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# **DISEASE RESISTANCE**



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# MECHANISMS OF DISEASE RESISTANCE

1. **Disease escape:** The ability of susceptible host plants to avoid attack of disease due to environmental conditions factors, early varieties, change in the date of planting, change in the site of planting; balanced application of NPK etc. Eg. Early varieties of groundnut and potato may escape 'Tikka' and 'Late blight' diseases respectively since they mature before the disease epidemic occurs. Changing planting season in sugarcane from June to October has successfully escaped leaf-rust. Virus free seed potato is produced by sowing the crop in October in Jullundher and other places instead of November, the normal planting time.



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**2. Disease endurance or tolerance** : The ability of the plants to tolerate the invasion of the pathogen without showing much damage. This endurance is brought about by the influence of external characters. Generally, tolerance is difficult to measure since it is confounded with partial resistance and disease escape. To estimate tolerance the loss in yield and some other trait of several host varieties having the same amount of disease eg., leaf area covered by disease etc., is compared. Eg. In Barley the variety Proctor shows 13% yield loss as compared to 20% loss in the varieties Zephy and Sultan.



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3. **Disease Resistance** : The ability of plants to withstand, oppose or overcome the attack of pathogens. Resistance is a relative term and it generally refers to any retardation in the development of the attacking pathogen. In case of resistance, disease symptoms do not develop and the rate of reproduction is never zero i.e.,  $r < 0$  but it is sufficiently lower than 1 (the rate of reproduction on the susceptible variety) to be useful. The inhibition of growth of the pathogen is believed to be nutritional in nature and in some cases chemical growth inhibitors may be involved. Resistance is largely controlled by inherited characters i) may be controlled by single dominant gene in Ottawa 770 B, Newland flax variety, wheat all rusts NP 809



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4. **Immunity:** When the host does not show the symptoms of disease it is known as immune reaction. Immunity may result from prevention of the pathogen to reach the appropriate parts of the host e.g. exclusion of spores of ovary infecting fungi by closed flowering habit of wheat and barley. It is more generally produced by hypersensitive reaction of the host usually immediately after the infection was occurred. In immune reaction the rate of reproduction is zero i.e.  $r = 0$ .
5. **Hypersensitivity:** Immediately after the infection several host cells surrounding the point of infection are so sensitive that they will die. This leads to the death of the pathogen because the rust mycelium cannot grow through the dead cells. This super sensitivity (hypersensitivity) behaves as a resistant response for all practical purposes.



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Phytoalexins are specific polyphenolic or terpenoid chemicals and are produced by the host in response to the infection by a pathogen. More than 30 different phytoalexins have been identified. Phytoalexins are either fungicidal or fungistatic. Eg. Rust fungi and virus attack.

## **Factors for disease resistance (Causes of Disease resistance)**

The disease resistance may be caused due to

1. Morphological, structural and functional characteristics which prevents the entrance of the pathogen *i.e.* prevents the first stage of infection.
2. Biochemical or anatomical properties of tissue which prevent the establishment of parasitic relationship.



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## **a. Morphological characters**

Certain morphological features of the host may prevent infection. Eg. Resistance to Jassid attack in cotton has been shown to be correlated with the hairiness of varieties : hairy type resists the attack more, than glabrous types.

Failure to germinate rust spores on the leaves of the barley due to waxy coating. Young sugarbeet leaves practically immune to attack of the *circospora* because the stomata size is very small.

## **b. Physiological characters**

### **Protoplasmic factors or chemical interactions :**

By virtue of its chemical composition the protoplasm may exert an inhibitory influence on the pathogen bringing about the desired resistance in the plant.



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Eg. : Resistance of grape to powdery mildew is highly correlated with the acidity of cell sap.

Presence of toxic substance in the red pigment in the coloured onions. The outer scales resist the smudge fungus attack when the scales are removed they become susceptible

**c. Anatomical:** More secondary thickening of the cell walls of resistant potato varieties which resists the mechanical puncture of the invading *Pythium* pathogen.

**d. Nutritional factors :**Reduction in growth and in spore production is generally supposed to be due to unfavourable physiological conditions within the host. Most likely a resistant host does not fulfill the nutritional requirements of the pathogen and thereby limits its growth and reproduction.



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e. **Environmental factors** :In addition to the above the environmental factors have marked effect on the pathogen attack. Temperature, moisture, humidity and soil PH and fertility status of the soil effects the pathogen reaction greatly.

