

What shall we do with *Bt* brinjal? A debate among scientists*

The diversity of opinions that debates about *Bt* brinjal have generated over the last year (for example, see refs 1–8) has contributed to the haziness of the future of the variety (Figure 1, Box 1). This note attempts to collate the opinions of various scientists in the hope that some clarity may emerge if the different arguments are presented in one place.

What shall we do with *Bt* brinjal? The answers range between two extremes. P. M. Bhargava (founder and former Director of the Centre for Cellular and Molecular Biology, Hyderabad) asserts: 'Wisdom demands that we abandon *Bt* brinjal altogether as we just do not need it.' G. Padmanaban (Indian Institute of Science, Bangalore) definitively states: 'The moratorium should be lifted immediately.' Both these points of view have supporters in the scientific community. G. Shanmugam (Oncophyta Labs, Madurai), who agrees with Bhargava, says: 'I am of the opinion that we do not need *Bt* brinjal now. We have hundreds of varieties of brinjal, some are said to be resistant to the borer. This has to be evaluated. Also ecofriendly ways of controlling this pest are to be explored.' However, as the current mode of controlling the brinjal fruit and shoot borer (BFSB), *Leucinodes orbonalis*, is through excessive use of pesticides, Keshav R. Kranthi (Central Institute for Cotton Research, Nagpur) feels that *Bt* technology is the best option. Drawing on his experience with *Bt* cotton, he says: '*Bt* technology is best suited to control cryptic borers such as cotton bollworms, which are internal feeders, much like the BFSB. The harm that even the "safest" chemical pesticides used on brinjal can cause far outweighs any possible perceived direct or indirect effects that *Bt* brinjal is known to cause. Therefore, the moratorium on *Bt* brinjal can be lifted immediately.'

Some of the scientists who support the release of the brinjal variety suggest limited field trials to start with. One of the advocates of this route is Padmanaban, who says, 'As a measure of abundant caution, the seeds can be distributed to a limited number of farmers for independent trials in fields to assess yield, level of

pesticide spray required, etc. before full-fledged commercial release.' H. S. Gupta (Indian Agricultural Research Institute, Delhi), who also believes that *Bt* brinjal must be released as soon as possible, asserts, 'Limited release can be the immediate solution, but this should be for a short period only and it should be followed by full scale release.' He adds, 'Now the same gene has already been transferred to several Indian varieties that can be released for cultivation.' Mahtab S. Bamji (Dangoria Charitable Trust, Hyderabad) also feels that limited release of *Bt* brinjal might be a good first step: 'It can be released to a few farmers with larger fields which will permit refuge area, and be closely monitored for putative adverse effects and benefits.' But some scientists do not agree. 'For a plant there is no such thing as a limited release. There are many examples which show that once you release a plant, you cannot recall it unlike a drug. Parthenium and water hyacinth are good examples, if you know about their story in our country,' Bhargava cautions. M. S. Swaminathan (M.S. Swaminathan Research Foundation (MSSRF), Chennai) does not

believe in limited release either, and suggests that the brinjal variety must be released as soon as the basic considerations underlying the precautionary principles are fulfilled.

The tests that have been conducted on *Bt* brinjal have been a major cause of difference of opinion among scientists. While some believe that the tests are abundantly sufficient, others feel that they are absolutely inadequate. V. S. Chauhan (International Centre for Genetic Engineering and Biotechnology, New Delhi) says, 'There was (and there is) no problem with *Bt* brinjal as far as the science (toxicity, safety, etc.) is concerned. And if this is the main issue, then the moratorium should be lifted immediately.'

There are others who share this opinion: Gupta feels that 'The debate on inadequacy of the tests is not based on scientific facts but on pure assumptions.' Padmanaban draws on prior experience with other genetically modified plants for insect resistance when he says, 'The tests carried out are adequate. In addition, there is data available on *Bt* corn, consumed by millions globally for over



Figure 1. The popular media debate *Bt* brinjal.

*All the quotations used in this note are based on personal communications to the author.

Box 1. Some important documents.

