DELHI UNIVERSITY'S GENETICALLY MODIFIED (GM) MUSTARD

A Genetically Modified (GM) mustard variety could be on the verge of approval in India for commercial cultivation[1], and this Briefing Paper is to facilitate an informed debate about this GMO. This would be the second attempt to push for commercial cultivation of GM mustard in India – the first time around, in 2002, the application for the approval of a GM mustard developed by a subsidiary of Bayer (a German multinational corporation) called ProAgro, was rejected by the Indian regulators[2].

So far, India has officially approved only GM cotton (Bt cotton) for commercial cultivation in the country while several GM food crop trials have been underway for many years now. In 2009, even though the Genetic Engineering Appraisal Committee (GEAC, which was then called as Genetic Engineering Approval Committee and subsequently renamed) - the apex regulatory body related to GMOs under the Ministry of Environment, Forests & Climate Change (MoEF&CC) in the Government of India - approved Bt brinjal for commercial cultivation, the Government of India overturned the regulators' approval and placed an indefinite moratorium on the commercial release of Bt brinjal on February 9th 2010 after a series of public consultations and a nationwide debate. After the moratorium on Bt brinjal, a public sector GM mustard hybrid has now been apparently lined up for approval for commercial cultivation – this then opens the doors to many other GM food crops like GM maize/corn, GM rice, GM brinjal of several MNCs like Monsanto, Syngenta and Dow. This Briefing Paper focuses on Delhi University's GM mustard developed by DU's Centre for Genetic Manipulation of Crop Plants or CGCMP.

MUSTARD IN INDIA

Rapeseed-Mustard (Rai, Sarson, Toria, Taramira etc., being the local names) is an oilseed, vegetable and fodder crop grown on around 5.5 to 7 million hectares in India. It is mostly grown as a rabi or winter crop in India. While it is sown as a sole crop in some regions, it is also grown as an intercrop in others.

Brassica (rapeseed/mustard) has slowly taken over soyabean and groundnut as the most important edible oilseed crop in India. While soyabean oilseed production was 146.66 lakh tonnes in 2012-13 and 119.89 lakh tonnes in 2013-14, in terms of oils, it was only second to rapeseed & mustard (R&M): soyabean was 23.47 lakh tonnes while R&M was 24.89 lakh tonnes in 2012-13; this further fell to 19.19 lakh tonnes of soybean in 2013-14, with R&M being 24.68 lakh tonnes in 2013-14[3]. The average annual growth rate of R&M between 2008-09 and 2013-14 has been 3% in area, 7.3% in production and 3.9% in yield (the yield growth rate for total oilseeds was only at 1.3)[4]. This is actually more impressive than the Indian maize and cotton stories in the recent past, which are usually touted as examples of success.

At the global level, India is reported to be the third largest rapeseed-mustard producer in the world, after China and Canada. The area of cultivation under rapeseed-mustard hovered around 2.8% of the Gross Cropped Area of India in the recent past. R&M is grown mostly under irrigated conditions in India, with 73.2% of the crop area cultivated in India being irrigated by 2011-12, compared to only 59.8% in 1990-91. Concomitantly, yields have also been showing an improvement. From 3.68 quintals per hectare in 1950-51 (irrigation data not available), to 9.04 quintals/ha in 1990-91, yields touched 12.62 quintals per hectare on an average by 2012-13. Gujarat's yield of R&M has touched 16.95 quintals per hectare by 2012-13 (or, around 1.7 tons per hectare).

From around 0.76 million tonnes of production in 1950-51, production has increased over the decades to touch 7.96 million tonnes in 2013-14 (4th Advance Estimates; it touched 8.18 million tonnes in 2010-11). In 2013-14, the three largest rapeseed-mustard producing states were: Rajasthan (48.12% of All-India production), Madhya Pradesh (11.31%) and Haryana (11.06%). Together, they account for more than 70% of India's production. Other important mustard growing states include Uttar Pradesh, West Bengal, Gujarat, Assam, Bihar, Punjab[5] etc[6].

Mustard oil is reported to have the lowest amounts of saturated fatty acids and contain adequate amounts of linoleic and linolenic fatty acids. In terms of conversion to oil from seeds, R&M has a 33% conversion rate which is higher than several other oilseeds like soyabean, groundnut etc[7]. The conversion to oilseed cake (used for cattle feed as well as soil fertility input) is 67%. Brassica juncea is the dominant species grown in India, followed by B. rapa and B. napus.

DELHI UNIVERSITY'S GM MUSTARD

At present, a GMO developed by the Centre for Genetic Manipulation of Crop Plants (CGMCP), University of Delhi South Campus, New Delhi of a Brassica juncea mustard hybrid (DMH 11) containing bar, barnase and barstar genes (Events bn 3.6 (Barnase Line), and modbs 2.99 (Barstar line) & bn 3.6Xmodbs2.99 containing bar, barnase and barstar genes) has reportedly completed Biosafety Research Level (BRL) II trials, which in the Indian regulatory parlance is the penultimate research stage, before it is considered for commercial cultivation. As per a presentation made by Dr Deepak Pental, the reported developer of the GMO, to the GEAC in its 73rd Meeting, the proposal on "Transgenics in Mustard (Brassica juncea) for heterosis breeding" with main objectives of (a) development of male sterile lines in B juncea by fusing barnase gene and (b) restoration of fertility by barstar containing B. juncea transgenic lines, was funded by the Department of Biotechnology from 1994. Limited field trials are supposed to have been done at Jaunti village during Rabi 2002-03 and Rabi 2003-04, followed by trials at multiple locations during Rabi 2005-06. It is reported that the multi-location trials happened under the aegis of Indian Council of Agricultural Research. While the BRL I trials (Biosafety Research Level I) have taken place from 2010 onwards in Rajasthan, the second year trials of BRL I were sought to be stopped by the Rajasthan state government with one of the 3 trials burnt down and destroyed a little before harvest. In terms of BRL II (these are considered to be the penultimate stage to commercial cultivation approval consideration), in Rabi 2014-15, 3 trials took place (in Ludhiana, Bathinda and Delhi)[8].

All the biosafety reports, the biology of the crop and other literature are supposed to be made available in the public domain, as has also been reiterated by the Supreme Court (SC) in one of its interim orders in a Public Interest Litigation on GM crops, being heard by the SC since 2005, apart from CIC (Central Information Commission) Orders. However, despite reports that BRL-II trials have been completed, no information on GM mustard has been put out on the websites maintained by the regulators. RTI applications for the biosafety data of this GM mustard are being repeatedly turned down by regulators on the pretext that "it is under process". It can be assumed that either the regulators are withholding preliminary biosafety information based on which they had approved BRL II trials or that BRL II trials have been approved in the absence of any solid data required for such decision-making.

