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The Battle of Plant Cell

Abhishek TS
PhD Research Scholar, Dept. of Entomology, School of Agriculture, Lovely Professional University, Phagwara, Punjab.

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Abstract: -

In response to pathogen attack, every plant has a diverse set of defence mechanisms, which include structural and cellular defence systems as well as host-pathogen interactions. In this article, we have demonstrated and discussed the role of physical and biochemical defence mechanisms in plants when they are attacked by pathogens such as fungi, bacteria, viruses, and nematodes, such as the production of waxes, the formation of layers on surfaces, and secondary metabolites such as phytoalexins.

Introduction: -

Plants are organisms that are constantly exposed to harsh environments due to their sessile nature, including pathogenic species such as bacteria, fungus, viruses, and nematodes. They've evolved numerous layers of defence mechanisms to detect potentially hazardous germs throughout time (Freeman and Beattie, 2008). Plants can activate and deploy a variety of defences to fend off and defend themselves from pathogen attacks (Shittu et al., 2017). (Okungbowa and Shittu, 2012). Pathogens may retaliate by suppressing or evading plant defence mechanisms, or by rendering them ineffective (Shittu and Obiazikwor, 2018). Plant defence mechanisms include prefabricated barriers such as cell walls, bark, and cuticles (Laura et al., 2015).

Plant Pathogens: -

A plant pathogen is an organism or virus that may live and reproduce on plants, compromising their health and generating disease symptoms. Plant diseases can be fungus, bacteria, viruses, or nematodes, and they have varying degrees of host specificity, with some having a broad host range and others only targeting specific species (Lisbeth Mikkelsen et al., 2006). A virulent pathogen is one that produces disease, while an avirulent pathogen is one that does not. A pathogen must have three criteria in order to produce disease in plants; otherwise, disease would not arise. This is known as the disease triangle (figure 1).

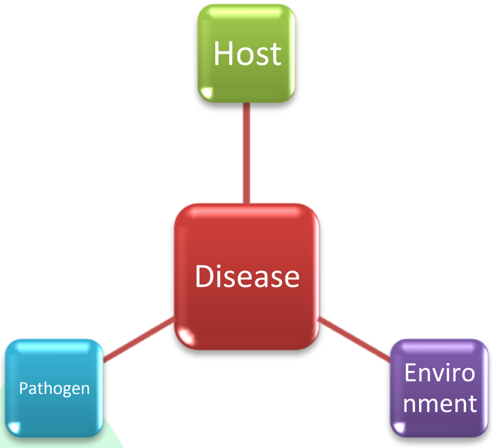

Figure 1: - Disease Triangle

Pathogen Identification: -

Plants' ability to adapt to possible pathogen challenges implies that they recognise these pathogens as 'non self.' Plants recognise a wide range of signals from microbes and the environment to generate defence responses, whereas mammals use antigen-antibody interactions to recognise non-self (David and John, 1997).

Defence Mechanisms in Plants: -

Plants protect themselves against pathogens using a combination of weapons from two arsenals known as host resistance:

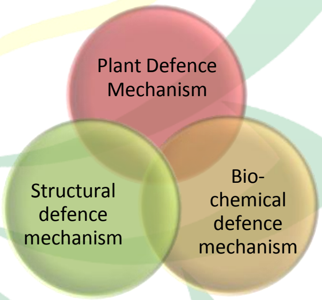

Figure 2: - Defence Mechanism in Plants

(1) **Structural characteristics: -** that act as physical barriers, preventing the pathogen from entering and spreading throughout the plant; and

(2) **Biochemical reactions: -** that occur in the plant's cells and tissues, producing substances that are either toxic to the pathogen or create conditions that prevent the pathogen from growing in the plant. The pre-existing and induced defence

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mechanisms are two types of innate defence mechanisms that can act at any stage of infection in plants and can occur simultaneously if the conditions are favourable.

This is the defence mechanism that serves as the plant's intrinsic first-line defence even before pathogen infestation. It is divided into three categories: pre-existing structural defence, pre-existing biochemical defence, and defence through the lack of critical elements.

a. Pre-existing structural defence mechanisms:

This defence mechanism consists of superficial structures located on the plant's surface that act as physical barriers to disease entrance (Laluk and Mengiste, 2010).

