Popular Article Chapter- 7

GENOME EDITING IN PLANTS FOR SUSTAINABLE AGRICULTURE OF INDIA

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Abstract

India has special and important technology called genome editing in plants.In genome editing specific gene is targeted and introduced with a small mutation this could be a single base of a DNA code added or taken away and the final plant has no foreign DNA. We can use genes that make these plants more resistant, and therefore the plants are innately resistant rather than externally applying chemicals India's recent developments in genome editing and modern technologies, tools, and processes in various crops. This research concludes the current scenario and methodologies in genome editing of plants in order to achieve sustainable agriculture.

Keywords: Genome editing, Plant genes, ZFN, TALEN, CRISPR Cas9, gene editing methods, plant breeding, RNAi, new technology.

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Introduction

The world's population is increasing day by day but the agricultural resources like land water or reducing. To feed the rapidly growing population, there is a need to improve food production and enhance agriculture. Conventional breeding of plant breeding has played a great role in developing new seeds for increasing food production. But climate change in India affects agricultural production adversely. Since the discovery of DNA-the basis of all life, our knowledge of plant genetics and genomics is increased. Scientists have developed to link genes to specific characteristics of an Organism. We have entered the era of target breeding that allows us to make precise and desired changes in the plant genome. Genome editing permits editing the genes in plants to make changes in the DNA more effect efficiently than conventional tools of plant breeding. Genome editing helps to develop new varieties with complex traits like resistance to multiple abiotic stresses like drought heat and flooding.

Genome Editing in India

Genome editing has become a game-changer and it has the ability in contributing to food security, climate resilience, nutritional security, and sustainable development. Genome editing typically involves finding the part of a plant genome that could be changed to render it less vulnerable to disease or resistant to certain heavy sides or increase yields, quality or other desirable traits. Researchers use 'molecular scissors' to break apart the genome and repair it, which is a process that occurs naturally when plants are facing stress and can be throw up new mutations that enable the plant to withstand further attacks.Researchhas shown that certain genome-edited crops are similar and indistinguishable from the ones developed through random mutagenesis or naturally occurring mutations and there is no foreign DNA present in the final product. In India, genome-edited crops like tomato and soybean are approved for commercialization.Genome editing technology in India is not only in use in plants but also has a major influence in the health and pharma sector.Genome editing has emerged as a tremendous strategy for efficient and targeted genome manipulations, especially for crops which have complex genomes and which are difficult to improve through conventional breeding approaches.

Applications

- Genome editing helps in target gene mutation which is highly efficient
- Genome editing is highly efficient in making site-specific integration and gene stacking in the process of gene replacement via Homologous recombination.
- Genome editing is utilized in chromosomal engineering through which site-directed deletions and translocations can be done
- Modifications under labelling of multiple genomic sites is possible through genome editing
- Genome editing reduces the costs which make molecular breeding cost-effective
- It is the only accurate and simple technique to replace genetically engineered crops and satisfy the public concerns

Important Tools in Genome Editing in India

1) **ZFN**
   ZFNs stand for zinc-finger nucleases, these are artificial restriction enzymes.they are made up of two parts DNA binding domain and the DNA cleavage domain. DNA binding domain helps in binding of ZFNs to a specific gene.whereas the DNA cleavage domain cleaves the DNA at a particular site.Using this genome editing tool researchers can pick any spot on the genome in plants, and insert the gene of interest to obtain an edited genome.
2) **TALEN**
   The TALEN system consists ofa transcription activator-like (TAL) protein that is fused to the FokI nuclease.Each of the 33 repeats in the TAL DNA binding domain can differ by two amino acids, which determines which nucleotide it will bind. By combining 12-31 of these repeats, a TALEN can be engineered to bind to a specific DNA sequence. Two TALENS must dimerize in order to create a double standard break in the DNA. For this method, the cell can repair the double standard DNA via the NHEJ repair pathway. Then selection must be carried out to isolate the cells with the frameshift mutation leading to gene knockout.
3) **CRISPR-cas9**
   CRISPR-cas9 is called "Clustered regularly interspaced short palindromic repeats and CRISPR-associated protein 9". This tool is creating massive usage in the genome editing sector.One of the advantages of CRISPR systems over other genome-editing methods is their potential for multiplexing, the simultaneous editing of multiple target sites.It can be used in plant breeding to improve plants in many different ways. It is a tool provided by nature and planned breeders make very wisely use of the tool to apply in plant breeding. This method is accurate, cheaper, and faster than previous methods like ZFNs and TALENs. The genome-editing technology in CRISPR-cas9 allows very efficient trades management for the breeder. Cas9 is a nuclease guided by small RNAs through Watson-Crick base pairing with target DNA.This technique can be used for knocking out susceptibility genes, they are the genes that make the plant susceptible to diseases. When the susceptibility gene is knocked out by gene editing then the plant becomes resistant.

