



Guardian of Green

(*Sneha Kumari)

College Of Post Graduate Study in Agricultural Science, Umiam -793103
(Central Agricultural University, Imphal)

*Corresponding Author's email: snehasinghisoodiya25@gmail.com

Systemic Acquired Resistance (SAR) is a fascinating defense mechanism in plants. Upon exposure to pathogens or stress, plants activate SAR to enhance their immunity. This adaptive response involves the production of signaling molecules that travel through the plant, priming distant tissues for defense. Through SAR, plants develop heightened resistance to various threats, bolstering their ability to fend off future infections or environmental challenges. This sophisticated process showcases the remarkable adaptability of plants and provides essential insights for developing sustainable agricultural practices and enhancing crop protection.

Basics of SAR

Definition: - SAR in plants, or Systemic Acquired Resistance, is a defence mechanism triggered by exposure to pathogen or stress. It induces immunity throughout the plant by signaling molecules, improving resistance against future threats and offering valuable insights for sustainable agriculture and crop protection.

How it function as a defense mechanism?

Systemic Acquired Resistance (SAR) is like an alarm system in plants. When a plant faces threats like harmful pathogens or stress, it activates SAR. Special molecules acts as messengers, spreading the warning throughout the plant. This helps all parts of the plant prepare to defend against potential attacks. SAR trains the plant's immune system to be stronger, making it more resistant to future dangers. It's like giving the plant a superpower to protect itself. By understanding how SAR works, scientists can develop strategies to enhance plant health, ensure better crop protection, and promote sustainable agriculture.

Mechanism of SAR

SAR involve a complex network of signals and response within the plant. Here's an overview of the key steps:

1. **Recognition of Pathogens:** When a plant encounter a pathogen (bacteria, viruses, fungi, etc.) or experiences stress, it triggers a localized immune response. Receptor proteins on the plant cell's surface recognize specific molecules from the pathogen, initiating the defense process.
2. **Signal Production and Transmission:** Upon pathogen recognition, the plant produces small signaling molecules, such as salicylic acid (SA), which acts as messengers. These molecules move from the infection site to other parts of the plant through the phloem (vascular tissue responsible for nutrient transport).
3. **Priming and Amplification:** The signaling molecules reach distant plant tissues, where they "prime" those tissues for potential future attacks. Priming enhances the

responsiveness of these tissue to subsequent pathogen encounters, leading to a faster and stronger defense response.

4. Gene Expression and Defense Proteins: The primed tissues activate specific genes involved in defense mechanisms. This results in the production of antimicrobial proteins, enzymes, and other compounds that actively fight against pathogens or help repair damaged cells.
5. Systemic Protection: SAR provides systemic protection, meaning that even parts of the plant not directly exposed to the initial threat become more resistant to infections. This preparedness can last for an extended period, enhancing the overall resilience of the plant.
6. Cross-Talk with other Pathways: The SAR pathway interacts with other defense pathways, like Jasmonic Acid (JA) and Ethylene (ET) signaling, to create a comprehensive defense strategy tailored to the specific pathogen or stress condition.

Understanding the cellular and molecular mechanisms behind SAR is vital for developing innovative ways to enhance plant resistance, leading to better crop protection, reduced pesticide use, and sustainable agriculture practices.

Real-life Example and case study

A real-life example of Systemic Acquired Resistance (SAR) can be seen in the interaction between tomato plants and the pathogen *Pseudomonas syringae*, which causes bacterial speck disease.

When a tomato plant is infected with *Pseudomonas syringae* in one part, the plant activates its local defense responses in the infected area through pattern- Triggered Immunity (PTI). However, the plant also initiates the SAR pathway. Salicylic acid (SA) is produced and transmitted through the vascular system, reaching uninfected parts of the plant.

This real-life example illustrate how SAR allow plants to develop a “ memory “ of past encounters with pathogens, leading to a more robust and coordinated defense response, thereby enhance the plant’s resistance and survival in the face of future threats.

Comparison with other defense mechanisms

Differences between Systemic Acquired Resistance (SAR), Induced Systemic Resistance (ISR), and Innate Immunity in plants:-

1) Initiation:-

- SAR: Triggered by the recognition of pathogens or stress, leading to the production of signaling molecules that spread throughout the plant to activate defense responses.
- ISR: - Induced by beneficial microbes, such as plant growth- promoting rhizobacteria (PGPR), which activate defense pathways without any direct infection.
- Innate Immunity: - Pre-existing defense mechanisms present in the plant, providing a constitutive level of protection against a broad range of pathogen.

2) Signal Molecules:-

- SAR: Involves signaling molecules like salicylic acid (SA) that are critical for transmitting the defense response from the infected to uninfected tissue.
- ISR: Dependent on volatile organic compounds, jasmonic acid (JA) and ethylene (ET) signaling, produced by beneficial microbes to induce plant defenses.
- Innate Immunity:-Relies on pre-existing receptor proteins that recognize pathogen-associated molecular patterns (PAMPs) or effector molecules to initiate the defense response.

3) Duration and Memory :-

- SAR: Provide long-lasting immunity and establishes a memory of previous pathogen encounters, leading to faster and stronger defense responses upon re-infection.

- ISR: Induces short-term resistance, typically lasting a few days to weeks, and lacks a long-lasting memory effect.
 - Innate Immunity: Offers constant protection without memory effects, as it is a constitutive defense.
- 4) Localization:-
- SAR: Initially activates a local defense response at the infection site before spreading systemically throughout the entire plant.
 - ISR: Mainly induces defense responses in the areas of the plant in direct contact with the beneficial microbes.
 - Innate Immunity: Active in all parts of the plant without prior exposure to pathogens, providing a basal level of protection.
- 5) Pathogens Targeted :-
- SAR: Effective against a wide range of pathogens, including bacteria, viruses, and fungi.
 - ISR: Particularly effective against certain soil-borne pathogens, nematodes, and insect pests.
 - Innate Immunity: Provides broad-spectrum protection against a variety of pathogens.

In summary, SAR is activated upon pathogen recognition, spreads systemically throughout the plant, and establishes a memory of past infections, resulting in prolonged immunity. ISR is induced by beneficial microbes and primarily targets specific pathogens or pests in localized areas. Innate immunity, on the other hand, is a constant, pre-existing defense mechanism found in all parts of the plant, providing broad-spectrum protection without memory effects. Each defense mechanism plays a unique role in enhancing the plant's ability to fend off threats and adapt to its environment.

Benefits

- SAR enhances immune response. It provides broad-spectrum, long-lasting protection against pathogens by activating defense mechanisms after initial exposure, improving overall plant health.

Conclusion

SAR is a vital defense mechanism in plants, conferring significant benefits to their overall health. By priming the immune system after initial exposure to pathogens, SAR enables broad-spectrum and long-lasting protection, bolstering plant resilience. This adaptive response plays a crucial role in plant survival and productivity, reducing the reliance on chemical pesticides and fostering sustainable agricultural practices. Understanding and harnessing SAR can lead to more effective plant protection strategies and contribute to global food security and environmental preservation.