

Lecture: - 5

Self -Incompatibility

5.1 Self-incompatibility (SI):-It refers to the inability of a plant with functional pollen to set seeds when self pollinated. It is the failure of pollen from a flower to fertilize the same flower or other flowers of the same plant.

- Self- incompatibility was first reported by Koelreuter in *Verbascum phoenicum* plants.
- Term coined by “STOUT” in 1917.

General features of Self-incompatibility:-

- Prevent selfing and promotes out-breeding so increases the probability of new gene combinations.
- Causes may be morphological, physiological, genetical or biochemical.
- Normal seed set on cross pollination.
- May operate at any stage between pollination and fertilization.
- Reduces homozygosity.

5.2 Mechanism behind self incompatibility:-

- **Pollen-stigma interaction:**-The pollen grains do not germinate on the stigma of the same flower. If they germinate the pollen tube fails to penetrate the stigma as in Rye, Cabbage and Radish.
- **Pollen tube-style interaction:**- In most cases of the gametophytic system, pollen grains germinate and pollen tubes penetrate the stigmatic surface. But in incompatible combinations, the growth of pollen tubes is retarded within the stigma, e.g., in *Oenothera*, or a little later in the style, e.g., in *Petunia*, *Lycopersicon*, *Lilium* etc. In the latter case, there is a cessation of protein and polysaccharide synthesis in the pollen tubes, which leads to the degeneration of tube wall and the bursting of pollen tube.
- **Pollen tube-ovule interaction:**-In some cases, e.g., *Theobroma cacao*, pollen tubes reach the ovule and effect fertilization. However, in incompatible combinations, embryos degenerate at an early stage of development.

5.3 Classification:-Based on flower morphology, self-incompatibility system is of two types viz., heteromorphic system and homomorphic system.

5.3.1 Heteromorphic system:-In heteromorphic self-incompatibility , the genes responsible for self- incompatibility in heterostylous flowers are strongly linked to the genes responsible for flower polymorphism, so these traits are inherited together.

- The associated concepts are distyly and tristlyly.

Distyly: It refers to two types of styles (short and long) and stamens (low and high).

- This system operates in the family Primulaceae.
- In Primula, there are two types of flowers.
 - i. Thrum type which has short style and high anthers.
 - ii. Pin type with long style and high anthers.
- The crosses are compatible only between the style and stamen of matching length.
- In other words, crosses are compatible between Pin x Thrum or Thrum x pin but not between Pin x Pin and Thrum x Thrum flowers.
- Later on, it was discovered that, incompatibility barrier between Pin and Pin and Thrum x Thrum are governed by a single gene S which behaves in a heterozygous (Ss) and Pin is homozygous recessive (ss).
- Thus thrum is dominant over Pin. Cross between thrum and Pin produce thrum and Pin in 1:1 ratio in F1.

| MATING | | PROGENY | |
|---------------|----------|-----------------|------------------------|
| Phenotype | Genotype | Phenotype | Genotype |
| Pin x Pin | Ss x Ss | | Incompatibility mating |
| Pin x Thrum | Ss x Ss | 1 Thrum : 1 Pin | 1 Ss x 1 Ss |
| Thrum x Pin | Ss x ss | 1 Thrum * 1 Pin | 1 Ss x 1 ss |
| Thrum x Thrum | Ss x Ss | | Incompatible |

Tristyly: - When style has three positions (short, medium and long) and filaments are of three lengths corresponding to the length of style.

- Any one plant has one style length and four stamens with two different lengths of filaments pollination are compatible only between stigmas and anthers at the same level. Thus each type of plant can effectively fertilize the other two types.
- It is determined by two genes S and M, each with two alleles.
- S gives rise to short style,
- S and M to medium style and
- s and m to long style.
- The number of possible genotypes is greater, but a 1:1 ratio exists between individuals of each SI type.

5.3.2 Homomorphic System:- In the homomorphic system, incompatibility is not associated with morphological differences among flowers.

- The incompatibility reaction of pollen may be controlled by the genotype of the plant on which it is produced or by its own genotype.
- This system is very much important in crop plants.
- Homomorphic system is of two type:-
 - a. **Gametophytic system**
 - b. **Sporophytic system**

5.3.2.1 Gametophytic Incompatibility:-The incompatibility reaction of pollen is determined by its own genotype, and not by the genotype of the plant on which it is produced.

