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# Major Objectives of Plant Breeding



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# Major Objectives of Plant Breeding

- 1. Higher yield :** The ultimate aim of plant breeding is to improve the yield of economic produce. It may be grain yield, fodder yield, fibre yield, tuber yield, cane yield or oil yield depending upon the crop species. Improvement in yield can be achieved either by evolving high yielding varieties or hybrids.
- 2. Improved quality:** Quality of produce is another important objective in plant breeding. The quality characters vary from crop to crop. Eg. grain size, colour, milling and backing quality in wheat. Cooking quality in rice, malting quality in barley, size, colour and size of fruits, nutritive and keeping quality in vegetables, protein content in pulses, oil content in oilseeds, fibre length, strength and fineness in cotton



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- 3. Abiotic resistance:** Crop plants also suffer from abiotic factors such as drought, soil salinity, extreme temperatures, heat, wind, cold and frost, breeder has to develop resistant varieties for such environmental conditions
- 4. Biotic resistance:** Crop plants are attacked by various diseases and insects, resulting in considerable yield losses. Genetic resistance is the cheapest and the best method of minimizing such losses. Resistant varieties are developed through the use of resistant donor parents available in the gene pool.



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**5. Change in maturity Duration/ Earliness:** Earliness is the most desirable character which has several advantages. It requires less crop management period, less insecticidal sprays, permits new crop rotations and often extends the crop area. Development of wheat varieties suitable for late planting has permitted rice-wheat rotation. Thus breeding for early maturing crop varieties, or varieties suitable for different dates of planting may be an important objective. Maturity has been reduced from 270 days to 170 days in cotton, from 270 days to 120 days in pigeonpea, from 360 days to 270 days in sugarcane.



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- 6. Determinate Growth :**Development of varieties with determinate growth is desirable in crops like Mung, Pigeon Pea (*Cajanus cajan* ), Cotton (*Gossypium sp.*), etc.
- 7. Dormancy:** In some crops, seeds germinate even before harvesting in the standing crop if there are rains at the time of maturity, e.g., Greengram, Blackgram, Barley and Pea, etc. A period of dormancy has to be introduced in these crops to check loss due to germination. In some other cases, however, it may be desirable to removedormancy.
- 8. Desirable Agronomic Characteristics:** It includes plant height, branching, tillering capacity, growth habit, erect or trailing habit etc., is often desirable. For example, dwarf ness in cereals is generally associated with lodging resistance and better fertilizer response. Tallness, high tillering and profuse branching are desirable characters in fodder crops



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**9. Elimination of Toxic Substances :** It is essential to develop varieties free from toxic compounds in some crops to make them safe for human consumption. For example, removal of neurotoxin in Khesari (*Lathyrus sativus*) which leads to paralysis of lower limbs, erucic acid from *Brassica* which is harmful for human health, and gossypol from the seed of cotton is necessary to make them fit for human consumption. Removal of such toxic substances would increase the nutritional value of these crops.

**10. Non-shattering characteristics:** The shattering of pods is a serious problem in green gram. Hence resistance to shattering is an important objective in green gram.

**11. Synchronous Maturity :** It refers to maturity of a crop species at one time. The character is highly desirable in crops like Greengram, Cowpea, and Cotton where several pickings are required for crop harvest.



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**12. Photo and Thermo insensitivity:** Development of varieties insensitive to light and temperature helps in crossing the cultivation boundaries of crop plants. Photo and thermo-insensitive varieties of wheat and rice has permitted their cultivation in new areas. Rice is now cultivated in Punjab, while wheat is a major *rabi* crop in West Bengal.

**13. Wider adaptability :** Adaptability refers to suitability of a variety for general cultivation over a wide range of environmental conditions. Adaptability is an important objective in plant breeding because it helps in stabilizing the crop production over regions and seasons.

**14. Varieties for New Seasons :** Traditionally Maize is a *kharif* crop. But scientists are now able to grow Maize as *rabi* and *zaid* crops. Similarly, mung is grown as a summer crop in addition to the main *kharif* crop.



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# **Important concepts of breeding Self pollinated, Cross pollinated and Vegetatively propagated crops:**

## **MODES OF POLLINATION:**

Pollination refers to the transfer of pollen grains from anthers to stigmas. Pollen from an anther may fall on to the stigma of the same flower leading to self-pollination or Autogamy. When pollen from flowers of one plant are transmitted to the stigmas of flowers of another plant, it is known as cross-pollination or allogamy. A third situation, geitonogamy, results when pollen from a flower of one plant falls on the stigmas of other flowers of the same plant, e.g., in Maize. The genetic consequences of geitonogamy are the same as those of autogamy.



