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Maneuvering Technology for Surplus Extraction: The Case of Bt Cotton in India

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In the debate over minds and mouths vs. hands ensuing Malthusian proposition on population, economists believe that ingenuity could be embodied into technology in surmounting the challenges of food shortages. Biologists have proved that technology can be embedded into seed. This was demonstrated in Indian agriculture for the first time through Green Revolution (GR). Introduction of transgenic hybrid cotton in India is the next landmark in the annals of agricultural research and developmental strides the country has treaded. The development of Bt cotton represents a new type of technical change in cotton production and the first genetically modified cotton introduced nine years ago, transformed the landscape of Indian cotton scenario. This technological breakthrough has expanded the production frontier of cotton and improved producer welfare. The direct benefits documented on using Bt cotton to control insect pests include reduced use of broad-spectrum insecticides, lower farming risks and production costs, better yields and profitability, expanded opportunities to grow cotton and a brighter economic outlook for the cotton industry (Edge *et al.*, 2001). After rigorous screening of the economic potentials and side effects in various trials across the nation for several years by the Ministry of Environment and Forests (MoEF) and the Department of Biotechnology (DBT), Government of India, commercial cultivation of Bt cotton was approved first for the southern and central states of India for three years since 2002-03 kharif, subject to reviewing of its performance before permitting its continuance and extension to the northern zone.

The first generation application of biotechnology in Indian agriculture, through development and commercial cultivation of Bt cotton has once again resurrected the potentials of human ingenuity. Within half a decade, cotton production more than doubled in India. Ironically, the technology is aimed at yield loss abatement due to the target pest, than yield enhancement *per se*. While GR was confined to a few superior cereals and well endowed regions, Bt cotton technology has quickly transgressed scales and ecosystems. While GR was the result of meticulous planning and execution by the state, Bt cotton's successful venture in terms of seed production and marketing, was mainly by the private sector with the support of the public sector scientists and extension workers. Contrary to the expectations and contention of the critiques that Bt cotton cultivation will exacerbate the rich-poor divide, the technology has brought in more equality in farm- income distribution (Morse *et al.*, 2007), reduced yield variability among cultivators and increased stability over time, indicating risk mitigation due to consistency in performance and wider adoption across size, class and ecosystems (Ramasundaram, 2005).

The area under Bt-cotton in the country increased exponentially from 29000 hectares in 2002 to over 9.4 million hectares in 2010 (James, 2010). Till date Genetic Engineering and Approval Committee (GEAC) of Government of India has granted approval for the commercial cultivation of more than 200 Bt cotton hybrids developed by more than 35 seed companies and evaluated by public sector organisations, and more than 1400 event-based hybrids, featuring three genes and six events developed by four companies, viz., Mahyco Monsanto Biotech (MMB) Ltd., JK Agri Genetics, Nath Seeds and Metahelix, besides the lone public sector Bt cotton variety, BN Bt and hybrid NHH44 Bt, by Central Institute of Cotton Research (CICR) in collaboration with University of Agricultural Sciences (UAS), Dharwad. A considerable number of non-approved Bt hybrids are marketed and cultivated in stealth, though a vast proportion of the crop area is under only less than half a dozen Bt hybrids. Many empirical studies have shown that there is no real substance in the negation of the benefits of Bt cotton in India and the variation in the positive effect can be attributed to heterogeneity of the environment, pest pressures, farmer's practices and social context (Bennet *et al.,* 2005; Morse *et al.,* 2005; 2007; Naik *et al.,* 2005; Gandhi and Namboodiri, 2006; Qaim *et al.,* 2006; Smale *et al.,* 2006).

Based on the number of seed packets being sold, it can be ascertained that more than 85 per cent of the crop area is under Bt cotton[2]. While the productivity of cotton has increased from 301 kg/ha in 2002-03 to 526 kg/ha in 2009-10, the reduction in real cost of production (adjusted for inflation) ranged between 16 per cent in Andhra Pradesh and 46 per cent each in Gujarat and Punjab. Plant protection costs in Bt hybrids dropped by a half against the conventional hybrids. The partial budgeting has shown higher returns in terms of savings in plant protection and in higher yields through averting yield loss over added costs due to higher seed cost and picking expenditure (Ramasundaram, 2005). The economic surplus computed in an ongoing study at this Centre has shown that the producer surplus realised through Bt cotton cultivation during the assumed life-time of the product of 14 years reckoned since 2002-03 is about Rs 24000 crores at constant prices (2002). The total innovator surplus has been found about Rs 4000 crores. The producer surplus accumulation and distribution would have been subdued but for the state intervention in rationalizing the seed pricing.

