Falsehoods perpetrated by GM technology bashers on GM mustard

A report by NAAS scientists

The General Body of the National Academy of Agricultural Sciences (NAAS) in its annual meeting on June 5, 2017 passed a resolution supporting the decision of the Genetic Engineering Appraisal Committee (GEAC) recommending environmental (commercial) release of GM mustard hybrid DMH-11 and its parental lines **(Annexure 1)**. An overwhelming majority of the fellows in attendance were deeply concerned about unscientific and ill-motivated attacks on the use of GM technology for improving the edible oil economy of the country.

Ever since the Government of India activated decision making process by the regulatory bodies – hard-core GM technology bashers have been very active in spreading lies and fears on GM crops – particularly mustard. In some recent write-ups – GM bashers have tried to show that the opposition to the release is based on scientific data. Such arguments are open to analysis. President, NAAS, requested Prof. R B Singh (past-President NAAS) and a few other colleagues to analyse the arguments put-forth by GM bashers purely from a scientific perspective. The broad conclusion is that almost all the negative reports on GM mustard appearing on websites, newspapers and letters to the Ministers and PMO are fallacious, wilfully distort scientific data and have been made with the sole intention of scuttling the use of a technology which could be of great interest and value to the country. Here is an analysis of some of the arguments.

- In some recent articles GM bashers have compared yields of rapeseed (a sister crop of mustard) in Europe, Canada, USA, China and India. Presented graphs show that non-GM rapeseed in Europe yields upto 3.9 tons/hectare while GM rapeseed in Canada yields only 1.9 tons/hectare. Their argument is – that GM is of no value. While the data taken from FAO stats is correct – the interpretation is dead wrong. In Europe rapeseed is a 300 day crop, in Canada it is a 120 day crop. Yields of the two cannot be compared. This argument is a wilful misrepresentation of scientific facts **(Annexure 2)**. The argument was first made by an international level anti-GM activist Colin Todhunter – and subsequently advanced by many others including T S R Subramanian (Hindu, May 25, 2017) and a member of NAAS, Prof P C Kesavan in his letter to the President , NAAS.

- Another charge being made ad nauseam is that BRL-I and BRL-II (Biosafety Research Level I and II) field trials conducted in the years 2010-11, 2011-12 and 2014-15 were not adequate for yield assessment of hybrid DMH-11 as the national check Kranti was not included in the trials. The claim is that the country will not benefit from the release of DMH-11. An involved analysis of the data generated in the trials conducted by ICAR-AICRP-RM (All India Coordinated Research project – Rapeseed/Mustard) in the last eight years clearly shows that national check Kranti and zonal check RL-1359, both tested at the same 51 locations for yield in zone II, have very similar weighted mean yields **(Annexure 3)**. Kranti was not an entry in the BRL trials – RL-1359 was – and served as an appropriate check. Yield of hybrid DMH-11 was around 35% more that RL-1359 in the BRL trials – a significant increase for a first generation hybrid **(Annexure 4)**. The argument that BRL trials were not adequate for assessing the yield potential of hybrid DMH-11 is nothing but mischief.

- The first rapeseed hybrid released in Canada using a GM technology similar to what has been used in mustard yielded only around 13% more than the Canadian mega variety Westar. In 2008, a hybrid was released with close to 46% yield advantage over Westar. A robust hybrid seed production system is a one-time breakthrough – finding and breeding parental lines for developing hybrids with higher yields is an ongoing exercise. This is text book knowledge in plant breeding.

- It has also been alleged that some of the new varieties outperform hybrid DMH-11. Some disgruntled scientists are also part of this campaign – comparing yields from different trials without referring to a common entry – a national or a zonal check; such comparisons are scientifically infructuous **(Annexure 5)**. An analysis of the post-release yield data of the new varieties shows that these are more or less at par in yield with the current national check – Kranti **(Annexure 6)**. As a consequence, Kranti released in 1983 still remains the national check. Further, there is no significant seed indent for the new varieties and the old varieties Varuna (released in 1976) and Pusa Bold (released in 1984) still remain the most popular public system varieties amongst the farmers **(Annexure 7)**.

- Contrary to GM basher's propaganda – that very high diversity is available in Indian mustard – scientific analysis has shown that the Indian gene pool of mustard is very narrow. As a consequence, inspite of extensive efforts by our plant breeders – there is very little impact of pure-line breeding on mustard yields in recent years **(Annexure 8)**. The only way out of the current yield stagnation is to exploit hybrid breeding in mustard. Currently, in rapeseed growing countries – 86 % of the area in Canada, 80% of the area in China and 90% of the area in Europe is under hybrids. We have been lagging behind because of lack of a robust system for hybrid seed production in mustard which is available now and has been cleared by GEAC for environmental release.

- The biggest misrepresentation being carried out is – the hybrid contains a herbicide resistance conferring transgene; therefore, farmers will use the herbicide and lakhs of landless workers will lose their livelihoods. Yes, the used GM technology contains a gene that confers resistance to herbicide glufosinate – the hard fact is that herbicide use is required only for hybrid seed production and permission is being sought from the Ministry of Agriculture only for this limited use. The debate on using HT crops for protection against weeds and for conservation tillage is still an open question in India and will have to be decided by the Central Government at an appropriate time.

- Another myth being conjured is genetic pollution of existing varieties. All varieties are multiplied in isolation of 100-200 meters to maintain seed purity following well established ICAR guidelines. Transgenes do not jump out of a plant and spread. Their spread follows well established models of population genetics. Genes that confer high selective advantage will spread in the population at a very fast rate. As herbicide is not going to be used in the farmer's field growing mustard hybrids and there are no feral populations of wild mustard in the fields of mustard crop – the arguments on spread of herbicide resistance gene are complete falsehoods and part of a vicious propaganda to scare.

- GM method of hybrid seed production used in mustard was introduced in the sister crop rapeseed in Canada in 1996 and later in USA and Australia after very involved biosafety studies. Inspite of almost 20 years of prior safe consumption record – all the biosafety studies stipulated by GoI have been carried out on GM mustard. Since 1996, huge amount of oil and seed meal extracted from GM rapeseed has been consumed worldwide – oil by human beings, meal by livestock. In 2016 alone, Canada exported 10.5 MT of seed, 2.8 MT of oil and 4.4 MT of seed meal of rapeseed to many countries around the world, including Japan and India **(Annexure 9)**. There are no reports of ill-effects from any of the growing or consuming countries. If there are any such reports – why GM bashers are not bringing these to public attention? They cannot – as no such reports exist.

Productivity of oilseed crops is stagnating in India for more than ten years **(Annexure 10)**. Last financial year we imported around Rs. 68,000 crore worth of edible oils **(Annexure 11)**. This amount should have been earned by our farmers. Our national goal should be to double the edible oil production in the country in the next ten years. Developments in mustard breeding – a robust hybrid seed production system and finding of divergent gene pools – will help in achieving higher productivity in one of the most important oilseed crop of India.

NAAS endorses environment release of GM mustard hybrid DMH-11 and its parental lines as recommended by GEAC. Benefit of public funded research must reach our farmers. Falsehood of GM bashers will not help Indian agriculture, proper use of science and technology will.