Pre-existing defence structures include: -

i. **Waxes and cuticles:** Waxes and cuticles are mixtures of long-chain aliphatic compounds that generate a water-repellent surface on the aerial parts of plants and prevent the creation of a film of water on the plant surface, which is necessary for spore germination (Marcell and Beattie 2002). When there is no water film, pathogens such as fungi and bacteria cannot germinate (fungi) or reproduce (bacteria) (Horsfall, and Cowling, 1980). A thick cuticle may improve infection resistance by preventing germs from immediately penetrating hosts, but it is not always associated with resistance (Marcell and Beattie 2002).

ii. **Epidermal cell walls:** These are the initial layer of living host cells that come into contact with invading pathogens and form the first line of defence (Doughari, 2015).

iii. **Stomata and lenticels:** Natural apertures such as stomata and lenticels allow numerous harmful bacteria and fungi to enter plants, yet the structure of these openings can sometimes hinder pathogen access (Cao et al., 2001). The Szinkum citrus variety's resistance to the citrus canker bacterium is attributed to its small stomata and their very narrow holes, which are encircled by elevated, broad lipped structures that prevent water drops bearing germs from entering (Singh, 2005). Lenticels' size and internal structure may also have a function in plant pathogen defence.

Apple types with large lenticels on fruits allow Pseudomonas papulosum, which causes apple leaf spot disease, to enter easily, whereas variants with small lenticels prevent the infection from entering (Singh 2005).

iv. **Thick-walled tissues:** Environmental factors can cause the cell walls of some tissues inside the plant to thicken. Pathogens are hampered by such barriers. Pathogens may be prevented from entering the stems of many cereal crops by the vascular bundle or extended areas of sclerenchyma cells (Dixon et al., 1994).

(B) Post-inflectional structural defence mechanism (Induced Structural Defences) :-

After the virus successfully penetrates the host's pre-existing defence barriers, some structures grow inside the host to prevent the disease from spreading further. These sections include:

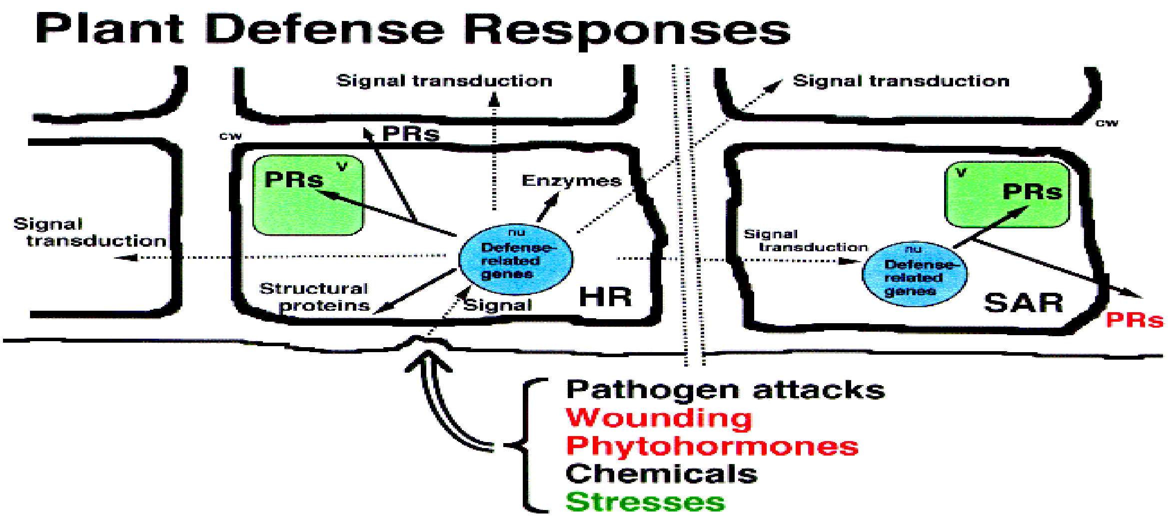

Figure 3: - Defence responses by plants

a) Histological defence mechanisms; and b) Cellular defence mechanisms

a) Histological defence mechanisms: -

Formation of cork layers

Infection by fungi or bacteria, as well as some viruses and nematodes, causes plants to develop many layers of cork cells beyond the area of infection, presumably as a result of pathogen-secreted chemicals stimulating the host cells.

