Go Green, Learn Green
An Agricultural Monthly e-Magazine
Volume 02, Issue 09, 2024
ISSN: 2584-153X
Article ID: G-24-0920

REVOLUTIONIZING PLANT DISEASE MANAGEMENT WITH GENOME EDITING TECHNOLOGIES

Dr. Akshaya S. B

Assistant Professor (Plant Pathology), SRM College of Agricultural sciences, SRM Institute of science and Technology, Baburayanpettai, Chengalpattu 603201, Tamil Nadu, India

Corresponding Author Mail ID: akshayaagri14@gmail.com

Introduction

Advancements in genome editing techniques have completely transformed the way plant diseases are managed. These tools offer exceptional precision in engineering resistance against harmful pathogens. By employing these methods, meticulous modifications can be achieved in the genetic makeup of plants. This enables the manipulation of genes that render plants vulnerable to pathogens, the enhancement of defense mechanisms, and the establishment of enduring resistance against a range of plant diseases. Over the past few years, there has been remarkable advancement in genome-editing technologies, which has had a revolutionary effect on plant breeding research. This has led to the development of crops that exhibit enhanced resilience against a wide range of challenges. The advent of programmable nucleases has revolutionized DNA manipulation, allowing for an unprecedented level of precision.

There are several types of nucleases such as zinc-finger nucleases, transcription activator-like effector nucleases (TALENs), and CRISPR RNA-guided CAS endonucleases can be used to specifically target DNA sequences. Although each single nucleases can be tailored to target specific DNA sequences with varying degrees of ease. Based on the above information CRISPR-Cas9 genome editing tool has unlocked a vast range of potential for progress in plant pathology and resistance breeding.

I. CRISPR/Cas-based Genome Editing

The Clustered Regularly Interspaced Short Palindromic Repeats/CRISPR-associated proteins is a cutting-edge genome editing tool derived from bacterial immune system. This system consists of two main components: a guide RNA (gRNA) that directs the Cas nuclease to find a specific DNA sequence, and the Cas nuclease itself, which creates precise double-strand breaks (DSBs) at the designated location.

Applications in Plant Disease Management

a. Targeted Gene Knockout

CRISPR/Cas9 has the potential to disrupt susceptibility genes in plants, making them more resilient against infection by specific pathogens. As an illustration, when susceptibility genes involved in host-pathogen interactions are knocked out, it can result in resistance against fungal, bacterial, and viral pathogens.

b. Pathogen-Derived Resistance

CRISPR/Cas can introduce genetic changes in plants that mimic natural resistance mechanisms observed in wild relatives or other plant species. By introducing resistance alleles or modifying key regulatory elements, plants can be engineered to recognize and respond more effectively to pathogen attack.

c. Enhanced Immune Responses

CRISPR/Cas possesses the remarkable capability to trigger genetic alterations in plants that mimic the innate defence mechanisms observed in untamed counterparts or different plant species. By introducing resistance alleles or modifying key regulatory elements, plants can be engineered to improve their capacity to detect and respond to pathogen attacks.

Other Genome Editing Techniques

II. Transcription Activator-Like Effector Nucleases (TALENs)

TALENs are an incredibly powerful tool for editing the DNA of plants, allowing for precise modifications to be made in their genomes. Just like CRISPR/Cas, TALENs have the ability to generate double-strand breaks at precise spots in the genome, enabling precise modifications to the genetic material.

Applications in Plant Disease Management

a. Gene Knockout: It can be used to knockout susceptibility genes or virulence factors in plants, providing durable resistance against pathogens.

b. Gene Activation/Suppression: TALENs are used to activate or suppress the expression of specific genes involved in plant immunity, allowing for fine-tuning of defence responses.

Advantages and Limitations

Advantages

1. High specificity: Exhibit high target specificity, minimizing off-target effects.

2. Flexibility: Target a wide range of DNA sequences, making them versatile tools for genome editing.

3. Efficiency: TALENs induce precise DNA cleavage, leading to efficient gene knockout or editing.

Limitations

1.Labor-intensive design: Designing TALEN constructs requires expertise and can be time-consuming.

2.Delivery challenges: Efficient delivery of TALEN constructs into plant cells can be challenging, particularly for certain plant species.

3. Off-target effects: While TALENs are highly specific, off-target cleavage events can occur, necessitating careful design and validation.

Challenges and Future Perspectives

While genome editing techniques offer tremendous potential for enhancing plant disease resistance, several challenges remain:

a. Off-Target Effects: It is important to note that genome editing tools like CRISPR/Cas9 have the potential to cause unintended mutations in the plant genome at off-target sites. New approaches are being developed to reduce unintended effects, including advancements in gRNA design and the utilisation of high-fidelity Cas nucleases.

b. Regulatory Approval: The regulatory framework for genome-edited crops varies from country to country, which presents hurdles for the commercialisation and adoption of genome-edited plants. In order to fully realise the promise of genome editing in agriculture, it is necessary to make efforts to harmonise regulatory requirements and promote public acceptance.

Conclusion

Genome editing techniques, particularly CRISPR/Cas9-based systems, hold great promise for revolutionizing plant disease management. By enabling precise modifications of plant genomes, these tools offer novel strategies for enhancing plant resistance to pathogens and ensuring global food security. With ongoing advancements in genome editing technology and continued efforts to address regulatory and societal concerns, genome-edited crops have the potential to play a central role in sustainable agriculture in the years to come.

Reference

- Andolfo, G., Iovieno, P., Frusciante, L., & Ercolano, M. R. (2016). Genome-editing technologies for enhancing plant disease resistance. *Frontiers in Plant Science*, *7*, 1813.
- Langner, T., Kamoun, S., & Belhaj, K. (2018). CRISPR crops: plant genome editing toward disease resistance. *Annual review of phytopathology*, *56*(1), 479-512.
- Yin, K., & Qiu, J. L. (2019). Genome editing for plant disease resistance: applications and perspectives. *Philosophical Transactions of the Royal Society B*, *374*(1767), 20180322.