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Pathogenesis-Related (PR) Proteins: Role in Defence of Phytopathogens

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Abstract

Pathogenesis-related proteins are a diverse group of molecules that are induced by various plant pathogens, including fungi, bacteria, and viruses, as well as resistance-related signalling molecules. Intrinsic immunity, especially systemic acquired resistance (SAR), is an important part of implantation. Previous studies have shown that PR genes are more resistant to many stresses, so most active researchers use PR genes for many stresses, which suggests that PR genes are stronger, more resistance to many types of plant-based crops are excellent candidates for development of multiple stress tolerant crop varieties.

Keywords: PR proteins, phytopathogens, effector-triggered immunity (ETI), SAR, etc.

Introduction

Although the term pathogenesis-related protein (PR) was coined in 1980, this protein was first described in 1970 from leaves of tobacco plants infected with tobacco mosaic virus. One of the most active proteins in pathogenesis-related proteins (PRs) is a plant defense mechanism. PR protein accumulation under pathogen attack or abiotic stress is an important part of the immune response in plants. PR proteins are associated with the formation of hypersensitivity (HR) and systemic resistance (SAR) responses to fungal, bacterial and viral infections, and are located in hundreds of viruses. With more than 100 members documented in 70 plant species, the PR-10 family is the largest of all the individual classes of PR10 proteins. Molecular communication between plants and pathogens begins almost as soon as the pathogen comes into contact with the plant surface.

- **Definition of Pathogenesis-related proteins:** A group of proteins already present in trace amounts before infection, but produced or reached high level after infection.
- **Characteristics of PR proteins**
- Originally called “b” protein (also known as stress protein).

- It is located between cells or inside the cell.
- PR protein has very different biological properties. It is thermostable, resistant to proteases, and soluble at low pH (3).
- It is highly acidic or starchy, so it is highly soluble and reactive.
- Various plant organs (leaves, stems, seeds). , roots) produce different types of PR proteins.
- Many different types of proteins are produced in host plants.
- A high molecular weight protein linked to inhibition of sperm growth and release.
- There are 17 families of PR proteins.
- Size of the different PR proteins (mainly from 5 to 75 kDa)
- Example: β-1, 3 glucanase and chitinase that work in the wall part of the fungus.
- Lysozyme works with glucosamine and muramic acid and has the ability to kill bacterial pathogens (destroy ß-1, 4 glycosidic bonds).

Classification of pathogenesis related proteins

Family	**Type Member**	**Properties**
PR-1	Tobacco PR-1a	Antifungal
PR-2	Tobacco PR-2	ß-1,3-glucanase
PR-3	Tobacco P, Q	Chitinase (class I,II, IV, V, VI,VI)
PR-4	Tobacco 'R'	Chitinase class I,II
PR-5	Tobacco S	Thaumatin-like
PR-6	Tomato Inhibitor I	Proteinase-inhibitor
PR-7	Tomato P69	Endoproteinase
PR-8	Cucumber chitinase	Chitinase class III
PR-9	Tobacco'lignin-forming peroxidase	Peroxidase
PR-10	Parsley 'PR1'	Ribonuclease-like
PR-11	Tobacco 'class V' chitinase	Chitinase class I
PR-12	Radish Rs-AFP3	Defensin
PR-13	Arabidopsis THI2.1	Thionin
PR-14	Barley LTP4	Lipid-transfer protein
PR-15	Barley OxOa (germin)	Oxalate oxidase
PR-16	Barley OxOLP	Oxalate oxidase-like
PR-17	Tobacco PRp27	Unknown

Role of PR proteins in Plant Defense

- **Fungal resistance:**
  - Fungi are one of the most serious plant pathogens, causing significant yield loss in a variety of agriculturally important crops worldwide.
  - Fungal plant diseases are classified according to their habitat into biotrophic, hemibiotrophic and necrotrophic. Cutinases, pectinases, cellulases and proteases are just some of the hydrolytic enzymes produced by fungi to break down and penetrate plant walls. Pathogen recognition, activation of defense signaling pathways, and production of antifungal substances such as PR proteins are just some of the immunological responses that plants use to fight fungal infections (Bowles, 1990).
  - Fungi are one of the most serious plant pathogens and cause severe crop damage in most agricultural crops. Fungi often produce hydrolytic enzymes such as cutinases, pectinases, cellulases, and proteases that degrade plant cell walls.
  - To protect against fungal pathogens, plants use a variety of defense strategies, including pathogen signaling, activation of defense signaling pathways, and production of antifungal compounds such as PR proteins to limit pathogen attack and replication. In several transcription studies, PR genes have been found to be up-regulated in many crops after fungal infection and effective in disease resistance.
  - Under control conditions, PR genes show low levels of expression, but after fungal infection they are significantly increased in local disease zones and in neutral zones of the host plant, activating the resistance barrier (SAR).
  - Several in vitro studies have shown that PR proteins kill fungal cells by targeting or permeabilizing the cell wall. Overexpression of PR genes alone or in combination in different cultivars increases resistance to both biotrophic and necrotrophic fungi.
  - Genetic modification of defense components It is a very important method to prevent fungal diseases. For example, PR proteins are good candidates as targets for the development of cultivars with persistent and complete resistance to fungal pathogens (Ali *et al*., 2017a, 2018).

