develop transgenics and bring them to a level that they can be grown commercially, takes a long time. Local efforts currently in progress would take at least 10 years to reach the level already attained by MAHYCO. What MAHYCO has done is the best possible strategy, and the same should be followed by all developing countries, to utilize GE for the improvement of their crops. The ultimate test of the new crop varieties is the benefits realized by the farmers in terms of net returns, and their acceptance (willingness to pay for the value-added seed). From the business viewpoint, *Bt*-cotton providing insect resistance is a need-based 'product' with a large potential market. The most serious environmental risk it poses is the possibility that the *CryIAc* gene may be transferred to other cotton varieties through outcrossing[4]. The probability of its moving to wild, related species is almost nil as wild species of genus *Gossypium* are not found in the neighbourhood of cotton fields and the cytogenetic barriers[4]. Moreover, such spread of the *Bt* gene cannot cause adverse environmental effects. The other risk of the breakdown of resistance due to increase in the population of already existing resistant insect biotype or due to new mutations is a part of resistance breeding[3]. Plant breeders incorporate new *R* genes while insects and pathogens, for their own survival, evolve mechanisms to overcome the resistance[5,6].

Further, the author says '. . . Distortion of these facts by the media may have led to exaggerated response by the public'. Yet the analysis is based on at least 8 citations from popular media – *Business Line*, *Frontline*, *The Hindu* and *The Hindustan Times*.

The questions raised by the author on the scientific aspects of GE technology need no comments. The Royal Society of London, the US National Academy of Sciences, the Indian National Science Academy, the Brazilian Academy of Sciences, the Chinese Academy of Sciences and the Third World Academy of Sciences in their report[7], based on expert evaluation, and extensive discussions have recommended the use of GM technology. With respect to pest resistance the report says: 'There is clearly a benefit to farmers if transgenic plants are developed that are resistant to a specific pest'. Further it says: 'There may also be a benefit to the environment if the use of pesticides is reduced. Transgenic crops containing insect-resistance genes from *Bacillus thuringiensis* have made it possible to reduce significantly the amount of insecticide applied to cotton in the USA'.

The social issues are much more complex in India. GM crops were widely accepted in North America and the area cultivated with GM crops increased rapidly. In 1999, the area under GM crops was 28.7 (US), 4 (Canada), 6.7 (Argentina) and 0.3 million ha (China)[8]. The opposition to GM crops was initiated by the Union of Concerned Scientists in US[1], followed by Greenpeace in Europe. Gordon Convay[9], President of the Rockefeller Foundation attributes the European opposition to GM crops as 'the worry of the domination of food chain by American companies'. Others[10] attribute it to lack of economic imperatives among the farmers due to Government subsidies. In India cotton is very important for the national economy and directly or indirectly provides employment to a large number of families in handloom, powerloom, textile and garment industry[2,11]. For many *Bt*-cotton represents an imported technology controlled by a MNC, protected under the IPR, the seeds of which would be sold by a private company partly controlled by MNC; and since these are hybrids, farmers will have to buy seeds from the company every year. People fear that participation of the MNCs in the seed industry would lead to subjugation of the Indian farmer. In the changed scenario, to be globally competitive, what matters is the quality of the produce and the production cost. While intensifying cotton production, the pesticide load on the soil and environment in the growing areas should be minimized. The new textile policy[12] envisages exports to the tune of 50 billion US dollars annually by the year 2010 from 11 billion at present. *Bt*-cotton can certainly make its contribution towards reaching this target. Besides the questions raised by the author, the adverse impact on production, productivity, quality, production cost and environment by not accepting the *Bt*-cotton also need to be examined using sound scientific data.

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2. Gaur, M., *King Cotton*, Press and Publicity Syndicate of India, Jogeshwari, Mumbai, 1994, p. 258.
3. Tuli, R., Bhatia, C. R., Singh, P. K. and Chaturvedi, R., *Curr. Sci.*, 2000, **79**, 163–169.
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5. Gould, F., *Am. Sci.*, 1991, **79**, 496–507.
6. Keen, N. T., *Plant Mol. Biol.*, 1992, **19**, 109–122.
7. Report on Transgenic Plants and World Agriculture, Prepared under the auspices of several science academies, INSA, New Delhi, 2000, p. 27.
8. Akhtar, M., *TWAS Newsl.*, 2000, **12**, 4–6.
9. *Fortune*, February 2000, 164–170.
10. see Carlos, Jolly, in Bhatia, C. R., *Curr. Sci.*, 1999, **76**, 866–868.
11. Bhatia, C. R., in *Biotechnology for Asian Agriculture* (eds Getubig, I. P., Chopra, V. L. and Swaminathan, M. S.), APDC, Kuala Lampur, 1991, pp. 39–44.
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Response:

Bhatia states that the main difference between the Monsanto and MAHYCO projects lies in the fact that no public funds were involved in the latter; that *CryIA(c)* is currently the most appropriate gene, given the time lag in developing other genes for the purpose; that the scale of trials (area and duration) is within standard practice, given limited resources; that evolution of resistance in insects and pest management is general problem in crop improvement; that few scientific issues of concern remain regarding GE technology; and that societal issues, such as fears surrounding intellectual property rights (IPRs), cannot be given importance while entering the global market. My comments are on two scientific aspects: (i) pest resistance in *Bt* cotton, scientific issues in GE, and (ii) societal aspects (*Not* directly related to the *Bt* cotton project): transparency of the regulatory process, and IPRs.