CLAIMS: The crop developers claim around 25-30% higher yield with this GM Mustard hybrid[9]. What is not mentioned is that the yield increase with this GM mustard is no different from yield increases from non-GM hybrids that are already in the market – this GMO therefore is not for farmers' benefit but for seed manufacturers' benefit, as described further later in this paper. This GMO development project, supported by the DBT (Department of Biotechnology, Ministry of Science & Technology, Government of India) initially, followed by the National Dairy Development Board (NDDB) and the European Union amongst others, has apparently had investments of around 45 crore rupees uptil 2012 for its development[10] (a latest figure mentioned is 70 crores of public money spent on this GMO[11]).

After the failure to prove safety of transgenic technology in the case of Bt brinjal, the current attempt is to bring in this GM mustard as the trojan horse for transgenic technologies in food crops in India. The argument that is being put forward is that this GMO is from the public sector and therefore, will not be expensive nor monopolistically-controlled. It is also being argued that with this GM mustard being brought in, India's oilseed/oils import reliance will come down. The promoters also claim that this is safe and similar to GM canola in Canada. It is not out of place to point out that all the claims around Bt cotton have been proven to be false and incorrect, as

the past 13 years of experience in India shows. Agro-chemical use has increased in cotton in India (both pesticides and fertilisers) with the per hectare use of pesticides reaching 0.9 kg/ha, similar to the early 2000s, in the pre-Bt cotton era[12]. Farmer suicides continue unabated with most being of Bt cotton farmers. leading cotton scientists are now talking about the need to promote non-GM Indian cottons as a solution to the agrarian crisis around cotton[13].

'PRELOGUE': PRO-AGRO GM MUSTARD REJECTED FOR COMMERCIAL CULTIVATION IN 2002

In November 2002, the Genetic Engineering Appraisal Committee (in its 34th meeting on 7th November 2002) 'deferred' its decision to accord approval for commercial planting of GM mustard on an application of Pro-Agro. It was reported that the GM seeds for this GMO were obtained from Belgium seven years prior to the 2002 attempt at commercialization. The barnase/barstar gene system for male sterility and restorer lines, as has been used in the DU GM Mustard case, was used in the Pro-Agro GM Mustard too. It also had the bar gene and a phosphonithricin resistance-coding (pat, or phosphonithricin acetyl transferase) gene ostensibly as a marker but it is also herbicide-resistant (to glufosinate ammonium with brand names Liberty, Basta etc.)[14]. In the 36th meeting of the GEAC held on 25th April 2003, the matter of Pro-Agro's GM mustard came up for discussion again and GEAC concluded that further studies should be taken up to address all biosafety and agronomic issues. A couple of years later, Bayer (Aventis, the parent company of Pro-Agro was taken over by Bayer) confirmed its plans to call off research on this GMO in its communication with an environmental organization[15].

Many argued that the Pro-Agro GM mustard was developed for herbicide resistance against glufosinate, using the Bar gene, though the official claim was of yield increase ostensibly with GM mustard. While the company argued that glufosinate was not permitted for use in mustard in India[16]; however, the reality was that glufosinate was indeed being used in tea gardens! It is not difficult to imagine, in a country like India where end-use regulation of many products/technologies is well nigh impossible, that it will be diverted to be used on GM mustard for its herbicide tolerance).

GEAC's deliberations in the November 2002 and April 2003 meetings (and some media interviews by ICAR officials) dwelled on the following[17]:

- Pollen flow studies as reported by the company showed transgenes escaping upto 35m, while the ICAR trials indicated pollen flow upto 75 meters. "Considering the agro-climatic conditions and small land holdings of Indian farmers, the Committee was of the view that the non-GM mustard seed from the adjoining fields is likely to get contaminated by the male sterility barnase, barstar, neomycin and bar genes. This factor may affect the stability of the properties of the non-transgenic varieties".
- While the company showed seed yield increase ranging from 16% to 23% over the best check Varuna in different GM hybrids, ICAR results showed only 5% upwards. "The agronomic superiority of these transgenic mustard seeds is yet to be fully established", recorded the GEAC.
- The Indian Council for Agricultural Research under whose supervision the trials are supposed to have taken place clarified that it did not supervise the number of trials that the company claimed, and that it conducted trials only at 4 locations which is not adequate.
- "Mustard being an edible crop, important policy issues related to labeling, traceability etc., need to be put in place prior to commercial release", decided GEAC.
- Trial studies conducted by the company also indicated the presence of male sterile plants in the progeny population of non-transgenic Brassica growing in the vicinity of transgenics. It has been estimated that the average per cent of male sterile plants ie., the presence of barnase gene is about 0.31%. The Committee noted that the presence of barstar and bar gene in the contaminated native plants is an important issue that has not been taken into consideration while estimating the transgene spread.
- The use of Bar gene as a marker gene, increased weediness and consequent use of more toxic persistent herbicides were discussed. Further studies should be conducted by ICAR to address all biosafety issues including resistance to herbicide, it was concluded.

- The Committee noted that mustard being an edible crop, further studies to establish health safety aspects need to be conducted.

Overall, it can be seen that the Pro-Agro GM mustard underwent less rigorous trials than the regular varietal selection trials that take place as All India Coordinated Crop Improvement Research Projects in the National Agricultural Research Systems (NARS). On the health front, it was seen that there was no safety data on mustard leaf which is used as a vegetable while data produced by the applicant was only on mustard oil. Contamination and creation of superweeds were the other reasons cited – even if probability is small, is the risk acceptable, was the reported question dwelled upon by the regulators[18]. Given that GM mustard may not be useful in all the areas that it is cleared for in such a case, how does one regulate its spread once GEAC clearance is given, was another pertinent question asked by the regulators as per media reports, which went unanswered. There was much demand for making results of GM testing public in the aftermath of this GM mustard rejection.

It has to be noted that GEAC's views and conclusions above were at a time of the Indian biotech regulatory history when decisions were taken based only on the company's presentation of its own data, without any independent scrutiny of data, fresh data analysis or evaluation by expert committees into specific aspects of biosafety and other issues. It is important to re-narrate the above story, given that the claims, technology and testing processes are similar to DU's GM mustard in the current instance, apart from the fact that one emerged from the private sector and the other from the public sector. It is apparent that the above rationale used by the regulators in 2002 remains pertinent irrespective of public or private sector genesis of the GMO. With this background, we move back to Delhi University's GM Mustard.