Annexure 1

Resolution passed by NAAS General Body in its meeting held on June 5, 2017.

National Academy of Agricultural Sciences (NAAS), New Delhi

Resolution on Commercialization of GM Mustard

Adopted at the 24th Annual General Body Meeting of the Academy

June 5, 2017

Whereas, The National Academy of Agricultural Sciences (NAAS), presently comprising nearly 625 Fellows, is the national think-tank for analyzing technological, socio-economic, and eco-environmental aspects of agricultural and food systems transformation and for suggesting holistic solutions for sustained, inclusive and accelerated agriculture-led development;

Whereas, The best bet for alleviating the stubbornly high incidences of hunger, undernutrition, and poverty in an agriculturally important country like India, and that efficacy of such an agriculture will be underpinned by the development of ever-improving technologies and technological innovations as well as their effective adoption to produce More from Less for More (MLM);

Whereas, Despite ushering in the Green Revolution during the past 50 years and achieving food self-sufficiency and Right to Food based on home-grown food and becoming a formidable exporter of rice, cotton and other commodities, the situation of edible oilseeds remains gloomy;

Whereas, India meets 60% of its demand for edible oils through imports, costing nearly Rs. 80,000 crore annually, let alone the opportunity lost for the farmers to enhance their agricultural productivity and income, and national average yield of oilseed crops is low and sluggish;

Whereas, Brassica/rapeseed mustard is an important oilseed crop of India, occupying 6.6 million hectares of the 33 m ha global area, of which 8.5 m ha in Australia, Canada, and USA is under GE Mustard, and farmers in these countries have been reaping socio-economic and environmental benefits from GM canola since 1996, rendering Canada as the foremost exporter to India;

Whereas, In order to enable India also to benefit from GM mustard, our scientists have toiled hard during the past 20 years to develop promising biotech mustard varieties, such as mustard hybrid DMH-11, using *barnase-barstar* system to produce stable male sterile and fertility restorer lines for hybrid seed production;

Whereas, In field trials, DMH-11 has out-yielded the national and zonal checks by 20 to 30%, and future breeding using these two transgenic events will provide mustard hybrids with canola quality and better yield through mustering extensive diversity available in mustard in the country for creating progressively higher yielding superior multi-trait hybrids;

Whereas, Appreciating that regulatory approval is an essential requirement for commercialization of GE crops, India has developed a multi-tier regulatory system, which is one of the most robust regulatory systems in the world to address the biosafety and environmental concerns;

Whereas, The DMH-11 hybrid and its parental lines were rigorously tested for biosafety as per the guidelines and procedures, and all the biosafety studies conducted were submitted to GEAC in September 2015, and clearance from GEAC has been accorded on May 11, 2017, after thorough analyses by the expert committees;

Whereas we have apprised ourselves of all the conducted studies and unequivocally state that this technology is as safe as the non-GE mustard and will help the farmers and the country in improving its edible oils economy;

Whereas, The scientific and regulatory authorities around the world have consistently and repeatedly refuted the unfounded concerns of the activists, the Academy is deeply concerned about unscientific and ill-motivated attacks on the use of the GM mustard hybrid for improving the edible oil economy in India;

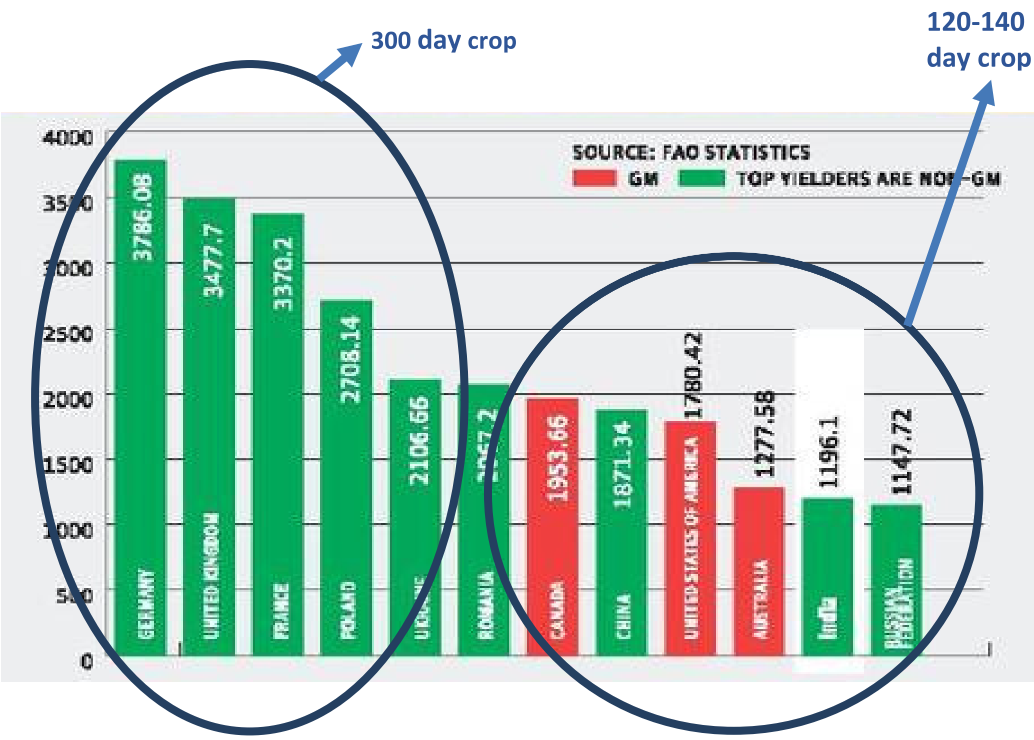
Therefore, towards greening the edible oil economy and connecting the people to nature on this World Environment Day, June 05, 2017, now, we the Fellowship (nearly 200 at this AGM) of the National Academy of Agricultural Science (NAAS), New Delhi, resolve that:

- The Central and State Governments should immediately endorse the recommendations of the GEAC so that the coming growing season can be fully utilised for the multiplication of parental lines and production of hybrid seed, which will hasten the environmental release of the two mustard parental transgenic events and hybrid DMH-11, thus allowing this technology to be available to farmers soon at a low-cost, and to breeders, to develop better and better hybrids in future;
- Having fully met the regulatory, biosafety, and performance requirements, a biotech product must not be denied to the farmers, who should have options to make informed choices, and empowered to become globally competitive in the fast changing world;
- All stakeholders must have full faith in the power of science & technology and the national regulatory & scientific agencies to improve our agricultural and food system productivity, profitability, and sustainability in perpetuity so that we not only help the farmers in improving their income and help the country in reducing the burgeoning edible oil deficit, but also ensure that science is not denied the opportunity to serve the society; and
- Finally, the government should proactively support the agricultural scientists to pursue frontier sciences and to take new developments in science and technology to the farmers, as delays in decision making will only dishearten and de-motivate the scientific community, particularly young scientists.

Annexure 2

Contains a Figure (Fig 1) used by GM bashers – comparing yields of rapeseed (*Brassica napus)* in Europe, Canada, USA, India and China showing non-GM rapeseed in Europe yielding more than GM rapeseed in Canada. An analysis of the data is given along with the figure.