1. Protocol for large-scale field trials of *Bt* brinjal hybrids MHB-4 *Bt*, MHB-9 *Bt*, MHB-10 *Bt*, MHB-80 *Bt* and MHB-99 *Bt* containing the *cry1Ac* gene for testing of efficacy and yield during kharif 2006; http://www.moef.nic.in/divisions/csurv/geac/protocol_trial.pdf
2. Minutes of the 2nd meeting of the Expert Committee on *Bt* brinjal held on 3 July 2007; www.envfor.nic.in/divisions/csurv/bt_brinjal.doc
3. *Bt* brinjal development: list of studies conducted; http://www.moef.nic.in/divisions/csurv/geac/brinjal_part-I.pdf
4. Bio-safety data of *Bt* Brinjal containing *cry1Ac*; http://moef.nic.in/divisions/csurv/geac/bt_brinjal.html
5. Additional data generated on safety and efficacy of *Bt* brinjal; http://moef.nic.in/divisions/csurv/geac/Bt_Brinjal/Bt_Brinjal.htm
6. Development of fruit and shoot borer tolerant brinjal, Mahyco, 2008; <http://www.envfor.nic.in/divisions/csurv/geac/images/cry1AC/TOXICOLOGY%20-AND%20ALLERGENICITY%20STUDIESvol1.pdf>
7. Report of the Expert Committee (EC-II) on *Bt* brinjal, 8 October 2009; <http://moef.nic.in/downloads/public-information/Report%20on%20Bt%20brinjal.pdf>
8. Report of the independent expert committee on *Bt* brinjal; http://www.munlochygmvigil.org.uk/Report_of_the_Independent.pdf
9. Decisions taken in the 97th meeting of the Genetic Engineering Approval Committee (GEAC) held on 14 October 2009; <http://moef.nic.in/divisions/csurv/geac/decision-oct-97.pdf>
10. National consultations on *Bt* brinjal: a primer on concerns, issues and prospects, Centre of Environment Education (CEE); <http://moef.nic.in/downloads/public-information/Bt%20Brinjal%20Primer.pdf>
11. National consultations on *Bt* brinjal: Report, CEE, 10 February 2010; http://moef.nic.in/downloads/public-information/Annex_BT.pdf
12. Decision on commercialization of *Bt* brinjal, Ministry of Environment and Forests, 9 February, 2010; http://moef.nic.in/downloads/public-information/minister_REPORT.pdf
13. Decisions taken in the 101st meeting of the GEAC held on 9 June 2010; <http://www.moef.nic.in/divisions/csurv/geac/decision-jun-101.pdf>
14. Decision taken in the 107th meeting of the GEAC held on 9 February 2011; <http://www.moef.nic.in/divisions/csurv/geac/decision-feb-107.pdf>
15. Minutes of the meeting of the GEAC held on 27 April 2011; <http://moef.nic.in/divisions/csurv/geac/spcl-MoM.pdf>
16. Decisions taken in the 109th meeting of the GEAC held on 11 May 2011; <http://moef.nic.in/divisions/csurv/geac/decision-may-109.pdf>
17. Draft of the National Biotechnology Regulatory Authority Bill (2008); http://dbtindia.nic.in/Draft%20establishment%20plan%20for%20NBRA_28may2008.pdf
18. Introductory presentations made at the brainstorming meeting on GM crops, 1 June 2010; http://www.ias.ac.in/academy/inter_academy/GMCrops-presentation.pdf
19. Interacademy report on GM crops; http://www.ias.ac.in/academy/inter_academy/GMCrops-interAcademy-report-updated.pdf

10 years. There has been no authenticated report of problems with health or environment safety.’ Bamji reiterates the same point: ‘*Bt* crops have been part of human food since many years and no adverse health or environmental effects have been recorded. Needless time and money should not be wasted on more testing There should be a strong and independent monitoring and regulatory mechanism. Opinions of experts should be respected.’

