

Lecture: - 14

SYNTHETICS AND COMPOSITES VARIETIES:

- The possibility of commercial utilization of synthetic varieties in maize was first suggested by Hayes and Garber in 1919. Synthetic varieties have been of great value in the breeding for those cross-pollinated crops where pollination control is difficult, e.g., forage crop species, many clonal crops like cacao, alfalfa, clovers (*Trifoulim* sp.) etc.
- The maize improvement programme in India now places a considerable emphasis on synthetic varieties. The maize programme of CIMMYT. Mexico is based on population improvement; the end-product of such a programme is usually a synthetic variety.
- **Definition:-**A synthetic variety is produced by crossing in all combinations a number of lines that combine well with each other. Once synthesized, a synthetic is maintained by open-pollination in isolation.
- A composite variety is produced by mixing the seeds of several phenotypically outstanding lines and encouraging open-pollination to produce crosses in all combinations among the mixed lines. The lines used to produce a composite variety are rarely tested for combining ability with each other.

14.1 OPERATIONS IN PRODUCING A SYNTHETIC VARIETY:

- By definition, a synthetic variety consists of all possible crosses among a number of lines that combine well with each other. The lines that make up a synthetic variety may be inbred lines, clones, open-pollinated varieties, short-term inbred lines or other populations tested for GCA or for combining ability with each other. The operations involved in the production of synthetic varieties are briefly described below.

Evaluation of Lines for GCA:

- GCA of the lines to be used as the parents of synthetic varieties is generally estimated by top cross or polycross test. The lines are evaluated for GCA because synthetic varieties exploit that portion of heterosis, which is produced by GCA.
- Polycross refers to the progeny of a line produced by pollination with a random sample pollen from a number of selected lines. Polycross test is the most commonly used test in forage crops.

- Polycross progeny are generally produced by open-pollination in isolation among the selected lines. The lines that have high GCA are selected as parents of a synthetic variety.

Production of a Synthetic variety:

A synthetic variety may be produced in one of the following two ways.

- Equal amounts of seeds from the parental lines are mixed and planted in isolation. Open-pollination is allowed and is expected to produce crosses in all combinations. The seed from this population is harvested in bulk; the population raised from this seed is the Syn1 generation.
- All possible crosses among the selected lines are made in isolation. Equal amounts of seed from each cross is composited to produce the synthetic variety. The population derived from this composited seed is known as the syn1 generation.

Multiplication of Synthetic Varieties

- After a synthetic variety has been synthesized, it is generally multiplied in isolation for one or more generations before its distribution for cultivation. This is done to produce commercial quantities of seed, and is a common practice in most of the crops, e.g., grasses, clovers, maize etc. But in some crops, e.g., sugarbeets, the synthetic varieties are distributed without seed increase, i.e., in the Syn1 generation.
- The open-pollinated progeny from the Syn1 generation is termed as Syn2, that from Syn2 as syn3 etc. The performance of Syn2 is expected to be lower than that of syn1 due to the production of new genotypes and a decrease in the level of heterozygosity as a consequence of random mating. However, there would not be a noticeable decline in the subsequent generations produced by open-pollination since the zygotic equilibrium for any gene is reached after one generation of random mating. The synthetic varieties are usually maintained by open-pollinated, and may be further improved through population improvement schemes, particularly through recurrent selection.

14.2 MERITS OF SYNTHETIC VARIETIES:

- Synthetic varieties offer a feasible means of utilizing heterosis in crop species where pollination control is difficult. The farmer can use the grain produced from a synthetic variety as seed to raise the next crop.

- In variable environments, synthetics are likely to do better than hybrid varieties. The cost of seed in the case of synthetic varieties is relatively lower than that of hybrid varieties.
- Seed production of hybrid varieties is a more skilled operation than that of synthetic varieties.
- Synthetic varieties are good reservoirs of genetic variability.
- There is good evidence that the performance of synthetic varieties can be considerably improved through population improvement.

