POLICY BRIEF 34

Economic Benefits of Bt Brinjal – An Ex-Ante Assessment

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Background

Brinjal (*Solanum melongena* Linn) is the fourth most important vegetable grown after potato, onion and tomato in India. It is planted in three seasons; first in *Kharif* (June-September), second in *Rabi* (November-February) and third in the month of March. This vegetable crop is primarily grown by small and marginal farmers and it is an important source of income for them. Brinjal production faces a number of problems which cause enormous yield losses. Fruit and shoot borer (FSB) is the most devastating insect-pest of brinjal, which causes 60-70% yield loss, besides deteriorating product quality. Farmers rely mainly on the application of chemical pesticides to control FSB. The chemical control involves excessive and indiscriminate use of pesticides, causing multiple side-effects that include exposure of farm labourers and consumers to pesticide residues, increased cost of cultivation, environmental pollution, destruction of natural enemies of pests, and resurgence of pest population, etc.

The other methods to control FSB, like integrated pest management, and mechanical control are not much popular among farmers due to lack of collective action, high labour requirements and complexities involved in their application. Recently, transgenic/genetically modified technology has emerged as an alternative to chemicals in controlling insect-pests, reducing herbicides and related problems, and providing some other benefits. However, the use of genetically modified (GM) technology has raised some apprehensions like safety of food, affordability of technology, impact on biodiversity, and safeguarding of environment.

Even though the experience with cultivation of Bt (*Bacillus thuringiensis*) cotton in India has provided strong evidence to convince various stakeholders about the benefits of biotech crops, concerns have been expressed about the ability of small farmers to participate in biotech crops cultivation, which involves issues of large capital, new skills, affordability, and sometimes segregation. Nevertheless, first GM food crop (viz. Bt brinjal) has been developed in India and it can be readily taken for field cultivation. Several studies have demonstrated the potential of insect-resistant GM (or biotech) crops in increasing crop productivity and reducing insecticide-use on plants in the developing countries (Krishna and Qaim, 2008; Hareau *et al.,* 2006). Globally, many biotech crops, namely cotton, maize, soybean, and canola are being grown on a large scale and both public and private sectors are investing heavily for harnessing the potential of this technology. It is still not clear whether the development of biotech technologies would be a profitable venture for crops grown in smaller areas. Considering unanswered queries and implications of biotech food crops, the Government of India has imposed a moratorium on the release of Bt brinjal for cultivation. This brief aims to contribute to the debate on potential benefits of Bt brinjal in terms of yield gain, reduction in insecticide use, and monetary benefits to producers, consumers and society in the context of smallholder agriculture.

Data and Methodology

The brief has usesd both, secondary as well as primary data. Data on brinjal production and prices at national levels (for 2008) was taken from the *Indian Horticulture Database* (NHB, 2009). Farm level data were taken from a large field survey conducted by NCAP[1]. The potential economic benefits of Bt brinjal and their distribution between producers and consumers was estimated using the economic surplus method, as it is the most common method used to evaluate the impact of commodity-related technological progress in agriculture (Alston *et al.,* 1995; Norton and Davis, 1981). The economic gains of Bt brinjal have been simulated under 3 different scenarios considering its adoption level at 15%, 30% and 60%. A lower adoption level has been assumed for the eastern region (particularly in West Bengal) due to use of higher percentage of open-pollinated varieties of seeds (95%), own-saved seeds (84%), presence of a soil organism not suitable for hybrid cultivation, etc. A lower adoption base has also been assumed for the northern region. Application of a higher share of hybrid quality seeds (84-92%) in Gujarat and Karnataka, provided a base for assuming a higher adoption rate in the western and southern regions.