Figure 1. Non-GM rapeseed in Europe yields more than GM rapeseed grown in Canada and USA



From The Hindu of May 25, 2017 – an article by TSR Subramanian and many other write ups by anti-GM activists

- **The yield data is correct but interpretation of data is wrong.**
- **In EU countries rapeseed is a 300 day crop. In Canada and USA it is a 120 day crop. Yields of a 300 day crop cannot be compared with a 120 day crop.**
- **Yields in Canada, China and US are higher than in India as more than 80% of their crop is hybrids.**
- **Barnase/barstar is a pollination control mechanism to produce hybrid seed and does not increase the yield of the crop *per se.* Heterosis is based on selection of parents. Barnase/barstar system is a very efficient system for hybrid seed production.**

Annexure 3

Data from ICAR-AICRP trials on rapeseed/mustard comparing – yield of national check and zonal checks.

Table 1 - Comparison of yield of Kranti (National check) with RL-1359 (Zonal check) in zone-II.

Table 2 - Comparison of yield of Kranti (National check) with Maya (Zonal check) in zone-III.

Table 1. Comparison of Kranti (NC) and RL-1359 (ZC) for mean seed Yield in Kg/ha in AICRP on Rapeseed-Mustard in IVT, AVT, IHT and AHT) trials in zone II

S. No.	Year of Testing	References :	IVT (Plot size : 1.5x5m)=7.5 m²		AVT (Plot size : 2.7x5m)=13.5 m²		IHT (Plot size : 2.25x5m)=11.25 m²		AHT (Plot size : 4.05x5m)=20.25 m²	
			Kranti (NC) Kg/ha	RL-1359 (ZC) Kg/ha	Kranti (NC) Kg/ha	RL-1359 (ZC) Kg/ha	Kranti (NC) Kg/ha	RL-1359 (ZC) Kg/ha	Kranti (NC) Kg/ha	RL-1359 (ZC) Kg/ha
1	2007-08	AICRP-RM 2008 PB36 (IVT), PB42 (AVT), PB52 (IHT), PB56 (AHT)	1710 (5)	1741 (5)	1683 (6)	1684 (6)	1730 (4)	1898 (4)	1410 (4)	1818 (4)
2	2008-09	AICRP-RM 2009 PB36 (IVT), PB44 (AVT), PB53 (IHT), PB57 (AHT)	2309 (7)	2456 (7)	2288 (7)	2297 (7)	2828 (6)	2729 (6)	2460 (6)	2527 (6)
3	2009-10	AICRP-RM 2010 PB33 (IVT), PB40 (AVT), PB52 (IHT)	2340 (6)	2428 (6)	2141 (7)	2160 (7)	2107 (7)			
4	2010-11	AICRP-RM 2011 PB33 (IVT), PB40 (AVT), PB54 (IHT), PB58 (AHT)	2500 (7)	2294 (7)	2193 (7)	2239 (7)	2515 (5)		2329 (6)	2378 (6)
5	2011-12	AICRP-RM 2012 PB31 (IVT), PB38 (AVT), PB47 (IHT)	2444 (7)	2619 (7)	2197 (7)	2145 (7)	2283 (5)			
6	2012-13	AICRP-RM 2013 PB41 (IVT), PB46 (AVT), PB63 (IHT)	2349 (7)	2398 (7)	2072 (5)	2182 (5)	2109 (5)			
7	2013-14	AICRP-RM 2014 PB51 (IVT), PB56 (AVT), PB72 (IHT)	2398 (6)	2495 (6)	2648 (5)	2418 (5)	2637 (4)			
8	2014-15	AICRP-RM 2015 PB47 (IVT), PB52 (AVT), PB66 (IHT)	2165 (6)	2285 (6)	2134 (3)	2227 (3)	1991 (7)	2185 (7)		
Mean Seed Yield			**2298 (51)**	**2359 (51)**	**2167 (47)**	**2163 (47)**	**2271 (43)**	**2309 (17)**	**2148 (16)**	**2294 (16)**

*Values in parenthesis indicates the number of testing locations

Conclusions

- Yield of national check Kranti and zonal check RL-1359 are very similar in IVT, AVT, IHT and AHT trials conducted since 2007.

Table 2. Comparison of Kranti (NC) and Maya (ZC) for mean seed yield in AICRP on Rapeseed-Mustard in IVT, AVT, IHT and AHT trials in Zone III

S. No.	Year of Testing	References:	IVT (1.5 x 5 = 7.5 m^2)		AVT (2.7 x 5 m = 13.5 m^2)		IHT (2.25 x 5m = 11.25 m^2)		AHT (4.05 x 5 m = 20.25 m^2)	
			Kranti (NC) Kg/ha	Maya (ZC) Kg/ha	Kranti (NC) Kg/ha	Maya (ZC) Kg/ha	Kranti (NC) Kg/ha	Maya (ZC) Kg/ha	Kranti (NC) Kg/ha	Maya (ZC) Kg/ha
1	2007-08	AICRP-RM 2008 PB38 (IVT), PB54 (IHT), PB57 (AHT)	2034 (6)				1947 (7)	2062 (7)	1681 (7)	1829 (7)
2	2008-09	AICRP-RM 2009 PB38 (IVT), PB55 (IHT), PB58 (AHT)	1605 (5)	1636 (5)			1557 (6)		1586 (6)	1460 (6)
3	2009-10	AICRP-RM 2010 PB35 (IVT), PB41 (AVT), PB54 (IHT), PB56 (AHT)	1704 (8)	1558 (8)	1663 (8)	1707 (8)	1626 (7)		1800 (7)	1699 (7)
4	2010-11	AICRP-RM 2011 PB35 (IVT), PB41 (AVT), PB56 (IHT)	2137 (6)	2011 (6)	2220 (6)	2119 (6)	2092 (6)			
5	2011-12	AICRP-RM 2012 PB33 (IVT), PB49 (IHT)	1842 (5)	1709 (5)			2062 (6)			
6	2012-13	AICRP-RM 2013 PB43 (IVT), PB49 (AVT), PB64 (IHT)	1632 (6)	1597 (6)	1600 (6)	1661 (6)	1940 (6)			
7	2013-14	AICRP-RM 2014 PB53 (IVT), PB57 (AVT), PB73 (IHT)	1620 (4)	1952 (4)	1604 (3)	1443 (3)	1971 (5)			
8	2014-15	AICRP-RM 2015 PB49 (IVT), PB53 (AVT), PB68 (IHT)	1941 (4)	1974 (4)	1516 (3)	1579 (3)	1927 (4)			
Mean Seed Yield			**1817 (44)**	**1748 (38)**	**1753 (26)**	**1746 (26)**	**1883 (47)**	**2062 (7)**	**1694 (20)**	**1673 (20)**

Values in parenthesis indicate the number of testing locations

Conclusions

- Yield of national check Kranti and zonal check Maya are very similar in IVT, AVT, IHT and AHT trials conducted in Zone III.

