Farmers' Perception, Adoption and Socio-economic Assessment of Bt. cotton in India

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Abstract

Unprecedented rates of diffusion and adoption of Bt cotton have demonstrated escalating pre-dominance of Bt. Cotton hybrids as they ensured opportunity for double cropping, 34 - 63 per cent higher yield, about 142 per cent higher income, reduction in pesticide usage from 4 – 12 to 2-4 sprays (though for last two years due to higher incidence of sucking pests and mealy bug ,1-2 extra sprays are required), reduction in the incidence of pesticide-led health hazards from 4-6 cases per season per village to none to one and increased employment days for women during cotton picking. The farmers held positive perception about Bt. Cotton. Recommendations of Bt hybrids according to their suitability to agro-ecological conditions; standardization and dissemination of agro-techniques; development of communication content and dissemination of extension literature related to Bt cotton cultivation should be stressed for effective utilization of the technology.

Key words: Bt. Cotton, Farmers' criteria, Farmers' perception, Logit model, Perceived advantages, Policy initiatives

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Introduction

Appropriation of about 9 per cent of total cultivated area of India, accounting for 26 per cent of global acreage of cotton, contributing about 21 per cent to total global production of cotton and sustaining the livelihood of about 60 million people in India including 4.5 million farmers speak for the importance of cotton cultivation in India. Its cultivation received a tremendous fillip all over the globe with introduction of Bt cotton hybrids. Concerns and controversies notwithstanding, India embarked upon commercial deployment of genetically modified crops in the form of *Bt* (*Bacillus thuringiensis*) cotton in 2002 to address the agrarian and ecological distress with the belief that its resistance against the most devastating American Bollworm insect pest will help in containing colossal yield loss, reducing the burgeoning consumption of expensive, toxic and environment damaging pesticides as well as assuring better yield, income and health to farm families. The rate of adoption of Bt cotton was unprecedented with 168-fold increase in its acreage during 2002 to 2009. Approximately 5.6 million small and resource poor farmers planted Bt cotton hybrids in 2009 representing about 88 per cent of the total number of 6.4 million farmers who grew cotton in India in 2009 and Bt cotton accounted for 87 per cent of the estimated 9.6 million hectares of cotton in India (ISAAA, 2009). It amply reflects the growing conviction, acceptance and demand of Bt cotton hybrids among the farmers.

The cotton yield witnessed an increasing trend (Figure 1) during 2001-02 to 2008-09 with a leap from 308 kg per hectare to 526 kg per hectare, in which the role of Bt cotton has been pivotal. The average productivity of Bt cotton stood at 20.75 quintals per hectare as compared to 17 quintals from non-Bt hybrid cotton crop, while the profit as percentage of investment with regard to non-Bt hybrid cotton and Bt cotton stood at 62 per cent and 73 per cent in Maharashtra;

80 per cent and 78 per cent in Gujarat, 44 per cent and 57 per cent in Andhra Pradesh and 42 per cent and 49 per cent in Tamil Nadu - Karnataka cluster (Business standard, 2009).

The first approval for commercial cultivation of Bt cotton in India was granted to three cotton hybrids MECH 12 Bt, MECH 162 Bt, MECH 184 Bt developed by Mahyco. Following the approval of GEAC, commercial cultivation of Bt cotton was undertaken during 2002 in 6 states in India i.e. Andhra Pradesh, Gujarat, Madhya Pradesh, Karnataka, Maharashtra and Tamil Nadu and the total area under cultivation was .038 million hectare and by 2009, its acreage soared to 8.38 million hectares (Table-1) and number of Bt hybrids increased to 522 (including a Bt variety). Maharashtra and Gujarat are the leading states in cotton production (Figure-2 2). Even in the case of Bt. Cotton, Maharashtra (40%), Gujarat (20%) and Andhra Pradesh (16%) together account for 76 percent of its acreage (Figure-3).

Data and Methods

The study was conducted in the states of Maharashtra, Madhya Pradesh, Karnataka, Punjab and Haryana during the years 2009, 2005&2009, 2007, 2006 and 2008, respectively. One hundred Bt. Cotton farmers and thirty non-Bt cotton farmers from each state were selected randomly and interviewed. For identifying factors associated with adoption decision one hundred eighty farmers from Punjab and Karnataka (60 Bt. Cotton farmers and 30 non-Bt cotton farmers from each state) were randomly selected. Non-linear logit regression model was employed.

Perception, according to Morgan *et. al.* (1993) refers to the awareness of objects, qualities, or events stimulating the sense organs. It is a person's immediate experience of the world. In the present study, perception was considered as the meaning attributed by the respondents to transgenic technology and features of its products. It was measured with the help of respondents' response to Likert -type scale with a battery of statements on 5-point continuum i.e. strongly agree, agree, undecided, disagree and strongly disagree with corresponding weightage of 5,4,3,2 and 1 regarding transgenic technology and product (Bt. crops) as well as related biosafety issues and socio economic and ecological implications. The Crobanch alpha

reliability coefficient of the scale was 0.67. The content validity of the scale was ascertained through a group of judges drawn from the fields of transgenic research and social science. The weighted mean perception scores for each statement were calculated to assess the perception of farmers.