Bacterial resistance

- Many bacterial diseases have been isolated and found in many important agricultural crops, resulting in crop losses. Bacterial pathogens can enter the host through a variety

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of routes, including stomata, rhizomes, mechanical damage, leaf-feeding insects, and chemical absorption.

- Plants can protect themselves from bacterial infections through a series of immune responses. A key component of the first line of defense is the detection of bacterial infection by host PRRs. Fighting these plant bacteria elicits two main immune responses in the host: PTI and ETI (Figure 1).
- ETI activates a variety of signaling pathways, including SA pathway activation, SAR activation, and PR protein production. Pathogenesis-related proteins are popular weapons against various bacterial pathogens and enhance immunity.
- Many *in vitro* studies have revealed that PR proteins like PR-10 (Ribonuclease like protein), PR-12 (defensin), PR-13 (thionin) and PR-14 (Lipid transfer protein) are having antibacterial properties. Among them PR-10 shows broad spectrum of antibacterial activity against *Pseudomonas syringae*, *P. aureofaciens*, *A. radiobacter*, *Agrobacterium tumefaciens* and *Serratia marcescens*. Overexpression of PR-14 in rice has been shown to increase resistance to bacterial and fungal pathogens

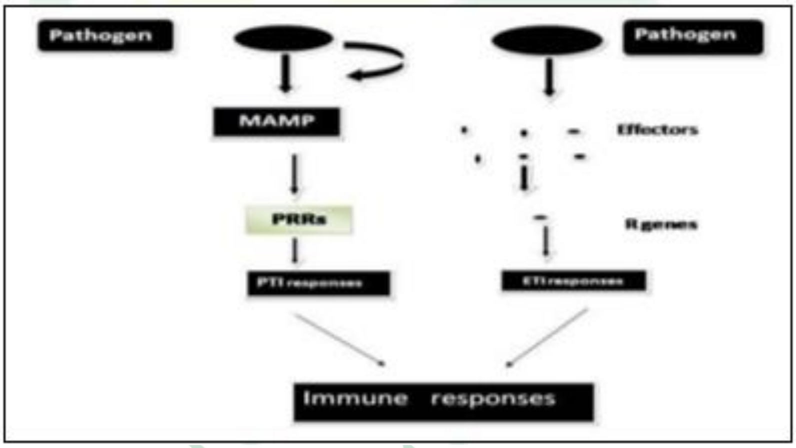

Fig. 1. A summary of the plant immunological response to bacterial infections. Pathogenassociated molecular patterns-triggered immunity (PTI) and effector-triggered immunity (ETI) are the two forms of immune responses that are activated after a pathogen attack (ETI).

Against viral pathogens:

- Plants are infected by viruses that are obligate biotrophic pathogens. Viruses hijack the host machinery and affect the plant health by suppressing the immune response.

- In response to plant-virus interactions, plants produce a variety of antibodies, such as RNA-binding proteins (RBPs), ribosome-inactivating proteins (RIPs), and PR proteins.
- After viral infection, PR proteins get accumulated in non-infected organs thereby block further virus propagation. Several studies have shown that PR-2a and PR-3, known antifungal proteins from *Nicotiana tabacum*, exhibit potent antiviral activity against TMV. PR-9 protein (peroxidase) also has antiviral activity. Several studies have shown that the *Capsicum annuum* PR-10 (CaPR10) protein exhibits ribonucleolytic activity against TMV. Proteins such as PR-12, PR-13 and PR-14 are known to have antiviral activity.
- These compounds not only inhibit virus-cell fusion, but also target the viral envelope, causing holes in the viral envelope and releasing viral pathogens. Previous studies have shown that overexpression of the PR-1b protein in tobacco plants increases resistance to TMV.

Conclusion

Biological stress is a growing concern in modern agriculture, so many research institutions are working hard to develop resistant varieties using various technologies such as PR proteins. Today, biological stress is a major challenge in modern agriculture, and much research is being done to develop resistant varieties using different approaches, including PR proteins. An important feature of PR proteins is that they are effective against various biological agents such as fungi, bacteria or viruses. In this sense, genetic engineering is the best way to use PR proteins for the development of trans-resistant plants. Therefore, advances in approaches such as genomics, transcriptomics, phenomics, proteomics, metabolomics, and ionomics have greatly helped to understand the detailed network of PR genes and the interactions of PR proteins with other plant and pathogen proteins. These studies will undoubtedly provide new genetic resources of PR genes that can be used effectively to respond to infectious diseases.

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