AGRI MAGAZINE
(International E-Magazine for Agricultural Articles)
Volume: 02, Issue: 07 (July, 2025)
Available online at http://www.agrimagazine.in

Priming Plant Immunity: The Emerging Role of Elicitors in Systemic Resistance Against Biotic Stress

*S Sunil[1] and PV Phanindra[2]
[1]M.Sc. Scholar, Department of Mycology Plant Pathology, Institute of Agricultural Sciences, BHU, Varanasi, Uttar Pradesh, India
[2]PhD Scholar, Department of Mycology Plant Pathology, Institute of Agricultural Sciences, BHU, Varanasi, Uttar Pradesh, India
*Corresponding Author's email: sunil2000@bhu.ac.in

The increasing incidence of plant diseases, driven by pathogen evolution and climate change, is a major threat to agricultural productivity. Traditional reliance on chemical pesticides is unsustainable, necessitating the development of eco-friendly and effective alternatives. Elicitors—natural or synthetic molecules that stimulate plant defense—offer a promising approach for inducing systemic resistance against a wide range of biotic stressors including fungi, bacteria, viruses, and nematodes. This article explores the classification, mechanisms, and applications of elicitors, with emphasis on how they prime plant immune systems for broad-spectrum, long-lasting protection. Advances in molecular biology, biotechnology, and nanotechnology are further enhancing the efficacy and delivery of elicitors in crop systems.

Keywords: Elicitors, systemic resistance, ISR, SAR, plant defense, PR proteins, biotic stress, priming, sustainable agriculture.

Introduction

Global agriculture is under increasing pressure due to biotic stresses that account for 20–40% of annual crop losses (Savary et al., 2019). While fungicides, bactericides, and pesticides offer short-term relief, their environmental and health impacts, coupled with the emergence of resistant pathogens, have led researchers to seek sustainable disease management strategies. One such solution lies in elicitors—compounds capable of activating plant immune responses by mimicking pathogen signals or stress cues. Elicitors can prime the plant for systemic acquired resistance (SAR) or induced systemic resistance (ISR), enhancing the plant's ability to mount faster and stronger responses upon pathogen attack (Meena et al., 2022).

What Are Elicitors?

Elicitors are defined as non-pathogenic molecules that trigger plant defense pathways when recognized by specific receptors. They are categorized into:

Based on Origin

- **Exogenous (external):** Derived from pathogens or beneficial microbes.
- **Endogenous (internal):** Released from plant cells during stress or damage.

Based on Source

- **Biotic elicitors:** Include microbial cell wall components (e.g., chitin, lipopolysaccharides), bacterial flagellin, and fungal ergosterol.
- **Abiotic elicitors:** Include chemical compounds (e.g., salicylic acid, jasmonic acid), nanoparticles, UV radiation, and ozone.
- **Synthetic elicitors:** Artificial molecules like benzothiadiazole (BTH) or probenazole that mimic natural defense inducers.

These compounds do not directly kill pathogens but activate plant immunity, making them eco-friendly alternatives to pesticides.

Mechanisms of Action: SAR and ISR

Plant immunity operates through two major pathways:

Systemic Acquired Resistance (SAR)

- SAR is triggered by localized infection or chemical inducers.
- It involves salicylic acid (SA) signaling and leads to the expression of pathogenesis-related (PR) proteins.
- SAR offers broad-spectrum and long-lasting resistance, especially against biotrophic pathogens.

Induced Systemic Resistance (ISR)

- ISR is initiated by plant growth-promoting rhizobacteria (PGPR) like *Pseudomonas* and *Bacillus* spp.
- It depends on jasmonic acid (JA) and ethylene (ET) pathways.
- ISR is effective against necrotrophic pathogens and certain insects.

Elicitors act by stimulating these pathways, thereby "priming" the plant to respond more effectively to future attacks (Meena et al., 2022).

Molecular Basis of Elicitor-Induced Resistance

Recognition of elicitors involves **pattern recognition receptors (PRRs)** located on the plant cell surface. Upon detection, a cascade of molecular events unfolds:

- **Ion fluxes and oxidative burst**
- **Activation of mitogen-activated protein kinases (MAPKs)**
- **Transcriptional reprogramming**
- **Accumulation of secondary metabolites** like phytoalexins, lignin, and flavonoids

This results in enhanced cell wall strengthening, production of defense-related enzymes (e.g., peroxidases, polyphenol oxidases), and secretion of PR proteins such as chitinases and glucanases.

