



Gene Editing in Mustard Breeding

For Prelims: [Gene editing](#), Mustard in India, [CRISPR/Cas9](#), Glucosinolates, [Genetic Engineering Appraisal Committee](#), [DNA](#), [Genetically modified \(GM\) plants](#)

For Mains: Significance of Gene Editing in Mustard Breeding, Difference in Genome Editing and Genetic Modification.

[Source: IE](#)

Why in News?

Indian scientists have developed the **first ever low-pungent mustard** that is pest and disease-resistant. It is based on [CRISPR/Cas9 gene editing](#), while being non-GM and transgene-free.

What is the Significance of Gene Editing in Mustard Breeding?

▪ Background:

- Traditional mustard seeds (*Brassica juncea*) that are grown in India contain about **120-130 parts per million (ppm) of compounds called glucosinolates**, which are a group of sulphur and nitrogen-containing compounds contributing to the **characteristic pungency of their oil and meal**.
 - These compounds serve as **natural defenders, protecting the plant from [pests and diseases](#)**.
 - In comparison, **canola seeds have much fewer glucosinolates**, around 30 ppm. These lower levels let the canola oil and meal have a **specific pleasant taste**.
- Oilseeds yield oil for cooking, and **their leftover meal**, a protein-rich ingredient, is used in **animal feed. Rapeseed meal, rich in glucosinolates**, is fed to livestock but requires mixing with grass and water.
 - High glucosinolates are also known to **cause goiter (swelling of neck)** and internal organ abnormalities in livestock.
- Scientists have been **working on a goal to develop mustard seeds that have fewer glucosinolates**, similar to canola seeds.
 - However, reducing glucosinolates in mustard seeds can weaken the plant's overall ability to defend itself against pests and diseases, which presents a challenge.

▪ The Role of Gene Editing in Mustard Breeding:

- Scientists directed their efforts toward modifying specific genes known as **glucosinolate transporter (GTR) genes**.
 - These genes play a crucial role in how glucosinolates, important compounds in mustard seeds, build up.
- To achieve this modification, **they employed a gene-editing tool called [CRISPR/Cas9](#)**, which works like precision scissors to alter gene sequences accurately.
- In a particular mustard variety named '**Varuna**,' the researchers focused on 10 out of the 12 GTR genes.
 - Through these genetic modifications, **they deactivated the proteins produced**

by these genes, resulting in a significant reduction in glucosinolate levels within the seeds.

▪ **Implications of Gene Editing on Plant Defense and Pest Resistance:**

- The modified mustard plants showcased glucosinolate levels in their seeds that were **lower than the 30 ppm threshold set for canola-quality seeds**.
- Interestingly, the **leaves and the walls of the pods around the seeds displayed higher amounts of glucosinolates**.
 - This increase was attributed to a disruption in the transport of these compounds. This heightened accumulation of glucosinolates in the leaves and pods plays a **crucial role in bolstering the plant's ability to resist pests**.
- As a result of these genetic modifications, the edited mustard lines exhibited robust defense mechanisms against both fungal and insect pests.

What is the Difference between Genome Editing and Genetic Modification?

- The GTR genes-edited mustard lines are the **result of genome editing (GE), distinguishing them from [genetically modified \(GM\) plants](#)**.
 - Unlike GM crops, where **foreign genes are introduced, like those of the Bacillus thuringiensis bacteria in cotton or Bar-Barnase-Barstar (isolated from other soil bacteria) in the GM hybrid mustard (DMH-11), GE focuses on modifying the genes that already exist** without adding new genetic material.
 - The recently developed mustard lines are completely free of transgenes and do not possess any foreign genes.
- It's important to note that the **CRISPR/Cas9 enzyme**, which is employed for gene editing, is **not present in the final genome-edited plants**.
 - This sets them apart from transgenic GM crops, where the introduced genes can persist.
- **Regulatory Landscape and Future Prospects:**
 - In India, the regulation of genetic modification is stringent and necessitates approval from the **[Genetic Engineering Appraisal Committee \(GEAC\)](#)** under the **Ministry of Environment, Forest and Climate Change**.
 - However, an official memorandum from the MoEFCC has **exempted genome-edited (GE) plants that don't incorporate foreign DNA from requiring GEAC approval** for open field trials.
 - The newly developed genome-edited mustard lines are **poised to undergo open field trials**, having obtained clearance from the **[Institutional Bio-safety Committee \(IBSC\)](#)**.
 - The potential benefits of these advancements are substantial, particularly because **India currently imports a significant amount of [edible oils](#)**, incurring substantial costs annually.
 - These innovations hold the promise of enhancing domestic oilseed production by bolstering crop yields, resistance to pests, and product quality.
 - This progress could **ultimately contribute to diminishing the country's reliance on imported vegetable oils**.

What is the Status of Mustard Cultivation in India?