Results and Discussion

Bt.Cotton Adoption Decision and Associated Factors

Several farm level empirical studies have amply shown the economic benefits of Bt cotton (Smale, Zambrano and Cartel, 2006) but its inconsistency and differential performances (Sahai and Rahman, 2003) as well as the risk perception and apprehension among the farmers about the potential impact on human, cattle and soil due to lack of educational interventions kept the controversy and debate alive. Services from public extension system were non-existant as the technology (Bt cotton seeds) was deployed from private companies and hence the farmers were solely dependent upon seed dealers for information, who unlike public extension system had more vested interest to earn profit by enhancing the sale of seeds than in educating the farmers and solving their problems. Amidst such scenario adoption decision making about such technology like Bt cotton by farmers needs closer examination. Largely the decision whether to adopt or not to adopt is dependent upon conscious evaluation of social, economic, technical, cultural and situational perspective of any technology. Resource endowments are the major determinants of observed adoption behaviour in economic constraints model (Aikens *et.al*., 1975), where lack of access to capital and inadequate farm size could significantly impede adoption decisions (Karki *et al.*, 2004). Univariate and multivariate logit and probit models have been used extensively in studying adoption behaviour of farmers (Adeogun *et al*., 2008). However, Shekya and Flinn (1985) have recommended probit model for continuous dependent variables taking value between 0 and 1, while logit model for discrete dependent variables taking binary value of either 0 or 1. Here in this study, farmers were grouped as adopters and non-

adopters of Bt. Cotton based upon its cultivation by them on their farm. A value of 1 was given to adopter and value 0 was given to non-adopter.

The synthesis of the adoption process presented by Feder *et.al*.(1985) suggests that generally the level and quality of human capital affects the choice of new technologies in agriculture and for early adopters and for an efficient use of inputs, it plays a particularly positive role (Sheikh *et al*, 2003). Among the factors hypothesized to influence adoption of Bt cotton and included in the logit model, a positive relationship with adoption of Bt cotton was expected in case of level of education, size of holding, size of irrigated land holding, own capital base, social participation, scientific orientation, information source pluralism, extension contact, mass media exposure, achievement motivation and innovativeness, while negative relationship was hypothesized for the factors like age of the farmers and perception (negative)about Bt cotton technology.

The positively significant coefficients of explanatory variables indicate their positive influence on adoption decision of farmers towards Bt cotton. As expected, the variables such as size of holding, irrigated land holding, capital base, extension contact, innovativeness, achievement motivation, and perception had positively significant influence on adoption decision for Bt cotton(Table 2). In contrary to a priori expectation, information source diversity, mass media exposure, social participation and education were not found to have a significant influence on adoption decision of farmers. Unlike the major agricultural technologies, the public extension system had negligible role to play in dissemination of Bt cotton as its deployment was solely from the private sector and seed dealers primarily were involved in sale and dissemination of Bt cotton. Therefore, information source diversity and mass media didn't have significant role. Though overtly the pubic extension system had little to contribute in diffusion process of Bt cotton, it remained the most reliable source for farmers for drawing conviction and reinforcement while taking plunge in adopting Bt cotton.

The size of holding had positively significant coefficient and the marginal probability figure shows that the probability of adoption was likely to increase by a factor of .07 with unit increase (one acre) in land holding size. The finding followed the expectation. As with increase in landholding, the farmers had better choices and options for experimenting with new technologies as compared to farmers with small holding, which facilitated the adoption process. Interestingly the coefficient for size of irrigated land holding was significant but negative . Irrigated conditions in research area generally were not readily available so proportion of irrigated land holding was very less and the possession of irrigated land holding would demand additional investment and thus enhance the cost of cultivation of Bt cotton. That is why the sign for irrigated land holding was negative. The odds of adoption was found to increase by a factor of 0.2 with every unit increase in capital base. Generally the farmers had to purchase Bt cotton seeds on cash payment and they had to book their seed requirement in advance, therefore, possession of own capital base promoted adoption of Bt cotton. Perceived risks associated with any technology act as retarders of their adoption; however, positive and favourable perception augmented the adoption process. The coefficient of risk perception was positively significant and the probability of adoption was likely to increase by a factor of 0.158 with unit increase in perception about Bt cotton. Though farmers harboured risks but largely held positive perception of Bt cotton due to spectacular field performance in terms of effective management of bollworm, which has been the most devastating pest of cotton; reduced use of pesticides; higher yield and higher monetary return. The coefficient of scientific orientation was positively significant, which implies that it increased the possibility of adoption by providing rational understanding and dispelling the unfounded myths and concerns about the technology. Particularly with Bt cotton, the proposition holds true as with the very deployment of Bt cotton in India, the nation was rife with numerous health related risks and concerns. News of killing of goats and sheeps by feeding upon Bt cotton plants in Andhra Pradesh was so pressing that the nation witnessed incessant debate and protests. Uprooting and burning of Bt brinjal and Bt rice plants under field trials by farmers express their apprehension

and need for proper understanding of the principle of the technology. However, in spite of such perceptual conflict, the acreage of Bt cotton had mercurial growth, but certainly better scientific orientation of farmers could help them make informed and rational analysis of the technology and related risks and concerns. It is evident from the table-2 that the odds of adoption is likely to increase by a factor of 0.917 with increase of one unit in scientific orientation of farmers, which goes as per *a priori* expectation. Similar results were obtained for the variables of innovativeness and achievement motivation. With per unit increase in these two variables odds of adopting Bt cotton could increase by a factor of 0.143 and 0.228, respectively.