Production Profile of Brinjal

More than 2000 varieties of brinjal are grown in India. Amongst different states, West Bengal comes at the top with 28% share in national brinjal production, followed by Orissa (21%), Bihar (12%) and Gujarat (10%) during

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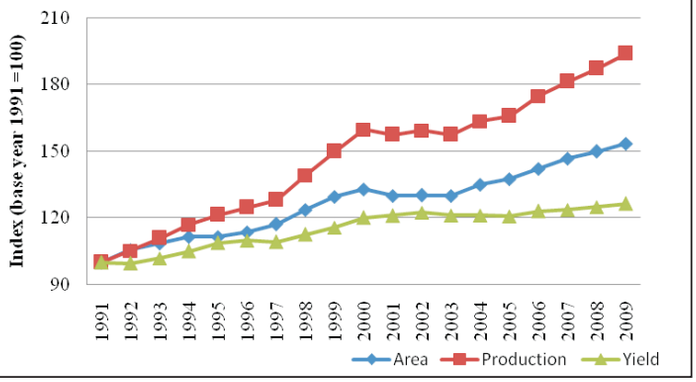
[1] Field survey was conducted during August to October 2009 under the research project on 'Ex-ante study on socioeconomic benefits of Bt brinjal' undertaken at NCAP with financial support from the Ministry of Environment and Forests, Government of India, New Delhi.

Figure 1. Progress in area, production and yield of brinjal in India



triennium ending (TE) 2009. On the yield front, both Bihar and Karnataka produced about 21 t/ha, while West Bengal, Gujarat, Maharashtra, and Andhra Pradesh were at par with country's average yield of 17t/ha.

A significant progress has been made in the production of brinjal during the past two decades (Figure 1). Between 1991 and 2009, area under brinjal cultivation increased by 52.6% (from 3.8 lakh ha to 5.8 lakh ha), production increased by 94% (from 50.6 lakh tonnes to 98.1 lakh tonnes), and yield rose by 26.8% (from 13.4 t/ha to 17.0 t/ha). These data show that increase in brinjal production has largely been driven by increase in its area, though yield-increase also contributed to it. Given the serious constraint on area expansion, productivity increase will be the main source of output growth in future.

The Brinjal Farmers

The brinjal farmers in India are resource-poor and mainly belong to small and marginal farm categories. According to an estimate about 1.4 million small and marginal farmers in India grow brinjal crop, which provides regular and steady income to them (Choudhary and Gaur, 2009). Our farm survey of brinjal farmers in major producing states has also shown similar pattern. Study has revealed that between 78% and 95% of sample farmers belonged to smallholder category (below 2 ha) in the states of Gujarat, Uttar Pradesh (eastern region) & Bihar and West Bengal (Table 1). The share of smallholding farmers in Karnataka was about 50%. Therefore, the potential clients for Bt brinjal or for that matter of any other new technology of brinjal cultivation, are small and marginal farmers.

Table 1: Distribution of brinjal farmers by landholding size across selected states of India (%)

Farmers by landholding size	West Bengal	Gujarat	Eastern Uttar Pradesh & Bihar	Karnataka
Marginal farmers (< 1 ha)	75.6	46.4	51.9	31.4
Small farmers (1-2 ha)	19.8	31.1	27.6	18.3
Other farmers (> 2 ha)	4.6	22.5	20.5	50.2
Average landholding size (ha)	0.79	1.43	1.44	2.38

Source: Kumar and Prasanna (2010)

Development of Bt Brinjal

The Bt brinjal is the first GM food crop in India. It has been developed by the Maharashtra Hybrid Seed Company Ltd. (Mahyco), by inserting a gene *cry1AC* from a soil bacterium called *Bacillus thuringiensis* through an *Agrobacterium*-mediated gene transfer. As noted earlier, many issues need to be resolved before adopting Bt brinjal for field cultivation. This brief provides estimates of its potential monetary benefits which could be helpful in policy debates and decisions-making on release of Bt brinjal for field cultivation. The data used in simulating the economic gains are given in Table 2.

Table 2: Summary data used for simulation of economic gains from Bt-brinjal hybrids

Particulars	All-India
1. Production (thousand tonnes)	10377
2. Price of brinjal without Bt (Rs/kg)	8
3. Maximum yield gain (%)	33
4. Reduction in cost (%)	17
5. Price elasticity of demand	-0.515
6. Price elasticity of supply	1.0
7. Adoption rate (%)	
Scenario I	15
Scenario II	30
Scenario III	60

Source: Production and price data are taken from NHB (2009); yield gain and reduction in cost are taken from Mahyco (2009); demand elasticity from Kumar (2010); and supply elasticity from Krishna and Qaim (2008); and adoption rates are authors' own assumptions.

