rahman, 2003) indicating that smaller boll size and premature drying and shedding of fruiting parts, were the main reasons for the poor performance of Bt cotton.

When farmers were asked for their satisfaction with Bt

cotton, many (49.2%) were partially satisfied with the effectiveness of Bt cotton, while 32.3% were fully satisfied and 25.3% were not satisfied (Table III). There was no significant difference for the satisfaction level among the age categories but a significant difference was found among the education categories. Illiterate farmers were not satisfied, as they were not aware of the characteristics of Bt cotton, while most of literate farmers were satisfied and showed their interest in growing transgenic Bt cotton.

The study showed that most of the farmers consulted pesticide sellers and dealers for pest problems. Advertisements by pesticide companies often negatively affect the adoption of any IPM approach by encouraging farmers to rely only on pesticide use (Sharma, 1998). Farmers are easily influenced by pesticide sellers and dealers in the case of pest problems in Bt cotton and rely on the use of chemicals, the same scenario as in the case of conventional cotton. A well developed and coordinated programme of farmer participatory training and research that focuses on experimental learning and field observation could overcome this problem by enhancing farmers' knowledge and perceptions of pests and non-chemical alternative management options (Braun *et al.*, 2000; CABI, 2001). For further reference a more detailed survey of a large sample of farmers is required. It would include farmers' perceptions of insect pest incidence and management practices in Bt cotton and other aspects of adoption behaviour, is required before the final judgment of the benefits of Bt cotton to small farmers.

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