Molecular Basis of Plant Response to Biotrophic and Hemibiotrophic Pathogens

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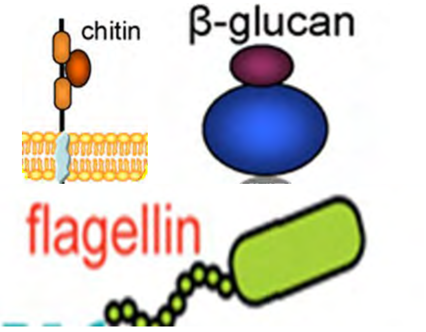
INTRODUCTION: Although plants are under constant attack by pathogens in nature, their immune systems allow infection only by limited numbers of adapted pathogens. One strategy to understand what determines the outcome of plant–microbe interactions is to study the molecular mechanisms that are adopted by plant pathogens to overcome plant immunity. As a result from co-evolution with their hosts, three prominent infection strategies. Biotrophic pathogens that require living plant tissue to survive and complete their life cycle. Members of this group include the rusts, downy mildews, powdery mildews, *Cladosporium* and species in the *Ustilago*. In contrast, necrotrophic pathogens secrete enzymes and toxins that kill the host tissue ahead of pathogen invasion, thus avoiding direct contact with defense molecules in living plant cells. Hemibiotrophic fungi combine both strategies. Genera *viz., Magnaporthe, Colletotrichum* and *Phytophthora fungi* belongs to hemibiotrophs. Collectively, they represent destructive plant parasites, causing huge economic losses and threatening global food security. In recent years it has become apparent that, like bacterial pathogens of plants and animals, plant pathogenic fungi produce and secrete many so-called effector proteins that interact with the host and play an important role in virulence.

Terminology

1. **Elicitor:** Compounds stimulating any type of plant defence
2. **Pathogen-associated molecular patterns (PAMPS):** Conserved microbial molecular signatures, associated with groups of pathogens, activate immune responses

   Ex: chitin, gulacan, flagelin etc,
3. **Microbe-associated molecular patterns (MAMPS):** The conserved microbe-specific molecules associated with beneficial organisms.
4. **Damage-associated molecular patterns (DAMPS):** Endogenous molecules and fragments from damaged cells and tissues can also be recognized as danger signals

Ex: Oligogalacturonides (OGs), Peptides, and Cutin monomers



Pathogen Associated Molecular Patterns (PAMP'S)

Multilayered Plant Immunity: Interactions between pathogens and their hosts are complicated and dynamic. The plant innate immune system is composed of pathogen–associated molecular pattern (PAMP)–triggered immunity (PTI) and effector–triggered immunity (ETI) pathways. Plants recognize pathogens through two major groups of receptors. Initially, plants sense pathogens via perception of their conserved PAMPs by pattern– recognition receptors (PRRs) located on the cell surface. This first level of recognition results in PAMP–triggered immunity (PTI), which is sufficient to ward off most pathogens. Different from PTI, diverse plant pathogens independently evolved mechanisms to secrete and release effector proteins into host cells evolutionarily. These effectors interact with cellular host targets and regulate PTI and/or host metabolism in a manner conducive to pathogen multiplication and dispersal. Nevertheless, these specific effectors can be recognized by a second set of polymorphic intracellular immune receptors in plants, which mostly belongs to the nucleotide–binding site–leucine–rich repeat (NB–LRR) protein family (Lorang *et al.,* 2012).

Effector recognition by Plant Immune Receptors: To counteract effector molecules, plants have developed an additional layer of immune recognition based on intracellular NB-LRR (nucleotide binding – leucine-rich repeats) receptor proteins that can detect individual effectors either directly or indirectly. These receptors are often referred to as resistance (R) proteins and the effectors they recognize as avirulence (Avr) proteins. Generally, the plant ETI response to R-protein-mediated recognition is more severe than PTI and frequently results in localized plant cell death, also known as the hypersensitive response (HR). This response is particularly effective against biotrophic and hemibiotrophs pathogens which depend on living host cells for nutrition.

References

Lorang, J., Kidarsa T., Bradford, C. S., Gilbert, B. and Curtis, M., 2012, Tricking the guard: exploiting plant defense for disease susceptibility. *Science.*, **338**: 659-662.

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Black Pod Disease of Cocoa

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INTRODUCTION: Cocoa (*Theobroma cacao* L.) is a cross-pollinated, perennial diploid plant belonging to the family Malvaceae and it is considered as an important plantation crop indigenous to South America- Amazon river basin. The crop prefers a warm humid tropical condition for growth and hence, it is confined to the equatorial and tropical countries. Cocoa introduced in India during 1798 and now it is cultivated predominantly in four states *viz.*, Kerala, Andhra Pradesh, Tamil Nadu and Karnataka. Cocoa is a shade loving crop, grown as an intercrop in existing coconut and arecanut gardens. Black pod disease is an important disease in cocoa caused by which cause 40-60 % yield loss. The pathogen is also known to cause canker, seedling die back, twig die back and chupon blight in cocoa.

Epidemiology

In India, the epidemic of black pod diseases is often most severe during South-West monsoon period (June- August). Environmental conditions such as high rainfall, high humidity (70-80 percent) and temperature (18-23°C) favor the development of disease. The layer of dead leaves on the soil and plant debris like pods, husks in which *P. palmivora* thrives saprophytically serve as a source of primary inoculum. The spread of pathogen also occurs by contact, rain splashes, insects and rodents.

Symptoms

The major symptoms produced by *P. palmivora* on cocoa plant include seedling blight, trunk canker, dieback of twigs, blight and necrosis of leaf, petiole and rotting of fruit. Cocoa pods are infected by *Phytophthora* at any stage *viz.*, from cherelle to mature pods and the pathogen penetrates the waxy cuticle and attack epidermis results in *shriveling,* wilting and dying of young pods and finally the affected internal tissues, beans turns dark brown in colour (Photo 1). The symptom of black pod disease starts with small necrotic lesion on the cocoa pod with brown or black colour, which eventually enlarges and rapidly covers the entire pod surface. White webs of mycelium also appear on the infected pods at an advanced stage of infections.

Photo.1. Intensity of *Phytophthora* pod rot (PPR) disease infection in field

Disease Management

The effective control of black pod disease involves three main strategies *viz.*, cultural practices and use of chemicals and use of resistant varieties.

1. Periodical removal and destruction of infected pods, unharvested but infected and mummified pods, will help to reduce the incidence of the diseases
2. Frequent harvesting will reduce the spread of the disease from infected pods
3. Overcrowded large tree with thick shade should be avoided
4. Regular pruning and removal of basal chupons regulate shade, increases air circulation and reduce the humidity under the canopy and further reduce the spread of the disease
5. The thick overhead shade trees in the border of the garden should be removed
6. Avoid water stagnation during monsoon season
7. The proper drainage system will reduce the amount of inoculum in and on the soil
8. Spray 1 % Bordeaux mixture at onset of monsoon and frequent intervals
9. Foliar spray of *Pseudomonas fluorescens*