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16. Breeding for Biotic Stress Resistance

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Abstract:

Breeding for biotic stress resistance is critical for sustainable agriculture, aiming to develop crop varieties resilient to pest and disease pressures. This involves systematic selection and breeding of plants with inherent genetic traits that confer resistance or tolerance to biotic stresses. Utilizing traditional breeding methods, such as hybridization and selection, alongside modern biotechnological tools like marker-assisted selection, breeders can accelerate the development of resistant cultivars.

Through meticulous phenotypic evaluation and molecular analyses, genetic sources of resistance are identified and integrated into breeding programs. The resulting resistant varieties offer farmers effective and environmentally friendly solutions to combat biotic stresses, ensuring stable crop yields and food security.

Keywords:

Biotic Stress, Crop Yield, Food Security, Resistance, Susceptible.

16.1 Disease Resistance:

Stress: Restrictive force, pressure, or unfavorable weather circumstances for crop growth brought on by environmental or biological variables.

Biotic - adverse consequences brought on by pests and illnesses abiotic stressors

Abiotic (non-living)- Negative effects on the host caused by environmental conditions such as heat, cold, salinity, alkalinity, drought, and air pollution, among others.

Host- Plant that is afflicted by a disease or that a pathogen may live on.

Pathogen- An organism known as a pathogen causes disease.

Disease- An abnormality in the plant induced by a pathogen is referred to as a disease.

Pathogenicity: A pathogen's capacity to infect a particular strain of the host

Virulence: A pathogen's ability to cause disease

Avirulence-A pathogen's avirulence refers to its incapacity to spread or cause disease.

Pathotype: A classification of pathogen strains based on how virulent they are against known host resistance genes.

Epidemic: A sudden, severe breakout of a disease that starts with a low infection level.

16.2 Variety Among Fungus-Causing Pathogens:

a. Hybridization: The zygote undergoes recombination of the genes of the two parental nuclei, and the haploid nuclei tor gametes that emerge during meiosis are distinct from the gametes that formed the zygote as well as from one another. Consequently, each diploid pathogen has a unique genetic makeup. even within the same species, unique from any other disease, and variable. The study of a single pathogen is never finished. Phytophthora infestans, for instance.

b. Heterokaryosis: A condition in which fungi produce hyphae with distinct genetic compositions. to create heterokaryons when they coexist in the same cell.

c. Parasexuality: Parasexuality is the reassortment of genetic material into haploid and diploid forms, preparing it for both natural and artificial selection. Race mixtures that have coexisted on a susceptible host genetically meld to form new races, such as phytophthora infestans

d. Mutation: The speed at which a virus produces new variations will rely on the frequency of gene mutations at a specific location. From gene to gene, the mutation rate varies, and from one pathogen to the next. For instance, Melampsora lini, a new race created by UV light (Flor 1956).

e. Cytoplasmic adaptation: According to Jinks (1966), there are several instances of significant traits like growth rate and pathogenicity being passed down through the cytoplasm.

The virulence of *P.graminis f. sp. avenae*, which carries the gene E, is inherited from the mother and may regulated by a single plasma gene.

16.3 Mechanisms of Disease Resistance:

There are several methods of illness resistance, including disease immunity, disease endurance, and disease resistance.

A. Disease escape: A sensitive host plant's capacity to fend off disease attack as a result of environmental influences, early variations, a charge for the plating date, and a change in the location application of NPK in a balanced manner, etc.

Early potato and groundnut varieties, for instance, may Since they reach maturity before the disease, they are able to avoid the 'Tikka' and 'Late blight' diseases, respectively outbreak happens. Sugarcane has successfully been planted from June to October invading leaf rust.

In potato, the crop is planted in October to yield seed potatoes that are virus-free instead of November, when planting is often done.

B. Disease endurance or tolerance: The capacity of the plant to withstand the pathogen's invasion without suffering significant harm. This perseverance results from the influence of outside characters. In general, tolerance is challenging to quantify since it is confused with partial illness evasion and resistance. To gauge tolerance for yield loss and other aspects of Several host types with comparable disease burdens, such as leaf area affected by disease, are compared. E.g. Proctor, a type of barley, has 13% yield loss in comparison to 20% loss in the Zephy and Sultan variants. Wheat cultivars are more resistant to rust and other diseases when fertilized with potash and phosphorus. In Japan, silicate-fertilized rice is resistant to blast infection.