Among the people who think *Bt* brinjal has not been tested sufficiently is P. C. Kesavan (MSSRF, Chennai). On being asked if more tests need to be conducted, he says: ‘The word “more” testing gives an impression that lots of tests have already been carried out (Box 2). My view is that there have been no tests car-

ried out effectively to unravel chronic, long-term, toxicological effects when *Bt* brinjal is consumed as a vegetable. In a recent paper, Gilles-Eric Séralini *et al.*⁹ have elegantly shown that the 90-day-long tests are insufficient to evaluate chronic toxicity. Kidney and liver functions require to be assessed on a reasonably long-term basis. It should also be emphasized that scores of studies reveal that *Bt* exerts harmful effects on test animals. A study carried out by independent doctors in Canada¹⁰ found traces of *Bt* toxin in the blood of 93% of pregnant mothers, in 80% of the umbilical cords, and in the blood of 69% of non-pregnant mothers. These findings support my contention based on various related reports that *Bt* toxin is not specific to lepidopteran pests and that it is not ex-

perimentally proven that *Bt* toxin would be destroyed in the gut and pass out of the body without causing harm. It is not scientific and ethical to push these data under the carpet.... Instead of setting them aside as commissioned or doctored reports, we should conduct the necessary tests and accept or reject them, purely on proven scientific basis. The commercial push for GM foods in general, and *Bt* crops in particular, must be countered by an ethical or political pull until all the essential toxicological tests, which may take as many as ten years, are properly conducted and bio-safety is established beyond an iota of doubt.’

As if in response to Kesavan’s doubts about the adequacy of the tests on *Bt* brinjal, Kranthi says: ‘*Bt* cotton was approved for commercial cultivation in

Box 2. Suggestions on tests for *Bt* brinjal.

1. There are issues related to risk of resistance development of the fruit and shoot borer to *Bt* brinjal, especially because it is a monophagous pest and the recommended refugia of 5% would be grossly insufficient to delay resistance significantly. Studies on initial frequency of resistance conferring alleles, inheritance of resistance, number of resistance mechanisms and alleles, fitness cost associated with resistant alleles, cross-resistance profile, dispersal and migration, diapause, etc. need to be carried out to determine the most effective resistance management strategies (K. R. Kranthi).
2. Less than a metre distance between *Bt* and non-*Bt* brinjal crops is to be tested for cross-pollination since the 300 m distance (that is recommended) is not feasible in our agri practice with small adjacent holdings (G. Shanmugam).
3. A battery of genetic toxicological studies in rats and mice to assess long-term carcinogenic, clastogenic and mutagenic activity of the *Bt*-cry proteins (P. C. Kesavan).
4. The bio-safety regulations for acute and chronic effects of GM foods on human and animal populations are gradually getting standardized. In addition, we also need information on the impact on biodiversity and environment (M. S. Swaminathan).
5. Socio-economic analysis: Is there need for the change that the GMO can bring about, and are there cheaper and better alternatives?
6. Characterization of the transgene and its expression; proteomics, transcriptomics and metabolomics analyses, which would also help in identifying any changes in glycosylation patterns.
7. Changes in surface properties that may affect normal interaction between species, and with the environment.
8. Gene flow and dispersal of the plant into areas where positive harm could be done (as has happened with water hyacinth and parthenium).
9. Stability of the transgene product in the whole organism and/or parts thereof, under various conditions of storage or handling.
10. Development (if not already available) of a technique to determine with accuracy 0.01% contamination with GMO or its product.
11. Effect on interaction with (cattle) GI microflora, and possibility of any contraindication in regard to use of drugs, including probiotics in humans, effect on useful insects, microflora and micronutrients of the soil, and impact on ecology.
12. Allergenicity and acute toxicity studies with native (not 'surrogate') protein, and chronic toxicity studies (including carcinogenicity).
13. Bruce Ames' test using pure protein and appropriate plant extracts for mutagenicity.
14. Development of resistance to the trait that is introduced.
15. Comparison of the growth characteristics of the GMO and the parent organism.
16. Emergence of new dangers such as super weeds.
17. Effect on the population density of non-susceptible pests, following at least five successive plantations.
18. Additional environment effects such as fitness of intraspecific hybrids and backcrosses, identification of wild relatives, hybridization, overlap of flowering time and geographic distribution with brinjal, identification of pests of wild relatives, fitness advantage of *Bt* transgene and its quantification, etc. (5–18, adapted from P. M. Bhargava).

