When biotechnologists lack objectivity*

Andrew Paul Gutierrez, Peter E. Kenmore and Aruna Rodrigues

We dismiss Deepak Pental's strong biased criticisms of P. C. Kesavan and M. S. Swaminathan; evaluate the nature of disagreements of the GMO problem, and review two major controversies concerning GMO's in India: Bt cotton and the proposed commercialization of GMO herbicide-tolerant (HT) mustards. The data show that the very modest gains in cotton yields were due to increased fertilizer use and not Bt cotton adoption, and that better non-GMO options are available. Using data made available through Right to Information Act, we show that the process of biosafety testing of GMO mustard DMH 11 and its HT parents was flawed and that no yield gains accrued compared to the available non-GMO hybrid DMH-1.

Deepak Pental[1] has written an ill-advised screed against Swaminathan and Kesavan[2]. He accuses them of lacking evidence-based analyses of the new developments in the area of genomics and genetic engineering in plant breeding, that they are aligned with overzealous environmentalists and ideologues against the use of GE technologies in crop breeding, distorted the history of plant breeding, rejected emerging consensus on the safety of genetically engineered (GE) crops, and suggest solutions inadequate to meet the challenge of low-input, high-output agriculture. Pental suggests a complete rejection of their analyses while invoking comparison to Lysenko. The need to counter Pental is critical because of his influence as part of a lobbying force for unbridled legislation for GE technologies, and as a purveyor of scare tactics that food security in India will be compromised without them. However, it serves little purpose to rebut Pental's biased unfounded charges against Kesavan and Swaminathan. Rather we question his failure to consider whether genetically modified crops (GMOs) are safe for human and ecological health, increase yield and quality, are rigorously tested using proper risk assessment biosafety protocols, and whether biosafety research level (BRL) mechanisms for GMOs field testing under various programmes are being implemented? These are the major themes of our rebuttal.

The safety of GMOs

Pental proffers that the safety record of GMO technology is truly remarkable given the prolonged exposure of hundreds of millions of people. But will GMO technological fixes obey the *Law of Unexpected Consequences* as occurred with DDT developed by Paul H. Muller (1948 Nobel Prize in Physiology or Medicine)? Not only were birds disappearing due to DDT poisoning[3], but 40 years later, a link was discovered between age-related breast cancer in women exposed to DDT *in utero*, before puberty and before first pregnancy[4]. DDT is a sobering example, and the best that can be said is that at the start, DDT was thought to be beneficial.

Some GMO plants make proteins (e.g. *Bt* toxins) that are totally new to the parental species, and their potential health and ecological effects are mostly untested – will they also lead to cases of *Unexpected Consequences*? Direct toxicity may be rapidly detected, but carcinogenic activity or toxicity would take decades to be demonstrated, if ever[5,6]. Other GM plants when made tolerant to herbicides have led to massive increases in herbicide use in USA and elsewhere in the Americas (e.g. glyphosate and glufosinate ammonium)[7]. The International Agency for Research on Cancer of the WHO (IARC) Report (2015) classified glyphosate as a probable human carcinogen, and there are currently over 14,000 legal cases unwinding in the courts in the US linking glyphosate with non-Hodgkin's lymphoma. Among the unexpected ecological consequences of massive herbicide use in agriculture are the development of resistant weeds in North and South America[7,8], altered development in amphibians (e.g. ref. 9), and massively polluted air, soil, and water in the USA with an herbicide that is a chelating agent of soil micronutrients required by plants[10]. A unique risk of GMOs, recognized early is genetic contamination of sexually compatible non-GM crops and wild species through gene flow – a risk that cannot be contained or reversed (e.g. rape and flax seed in Canada, corn in Mexico, rice, wheat, and StarLink corn in the US, cotton in Mexico and India), and can occur through human error, commingling, trading, spillages and other ways (e.g. refs 11, 12). The effects of GMO genetic contamination are irrevocable[13] – once a GMO is released, *nature takes over*.

Genetic contamination is a major focus of the Cartagena Protocol on Biosafety (CPB) of the Convention on Biological Diversity (CBD) for transboundary movement of GMOs/LMOs (living modified organisms), and this concern is cemented in the precautionary principle (PP)[14]. Genetic contamination is of special concern in India which has rich genetic diversity of crops/plants, and yet there are ongoing efforts to release GMO herbicide tolerant mustard (*Brassica juncea*) (see below) in 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). Application of the PP to bar GMOs, particularly in centres of origin or diversification, from being unleashed into the environment is paramount. We must question why regulators would ever consider approval of GMOs of native species (e.g. of Desi cottons, brinjal eggplant, mustard, rice, among others). The magnitude of the inherent danger is 'miscalculation to infinite' as concerns ecological and human health, and of the biodiversity of nature and of food and fibre crops.

*Dedicated to Professors Robert van den Bosch and Pushpa M. Bhargava (both deceased) for speaking truth to power for the public good.

Hence, Pental's assurances aside, the health and environmental hazards of GMO crops are becoming increasingly apparent (e.g. refs 15–17), and severe conflicts of interest make GMO technology virtually impossible to regulate, including in the USA, which Pental touts as a paragon of transparency and objectivity concerning GMO development. For example, in 2009, 26 leading university entomologists from the US corn-belt wrote a letter to the USA Environmental Protection Agency about the restriction of researcher access to corporate GMO seed for experimental purposes: '... No truly independent research can be legally conducted on many critical questions involving these [GMO] crops'[18]. And things have only worsened in USA under the current administration. In India, the conflicts of interest are also rampant.

In India, two ongoing GMO controversies are the implementation of GMO *Bt* cotton and the attempt to commercialize herbicide-tolerant (HT) mustard developed by Pental and his team at Delhi University South Campus (DUSC). We examine the facts concerning *Bt* cotton and HT mustard in sequence.