C. Disease Resistance: A plant's capacity to fend against, defeat, or survive a pathogen attack. Resistance is a relative phrase that generally refers to any slowdown in the growth of the virus that is attacking. Disease symptoms to appear in the event of resistance, and while never zero, or r? o, the rate of reproduction is sufficiently less than one (the rate of it must be helpful (reproduction on the sensitive variety). The pathogen's growth is restrained by this factor. i) A single dominant trait may be substantially responsible for controlling resistance gene in wheat NP 809, Newland flax variety, and Ottawa 770 B all rusts

D. Immunity: An immune reaction occurs when the host does not manifest illness signs. Immunity may occur via blocking the pathogen's access to the relevant sections of the host, such as the exclusion of ovary-infecting fungi's spores by wheat's closed flowering habit and also of barley. It is more frequently caused by the host's hypersensitive reaction, which typically occurs right away following the onset of the infection. The rate of reproduction in an immune response is zero, or $r = 0$.

E. Hypersensitivity: Following infection, numerous host cells at the site they will perish since the sickness is so delicate. 1Because the rust mycelium cannot develop through the dead cells; this causes the pathogen to die. For all intents and purposes, this extreme sensitivity (hypersensitivity) acts as a resistive reaction. Particular polyphenols are called phytoalexins. or terpenoid compounds, which the host produces in reaction to a pathogen infection. There are more than 30 distinct phytoalexins known. For instance, rust fungus and virus assault.

16.4 Disease Resistance-Related Factors (Causes of Disease Resistance)

The disease resistance could result from

- Morphological, structural, and functional traits that block the pathogen's entry, i.e., stop the first stage of infection.
- Tissue's biochemical or anatomical characteristics that inhibit the formation of parasites relationship.

a. Morphological Characteristics: The host may not become infected if it has certain morphological characteristics. For instance, it has been demonstrated that the hariness of cotton correlates with resistance to Jassid assault. Varieties: Compared to glabrous kinds, hairy types are more resistant to assault. Rust spores on the barley leaves didn't germinate because of the waxy coating. Because of the size of the stomata, young sugarbeet leaves are virtually impervious to attack by the Circos Pora is quite tiny.

b. Physical Characteristics: chemical interactions or protoplasmic components: Because of its chemical makeup, protoplasm may have an inhibitory effect on the pathogen causing the plant to develop the required resistance. For instance, the acidity of cell sap is closely connected with the grape's resistance to powdery mildew. The presence of a hazardous chemical in the red onion pigment. The outside scales fend off the assault by smudging fungus they become vulnerable when the scales are removed.

c. Anatomical: In resistant potato cultivars, the cell walls have undergone further secondary thickness, preventing mechanical puncture by the encroaching Pythium disease.

d. Nutritional Factors: It is commonly believed that a reduction in growth and spore production because the host's physiological conditions are not optimal. Probably a resilient host does not meet the nutritional needs of the infection, which inhibits its growth reproduction.

Environmental influences: In addition to the aforementioned, environmental influences have significantly the pathogen attack's impact. Temperature, moisture, humidity, soil PH, and the level of fertility. The pathogen reaction is heavily influenced by the soil. Disease resistance is based on genetics. Biffen conducted the first investigation into the genetics of illness resistance in 1905. He revealed the wheat variety's inherited resistance to leaf rust. Crosses with some vulnerably riveted varieties. In F2 there were 3 susceptible: 1 resistant plant indicating that resistance was controlled by a single recessive gene /1The majority of past research was done without taking taking the pathogen's physiological specialization (pathotype differentiation) which could significantly affect the conclusions made. That illness is now recognized.

Disease Resistance Sources:

There are four different ways to develop disease resistance:

A. A well-known type

B. collection of DNA

C. Companion species

D. By way of mutations

A. A well-known variety: Most cultivated varieties have documented disease reactions, so a breeder might find the resistance he needs in a farmed variety. Additionally, resistant plants were bred from commercial types, as was the case with cabbage yellows. resistance to curlytops, etc. These serve as the foundation for fresh resistance breeds.

B. Germplasm gathering: When a disease or its novel pathotype is resistant to current treatments, A germplasm collection of uncultivated varieties should be screened. In several cases from the germplasm collections, disease resistance was discovered. For instance, resistance to neckblotch resistance of watermelon barley to wilt

C. Related species: It is frequently possible to find resistance to a disease in related species, which can then be spread through interspecific hybridization. For instance, wheat's resistance to stem, leaf, and stripe rusts

D. Mutation: Either naturally occurring mutations or selected mutations might lead to disease resistance. induced by means of mutagenic therapies.

