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THERE IS NO NEED FOR GENETICALLY MODIFIFED MUSTARD

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#338, 8th Cross, Wilson Garden
Bangalore 560025, Karnataka, India
T: +91 80 42821010 F: +91 80 41154862
E: supporter.services.in@greenpeace.org
www.greenpeaceindia.org

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Acknowledgements:
Dr. Janet Cotter, Shivani Shah

Design and Layout:
Jyoti Mardi

Contact:
shivani.shah@greenpeace.org

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GENETICALLY MODIFIED mustard is not needed

The proposal to allow cultivation of the genetically modified (GM) oilseed mustard (*Brassica juncea*) DMH-11 (also tolerant to the herbicide, glufosinate ammonium) is based on the paradigm that conventional breeding techniques cannot produce hybrids with sufficient yields[1]. However, this paradigm doesn't take into account recent advances with either conventional breeding or the production of hybrid varieties, both of which can produce high-yielding varieties.

GENETIC ENGINEERING is not needed to produce hybrid varieties

The use of hybrid varieties to increase crop yields is not new[2]. Maize, wheat and rice hybrid varieties are commonly grown throughout the world. All these hybrids are non-GM.

Genetic engineering is not necessary to produce hybrids. Essentially, hybrid plants are developed simply by crossing two parents of different varieties that result in an offspring (a hybrid) with increased vigour.

There are many ways to produce these hybrids in non-GM plant breeding. One method that is common in the mustard family of plants (brassicas) is to produce a male sterile plant so that it must be pollinated by a different plant to give an offspring from two parents. In mustard, the male sterile plant can be a naturally occurring variety[3].

The genetic engineering in the GM mustard aims to short cut the development of hybrids using male sterility by the insertion of genes known as the "bar/barnase" system.

A study comparing yields between North America and Western Europe found that the yield gap in oilseed rape between Canada and Western Europe had increased since in adoption of GM oilseed rape in Canada, with the non-GM Western Europe giving higher yields[5].

Genetic engineering using bar/barnase genes in the GM mustard is not a new technology. It was used in one of the first GM crops (oilseed rape, *B. napus*), to be approved for cultivation in Canada in 1995, over 20 years ago[4] and is one of the main GM varieties grown there.

A study comparing yields between North America and Western Europe found that the yield gap in oilseed rape between Canada and Western Europe had increased since in adoption of GM oilseed rape in Canada, with the non-GM Western Europe giving higher yields[5].

This means that Canadian adoption of the GM technology used in GM Indian mustard has not resulted in yield increases beyond those seen in non-GM Western Europe, and could even have resulted in lower yield increases.

Similarly, although increases in yield for GM herbicide - tolerant oilseed rape were reported in the USA, these were thought to be predominantly related to the breeding stock (germplasm) used and the herbicide regime employed[6] .

In Canada and other countries where it is grown, GM oilseed rape containing the bar/barnase genes (i.e. the same GM technology as the GM Indian mustard) is marketed as a herbicide tolerant GM crop - "LibertyLink"[7]. LibertyLink is a reference to the tolerance of the GM crop to the herbicide glufosinate ammonium, which is sold under the trade name of Liberty, or Basta[8] in India.

MONITORING of herbicide use with GM Mustard is NOT POSSIBLE

Glufosinate ammonium is restricted in the European Union[9] because of concerns regarding its toxicity, particularly to small mammals. However, it is sold in India and approved for use in tea and cotton cultivation[10]. This means that, though the GM mustard may not be marketed as herbicide tolerant, farmers may use it as a GM herbicide crop, entailing all the problems of GM herbicide tolerant crops and associated herbicides that are found in countries where these crops are grown such as the USA[11], for instance increases in herbicide-tolerant weeds.

Monitoring herbicide usage associated with the GM herbicide-tolerant mustard in the Indian scenario would not be possible because there is no requirement to report such pesticide usage. For example, a recent Greenpeace study found that over half of the pesticides found in samples of tea were not registered for use in the cultivation of tea[12].

Moreover, GM herbicide-tolerant (HT) crops are unsustainable and not suited to agriculture in India. The Supreme Court's Technical Expert Committee (TEC) in 2013 gave a strong recommendation: "The second largest number of applications were for HT crops. The TEC has examined the issues in relation to HT, particularly with regard to sustainability and the likely socio-economic impact on major sections of rural society. On both these counts, based on the reasons presented in the section on Herbicide Tolerance, the conclusion of the TEC is that HT crops would most likely exert a highly adverse impact over time on sustainable agriculture, rural livelihoods, and environment. The TEC finds them completely unsuitable in the Indian context[13]."

There remain considerable concerns over the environmental and human health safety of GM crops. Long-term environmental and health monitoring programmes either do not exist or are inadequate.

With increased investment in non-GM hybrid production, rather than further investment in genetic engineering, the production of reliable, high-yielding hybrid varieties seems highly likely.

ADVANCES IN SCIENCE –

non-GM Hybrids and Marker Assisted Selection (MAS)

In the last decade, there have been major advances in conventional plant breeding, including the production of non-GM hybrids of Indian mustard, *B. juncea*[14]. High-yielding, non-GM hybrids of related mustard oilseed crops *B. napus* and *B. rapa.* are commonly grown throughout the world and the development of non-GM hybrids of Indian mustard is gathering pace.