Extension contact is generally known to propel the adoption process. In this study though it had significant coefficient value, the sign was negative. Does it mean that with per unit increase in extension contact, the odds of adopting Bt cotton is likely to reduce by a factor of 0.127? The result in the first instance looks awkward. However, viewed differently, it indicates that since the public extension system had very low to no role in dissemination of Bt cotton, the flow of information and guidance about Bt cotton were not available in sufficient quantum and regularity, and that's why the sign was negative for extension contact in terms of promoting adoption of Bt cotton. Deployment of Bt cotton in India has been private oriented and dealer driven. The private seed dealers are the major players in distribution and dissemination of Bt cotton, therefore, farmers approached them for procurement and advice. Mass media exposure didn't exhibit significant influence in adoption of Bt cotton, which reveals that farmers relied more on subjective evaluation information from their neighbours and fellow farmers for making adoption decision about Bt cotton. As a result, contrary to *a priori* expectation, information source pluralism too didn't have significant coefficient. Similarly the influence of explanatory variables of age and education was not in accordance with expectation. Generally higher age and lower education make a person more skeptical to innovation and resistant to change, while lower age and higher education help in decreasing risk aversion factors and increases rate of adoption.

However, in this study their influence on adoption was not found to be significant. It shows that perceived benefits of Bt cotton is so intense that diffusion of Bt cotton has permeated well through the age and education barriers.

Criteria –based Farmers' Assessment of Bt. Cotton

Identification of Farmers' Criteria of Varietal Assessment:

For ensuring participatory assessment, farmers' criteria for varietal assessment were elicited and their prioritization was done with ranking. With the highest mean score of 9.33, the yield potential was considered as the first and foremost criterion for selection of any hybrid / variety followed by the low incidence of pest and low cost of their management (MS:9.00), input requirement (MS:8.33) and germination potential (MS:8.33) (Table-3). Size of ball and plant and irrigation intensiveness with equal mean scores of 8.00 were the fourth most important criteria followed by suitability to farm (MS:7.66), quality (MS:6.66), cost of seed (MS:6.33), labour saving (MS:6.33), drudgery in picking (MS:6.33), harm to soil (MS:6.00) and harm to other crops (MS:5.00).

Performance and Farmers' Assessment of Bt cotton *vis-à-vis* non-Bt.cotton

The criteria based comparative assessment of various Bt. hybrids viz., MECH 12, MECH 162, MECH 184 and RCH 2 *vis-à-vis* non-Bt hybrids/varieties (Bunny, Ajit, Ankur, etc) cultivated by the farmers was done. A matrix of criteria for assessment as prioritized by them and Bt hybrids and non-Bt hybrids/ varieties grown by them was made on a large chart paper or ground and administered to a set of 20 key informants (preferably the Bt and non-Bt cotton cultivators). They were asked to rank with score range of 0-10 for each combination by placing the pebbles or plastic coins. Higher the degree of trait /property with respect to the criteria, higher was the score given. The findings revealed differential performance not only between Bt. cotton hybrids and non-Bt cotton but also among the several Bt. hybrids with respect to the criteria (Table-4).

For yield all the Bt hybrids were given higher score in comparison to non-Bt hybrids/ varieties. The average yield of Bt cotton was 25.5 qtls/hectare in MP as against 14.5 qtls/ hectare in case of non-Bt cotton. However, among the Bt hybrids MECH 162 was ranked higher for yield where the yield was obtained in range of 25 – 62 qtls per hectare followed by MECH 184 and MECH 12. MECH 162 and RCH 2 were preferred for lesser incidences of pests both American bollworm and sucking pests than other Bt hybrids. Bt hybrid MECH 184 was considered at par with non-Bt Bunny for incidences of sucking pests. For germination potential, MECH 162 was considered the best with score of 10 followed by MECH 184, RCH 2 and MECH 12. Interestingly the non-Bt Bunny variety was found the second best in germination potential. MECH 12 was ranked the best followed by MECH184 for boll size, cotton percentage, cotton quality, staple length, ease in picking and high market value ($2.2-$2.78 per qtl more). Astonishingly Bt hybrid MECH 184, which had been given better score on many a parameter in comparison to other Bt hybrids, was rated much inferior even than the non-Bt hybrids/varieties for incidences of boll drop, stem splitting, wilting and reddening of leaf. Because of these problems, farmers were baffled in the initial years of Bt cultivation and disenchantment with Bt cotton hybrids and related protest gained momentum. Such incidences underline the importance of communicating technology packages besides seed. Mere seed alone cannot be a sufficient technology to assure production and profit. The farmers observed that Bt hybrids were irrigation intensive. For light soil RCH 2 was ranked the best, while for heavy soil MECH 12 was found the best (MS: 10).

MRC-6301, MRC-6304, RCH-134, RCH-317, Ankur-651, Ankur 2534 were the major Bt cotton hybrids deployed in Punjab. The criteria based ranking by the farmers revealed RCH-134 as the most popular approved Bt hybrid and mean scores for it were higher than unapproved Bt hybrids/ varieties and non- Bt hybrids/ varieties for all criteria (Table-5). However, cases of cultivation of unapproved Bt hybrids/ varieties were rampant.