The national cotton economy offered an uncharacteristically unique opportunity of high productivity accompanied by high prices to the Indian producers during the Bt era. In the alternative scenario of continuing with only non-Bt cotton, computed by the authors, with the historical trend in cotton productivity, the country's production would have been only 13-14 million bales at the yield level of less than 300 kg/ha as against 526 kg/ha during 2009-10. The total pesticide consumption in Indian agriculture would have been around 60 thousand tonnes against 42 thousand tonnes currently (Table 1).

Table 1: Scenarios of cotton production in India

Parameters	With Bt cotton (Current)	Without Bt Cotton
Yield (kg/ha)	526	293
Production (million bales)	32.5	13-14
Pesticide consumption (tonnes)[a]	41822	59822
Export (million bales)	8.5	1.2-1.5
Import (million bales)	0.70	4.07

Basic data sources: Agricultural Statistics at a Glance, Ministry of Agriculture, Government of India, various issues; Directorate General of Commerce, Intelligence & Statistics, Ministry of Commerce, Government of India

a. Of the total pesticide consumed in India during the pre-Bt period, about 55 per cent was accounted for by cotton crop alone. It is pertinent to mention that the pesticide industry has come out with newer molecules having desired effect with milder concentrations, reducing total quantity.

Bt cotton cultivation, while providing a saving in plant protection labour, absorbs more of harvesting labour which is a female domain. It thus promotes labour and gender equity. Thus, Bt cotton meets the canons of appropriate agricultural technology viz., equity, productivity, profitability and ecological sustainability (through pesticide saving).

With a lint-seed ratio at 1:2, the estimated cotton seed (byproduct) production through Bt cotton cultivation since 2002-03 is 15.58 million tonnes. With negligible export of cotton seed, a large quantity has gone for cattle feed and for blending edible oils thereby entering in the food chain with no reported deleterious effect on human and animal heath till now.

Implications for Biosecurity and Biodiversity

The Bt cotton as a test case of genetically modified organisms (GMO) has found wider acceptability among the cultivators. But as the technology has been pioneered successfully by the private sector, it has been purposively packaged into ruling and robust hybrids as a handsome business proposition, calling for purchase of seeds by producers every season. Even before the introduction of Bt trait into cotton, hybrids were quite popular with farmers because they fetched higher profits due to their superior yields and fibre qualities as compared to '*desi*' cotton varieties. Hybrids offer a good value capture mechanism to the seed companies through repeated sale of seeds (Manjunath, 2011). Economically, seed as a produced means of further production is a capital whereas grain is only an inventory. When a farmer cannot save part of his produce for seed purpose, the agrarian relations get distorted in an economy with long-term implications where agriculture is the mainstay of the vast populace. Further, seed security is no lesser than nuclear security in preserving the country's sovereignty. While the hybrid technology has rendered inventorisation of capital, capitalization of inventories (inputs) with associated sunken cost, has always been fraught with uncertainties with far-reaching implications on the livelihood security of its cultivators, as experienced during crop failures. Here comes the need for value addition through incorporation of traits viz., drought tolerance, enhanced yield, improved fibre quality, etc.

Implications for Plant Varieties Protection and Farmers' Rights

The hallmark of the farmers' rights is to honour his claim of retaining his own produce for the seed purpose. Own-seed use as in cultivation of varieties, reduces the cost of cultivation. In open pollinated varieties, seed replacement every year is not necessary. Not that hybrid technology is not available and/ or not possible elsewhere in advanced countries, but the 100 per cent seed replacement rate in varieties themselves offer guaranteed business to seed companies, obviating the need for hybrid development. The seed replacement in the case of varieties every year has been economical for the cultivators in those countries because of massive state support programmes for agricultural inputs.