The myth of *Bt* cotton success in India

Pental asserts that *Bt* cotton introduced in India in 2002 was a success, and yet a rigorous evaluation of *Bt* cotton efficacy has not occurred. Total national or state-wide cotton production figures are used to show the success of *Bt* cotton on a global scale, but this is an improper statistic for farm-level evaluation, which should be expressed as kilogram per hecatre[19]. Pental and others use this purported success to justify the wholesale introduction of GE technology into Indian food crops (e.g. brinjal, mustard). Below, we first briefly review the history, ecology and national data of Indian cotton production.

For more than 5000 years, 'Desi' cottons (*Gossypium arboreum* and *G. herbaceum*) have been grown in India without irrigation and synthetic inputs (effectively organic)[20]. Starting in the 1790s, New World open-pollinated long-season cottons (chiefly *G. hirsutum* and later *G. barbadense*) were introduced to India to increase yields[20]. Long-season F1 hybrid cotton (normally *G. hirsutum*) was developed in India in the mid-1970s (ref. 21) and ushered in higher use of fertilizer; the use of tube-well irrigation where available, and of insecticide to protect against the native key pest, viz. the pink bollworm (*Pectinophora gossypiella*) which is a known problem in long-season cotton[22]. Predictably, as has occurred worldwide, insecticide use induced regional outbreaks of indigenous secondary pests that normally are not abundant in cotton[23]. In India, outbreaks of secondary pests such as the native 'American' bollworm (*Helicoverpa armigera*), whitefly and others were induced by insecticides that destroy their natural enemies, and under continued ecological disruption became far more damaging than the target pink bollworm[19]. During 1980–1990, India became fully launched on the pesticide treadmill.

Figure 1 *a* and *b* shows data on the use of insecticides since 1999 and the relationship between declining yield with increasing insecticide use, i.e. farmers were spending money to lose money[19].

Transgenic GMO F1 hybrid long season *Bt* cotton unique to India were introduced in 2002 to resolve the insecticide-induced American bollworm problem[19]. Insecticide use declined for a period after 2004, but by 2012 began to increase despite >90% adoption of *Bt* cotton (Figure 1 *a* and *b*). The *Bt* technology is not yield-enhancing, it only serves to protect the yield potential of the variety against some species. The F1 hybrid seed of *Bt* cotton is fertile, but it is not saved for replanting because highly variable phenotypes result, forcing farmers to purchase seeds annually. By 2012, more than 1000 *Bt* hybrid GMO varieties of variable quality were planted in India[19] (Figure 2). The *Bt* trait provided good initial control of pink and American bollworms, but insecticide use increased after 2006 targeting new secondary pests regionally such as whitefly, jassids, mealybug and aphids not controlled by *Bt* cotton. Furthermore, resistance in pink bollworm to *Bt* cotton is becoming widespread[24], and new *Bt* constructs are being

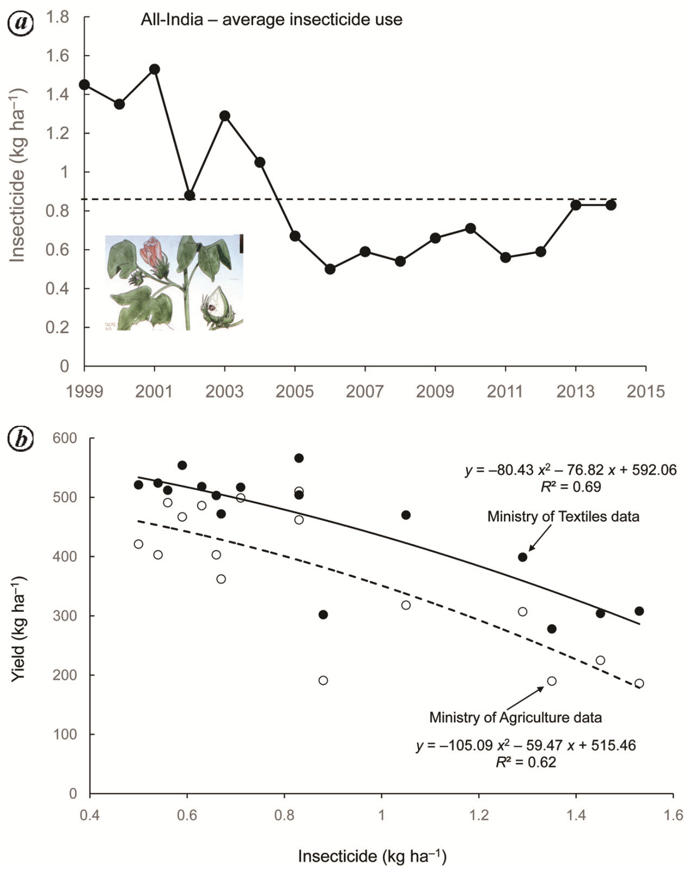

Figure 1. Insecticide use in cotton during the period 1995–2015. ***a***, Kilogram/hectare of insecticides (Ministry of Agriculture). ***b***, relationship of insecticide use and historical yields. (Data from the Ministry of Textiles (•) and Ministry of Agriculture (○).)

proposed – a case of a technological dog chasing its own tail. Most agronomists do not understand the ecological bases for this failure and continue to believe that *Bt* cotton was a spectacular success responsible for the meagre increases in average yield across India. National data summarized in Figure 2 put this myth to rest, while examination of state data gives a similar story.

Average lint cotton yield data for India that include irrigated and rainfed cotton show that by 2005 and 2006, when *Bt* adoption was only 12% to 38% respectively, average yield had reached 500 kg ha^{-1}; a yield stagnation level that continues to plague India. The *Bt* trait in cotton was not responsible for the modest increase in average yield.