Socioeconomic Impacts

Bt brinjal hybrid is expected to provide two types of benefits to the producers. One, higher yield due to reduction in damage from FSB infestation; and two, reduction in cost due to savings in insecticides-use to control FSB. Also, consumers are anticipated to benefit from increase in output supply, reduction in output price and quality produce, free from FSB-infestation and chemicals used for its control.

(i) Yield gain and reduction in insecticide-use

The performance of Bt hybrids over non-Bt and popular hybrids of brinjal was examined in terms of yield gain and reduction in insecticide-use (Table 3) using data from large-scale field trials (LSTs) conducted by the Indian Institute of Vegetable Research (IIVR), Varanasi, a premier research institute under the Indian Council of Agricultural Research. These trials were conducted at 8 locations for 7 Bt brinjal hybrids, their non-Bt counterparts and best popular check during 2007-08 and 2008-09 to assess marketable fruit yield. The data on reduction in insecticide-use were taken from the trials conducted by the All India Coordinated Vegetable Improvement Project (AICVIP) during 2004-05 and 2005-06. Analysis revealed that use of Bt technology could result in a significant reduction in insecticide-use. Overall, the quantities of insecticides used against FSB were reduced by 77.2%, which amounted to 41.8% reduction in the total insecticide-use in brinjal (Table 3).

Table 3: Reduction in insecticide use and increase in fruit yield due to Bt brinjal hybrids

Year	Reduction in insecticide use* (%)		Increase in marketable fruit yield (%) over	
	Against FSB	Against all insect pests	Hybrids used to develop Bt	Popular hybrids
2007-08	80.0	40.4	32.1	51.6
2008-09	74.5	43.2	45.2	58.9
Average	77.2	41.8	37.3	54.9

Note: *relates to the years 2004-05 and 2005-06
Source: IIVR (2009), and AICVIP/ ICAR (2007)

Simultaneously, experimental data showed that yield of Bt brinjal hybrids was consistently higher than non-Bt hybrids. The yield gain was 37.3% over non-Bt hybrids (refers to hybrids used for incorporating Bt) and 54.9% over popular hybrids. This difference in yield indicated that Bt gene in brinjal was much more effective than use of chemicals in controlling FSB and the consequent low yield loss. Overall, the incidence of shoot damage in Bt hybrids was very low, 0.24% as compared to 4.64% in check and 4.86% in non-Bt hybrids.

The potential economic benefits of Bt brinjal to farmers, consumers and total economy have been computed at the national level under three scenarios corresponding to different adoption levels, assumed for Bt brinjal hybrids (*see* Table 2).

(ii) Benefits to brinjal producers

Farmers were benefited at multiple levels. They saved on quantity of insecticide used (Table 3) which directly affected saving in cost on insecticides and on labour in spraying of insecticides. The considerable increase in yield was due to low damage from FSB, which led to higher production and increase in income per unit area. Corresponding to the assumed adoption levels of Bt hybrids, 30 thousand tonnes to 119 thousand tonnes of brinjal output can be added to total production from the existing area under brinjal (Table 4). The Bt technology would also generate large savings (Rs 47 crore to Rs 187 crore) due to reduction in insecticide-use to control FSB, and in turn, large increase in net returns. Our computations did not include labour saving due to reduction in the number of pesticide sprays as experimental data did not capture this. However, our field survey revealed that 41.8% reduction in pesticide use due to Bt variety could save 4-8% of labour used in production of brinjal in major producing states.

Table 4: Potential economic benefits of Bt brinjal to farmers and consumers under different scenarios at all-India level

Particulars	Scenarios: Adoption level		
	Low (15%)	Medium (30%)	High (60%)
Benefits to farmers			
(i) Increase in production ('000 tonnes)	29.70	59.40	118.80
(ii) Saving from insecticides for FSB (in crore Rs)	46.80	93.60	187.20
(iii) Increase in net returns (in crore Rs)	623.15	1246.30	2492.60
Benefits to consumers			
(i) Likely reduction in price (%)	3.00	7.00	15.00

Reduction in direct exposure to insecticides would lead to lesser health problems. Undoubtedly, it would offer invaluable environmental and health benefits to farmers, as reported by other studies (Krishna and Qaim, 2007; 2008).

