A decade of *Bt* cotton experience in India: pointers for transgenics in pipeline

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The development of *Bt* cotton hybrid is a landmark game-changer in technological application in Indian agriculture after the green revolution. There is substantial evidence that the adoption of *Bt* cotton provides economic benefits from increased yields due to limited damage from the bollworm pest complex and reducing costs through lower use levels of insecticide. *Bt* cotton is a loss-minimizing technology protecting the host genotypes from the onslaught of the key pest, viz. the American bollworm, *Helicoverpa armigera* (Hubner) in particular, and other bollworms, the spotted *Earias vittella* (Fab.), spiny *E. insulana* (Boisd.) and the pink *Pectinophora gossypiella* (Saunders), in general. *Bt* cotton developed in India is a combination of gene and hybrid technologies. The embedded *Bt* gene acts as an *in situ* biological pesticide factory obviating the need for any chemical spray for the suppression of the lepidopterous pests. For the gene to have its maximum effect, the host genotype chosen from the existing stock of hybrids should have a robust yield potential as indicated by the wider and popular acceptance of its non-*Bt* version (conventional hybrid) with the cultivators getting reflected in terms of acreage.

The success of biotech firms is in linking useful genetic events with high-quality germplasm to create genetically modified varieties (GMVs) to gain rapid market penetration and capture value for the creators[1]. The choice of the variety of cotton used as 'background' in comparison has a significant impact on the relative performance of *Bt* cotton[2]. When Monsanto in collaboration with Mahyco and started Monsanto–Mahyco Biotech (MMB), it is but natural for Monsanto, having proprietary rights over the *Bt* gene, to transfer this technology into a few cotton hybrids under Mahyco. The development of *Bt* cotton in India underwent a stringent regulatory process before it finally reached farmers' fields. Pre-release biosafety testing studies on aggressiveness, allergenicity, biochemical changes, gene stability, toxicity to goats, cows, buffaloes, chicken and fish, insect toxicity, pollen flow, soil persistence, presence of *Bt* protein in oil and agronomic evaluation, viz. preliminary, advanced-stage multi-location and large-scale field trials were conducted under strict monitoring. After fulfilling all biosafety and regulatory procedures, approval from the Government of India (GoI) for the commercial cultivation of three hybrids, viz. MECH-12, MECH-164 and MECH-185 was granted.

The promoters of the technology have been provided monopoly power under IPR laws for a limited period to incentivize and enable them appropriate benefits of their research efforts and investments at the earliest. But, the initial years were characterized by large-scale reporting of 'illegal' *Bt* cotton hybrids in cultivation. Besides moral and legal aspects, an important technical and economic reason not concerned with the regulatory bodies but seriously overlooked, too has contributed immensely to this phenomenon of 'illegal *Bt*' (not Nav Bharat 151, but others which came into the market after 2002–03). The research-induced technical change causes upward shift in production function resulting in expansion of supply. The nature of this shift in supply curve and its elasticity determines the distribution of the benefits of the new technology to the owner/supplier of technology. In turn, the monopoly power of a commodity depends on its price elasticity. The more inelastic the supply curve is, the more would be the volume of business and accumulation of revenue. A commodity becomes inelastic in supply in the absence of its substitutes. But with cotton, the non-*Bt* MECH had powerful substitutes (many field surveys have indicated that till MECH *Bt* hybrids were released for commercial cultivation, their non-*Bt* hybrids hardly occupied 6–7% of the then hybrid cotton area, whereas more than 70% of the hybrid cotton area in Central India was under a few popular hybrids, viz. Ankur-651, Bunny, RCH-2, JKHY-2, NHH-44 and PKV-2) in the market and their exclusion from consideration for transfer of the *Bt* gene, by hindsight is not an ideal corporate move. Mahyco, is a major player in vegetable than cotton seed production (it is pertinent to mention that in USA Monsanto tied up with Delta and Pine Land Seed Company and chose its varieties, occupying more than 50% of the country's crop area, for transfer of *Bt* gene). While the possession of gene technology got Mahyco the monopoly rights for the first three years, the market share of the non-*Bt* counterpart of the chosen genotypes was overlooked. This move instead of rendering the supply curve more inelastic resulted in the proliferation of illegal *Bt* hybrids, as those robust genotypes found favour with farmers rather than the officially approved ones, obviously because it was a loss minimizing than yield maximizing technology demanding a good genotype.