Annexure 4

Contains a Table (Table 3) giving data on performance of GM hybrid DMH-11 and its parental lines. Variety RL-1359 was the zonal check at six out of eight locations, Maya was zonal check at one location.

Table 3. Mean seed yield (Kg/Ha) of DMH-11 in BRL-1 (2010-11) & BRL-II (2011-12) trials

S.No.	Variety	Mean seed yield kg/ha			Weighted mean	% increase of DMH-11 over
		2010-11	2011-12	2014-15		
1	Varuna	2093 (3)	2272 (2)	1887 (3)	2060 (8)	27.4
2	Varuna (barnase)	2096 (3)	2291 (2)	1861 (3)	2060 (8)	
3	EH-2	1897 (3)	1741 (2)	1378 (3)	1664 (8)	
4	EH-2 (barstar)	2009 (3)	1611 (2)	1558 (3)	1740 (8)	
5	Maya/RL-1359 (ZC)	2037 (3)	2016 (2)	1776 (3)	1933 (8)	35.8
6	DMH-11	2600 (3)	3025 (2)	2386 (3)	2626 (8)	

Values in parenthesis indicate the number of testing locations

- Plot size in the BRL trials was $45m^2$ whereas the plot size in AICRP AVT trials is $13.5m^2$ and AHT trials is $20.25m^2$. Larger plot size gives more accurate yield data.
- Trials in 2010-11 and 2011-12 were conducted at Navgaon, Kumher and Sriganganagar.
- Trials in 2014-15 were conducted at Delhi, Ludhiana and Bhatinda.

Conclusions

- DMH-11 has significant yield advantage over zonal checks and mega variety Varuna.

Annexure 5

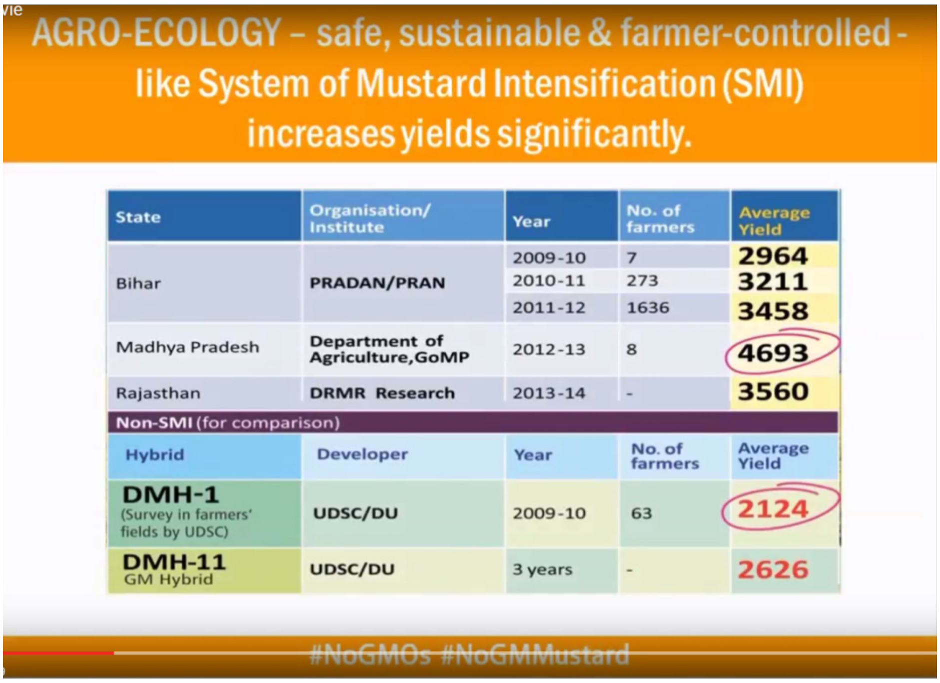
Contains the following Figures and Tables.

Fig 2 - Showing improper comparison between mustard grown under SMI with yields of DMH-1 and DMH-11.

Fig 3 - A misleading comparison of yields of DMH-11 with other hybrids developed using non-GM (CMS) systems.

Table 4 - Original data from NDDB/CGMCP trials showing yield potential of DMH series of hybrids – all DMH hybrids are based on crosses between Indian x east European lines.

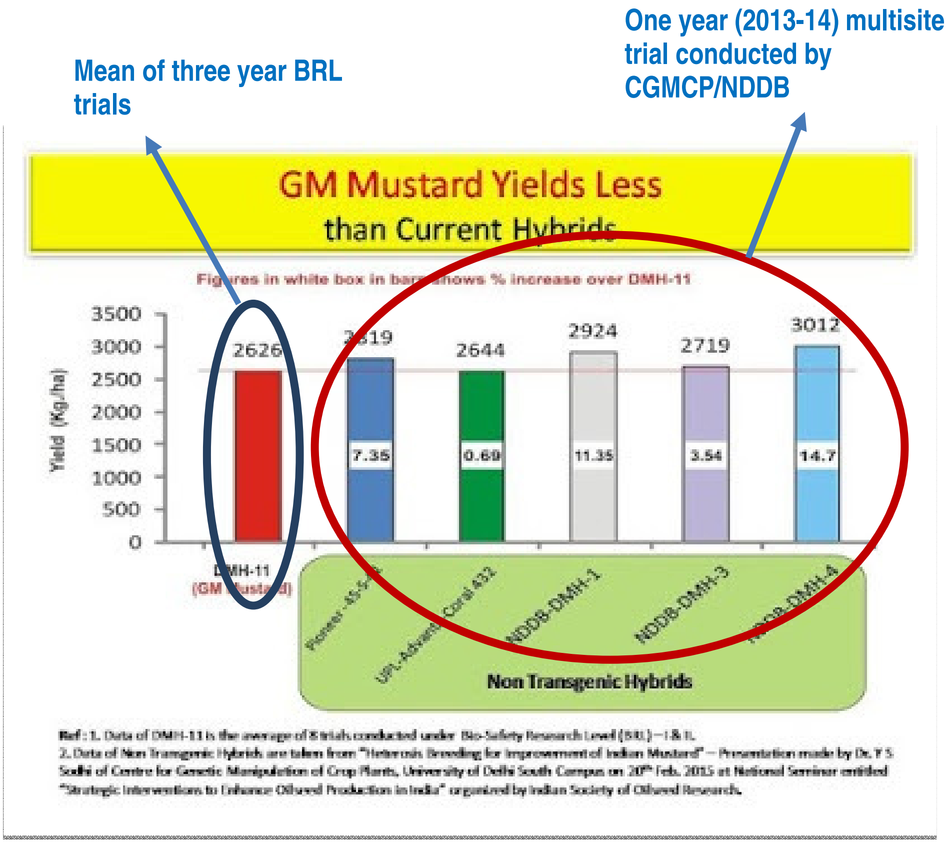
Figure 2. There are alternate methods of yield increase like SMI – System of Mustard Intensification