Abscission Layer Formation

An abscission layer is generated by a gap between two circular layers of leaf cells that surround the infection site. When the leaf is infected, the middle lamella between these two layers of cells dissolves throughout the thickness of the leaf, fully isolating the infection from the rest of the leaf.

Tyloses are formed

Tyloses are overgrowths of nearby live parenchymatous cells' protoplasts that protrude into xylem vessels via pits. Tyloses create an impermeable barrier to water and nutrient transport.

Formation of Gums

Gums play a protective role because they are promptly deposited in the intercellular gaps and within the cells around the infection site, establishing an impermeable barrier that completely encloses the pathogen (Tom Schultz, 2006).

b) Cellular defence system

Hyphal Sheathing: The inward stretching of the cell wall causes the hyphae of fungi to be encased in a sheath. D u e t o s h e a t h I n g largely retards disease penetration and provides a partial check on pathogen transmission, such as late blight produced by *Phytophthora infestans.*

Deposition of callose:

Callose, a -1,3-glucan, is deposited in a variety of specialised wall or wall-associated structures. This occurs both during normal plant development and in response to injury or disease attack (Vance et al., 1980).

Biochemical defence mechanism:

Plants have metabolic processes in their cells that generate resistance to pathogen attack in addition to diverse structural defensive systems. Biochemical defence is the name given to this sort of plant defence.

This is a defence system that involves a variety of metabolic processes in plant cells or tissues prior to pathogen infection. By interfering with pathogens' and pathogenesis' actions, these substances can prevent or reduce infection (Doughari, 2015).

Biochemical defences are two types.

1. **Pre-existing biochemical defence mechanism**
2. **Post inflectional biochemical defence mechanism**
   a. **Pre-existing biochemical defence mechanism**
      i. **Inhibitors released by the plant into the environment:**

Plants emit organic chemicals through their aerial surfaces and roots, which collect in minute drops or spread into their surroundings. Some of these exudates are directly inhibitory to several pathogenic microorganisms, while others may stimulate the spread of certain microbial groups that act as antagonists to other dangerous microbes (Dangl and Jones, 2016). The fungitoxic exudates protocatechuic acid and catechol, which hinder the fungus' germination and tear the developing sperm tubes, are produced by red-scale onion types resistant to onion smudge disease caused by Colletotrichum circinans (Singh, 2005).

ii. Plant cell inhibitors present prior to infection:

In many host-parasite partnerships, plants' inherent poisonous compounds serve as the beginning point for resistance (Leong et al., 2002). While resistant cultivars have high levels of these compounds, vulnerable variants may have lower levels or none at all. Several fatty acid molecules found in high concentrations in cells, such as dienes and phenolics, are responsible for the resistance of immature tissues to parasite fungus taxa like Botrytis (Doughari, 2015). Many of these chemicals are efficient hydrolytic enzyme inhibitors. Other pre-existing chemicals with antifungal membranolytic action include saponin, avenacin in oats, and tomatine in tomatoes (Hammond-Kosack and Jones, 1997).

2. **Post-inflectional biochemical defence mechanism:**

After a pathogen attack, plants release a variety of biochemical compounds such as phytoalexins and hypersensitive defence. These chemicals are fungicidal or fungistatic in nature and are formed near the damage site. A chain of metabolic reactions starts to repair the wound.

Phytoalexins: -

These are harmful antimicrobial compounds produced in plants only following stimulation by certain phytopathogenic microorganisms or mechanical injury. Healthy cells next to injured and necrotic cells release phytoalexins (Hammond-Kosack and Jones, 2000). Muller and Borger proposed the basic concept of this occurrence in 1941 while working on late blight of potato (Phytophthora infestans), for example, Pisatin in Pea pods in response to Ascochyta pisi or damage. Bean pods and leaves with phaseollin are resistant to bean anthracnose caused by Colletotrichum lindemuthianum. Rishitin is produced in potato tubers after Phytophthora infestans infestation.

Conclusion:-

Plants use structural and biochemical defence mechanisms to protect themselves against various infections, acting as a barrier to the pathogens. However, plant defence mechanisms only reduce pathogen growth to a limited level, which is insufficient for disease resistance in plants.

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