RAMA UNIVERSITY

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LECTURE 16

DISEASE RESISTANCE AND DEFENSE MECHANISMS IN PLANTS

DISEASE RESISTANCE

Disease resistance

- Resistance is the ability of a host plant to resist the growth or establishment of a pathogen.
- Many plant pathogenic microorganisms are specific to certain host plants.
- The plant species and cultivars vary widely in their capacity to resist the establishment of a pathogen.
- When a pathogen enters the host, it must overcome several barriers before establishing itself.
- Sometimes the host reacts to the entrance of the pathogen or alters growth of the pathogen and thus effectively checks the establishment of the disease.
- There is great variation in the degree of resistance of a plant to a given parasite.
- This is influenced by various factors, involving the host, parasite and environment.

Disease escape: When the plant, though genetically susceptible to the pathogen, may show resistance in the field; such a condition is termed as disease escape.

- It happens when the optimum conditions are not present for the disease development on the crop variety, or the crop may not be in the proper stage of growth when the pathogen is most active.
- The host plant may be susceptible to the pathogen when it is young and develop resistance at maturity or vice-versa.

Disease endurance: In some cases, the plant is capable of carrying on most of the normal metabolic processes in spite of the diseased condition without reducing the yield to a considerable extent. It is known as disease endurance or disease tolerance.

Hypersensitive reaction or hypersensitivity: In hypersensitivity, when the pathogen enters the host, the cells in the immediate vicinity react in such a manner as to delimit the spread of the pathogen through death reaction of the cell, or by forming other barriers.

- The symptoms of such reactions in the host appear as minute specks, which the indicative of high resistance in the plant.
- The plant may be called resistant to the disease, if it shows hypersensitive reaction to infection by the pathogen.

Types of resistance

Resistance to diseases is also a genetically controlled character. Plants possess two different types of resistance:

- **Monogenic-** It is controlled by specific single gene. This type possesses high resistance to a given strain or race of the pathogen but it susceptible to other races.

- **Polygenic-** It is controlled by many genes and is not so high but at the same time does not easily breakdown due to the evolution of new races. This is also referred to as durable resistance.

Vertical vs. horizontal resistance

- The concept of vertical and horizontal resistance was suggested by Vander Plank in 1968.
- Resistance is vertical (differential) when it is completely effective against some races of a pathogen but not against the others.
- Vertical resistance is complete but is not permanent.
- Horizontal resistance is effective against all races of a pathogen.
- Horizontal resistance, though incomplete, is of permanent nature.

Conceptual explanation of different terminologies used to explain vertical and horizontal resistance by research workers are illustrated hereunder:
Gene for gene hypothesis

- It was first proposed by Flor (1942, 1945) as the simplest explanation of the result of studies of the inheritance of resistance and pathogenicity flax-rust host-pathogen system, and now applies to most of the combinations.
- According to this hypothesis, "for a resistance gene in the host there is a complementary avirulence gene in the pathogen."
- The coexistence of host plant and pathogen side by side in nature indicate that they have co-evolved; and changes in virulence of pathogen have been continuously governed by the changes in host or vice versa.
- This concept has been shown to operate in many other diseases like rusts, smuts, apple scab, late blight of potato and many other fungal , bacterial , virus and higher parasitic plant diseases.
- Generally, but not always in the host, gene for resistance is dominant (R) and gene for susceptibility is recessive (r).
- In pathogen, however, gene for avirulence that have inability to infect is dominant (A) and for virulence it is recessive (a).
- Thus plant variety when carrying gene for resistance (R) for certain pathogen and other lacking gene (R) i.e. carrying gene for susceptibility (r) are inoculated with two races of pathogen, one of which carries a gene for avirulence (A) and other carrying the gene for virulence (a) against (R); it gives a 4 gene combinations as below:

(-) denotes incompatible (resistant reaction); (+) denotes (compatible) susceptible reaction

- Out of the four combinations as above; only AR interaction is resistant or incompatible i.e. host has certain gene for resistance(R) that recognizes the corresponding genes for avirulence (A), so there is incompatibility.
- In Ar combination, infection results because host lacks the gene for resistance so pathogen can attack with other gene for virulence.
- In aR combination, infection occurs, although the host has gene for resistance but the pathogen lacks the gene for avirulence (A) which is recognized by specific gene for resistance; hence no defence mechanism is activated.
- Finally in ar gene combination, as plant lacks the gene for resistance and have gene for susceptibility (r) and pathogen have the gene for virulence (a), it results in infection.

Genetics of resistance

- Gene for resistance appear and accumulate first in host through evolution and they coexist with non-specific genes for pathogenicity that exist in pathogen.
- Genes for pathogenicity exist in pathogen against all host plants that lack specific resistance.
- When a specific gene for resistance appears in the host or bred into the host, the gene enables the host to recognize the product of the particular gene for virulence in pathogens, the pathogen gene is then thought of as the virulence gene (avrA) of pathogen that correspond to plant resistance gene (R).
- The change in the function of the pathogenic gene is because of subsequent recognition of avrA product i.e. elicitor molecule by the receptor coded by R gene which triggers the hypersensitive response reaction in the plant that keeps the plant resistant.

Breakdown of resistance

- A new gene for virulence that attacks existing gene for resistance appears by mutation of an existing avr gene which then avoids gene for gene recognition and the resistance breaks down.
- Plant breeders introduce another gene for resistance (R) in plant which recognizes the protein of new gene for virulence of pathogen and extend the resistance of host beyond the range of new gene for virulence in pathogen.
- This produces a variety that is resistant to all races that have an avirulence gene corresponding to specific gene for resistance until another gene for virulence appears in pathogen.