State	Organisation/ Institute	Year	No. of farmers	Average Yield
Bihar	PRADAN/PRAN	2009-10	7	2964
		2010-11	273	3211
		2011-12	1636	3458
Madhya Pradesh	Department of Agriculture,GoMP	2012-13	8	4693
Rajasthan	DRMR Research	2013-14	-	3560
Non-SMI (for comparison)				
Hybrid	Developer	Year	No. of farmers	Average Yield
DMH-1 (Survey in farmers' fields by UDSC)	UDSC/DU	2009-10	63	2124
DMH-11 GM Hybrid	UDSC/DU	3 years	-	2626

- **Yields upto 4.7 tons/hectare are nothing short of a miracle.**
- **If such a system exists why the farmers have not adopted it?**
- **We believe this data is not authentic. The comparisons are completely misleading.**

Figure 3. Hybrid DMH-11 yields lower than non-GM hybrids



Business Standard: May 16, 2017 by Devinder Sharma and many other write ups

- Yield data of non-transgenic hybrids is from a trial conducted by CGMCP/NDDB in the year 2013-14 (data sheet is attached).
- DMH-11 was not part of this trial. As GM material, it could not have been put in a general trial.
- Yield trial of 2013-14 was conducted as per AICRP-RM guidelines (each replication is of $20.25m^2$).
- Yield data of DMH-11 is the mean of BRL-I and BRL-II trials conducted over three years and three locations each year. Plot size of each replication is $45m^2$.
- Data from trials conducted in different years and different locations cannot be compared directly – only trends can be discerned. In the CGMCP/NDDB trial, percent yield increase of DMH-4 over zonal check is 18.35% and over national check Kranti is 29.38%. In the BRL trials yield increase of DMH-11 over zonal checks is 35.8%.
- This figure is an example of wrong interpretation of data with the sole aim to mislead.

Table 4. Performance of non GM hybrids vs zonal check and national check in a trial conducted by CGMCP scientists with support from NDDB in year 2013-14 (seed yield Kg/ha)

S. No.	Name of the Entry	Alwar	Delhi	SGNR	Palanpur	Mean	% over DMH-1	% over ZC	% over Kranti
1	Shraddha MRR 8012	1685	2073	2183	2506	2112	-27.8	-17.02	-9.28
2	Bayer ProAgro 5121	2169	2246	2451	2332	2300	-21.4	-9.27	-1.22
3	Bayer ProAgro 5222	2283	2301	2486	2348	2355	-19.5	-7.47	1.16
4	Pioneer 45-S-31 (hybrid)	2127	2720	2654	2643	2536	-13.3	-0.35	8.98
5	Pioneer 45-S-42 (hybrid)	2546	2926	2678	3125	2819	-3.6	10.77	21.09
6	UPL-Advanta-Coral 432 (hybrid)	2564	3056	2761	2194	2644	-7.6	3.89	13.57
7	UPL-Advanta-PAC 437 (Hybrid)	2394	2873	2745	2478	2623	-10.3	3.06	12.67
8	Dhanya Seeds 999	2177	2718	2695	2573	2541	-13.1	-0.16	9.15
9	NDDB DMH-3 (hybrid)	2300	3085	2750	2740	2719	-7	6.84	16.8
10	NDDB DMH-4 (hybrid)	2683	3143	2937	3286	3012	3	18.35	29.38
11	NDDB DMH-1 (Check for hybrid)	2539	3179	2913	3066	2924	0	14.89	25.6
12	NRCHB 506 (Check for hybrid)	2025	2037	2574	2376	2256	-22.9	-11.36	-3.09
13	Zonal check (NRCDR-2,RGN-73, Bio-902) zonal check (ZC)	2445	2586	2445	2703	2545	-13	-	9.32
14	Kranti (NC)	2091	2436	2144	2642	2328	-20.4	-8.53	-

- The data was presented by CGMCP scientist Dr Y S Sodhi in a ICAR meeting and has been picked by activists from the slide presented by Dr Sodhi.

- The Table shows that DMH series of hybrids yield higher than zonal and national checks. These hybrids and DMH-11 have been developed by crosses between Indian gene pool lines and east European gene pool lines. DMH-1, DMH-3 and DMH-4 are based on CMS system 126-1 developed by CGMCP. The difficulty is in large scale production of hybrid seed using CMS 126-1 as it works only in Pusa bold – but here also sterility breaks down at low temperatures. DMH-11 was not entered in this trial as GM materials as per the rules require different trial arrangements.

- The barnase/barstar system currently is the most robust system of hybrid seed production as it allows production of hybrids between any two parents with very high purity.

Annexure 6

Yield data on some of the new varieties of mustard released by ICAR.

Table 5a - Yield performance of some of the new varieties in zone-II – both pre-release and post-release performance is given.

Table 5b - Yield performance of a new varieties for zone-III – both pre-release and post-release data is provided.

Table 5a. Comparison of pre and post release seed yield of new varieties tested in AICRP trials of Zone II

New Variety	Trial stage	year of testing	Reference	New Variety kg/ha	Kranti (NC) kg/ha	RL-1359 (ZC) kg/ha	% over Kranti
NRCDR-2 (2007)	IVT pre release	2003-04	AICRP-RM 2004 PB34	2626 (5)	2252 (5)	2538 (5)	
			Mean seed Yield	**2626 (5)**	**2252 (5)**	**2538 (5)**	**16.61**
	IVT post release	2009-10	AICRP-RM 2010 PB33	2290 (6)	2340 (6)	2428 (6)	
		2010-11	AICRP-RM 2011 PB33	2537 (7)	2500 (7)	2294 (7)	
		2011-12	AICRP-RM 2012 PB31	2421 (7)	2444 (7)	2619 (7)	
		2012-13	AICRP-RM 2013 PB41	2265 (7)	2349 (7)	2398 (7)	
			Mean seed Yield	**2382 (27)**	**2411 (27)**	**2435 (27)**	**-1.22**
	AVT pre release	2004-05	AICRP-RM 2005 PB43	1951 (6)	1783 (6)	1544 (6)	
		2005-06	AICRP-RM 2006 PB49	2142 (7)	1837 (7)	1861 (7)	
			Mean seed Yield	**2054 (13)**	**1812 (13)**	**1714 (13)**	**13.35**
	AVT post release	2010-11	AICRP-RM 2011 PB40	2247 (7)	2193 (7)	2239 (7)	
		2011-12	AICRP-RM 2012 PB39	2087 (7)	2197 (7)	2145 (7)	
		2013-14	AICRP-RM 2014 PB56	2638 (5)	2648 (5)	2418 (5)	
			Mean seed Yield	**2291 (19)**	**2314 (19)**	**2251 (19)**	**-1.00**
RH-749 (2013)	IVT pre release	2009-10	AICRP-RM 2010 PB33	2826 (6)	2340 (6)	2428 (6)	
			Mean seed Yield	**2826 (6)**	**2340 (6)**	**2428 (6)**	**20.77**
	IVT post release	2013-14	AICRP-RM 2014 PB51	2611 (6)	2385 (6)	2497 (6)	
		2015-16	AICRP-RM 2016 PB57	2172 (7)	2342 (7)		
		2016-17	AICRP-RM 2017 PB	2648 (8)	2378 (8)		
			Mean seed Yield	**2482 (21)**	**2372 (21)**	**2497 (6)**	**4.64**
	AVT pre release	2010-11	AICRP-RM 2011 PB40	2487 (7)	2193 (7)	2239 (7)	
		2011-12	AICRP-RM 2012 PB38	2419 (7)	2197 (7)	2145 (7)	
			Mean seed Yield	**2454 (14)**	**2195 (14)**	**2192 (14)**	**11.80**
	AVT post release	2014-15	AICRP-RM 2015 PB52	2326 (3)	2134 (3)	2227 (3)	
		2016-17	AICRP-RM 2017 PB	2162 (5)	2177 (5)		
			Mean seed Yield	**2223 (8)**	**2161 (8)**	**2227 (3)**	**2.87**
Giriraj (2013)	IVT pre release	2010-11	AICRP-RM 2011 PB33	2757 (7)	2500 (7)	2294 (7)	
			Mean seed Yield	**2757 (7)**	**2500 (7)**	**2294 (7)**	**10.28**
	IVT post release	2014-15	AICRP-RM 2015 PB47	2477 (6)	2165 (6)	2285 (6)	
		2015-16	AICRP-RM 2016 PB57	2514 (7)	2342 (7)		
		2016-17	AICRP 2017 PB	2425 (8)	2378 (8)		
			Mean seed Yield	**2470 (21)**	**2305 (21)**	**2285 (6)**	**7.16**
	AVT pre release	2011-12	AICRP-RM 2012 PB38	2414 (7)	2197 (7)	2145 (7)	
		2012-13	AICRP-RM 2013 PB46	2246 (5)	2072 (5)	2182 (5)	
			Mean seed Yield	**2344 (12)**	**2145 12)**	**2160 (12)**	**9.28**
	AVT post release	2016-17	AICRP 2017 PB	2236 (5)	2177 (5)		
			Mean seed Yield	**2236 (5)**	**2177 (5)**		**2.71**