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## **Self-pollination:**

Many cultivated plant species reproduce by self-pollination. Self-pollination species are believed to have originated from cross-pollinated ancestors. These species, as a rule, must have hermaphrodite flowers. But in most of these species, self-pollination is not complete and cross-pollination may occur up to 5%. The degree of cross-pollination in Self-pollinated species is affected by several factors, e.g., variety environmental conditions like temperature and humidity, and location.



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## **Mechanisms promoting self-pollination:**

The various mechanisms that promote selfpollination are generally more efficient than those promoting cross - pollination. These mechanisms are listed below.

- 1. Cleistogamy:** In this case, flowers do not open at all. This ensures complete selfpollination. since foreign pollen cannot reach the stigma of a closed flower. Cleistogamy occurs in some varieties of wheat, oats, barley and in a number of other grasses.
- 2.** In some species, the flowers open, but only after pollination has taken place. This occurs in many cereals, such as, wheat, barley, rice and oats. Since the flower does open, some cross-pollination may occur.



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3. In crops like tomato and brinjal, the stigmas are closely surrounded by anthers. Pollination generally occurs after the flowers open. But the position of anthers in relation to stigmas ensures self-pollination.
4. In some species, flowers open but the stamens and the sigma are hidden by other floral organs. In several legumes, e.g., pea, mung, urd, Soybean and gram the stamens and the stigma are enclosed by the two petals forming a keel.
5. In a few species, stigmas become receptive and elongate through staminal columns. This ensures predominant self - pollination.



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## **Genetic Consequences of Self-Pollination:**

Self-pollination leads to a very rapid increase in homozygosity. Therefore, populations of self-pollinated species are highly homozygous, self-pollinated species do not show inbreeding depression, but may exhibit considerable heterosis. Therefore, the aim of breeding methods generally is to develop homozygous varieties.

## **Cross-Pollination:**

In cross-pollinating species, the transfer of pollen from a flower to the stigmas of the others may be brought about by wind (*anemophily*). Many of the crop plants are naturally cross-pollinated. In many species, a small amount (up to 5-10 percent) of selfing may occur.



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## Mechanisms promoting cross pollination:

There are several mechanism that facilitate crosspollination; these mechanisms are described briefly.

1. **Diclity** : *Diclity* or *unisexuality* is a condition in which the flowers are either staminate (male) or pistillate (female).
  - a) **Monoecy**: Staminate and pistillate flowers occur in the same plant, either in the same inflorescence, *e.g.*, Castor, mango and coconut, or in separate inflorescences, chestnut, strawberries, rubber, grapes and cassava.
  - b) **Dioecy**. The male and female flowers are present on different plants, *i.e.*, the plants in such species are either male or female, *e.g.*, papaya, date, hemp, asparagus, and spinach. In general, the sex is governed by a single gene, *e.g.*, asparagus and papaya. In some cases, there are hermaphrodite plants in addition to males and females, and a number of intermediate.



2. Stamens and pistils of hermaphrodite flowers may mature at different times facilitating cross -pollination.
  - a) **Protogyny**. In crop species like bajra, pistils mature before stamens.
  - b) **Protandry**. in crops like Maize and sugarbeets, stamens mature before pistils.
4. A combination of two or more of the above mechanisms may occur in some species. This improves the efficiency of the system in promoting cross-pollination. For example, Maize exhibits both monoecy and protandry.
5. **Self-Incompatibility**: It refers to the failure of pollen from a flower to fertilize the same flower or other flowers on the same plant. Self-incompatibility is of two types :sporophytic and gametophytic. In both the cases, flowers do not set seed on selfing.



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Self-incompatibility is common in several species of Brassica, some species of Nicotiana, radish, rye and many grasses. It is highly effective in preventing selfpollination.

**6. Male Sterility:** Male sterility refers to the absence of functional pollen grains in otherwise hermaphrodite flowers. Male sterility is not common in natural populations. But it is of great value in experimental populations, particularly in the production of hybrid seed. Male sterility is of two types : genetic and Cytoplasmic.

Cytoplasmic male sterility is termed Cytoplasmic-genetic when restorer genes are known. In view of the importance of self-incompatibility and male sterility, a more detailed discussion on them follows later.



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**Genetic Consequences of Cross-Pollination:** Cross-pollination preserves and promotes heterozygosity in a population. Cross-pollinated species are highly heterozygous and show mild to severe inbreeding depression and a considerable amount of heterosis. The breeding methods in such species aim at improving the crop species without reducing heterozygosity to an appreciable degree. Usually, hybrid or synthetic varieties are the aim of breeder wherever the seed production of such varieties is economically feasible.



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## **Often Cross-Pollinated Species:**

In many crop plants, cross -pollination often exceeds 5 per cent and may reach 30 per cent. Such species are generally known as often cross-pollinated species, e.g., Jowar, Cotton, arhar, safflower etc. The genetic architecture of such crops is intermediate between self-pollinated and cross-pollinated species. Consequently, in such species breeding methods suitable for both of them may be profitably applied. But often hybrid varieties are superior to others.