Kranthi[25] (former Director of the Central Institute of Cotton Research (CICR)) identified increased fertilizer use as the reason for the increased yield. The increase in fertilizer use and the relationship of fertilizer use and yield are shown in Figure 3 *a* and *b* respectively. Despite increases, Indian yields are no more than some of the poorest African countries, which do not cultivate hybrid cotton or *Bt*-cotton. In 2017, 31 countries were ranked above India in terms of cotton yield (i.e. kg ha^{-1}), and of these, only 10 grew GM cotton[26].

Using the Ministry of Agriculture data for the period 1999–2015, linear multiple regression of kg lint cotton ha^{-1} (Y) on kg insecticide ha^{-1} (X_I) and kg fertilizer ha^{-1} (X_F) results in a highly significant fit to the data ($Y = -126.3\ X_I + 1.582\ X_F + 119.2$, $R^2 = 0.88$, $F = 46.15$). The interaction term X_IX_F is highly significant, but when included in the regression, the component independent variables are not significant. The independent variable of percentage *Bt* cotton area is strongly correlated to fertilizer use. Similar summary results were obtained using the Ministry of Textiles data.

Furthermore, as the *Bt* technology was being implemented, costs of production were increasing in the face of stagnant yields, with labour costs showing the greatest increase (Figure 4).

However, non-GMO solutions to stagnant yields, and high costs of GMO and related technologies were available for rainfed and irrigated cotton. For example, CICR field trials at Nagpur, Maharashtra on high density (HD > 15 plants m^{-2}), short season (SS) pure-line, non-*Bt* varieties of rainfed cotton (e.g. variety PKV-81) yielded 1967 kg seed cotton ha^{-1} (i.e. ~668 kg lint cotton)[27]. This is more than double the current average yield in Maharashtra[19]. Furthermore, the HD–SS varieties (including Desi varieties) would reduce seed costs, avoid heavy late-season pink bollworm infestation, reduce insecticide use and associated secondary pest outbreaks, help better utilize available monsoon rainfall, reduce yield variability and allow seed-saving for replanting. Farmer income would also

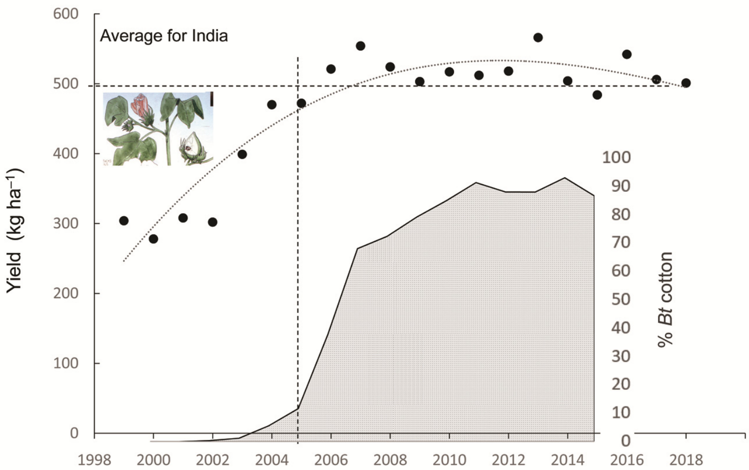

Figure 2. Average national lint cotton yield for India and the time pattern of % *Bt* adoption during 1999–2018. (Data from the Ministry of Agriculture.)

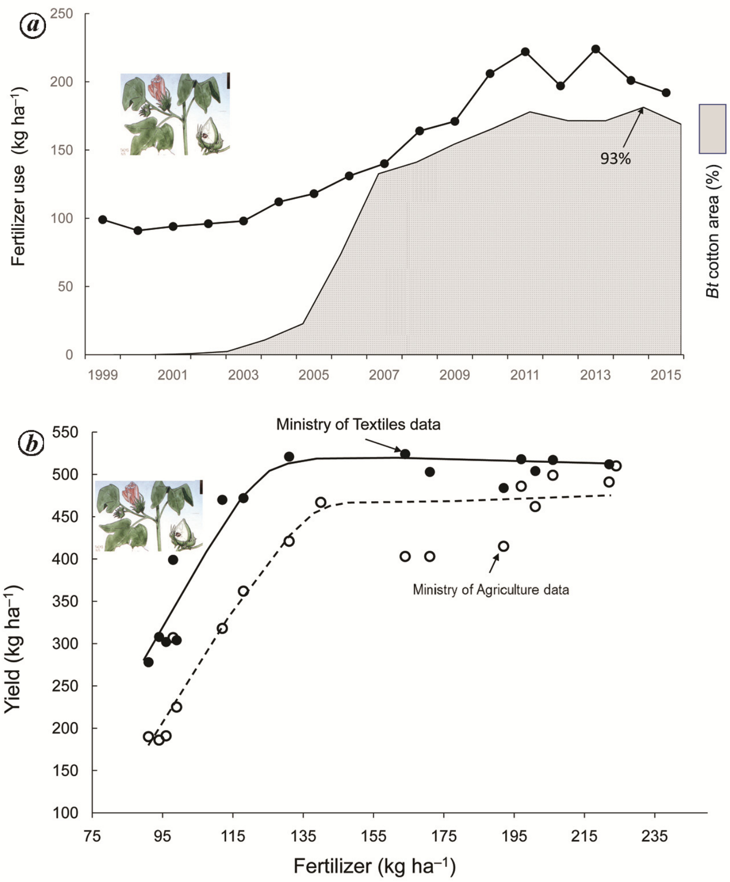

Figure 3. Fertilizer use during the period 1999–2015. ***a***, Kilogram per hectare of fertilizer. ***b***, Relationship of fertilizer use and historical yields. (Data from the Ministry of Textiles (•) and Ministry of Agriculture (○).) Note the shaded area of *Bt* cotton adoption.

increase and help reduce indebtedness and likely decrease farmer suicides that number more than 300,000 since 1995 (refs 28, 29). The transition to HD–SS varieties would require training such as farmer-field schools to implement and ween farmers away from insecticide overuse, while the tools of agroecosystem analysis could be used to design best practices[29]. However, no rainfed variety (including GMOs) can eliminate risks of the gamble of the monsoon in rainfed cotton.