Values in parenthesis indicate the number of testing location

Conclusions

- In all the varieties, the post release trials show a considerable decline in yield advantage over the national check Kranti. In post release trials the yield advantage of NRCDR-2 dipped to -1.22 % in IVT and -1.00 in AVT, yield advantage of RH-749 dipped to 4.64 % in IVT and 2.87 % in AVT and of Giriraj dipped to 7.16 % in IVT and 2.71 % in AVT over Kranti (NC).

Table 5b. Comparison of pre and post release seed yield of new variety tested in AICRP trials of Zone III

New Variety	Trial stage	year of testing	Reference	New Variety kg/ha	Kranti (NC) kg/ha	Maya (ZC) kg/ha	% over Kranti
RGN-73 (2007)	IVT pre release	2002-03	AICRP-RM 2003 PB31	1771 (6)	1435 (6)	1421 (6)	
		Mean seed Yield		**1771 (6)**	**1435 (6)**	**1421 (6)**	**23.41**
	IVT post release	2009-10	AICRP-RM 2010 PB35	1691 (8)	1704 (8)	1558 (8)	
		2010-11	AICRP-RM 2011 PB35	2367 (6)	2137 (6)	2011 (6)	
		2011-12	AICRP-RM 2012 PB33	1875 (5)	1842 (5)	1709 (5)	
		2012-13	AICRP-RM 2013 PB43	1710 (6)	1632 (6)	1597 (6)	
		2013-14	AICRP-RM 2014 PB53	1703 (4)	1620 (4)	1952 (4)	
		2014-15	AICRP-RM 2015 PB49	2082 (4)	1941 (4)	1974 (4)	
		2015-16	AICRP-RM 2016 PB59	1788 (5)	1848 (5)	1749 (5)	
		Mean seed Yield		**1882 (38)**	**1814 (38)**	**1762 (38)**	**3.75**
	AVT pre release	2003-04	AICRP-RM 2004 PB42	2226 (6)	1988 (6)		
		2004-05	AICRP-RM 2005 PB44	2069 (6)	1772 (6)	1656 (6)	
		Mean seed Yield		**2147 (12)**	**1880 (12)**	**1656 (6)**	**14.20**
	AVT post release	2010-11	AICRP-RM 2011 PB41	2288 (6)	2220 (6)	2119 (6)	
		2012-13	AICRP-RM 2013 PB49	1621 (6)	1600 (6)	1661 (6)	
		2013-14	AICRP-RM 2014 PB57	1623 (3)	1604 (3)	1443 (3)	
		2014-15	AICRP-RM 2015 PB53	1872 (3)	1516 (3)	1579 (3)	
		2015-16	AICRP-RM 2016 PB62	1631 (3)	1597 (3)	1340 (3)	
		Mean seed Yield		**1849 (21)**	**1765 (21)**	**1703 (21)**	**4.76**

Values in parenthesis indicate the number of testing locations

Conclusions

- The post release trials show a considerable decline in yield advantage over the national check Kranti. In post release trials the yield advantage of RGN-73 dipped to 3.75 % in IVT and 4.76 % in AVT over Kranti (NC). However, RGN-73 seems to have some superiority.

Annexure 7

Contains a Table (Table 6) showing DAC's (Department of Agriculture and Cooperation) indent for breeder seed of different varieties over the last seven years.

Table 6. Quantity of the breeder seed Indented of Centrally released varieties in quintals

Year of seed Production	Reference :	Varuna (1976)	Kranti (1983)	RH-30 (1983)	Pusa Bold (1984)	Rohini (1986)	Pusa Jai Kissan (1993)	Maya (2003)	NRCDR-2 (2007)	RGN-73 (2007)	RH-749 (2013)	Giriraj (2013)
2009-10	**AICRP-RM 2010 PB 19**	1.71	0.55	2.98	12.15	1.42	3.38	1.55	0.20	0.47	-	-
2010-11	**AICRP-RM 2011 PB 19**	3.76	1.30	2.23	8.32	0.74	4.89	1.30	0.53	0.59	-	-
2011-12	**AICRP-RM 2012 PB 18-19**	2.21	1.90	2.16	3.62	1.08	3.79	0.15	0.10	0.41	-	-
2012-13	**AICRP-RM 2013 PB 21-22**	10.26	5.40	2.16	16.18	1.08	6.34	1.65	0.30	0.41	-	-
2013-14	**AICRP-RM 2014 PB 32-34**	1.18	1.40	1.70	13.71	1.53	3.14	0.25	0.10	0.5	0.04	-
2014-15	**AICRP-RM 2015 PB 24-26**	11.40	0.05	1.84	30.21	3.16	1.66	0.15	0.8	0.27	0.26	0.22
2015-16	**AICRP-RM 2016 PB 31-32**	3.06	0.00	1.59	7.91	2.43	2.43	0.15	1.6	0.17	0.65	0.02
Mean		**5.21**	**0.48**	**1.71**	**17.28**	**2.37**	**2.41**	**0.18**	**0.83**	**0.31**	**0.32**	**0.12**

Conclusions

- In the last seven years maximum demand seems to be for Pusa bold followed by Varuna.
- There is very poor demand for the four new releases – NRCDR-2, RGN-73, RH-749 and Giriraj. Is it due to poor extension or is there some problem with these varieties?