Recent Advances in Elicitor Research

Natural Elicitors

- **Chitosan**, a deacetylated form of chitin, induces SAR and improves resistance in rice, tomato, and grapes.
- **β-glucans** from fungi stimulate lignification and callose deposition.
- **Lipopolysaccharides (LPS)** from gram-negative bacteria enhance tolerance to pathogens like *Pseudomonas syringae*.

Synthetic Elicitors

- **Acibenzolar-S-methyl (ASM)**, a synthetic SA analog, has been shown to induce SAR in tobacco and tomato.
- **Tiadinil and probenazole** are widely used in Japan for rice blast management.

Nanotechnology-Assisted Elicitor Delivery

Nanoparticle-based elicitors offer improved stability, targeted delivery, and slow release of bioactive molecules. Silver nanoparticles functionalized with salicylic acid have shown enhanced resistance in tomatoes against *Alternaria solani* (Khare et al., 2021).

Applications in Crop Protection

Elicitors have been tested successfully against several economically important diseases:

Crop	Pathogen	Elicitor	Outcome
Tomato	*Alternaria solani*	SA + Chitosan	Reduced lesion size, higher defense enzymes
Rice	*Magnaporthe oryzae*	BTH, PGPR	Enhanced PR gene expression
Grapevine	*Botrytis cinerea*	β-glucans, chitosan	Reduced fruit rot
Wheat	*Puccinia striiformis*	ASM + ZnO nanoparticles	Increased resistance, yield improvement

Benefits Over Conventional Pesticides

- **Environmentally benign:** Elicitors are biodegradable and do not persist in soil or water.
- **Reduced resistance development:** Since they do not target pathogens directly, resistance evolution is slower.
- **Broader spectrum of activity:** Can induce resistance against fungi, bacteria, viruses, and some nematodes.
- **Compatibility with IPM:** Elicitors integrate well with biological control agents and agronomic practices.

Challenges and Limitations

Despite promising results, elicitor use faces several hurdles:

- **Inconsistent field performance** due to environmental variability.
- **Short shelf-life and instability** of some natural elicitors.
- **Cost of production** for synthetic compounds and nano-formulations.
- **Limited awareness** among farmers and lack of commercial formulations.

To overcome these, future efforts must focus on formulation development, dosage optimization, and extension training.

Future Prospects

Elicitor technology is poised for wider adoption with support from recent innovations:

- **CRISPR-Cas gene editing** to enhance plant receptor sensitivity to elicitors.
- **Omics-based approaches** (transcriptomics, metabolomics) to understand elicitor-plant-pathogen interactions.
- **Synthetic biology** to produce designer elicitors with higher efficacy.
- Development of **elicitor consortia**—combinations of microbial and chemical inducers for synergistic effects.

With increasing regulations on pesticide use and global demand for eco-safe agriculture, elicitors could become the cornerstone of next-generation crop protection.

Conclusion

Elicitors represent a paradigm shift in plant disease management. By activating natural defense pathways like SAR and ISR, they offer a sustainable, broad-spectrum, and environmentally friendly solution to combat biotic stresses. While challenges remain in field translation and commercial development, ongoing research in molecular biology, nanotechnology, and formulation science holds immense promise. Embracing elicitor-based strategies could significantly reduce our dependency on chemicals and pave the way for resilient agricultural systems.

References

1. Khare, E., Mishra, J., Arora, N. K., & Singh, S. (2021). Biotechnological and nanotechnological approaches for sustainable agriculture. *Frontiers in Pharmacology, 12*, 720726. https://doi.org/10.3389/fphar.2021.720726
2. Meena, R. S., Yadav, G. S., Mishra, P. K., & Yadav, A. (2022). Role of elicitors to initiate the induction of systemic resistance in plants to biotic stress. *Plant Stress*, *4*, 100074. https://doi.org/10.1016/j.stress.2022.100074
3. Savary, S., Willocquet, L., Pethybridge, S. J., Esker, P., McRoberts, N., & Nelson, A. (2019). The global burden of pathogens and pests on major food crops. *Nature Ecology & Evolution*, *3*(3), 430–439. https://doi.org/10.1038/s41559-018-0793-y
4. Thaler, J. S., Humphrey, P. T., & Whiteman, N. K. (2012). Evolution of jasmonate and salicylate signal crosstalk. *Trends in Plant Science*, *17*(5), 260–270. https://doi.org/10.1016/j.tplants.2012.02.010
5. Wiesel, L., Newton, A. C., Elliott, I., Booty, D., Gilroy, E. M., Birch, P. R., & Hein, I. (2014). Molecular effects of resistance elicitors from biological origin and their potential for crop protection. *Frontiers in Plant Science*, *5*, 655. https://doi.org/10.3389/fpls.2014.00655