- *Pest resistance in Bt cotton*: While pest resistance is a general issue, resistance to *Bt* crops may evolve faster than to traditional pesticides, therefore management plans need to be clearly laid out at the outset (see my response to Barwale's comments).
- *Ecological impacts and GE*: A recent review (Wolfenbarger, L. L. and Phifer, P. R., *Science*, **290**, 2088–2093) states that '. . . key experiments on both the environmental risks and benefits are lacking. The complexity of ecological systems presents considerable challenges for experiments to assess the risks and benefits and inevitable uncertainties of genetically engineered plants'. Therefore, rather than dismiss the potential for negative environmental impacts, regulatory procedures should ensure that the potential risks and any corrective measures are initially spelt out so that appropriate monitoring can be done, with follow-up as necessary.
- *Availability of information*: Bhatia questions my use of newspapers as a source of information after having commented on distorted facts in the media. This fact reinforces my point that information needs to be accessible: I had to use newspapers largely because other sources of information on these matters are not easily accessible to someone not directly involved in this work. I strongly urge the Department of Biotechnology and the Department of Environment to make public information on developments at various stages of the regulatory process, via a website, as done in the US by the United States Department of Agriculture (e.g. http://www.aphis.usda.gov/bbep/bp/) and Environmental Protection Agency (e.g. http://www.epa.gov/fedrgstr/index.html).
- *Intellectual Property Rights*: Bhatia notes that many Indian farmers fear the entry of multinational corporations (MNCs) into seed production in India since, to them, it spells the end of seeds as public goods (and he feels that the need to be globally competitive outweighs such concerns). The issue of IPRs is intimately tied up with the advent of MNCs, and this nexus of forces is feared by many people. These fears are likely to recur unless it is clear that the public interest is held above other interests. Contrary to common impression, there are a few signs that the dreaded 'terminator technology' is a thing of the past (e.g. Rafi, Suicide seeds on the fast track, http://64.4.69.14/web/allpub-display.shtml?pfl=com-list-all.param), and the public should continue to be aware of such facts. Other patent-associated problems, such as surrounded carotene-enriched 'golden rice', need to be addressed: e.g. 'Enabling Technologies', at the Centre for the Application of Molecular Biology to International Agriculture (http://www.cambia.org/main/r_enab_tech.htm). All options should be explored in imaginative ways and not foreclosed in an attempt to save time.

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Bt-cotton: Government procedures

Geeta Bharathan (*Curr. Sci.*, **79**, 1067–1075) has touched upon several aspects of *Bt*-cotton in India, some of which are inexact and are not based on facts. It is the intention of this note to provide clarification on the working procedures of the Government on the *Bt*-cotton trial, which are elaborated below:

- Permission for conducting contained field trials for collection of data was accorded by the Department of Biotechnology (DBT) for *Bt*-cotton hybrids containing *Cry1Ac* gene to M/s Maharashtra Hybrid Seeds Co Ltd (MAHYCO), Mumbai and not to M/s Monsanto. All the testing and evaluation work is being done utilizing the cotton hybrids of MAHYCO, and these hybrids are designated by the prefix of MECH with a numerical suffix, but not with the designation of Bollgard.
- There was no committee headed by V. L. Chopra that rejected the induction of the *Bt*-cotton technology at any stage. The initial negotiation for technology transfer between India and Monsanto was for a package comprising the supply of two constructs containing *Cry1Ac* as well as *Cry1Ab*, transformed *E. coli* competent to express these two *Cry* genes, and transgenic cotton seeds of Coker-312 containing *Cry1Ac* gene, besides including training of Indian personnel in molecular biology relevant to cotton transformation. This negotiation broke down because of disagreement between the Government of India and Monsanto on financial terms of the technology transfer.
- MAHYCO's proposal for importing transgenic cotton seeds of Coker-312 containing *Cry1Ac* gene was for investigating step-by-step the basis for the insertion of the *Bt*-transgenic traits into Indian cotton cultivars by backcrossing using the Coker-312 as the parent line; establishing the stability of the back crossed cultivar; assessing the quantum of expression of *Bt* proteins in different plant parts; evaluating the efficacy of the transgenic plant parts against the target bollworm; assessing the environment risks of the transformed *Bt* cultivars in Indian germ plasm; and evaluating the food safety of the *Bt*-cotton on experimental animals. This proposal was approved in the research mode to MAHYCO in accordance with the existing rules. This is consistent with the Indian Environment (Protection) Act (EPA 1986), and Rules 1989.
- It is, perhaps, therefore, not fair to state without full knowledge about the facts as has been mentioned by the author (p. 1069). 'The factors that led to the approval of a project that, superficially, appears no different from the first (rejected) project are not available to the public'. The following points are noteworthy: (a) if the earlier proposal could have been clinched, India would have been ahead of many countries in transgenic plant research, as contemporary knowledge and training in transgenic research would be fast forthcoming. (b) While the first field experiments on transgenic plants were carried out in USA in 1985, the *Bt*-cotton cultivars containing *Cry1Ac* gene were not yet approved in USA during the time when India was negotiating for procuring this technology. (c) Recombinant DNA technology applied to create transgenic plants in a wide range of cultivars, including cotton is not easy to master.

India has great skill in plant tissue culture and also has access to many transgenic constructs, with opportunities to transform the plant cells/calli into transgenic lines. Yet we have not been able to produce transgenic cotton lines,