Four non-GM hybrids of Indian mustard (NRCHB-506, DMH-1, CORAL-432 (PAC-432) and CORAL-437 (PAC 437)) were released in India between 2008 and 2011, with more expected in the coming years[15]. These new hybrids give about 10-15% yield increases compared to the non-hybrid parents[16]. In addition, new non-GM hybrid systems have recently been developed with "significant potential"[17]. It's not possible to say how the yields of the GM mustard would compare to these modern high-yielding hybrids as no comparative studies have been performed. The yields of the GM mustard have only been compared to the non-hybrid parents (Varuna and EH2) and one non-hybrid variety (Maya – RL1359)[18], not to modern high-yielding hybrids.

It's reported that some of the non-GM hybrids developed so far do not operate well under cold conditions, e.g. frosts. However, non-GM hybrids of oilseeds are widely used in cold climates, e.g. Canada and N. Europe, so this is not a fundamental limitation of non-GM hybrid development but a problem that can be solved with more development. Far from being "stuck"[19], it appears that the development of non-GM mustard hybrids is producing promising results. With increased investment in non-GM hybrid production, rather than further investment in genetic engineering, the production of reliable, high-yielding hybrid varieties seems highly likely.

Another breeding method, marker assisted selection (MAS) can also be used to increase yields. MAS is high-tech conventional breeding. It uses advances in DNA sequencing to locate genetic markers that are linked to desired qualities (in this case yield) which then enables breeders to develop plants with these desired traits through non-GM, conventional breeding[20]. Although most work, to date, has been on increasing yields in rice, MAS could be applied to Indian mustard. MAS can be a powerful way of using genes from wild relatives through conventional breeding. For example, breeding in a gene from a wild rice into popular rice varieties boosted rice yields by up to 36%[21]. Investment in modern conventional breeding techniques can deliver substantial increases in yield. Genetic engineering is not necessary to increase yields. However, it is not only what is grown, but how it is grown.

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YIELD INCREASES THROUGH ECOLOGICAL FARMING METHODS

Yields do not only depend on the crop variety planted, but also on the farming techniques used. The use of fertilisers and pesticides (herbicides and insecticides) lock farmers onto a pesticide treadmill. Pesticides have consequences for water quality, soil, they can disrupt ecosystems, and have implications for the consumer in terms of pesticide residues in food[22]. In particular, for Indian mustard, there is research suggesting that low-input techniques can raise yields considerably[23]. Many of these are consistent with both ecological farming and suited to low-income farmers and include

- **Use of green manures prior to sowing mustard as organic fertiliser**
- **Inter-cropping of mustard with potato, wheat or barley, followed by only mustard**
- **Use of mulching and hoeing practices to reduce weeds**
- **Thinning and de-topping at the budding stage of mustard**
- **Sowing of mustard after rice[24]**

WEED MANAGEMENT THE ECOLOGICAL WAY

Weeds can reduce yields by 20-30%[25]. Therefore, tackling weeds could raise yields by the same magnitude as the increase of 25% cited for the GM mustard[26]. In scientific research, some of the highest yields were found by using the simple practices of weeding (hoeing) or weeding (hoeing) with mulching in comparison to a range of herbicide treatments[27].

> ***"Agricultural inputs like fertiliser, irrigation, insecticides, pesticides, and herbicides, and so forth, are very expensive. Some non-monetary or low monetary inputs can enhance the yield considerably with a slight increase in the cost of cultivation. There are a number of low monetary agro techniques which enhance the mustard yield considerably"[28].***

Other management practices that are reported to substantially reduce weeds include weed seed predation and the use of weed-free, clean-crop seeds[29]. Seed predation is thought to be especially useful in no-till (no plough) farming systems where seeds remain on the surface and can be eaten by animals such as birds and harvester ants (whose nests can be damaged by ploughing)[30].

SYSTEM OF CROP INTENSIFICATION

One new ecological method of growing mustard is the system of crop intensification (SCI)[31]. This system was originally developed for rice, and has had considerable success in raising yields. Research has shown that it is effective in other crops, including Indian mustard. Essentially, healthy young plants are either transplanted or sown at a lower-than-normal density in soil enriched with soil organic matter and well aerated. This enhances below-ground growth of roots, which translates to higher above ground yields.

The application of SCI to mustard has reportedly given high yields of 2,500 kg/ha[32], approximately to the yields claimed by the GM mustard of 2,670 kg/ha[33]. For another type of mustard (*B. nigra*), yields in the Gaya district of Bihar tripled in the first year of adopting SCI, whilst costs halved[34]. A World Bank evaluation found the average increase in oilseed production using SCI was 50%, with profitability nearly doubled[35]. However, more research would be needed to evaluate this method in the different regions of India.

IN CONCLUSION

There is no inherent need for genetic engineering to produce high-yielding hybrids of any type for Indian mustard.

Non-GM hybrid systems are already producing high-yielding Indian mustard seeds.

Further investment in the use of new, non-GM hybrid systems and marker assisted selection for Indian mustard, instead of genetic engineering, will undoubtedly produce reliable, high-yielding seeds.

Changes in management practices, particularly to low-input methods consistent with ecological framing and suited to low- income farmers can enhance yields substantially.

New methods of growing, such as SCI, need to be evaluated in different regions of India.

A mid to long-term policy that boosts domestic production of oil seeds, particularly mustard is needed.

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