USA in 2006 and subsequently in 12 other countries, including India. The approvals were based 90-day chronic toxicity tests as has been the standard international norm. The *CryIAc* gene used in *Bt* cotton is the same as the one used in *Bt* brinjal. Fourteen years of cultivation in USA and 9 years in India and other countries, have not resulted in any bio-safety concerns, including harm to other insect species of consequence, anywhere in the world. Enhancing stringency of bio-safety testing should be based on concerns, if any, that may have emerged over the past 14 years of GM cultivation, which has not been the case with *Bt* cot-

ton.' However, some scientists doubt if the success of *Bt* cotton in our country, or the widespread use of *Bt* crops in other countries, can be used as bases to evaluate the safety of *Bt* brinjal. Swaminathan says, '*Bt* brinjal and *Bt* cotton cannot be compared with each other. In the case of bio-safety regulations, every case should be studied and treated separately.' Kesavan cites examples of other technological advances that proved to be harmful after they had been used for many years: 'One should recall the case of rDNA tryptophan killing 40 or more and causing paralysis to over 2000 people in USA during the 1980s, the case of

the mad cow disease in the UK, the environmental and ecological havoc caused by DDT ...', and therefore feels that it is best to exercise extreme caution in the case of *Bt* brinjal.

Some of the lack of trust in the tests that have been conducted comes from the belief that 'it is important that we have a reliable national laboratory in public, private or joint sector which can do all the tests and, therefore, check the reliability of tests done by others' (P. M. Bhargava, pers. commun.), or that 'these tests are to be conducted by public sector organizations which do not receive funds from private companies' (G. Shanmugam,

pers. commun.). But there are people who strongly object to this: 'Is there evidence that data of the tests done so far are not reliable? There are set, standard procedures to produce toxicity and other relevant data and they should be followed. There is no need what-so-ever to use different procedures. What is an independent and reliable institution? One has to trust the data that is produced and submitted for scrutiny – there will be no end to this. If there is going to be a Government-supported institution to do this, let it be so. But, I do not see how this addresses the question of trust deficit. It might add more confusion and unhealthy practices,' points out Chauhan.

Apart from the tests, scientists have also voiced their concern about the safety of releasing *Bt* brinjal in India, which is considered by many to be the centre of origin of brinjal^{11,12}. Kranthi, who supports releasing *Bt* brinjal, understands this problem, but he also sees a possible solution: 'It is extremely important that biodiversity of crops in their centre of origin is conserved and enhanced. Extensive cultivation of hybrids, especially GM crops, does discourage evolution of land races and cultivation of native traditional varieties, thus curtailing natural micro-evolution of diversity. Since hybrid seeds cannot be re-sown as opposed to varieties which are self-replicating, they do not strengthen or facilitate evolution of biodiversity. Therefore, GM varieties are preferred over GM hybrids to conserve biodiversity.' The development of resistance to the variety has also been seen as a drawback. Maintaining a 'refuge zone' around the field is a method to limit resistance development, but many like Bamji wonder if this is a feasible option in a country like India: 'Since most farmers in India have small and marginal land holdings, GM crops may not be suitable for them unless cooperative farming is done and a common refuge area set aside for many small and marginal farms.'

Despite the many differences of opinion among scientists, there is general agreement about the need for an unbiased regulatory system for genetically modified crops. Kranthi gives a perspective of the existing system of regulation, based on his experience with *Bt* cotton: 'Though reasonably stringent, effective and efficient, our regulatory system does not inspire complete confidence because the Review Committee on Genetic Manipu-