The farmers preferred unapproved Bt hybrids/ varieties because of low cost of seed, easy accessibility and availability of seed, no incidence of American bollworm like in case of approved Bt. hybrids, early development of bolls and the yield secured by the unapproved Bt hybrids/ varieties being almost at par with approved Bt hybrids. If approved Bt hybrids secured yield in range of 25-40 qtls/ hectare, farmers could get 20-40 qtls/ hectare from unapproved Bt hybrids seed(Table-6). Early development of bolls facilitated the process of sale contractual arrangement and ensured better deal to farmers as the contractors got assured of yields from the crop by observing the bolls. Boll development in case of approved Bt hybrid seed began 90 days after sowing, while in case of unapproved Bt hybrids seed it started only 40 days after sowing. Though there was no guarantee of seed purity, farmers with previous experiences relied upon unapproved Bt hybrids seed with the trust and hope that all plots would not be affected. Moreover, the very low cost and provision of availability on credit lured them to go in for unapproved Bt hybrids seed. Generally the seeds of unapproved Bt hybrids were traded illegally and were available through informal network. Convenience factor again played a role in adoption of unapproved Bt hybrids seed because approved Bt hybrids seed could be purchased only on cash payment and seeds were available only through the authorized dealers and that too on the basis of prior demand. One had to place demand of his requirement in advance before the season and if more seeds were required later either for enhancing the acreage or gap filling in the plot, seeds were not available even on higher rate. Black marketing had become common and farmers suffered. On the contrary the unapproved Bt hybrids seed were readily available and could be procured even on credit, which was highly convenient for the farmers particularly the small and marginal farmers. Availability on credit saved the farmers from struggling for loans.

Besides the concerns of higher seed rate, use of second generation of hybrid seed (F2) and more number of irrigation required than the approved Bt hybrids seed, the major disturbing issue is lack of direction of using refuge lines.

Refuge lines connotes planting of same hybrid as of Bt hybrids but without Bt gene (non-Bt hybrid) along the borders of Bt hybrid crop plot to contain the development of resistance in the American bollworm against the Bt gene and for higher longevity of the Bt hybrid. Generally 5 lines or 20 per cent of area of Bt crop plot are to be put under non-Bt hybrid along the border of Bt hybrid crop. It is one of the vital practices of biosafety management. Alarmingly, there is no direction at all about use of refuge lines in case of unapproved Bt hybrids seed like the approved Bt hybrids seed. The packets of approved Bt hybrids seed not only contain along with it the separate packet of non-Bt hybrid seed for sowing as refuge lines but also the necessary guidelines and method of planting refuge lines. The gross negligence on biosafety measure needs attention to manage any kind of technology-led undesired consequences.

Assessment of Socio-economic Benefits of Bt cotton

Perceived advantages of Bt cotton: The salient advantages of Bt. Cotton Shared by the farmers were enlisted and again they were asked to rank order the advantages of Bt cotton as perceived by them. With Friedman test the mean ranks of the advantages were worked out and it is evident from table-3 that high yield, which was perceived as the prime advantage by the farmers, obtained first rank followed by less pesticide use, less labour requirement and easy picking of cotton. The significance value less than .01($p<0.01$) shows highly significant difference between the rank scores for different advantages. It means farmers could distinctly differentiate and rank the perceived advantages.

Higher yield obtained with Bt hybrids in comparison to conventional hybrids led the farmers rank yield as the first among the perceived advantages. These perceived advantages facilitated development of positive perception among the farmers.

Yield of Bt cotton: The average yields of Bt cotton obtained by the farmers of Punjab and Karnataka were found to be 26.5qtls/hectare and 24.18 qtls/hectare, respectively. The average

yield for equal percentages of the farmers of Punjab (i.e. 46 per cent) fell in the yield categories of 22.5-27.5qtls/hectare and 35-40qtls/hectare. However, in case of Karnataka, for a majority of them (54 per cent) average yield was in category of 20-25 qtls/hectare and for 30 percent of them it was in category of 27.5-32.5 qtls/hectare. A majority of farmers of Punjab (54%) obtained yield above the mean yield i.e., 26.47qtls/hectare, while in case of Karnataka a little above one third of them obtained yield above the mean yield of 24.18 qtls per hectare. Comparison of mean yields of Bt. cotton and non-Bt. cotton in Punjab and Karnataka revealed highly significant difference ($P<.01$) .By cultivation of Bt. cotton, Punjab farmers obtained 73.6 percent extra yields as against traditional cotton, while in case of Karnataka the farmers gained 51.8 percent increase in their average yield. Similarly the mean difference in yield of Bt. cotton of Punjab and Karnataka was highly significant ($P<.01$). The higher yield secured by Bt. cotton hybrids might have led to development of positive perception about it among the farmers.

By adopting Bt. cotton hybrids the farmers in Maharashtra and Madhya Pradesh secured increased yield to the tune of 25-37.5 quintals per hectare in irrigated condition while 17.5-22.5 quintals per hectare in rainfed condition as against respective yield of 10-15 and 5-10 quintals per hectare from non-Bt hybrids. Farmers could secure 34 - 63 per cent higher yield and about 142 per cent higher income due to Bt cotton. The progressive farmers of Maharashtra could harvest yield upto 67.5-75 quintals per hect by extending the crop life with assured irrigation upto April. Increase in yield also led to increase in on-farm employment days for women during cotton picking

Socio-economic Benefits of Bt cotton: The major socio-economic benefits of Bt cotton included reduction in pesticide spray, reduction in average cost on pesticide spray, reduction in the incidences of pesticide related health hazards in villages, increase in yield per acre and enhancement in returns.