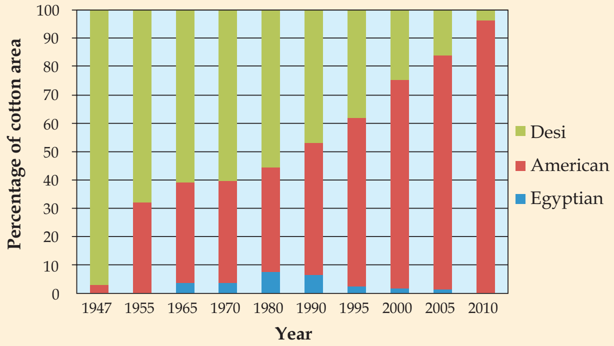
India is the only country in the world cultivating commercial hybrids in cotton. Farmers prefer hybrids because they provide much higher yields than the traditional varieties. But, hybrid seeds saved from one generation if used to raise the next crop, cause segregation of traits and there is decline in hybrid vigour, leading to a poor harvest (Manjunath 2011). It is worthwhile to note that there is no direct relationship between use of Bt technology and saving of seed.

At the dawn of independence, India was left only with 60 per cent of cotton area and 100 per cent of industry ceding away 60 per cent of the irrigated cotton to Pakistan. Ninety-six per cent of the cotton area was under *desi* (indigenous) varieties[3]. By 1970, the area of *desi* reduced to 10 per cent, with a corresponding increase in the American cotton varieties to 35 per cent. After the introduction of hybrids in 1970s, the area under the American cotton varieties (35 %) and hybrids (40 %) increased rapidly to 75 per cent by 2000. However, in the irrigated cotton tracts of Punjab and Haryana, cotton varieties (American and *desi*) accounted for more than 90 per cent of crop area even during the early years of previous decade, while the area under hybrids was not more than 3-4 per cent, as varieties rather than hybrids suited better for cotton-wheat system in the region. After the introduction of Bt hybrids, more than 90 per cent of Indian cotton area is under hybrid cotton in all the states, including north zone (Figure1). Bt hybrids ensure synchronous flowering reducing the number of pickings and facilitating earlier termination of crop and vacation of field for the succeeding wheat crop in agriculturally-intensive areas like Punjab, where the turnaround time in cotton-wheat rotation has eased than what was earlier (Ramasundaram, 2005). The adoption of the Bt technology at an exponential rate was invasive and unparalleled. This indicates that the demand of Indian farmers was more for the Bt gene than hybrids *per se*.

The total hybridization (attempt to bring 100 % area of any crop under hybrids) amounts to indirectly rendering farmers' right infructuous, as the seeds cannot be used for further cultivation. The impending elimination of varieties' cultivation has implications for bio- security and biodiversity, resulting in pan genetic vulnerability. It appears as though cotton varieties literally need protection from hybrids' explosion.

In addition to this, a wider adoption of Bt hybrids poses production and utilization problems as Bt cotton was developed in hybrids with trait for medium and long

Figure 1: Area under cotton among different species (%)



staples. Thus, with more than 90 per cent of cotton area in India coming under Bt hybrids, inadvertently it has led to surplus production of long staple cotton more than what India can consume (87 % against 33-35 %). Simultaneously, there is reduction in the production of short staple cotton, a trait of *desi* and some varieties of cotton against the requirement of 10-15 per cent. The trend has distorted the utility pattern of cotton rendering Indian cotton cultivators vulnerable to potential price crash. Besides, the clamour for the Bt technology has resulted in seed shortage and black marketing.

Implications for Cost of Production

Cost reduction is an important means of raising the net return, particularly in rainfed agriculture. In poor soils, hybrids calling for external input-use do not perform better than varieties. Nor the irrigated states of Punjab, Haryana and Rajasthan had any special advantage of cultivating hybrids as indicated by its area being less than 5 per cent in 2001-02, ie, 35 years after the release of the first hybrid in 1967. Had the Bt gene been available in the open pollinated varieties, perhaps the cultivators would have easily adopted the same, as it facilitates saving and using of the seeds. As the option was not available, the adopter availed the option of Bt technology through hybrids. The development has denied the cultivator the choice of making informed decisions.