GM TECHNOLOGY IS FOR SEED MANUFACTURERS - INDIA'S OIL IMPORTS HAVE NOTHING TO DO WITH THIS TECHNOLOGY

As mentioned earlier, the hybridization process that this genetic modification of mustard is supposed to facilitate is mainly meant for seed manufacturers. As far as farmers are concerned, this GM mustard is similar to non-GM mustard hybrids already in the market. In fact, the Ministry of Agriculture has recently announced that it has standardized the seed production technology of Indian mustard hybrid NRC Sankar Sarson which yields 2.4 tonnes per hectare[19]. It is also important to note that there is evidence to show that even without meddling with seed variety improvement, agronomic practices like System of Mustard Intensification can yield up to 2.5 tonnes to 3 tonnes per hectare. When all principles of SRI were used, yields touched 4 tonnes per hectare! Such evidence has been collected from experience of around 1600 farmers, with government machinery supporting the effort in Bihar, which is more areas and fields than DU's 2 to 4 trials in the BRL I and II stages[20]. It also has to be noted that instead of comparing against another hybrid, DU's GM mustard is being tested against an OP variety check called Varuna.

Coming to claims that India's edible oil import bill will come down with the use of DU's GM mustard – it is apparent that this techno-centric view (which also discounts that mustard hybrids already exist in the market) neglects policy/political triggers that can bring down India's oil imports, and it is in that domain that action is indeed needed as experts have pointed out time and again. For instance, import duties have been cut drastically from an applicable/bound rate of 300 per cent to almost zero now, with cheaper imports inundating the country. Further, it has to be recalled how the Oilseeds Technology Mission launched in 1985 turned around the situation of India importing roughly 50% of its edible oil imports for its domestic requirement to just 3 percent by 1993-94[21]. Increasing production of oilseed crops like mustard therefore requires adequate policy support, like raising import tariffs to stop cheap edible oil from flooding the market, providing an economic price to mustard farmers and actually procuring their produce would go a long way in India increasing its mustard production and reducing its import bills on this front. It may not be too out of place to also point out that an average Indian consumes double the edible oil recommended by doctors in their caution against health problems like cardiac illnesses.

GENES USED IN GM MUSTARD MAKE IT A GENETIC USE RESTRICTION TECHNOLOGY/GURT

DU's GM Mustard uses the barnase gene which creates male sterility. This is therefore a trait-related Genetic Use Restriction Technology (GURT). While the developers claim that the hybrid has fertility restored by the barstar gene from the restorer line, and that the barnase will not "leak", it is clear from the unstable and unpredictable science of GM as well as simple biological processes like meiosis that this cannot be fully leak-proof. In any case, the parental lines will also need open air production, and they present the possibility of greater 'leaking', even as the hybrid GMO is also not 'leak-proof'. The Protection of Plant Varieties and Farmers' Rights Act (PPVFRA) of 2001, under Section 29 (3) classifies GURT and Terminator as a technology that is injurious to the life or health of human beings, animals or plants and lays down that no variety of any genus or species which involves GURT will be registered.

INDIA IS A CENTRE OF DIVERSITY FOR MUSTARD

It is well established that India is a Centre of Diversity for Indian Mustard (Brassica juncea)[22], even as various scholars have presented contradictory evidence with regard to the question of Centre of Origin[23]. One of the members in the Supreme Court Technical Expert Committee (TEC) in one of his publications in 1991 had confirmed that India is the Centre of Origin for various Brassica spp (rai, sarson and toria types)[24]. In fact, it is recorded that the Brassicaceae diversity is high in all regions of the country. One of the reasons for the moratorium placed on Bt brinjal was related to the fact that India was the Centre of Origin and Diversity of brinjal. The Supreme Court's TEC, in its majority report, had asked for GM research to be stopped for all those crops for which India is the Centre of Origin and/or Diversity. One decade earlier, the Swaminathan Task Force Report on Application of Agricultural Biotechnology cautioned against transgenics in crops for which we are the Centre of Origin and/or Diversity.

There are numerous varieties of Brassica juncea grown in India, including many released varieties. According to the Directorate of Rapeseed-Mustard Research (DRMR) of Indian Council of Agricultural Research (ICAR), 91 varieties of Indian mustard were released by the public sector after the inception of the All India Coordinated Research Project on Rapeseed Mustard in 1967, till 2013. The Directorate alone has 1868 accessions of Indian Mustard (2452 accessions of R&M) through acquisition from national and international agencies; further, around 12755 accessions of rapeseed-mustard are supposed to be available in India[25]. This provides a glimpse of the tremendous diversity that is present in this crop.

CONTAINMENT IMPOSSIBLE, CONTAMINATION INEVITABLE

Being both a self and cross-pollinated crop[26], contamination from GM canola/rapeseed has been proven time and again in many parts of the world. Apart from biological contamination, given that pollination by bees over considerable distances can happen, there are many other potential routes which make containment impossible. The seeds are small enough to slip through post-harvest processes to become admixtures and get transported to distant locations. Seeds can even be blown over to neighboring fields. Apart from this, volunteer and feral plants are common even as seeds remain viable for many seasons.

Several contamination incidents that have been reported are from commercial cultivation, imports as well as field trials. It appears that GM oilseed rape got imported into France from the Canadian harvest, in 2002, in a consignment of rape seed. Japanese port areas as well as prefectures far from these import locations have been found to be contaminated with GM rapeseed (reports emerged from 2004 onwards). Recent reports (2010) indicate that modified genes have spread to wild relatives[27]. In 2013, in South Korea, contamination from GM oilseed rape, which is not authorized for cultivation in the country, was found in a government survey around major ports, around processing factories and around livestock breeding areas. In 2012, 2013 and 2014,

unauthorized GM rapeseed was recorded growing wild without authorization in Switzerland. Research published in Environmental Sciences Europe shows that feral GM oilseed rape plants were found in four locations in Switzerland and in two locations, were able to survive herbicide applications. Evidence of unauthorized GM mustard growth was found along railway lines along borders with Italy and France, till oilseed processing factories in Switzerland[28].

In Canada, it has been observed that large scale anthropogenic dispersal processes of GM mustard have occurred despite limited natural seed dispersal. Most organic farmers are no longer able to grow their oilseed rape crop because of contamination.