So why were the available non-GMO HD-SS varieties not implemented and further developed in India? The obvious answer is that the current GMO *Bt*-cotton hybrids were developed as a 'value capture' mechanism that enabled the seed industry to side-step intractable legal intellectual property rights (IPR) protection in an environment where land holdings are mostly <1 ha (ref. 19). But this raises the ethical question of why the interests of poor farmers were sacrificed for corporate commercial benefit. This reasoning also draws into question attempts for proposed unbridled introduction of GMO technology to other crops in India (e.g. Desi cottons, mustard and brinjal).

Biosafety testing for commercializing GMO mustard

The data analysed below submitted by the promoter of GMO mustard were obtained under the Right to Information Act (RTI) from the ICAR-Directorate of Rapeseed Mustard Research (DRMR) and the regulators (e.g. Review Committee for Genetic Manipulation (RCGM)). The biosafety testing of GMO mustard in India had – and has – conflicts of interests at many levels: personal, professional, embedded governmental agencies and conflicted regulators, and in the collection and analysis of the data (see refs 30–33). Furthermore, several violations of the criteria for agronomic biosafety testing occurred (as identified in Supreme Court submissions) in the various field trials conducted by the promotors to obtain permission to commercialize the GMO hybrid herbicide-tolerant mustard HT DMH-11 and its HT parent line events developed by Pental's team at the Centre for Genetic Manipulation of Crops Plants (CGMCP), University of Delhi South Campus. Any of these and other violations of biosafety risk assessment and established criteria of field trials would make these trials and the request for commercial approval invalid, and in the scientific arena, would be reason for censure of the responsible parties. And yet, Pental[1] assures: 'The GE parental lines, their normal comparators and the first transgenic hybrid DMH-11 (Varuna × EH-2) were subjected to all the biosafety tests stipulated by the Government of India (GoI).' Below we briefly review the hybridization procedures used, and some of the data submitted and violations by the promoters.

A brief review of hybridization technology for developing HT DMH-11

Heterosis or hybrid vigour is commonly used to increase yields, and the innovation of male sterility allows it to be more easily used in hybridization technology. The common approaches and variants used to produce hybrids are: the non GMO cytoplasmic male sterility systems (CMS), the 'GM–*barnase–barstar*' system, and hand pollination. Conventional CMS 'pollination control' technology is used for the same purpose as GM–*barnase–barstar*[34]. Specifically, the non-GMO hybrid DMH-1 (with non-GMO parents Varuna × EH-2) was developed using CMS by Pental's team at DUSC, was released in 2008, and is currently designated a National Check. Pental and colleagues claimed that *B. juncea* hybrid (non GMO DMH-1) '... has given around 30% heterosis over the best national and regional checks in multi-site trials conducted in the north-western states of India'[34]. The *barnase–barstar* technology was used to develop the GMO HT (hybrid) DMH-11 using GMO HT events based on the same non-GMO parent lines initially used to develop CMS (non-GMO) DMH-1.

Review of field trial data for DMH-11

Field comparative trials for mean seed yield (MSY) were conducted in 2006–07, 2010–11, 2011–12 and 2014–15. All trials were self-supervised lacking oversight by experienced breeders of the DRMR, and the results of the trials were self-analysed by the developers for submission to the regulators.

The 2006–07 field trials: These trials were conducted at 10 locations that compared MSY of the GMO hybrid HT DMH-11 against 'comparator' varieties of mustard: (CMS (non-GMO) hybrid DMH-1, and mustard varietal lines (non-GMO) Varuna and Kranti, and a zonal check) (Table 1). In the following text we refer to three of the relevant varieties as HT DMH-11, DMH-1 and Varuna. We examined consistency of the data and estimated the differences in relative MSY across different field trial locations.

The 2006–07 MSY data for HT DMH-11 are plotted against MSY for hybrid DMH-1 (Figure 5 *a*) and Varuna (Figure 5 *b*). (Note that MSY for HT DMH-11 at Sriganganagar and Kota are lower than for Varuna.) MSY of HT DMH-11 regressed on MSY for DMH-1 across locations produced a good fit (i.e. $y = 0.919x + 102.94$, $R^2 = 0.75$) (Figure 5 *a*), with

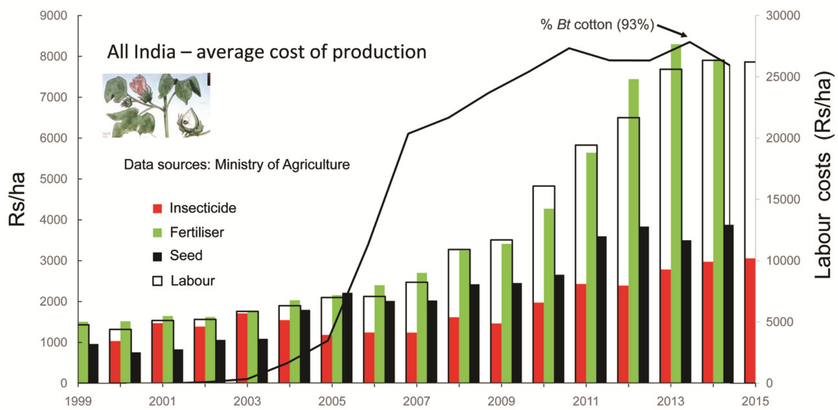

Figure 4. Summary of average costs of production/ha in India. *Bt* area is indicated by the solid line.