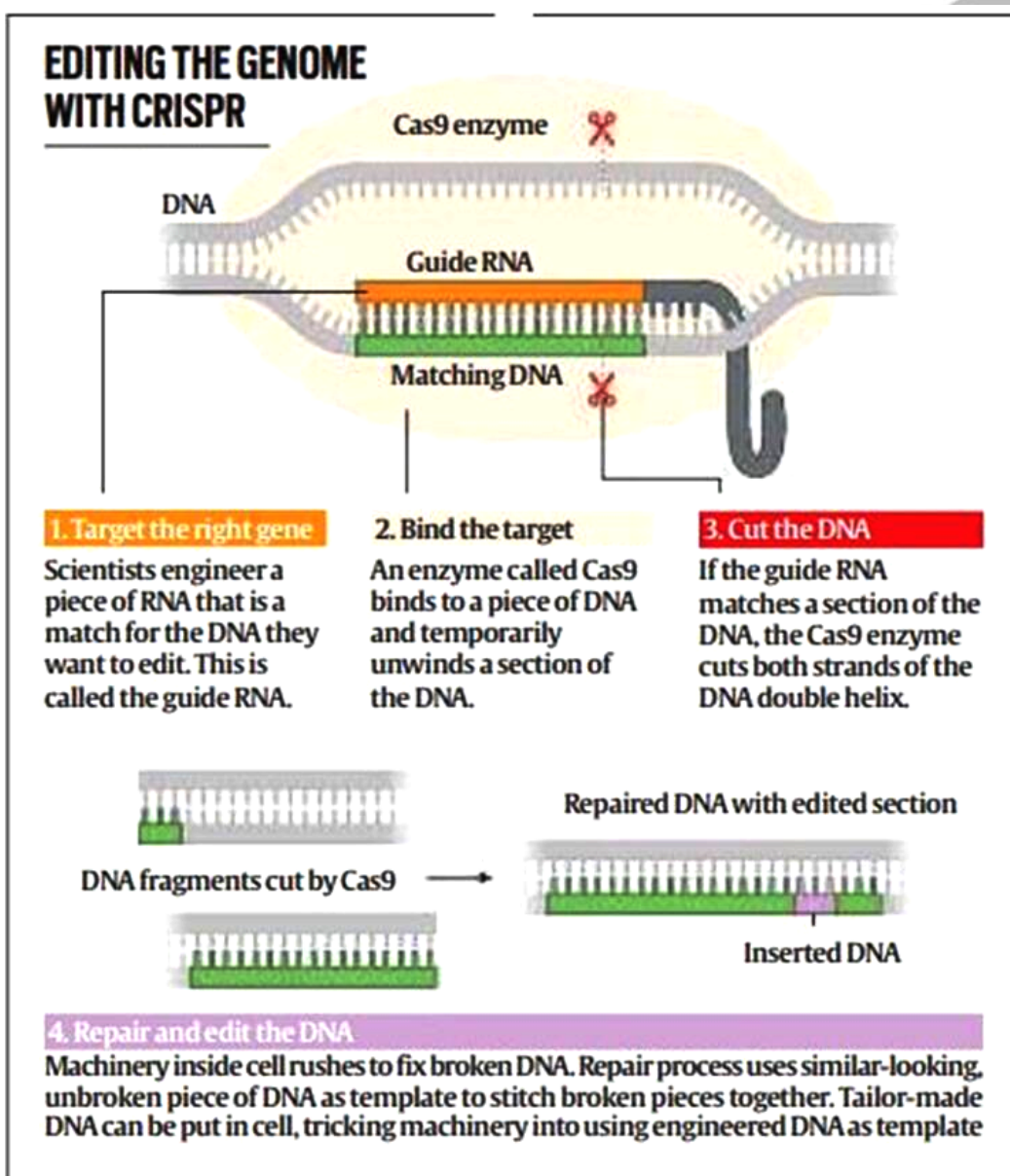
- Mustard is India's most widely-cultivated oilseed crops, planted annually on **9 million hectares area respectively**. It is grown in Rabi season.
 - Its higher average oil extractable content (38%) makes mustard a good "oilseed" crop, while a **source of both fat for humans and protein for animals**.
- Mustard is an important cash crop for farmers in **Rajasthan, Haryana, Madhya Pradesh and Uttar Pradesh**, among others.

What is CRISPR Cas9 Technology?

- CRISPR-Cas9 is a groundbreaking technology that empowers geneticists and medical researchers

to modify specific portions of the genome.

- This is achieved through the precise **removal, addition, or modification of segments within the DNA sequence.**
- The CRISPR-Cas9 system involves two important components that bring about changes or mutations in DNA. These components are:
 - An enzyme known as **Cas9**, which acts like a **pair of precision "molecular scissors."**
 - Cas9 has the **ability to cut the two strands of DNA** at a specific spot within the genome. This precise cutting enables the **addition or removal of segments of DNA.**
 - A segment of RNA referred to as guide **RNA (gRNA)**. This consists of a small, pre-designed RNA sequence.
 - This RNA sequence is embedded within a longer RNA structure. **The lengthier part of the RNA attaches itself to DNA**, while the specific sequence within it functions as a "guide" for Cas9.
 - This guidance mechanism **directs the Cas9 enzyme to the exact location in the genome where it should make the cut.**
 - This ensures that the cutting action of the Cas9 enzyme takes place accurately at the intended point in the genome.



UPSC Civil Services Examination, Previous Year Question (PYQ)

Prelims

Q. What is Cas9 protein that is often mentioned in news? (2019)

- (a) A molecular scissors used in targeted gene editing
- (b) A biosensor used in the accurate detection of pathogens in patients
- (c) A gene that makes plants pest-resistant
- (d) A herbicidal substance synthesized in genetically modified crops

Ans: (a)

Mains

Q. What are the research and developmental achievements in applied biotechnology? How will these achievements help to uplift the poorer sections of society? (2021)

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