Bt brinjal and GM crops: towards a reasonable policy ahead

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Release of GM crops should await incorporation of existing advances in plant transformation technology for assured biosafety. Further, for the transfer of transgene from primary transformant by backcrossing, location-specific hybrids/varieties should be used rather than eco-unfriendly high yielding hybrids.

The recent constraint on the commercial release of *Bt* brinjal has become a controversial decision. Many scientists and some politicians consider it as a setback to advances in agriculture biotechnology and therefore to attainment of food security. We are at a crossroad and must look for the way ahead in the context of release of *Bt* brinjal, other genetically modified crops and the relevant avenues of plant transformation by recombinant DNA technology (r-DNA) or genetic engineering (GE).

Recombinant DNA technology is a path-breaking technique because unlike conventional plant breeding, through this technology genes can be transferred between non-crossable species; between microbes, animals and plants. Even a gene of some desirable trait linked to an undesirable trait in the same chromosome can be transferred by this technique, which is otherwise impossible to achieve by conventional breeding. *Bt* brinjal contains the *Bt* toxin gene from the soil bacterium *Bacillus thuringiensis*. The *Bt* toxin confers resistance to the pests, fruit and shoot borer (FSB, *Leucinodes orbonalis*) and fruit borer (*Helicoverpa armigera*). Like other GM crops, commercial production of agriculturally suitable *Bt* brinjal involves two steps: (1) Production of the primary transformant by GE. A gene to be transferred, the transgene, e.g. *Bt* gene, is inserted into a chromosome of a target crop variety, the cells or tissue explants of which can accept and integrate it into its genome. Such transformed cells regenerate into whole plants. The host variety for this primary event has high acceptance for the transgene DNA, but is usually not agriculturally suitable and therefore, arises the need for the second step. (2) Production of the commercially viable and agriculturally suitable GM crop by transferring the *Bt* gene from the primary transformant to a hybrid or variety by a conventional plant breeding technique based on cross pollination.

Thus, Mayhco produced *Bt* brinjal primary transformant by incorporating the *Bt* gene into a bacterial plasmid DNA, pMON10518 and transferring this r-DNA by the common *Agrobacterium*-mediated transformation technology to a brinjal variety. This primary transformant was crossed with several brinjal hybrids, MHB 4, 9, 10, 80, 99, etc. to produce the GM, *Bt* MHB lines for commercial release. This gist of the technology can help us evaluate the pros and cons of the introduction of *Bt* brinjal and other GM crops.

It is worthy to note that the primary transformant for most commercially released GM crops is produced by r-DNA protocols of mid-nineties. For instance, Mayhco has used a slightly modified technique of Fari *et al.*[1]. The plasmid used continues to have, besides the *Bt* transgene, antibiotic resistance markers (*npt*II and *aad*) and the 35S CaMV promoter. From mid-nineties onwards plant transformation technology has moved ahead rapidly. Scientists around the world have endeavoured to make the technology better in terms of biosafety. They were aware that as the transgene-vector recombinant DNA had the capacity of 'jumping into' alien species it could also 'jump out' of a transgenic crop and 'jump into' another species causing gene contamination. Several strategies have been developed for gene containment in transgenic crops[2]. A major apprehension was for the antibiotic resistance marker DNA fragments spreading to other species from the GM crop. However meagre the chance for this, safe markers were developed and also protocols for obtaining marker-free transgenic crops[3,4]. Similarly, there were reservations about the otherwise efficient Cauliflower Mosaic Virus promoter (35 S CaMV promoter) as it imparts constitutive and non-specific tissue expression. So, tissue-specific promoters have been designed and innovations have also focused on stimulus-based or temporal expression in plants[5,6]. Random unpredictable insertion of the transgene into the genomic DNA has been another concern of the researchers. Such random insertion, even in non-genic segments of the genome, could have some unintended negative consequences, like random musical note insertion into a symphony offsetting the tune. Therefore, attempt for site-directed nonrandom insertion of a transgene has been a thrust area of research with some success in plants[7]. A rapidly developing area constitutes attempts to insert multiple genes in a crop, gene stacking[8] and pyramiding. Some examples are Golden rice, *Bt* crops with two *Bt cry* genes, the production of a GM cotton with *Bt* gene and gene(s) for resistance to sucking pests developed at the National Botanical Research Institute, Lucknow by Rakesh Tuli's team. The existing state of art, efforts and valuable recommendations with regard to agriculture biotechnology in India have been documented[9,10]. Despite the advances, the use of an underdeveloped r-DNA technology of mid-nineties is improper, although it could be due to the financial constraints imposed by IPR regimes. But, for public good, solutions must be found in this matter too.