In 2010, research in the USA showed transgenic oilseed rape growing wild, highlighting lack of proper monitoring and control of GM crops in the USA. Testing identified that some of the surveyed plants in North Dakota were new GMOs which contained both Monsanto's and Bayer's transgenes resistant to two different herbicides – glyphosate and glufosinate! These plants show that different GM plants had cross-bred to produce a plant with a new trait that did not exist, was not developed nor was approved[29]!

In the UK's farm scale evaluations of GM crops, a GM oilseed rape cross-fertilised with a distantly related weed plant, charlock, which was discovered in a follow up study 2 years after a 3-year research[30]! Weeds with herbicide tolerance traits would obviously pose a great problem for farmers. In the UK, in 2008, a conventional oilseed rape trial was found to contain small traces of unauthorized GM material.

There are high profile cases like those of Percy Schmeiser in Canada and Steve Marsh in Australia related to GM canola contamination of non-GM/organic fields. In the former, Monsanto sued Schmeiser claiming patent infringement which the Supreme Court of Canada upheld even though it was GM canola which had blown into his field from a neighbour's, and contaminated his crop! In the case of Steve Marsh, an Australian organic farmer, contamination again from a neighbor's field cost him his organic status. Even here, Marsh lost his case against his neighbor when the judge ruled that the neighbor could not be held responsible. The case has gone on appeal to a higher court now.

When asked about contamination of other (wild) species by the GM mustard, the applicant of GM mustard under discussion, Dr Deepak Pental, admitted in an interview to journalists from Down To Earth that non-transgenic Brassica juncea as well as Brassica rapa that is grown in eastern India can 'receive' these genes (from GM mustard). He also said that "it is wrong to claim that transgenes won't move to non-transgenic material. If you have a selection over it like a herbicide, then they spread very quickly....But GM Brassica juncea can cross with non-GM juncea"[31].

Taken together, all the above instances prove beyond doubt that GM rapeseed-mustard would be impossible to contain – biologically, it would contaminate non-GM varieties apart from crossing with wild relatives; it would also spread as physical admixtures to unexpected and distant locations too.

GM contamination occurs independent of commercialization is well proven by now[32], and open air releases in the name of trials too pose a serious risk – what is shocking is that even though ICAR found contamination at 75 meters in the case of Pro-Agro's GM mustard, the isolation distance prescribed at present for GM mustard trials is only 50 meters, revealing the complete lack of responsibility of the regulators. This would also mean end of choice for farmers and consumers, and will also jeopardise organic mustard production seriously.

The Supreme Court of India, in the ongoing PIL on GMOs has expressly ordered that the regulators should ensure that no such contamination takes place.

DU'S GM MUSTARD IS HERBICIDE-TOLERANT

In India, various government-commissioned, Parliamentary and Court-appointed Committees/Task Forces have repeatedly recommended against herbicide tolerant crops in the country. This is advice that combines biosafety issues related to herbicide tolerant GM crops as well as the serious dangers posed by herbicides, in addition to taking on board socio-economic considerations related to herbicide use as labour-displacing technologies (a majority of women workers in the country draw their employment as agricultural labourers and one of the major employment generating agri-operations is de-weeding).

The DU's GM mustard, like the Pro-Agro GM mustard that was not approved by the Indian regulators in the past, is a herbicide-tolerant GM crop. In fact, it appears from initial publications of crop developers that the purpose of development of this GM mustard was primarily to induce herbicide tolerance[33]! While the applicant may choose to apply for permission under the garb of a high-yielding trait, the regulators cannot and should not overlook the herbicide tolerance trait – that was one of the reasons why the ProAgro GM Mustard application in 2002 was not approved. This is particularly dangerous in the Indian context where there is no end-use regulation of pesticides including herbicides. The increasing health and environmental risks with herbicides in our farming, as well as the exponential increase in herbicide usage with the advent of GM crops is well-documented. Glufosinate is shown in animal experiments to be toxic to the neurological and reproductive systems; it is also documented in studies to be toxic to beneficial insects that control crop pests and to pollinators[34]. This being a herbicide tolerant GM crop, has to be treated with all the precaution that it entails due to the known and documented risks associated with them – the repeated advice of various committees for herbicide tolerant GM crops to be banned in India should be applied in this case.

MUSTARD IS ALSO A VEGETABLE CROP IN INDIA

Mustard leaf is eaten directly as a food in Indian cuisine, especially in north India. Leaves are used in salads as well as cooked as a main dish (sarson da saag) to go with Indian bread. Indian mustard therefore is not just an oilseed. In the case of Bt brinjal, this was one of the main considerations (direct consumption of the GMO as a food product) for the indefinite moratorium. Mustard and its leaves are in fact consumed in more direct ways than even brinjal.

In 2010, during the Bt brinjal commercialization debate in India, Dr M S Swaminathan, described as 'India's most distinguished and senior most agricultural scientist' by the then Minister for Environment & Forests in his Moratorium orders dated February 9th 2010, had the following three issues to raise: chronic toxicity since brinjal is an element of such frequent consumption in India; independent tests that command credibility and not depend only on data provided by the developers themselves; the need to have an independent regulatory system that will be in a position to study all aspects of GM technology in agriculture and arrive at a measured conclusion; the need to conserve India's genetic heritage in brinjal[35]. *It is not out of place to point out that all these issues are equally pertinent in the case of this GM mustard too!*

PLAGIARISM & EPA VIOLATION CASE AGAINST THE CROP DEVELOPER

There is a major controversy brewing with claims and counter-claims around another GM Mustard reportedly being developed in Delhi University. Government of India's Department of Science and Technology revealed that it has no idea where the GM lines in this high profile case came from, and who gave permission for research[36]. There is indeed a court case with charges on the developer of this GM mustard of stealing GM seeds from the laboratory of another Delhi University Professor called P Pardha Saradhi (apart from plagiarism charges), and using such 'hazardous material' without regulatory approval. In this high profile case, Pardha Saradhi has accused Pental of appointing a PhD student called KVSK Prasad (who was earlier a student of Pardha Saradhi in Jamia

Millia Islamia). The case is against Pental and Prasad, for Prasad stealing seed of CodA transgenic Indian mustard, in collusion with Pental; the petitioner, Pardha Saradhi, claims that this was in reality developed by him and his team under an India-Japan Cooperative Science Programme[37]. It is the same Deepak Pental who is the official applicant and crop developer in the case of this GM mustard that has reached BRL II stage. It is unclear whether the Indian GM regulators have taken cognizance of the plagiarism controversy around Pental and whether any additional steps are being taken to ensure that the crop developers are indeed the 'owners'/creators of this mustard which is under consideration.

