require either chemicals or gene-based solutions, in some cases – both. A four-country comparison of agrochemical usage shows India to be one of the lowest users of agrochemicals (Figure 3). Thus, a choice will have to be made between chemical or gene-based solutions for increasing the yields. Much of the current global prosperity is due to science and technology. Developing countries require science and technology to defeat poverty, hunger and malnutrition. The lesson from the DDT story is not to reject technology but to be ever so vigilant – and, therefore, evidence-based regulation. If the fear is on food security being hijacked by the transnationals as articulated by Pushpa Bhargava[9] – 'An approval of GM mustard – (making it the first GM food crop to be approved in India) would open the window for other GM food crops to rush in, eventually transferring virtually our entire food production to the largely US-controlled MNCs that have the IPR for GM seeds and with whom we would never be able to compete', we should support open source knowledge generation like our work on mustard and provide the critical technologies to multiple seed companies so that they compete to bring the best value to the smallholding farmers.

The response to new technologies should not be dogmatic opposition but engagement with the latest developments and their creative use. Fear-mongering to scare the public may work, but only at the expense of rationality in decision-making – such tactics should be anathema to the scientific community. Ideologues have their compulsions, and only a few will have the courage like Mark Lynas[31] to change their stance after educating themselves. However, professional scientists should be more objective. They should refrain from casting aspersions on the scientific work of others without repeating the work or going deep into what others are reporting. Obfuscation needs to be shunned, even if it is for a perceived 'higher cause'.

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A reply by Gutierrez et al.

Biotechnologist Deepak Pental's strongly worded diatribe[1] against P. C. Kesavan and M. S. Swaminathan[2,3] prompted our initial rebuttal[4], and now he uses similar invective about myself and coauthors P. E. Kenmore and A. Rodrigues as well as P. M. Bhargava whom we quoted.

Pental ignored our analysis of *Bt* cotton in India showing that hybrid *Bt* cotton had little to do with the meager increases in yield that have plateaued since 2006. He dismissed our short history of technological blunders with the

comment that 'we need to be more vigilant'. We did not claim as Pental asserts that India is the centre of mustard diversity, rather we wrote '...India which is *a centre of diversity and domestication* of over 5000 wild and domesticated varieties of mustard and the wider "family" of brassicas that includes 9720 accessions (The National Bureau of Plant Genetic Resources (NBPGR))'.

Pental disingenuously dismissed the 15% increases of the observed 2011–12 (BRL I) mustard trial yield data, stating '...The GEAC was never given any other data than what was reported in the AFES document. If any submission with wrong calculations on the extent of yield increase was made – the mistake was corrected immediately.' However, the 'mistake' in calculations was retained in his application to the regulators for permission to proceed to BRL II large-scale trials (documents were obtained through RTI)[5]. Pental states in Appendix 1 of the AFES report that the Regulators gave approval to proceed to BRL II in Oct. 2014. Pental thereafter, proceeded to a final request for commercial approval in 2015. Pental corrected the yield data in his 2016 AFES report titled Assessment of Food and Environmental Safety (tables 7.2–7.4) submitted to the Genetic Engineering Appraisal Committee (GEAC)[6]. It bears repeating that in a step-by-step regulatory process, key applications appear to have been made to proceed to the next stage on the basis of the wrong data, or 'mistake' as Pental calls it. (As stated, the materials for this assessment were obtained using RTI.)

Pental corrected our error as to one of the parent lines of non-GMO DMH-1 mustard, but this does not change our conclusion based on analysis of his biosafety trials data that non-GMO DMH-1 and not the very inferior non-GMO Varuna should also have been used as the comparator for GMO HT DMH-11 developed using the GM *barnase–barstar* system[4]. Had this occurred, yield of non-GMO DMH-1 would have been equivalent to that of GMO HT DMH-11.

In a wide-ranging 7 June 2017 interview with *THE HINDU*, Pental attempted to explain his technological bias for the GM *barnase–barstar* technology (that makes GM hybrid development quicker), for genetic engineering in general, and for his linear thinking on the work that remains if India is to protect against the myriad of agricultural pests and diseases – problems he claims can best be solved with unspecified genetic engineering quick fixes for the benefit of Indian society. He was dismissive that Europe has achieved much higher yields using the non-GMO cytoplasmic male sterility systems (CMS) to develop non-GMO rapeseed. He appears not to consider the bioeconomic, social and ecological milieu of India for the proposed GMO hybrid biotechnologies he wishes to develop. He ignores the fact that HT GM technology has greatly increased herbicide use everywhere it has been implemented (e.g., maize, cotton, mustard in North America) with documented ecological and health problems[7] so that in economic terms, the benefits are private while the losses are public. But now thousands of law suits concerning medical problems related to herbicide exposure are winding through the courts in the USA. In more general terms, he fails to ask if GMO hybrids are needed, whether sound agro-ecosystem analyses of the problems have been done for posited GM-hybrid solutions, are the safety protocols and analyses rigorous, will GMO varieties be genetically polluting of non GM varieties as has occurred in native maize and cotton in North America, and who really profits from the proposed GM hybrid technology. As with hybrid *Bt* cotton, hybrid GMO mustard seed would be a value capture mechanism requiring annual purchases of seed – it would strongly curtail seed saving common in India. We need look no further than the severe ecological, economic, and social problems caused by the introduction of expensive hybrid *Bt* cotton unique to India[8,9] – a technology Pental touts as a grand success. 'Finally, recent calls by industry and its clients to extend implementation of the hybrid technology in aubergine (brinjal, eggplant) and mustard and likely other crops in India ... will only serve to tighten the economic hybrid technology noose on still more subsistence farmers for the sake of (corporate) profits.'[9]

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Further correspondence on this subject is closed.

— Editor