The second step of transfer of the transgene from the primary transformant to a suitable hybrid or variety is accomplished by conventional plant breeding. The main issue in this step is the choice of the acceptor host hybrid or variety. In commercial release, market factors have played a major role. GM crop production is an expensive enterprise and any strategy must ensure money back guarantee. Therefore, to attract farmers high-yielding hybrid lines have been used as acceptors for back-crossing. The acceptor varieties, in case of *Bt* cotton, have yields even higher than the green revolution varieties (HYVs)[11]. In our area of operation, Narmada basin in Bagli Block of district Dewas, Madhya Pradesh (MP) and the neighbouring 'white gold' cotton growing Nimarh area, covering districts Khargone and Khandwa, MP, the yields of improved local varieties (e.g. HR35, LRK516) are about 8–10 q/ha and of the high yielding GR hybrids about 15–18 q/ha. In contrast, the yields of very high yielding hybrids (e.g. Ajit 11 and Rasi 2) and *Bt* cotton (e.g. *Bt* Ajit 11 and *Bt* Rasi2) are about 25–30 q/ha. These very high yielding hybrids and their *Bt* counterparts require about 20–25% more inputs in terms of fertilizers and irrigation than the current GR hybrids. This is a major risk. It is established that continued HYV, inorganic fertilizer use and water mining have caused nutrient depletion and lowering of water tables in many GR areas. Therefore, cultivation of high yielding GM crops endanger farmlands by further hastening the loss of soil fertility. In India, with diverse agroclimatic zones, a preferable strategy would be to use acceptor lines that are best adapted to particular zones of cultivation of a crop. This approach, followed for *Bt* cotton and developed by the Central Institute for Cotton Research, Nagpur, needs reinforcement by GOI. It must be understood that claims of high yields of the commercially released GM crops are because of the use of high yielding acceptor hybrids/varieties and not the transgene.

Our experience with *Bt* cotton has revealed two aspects. From introduction of *Bt* cotton to the present standing crop in our area, the severity of sucking pests attack has enhanced, as indicated by an increased number of pesticide applications and use of new pesticides. Further, as *Bt* cotton is resistant to boll worms, the larvae sometimes attack the soybean crop of the adjoining fields of the same or other farmers. So, there seems to be little overall reduction in pesticide use. It will be worthwhile to try strategies as conservation biological control[12] or no pesticide management with *Bt* cotton. Otherwise, soybean would replace labour and pest-intensive cotton as in the adjoining Malwa.

In view of the above considerations, it will be wise to take precautionary measures. One should wait till GM crops, especially food crops of greater biosafety have been produced using the advances in plant transformation technology. Researchers in India should strive towards producing GM crops which are marker-free, with safe promoters, have site-directed insertion of single or stacked genes, the gene(s) expressing in specific tissues, preferably having temporal, need-based expression and having other necessary attributes for biosafety. A major endeavour of genetic engineers is the production of transplastomic GM crops through chloroplast transformation rather than nuclear transformation[13,14]. In such transgenic crops there is more transgene product as a plant cell contains only one nucleus but many chloroplasts. Further, with transplastomics there is little chance of gene contamination by pollen flow. This should become a thrust area of plant transformation initiative. Further, GM research should probably be mainly in the public domain with some well regulated public–private partnerships.

It is possible to wait without despair as there are enough varieties of crops developed at various research centres of the Indian Council of Agricultural Research and the Council for Scientific and Industrial Research to take care of food security. A shift in mindset is also necessary. We are too preoccupied with the GR pattern of agriculture. It must be realized that amongst farmers, only about 20% have enough land and water resources to successfully practice GR agriculture. The majority, nearly 80% are small and marginal farmers who can ill-afford the GR practices and they mostly are in the drylands which constitute 70% of our land mass. The real answer to attainment of food security probably, lies in making the lands of small and marginal farmers productive by proper water management in their village watersheds linked with a sustainable agriculture programme. Through watershed interventions of water and soil conservation coupled with implementation of a sustainable dryland agriculture package, we have been able to achieve, over time, food security in the villages we have worked in Bagli Block of district Dewas, MP. There are many such other success stories also. Now, with the MGNREGA initiative this is a greater possibility.

At this juncture, one must remember the caution of the Father of modern agriculture in India, M. S. Swaminathan ‘Unless R&D efforts on GM foods are based on principles of bioethics, biosafety, biodiversity conservation, and biopartnerships, there will be serious public concern in India, as well as many developing countries, about the ultimate nutritional, social, ecological and economic consequences. . .’

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