lation (RCGM) and Genetic Engineering Appraisal Committee (GEAC), which are under DBT, Ministry of Science and the Ministry of Environment respectively, do not have any testing facilities of their own. The laboratory and field trials are coordinated by RCGM, and the GEAC approves GM varieties and hybrids for commercial cultivation. Ironically, the Indian Council for Agricultural Research (ICAR), which is the apex organization for agricultural research in the country, has limited influence in the approval of GM crops suitable for different agro-eco regions. Interestingly, the entire field trials and majority of the bio-safety studies are conducted by the National Agricultural Research System (NARS) which operates under the aegis of ICAR. It would have been appropriate if RCGM examined the authenticity of the transgene inserts, GEAC conducted bio-safety studies and granted environmental bio-safety approval for a particular GM event, and the final field evaluation and commercial releases of the GM crops were coordinated by ICAR. GEAC thus far has approved more than 1000 *Bt* cotton hybrids over the past 8 years, despite their limited understanding of agricultural sciences, whereas the ICAR has released only 50 cotton hybrids in the last 40 years. It is widely felt by agricultural experts that the productivity in India declined from 560 kg lint/ha in 2007–2008 to 475 kg/ha in 2010, despite the increase of *Bt* cotton area from 38% in 2006 to 90% in 2010, because of the indiscriminate approvals of *Bt* cotton hybrids, most of which were susceptible to sap-sucking pests and diseases, and unsuitable for the agro-eco regions for which they were released.' There is widespread dissatisfaction with the existing system of regulation, but some scientists, such as Bhargava, are also critical of the Biotechnology Regulatory Authority of India (BRAI), which is to be set up to remedy the situation: 'As regards BRAI, the version that has been so far available to the public is nothing short of a disaster and a denial of all democratic and scientific values. I believe the revised BRAI bill has not been accessible to the public', Bhargava says. A few others are more optimistic: According to Chauhan 'The existing system for the regulation of GM crops is painfully slow and needs to be improved. It is expected that BRAI will take care of the gaps that currently exist. Once established, BRAI should

make all provisions to make sure that the decisions about GM crops address all problems related with GM crops, but also should have the authority to make a final judgment that should be accepted by all stakeholders, one way or the other.' Kranthi describes the ideal scenario: 'If the NBRA or BRAI comes into effect, it should establish a "National Institute for GM Product Bio-safety Assessment and Compliance" that can operate as a single-window system to examine, ascertain, verify and subject all proposed GM material to complete bio-safety assessment in a reliable and transparent manner. The process will simplify and expedite GM crop use through expert assessment. The relevant ICAR/NARS institutions can evaluate the GM crops for trait effectiveness, agronomy and economic benefits before they notify the GM crops for cultivation. Post-release monitoring for seed purity, compliance monitoring and any possible decline in efficacy and ecological impact of the trait should lie with the ICAR, while bio-safety monitoring and assessment of environmental effects should be the responsibility of the GEAC.'

Describing the setting up of BRAI, Swaminathan says: 'In 2003, when I chaired a Committee on Agriculture Biotechnology I came to the conclusion that we need an autonomous regulatory system which inspires public, political, professional and media confidence. This is why I recommended the setting up of a professionally led and autonomous Biotechnology Regulatory Authority, set up by an Act of Parliament. I also mentioned in the report that "the bottom line of a National Agricultural Biotechnology Policy should be the economic well-being of farm families, food security of the nation, health security of the consumer, protection of the environment, bio-security of the country and the security of our national and international trade in farm commodities". A credible regulatory system should not be under the control of those whom such a body is to regulate. For example, in the atomic energy case also, the atomic energy regulatory body should not be under the control of the Department of Atomic Energy. If this is not done, the Regulator will not inspire public confidence.'

Public confidence is also mediated in large part by means of communication. The popular media has by and large been anti-*Bt* brinjal; the general public and the

leaders of the states do not seem to favour the variety either^{13,14}. The scientist–lay man barrier may not have been scaled efficiently enough, but the need for communication is an area of general consensus. Swaminathan sees the necessity ('there has to be a culture of conversation between scientists and the public through dialogues, media and conflict resolution meetings'). So do Bhargava ('there should be a dialogue between all the stakeholders, including farmers, where no available information should be withheld'), G. Shanmugam ('interactions between the lay public and open-minded scientists may be contemplated similar to the MIT model mentioned by Balaram in a recent editorial in *Current Science*¹⁵'), and many others. However, the question of who must mediate the communication is still debatable. As Chauhan puts it, 'Scientist is too broad a term. A biologist, a chemist, or a physicist may not know or appreciate the field of transgenics and real issues involved with toxicity, safety, etc. Plant scientists working with transgenic plants and with the *Bt* group should be the ones who should have a dialogue with other scientists and the public. There are a lot of "Googled" scientists and activists who may choose to receive selective information from not too accurate sources and form opinions or further cement them. Unless stakeholders from the civil society, including

the scientists, come with an open mind, there will be little benefit from any dialogue. I personally find it difficult to convince "educated individuals" once they have taken a certain stand on any issue'.