In Karnataka and Punjab, as a result of Bt. Cotton, there was a spectacular reduction in pesticide sprays with the average number of pesticide sprays declining from 6.64 to 2.86. Prior to Bt cotton the farmers baffled with the menace of bollworms had to resort to 4-12 sprays to save the crop and their livelihood. Heavy dependence on pesticides for successful cotton cultivation often pushed the farmers in to indebtedness trap. However, as the Bt cotton is resistant against the bollworms, farmers need to spray only for managing the sucking pests and thus the average number of sprays declined by about 57 per cent. Though in last two years the freak incidence of mealy bug insect pest has emerged as a major concern for the cotton growers, Bt cotton has certainly helped them in containing pesticide use as well as the average cost of pesticide spray, which reduced by about 55.5 per cent. Consequently, the incidences of the pesticide related health hazards too witnessed a very sharp decline. The reduction percentage was about 98. Prior to Bt cotton, incidences of pesticide poisoning, nausea, irritation in eyes and skin, giddiness, breathlessness etc., were frequent among the labourers engaged in pesticide spray works. The average number of persons per village per season affected with pesticide related health hazards and taken to hospital for treatment was 8.8 but after Bt cotton adoption in the area the corresponding figure declined to 0.2. The cotton fields were perceived as fresh and free of pesticide pollution to a greater extent by a majority of farmers due to large scale adoption of Bt cotton in the area. Besides the advantages on pesticide front, the farmers also gained by effective management of bollworms and reduction in crop losses. They secured over 62 per cent higher yield and earned over 167 per cent additional income ($ 343.77) per hectare. In Haryana, in comparison to pre-Bt scenario when cotton area witnessed rampant and frequent sprays of lethal pesticides, the average number of health hazards due to pesticide spray (number of persons affected by pesticide induced health problems per season per village) had reduced significantly, even by over 89 per cent. Besides these benefits, farmers secured 38-67 per cent higher average yield and over 142 per cent higher monetary return from Bt cotton hybrids than the non-Bt cotton hybrids/ varieties. The farmers of Maharashtra reported that due to cultivation of Bt cotton

hybrids the number of pesticide sprays reduced from 4 – 8 to 2-4 sprays, though for last two years due to higher incidence of sucking pests and mealy bug they to had to go in for 1-2 extra sprays. The incidence of health hazards due to pesticide application had reduced from 4-6 cases per season per village to none to one due to adoption of Bt. cotton hybrids.

These benefits provided impetus to diffusion and adoption decision among the farmers.

Knowledge and skill gaps - missing links and disenchantment

Though farmers accepted the potential advantages of Bt cotton hybrids, they were cautious in their fuller adoption. Mixed pattern of cotton cultivation i.e. putting acreage under Bt cotton hybrids, unapproved Bt cotton hybrids (in case of Punjab) and non-Bt cotton hybrids was observed. Though the pace of adoption was phenomenal, the cases of disenchantment with Bt hybrids, where the expectations were not met, were the concerns of significance to boost up the adoption and fuller utilization of the technology. As the public extension system has not been in fray for dissemination of knowledge about transgenic technology, there was enormous void related to knowledge and skill about proper application of Bt cotton technology. Since Bt cotton was deployed by private seed agencies, the extension services related to it were largely carried out by them, whose major focus remained on promotion of sale of seeds and as a result the issues of bio-safety, agro-techniques and risk communication remained unattended. There was enormous lack of communication about Bt. technology and related issues. Farmers just knew that Bt cotton was a technology which saved crop against American bollworm without use of pesticide but they hardly knew that all Bt hybrids were not same and different hybrids were suitable for different situations. For example RCH 2 was suitable for light soil and MECH 162 was suitable for heavy soil. Bt hybrids for rainfed and irrigation systems have to be different. However, in want of proper knowledge the farmers just in the name of Bt cotton adopted Bt hybrids irrespective of their situation and location specificity and as a result the performance was

poor and disenchantment set in. Similarly some Bt hybrids (e.g. MECH 184) due to nutritional deficiency suffered from reddening of leaves and yield was affected. Farmers lacked knowledge about agro-techniques of Bt cotton cultivation. Even spacing and plant density varied which led to higher seed rate as farmers followed the same crop geometry as with earlier hybrids/ varieties keeping in view their plant vigour. They were not communicated about importance and use of refuge lines. Many farmers just kept aside the packet of non-Bt hybrids, which were given to be sown as refuge lines with the opinion that these would invite the problem of American bollworm again and affect the productivity of Bt hybrids. Many farmers pooled the packets of non-Bt hybrid seeds and sowed them in a separate plot to save Bt plot from American bollworm. Realizing the gap in knowledge and skill among the farmers about the transgenic technology, information and training needs of the farmers need to be assessed and addressed through training, interface and information dissemination.

Perception of farmers about transgenic technology and related biosafety concerns

A mean perception score of above 4 amply indicate that farmers expressed agreement to the fact that Bt cotton was high yielder,required less pesticide,reduced health hazard due to pesticide and was immensely beneficial.

Affirmation with the dimensions of Bt. Cotton hybrids that they are high yielder and eco-friendly and they reduced pesticidal pollution and health hazards revealed the positive perception of farmers about Bt cotton. The positive perception of the farmers using Bt. Cotton was further demonstrated by their disagreement with respect to statements which present negative shades of Bt. Cotton and related implications like inducing genetic pollution, dangerous to living beings, destroying soil microorganisms, ineffectiveness against American Cotton boll worm, inducing allergencity, increase in labour man days, picking being cumbersome, loss of farmers' autonomy for seed with enhanced dependency on seed companies and their monopoly, being pro-resource rich, failing in benefiting small farmers, etc. Farmers agreed to the statement that it was

advantageous if seed production of Bt cotton would be done by public institutions. They disagreed with the statement that Bt cotton was pro-resource rich farmers, instead they had an opinion that it benefited resource poor farmers also. Farmers were divided over the issue of transgenic food crops. Some showed willingness to cultivate transgenic food crops if they were profitable to them and if approved by scientists many of them told that they would consume transgenic food crops. They expressed that even if Bt food crops could be toxic they would be far less toxic than what we consumed with heavy pesticidal residues due to the rampant sprays taken up for food crops.