- Gametophytic incompatibility was first described by East and Mangelsdorf in 1925 in *Nicotiana sanderae*.
- Generally, incompatibility reaction is determined by a single gene having multiple alleles, e.g., *Trifolium*, *Nicotiana*, *Lycoperscion*, *Solanum*, *Petunia* etc.
- The S loci are extremely polymorphic; that is, there is an abundance of multiple alleles in the population.
- Incompatibility is controlled by the single S allele in the haploid pollen grain.
- Thus a pollen grain will grow in any pistil that does not contain the same.
- **In a single gene system, there are three types of mating;**
 - i) Fully incompatible, e.g., S1S2 x S1S2
 - ii) Fully compatible, e.g., S1S2 x S3S4
 - iii) Partially (i.e., 50% of the pollen) compatible, e.g., S1S2 x S2S3

5.3.2.2 Sporophytic Incompatibility:-The incompatibility reaction of pollen is governed by the genotype of the plant on which the pollen is produced, and not by the genotype of the pollen.

- It was first reported by Hughes and Babcock in 1950 in *Crepis foetida*, and by Gerstel in *Parthenium argentatum* (in the same year).
- In the sporophytic system also, the self -incompatibility is governed by a single gene, S, with multiple alleles ; more than 30 alleles are known in *Brassica oleracea*.
- In general, the number of S alleles is considerably larger in the gametophytic than in the sporophytic system.
- Pollen will not germinate on the stigma (diploid) of a flower that contains either of the two alleles in the sporophyte parent that produced the pollen.
- This holds true even though each pollen grain being haploid contains only one of the alleles.

- For example, the S₂ pollen, which was produced by a S₁S₂ parent, cannot germinate on an S₁S₃ stigma.

5.4 Elimination of Self Incompatibility:-

- In the case of single locus gametophytic system, incompatibility may be eliminated by doubling the chromosome number.
- Isolation of self-fertile (SF) mutations is a very useful tool in the elimination of self incompatibility.
- Self-compatibility alleles may be transferred from related species or varieties of the same species, if available, through a backcross programme.

5.5 Temporary Suppression of Self-Incompatibility:-

- **Bud pollination:** Pollination of immature bud with mature pollen.
- **Surgical method:** In this method pollen is applied in direct contact with ovule result in break down of S.I.
- **End of season pollination:** Self pollination at end of flowering season also lead to seed set.
- **High temperature:** Treatment of high temperature ranging from 30-60° C lead to break down of self incompatibility in *lycopersicon*, *brassica* spp.
- **Irradiation of style:** In solanaceae, acute irradiation with X-rays or Gamma rays induces a temporary loss of self incompatibility.
- **Double pollination:** In some spp. S.I. mating become possible when incompatible pollen is applied as a mixture with a compatible pollen or it applied after pollination with a compatible pollen.
- **Delay pollination:** Pollination of aged pistil several day after maturity with normal incompatible pollen.

5.6 Importance of Self-Incompatibility in Plant Breeding:-

Self-incompatibility effectively prevents self- pollination; as a result, it has a profound effect on plant breeding approaches and objectives.

- In self incompatible fruit trees, it is necessary to plant two cross-compatible varieties to ensure fruitfulness.

- Self-incompatibility may be used in hybrid seed production. For that, two self-incompatible but cross-compatible lines are to be interpolated; seeds obtained from both the lines would be hybrid seed.
- Self incompatibility provides a way for hybrid seed production without emasculation and without resorting to genetic or cytoplasmic male sterility. Self incompatibility system permits combining of desirable genes in a single genotype from two or more different sources through natural cross pollination which is not possible in self compatible species .
- In case of pineapple, commercial clones are self- incompatible. As a result, their fruits develop parthenocarpically & are seedless.
- There is no roughing problem in self incompatible line.
- Labour cost is less and seed production is more in self incompatible mechanism.

5.7 Limitations:-It is very difficult to produce homozygous inbred lines in a self incompatible species. Bud pollination has to be made to maintain the parental lines.

- Self- incompatibility is affected by environmental factors such as temperature and humidity. Incompatibility is reduced or broken down at high temperature and humidity.
- There is a limited use of self-incompatibility due to problems associated with the maintenance of inbred lines through hand pollination as it is tedious and costly.