Thus, there is a need to revive the cultivation of true varieties, and its emancipation in cotton poses a challenge to the public sector, particularly when there is no serious incidence of the target pest for almost a decade. The cultivators may inadvertently be over investing in Bt cotton hybrids in a recurring manner at least in certain parts like Maharashtra, where productivity enhancement has not been in commensuration with other rainfed cotton in the country. Even the current productivity in India is far below that of USA and China, having only true breeding varieties and no hybrids. It is pertinent to mention that hybrid cotton cultivation is unique to India and Bt cotton cultivation in rest of the world is only in open pollinated varieties. Hence, besides biotechnology and hybrid technology, there is a need to accentuate genetic improvement in landraces and open pollinated varieties (for example, development of compact varieties with less number of bolls cultivated in closer spacing), which have been successful in other countries. Bt varieties with desired traits like drought tolerance, shorter crop cycle, nutrient-use efficiency, etc. can be a better option. One can safely anticipate big demand for transgenic cotton varieties which will be much cheaper and also suited to harsh moisture stress conditions, particularly in view of the impending climate change. Hence, other areas like nutritional, edaphic and climatic factors need to be focused in trait selection for genetic enhancement of varieties through biotechnological means. Robustness of the host cultivar in yield enhancement will further augment the output. Public sector research should give more thrust on developing Bt varieties in this domain and contribute in bringing down the seed cost further.

This situation warrants to source new genotypes for varietal development from the vast germplasm available and new native Bt genes, resulting in development of successful transgenic Bt variety. There is a need to introduce sucking pest resistance in Bt cotton to make it more robust and less risky. A demand of big farmers is to have some ruling genotypes (hybrid) embedded with technology for a better performance, whereas small farmers want to have transgenic varieties suited for rainfed conditions (Ramasundaram, 2005). The existence of transgenic hybrids and varieties would cater to the demand for informed decision making by the farmers, besides bringing in greater competition in the seed industry.

This option to develop transgenic varieties needs to be exercised and expedited mainly by the public sector as the private sector seed companies in India tend to concentrate on hybrids, where returns are high and assured. The public sector bio-tech research in India needs to be strengthened by capital and capacity infusion to rise to the occasion as biotech research is capital-intensive and only private sector has made some breakthroughs in it worldover, barring China.

A large share of the Bt cotton varieties that Chinese farmers cultivate have been developed by scientists working in the public research institutes and are sold by the government seed companies. Political support for these scientists to allow commercialization of GM technology is one of the reasons that China approved the commercialization of GM crops earlier than most other developing countries (Paarlberg, 2001). In addition, the competition between public sector firms and foreign firms in providing Bt cotton varieties is undoubtedly one of the reasons why the price of Chinese GM cotton seed is so low.

In this context, there is a strong case for strengthening and investing in public sector research in evolving Bt cotton varieties that will reduce the seed cost and obviate the need to purchase seed every year. Collaboration between the public sector research of India and China is worth as the latter has the successful technology in development of transgenic cotton varieties. It may be noted that both India and China spend between 15 and 20 per cent of their resources on basic and strategic research in the apex agricultural research organizations, and rest are used for applied and adaptive research. Capacity development in agricultural biotechnology research is a major concern and increasing proportion of resources is being allocated to biotech research within as well as outside agricultural research system (Pal, 2008). China, being the biggest importer of Indian cotton, may have interest in any venture towards cheaper cotton production in India. Besides, India can also explore the possibilities of producing and exporting Bt cotton variety seeds to other countries with similar agro climates. If green revolution was from the public sector, the Bt cotton hybrid is from the private sector. The next push can come from the public -public cooperation between countries in development of Bt varieties for the agriculturally distressed areas and farmers.

Notes

[1]Technology (Bt gene construct and transfer) development is by the Monsanto company and it is continuous and evolving with value addition while the product (Bt hybrids) development is by the Indian companies.

[2]Assumed recommended seed rate of one packet (450 g) per acre and neither repeat sowing nor cultivation of F2 seeds nor high density planting and accounting for the area under *desi* short staple cotton and organic cotton as entirely non-Bt.

[3]The commercially cultivated cotton in India falls under major categories of *Desi* (Asiatic cotton, indigenous to India – *Gossypium arboreum* and *Gossypium herbaceum*) with short staple character, American (upland cotton introduced from America – *Gossypium hirsutum*) with medium and long staple character and Egyptian cotton (*Gossypium barbedense*) known for extra long staple fibres and higher counts (fineness). The cultivation of Egyptian cotton is confined to southern India in very limited area.

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