Conclusions

Suggested policy initiatives for safe deployment and handling of transgenic technology

Notwithstanding the numerous field –level constraints like rampant sale of spurious seeds, unavailability of genuine seeds, black marketing of seeds at exorbitant rate, lack of advisory services, emerging threats from other pests like mealy bug, etc, the experience in cultivation of Bt cotton has certainly established the importance of transgenic technology in terms of profitability and ecological benefits. Besides, it also strengthened the process of positive and favourable perception building among the end-users about the potential benefits of transgenic technology in general and Bt cotton in particular.

It reflects that farmers will accept cultivation of transgenic food crops if convinced of being profitable and devoid of health hazards. However, still not only educational drive is necessarily required to upgrade the knowledge and skill of farmers and other end users as well as the anti-transgenic social activists but also what is desired is availability in public domain of rigorous scientific experimentation based evidences and explanation about the facts of biosafety and health related concerns. Concerted efforts of educational campaign, scientists and end-users

interface, extension literature and aids, large scale demonstration and on-spot scientific explanation of biosafety concerns and misconceptions will go a long way in developing favourable perception and enhanced acceptance of transgenic technology.

Further, efforts should be initiated to address the field level and infrastructural constraints to facilitate development of supportive and caring climate for the end-users. The major suggestions to overcome the deployment and dissemination concerns include: recommendations of Bt hybrids to be made according to their suitability to agro-ecological conditions; standardization and dissemination of agro-techniques; development of communication content and dissemination of extension literature related to Bt cotton cultivation, Bt technology and related biosafety concerns as well as organization of scientists-farmers interface to bring clarity about the transgenic technology and to remove unfounded apprehension about the risks of transgenic technology among the farmers and end-users; and ensuring easy availability of quality and authentic seeds of Bt hybrids.

Emphasis should be laid upon augmenting the role of public extension system in deployment and dissemination of Bt technology. Since the farmers find public extension system as the most credible and reliable source of information, it is essential to develop programmes for capacity building of extension workers in transgenic technology so that they could put in the desired educational efforts, which often is overlooked by the seed agencies at present.

The nation-wide network of KVK must be utilized in deployment and dissemination of transgenic technology through involvement in field trails and extension programmes.

Necessary initiatives are required in areas of Biosafety regulation mechanism, capacity building of stakeholders for prudent compliance of biosafety measures and involvement of

farmers and extension workers in deployment of transgenic to harness the potential benefits of transgenic technology with adequate biosafety.

Since the country is soon going to embark upon deployment of transgenic food crops like Bt. Rice and Bt. Brinjal, etc, it is high time to ensure flow of information with scientific reasoning and evidences to foster development of positive perception and wider acceptance among public. Labeling of transgenic food crops and regulation of markets with strict compliance of biosafety measures will be highly essential. Hence foolproof policy need to be developed and implemented.

Public-private partnership should be emphasized upon research and development of transgenic technology to safeguard the farmers against the market monopoly of trade of seeds of transgenic crops.

The success of Bt cotton instilled conviction among all categories of farmers. Even landless people in village derived benefits of Bt cotton by its cultivation on leased-in lands. It is drawn from the study that to prepare the farmers for speedy adoption of technologies developed with modern approaches of genetic manipulation which trigger concerns and protests, strategy has to focus more on educational and perception building interventions as well as training in Bt cotton cultivation techniques, besides stressing upon the identified socio-psychological characteristics like scientific orientation, innovativeness, achievement motivation and positive perception. The role of public extension system need to be stressed upon for capacity building of farmers for optimum harnessing of the benefits of new generation technologies like Bt cotton.

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Table-1. Adoption of Bt cotton in India by major state during 2002-2009

State	2002	2003	2004	2005	2006	2007	2008	2009
Maharashtra	25	30	200	607	1840	2800	3130	3396
Andhra Pradesh	8	10	75	280	830	1090	1320	1049
Gujarat	10	36	122	150	470	908	1360	1682
Madhya Pradesh	2	13	80	146	310	500	620	621
Northern region	-	-	-	60	215	682	840	1243
Karnataka	3	4	18	30	85	145	240	273
Tamil Nadu	2	7	5	27	45	70	90	109
Other	-	-	-	-	5	5	5	8
Total	50	100	500	1300	3800	6200	7605	8381

(ISAAA, 2009)

Table -2. Regression result of Logit regression model

Variable	B	Standard error	Wald	df	Significance P-value	Exp (B)	Marginal probability
Constant	-12.902	3.179	16.471	1	.000	.000	-
Age	0.020	0.027	0.526	1	.468	1.020	0.003192
Education	0.315	0.407	0.596	1	.440	1.370	0.050277
Size of holding	0.458	0.143	10.283	1	.001**	1.581	0.073102
Capital	1.285	0.592	4.709	1	.030*	3.614	0.2051
Size of irrigated land holding	-0.717	0.237	9.122	1	.003**	.488	-0.11444
Information sources pluralism	0.264	0.596	0.196	1	.658	1.302	0.042137
Social participation	0.131	0.529	0.061	1	.804	1.140	0.020909
Scientific orientation	5.746	2.689	4.566	1	.033*	312.831	0.917122
Extension contact	-0.798	0.390	4.180	1	.041*	.450	-0.12737
Achievement motivation	1.432	0.442	10.504	1	.001**	4.185	0.228562
Innovativeness	0.899	0.456	3.892	1	.049*	2.457	0.14349
Mass media exposure	0.324	0.442	0.537	1	.464	1.382	0.051714
Risk perception	0.991	0.406	5.944	1	.015*	2.693	0.158174
Chi square = 79.639 (P< .0001); -2 loglikelihood = 111.136; Nagelkerke R^2 = 0.572; Accuracy of prediction of classes = 82 %; Level of significance : ** (P< 0.001); * (P< 0.05)							