(iii) Benefits to consumers

Analysis has revealed that adoption of Bt hybrids would benefit consumers in terms of reduction in price of brinjal to the tune of 3% to 15% (Table 4), and increase in its consumption. Also, additional production of brinjal (30-119 thousand tonnes) would improve the food and nutritional security of low-income consumers.

The potential economic gains to farmers and consumers due to adoption of Bt brinjal have also been estimated in terms of the economic surplus (both consumer and producer surpluses). The estimation showed that adoption of Bt brinjal could raise consumer surplus by Rs 381 crore and producer surplus by Rs 196 crore annually with adoption rate of 15% (Table 5). When the coverage of Bt brinjal would extend to 60% of the existing area under brinjal, consumer surplus would increase by Rs 1576 crore and producer surplus would increase by Rs 811 crore. The gains in economic surplus have been distributed between consumer and producer in the ratio of 66 : 34.

Table 5: Simulated gains in annual economic surplus from Bt brinjal under different scenarios at all-India level

Scenarios	Total economic surplus (in crore Rs)	Distribution of economic surplus by agents (in crore Rs)	
		Consumers	Producers
15% adoption level	577	381	196
30% adoption level	1167	770	397
60% adoption level	2387	1576	811

In absolute terms, the likely gains to total economy have been estimated between Rs 577 crore and Rs 2387 crore annually, corresponding to different levels of adoption. It is an enormous benefit in absolute terms for a vegetable with an aggregate area-coverage much smaller than that of any major food or fibre crop. Not surprisingly, the largest share in the overall gain accrues in the eastern region, where not only brinjal area is larger but farm level productivity gains and adoption rates are also assumed to be higher.

Conclusions and Policy Implications

Most of the vegetables available in the market are out of the reach of a common man due to their high prices, particularly in the recent period. The per capita availability of vegetables in the country is 190 gram per day as against the normative requirement of 280 gram per day. The vegetable deficit underscores the need for substantial increase in vegetable production and affordability to consumers. Further, the major challenge is to raise production from the limited arable land which necessitates increase in yield as the principal source of output growth. The study has clearly shown that adoption of Bt technology can reduce insecticide application

and insect-pest related yield losses, thus increasing the yield and reducing the cost of production of brinjal. Reduction in insecticide-use can be considered as a comprehensive impact from environmental and health risk point of view.

The study has revealed that Bt brinjal has enormous potential to benefit both consumers and producers. Field cultivation of Bt brinjal would add between 30 thousand tonnes and 119 thousand tonnes to total production from the existing area under it. A considerable increase in net returns from Bt hybrids is also expected. The consumers would gain by reduction in output prices and increased consumption of brinjal. The absolute gain in economic surplus from Bt brinjal hybrids could be Rs 577 crore annually at the country level under scenario I (assuming adoption rate of 15%). The expected economic surplus would be of Rs 1167 crore, under scenario II (adoption rate of 30%), and of Rs 2387 crore under scenario III (adoption rate of 60%). About 66% of the overall potential gains accrue to consumers, who would benefit from a technology-induced decrease in brinjal sale price. Since brinjal in India is an important vegetable across the low-income households, the price decrease is pro-poor. Positive nutritional effects can be expected from increased vegetable consumption. On the other hand, brinjal farmers would benefit from Bt technology as increase in productivity will be larger than drop in market prices.

In terms of regional distribution effects, the major share of welfare gains would accrue in the eastern states of India (West Bengal, Orissa, and Bihar), where most of the brinjal is produced and insect-pest problems are severe. To realize the welfare potentials fully, these states will need particular attention in terms of technology dissemination, product development and delivery. This needs strengthening of local seed market infrastructure. Development of Bt OPV will improve access of resource-poor farmers to technology, who might not adopt more expensive Bt hybrids due to income constraints. This will help in increasing farm income, reducing insecticide-use and contributing to ecological security. An effective policy support is also required to spread Bt technology and harness its potential.

To sum up, Bt brinjal offers a large scope to increase income of farmers, increase its supply, reduce cost of food to consumers, improve food safety and reduce health hazards and environment pollution. Therefore, appropriate and effective regulatory and institutional mechanisms need to be put in place to harness the benefits and to safeguard against any threat of GM technology to environment, health, and biodiversity.

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