## **Genetic basis of disease resistance**

The first study on genetics of disease resistance was done by Biffen in 1905. He reported the inheritance of resistance to leaf rust of wheat variety Rivet in crosses with some susceptible varieties. In F<sub>2</sub> there were 3 susceptible : 1 resistant plants indicating that resistance was controlled by a single recessive gene. Most of the earlier studies were conducted without taking into consideration the physiological specialization (pathotype differentiation) of the pathogen which can materially influence the conclusions drawn



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It is now recognized that disease resistance may be inherited in three different ways : Oligogenic, Polygenic and Cytoplasmic inheritance

### **Oligogenic inheritance:**

The disease resistance is governed by one or few major genes and resistance is generally dominant to the susceptible reaction. The action of major resistance genes may be altered by modifying genes in many cases. Eg. bunt resistance in Wheat. Oligogenes generally produce immune reaction. The chief characteristic of the oligogenic disease resistance is pathotypespecificity, i.e. resistant gene is effective against some pathogens, while it is ineffective against the others. In most cases, there are a number of major genes that determines resistance to a particular disease Eg. more than 20 different resistance genes are known for leaf rust of wheat,



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while those for stem rust resistance exceed 30. The genetics of oligogenic resistance has advanced by two events *viz.*,

1. Discovery of a resistance gene to the prevalent pathotype and
2. Evolution of a pathotype virulent to the new resistance gene

### **Polygenic inheritance:**

In this type the disease resistance is governed by many genes with small effects and a continuous variation for disease reaction is produced. The genes show additive and non additive effects and the environmental effect is also observed. The polygenic resistance does not show pathotype specificity as against the oligogenic resistance. It is almost same as horizontal resistance. In some cases the polygenic inheritance may have a oligogenic component, the oligogenes acting in an additive manner eg. bacterial blight resistance in cotton



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## **Cytoplasmic inheritance :**

Resistance in some cases is determined by cytoplasmic genes or plasma gene(s).

Eg. The T-male sterilizy cytoplasm (cms-T) in maize is extreamly susceptible to *Helminthosporium* leafblight, while the non-T cytoblasms are resistant to this disease.

## **Sources of Disease Resistance**

Resistance to diseases may be obtained from four different sources :

1. A known variety
2. Germplasm collection
3. Related species
4. Through mutations



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- 1. A known variety:** Disease reactions of most of the cultivated varieties are documented and a breeder may find the resistance he needs in a cultivated variety. Resistant plants were also lated from commercial varieties as in the case of cabbage yellows in cabbage curlytop resistance etc. These provide the basis for new resistance varieties.
- 2. Germplasm collection :**When resistance to a new disease or a new pathotype of a disease is not known in a cultivated variety germplasm collection should be screened. Several instances disease resistance were found from the germplasm collections. Eg.resistance to neckblotch in barley resistance to wilt in watermelon



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3. **Related species** : Often the resistance to a disease may be found in related species and transferred through interspecific hybridization. Eg. Resistance to stem, leaf & stripe rusts of wheat
4. **Mutation** : Resistance to diseases may be obtained through mutation arising spontaneously or induced through mutagenic treatments. Eg.1. Resistance to Victoria blight in oats was induced by irradiation with x-rays or thermal neutrons / also produced spontaneously
2. Resistance to stripe rust in wheat
3. Resistance to brown rust in oats
4. Resistance to mildew in barley
5. Resistance to rust in linseed
6. Resistance to tikka leaf spot and stem root in groundnut



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# Methods of Breeding for Disease Resistance

The methods of breeding for disease resistance are essentially same as those used for other agronomic traits. They are :

1. Introduction 2. Selection 3. Hybridization 4. Budding & Grafting 5. Mutation Breeding 6. Biotechnological methods.

1. **Introduction** : Resistant varieties may be introduced for cultivation in a new area.

Eg.· Early varieties of groundnut introduced from USA have been resistant to leaf spot (Tikka)

- Kalyanasona and Sonalika wheat varieties originated from segregating material introduced from CIMMYT, Mexico, were rust resistant.
- African bajra introductions have been used in developing downy mildew resistant cms lines.



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2. **Selection** : Selection of resistant plants from commercial varieties is easiest method. Eg. Kufri Red potato is selection from Darjeeling Red round
- Pusa Sawani behind (yellow mosaic) selection from a collection obtained from Bihar
  - MCU I was selection from CO4 for black arm resistance in cotton

3. **Hybridization** : Transferring disease resistance from one variety or species to the other.

a. Pedigree method is quite suitable for horizontal resistance. Artificial disease epiphytotics are produced to help in selection for disease resistance.

Eg. In wheat Kalyana Sona, Sonalaka, Malvika 12, Malvika 37, Malavika 206, Malavika 234



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4. **Budding & Grafting** : The disease resistance in vegetatively propagated material is transferred by adopting either by budding or grafting. By grafting or budding the resistant material, the resistance can be transferred.

5. **Mutation Breeding** : When adequate resistance is not available in the germplasm; Mutation breeding is resorted to induce resistance. This is also used to break the linkages between desirable resistant genes and other desirable genes.

**Precautions:** 1. The donor parent must possess the required amount of resistance

2. It must be simply inherited without any linkage

3. The recovery in the recipient parent should be more

4. Proper condition for full expression of the resistant genes has to be provided



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## **Advantages with breeding for disease resistance**

1. Helps in reducing the losses caused by pathogens
2. Reduces the high cost of disease control by chemical treatment
3. Helps to avoid the use of poisonous fungicides
4. Only method available to some specific diseases like viruses, wilt etc.

## **Limitations**

1. Linkage of resistant genes with genes of inferior quality
2. Occurrence of physiological races of varying capacities
3. Self sterility in host plants



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## Utilization and achievements

1. Rice ADT 10 x Co4 (resistant to blast)
2. 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