Table 1. Field trials of mustard varieties in 2006–07

Zone	Location	Varuna	DMH-1	Kranti	HT DMH-11	Zonal check
II	Sriganganagar	1527	1501	1606	1370	1344
	Delhi	1395	1884	1501	1748	1313
	Navgaon (Alwar)	1111	1434	1097	1264	1002
	Hisar	771	1302	889	1553	740
	Gwalior	592	1289	880	1347	755
III	Bharatpur (Kumher)	565	1098	940	923	1003
	Kanpur	1168	1110	1380	1319	1577
	Pantnagar	952	1666	1232	1311	1208
	Kota	2466	2488	2433	2325	2368
IV	S.K. Nagar	1690	1975	2272	2349	2295
	Average	1223.7	1574.7	1423.2	1550.9	1360.5
	STD	578.271	437.51	551.63	463.95	574.36

Data source: ICAR-Directorate of Rapeseed Mustard Research (DRMR), Rajasthan, response under RTI of 26/08/2016.

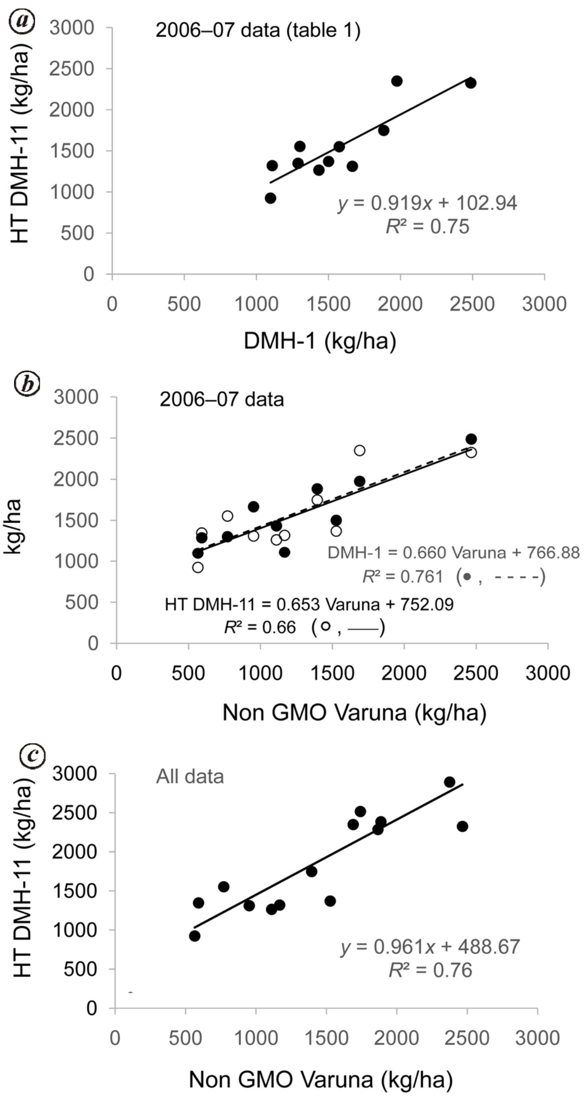

Figure 5. MSY data: ***a***, HT DMH-11 plotted on DMH-1; ***b***, DMH-1 and HT DMH-11 plotted on Varuna (2006–07 data, Table 1). ***c***, HT DMH-11 plotted on Varuna, including data for the 2006–07, BRL-I (2010–12) and BRL-II (2014–15) trials (Tables 1 and 2).

DMH-1 showing an average ~1.25% yield advantage over HT DMH-11 (i.e. computed by solving the regression for the mean value of x and then taking the ratio y/x). Regressions of DMH-1 and HT DMH-11 on Varuna yielded similar relationships (Figure 5 *b*) and predicted ~29% and 27% average advantages respectively, over Varuna. The relationships in Figure 5 *a* and *b* are important because DMH-1 and Varuna were included in the 2006–07 trials, and of the two, only Varuna was included in all other trials. Because Varuna is one of the parent lines of both DMH-1 and HT DMH-11, we can gauge the potential yield of DMH-1 in trials where it was excluded due to its strong MSY relationships with HT DMH-11 and Varuna.

BRL trials: Biosafety research trials in zones II and III in 2010 to 2014 are summarized in Table 2 as within zone MSYs (DRMR summary data). In these trials, DMH-1 was omitted, while the low-yielding 'comparator' Varuna with a known ~27% MSY disadvantage to HT DMH-11 and DMH-1 was included. The trials also included GMOs of HT DMH-11 parent varieties, 'event' GMO HT Varuna and 'event' GMO HT EH-2 containing transgenic *barnase* and *barstar* genes respectively.

MSYs in the BRL-I and BRL-II trials were generally much higher (for unknown reasons) than the 2006–07 trials for all varieties, with the MSY of HT DMH-11 being 69% higher (i.e. 2626 kg ha^{-1}/1550.9 kg ha^{-1}; see Tables 1 and 2). Nevertheless, the yield advantages of HT DMH-11 over Varuna in the BRL-I and BRL-II trials were 28% and 26.4% respectively, and as a percentage are essentially the same as found in the 2006–07 trials. The yield advantages of HT DMH-11 over parent GMO HT (event) Varuna (*barnase*) and GMO HT (event) EH-2 (*barstar*) in these trials were 27% and 28% respectively. A regression of all the MSY data for the 2006–07 and BRL-I and II trials for HT DMH-11 on Varuna (Figure 5 *c*) results in a good fit ($y = 0.96x + 488.67$, $R^2 = 0.76$). *The consistency of these data across trials suggests that if non-GMO hybrid DMH-1 had been included as a comparator in the BRL-I and II trials, no differences in MSY compared to HT DMH-11 would have been found* (see Figure 5 *b*). So, the obvious question is why was DMH-1 omitted from the BRL-I and II trials; was Varuna simply used as a *stalking horse*?