The host germplasm of the first MMB hybrids was not broadly adapted to Indian growing conditions[3] and crucial for establishing the counterfactual[4]. Disadoption of official *Bt* hybrids[5] in Maharashtra was reported in the second year itself and there were rampant reports of emergence of illegal but popular and cheaper *Bt* hybrids (on par with conventional hybrids and at prices one-fifth of official *Bt* hybrids) in Andhra Pradesh in spite of the monopoly status given to the three official *Bt* hybrids for three crop years. Till 2010, 220 studies related to socio-economic impact of *Bt* cotton have been made in India[2]. Not a single study has a non-*Bt* MECH hybrid (a less commonly used near isogenic) as a check or control for the official *Bt* cotton hybrids, as such a control was not available (except as 'refuge' given along with *Bt* cotton seeds) in a random survey (barring the studies sponsored by the promoters themselves). Almost all the studies do not take the trouble of giving details (names) about the genotype of the *Bt* and non-*Bt* hybrids studied, and in many cases it is only MECH *Bt* hybrid versus a ruling non-MECH non-*Bt* hybrid of the study area, as a non-MECH *Bt* control was not available with the farmers. When it comes to impact measurement, which essentially is an attribution exercise for a particular trait (insecticidal property of *Bt* gene in this case), it is imperative to ensure that the control does not differ genetically from the *Bt* hybrid, except for that trait (near isogenic). Obviously, comparisons under equal conditions of other farm, soil and socio-economic characteristics are difficult to achieve, less important compared to genotype differences and randomization in survey sample will take care of them. The best way to assess the impact of the gene alone would have been to develop a *Bt* cotton variety for the North zone where the area under hybrid cotton was negligible till 2002, and 100% crop area is under irrigation which would have facilitated suppressing the hybrid and irrigation effects. It is only a matter of conjecture now, as more than 90% of the crop area in the North Zone too has come under hybrids after the introduction of *Bt* cotton. Thus, there has never been an opportunity to attribute the entire effect to the gene alone. Hence, the need for selection of a right host genotype for transfer of *Bt* gene has implications for other *Bt* crops in the pipeline (brinjal, chickpea, maize, mustard, rice, sugarcane, tomato, etc.).

Most of the socio-economic impact studies on *Bt* cotton attribute the benefits accrued solely to the new technology ignoring the effects of the hybrids whose area itself has increased from less than 40% to more than 90% since the introduction of the technology. The proliferation of illegal (but popular) *Bt* cotton hybrids itself is an indication that the genotype is important and everything cannot be attributed to the gene alone. Besides, the area under irrigation also has increased considerably during this period. In fact, the cotton productivity has started stagnating after 2007, when more than 90% of the crop area has been brought under the new technology. This has led to a decimation of all the performing open-pollinated varieties of cotton. The popular cotton varieties like AKA 081, AKA 7, AKA 8, GCot 11, GCot 13, LRA 5166, LRK 516, MCU VT, MCU 5, PA 225, RG 8, Sahana, Surabhi, to cite a few have become almost extinct after the introduction of *Bt* cotton hybrids. A *Bt* version of these varieties would have been a boon for resource-poor regions not conducive to hybrids requiring high management and investment. But, there is a need to fortify them with drought resistance and output traits like quality aspects to revive them. Potential developments from biotechnological application will be more useful to low-input farming conditions of Indian agriculture when it goes beyond genetic engineering and transgenics for the present agronomic traits – herbicide tolerance and insect resistance. The best national average yield of 570 kg of lint/ha (17 q seed cotton/ha) with almost the whole crop area being under *Bt* hybrids, pales into insignificance when many countries harvest about 50–60 q/ha seed cotton as national average through straight varieties.

1. Traxler, G. and Falck-Zepeda, J., *AgBioForum*, 1999, **2**, 94–98.
2. Kaphengst, T., El Benni, N., Evans, C., Finger, R., Herbert, S., Morse, S. and Stupak, N., Assessment of the economic performance of GM crops worldwide. Report to the European Commission, 2011, p. 149; available at http://ec.europa.eu/food/food/biotechnology/reports_studies/docs/economic_performance_report_en.pdf
3. Arunachalam, V. and Bala Ravi, S., *Curr. Sci*., 2003, **85**, 1117–1119.
4. Melinda, S. *et al.*, Food Policy Review 10, International Food Policy Research Institute, Washington, 2009.
5. Ramasundaram, P., Vennila, S. and Ingle, R. K., *Outlook Agric.*, 2007, **36**, 175–180.

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