Table-3: Farmers' criteria for varietal assessment

Sl.No.	Criteria	Mean Score (MS)
1.	Yield	9.33
2.	Pest incidence and management cost	9.00
3.	Inputs requirement	8.33
4.	Germination potential	8.33
5.	Size of ball and plant	8.00
6.	Irrigation intensiveness	8.00
7.	Suitability to farm	7.66
8.	Quality	6.66
9.	Cost of seed	6.33
10.	Labour saving	6.33
11.	Drudgery in picking	6.33
12.	Harm to soil	6.00
13.	Harm to other crops	5.00

Table-4. Performance of Bt and non-Bt hybrids in MP

Criteria	Non-Bt hybrids	Bt hybrids				Mean score of Bt hybrids
		MECH12	MECH162	MECH184	RCH2	
Germination potential	9	7	10	9	8	8.50
Incidence of American bollworm	9	3	1	2	1	1.75
Incidence of sucking pest	9	8	5	9	5	6.75
Cost on spray	8	5	4	3	3	3.75
Boll size	5	10	6	8	9	8.25
Yield	5	8	10	9	7	8.50
Cotton%	5	8	6	8	6	7.00
Quality	7	10	8	9	9	9.00
Staple length	7	10	9	9	8	9.00
Market value	6	10	8	9	8	8.75
Ease in picking of cotton	3	8	6	4	5	4.75
Irrigation intensiveness	7	6	6	7	6	6.25
Suitability to light soil	7	5	7	3	10	6.25
Suitability to heavy soil	8	10	9	8	6	8.25
Incidence of boll drop	4	6	6	8	7	6.75
Stem splitting	2	4	-	8	3	4.25
Wilting	2	5	-	8	2	4.25
Reddening of leaves	6	6	-	7	7	5.00

Table-5: Comparative assessment of approved Bt, unapproved Bt and non-Bt cotton in Punjab

Sl.No	Criteria	Approved Bt hybrids	Non-Approved Bt hybrids/ varieties	Non-Bt hybrid/ varieties
1.	Yield	9	9	8
2.	Size of ball	9	8	8
3.	Less incidence of pests (Bollworm)	9	8	2
4.	Market rate	9	7	6
5.	Low irrigation requirement	7	4	5
6.	Ease in picking of cotton	10	8	7
7.	Suitability to light soil	6	5	5
8.	Germination potential	9	8	7
9.	Input requirement	7	7	9

Table-6: Comparative assessment of approved *vis-à-vis* unapproved Bt hybrids

Character	**Approved Bt hybrids**	**Unapproved Bt hybrids/varieties**
Yield	25-40 qtls/hectare	20-40 Qtt/hectare.
Incidence of bollworm	Nil	Nil
Boll development	90 DAS	40 DAS
Seed rate • Recommended • Practised	1125g-1625g/hectare 1625g/hectare	1125g per hectare 1125g-2250g per hectare
Seed cost	$16.67 per 450g	$6.67- $13.33 per 450g
Seed availability	On cash	On cash and credit
Seed accessibility	Authorized seed dealers	Informal networks
Purity of seed	Guaranteed	Not guaranteed
Irrigation frequency	5-7	8-10
Refuge lines	5 (20% area)	No direction

Table- 7. The ranking of the perceived advantages of Bt cotton by farmers

S.No.	Advantage	Mean Ranks
		Overall
1.	High yield	1.33 (I)
2.	Less pesticide	2.09 (II)
3.	Less labour	3.07 (III)
4.	Easy picking	3.51 (IV)
	Level of significance	**.000****