Genome Edited Crops in India

Genome Editing in Rice

Rice is the primary food in India. Rice is the intensive use of freshwater and accounts for more than half of the freshwater used in agriculture. Although advances in plant breeding and agricultural practices have greatly increased yields over the past few decades. Indian plant breeders developed genome-edited mutants of drought and salt tolerance genes in a mega rice cultivar MTU1010. This mutant is free from foreign DNA it uses about 25% less water and is tolerant to drought and salt stress. This is expected to increase water productivity, nutrient productivity, and yield under drought and salt stress environments through Genome editing.Through this method, the quality of rice and

nutrition should be increased easily.It is possible to produce high oleic/low linoleic rice, fragrant rice, rice with increased beta-carotene accumulation, rice with increased amylose content, low cadmium rice, red rice are obtained by genome editing.

Genome Editing in Mustard

With increasing income and changing food habits, consumption of edible oils has been rising over the years India heavily depends on imports to meet two-thirds of its edible oils demand. Genome editing will provide novel opportunities for both improving productivity and reducing the oil import of the country in near future. Using CRISPR-based genome editing, scientists are focusing on the improvement of nutritional oil quality through the development of transgene-free canola quality mustard lines. Thus, genome editingprovides several opportunities for raising the productivity levels as well as oilseed quality of oilseed mustard in the global market.

Genome Editing in Banana

Genome editing is important for the nutritional improvement of bananas. Banana is an important crop in several developing countries including India where it contributes not only to household food and nutritional security but also for income generation as a cash crop. The application of conventional breeding for genetic improvement of bananas is difficult due to technical reasons hence genome editing helps to overcome vitamin A micronutrient deficiency. In India,the carotin or biosynthesis pathway is successfully edited in the genes of bananas,for enhanced accumulation of beta carotene required for vitamin A synthesis in humans.

Conclusion

We must fully realize the potential of this innovative technology genome editing for addressing serious concerns of malnutrition and adaptation of crops to the fast-changing climate.We need science-based regulation and the support of policymakers for injuring profitability to the smallholder farmers and for ensuring environmental sustainability. Even it is a breakthrough technique in genetics it couldn't yet get a Nobel prize. If Genome editing is positively received, India stands to gain globally through the use of genome editing technologies for achieving sustainable development goals of the United Nations by 2030.

References

Gayatonde, Varsha &Prudhvi, Mr &Vennela, Prudhvi Raj. (2016). Genome Editing – A Boon for Agriculture Abtract. 4.

Ran, F., Hsu, P., Wright, J. *et al.* Genome engineering using the CRISPR-Cas9 system. *Nat Protoc* 8, 2281–2308 (2013).

Razzaq A, Saleem F, Kanwal M, et al. Modern Trends in Plant Genome Editing: An Inclusive Review of the CRISPR/Cas9 Toolbox. *Int J Mol Sci*. 2019;20(16):4045. Published 2019 Aug 19. doi:10.3390/ijms20164045.

Zafar Kashaf, Sedeek Khalid E. M., Rao GundraSivakrishna, Khan Muhammad Zuhaib, Amin Imran, Kamel Radwa, Mukhtar Zahid, Zafar Mehak, Mansoor Shahid, Mahfouz

Magdy M. Genome Editing Technologies for Rice Improvement: Progress, Prospects, and Safety Concerns, Frontiers in Genome Editing, Vol-2/2020. ISSN=2673-3439.

Zhang, Y., Massel, K., Godwin, I.D. *et al.* Applications and potential of genome editing in crop improvement. *Genome Biol* 19, 210 (2018).