Table 2. Comparative summary of MSY (kg/ha) for DMH-11 BRL trials during the two-year period 2010–12 (BRL-I) and for 2014–15 (BRL-II). (Source: RTI reply from DRMR). Data for BRL-I (two-year trials) are aggregated average values for both years in the relevant zones

Variety ↓	BRL-I (2 yr) MSY* 2010–12 (Zone II)	BRL-I (2 yr) MSY 2010–12 (Zone III)	BRL-I (2 yr) mean MSY 2010–12 (Zones II and III)	BRL-II MSY 2014–15 (Zone II)	BRL-I and II mean MSY All years (All zones)
Varuna (*barnase*)	2133	2235	2174	1861	2057
EH-2 (*barstar*)	1960	1685	1850	1557	1740
Varuna	2194	2121	2165	1887	2061
EH-2	1835	1833	1834	1378	1663
DMH-11	2891	2589	2770	2385	2626**
RL-1359/Maya (ZC)	1963	2126	2028	1775	1933

Source: DRMR data provided to the GEAC/CGMCP (Supreme Court Annexure M5 Table 18).
**Note: DMH-11 MSY kg/ha of 2626 kg/ha for BRL I and II in column 5. This MSY value is 69% higher than that of 1550 kg/ha for HT DMH-11 reported in the 2006–07 multi location trials (MLT, Table 1). The 2006–07 MLT data were not included in computing the MSY of 2626 kg/ha for HT DMH 11 in BRL I and II trials reported above.

Table 3. Reformatted data[a] of Table G[b] (Appendix 1) comparative MSY (kg/ha) of DMH-11 BRL I trials for the two-year period 2010–12 at two locations (Alwar and Kumher)[c]. Missing values for MSY ratios (column 3) in the original Table G (Appendix 1) are calculated here

Zone	Entry	BRL I 2010–11	BRL I 2011–12	% Increase 2011–12/ 2010–11	2011–12 MSY × ~1.15[d]	Adjusted % increase
II Alwar						
	Varuna (*barnase*)	1789	2098	17	2419	35.00
	EH-2 (*barstar*)	1842	1581	–16.5	1823	–0.11
	Varuna	1741	2169	24.60	2499	43.50
	EH-2	1716	1608	–6.30	1854	8.00
	HT DMH-11	2515	3157	25.50	3638	44.70
	RL-1359(ZC)	1767	1836	3.90	2116	19.80
III Kumher						
	Varuna (*barnase*)	1986	2484	25	2862	44.10
	EH-2 (*barstar*)	1730	1640	–5.20	1890	9.00
	Varuna	1866	2375	27	2736	46.60
	EH-2	1793	1873	4.50	2195	20.40
	HT DMH-11	2285	2892	26	3332	45.80
	Maya (ZC)	2057	2195	1.07	2530	23.00

[a]Source: Supreme Court Annexure M7: Yield reported to the RCGM by CGMCP (Pental team) – Summary of safety studies and field trials conducted on transgenic *Brassica juncea* containing *bar*, *barnase* and *barstar* genes submitted to Review Committee on Genetic Manipulation by the Centre for Genetic Manipulation of Crops Plants, University of Delhi South Campus, New Delhi on 2 April 2014; p. 27.
[b]See Table G in Appendix 1.
[c]Data from Sriganganagar in zone II in BRL-I (year 2010–11; Table 2) were not included in Table 3 (or Table G in Appendix 1) because the location was not included in all trials. Table 3 addresses only locations Alwar and Kumher.
[d]Note that BRL-I (2011–12) results were scaled up by ~15% before submission to the regulators at RCGM.

In addition to the lack of a demonstrated yield advantage of HT DMH-11 over DMH-1, we note some protocol violations in the data submitted to the regulators. The maternal inheritance of HT DMH-11 in the BRL trials was changed from the 2006–07 trials[36], and transgenic Varuna *barnase* and EH-2 *barstar* events were included as comparators, but essential full biosafety dossiers for them were not developed, or are held secret. Most egregious, the BRL-I (2011–12) data reported to the RCGM appear to have been scaled by ~1.15 (column 4 in Table 3; see Appendix 1 original Table G)[35]. This manipulation greatly enhanced the MSY ratios of the 2011–12 to 2010–11 data for most entries at Alwar and Kumher in zones II and III respectively. This resulted in apparent yield gains for HT DMH-11 of 44.7% and 45.8%, with MSY for 2011–12 of 3638 and 3332 kg ha^{-1} respectively, reported to the RCGM by CGMCP. Based on these 'enhanced figures' for HT DRM-11, the overall declared MSY for HT DMH-11 across BRL-I and BRL-II trial increased by 7.5% to 2824 kg ha^{-1} from 2626 kg ha^{-1} (Table 2); a value used by the developers of HT DMH-11 to request permission to undertake large-scale BRL-II field trials that are the penultimate stage protocols for commercial

Appendix 1. Table G (Ref. SC IA 47 of Oct. 2016 on pg. 41: Annexure M7) DMH 11: comparative MSY of Alwar and Kumher trials BRL-I 2010–11 and 2011–12 zone-wise and CGMCP/DUSC rigged data

