AgriCos e-Newsletter
ISSN: 2582-7049
AgriCos e-Newsletter
Open Access Multidisciplinary Monthly Online Magazine
Volume: 05 Issue: 04 April 2024 Article No: 09

RNAi Technology for Biotic Stress Management

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SUMMARY

RNA interference (RNAi) technology has shown significant potential for managing biotic stress in various organisms, particularly in an agricultural context. Biotic stress, caused by living organisms such as pests and pathogens, can have detrimental effects on crop yield and quality. RNAi provides a targeted and specific approach to combat these stresses by suppressing the expression of essential genes in the pests or pathogens. RNAi technology represents a valuable tool for biotic stress management in agriculture, offering targeted solutions for pest and pathogen control while potentially reducing the environmental impact associated with traditional chemical interventions. Continued research and advancements in delivery systems and regulatory frameworks will contribute to the broader adoption of RNAi-based strategies in crop protection.

INTRODUCTION

Stress is an external condition or substance adversely affecting metabolism, reproduction, growth, development, and productivity. Plant stress comes in different forms and durations. Biotic stress and abiotic stress are the types of stress. Biotic stress is a significant concern in agriculture and horticulture crops because it can lead to reduced crop yields and quality. RNAi is a process that inhibits gene expression by the double-stranded RNA (dsRNA), which can cause the degradation of target messenger RNA. RNA interference is also known as post-transcriptional gene silencing, co-suppression, and quelling. It is a natural mechanism for sequence-specific gene silencing. It has important practical applications in functional genomics, therapeutic intervention, and agriculture.

RNAi is a natural cellular process that regulates gene expression by degrading or inhibiting the translation of specific messenger RNA (mRNA) molecules. Small RNA molecules, such as small interfering RNA (siRNA) and microRNA (miRNA), play a crucial role in mediating RNAi.

RNAi for Plant Disease/Pest Resistance:

Pathogens can cause a huge reduction in crop yield that can have a significant negative economic impact and threaten to wipe out the entire plant species. Plant pathologists and plant biotechnologists have adopted different approaches to develop pathogen-resistant genotypes but in the last decade, RNAi-induced gene silencing emerged as an effective tool to engineer pathogen resistance. A robust RNAi pathway proved to be effective against different insects and pests which have opened new pathways for crop protection by developing insect-resistant cultivars of commercially important plants.

Application in plants:

- In agriculture, RNAi has been widely explored to develop crops with enhanced resistance to pests and pathogens.
- Specific genes essential for the survival or virulence of pests and pathogens are targeted using RNAi technology.
- This approach allows for the development of genetically modified plants that express RNA molecules targeting key genes in pests or pathogens. Leading to their reduced viability or virulence.

Benefits of RNAi in Biotic Stress Management:

- Precision: RNAi enables the targeted silencing of specific genes involved in the stress response of pests or pathogens.

- Environmentally friendly: compared to traditional chemical pesticides, RNAi-based strategies are often considered more environmentally friendly.
- Reduced off-target effects: advances in RNAi technology have led to improved methods for minimizing off-target effects ensuring the specificity of gene silencing.
- Potential for crop improvement: RNAi can be used not only for stress management but also for enhancing desirable traits in crops, such as improving nutritional content or increasing tolerance to abiotic stresses.

Factor affecting of RNAi:

Several factors can influence the effectiveness and practical application of RNA interference (RNAi) technology for biotic stress management. These factors encompass various aspects, ranging from the design of RNAi constructs to the delivery systems and environmental considerations.

- Target selection: the choice of target genes in pests or pathogens in crucial. Identifying essential genes that play a significant role in the survival or virulence of the organism is essential for effective RNAi-mediated control.
- RNAi construct design: designing RNAi constructs involves choosing the right sequence that can efficiently and specifically target the desired gene without causing off-target effects. The length, secondary structure, and sequence specificity of the RNA molecules are critical considerations.
- Delivery system: efficient delivery of RNA molecules to the target organism or tissue is a significant challenge. The delivery system must protect RNA molecules from degradation and ensure they reach the intended site of action.
- Stability and persistence: the stability of RNA molecules in different environmental conditions, such as soil or water, can impact their effectiveness. Ensuring persistence over time is crucial for sustained biotic stress management.
- Off-target effects: minimizing off-target effects is essential to avoid unintended consequences on non-target organisms or beneficial species. Advance in RNAi technology aim to enhance the specificity of gene silencing.
- Species-specificity: the specificity of RNAi is often species-dependent. Ensuring that the RNAi constructs are effective against the target species while having minimal impact on non-target organisms is a key consideration.
- Regulatory approval and public perception: the acceptance and regulatory approval of RNAi-based products, particularly genetically modified organisms, vary globally. Overcoming regulatory hurdles and addressing public concerns are crucial for the widespread adoption of RNAi technology in agriculture.
- Integrated with crop management practices: incorporating RNAi technology into existing crop management practices and agricultural systems is important. Compatibility with other pest and disease control methods, as well as consideration of integrated pest management approaches, enhances the overall effectiveness.

Considering these factors and addressing associated challenges will contribute to the successful implementation of RNAi technology for biotic stress management, providing sustainable solutions for agriculture.

CONCLUSION

RNAi technology could be an alternative biotechnological approach having numerous advantages particularly more specific, dominant, and sequence-based gene silencing. This tremendous potential of RNAi has been effectively exploited for inducing desirable traits like disease, and insect and virus-resistant, allergen-free, nutritionally rich, toxic-free crops. Especially RNAi is found to be a very promising technique to prove the function of any gene. It is hoped that RNA silencing-based technology will help mankind face the challenges of productive agriculture in the increasingly unfavourable environmental conditions associated with climate change.

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