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Mustard: At its Transgenic Appearance

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Secretary, DARE and DG, ICAR, Dr Himanshu Pathak issued an official statement on usage of GM mustard on 23rd December, 2022

Atamnirbharata in edible oil- The need of the hour

India's import of edible oils is on continuous rise to meet the domestic demand. During 2021-22, we spent Rs.1,56,800 crore on import of 14.1 million tonnes of edible oils consisting of mainly palm, soybean, sunflower and canola oils, which is equivalent to two-thirds of India's total edible oil consumption of 21 mt. Therefore, self-sufficiency in edible oil is essentially required to reduce the forex drain on agri-import.

Shortfall in domestic production and challenges

Productivity of oilseed crops viz., soybean, rapeseed mustard, groundnut, sesame, sunflower, safflower, niger and linseed in India is much lower than the global productivity of these crops. During 2020-21, India had total area of 28.8 million hectares (ha) under oilseed crops with total production of 35.9 million tonnes and productivity of 1254kg/ha, which is way lower than the global average. Edible oil recovery of8 mt from 35.9 mt of total oilseeds hardly meets even 35-40 per cent of the total edible oil requirement pegged at 21 mt per annum (mtpa). The situation will worsen in the future as the demand for cooking oil has been increasing year-on-year, with projected demand at 29.05 mt by 2029-30.

Rapeseed-mustard is an important oilseed crop in India grown on 9.17 million ha with total production of 11.75 million tons (2021-22). However, this crop suffers from low productivity (1281 Kg/ha) compared to global average (2000 kg/ha) Disruptive technological breakthrough is needed for enhancing productivity of oilseed crops in general and Indian mustard in particular in the country.

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Introduction

Marked the day of October 18th, 2022 when appearance approval for transgenic mustard came into limelight by thorough inbuilt efforts of the Genetic Engineering Appraisal Committee (GEAC) which falls under the Union Ministry of Environment, Forest and Climate Change recommended the "environmental release" of the transgenic hybrid mustard DMH-11 (Dhara Mustard Hybrid-11) for seed production and trial conduction referring to field demonstration studies with respect to its pollination agent scenarios. The beauty of this transgenic approach derives within the potential of soil itself, whether it is the provision of nutrients to plants as well as the genetic software manipulation derived from a bacterium species named *Bacillus amyloliquifaciens*inhabiting the soil.With years of ongoing research at Delhi University's Centre for Genetic Manipulation of Crop Plants (CGMCP), researchers ultimately witnessed the "to be cultivable plant's" genetic hybridization event leading to the development of the hybrid mustard DMH-11 containing two alien genes isolated from a soil bacterium called *Bacillus amyloliquefaciens*.

Mixing of gene pools: Hybridization

Hybridization of genes in general terms means the co-existence of two different/distinct gene pools in same genome falling under essentially the same organism, and as in hybrid mustard the event of hybridization involvessexualcrossing two genetically dissimilar plant varieties that can even be from the same species. The first-generation (F1) offspring from such crosses tend to have higher yields than what either parent can individually give finally deciphering the mechanism of heterosis. But this kind of man made effort induced hybridization is a difficult task to achieve in case of mustard due to certain biological limitations naturally present in the plant from evolutionary time scale which when indicated the divergence of self-pollinated and cross pollinated plants. The flowers have both female (pistil) and male (stamen) reproductive organs, making the mustard plants largely self-pollinating. Since the eggs of one plant cannot be fertilized by the pollen grains from another, it limits the scope for developing hybrids — unlike in cotton, maize or tomato, where this can be done through simple emasculation or physical removal of anthers.