		Data of MSY			CGMCP data rigged MSY BRL-I: Second year 2011–12	
BRL-I zone II	Entry	BRL-I First year 2010–11	BRL-I Second year 2011–12	BRL-I % change year on year (year 2 over year 1)	All entries increased by 15.2% ALWAR* (new %s)	
		Alwar	Alwar	Alwar	Second year over first year	
	Varuna (*barnase*)	1789	2098	17	2419	(35.0%)
	EH-2 (*barstar*)	1842	1581	(16)	1823	NIL
	Varuna	1741	2169	24.6	2499	(43.5%)
	EH-2	1716	1608		1854	(8.0%)
	DMH-11	2515	3157	25.5	3638	(44.7%)
	RL-1359 (ZC)	1767	1836		2116	(19.8%)
		Kumher	Kumher		Kumher*	
Zone III	Varuna (*barnase*)	1986	2484	25	2862	(44.1%)
	EH-2 (*barstar*)	1730	1640		1890	(09.0%)
	Varuna	1866	2375	27	2736	(46.6%)
	EH-2	1793	1873		2159	(20.4%)
	DMH-11	2285	2892	26	3332	(45.8%)
	Maya (ZC)	2057	2195		2530	(23.0%)

*Yield reported to RCGM by CGMCP: Source: Report on biosafety research level-I (BRL-I) second year trials conducted on transgenic *Brassica juncea* containing *bar*, *barnase* and *barstar* genes submitted to RCGM by CGMCP, DUSC New Delhi on 2 April 2014, pp. 27 (ref. SC Annexure M7). During BRL-I trials in year-2, Alwar and Kumher were the only two common locations (one in each zone).

approval. We note, however, that the correct 2011–12 MSY data were restored when reported on the Assessment of Food and Environmental Safety (AFES) web page[37].

Clearly, had non GMO DMH-1 been included in all trials, no MSY advantage for GMO HT DMH-11 would have been found.

Epilogue

Despite reports of success, the *Bt* trait in GMO hybrid cotton was not responsible for the modest increases in national or state yields (see); the gains were due to primarily increases in fertilizer use[25]. Moreover, non-GMO HD-SS cotton varieties and alternative management strategies are available to increase yields, and should be promoted for the public good[19].

The field trial data used to justify the introduction of HT mustard in India are deeply flawed, and no yield advantage has been demonstrated for GMO HT DMH-11 over available non-GMO varieties (e.g. CMS hybrid DMH-1), as the Union of India was forced to admit[38]. The procedures and regulatory structures for assuring the biosafety of GMOs were/are inadequate, and genetic contamination of native species (e.g., cotton, mustard, brinjal and others) must not be allowed, i.e. the precautionary principle. Further, human and ecosystem health must be valued higher than short-run profits.

In view of the valid concerns outlined here and by Swaminathan and Kesavan[2], we urge Pental to practice a modicum of introspection before suggesting that others who disagree with him and his agenda are merely luddites and ideologues. He seriously fails to recognize that perceived problems in crop breeding and protection, which biotechnologists attempt to solve, are first and foremost ecological in nature, and that sustainable bioeconomic strategies and solutions must be based on a clear understanding of the issues. Linear thinking based on presumed knowledge often leads to technological solutions (e.g. DDT and other more toxic agrichemicals) that create more problems than they solve (e.g., hybrid *Bt*-cotton in India). Worse, GE technological innovations are often implemented for purely commercial purposes, though often as Pental augurs, under the guise of humanitarian ethos.

Bhargava[31] stated the case for India succinctly: *Genetically modified mustard, if approved, will be the first such food crop to be commercially released in India. This will open the floodgates for other such crops making India one of the largest users of genetically modified crops in the world in the next 10 to 12 years. Given that its agriculture is largely in the hands of multinational seed and agrochemical companies, India will end up bartering its freedom for the benefit of a few and the misery of the rest.*

1. Pental, D., *Curr. Sci.*, 2019, **117**(6), 932–939; doi:10.18520/cs/v117/i6/932-939.
2. Swaminathan, M. S. and Kesavan, P. C., *Curr. Sci.*, 2018, **114**, 1585–1586.
3. Carson, R., Silent Spring, Houghton Mifflin Company, Boston, MA, USA, 1962, p. 368.
4. Cohn, B. A., La Merrill, M., Krigbaum, N. Y., Yeh, G., Park, J.-S., Zimmermann, L. and Cirillo, P. M., *J. Clin. Endocrinol. Metab.*, 2015, **100**(8), 2865–2872; https://doi.org/10.1210/jc.2015-1841.
5. Duforestel, M. *et al.*, *Front. Genet.*, 2019; https://doi.org/10.3389/fgene.2019.00885
6. Prof. David Schubert: Cell Biologist, Salk Institute, letter dated 23 January 2014 (in evidence to the Supreme Court in PIL 260 of 2005).
7. Benbrook, C. M., *Environ. Sci. Eur.*, 2016, **28**(1), 3. Feb 2. doi:10.1186/s12302-016-0070-0
8. Nandula, V. K., *Glyphosate Resistance in Crops and Weeds: History, Development and Management*, John Wiley, NJ, USA, 2010, p. 321.
9. Relyea, R. A. and Jones, D. K., *Environ. Toxicol. Chem.*, 2009, **28**, 2004–2008.