STATE GOVERNMENTS, INCL. LEADING MUSTARD-GROWING STATES, DID NOT EVEN WANT TRIALS OF GM MUSTARD

Some of the major mustard-growing states in India have taken a precautionary approach to GMOs, and have not favoured even field trials in their jurisdiction. This includes Madhya Pradesh which has been consistently saying NO to GM field trials in the state[38]. The government here argued that there is no credible and irrefutable evidence about GM crops not having adverse impact on humans/animals, biodiversity and environment. Meanwhile, in Rajasthan, while first year trials of GM mustard took place in 2010, in 2012, during the fag end of second year of BRL I trials (Biosafety Research Level I), the state government withdrew its NOC and issued directions for terminating the trials by burning the crops immediately. While two of the fields were harvested by then, in the third field, the government undertook destruction of the crop. The letter withdrawing the NOC stated: The matter for permitting trials of transgenic crops has indeed being fraught with concerns as no unanimity has arrived at, either in their favour or against them. ICAR too seems to be grappling with the disquiet. The government has taken a view to wait until a national consensus is evolved. It has also been decided that discussions should be held with all stake holders and to reach to a general agreement on the controversy." Following this development, Dr Pental knocked on the doors of the PMO and the GEAC. GEAC in its 116th meeting on April 11th 2012, discussed this matter (Agenda Item 6) and concluded that while the decision of the State Government of Rajasthan is rather arbitrary as the direction for withdrawal does not state any evidence of harm or non-compliance, that once a NOC has been issued, it should not be withdrawn in the interim period without any scientific reasons, "notwithstanding the above, the Committee also reiterated that agriculture is a State subject and decision of the State Government on whether to allow GM crop field trials or not should be honored".

Meanwhile, the state government of Haryana has not issued any NOC for GM mustard trials so far.

This means that three states which account for more than 70% of India's mustard production did not even want field trials to take place, and it is clear that this GM mustard did not get tested in major mustard producing states. It is important to note here that this aspect of state governments' rejection of GM food crops was one of the important factors for the Bt brinjal moratorium decision in 2010[39].

DU GM MUSTARD BIOSAFETY INFORMATION COMPLETELY MISSING

While the applicants might be talking about imminent processes around commercial cultivation approval, it is of serious concern that despite orders from the Supreme Court, the regulators in India have chosen not to put out biosafety information related to this GMO in the public domain, even in such an advanced stage of research. In response to an RTI application, the regulators replied on May 15th 2015 that 'the aforesaid matter is under process and the information cannot be provided at this stage'. Ironically, the GEAC, way back in its 79th meeting, dated 8/8/2007, on Agenda 2.0 (2.0)(A)(2.0) has reminded itself that the Supreme Court has directed the GEAC to post the biosafety data on the MOEF/DBT website in its hearing on 1/8/2007.

The Bt brinjal saga in India clearly demonstrates that crop developers, who claim safety with their product, are wary and secretive about biosafety data generated. Neither independent testing is done, nor long term tests

conducted for chronic toxicity and other issues. The impact assessment regime does not even take into account the actual growing and consumption conditions that prevail in India (including socio-economic). For instance, the impact on women and their work participation levels in the country by bringing in a herbicide tolerant crops, and therefore, on women's empowerment; on livestock health given that mustard seed cake is used as animal feed; on Ayurvedic practices and their impact; on organic farming; on soil productivity given that mustard cake is used as a soil amendment, for example.

The Bt brinjal moratorium decision note of the MoEF, Government of India, the Parliamentary Standing Committee Report on GM Food Crops as well as the Supreme Court Technical Expert Committee's report – all ask for a comprehensive overhaul of the testing regime and the regulatory regime in India. This is also the crux of the ongoing litigation in the Supreme Court of India. However, it is apparent that no such overhaul has taken place. In fact, GEAC and other regulators have become even more secretive and opaque in their functioning than ever before. This is apparent from the withholding of information regarding meetings, discussions, minutes and also not putting any information in the public domain in contravention to the Supreme Court orders. Without such an overhaul of the regulatory regime, it is also clear that this GM Mustard would not have reached this stage through an improved biosafety regime. Such a biosafety regime would begin with an assessment of the need for the GMO, as well as assessment of the alternatives available.

GM MUSTARD AND POTENTIAL IMPACTS ON HONEY BEES & THE HONEY INDUSTRY

Mustard is one of the major sources of honey for Indian bee keepers. Honey bees are the primary pollinators of mustard crop because it is highly attractive to bees and provides both nectar and pollen[40]. Insect pollinators play a vital role to increase productivity as proven by different reports from various parts of the world[41]. Bharatpur is the second largest honey collecting regions in the country, generating more than 1200 tonnes of honey annually. Bee-keeping in turn also increases the yield of crops by as much as 20-25% - the same range as the claimed yield advantage of GM mustard! In the case of mustard cultivation with bee keeping, additional income is also generated. India had exported nearly 32,500 MT of natural honey to other countries in the recent past, apart from production for domestic consumption of around 32,500 MT annually[42].

GM crops leave their impacts on non-target organisms like honey bees - as seen from a perusal of scientific evidence on the subject – in both direct (on the bees) and indirect (at eco-system level, with the impacts on bees emerging out of changes that happen to the eco-system like weed diversity or abundance being affected, for instance) ways, as well as in acute/lethal and chronic/sub-lethal ways[43]. The specificity of action of different genes that are used in creation of GM crops is not well researched and understood, even as there is evidence to show that the Genetic Engineering (GE) process itself can bring about changes in nectar or pollen composition (quality and quantity) as well as interference in the plant biochemical pathways that potentially impact pollinators. With Herbicide Tolerant GM crops in particular, it has been noted that these would have significant negative impacts on bee populations due to large scale changes in agro-ecosystem. Bee densities have been documented to be lower in GM HT crops than in conventional fields. Specifically in the context of GM Canola, it has been found that there is lower bee population and poorer seed setting in GM HT fields when compared to conventional and organic canola crops. This peer reviewed scientific paper from Canada captures the difference in bee abundance between organic, conventional and GM canola and clearly shows that bee abundance was the lowest in the GM fields, also leading to a lower yield advantage related to bee pollination[44]. It is seen that there is a loss of about six seeds per pod due to lack of pollen transfer, with the mean per cent seed set in GM HT Canola fields being only 78% of the total potential seed set, compared to organic fields in the study which had seed set rates of 99%. Bee abundances were approximately three times higher in organic fields than in GM HT canola fields. While leaving land around GM HT fields uncultivated is a strategy suggested by some, this is not going to be possible in the growing conditions of India with a majority of farmers being small and marginal holders. In addition to concerns with specific genes used in GE, the genetic transformation process and the ecosystem effects, is another matter related to seed treatment chemicals like neo-

nicotinoids used with hybrid seeds. This GM mustard's potential impact on honey industry and honey bees is therefore a matter of great concern.