The Technical Aspects

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Like a long answer type question when answered in sure short terms, related to aspects of hybridization of mustard like, 'HOW' it has been achieved, the answer shall be '**By Genetic Modification'.**

There are two genes which work coherently with another, where the activation of one is achieved by end product of the first one, say vice-versa. The following outcomes of this system have been attributed to the hybridization of genes from bacterial origin with that of mustard gene pool. The gene 'barnase' codes for proteins whichaffects the pollens production and renderthe plant into which it is incorporated male-sterile. This plant is then crossed with a fertile parental line containing, in turn, the second 'barstar' gene that blocks the action of the barnase gene. The resultant F_1 progeny is both high-yielding and also capable of producing seed/ grain, thanks to the barstar gene in the second fertile line.

Dr Deepak Pental

(Ex-VC, CGMCP)

People shown while harvesting mustard

(Source:Internet)

The CGMCP scientists have deployed the barnase-barstar GM technology to create what they say is a robust and viable hybridisation system in mustard. This system was used to develop DMH-11 by crossing a popular Indian mustard variety 'Varuna' (the barnase line) with an East European 'Early Heera-2' mutant (barstar). DMH-11 is claimed to have shown an average 28% yield increase over 'Varuna' in contained field trials carried out by the Indian Council of Agricultural Research (ICAR).

Keynote Advisory

Genetic Engineering Approval Committee (GEAC) is a governmentfunded Indian authority board specially responsible for appraisal of proposals relating to the "release" of GM organisms and products which may or maynot be hazardous which when released into the environment.

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However, the recommendation for environmental release of DMH-11 is based on the objective of seed testing prior to commercial use. So farmers have been notified and allowed for commercial production of seeds only.As evident from the words of Dr. Deepak Pental,**"***We can also introduce new traits relating to resistance against disease (Alternaria Blight and Stem Rot fungus) or canola oil quality (zero/ low levels of erucic acid and glucosinolates, seen as negative from a health standpoint),"*

Mustard varieties in India have a narrow genetic base. The barnase-barstar system enables breeding of hybrids from a wider range of mustards, including those of East European origin such as 'Heera' and 'Donskaja'. *"GEAC has also recommended the environmental release of DMH-11's parental lines (carrying the barnase and barstar genes) for them to be used to develop new hybrids. Such hybrids could give even higher yields than DHM-11"said Deepak Pental, former Delhi University vice chancellor, who led the CGMCP team that bred DMH-11 in 2002.*

Conclusion& Future Perspective

People's opposition to GM (Genetically Modified) crops aside from those involved in RSS-affiliate Swadeshi Jagran Manch and eco-system regulation general body setups of green groups have been a keen hindrance towards the scientific implementations of those whose years of hard work derived from countless hours of mental expenditure has been spent in labs. In GM mustard plants, the presence of a third 'bar' gene, making it tolerant to the weed killer chemical named ammonium derived glufosinate spray. To this, the remarks noted from aforementioned above, were like that this will create job losses to labor. As a result, scientific techniques were noted to be brought down to a non-implementable scale leading to loss of scientific wealth.

A clear cut statement has been released by DMH-11 developers which assure that bar gene displays the character of a marker gene meant to be employed to decipher among GM and non-GM plants, which will surely die in presence of the aforementioned herbicide type.The GEAC has recommended the *"usage of any formulation of herbicide…exclusively for hybrid seed production", while not permitting the same "for cultivation in the farmer's field under any situation".*

The second concern is over GM mustard threatening or undermining the population of honey bees. Mustard flowers are a source of nectar for honey bees and many other pollinator

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insects. However, the GEAC has cited the report of an expert committee under Department of Biotechnology scientist Dr. Sanjay Kumar Mishra and Director of the Indian Agricultural Research Institute Dr. A K Singh, which stated that "*based on the examination of scientific evidences available globally…it seems unlikely that the bar, barnase and barstar system will pose an adverse impact on honey bees and other pollinators".*

The GEAC has, at the same time, recommended that the applicant (CGMCP) should conduct "field demonstration studies with respect to the effect of [GM mustard] on honey bees and other pollinators" post the environmental release, "to generate scientific evidence in [the] Indian agro-climatic situation and as a precautionary mechanism".