Now, after all the debates have been presented, one may want to recall what the current position on *Bt* brinjal is. V. P. Kamboj (former Director, Central Drug Research Institute, Lucknow) summarizes the present status: 'The views of the RCGM and GEAC and three special committees constituted to review it, as also of the six science academies are before the Government of India. Its decision on *Bt* brinjal will decide the fate of transgenic crops.' Would the decision on *Bt* brinjal really have such a great influence on the future of GM crops in India? Well, that is debatable too!

1. Banerji, D., *Curr. Sci.*, 2010, **99**(10), 1319–1320.
2. Chokshi, A. H., *Curr. Sci.*, 2010, **98**(6), 734.
3. Chokshi, A. H., *Curr. Sci.*, 2011, **100**(5), 624–626.
4. Chong, M., *J. Risk Res.*, 2005, **8**(7–8), 617–634.
5. Padmanaban, G., *Curr. Sci.*, 2009, **97**(12), 1715–1716.
6. Padmanaban, G., *Curr. Sci.*, 2011, **100**(2), 157–158.

7. Shanmugam, G., *Curr. Sci.*, 2011, **100**(2), 147.
8. Seetharam, S., *Indian J. Med. Ethics*, 2010, **7**(1), 9–12.
9. Séralini, G. E. *et al.*, *Environ. Sci. Eur.*, 2011, **23**(10). From <http://www.enveurope.com/content/pdf/2190-4715-23-10.pdf>
10. Aris, A. and Leblanc, S., *Reprod. Toxicol.*, 2011, **31**(4), 528–533.
11. Samuels, J., *Curr. Sci.*, 2011, **100**(5), 603–604.
12. Singh, M., http://www.moef.nic.in/divisions/csurv/geac/Bt_Brinjal/Centre%20of%20Origin.pdf
13. National consultations on *Bt* brinjal: Report, Centre for Environment Education, 10 February 2010; http://moef.nic.in/downloads/public-information/Annex_BT.pdf
14. Malhotra, R., *Curr. Sci.*, 2011, **100**(11), 1610–1612.
15. Balaram, P., *Curr. Sci.*, 2011, **100**(6), 799–800.

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MEETING REPORT

Publish and perish*

If one does not follow certain ethics and norms in scientific publishing, one's career is bound to perish. If not immediately, maybe in the future. In a recent brainstorming two-day workshop on academic ethics, a small number of scientists, social scientists, editors and journalists discussed issues in publishing, such as scientific misconduct, plagiarism, and falsification and fabrication of data. It was questioned if an individual commit-

ting such a 'crime' must be held accountable or not, particularly when there is no clear evidence of misconduct on his part. Should one be punished because public funds were involved in conducting research? Should one's career be ended or marked forever due to a few misdeeds?

In a way our society encourages plagiarism at a very early stage in one's life – during school days, when a student is not inhibited from submitting a professionally made science project or in college/university level when students are made to copy experiments verbatim from their senior's practical notebooks. Highlighting this Rohini Muthuswami (Jawaharlal Nehru University, New Delhi) said

that answers in examinations are expected to be exact points as written in the textbooks. Advent of internet has inculcated among the students the copy–paste tactic of finishing assignments and term papers. 'Plagiarism cases are also fuelled by the race to publish more as our education system demands a Ph D degree with at least ten research publications as the minimum criteria for the post of professor', noted S. R. Hashim (Forum for Global Knowledge Sharing).

Satyajit Rath (National Institute of Immunology, New Delhi) said that talking about ethics conflicts with the emphasis that is laid on newly enrolled Ph D students who are told, 'you have to

*A report on a workshop on Academic Ethics, held at The Institute of Mathematical Sciences, Chennai, during 15–16 July 2011. It was organized by the institute in collaboration with the Forum for Global Knowledge Sharing.