MUSTARD AND INDIAN SYSTEMS OF MEDICINE LIKE AYURVEDA

Mustard is known variously as sarṣapa, siddhārthaka, rājikā and āsurī, and is well documented in the classical Ayurvedic literature like Caraka Saṃhitā, Suśruta Saṃhitā, Bhela Saṃhitā and Kāśyapa Saṃhitā. Scholars opine that the term āsurī, which occurs twice in both the Śaunaka[45] and the Paippalāda[46] recensions of the Atharva Veda denotes the mustard plant extending its historicity even farther into the past. This assumption is based on the comments of Sāyaṇa[47] and the medicinal properties ascribed to it in the Atharva Veda. However, in the later period and right up to contemporary times, the applications of mustard in diet and medicine got indisputably established in Ayurvedic practice. From various classifications, four varieties of mustard including Brassica juncea can be discerned in Ayurvedic use. Mustard has been used both as food and as medicine in Ayurveda. For medicinal purposes, the seeds and oil of mustard are used singly and in various formulations in Ayurveda, while mustard leaves are used sparingly. Mustard seed for instance is included in the group of drugs that cleanse the cranial cavity, used in decoction enema, have anti-prurient activity, induce emesis etc. A separate note on Mustard and Ayurveda will be put out soon by the Coalition for a GM-Free India.

OTHER ISSUES OF CONCERN

At the global level, GM canola area is showing a decline, as per data put out by industry lobby groups like ISAAA[48]. It had declined from 30% to 25% of canola grown in the world when compared to 2012. There are several other issues of concern and debate with regard to this GM mustard. Mustard is an important crop for organic farmers in India; with mustard contaminated with GM mustard as it inevitably will, this will have large ramifications for organic farming.

Forcing farmers into a state of dependency on marketed seeds: Meanwhile, it is seen that farmers' varieties of mustard (like in other crops) are being neglected to be promoted by the government. Through various legislations like the Protection of Plant Varieties and Farmers' Rights Act 2001, which is ostensibly to uphold farmers' rights also, through biased design and implementation of the law, it is seen that farmers' varieties are not being registered with the same haste as others'. Out of 54 applications received for farmers' varieties to be registered, the Authority under this law registered only one so far. On the other hand, extant varieties of companies were registered beyond the cut off period too. This can only be inferred as keeping at bay any competition against hybrids and GM varieties marketed by public and private sector[49].

Compromising on Rigorous Testing of GMOs Because Some Are From The Public Sector: It is apparent that biosafety issues will remain the same whether a GMO is created by a private sector entity or a public sector entity. However, the bending of rules and norms, and the compromise on biosafety assessment that the Indian regulatory regime has resorted to in the past, with regard to public sector GMOs, which also led to huge embarrassing scandals later on, is something that is worth bringing up here. As is well documented, the only public sector Bt cotton which was released in India is mired in an ownership controversy where the existence of the new gene itself is under question. Consequently, it had to be withdrawn. The details of this infamous case and the indictment is contained in the Agriculture Ministry-commissioned Sopory Committee report[50]. In the case of this GM mustard, while it is known that patents have been taken by public sector scientists[51], there is nothing to prevent further sale and ownership in future.

Even in the case of open air field trials, the GEAC has only chosen the less rigorous biosafety measures – for instance, prescribing only a 50-metre isolation for the field trials, even though bee pollination is certainly known to be high, causing cross-pollination, and even after documenting contamination upto 75 meters in the case of

Pro-Agro's GM mustard[52]. It is a matter of great concern that the regulators have chosen 50 metres for mustard trials when even the Indian Minimum Seed Certification Standards (IMSCS) laid down 100 meters isolation distance (foundation seed). A GEAC sub-committee also recommended 50-100 metres distance noting that the nature of pollination is both self and cross (with an acknowledgement that bees are the main pollinating agents), for maintaining a genetic purity of 97%[53]. Ideally, the standards for GMOs should have been zero tolerance for contamination, as laid down by a 2007 Supreme Court order, and anything that is following the 97% genetic purity standard is already compromising on 3% contamination! This is an indication of the lax/unconcerned and lackadaisical norms of the transgenic regulatory regime in India whose competence and independence is suspect especially after the Bt brinjal saga. Further, in the BRL II trial of this GM mustard in Bathinda, it has been found that biosafety norms laid down as the conditions for approval have been flouted, and activists have demanded action on the same[54].

When it comes to normal seed varietal release procedures in India, which are usually statutorily notified after such a "release", rigorous procedures have been laid down. Each variety has to pass through three phases of evaluation. Local programmes for testing are taken up in Initial Yield Evaluation Trial (IET) or Preliminary Yield Trial (PYT) – these trials are organized in selected number of places in each zone. Entries qualifying from yield, disease and quality point of view are then tested in Uniform Regional Trials (URTs) or Advanced Varietal Trials (AVTs) or Coordinated Varietal Trials (CVTs). These trials are organized at a very large number of locations in each zone, and multi-disciplinary expertise is drawn in – agronomists, entomologists, pathologists, nematologists and quality evaluation groups study the entries. Release and notification of a variety follows its identification and recommendation by the AICIP workshop after a minimum of three years of multi-locational trials and assessment for Value for Cultivation and Use (VCU), at the end of the AVT II stage (preceding this, IVTs are for 1-3 years)[55]. Contrasted with this, GM trials which should have been more rigorous, long term and multi-disciplinary as well as sequential (the SC TEC recommended that 'the sequence of testing should be carried out in order of increasing environmental exposure required to perform the test. Tests should be done under the minimum conditions of exposure required for the test. Testing therefore proceeds in a progressive manner that increases confidence regarding safety with increasing exposure') are allowed to take place in an unsafe and unscientific fashion. Therefore, there is indeed a big question mark on the regulators, their green signals and whether citizens can depend on these regulators for upholding biosafety related to food and environmental safety of these GMOs. Despite several credible agencies asking for a halting of GM environmental release in the garb of field trials and the like, the regulators have chosen to plod ahead in a business-as-usual mode, with various GM crops moving inexorably towards our food plates and farms, despite being unneeded, unwanted and unsafe.

