
ICRISAT

# Genome editing

## Background

- New breeding tools (NBTs) like genome editing are at the core of new-age agricultural innovations.
- NBTs enable highly efficient and precise trait generation and more efficient integration of genetic diversity in breeding programs without adversely impacting native phenotypes.
- Adding NBTs to a breeder's tool kit holds tremendous potential to modify crops' genetic makeup precisely and efficiently, providing the fastest possible means for specific and targeted crop improvement. This expedites the rate of genetic gains and the delivery of products that enable **'disruptive reduction'** in the input costs to the farmer and **'exponential gains'** in nutrition and grain quality traits for the consumers.
- NBT tools have been widely used in modern crop improvement for various traits and have shown immense potential in accelerating the development of elite crop germplasm.

## ICRISAT's Capability

- ICRISAT's genome editing team undertakes codevelopment of parental breeding lines through gene-editing approaches and plant biology tools to uncover the candidate gene and mechanisms responsible for key 'must haves', and 'game changing' future traits. Their notable achievements include:
- Increased shelf life of pearl millet flour and blast resistance in pearl millet;
- Striga resistance, forage quality, modifying the lignin composition for enhanced biofuel production and drought adaptation in sorghum;
- Protein content and quality in chickpea and pigeonpea, pod borer resistance in chickpea and pigeonpea;
- Food safety (reduced aflatoxin contamination) in groundnut and adaptation traits (reproductive plasticity) in pigeonpea to ensure buy-in and foster wider local adoption to maximize impact.

## Key achievements

### Tools and transformation systems

- ICRISAT has developed tools and capabilities in linking genotype to phenotype to identify the underlying causal mechanisms of agriculturally important but complex intractable traits.
- ICRISAT has developed high throughput transformation protocols and tissue culture facilities for dryland crops like chickpea, pigeonpea, groundnut, sorghum, and pearl millet. These are further utilized in gene editing applications to develop novel genetic variations for improved genetics.

### Increasing shelf life of pearl millet milled flour

- Pearl millet, considered a nutri-cereal rich in calcium, iron, zinc, lipids, and proteins, is part of the diet in India and Africa. Though a nutritionally balanced crop, it is underutilized due to its limited storability and quick rancidity of milled flour. In partnership with Corteva Agriscience, sustainable genetic solutions are being developed to fix the rancidity trait in the seed without affecting other nutritional and phenotypic parameters. Precise editing is underway to induce novel genetic variations in the identified candidate for enhanced shelf-life and reduced rancidity.

### Durable *Striga* resistance in sorghum

- Sorghum is a highly productive drought-tolerant crop susceptible to *Striga* parasitic plant infestations, resulting in 10-100% crop loss. Conventional breeding and good weed management practices cannot address this problem successfully. New breeding interventions are being introduced based on the underlying molecular mechanisms of hostparasite biological interactions. Transgene-free homozygous gene-edited sorghum plants were developed with altered host germination signals and high levels of resistance to *Striga*. These developed lines are ready for testing in Asia and Africa.

### Acynogenic forage sorghum

- The major constraint for sorghum forage is an accumulation of cyanogenic glycosides in sorghum vegetative tissues that worsens under abiotic stress conditions. ICRISAT identified the molecular mechanism through systems biology tools and precise editing for the key candidate gene(s) for low Hydrogen cyanide (HCN) or HCN-free sorghum to achieve global forage security.

### Aflatoxin resistance in groundnut

- Aflatoxin poses a threat as a carcinogen and hepatotoxin to the health of humans and livestock. The acceptable level of aflatoxin contamination in groundnut for human consumption is <4 ppb in Europe, <20 ppb in the USA, and <15 ppb in India.
- ICRISAT has developed groundnut germplasm through genetic engineering with improved genetic resistance to *A.flavus* infection and aflatoxin contamination. Further comparative proteome profiling of transgenic groundnut lines with untransformed lines revealed proteins associated with susceptibility. Altering the expression of these genes using gene editing will help develop aflatoxinfree groundnut lines through a non-genetically modified organism (non-GMO) approach.

### Photoperiod insensitivity in pigeonpea

- Photoperiodic incompatibility in high-latitude areasseriously hampers pigeonpea production and yields. Accordingly, manipulating flowering times is likely to contribute to increased crop yields. Based on the phenotypic and genotypic data, few candidate genes were identified for their possible role in reproductive plasticity. Superior photoperiodic traits are being modulated to produce elite pigeonpea lines that aregeographically adapted by