Annexure 8

Contains data on yield trends in mustard in India and a comparison of rapeseed/mustard yields in Canada, China and India.

Fig 4 - Yield trend in mustard in India since 1982-83.

Fig 5 - Three country yield comparison of rapeseed/mustard.

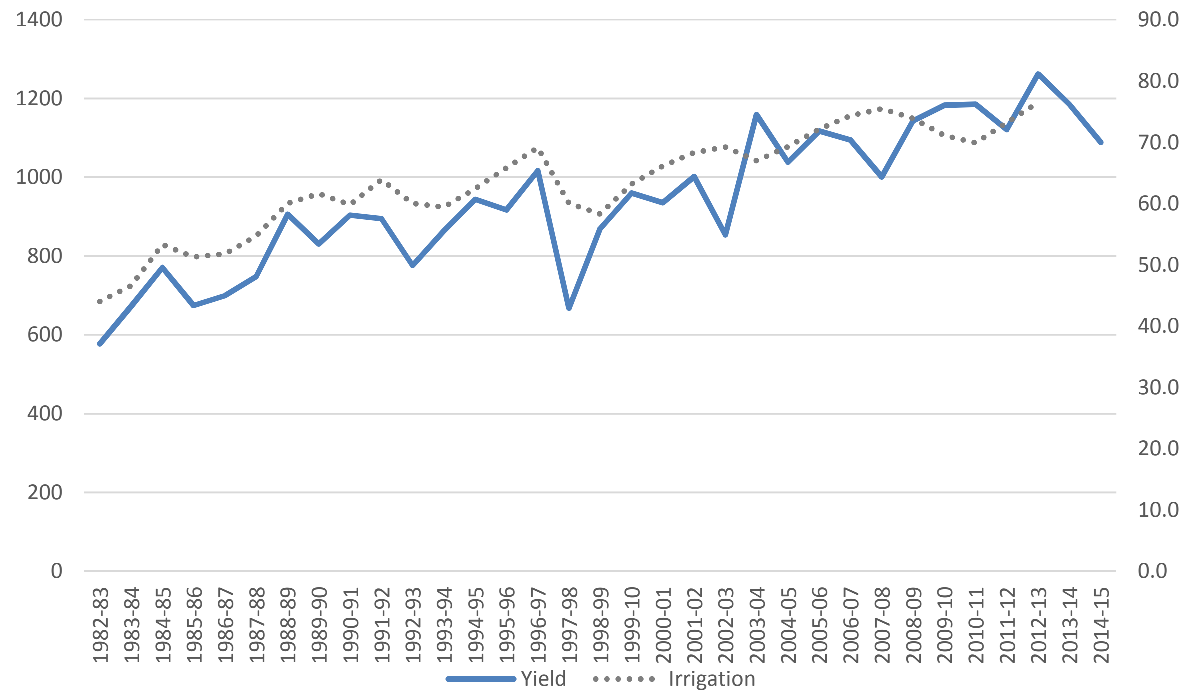


Figure 4. All-India yield (Kg/Hectare) alongwith area under irrigation (%)

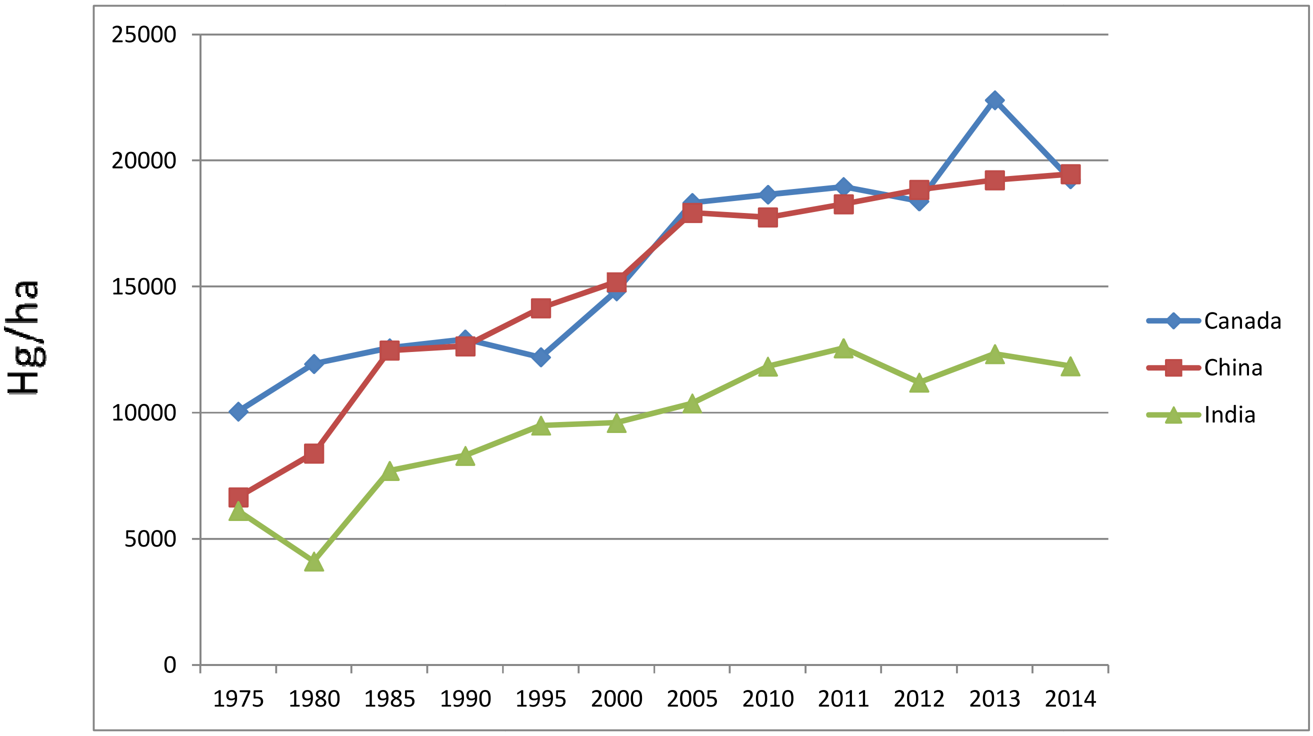


Figure 5. Three country comparison of rapeseed mustard yield (data from FAO stats)

Annexure 9

Contains data on export of GM Canola oil, seed and meal from Canada to different countries all over the world (Table 7 a b c).

Table 7a. Oil exports (Historic) - Canada

(000 Tonnes)

Country	Year													
	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2016
China	12	0	262	130	58	265	233	440	963	564	1003	855	501	596.8
Columbia	0	0	0	1	1	0	2	2	3	7	3	2	4	5.8
EU-27	5	22	0	49	193	56	0	0	28	183	31	10	7	37.4
Hong Kong	5	2	7	20	20	26	9	30	25	24	37	8	30	38.1
India	7	0	0	0	0	0	0	0	1	0	16	2	1	35.3
Iraq	0	0	0	0	0	0	0	0	16	0	0	0	0	0
Japan	3	0	10	24	4	10	12	8	6	23	18	10	5	7.6
Malaysia	0	2	5	20	26	15	27	5	17	26	24	3	12	64.0
S. Korea	28	2	8	19	20	18	39	30	38	66	56	30	76	113.0
Taiwan	15	3	17	37	24	22	4	18	12	12	15	18	9	16.6
U.S.A.	333	370	454	479	666	710	1005	971	1058	1492	1397	1227	1540	1871.4
Others	4	9	220	51	31	32	30	7	9	91	65	66	144	6.9
TOTAL	412.7	409.3	982.8	829.8	1043.6	1153.6	1361.0	1509.6	2175.4	2487.3	2664.3	2261.1	2329.4	2873.2

*Numbers may be off due to rounding.