AGRO-ECOLOGICAL AND ORGANIC APPROACHES, NOT GM, ARE THE ANSWER

What this GM mustard claims is not a sustainable or eco-friendly way of increasing yields. While there is more and more evidence around the world as well as in India about agro-ecological and organic approaches to increase mustard productivity[56], why do we need such a risky, unsustainable technology as with this GM mustard? GM mustard not only negates such evidence on safer and sustainable alternatives, it also jeopardises organic farming prospects in several ways.

We urge all citizens to actively involve themselves in an informed debate related to GM mustard, and this Briefing Paper is to initiate this process. This is about your ability to know and choose what you eat, its safety and how your environment is dealt with.

This briefing paper assumes that the reader has some basic information about genetic engineering, its science & technology, associated risks, India's regulatory regime, the ongoing Public Interest Litigation in the Supreme Court etc. For more basic information, please visit the Resources section of www.indiagminfo.org for some booklets and introductory handbooks on GMOs in our food/farming/environment, and the concerns therefrom. A compilation of scientific studies pointing to adverse impacts of GMOs is available here: http://indiagminfo.org/?p=657

REFERENCES

[1] Scientists to Submit GM Mustard Report to Government. May 19th 2015. Reuters Business News. http://in.reuters.com/article/2015/05/19/india-gmo-trials-idINKBN0O40AY20150519 accessed on May 28, 2015

[2] GM Mustard: ICAR refutes ProAgro's Claims. AgBioIndia Mailing List. 18 November 2002, reproduced by GM Watch. http://gmwatch.org/index.php/news/archive/2002/3284-gm-mustard-icar-refutes-pro-agros-claims accessed on May 28, 2015; India: GM Mustard put on hold. AgBioIndia Mailing List, 8th November 2002. http://www.gene.ch/gentech/2002/Nov/msg00023.html ; GM Mustard put on hold. Chandrika Mago, Times of India, New Delhi, November 8th 2002.

[3] http://eands.dacnet.nic.in/PDF/Pocket-Book2014.pdf

[4] Pocket Book of Agricultural Statistics 2014, Ministry of Agriculture, Government of India. Pp40

[5] Agricultural Statistics at a Glance 2014. Table 4.18(b). pp111. Ministry of Agriculture, Government of India. http://eands.dacnet.nic.in/PDF/Agricultural-Statistics-At-Glance2014.pdf accessed on May 28, 2015

[6] Updated info on statewise production- http://agriexchange.apeda.gov.in/india%20production/AgriIndia_Productions.aspx?productcode=16

[7] Pocket Book of Agricultural Statistics 2014, Ministry of Agriculture, Government of India

[8] From RTI information from DBT and from GEAC meeting minutes

[9] Private sector hybrids already exist in the Indian market.

[10] Interview with Deepak Pental by Latha Jishnu and Jyotika Sood in Down To Earth, May 15th 2012. http://www.downtoearth.org.in/content/stopping-gm-trials-anti-farmer accessed on May 29, 2015

[11] http://www.hindustantimes.com/india-news/niti-aayog-to-take-call-on-gm-crops/article1-1357120.aspx

[12] Andrew Paul Gutierrez, Luigi Ponti, Hans R Herren, Johann Baumgartner and Peter E Kenmore (2015): Deconstructing Indian cotton: Weather, yields and suicides. Environmental Sciences Europe 27:12. DOI: 10.1186/s12302-015-0043-8

[13] "CICR prefers high density planting of varieties to Bt hybrids": http://www.smartindianagriculture.in/cicr-recommends-high-density-cotton-planting-for-vidarbha-telangana/, accessed on July 9, 2015; Also refer to: Carla Romeu-Dalmau, Michael B Bonsall, Katherine J Willis and Liam Dolan (2015): Asiatic cotton can generate similar economic benefits to Bt cotton under rainfed conditions. Nature Plants. Article Number 15072. 1st June 2015. | DOI: 10.1038/NPLANTS.2015.72

[14] It is unclear if the patents for bar gene continue to be owned by Bayer Crop Science.

[15] http://www.greenpeace.org/india/en/news/giving-up-on-ge-greenpeace-ex/, accessed on June 8, 2015

[16] Glufosinate use is associated with health and environmental impacts. Check this, for instance: http://www.ncbi.nlm.nih.gov/pubmed/?term=Developmental+and+ dysmorphogenic+effects+of+glufosinate+ammonium+on+ mouse+embryos+in+culture ; Check pp41-65 for herbicides' impacts in this compilation: http://indiagminfo.org/wp-content/uploads/2013/11/Sci-ref-complete-book-2nd-edition.pdf

[17] As per RTI information obtained by Ananthoo on 1st July 2015 from MoEFCC

[18] Chandrika Mago (2002): GM Mustard Put On Hold. The Times of India. November 8th 2002

[19] State of Indian Agriculture 2012-13, Ministry of Agriculture, Government of India. http://agricoop.nic.in/Annual%20report2012-13/ARE2012-13.pdf

[20] Cultivating Rapeseed/Mustard with SRI Principles: A Training Manual. PRADAN and ATMA (Gaya), based on experience in Gaya and Nalanda districts in 2009-10 to 2011-12. http://sri.ciifad.cornell.edu/aboutsri/othercrops/otherSCI/In_SMImustard_Pradan.pdf accessed on July 7, 2015

[21] Devinder Sharma, June 26th 2015: Conspiracy Against Mustard. DNA (Daily News & Analysis). http://www.dnaindia.com/analysis/column-conspiracy-against-mustard-2098894

[22] http://www.australianoilseeds.com/__data/assets/pdf_file/0012/8301/S1-P6-ShengChen.pdf

[23] http://www.ncbi.nlm.nih.gov/pubmed/23519868 , accessed on May 29, 2015

[24] R S Paroda and R K Arora (Eds) (1991): Plant Genetic Resources – Conservation and Management. International Board for Plant Genetic Resources. http://www.bioversityinternational.org/fileadmin/bioversity/publications/Web_version/174/ch06.htm#2.%20Plant%20Diversity%20in%20the%20Indian%20Gene%20Centre%20R.K.%20Arora http://www.bioversityinternational.org/fileadmin/bioversity/publications/Web_version/174/ch05.htm

[25] "Technologies Developed: Crop Improvement", as put up on the DRMR website. http://www.drmr.res.in/technologies_developed.html accessed on May 29, 2015; It is important to note that yield-increasing agronomic technologies are also listed out here. Improvement in extension alone, along with convergence is supposed to have improved yields by 40% in an adopted village called Unchagaon in Bharatpur district of Rajasthan.

