Bt cotton and integrated pest management

The essay by Komarlingam[1] is a direct plea for integrated pest management (IPM) systems to rescue the much-acclaimed Bollgard II (Monsanto's second-generation hybrid *Bt* cotton) from imminent collapse. It represents how a 'top-down', corporate-driven and much hyped technology was more akin to a 'hatchet job' on sustainable cotton farming. Bollgard II was introduced in 2006 because Bollgard I had become ineffective due to pest resistance. Now Bollgard II has also failed because the pink bollworm (PBW) has developed genetic shield (resistance) against it too. It is unlikely that modern biotechnologists would not have known that 'selective pressure' would continue to operate, no matter how many *cry* genes are stacked together; but the greed to make huge profits at the expense of resource-poor small and marginal cotton farmers, particularly in India, is overwhelming. Now, in order to save Bollgard II and the profits thereof, IPM is sought to be introduced.

Komarlingam's statement[1] '*An area-wide PBW (pink bollworm) suppression would essentially utilize the tactics of integrated pest management (IPM), the elements of which are well known and were practised in endemic areas of PBW during the pre-Bt era, but were abandoned by the farmers with the introduction of Bt cotton*', raises a fundamental question as to the need at all for the *Bt* technology. Does one want to buttress a new, highly-celebrated but failing modern technology with an earlier, cost-effective, eco- and farmer-friendly IPM technology? From an eco-friendly and sustainable farming point of view, IPM does not induce 'selection pressure' and consequent development of pest resistance. Hence, it is sustainable unlike the *Bt* technology. It is unfortunate that Komarlingam[1] does not mind the undue cost enhancement inputs and financial burden on cotton farmers, who have to buy Bollgard II and integrate IPM with it. So, his view that resource-poor cotton farmers should sow 'hybrid' Bollgard II cotton and then follow it up with IPM is ludicrous[1].

Komarlingam's statement that IPM was 'abandoned by the farmers' with the introduction of *Bt* cotton is incorrect. In fact, the farmers were misled to believe that with *Bt* transgenic cotton, chemical pesticides would not be necessary. The resource-poor cotton farmers were *not* advised that they should necessarily continue with IPM to support high-cost Bollgard. Those who are familiar with the management of pests (weeds + insects) and the scientific knowledge gained so far, would surely abandon the *Bt* and Ht technologies, which do not benefit the farmers and sustainable agriculture, but instead help the developers to make huge profits. The two important and well-established facts regarding pesticidal transgenic crops are:

(i) Tabashnik *et al.*[2] have shown that case selection for resistance against Cry 2AB was found to also cause resistance against Cry 1Ac.

(ii) Benbrook[3] has provided data on herbicide usage in the US (US Department of Agriculture data). Just as PBW develops resistance against *Bt* toxin and emerges as 'super PBWs', the herbicide 'Roundup' (i.e. glyphosate)-resistant transgenic crops also lead to 'selection pressure' to create 'superweeds'. Dozens of weed species have become 'superweeds' devastating several thousand acres of crop fields of soy and corn across many states in the US. A dramatic consequence of the emergence of superweeds is the need to apply much larger quantities of the herbicide glyphosate. Thus, Benbrook[3] reports that herbicide-resistant genetic engineering technology has led to a 239 million kg increase in herbicide use between 1996 and 2011. It is known that glyphosate is harmful to health – an endocrine disruptor and 'a probable human carcinogen' (the International Agency for Research in Cancer, WHO).

In India, the current experience with *Bt* cotton reveals that pesticide use stands at almost the level of the pre-*Bt* era. A question therefore arises: what good have pesticide-producing crops done to sustain global agriculture and to render the environment free from chemical pesticide residues?

The focus on economic gains at the expense of the resource-poor small and marginal farmers becomes evident from the fact that the developers of *Bt* technology have used 'hybrids' and not pure varieties for developing *Bt* transgenic crops. Putting *Bt* gene(s) in a cotton hybrid compels the farmers to buy seeds afresh from the seed company for sowing each season. This was the 'unholy' objective aptly referred to as 'value capture' for the industry. It has resulted in a monopoly, contravening the Competition Act, 2002 (amended 2009), with over 1000 – mainly Monsanto – hybrids in *Bt* cotton, many of dubious quality, capturing 95% of the cotton market share. The impacts have been severe; acute farmer distress due to rising costs of cultivation, crop failures due to high incidence of PBW resistance, secondary pests associated with *Bt* crops, even a shortage of non-*Bt* seeds (also their contamination), etc. have contributed to the monopoly. There is little doubt that with 65% of cotton farming in India being rainfed (official data) and unsuited to *Bt* technology, suicides were disproportionately high among cotton farmers, which in some cases could be directly attributed to *Bt* cotton cultivated in rainfed areas. Scientifically absurd claims and proposals in support of *Bt* cotton have not done the nation and its cotton farmers any good. Gutierrez *et al.*[4] provide a correlation between adoption of hybrid *Bt* cotton cultivation in the rainfed areas and the rise in suicide among cotton farmers.

Srivastava and Kolady[5] made a macro-analysis of the benefits of *Bt* cotton using state-wide average data. In a critique of this paper, Gutierrez *et al.*[6] presented convincing arguments to conclude that the work of Srivastava and Kolady[5] is devoid of an understanding of the biological underpinnings of the cotton production system, and of the socio-economic impact of the introduction of *Bt* cotton technology on about 65% of India's resource-poor subsistence farmers cultivating rainfed cotton. Today, the field-based realities are vastly different from the tall promises and false claims made with regard to the benefits of hybrid *Bt* cotton. These are briefly:

- Yields declined after 2007 despite increase in hybrid *Bt* cotton area. Within five years of commercial release of hybrid *Bt* cotton, yields had leveled-off to 500–550 kg/ha; the area under hybrid *Bt* cotton increased from 76.3×10^5 ha in 2003 to about 120×10^5 ha by 2012. Insecticide usage declined by about 50% with just 30% *Bt* area, but increased to

near pre-*Bt* levels by 2013, despite an increase of over 90% in *Bt* area.