10. Mertens, M., Höss, S., Neumann, G., Afzal, J. and Reichenbecher, W., *Environ. Sci. Pollut. Res.*, 2018, **25**, 5298; https://doi.org/10.1007/s11356-017-1080-1; see Ritterman Jeff, Compilation of studies showing harm from glyphosate, 23 February 2015 (Truthout); http://www.truth-out.org/news/item/29244-will-richmond-reject-roundup-the-case-for-banning-glyphosate
11. Quist, D. and Chapela, I., *Nature*, 2001, **414**, 541–543.
12. Piñeyro-Nelson, A. *et al.*, *Mol. Ecol.*, 2009, **18**, 750–761.
13. Taleb, N. N., Read, R., Douady, R., Norman, J. and Bar-Yam, Y., Extreme Risk Initiative – NYU School of Engineering Working Paper Series, 2014; arxiv:1410.5787v1 [q-fin.GN].
14. The Cartagena Protocol and Convention of Biological Diversity, Preamble to the CBD and Principle 15 of the Rio Declaration, 1992.
15. Kurenbach, B., Marjoshi, D., Amábile-Cuevas, C. F., Ferguson, G. C., Godsoe, W., Gibson, P. and Heinemann, J. A., *mBio*, 2015, **6**(2), e00009-15; doi:10.1128/mBio.00009-15.
16. Heinemann, J. A., Agapito-Tenfen, S. Z. and Carman, J. A., *Environ. Int.*, 2013, **55**, 43–55.
17. Broderick, N. A., Raffa, K. F. and Handelsman, Jo., *Proc. Natl. Acad. Sci. USA*, 2006, **103**(41), 15196–15199; https://doi.org/10.1073/pnas.0604865103.
18. www.themonitor.com (accessed on 20 February 2011).
19. Gutierrez, A. P., *Curr. Sci.*, 2018, **115**, 2206–2210; doi:10.18520/cs/v115/i12/2206-2210.
20. Beckert, S., *Empire of Cotton: A Global History*, Alfred A. Knopf, New York, USA, 2014.
21. Basu, A. K. and Paroda, R. S., *Hybrid Cotton in India: A Success Story*, Asia-Pacific Association of Agricultural Research Institutions, FAO Regional Office for Asia & the Pacific, Bangkok, Thailand, 1995.
22. Kranthi, K. R., *Bt Cotton: Questions and Answers*, Indian Society for Cotton Improvement, Mumbai, 2012; http://www.cicr.org.in/pdf/Bt_book_Kranthi.pdf
23. van den Bosch, R., *The Pesticide Conspiracy*, University of California Press, Berkeley, USA, 1978.
24. Naik, V. C., Kumbhare, S., Kranthi, S., Satija, U. and Kranthi, K. R., *Pest Manage. Sci.*, 2018; doi:10.1002/ps.5038.
25. Kranthi, K. R., *Cotton Stat. News*, 2016, **39**, 1–6; http://www.cicr.org.in/pdf/Kranthi_art/Fertilizers_and_Bt.pdf (accessed on 10 December 2018).
26. Kranthi, K. R., *Cotton Statistics News*, 16 December 2014.
27. Venugopalan, M. V., Prakash, A. H., Kranthi, K. R., Deshmukh, R., Yadav, M. S. and Tandulkar, N. R., In World Cotton Research Conference (eds Kranthi, K. R. *et al.*), International Cotton Advisory Committee, Mumbai, 2011, pp. 341–346.
28. Kannuri, N. K. and Jadhav, S., *Anthropol. Med.*, 2018, **25**, 121–140; doi:10.1080/13648470.2017.1317398.
29. Gutierrez, A. P., Ponti, L., Herren, H. R., Baumgärtner, J. U. and Kenmore, P. E., *Environ. Sci. Eur.*, 2015, **27**(12), 17; doi:10.1186/s12302-015-0043-8
30. https://economictimes.indiatimes.com/news/economy/agriculture/scientist-who-developed-gm-mustard-hopeful-of-governments-nod/articleshow/59008785.cms (accessed on 28 October 2019).
31. Bhargava, P. M., *Econ. Polit. Wkly*, 2016, **1**(44–45), 40–43.
32. Reply of the Union of India @ Para 25 states: 'Thus, according to records, the R&D and technology development as well as biosafety assessment has been fully funded by the public sector and there are no commercial considerations involved'; https://economictimes.indiatimes.com/news/economy/agriculture/scientist-who-developed-gm-mustard-hopeful-of-governments-nod/articleshow/59008785.cms
33. Dr Pushpa M. Bhargava, Letter to the Chief Justice of India, 9 February 2016 in Writ Petition (Civil) 260 of 2005, Aruna Rodrigues vs Union of India.
34. Prof. Jack Heinemann's riposte: Statement for the SC of 16 August 2017, @ Annexure 3 of Petitioner's Rejoinder of Sept 2017.
35. Sodhi, Y. S. *et al.*, *Theor. Appl. Genet.*, 2006, **114**, 93–99; doi:10.1007/s00122-006-0413-0.
36. Report on biosafety research level-I (BRL-I) second year trials conducted on transgenic *Brassica juncea* submitted to the RCGM: Annexure M7 of Supreme Court Submission October 2016 (obtained under the Right to Information Act).
37. Report by D. Pental on assessment of food and environmental safety. 2016, Table 7.3 p. 105 (Supreme Court Ref @ Annexure Q1 of Petitioners' Rejoinder of November 2016).
38. Reply of the Union of India in IA 47 @ Pr. 88 at pg. 55–56: 'No such claim has been made in any of the submitted documents that DMH 11 out-performs non-GMO hybrids'.

ACKNOWLEDGEMENT. We thank Prof. J. A. Heinemann for useful comments on the manuscript and Dr K. R. Kranthi for access to data.

Andrew Paul Gutierrez is in the College of Natural Resources, University of California at Berkeley; Andrew Paul Gutierrez and Peter E. Kenmore are in the Center for the Analysis of Sustainable Agricultural System, Kensington CA, USA; Aruna Rodrigues is in Sunray Harvesters, Mhow 453 441, India.*
**e-mail: casas.global@berkeley.edu*