[26] http://www.inspection.gc.ca/plants/plants-with-novel-traits/applicants/directive-94-08/biology-documents/brassica-juncea/eng/1330727837568/1330727899677#c1

[27] Modified Genes Found in Wild Plant, Possibly Cross Between GMOs. July 2nd 2010. http://www.istockanalyst.com/article/viewiStockNews/articleid/4274136

[28] http://www.gmcontaminationregister.org/index.php?content=re_detail&gw_id=465&reg=0&inc=0&con=0&cof=0&year=2014&handle2_page=1 , accessed on May 30, 2015

[29] GM Crop Escapes Into the American Wild. Nature News. 6th August 2010. http://www.nature.com/news/2010/100806/full/news.2010.393.html , accessed on May 30, 2015

[30] http://www.theguardian.com/science/2005/jul/25/gm.food , accessed on May 30, 2015

[31] "Stopping GM Trials is Anti-Farmer" – Interview with Dr Deepak Pental by Latha Jishnu and Jyoti Sood. Down To Earth, May 15th 2002. http://www.downtoearth.org.in/content/stopping-gm-trials-anti-farmer, accessed on May 30, 2015

[32] Becky Price and Janet Cotter (2014): The GM Contamination Register: A review of recorded contamination incidents associated with genetically modified organisms (GMOs), 1997-2013. International Journal of Food Contamination. October 2014. 1:5. http://link.springer.com/article/10.1186%2Fs40550-014-0005-8

[33] Smriti Mehra, Ashwani Pareek, Panchali Bandyopadhyay, Pankaj Sharma, Pradeep Kumar Burma and Deepak Pental (2000): Development of transgenics in Indian oilseed mustard (Brassica juncea) resistant to herbicide phosphinothricin. Current Science. Vol. 78, No. 11, 10 June 2000
[34] EFSA (2005). Conclusion regarding the peer review of the pesticide risk assessment of the active substance: glufosinate. European Food Safety Authority. EFSA Scientific Report 27: 1--81. http://www.efsa.europa.eu/en/efsajournal/doc/27r.pdf.
[35] http://www.moef.nic.in/downloads/public-information/minister_REPORT.pdf
[36] Delhi University's Gene Mystery. Latha Jishnu in Down To Earth. February 15th 2015. http://www.downtoearth.org.in/content/delhi-universitys-gene-mystery accessed on May 30, 2015
[37] Former DU Vice Chancellor Deepak Pental sent to Tihar over Plagiarism Charges. Mail Today Bureau, New Delhi. Mail Today India, November 26, 2014
[38] Madhya Pradesh says NO to field trials for Genetically Modified Chickpea and Mustard. Milind Ghatwai in Indian Express, Bhopal, November 19th 2014. http://indianexpress.com/article/india/india-others/madhya-pradesh-says-no-to-field-trials-for-genetically-modified-chickpea-and-mustard/ accessed on May 30 2015
[39] www.moef.nic.in/downloads/public-information/minister_REPORT.pdf
[40] Neha Kunjwal, Yogesh Kumar and M S Khan (2014): Flower visiting insect pollinators of Brown Mustard Brassica juncea (L.) Czern and Coss and their foraging behavior under caged and open pollination. African Journal of Agricultural Research. Vol.9 (16). Pp.1278-86. 17th April 2014
[41] ibid
[42] http://www.cseindia.org/userfiles/food_safety-march12/Prakash_kejriwal.pdf
43 Lora A Morandin (2008): (Chapter 12) Genetically Modified Crops – Environmental Risks Associated with Bees, in Oxford University Press's "Bee Pollination in Agricultural Ecosystems
[44] Lora A Morandin and Mark L Winston (2005): Wild bee abundance and seed production in conventional, organic and genetically modified canola. Ecological Applications 15:871-81. http://www.esajournals.org/doi/abs/10.1890/03-5271
[45] AVS 1.24.1-4; 7.38. 1-2
[46] AVP 1.26.1-4 20.30.7
[47] Sayana's comment on AVS 1.24.1-4 is asuri asurma ayarupa stri and Asuri asurasya maya on AVS 7.38.2
[48] Global Status of Commercialised Biotech/GM crops 2014, ISAAA Brief No. 49, ISAAA, Ithaca, NY
49 Shalini Bhutani, 29th June 2015: "'Sarson mein IP ka tadka' leaves local farmers in the dock". http://indiatogether.org/ip-debate-on-gm-mustard-agriculture
[50] Report of Dr S K Sopory Committee on BNLA106 Event, 2012. www.**icar**.org.in/files/BN-**Bt**-**cotton**-report.pdf
[51] Regulation of lethal gene expression in plants. US patent Number US 6,833,494 (2004); Method for producing insulator construct: Indian Patent No. 199542; An insulator construct for controlling leaky expression of a lethal gene: Indian Patent No. 244002 (Nov 2010); A method for obtaining improved fertility restorer lines for male sterile crop plants developed using transgenic approaches for hybrid seed production and a DNA construct for use in said method: US Patent No. 7,741,541 B2 (2010); EP Patent No. 1644506 (2009); Indian Patent No. 238973 (2010)
[52] Neha Kunjwal, Yogesh Kumar and M S Khan (2014): Flower visiting insect pollinators of Brown Mustard *Brassica juncea* (L.) Czern and Coss and their foraging behavior under caged and open pollination. African Journal of Agricultural Research. Vol. 9(16), pp.1278-86
[53] Indian Minimum Seed Certification Standards. http://agricoop.nic.in/imagedefault/seed/INDIAN_MINIMUM_SEED_CERTIFICATION_STANDARDS.pdf
[54] http://indiagminfo.org/?p=870
[55] D S Virk (1998): The regulatory framework for varietal testing and release in India. In John R Witcombe, Daljit S Virk and John Farrington (eds): Seeds of Choice: Making the most of new varieties for small farmers. Oxford & IBH Pub., New Delhi http://www.envirobase.info/PDF/RLPSRbookchap6.pdf
[56] PRADAN & ATMA's experience in Bihar with System of Mustard Intensification, op cite; R Saha and P K Ghosh (2013): Soil organic carbon stock, moisture availability and crop yield as influenced by residue management and tillage practices in maize-mustard cropping system under hill agro-ecosystem. National Academy Science Letters. Vol. 36, Issue 5. Pp461-8; BC Kansotia, Yogesh Sharma and R S Meena (2015): Effect of vermicompost and inorganic fertilisers on soil properties and yield of Indian mustard. Journal of Oilseed Brassica, 6(1): 198-201; http://www.hindawi.com/journals/ija/2012/408284/ ; http://forageresearch.in/wp-content/uploads/2014/12/186-191.pdf etc.