It is emphasized that thus far modern biotechnology (GE crops) provides no traits for yield enhancement. The introduction of the *Bt* trait in hybrid cotton was in part to prevent our mainly resource-poor, small and marginal farmers from saving seeds for the next sowing season. Coupled with the greater adoption of *Bt* technology because of twin irresistible claims (of high-yielding hybrid *Bt* cotton and no pesticides), *Bt* cotton developers (essentially Monsanto), gained a monopoly in cotton farming in India in a short time-span. Its socio-economic implications have been dreadful: driving poor cotton farmers into a 'debt trap' and even to suicide. Many NGOs, including the M.S. Swaminathan Research Foundation (MSSRF), are providing skill and knowledge empowerment for self-created livelihoods to the widows of farmers who committed suicide, and school education for their children, in Vidarbha (Maharashtra) among other areas. MSSRF is also facilitating the widows and other dependents of deceased cotton farmers to derive benefits from various Government schemes.

I had the opportunity to examine the biosafety dossiers of *Bt* cotton and *Bt* brinjal in my then capacity as a Member of the Technical Expert Committee (TEC) appointed by the Honourable Supreme Court of India. The dossiers revealed several inadequacies in the toxicological evaluation of both *Bt* cotton and *Bt* brinjal. It is, therefore, not surprising that international experts who analysed these data have rightly pointed to the several serious flaws. Indeed, it opened a can of worms. In one case, the TEC was aghast to find that the toxicological data of *Bt* cotton presented to the then GEAC revealed a 'gender equality' in terms of body weights and growth rates of rats from the age of 6–8 weeks onwards to 20–22 weeks. That was a piece of new biology. The aspartate aminotransferase (AST) levels in both male and female rats were significantly higher in the *Bt* transgenic brinjal-fed group. The AST is a marker of organ integrity, and an increase in AST could indicate damage to liver and heart. It would appear that these significant flaws and omissions escaped scrutiny of the Genetic Engineering Appraisal Committee. Fortunately, the then Minister of Environment and Forests, Government of India imposed a moratorium on the commercialization of *Bt* brinjal.

The 'hybrid' mustard DMH-11 has several problems, of which one is that the Barnase–Barstar system in seed production programme requires a *bar* gene. This is an HT crop, the herbicide being Bayer's 'glufosinate', a neurotoxin, currently banned in the EU. Because of DMH-11, Bayer would gain a market in India.

The science is clear: 'Selection pressure' will act to induce the emergence of resistant forms of pests. In combination with socio-economic considerations (including the fact that resource-poor, marginal and small-holder farming does not 'allow' in practical terms, a 'refuge', in the absence of surplus land), hybrid *Bt* cotton should not have been introduced for commercial cultivation in India. What is far worse is to commandeer the use of IPM to resurrect Bollgard II cotton. Instead, the need of the hour is to admit past mistakes and rectify the errors as soon as possible.

There are many interesting examples of seeking support for GE crops by normally reputed science academies, such as National Academy of Agricultural Science (NAAS), which is eroding their reputation. In its 'Policy brief to accelerate utilization of GE technology for food and nutrition security and improving farmer's income' (NAAS, New Delhi, 1 August 2016), NAAS cites 107 Nobel laureates in their letter to the governments of the world stating that GE crops are '.....as safe as, if not safer than those derived from any other method of production'. The reproduction of this statement by NAAS would be amusing, if it were not such scientific 'cookery' – it is certainly curious as to how and why, Nobel laureates from different disciplines claim to be knowledgeable enough to make scientific judgements on 'modern biotechnology' – a discipline far removed from their own fields of expertise. It is indeed unfortunate that a science academy is so desperate that it requires using such questionable support. The agenda to promote the *Bt* and Ht transgenic crops obviously lacks science-based support. Claims of the benefits of *Bt* and Ht crops well exemplify 'science in post-truth era'[7].

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6. Gutierrez, A. P., Ponti, L. and Baumgartner, J. U., *Curr. Sci.*, 2017, **112**(4), 690–693.
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Response:

Kesavan's understanding that integrated pest management (IPM) is being sought through the published article on pink bollworm (PBW) management on *Bt* cotton, now that PBW has evolved resistance to Bollgard II *Bt* cotton, is not correct.

Biotechnologists and plant protection experts have always developed products bearing in mind that insect pests on crops can be successfully managed over a long time by not relying on a single mode of insect control. *Bt* cotton is no exception because, globally, it (for that matter, all *Bt* crops) is never positioned as a stand-alone method of insect management. *Bt* cotton is an integral part of IPM packages (at times region-specific) for the management of Lepidopteran pests of cotton and the good fit has been successfully demonstrated in cotton growing ecosystems of India[1–3]. As Kesavan has stated, IPM is preferred for *Bt* cotton for the reason that a multiprong approach to kill bollworms reduces the selection pressure exerted by *Bt* alone (along with the refuge planting)[4]. In the case of PBW, certain specific cultural practices (also integral to IPM) like early termination of crop or cultivation of early-maturing cotton in endemic and heavily infested areas, post-harvest ploughing, sanitation of cotton fields and gins from