** (P<.01)

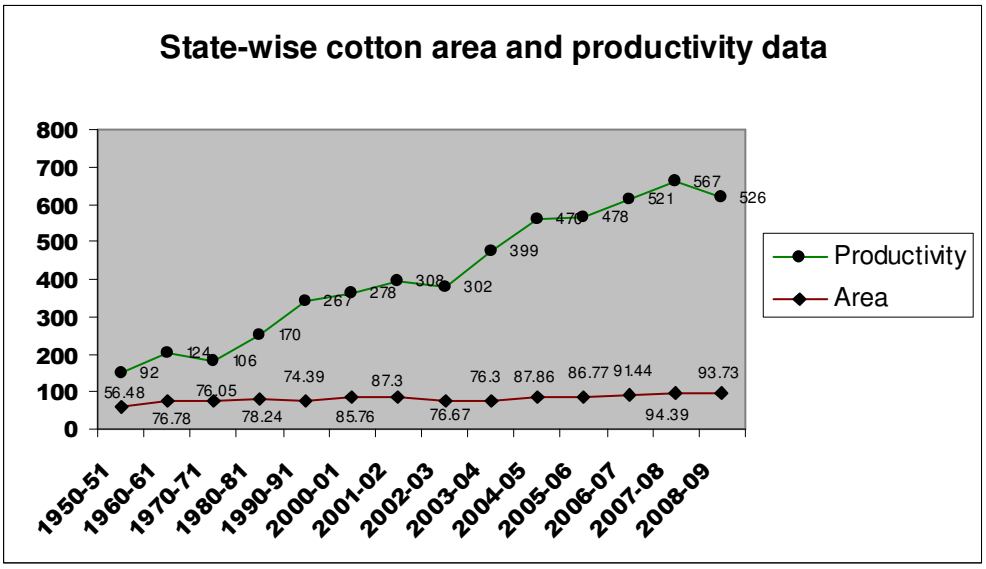

Figure-1. State-wise cotton area and productivity data

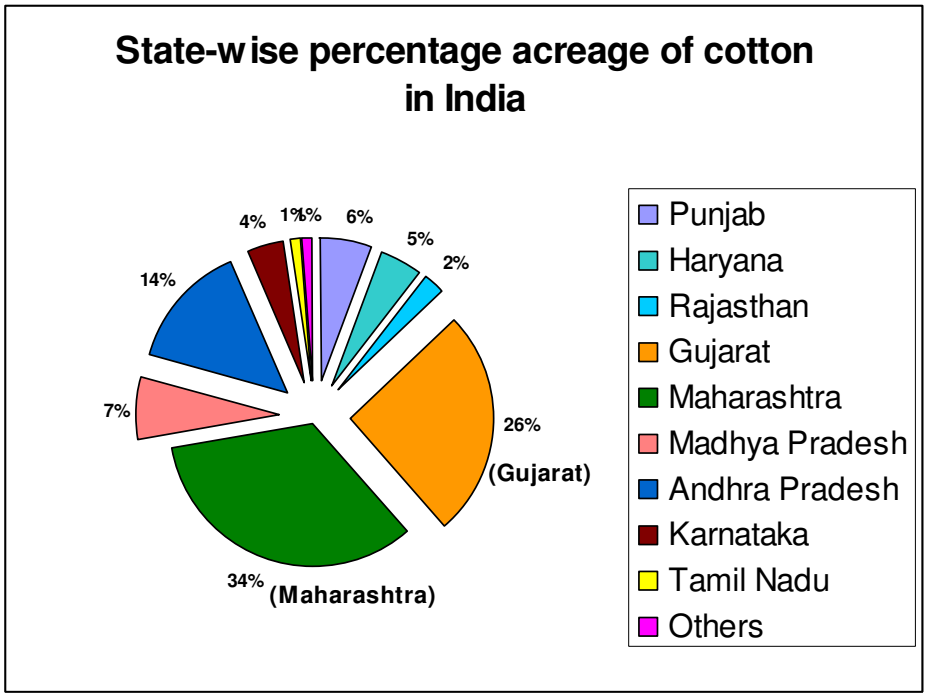

Figure –2:State-wise percentage acreage of cotton in India

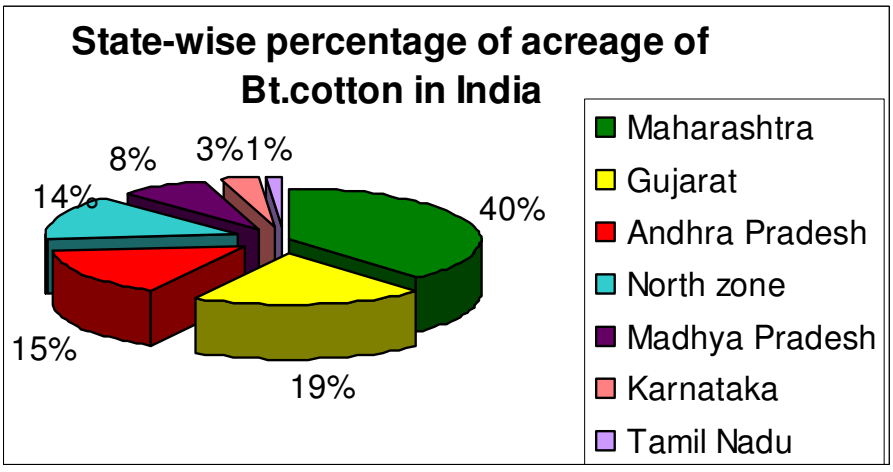

Figure –3 State-wise percentage of acreage of Bt.cotton in India

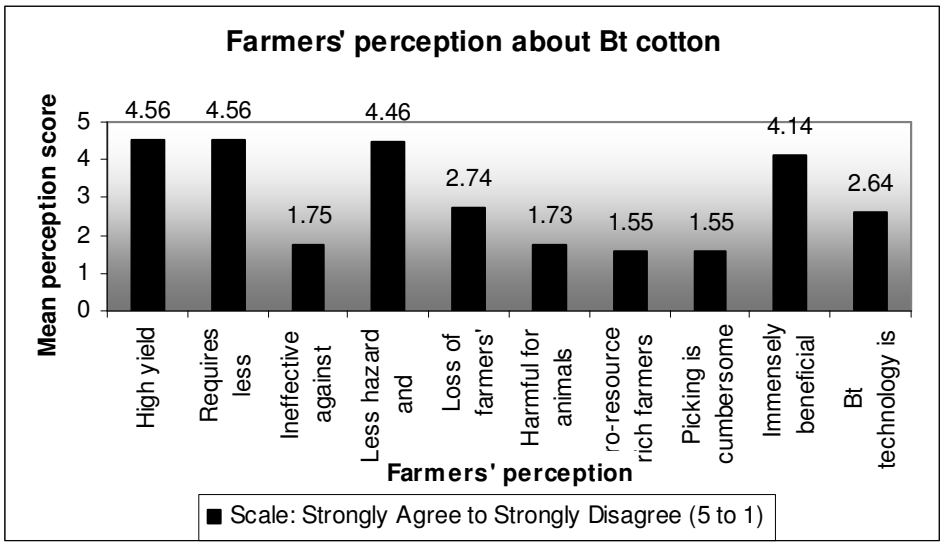

Figure-4: Farmers' perception about Bt cotton