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Perspective

# Non-Host Resistance Genes: Mechanisms and Benefits for Crop Improvement

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## DESCRIPTION

Crop plants are constantly exposed to a variety of pathogens that can cause severe losses in yield and quality. To protect crops from diseases, plant breeders and researchers have traditionally relied on host Resistance genes (R-genes) that confer specific immunity against certain races or strains of adapted pathogens. However, R-genes are often overcome by the evolution of new pathogen variants that can evade recognition by the plant immune system. Therefore, there is a need for more durable and broad-spectrum forms of resistance that can protect crops from a wide range of potential pathogens. One such form of resistance is Non-Host Resistance (NHR), which can be defined as the immunity of an entire plant species to all genetic variants of a non-adapted pathogen species. NHR is considered to be the most common and effective type of resistance in plants, as it prevents the establishment and reproduction of most pathogens that are not adapted to a particular host species. NHR is also expected to be more stable and long-lasting than R-gene-mediated resistance, as it does not depend on specific recognition events that can be bypassed by pathogen mutations.

The mechanisms of NHR are not fully understood, but they are likely to involve multiple layers of defense that act at different stages of the plant-pathogen interaction. Some of the possible components of NHR are- Pre-invasion defense involves physical and chemical barriers that prevent or reduce the entry of pathogens into the plant tissues. For example, the cuticle, cell wall, and antimicrobial compounds can act as pre-invasion defense mechanisms. Post-invasion defense involves cellular and molecular responses that limit or eliminate the growth and spread of pathogens inside the plant tissues. For example, Pattern-Triggered Immunity (PTI), Effector-Triggered Immunity (ETI), Programmed Cell Death (PCD), and Systemic Acquired Resistance (SAR) can act as post-invasion defense mechanisms.

To utilize NHR mechanisms for crop improvement, identification of the underlying genes is the first step. A number of studies have identified NHR genes effective against bacterial and fungal pathogens using various approaches, such as mutagenesis, transgenesis, transcriptomics, proteomics, and genomics. Some examples of NHR genes are:

- PEN1 gene encodes a syntaxin protein that is involved in vesicle trafficking and secretion at the plasma membrane. PEN1 contributes to NHR against powdery mildew fungi by facilitating the deposition of callose and antimicrobial compounds at the site of infection.
- SNC1 gene encodes a Nucleotide-binding Leucine-rich Repeat (NLR) protein that is involved in ETI. SNC1 confers NHR against bacterial pathogens by activating salicylic acid-dependent defense responses.
- NH1 gene encodes a WRKY transcription factor that is involved in SAR. NH1 confers NHR against bacterial pathogens by regulating the expression of defense-related genes.

The transfer of NHR genes from non-host species to host species is a promising strategy for enhancing crop resistance. Several methods have been used to achieve this goal, such as conventional breeding, genetic transformation, genome editing, and synthetic biology. For example, transgenic rice plants expressing barley MLO (Mildew Locus O) genes showed enhanced NHR against rice blast fungus. Similarly, genome-edited wheat plants with mutations in TaMLO-A1 genes showed enhanced NHR against wheat powdery mildew fungus. In conclusion, NHR is a valuable source of resistance for crop improvement that can overcome the limitations of R-gene-mediated resistance. By identifying and transferring NHR genes from non-host species to host species, it may be possible to develop more durable and broad-spectrum resistant crops that can cope with diverse pathogen challenges.

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