Table 7b. Seed exports (Historic) - Canada

Historic Canadian Canola Seed Exports (000 Tonnes) Calendar Year (January - December), Crop Year (August 1 to July 31)													
	2002 Cal. Yr.	2003 Cal. Yr.	2004 Cal. Yr.	2005 Cal. Yr.	2006 Cal. Yr.	2007 Cal. Yr.	2008 Cal. Yr.	2009 Cal. Yr.	2010 Cal. Yr.	2011 Cal. Yr.	2012 Cal. Yr	2013 Cal. Yr	2016 Cal. Yr.
Bangladesh	0	13	22	23	87	106	87	105	187	152	147	10	112.3
China	66	319	269	310	391	601	1476	3140	1520	1334	2987	2670	3542.5
EU-27	8	2	1	0	1	2	2	96	129	337	101	44	597.2
Japan	1508	1681	1620	1885	1923	1915	2197	1961	2107	2328	2349	2312	2280.6
Mexico	489	693	1081	1009	1045	1114	1282	1073	1485	1443	1543	1391	1477.7
Pakistan	0	398	4	97	443	420	94	387	703	813	228	0	1346.4
U.A.E.	0	0	0	34	330	217	505	306	773	803	534	233	629.9
U.S.A.	135	112	442	440	727	630	961	560	551	668	414	401	504.9
Others	1	22	1	2	176	10	56	2	13	12	30	30	45.9
TOTAL	2206.0	3241.5	3440.1	3797.4	5122.1	5014.1	6661.0	7630.2	7469.7	7890.0	8333.0	7090.4	10537.4

*Numbers may be off due to rounding.

Source: Canadian International Merchandise Trade Database - Statistics Canada

Table 7c. Meal exports (Historic) - Canada

Total Canadian Canola Meal (230641 + 230649) (000 Tonnes)
Calendar Year, Crop Year - August 1st to July 31st

	2002 Cal. Yr.	2003 Cal. Yr.	2004 Cal. Yr.	2005 Cal. Yr.	2006 Cal. Yr.	2007 Cal. Yr.	2008 Cal. Yr.	2009 Cal. Yr.	2010 Cal. Yr.	2011 Cal. Yr.	2012 Cal. Yr.	2013 Cal. Yr.	2016 Cal Yr
China	0	0	0	0	0	0	1	33	825	586	303	77	656.7
EU-27	0	31	37	18	0	24	10	7	40	61	72	90	20.6
Indonesia	0	0	0	0	0	1	0	9	7	0	1	2	0.8
Mexico	0	0	13	0	0	9	35	161	153	65	66	32	27.2
S. Korea	0	0	0	0	0	0	0	0	23	0	0	0	0
Taiwan	1	20	27	16	9	9	9	6	7	4	1	1	0
Thailand	0	0	6	7	0	1	0	41	18	22	42	42	77.8
U.S.A.	756	1075	1445	1361	1505	1542	1837	1468	1347	2337	2879	3060	3590.2
Vietnam	0	0	0	0	0	1	0	26	47	15	57	68	11.4
Others	8	1	11	10	15	2	1	0	6	10	24	35	0
TOTAL	764.8	1126.7	1538.7	1412.2	1528.6	1589.4	1892.7	1751.5	2472.2	3100.4	3347.1	3409.9	4384.7

*Numbers may be off due to rounding.

Source: Canadian International Merchandise Trade Database - Statistics Canada

Annexure 10

Contains Table 8 showing yield of major oil seed crops of the country during the past ten years.

Table 8. All India area and yield of six oilseed crops

Area ('000 Hectares)

Crop	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15*
Soybean	7708	8329	8882	9511	9735	9601	10109	10841	11716	11086
Rapeseed & Mustard	7277	6790	5826	6298	5588	6901	5894	6363	6646	5791
Groundnut	6740	5620	6300	6200	5478	5856	5264	4721	5505	4685
Sunflower	2340	2170	1910	1800	1477	929	732	831	672	552
Sesame	1723	1703	1799	1809	1942	2083	1902	1706	1679	1778
Safflower	365	377	320	292	288	244	250	184	178	211

Yield (Kg/Hectare)

Crop	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15*
Groundnut	1185	865	1460	1163	991	1411	1323	997	1764	1400
Rapeseed & Mustard	1117	1095	1001	1143	1183	1185	1121	1262	1185	1089
Soybean	1073	1063	1235	1041	1024	1327	1208	1353	1012	950
Safflower	627	637	703	649	621	617	580	591	638	457
Sunflower	615	567	764	639	576	701	706	655	750	752
Sesame	372	363	421	354	303	429	426	402	426	456

Sources: Database on Oilseeds Area, Production and Productivity hosted by Indian Institute of Oilseeds Research; AGRICULTURE- Statistical Year Book India 2016 (Ministry of Statistics and Programme Implementation)
*Fourth Advance Estimates of Yield of Commercial Crops During 2014-15

Conclusions

- Area under all oilseeds is decreasing except for soybean. Area under sunflower has declined very sharply.
- No significant yield increase has occurred in any of the oilseed crops since 2005-06. While groundnut and soybean are kharif crops and dependent upon rains – mustard yields are stagnating inspite of increasing irrigation facilities for this rabi season crop.

Annexure 11

Contains data on domestic production and imports of vegetable oils by India (Table 9).

Table 9. Domestic Production and Imports of Vegetable Oil
Source : Dept. of Agri and Dept. of Commerce, GOI

Year	Domestic Production MMT	Veg. Oil Imports MMT	Total Consumption MMT	Import Rs in Crore
1996-97	7.13	1.41	8.54	2929
1997-98	6.06	1.27	7.33	2765
1998-99	6.96	2.62	9.58	7589
1999-00	6.02	4.20	10.22	8046
2000-01	5.50	4.18	9.68	6093
2001-02	6.15	4.32	10.47	6465
2002-03	4.66	4.37	9.03	8780
2003-04	7.14	5.29	12.43	11683
2004-05	7.25	4.75	12.00	11077
2005-06	8.32	4.29	12.61	8961
2006-07	7.37	4.27	11.64	9540
2007-08	8.65	4.90	13.55	10301
2008-09	8.46	6.72	15.18	15838
2009-10	7.95	8.03	15.98	26483
2010-11	9.78	6.91	16.69	29860
2011-12	8.96	8.45	17.41	46255
2012-13	9.22	11.01	20.23	61107
2013-14	10.06	10.43	20.49	56776
2014-15	8.80	12.46	21.26	65184
2015-16				68927