- The induction of Victoria blight resistance in oats by thermal neutron or x-ray irradiation, as well as spontaneously created
- Wheat's resistance to stripe rust
- Oats' resistance to brown rust
- Barley's resistance to mildew
- Linseed's resistance to rust
- Groundnut stem root and tikka leaf spot resistance

16.5 Vertical and Horizontal Resistance (Van Der Plank):

Major genes often determine vertical resistance, which is defined by pathotype specificity. In the case of vertical resistance, the immunological or susceptible response depends on the existence of a dangerous pathotype. Epidemics develop when pathogenic pathotypes are more common. prevalent in vertical resistance situations. Consequently, an avirulent pathotype will result in an immune response, or almost so, but the virulent pathotype will cause a susceptible response, or r=1.It is also referred to as pathotype-specific, race-specific, or just specific resistance.

16.5.1 Transverse Resistance:

Non-racial pathotypes, general or field resistance, and non-racial and partial pathotypes. Horizontal Resistance is typically governed by polygenes, which are several genes with minor effects pathotype not particular. The reproduction rate in this instance is less than one but not zero. Regulate horizontal resistance are poly genes.

16.6 Breeding Techniques for Disease Resistance:

In general, the techniques used to breed for disease resistance are the same as those used for other Agricultural qualities.

A. Introduction
B. Selection
C. Hybridization
D. Grafting and budding
E. Mutation Breeding
F. Biotechnological techniques

A. Introduction:

Resistant varieties may be planted in a new location. For instance, early varieties of groundnut imported from the USA were resistant to leaf spot (Tikka), while wheat variants Kalyanasona and Sonalika were developed from segregating material imported from Mexico's CIMMYT were rust-resistant.

- African bajra introductions have been used to create CMS lines that are resistant to downy mildew.

B. Selection:

The simplest technique is to choose resilient plants from commercial kinds. For instance, the Kufri Red potato is a selection of the Darjeeling Red round.

- A selection from a Bihar-sourced collection called Pusa Sawani behind (yellow mosaic)
- MCU I was chosen from CO4 for my resistance to the cotton's black arm.

C. Transferring disease resistance from one species or variety to another through hybridization.

The pedigree approach is excellent for dealing with horizontal resistance. To aid in the selection of disease resistance, artificial disease epiphytic organisms are created.

a. For instance, in the Kalyana Sona, Sonalaka, Malvika 12, Malvika 37, Malavika 206, and Malavika 234 wheat varieties. Cotton with Laxmi (Gadag 1 x CO2) for resistance to leaf blight

b. A less desirable agronomic variety's resistance genes are transferred via the backcross procedure to a vulnerable cultivar that is popularly adopted and has significant agronomic value. Backcrossing is a sensible option because the parent is an entirely unadapted variety. if resilient breed possesses some positive traits, they decided to handle the material with the pedigree approach.

D. Budding & Grafting:

Either budding or grafting is used to impart the disease resistance in vegetatively propagated material. The resistant material can be transmitted via grafting or budding.

E. Mutation Breeding:

Used when the germplasm lacks sufficient resistance; Mutation Resistance is created by breeding.

This is also used to sever connections between additional beneficial genes, including resistance genes.

16.6.1 Precautions:

a. The donor parent needs to have the necessary level of resistance.
b. There must be no linkage—it must simply be inherited.
c. The receiver parent's recovery ought to be more pronounced
d. The right environment must be created for the resistance genes to manifest themselves fully.

16.6.2 Benefits of Disease Resistance Breeding:

a. Aids in minimizing pathogen-related losses
b. Lowers the expensive cost of chemical treatment for disease control
c. Facilitates avoiding the use of toxic fungicides
d. The only treatment for some particular illnesses, such as infections and wilt, etc.

16.6.3 Limitations

a. Linkage of resistant genes with genes of inferior quality
b. Occurrence of physiological races of varying capacities
c. Self-sterility in host plants

Utilization and achievements

a. Rice ADT 10 x Co4 (resistant to blast)
b. Potato Solanum tuberosum x Solanum demissum (susceptible to late blight) (wild resistant to late blight)

F1 backcrossed with Sol. tuberosum (Resistant variety)

Varieties resistant to different diseases

Rice: Blast Co25, Co26,

Wheat: all three rusts: NP 809

Yellow rust: NP 785, NM86

Black rust: NP 789

Brown rust: NP 783, NP 784

Sugarcane: Red rot Co 419, Co 421, Co 527

Cotton: Wilt Vijay, Kalyan, Suyog

Groundnut: Tikka leafspot Ah 45

Chilli: Mosaic resistant Pusa red, Pusa orange

16.7 References:

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