14.3 DEMERITS OF SYNTHETIC VARIETIES:

- The performance of synthetic varieties is usually lower than that of the single or double cross hybrids. This is because synthetics exploit only GCA, while the hybrid varieties exploit both GCA and SCA.
- The performance of synthetics is adversely affected by lines with relatively poorer GCA.
- Synthetics can be produced and maintained only in cross-pollinated crop species, while hybrid varieties can be produced both in self- and cross-pollinated crops.

14.4 FACTORS DETERMINING PERFORMANCE OF SYNTHETIC VARIETIES:

- The yield of syn2 would be less than that of syn1 due to loss in heterozygosity as a result of random mating.
- The decrease in yield ability of syn2 would depend on:-The number of inbred lines and on the difference in the yielding abilities of syn1 and syn0 generations.
- **Sewall Wright**, 1922 suggested the formula for predicting the performance of syn2.

$$\text{syn2} = \text{syn1} (\text{syn1} - \text{syn0}) / n$$
, where n = number of parental lines

How to improve the performance of syn2? There 3 ways:-

- By increasing the number of lines
- By increasing the performance of syn1
- By improving the performance of parental lines

Difference between synthetics and composites Synthetics

Synthetics	Composites
No. of inbredlines are less (6-8)	No. of lines are more (even upto 20)
GCA of parental lines is tested	No. testing
Performance can be predicted	Can't be predicted
Broad based	More broad based
Synthetic can be reconstituted at a later date	Date cannot be reconstituted
Seed replacement after 4-5 years	After 3-4 years

14.5 Achievements:-

- Synthetic varieties have been widely used in forage crops and in crops where pollination control is difficult. The maize breeding programme at CIMMYT, Mexico and the pearl millet programme at ICRISAT, Hyderabad are based on synthetic varieties generally developed through population improvement.
- The maize breeding programme in India is placing increasingly greater emphasis on the production of synthetic or composite varieties.
- In India, the first composite varieties were released in 1967; the six maize composites were, Ambar, Jawahar, Kisan, Vikaram, Sona and Vijay.
- Composite 1, has been evolved in Brassica campestris Var. toria. It was developed by compositing 10 elite toria strains; it matures in 100 days, exhibits profuse branching and yields about 11 q/ha seed, which contains about 40% oil.

METHODS OF BREEDING FOR VEGETATIVELY PROPAGATED CROPS

Clone: A clone is a group of plants produced from a single plant through asexual reproduction. The crop plants can either be propagated by seeds or by vegetative parts. Vegetative propagation is resorted due to:

- Lack of seed: e.g. Ginger, Turmeric
- There is short viability of seed: e.g. Sugarcane
- The seed production is very rare: e.g. Banana
- Seeds are produced under special conditions only: e.g. Sugarcane, potato

Characteristics of Asexually propagated crops:

- Majority of them are perennials: e.g. Sugarcane, fruit trees.
- The annual crops are mostly tuber crops: e.g. Potato, cassava, Sweet potato
- Many of them show reduced flowering and seed set.
- They are invariably cross pollinated
- These crops are highly heterozygous and show severe inbreeding depression upon selfing.
- Majority of asexually propagated crops are polyploids: e.g. Sugarcane, Potato, Sweet potato.
- Many species are interspecific hybrids. e.g. Banana, Sugarcane

Characteristics of a clones:

- All the individual belonging to a single clone are identical in genotype
- The phenotypic variation within a clone is due to environment only
- The phenotype of a clone is due to the effects of genotype(g), the environment(e) and the genotype x environment interaction (GxE), over the pop.mean(M)
- Theoretically clones are immortal. They deteriorate due to viral/bacterial infection and mutations.
- Clones are highly heterozygous and stable
- They can be propagated generation after generation without any change.

Importance of a clone:

- Owing to heterozygosity and sterility in many crops clones are the only means of propagation.
- Clones are used to produce new varieties.
- Clones are very useful tools to preserve the heterozygosity once obtained. In many crops the superior plants are maintained. (Mango, orange, apple, sugarcane).

Clonal selection:

Sources of clonal selection:-Local varieties, introduced material, hybrids and segregating populations

The various steps involved in clonal selection are briefly mentioned below.

- **First year:** From a mixed variable population, few hundred to few thousand desirable plants are selected. Rigid selection can be done for simply inherited characters with high heritability. Plants with obvious weakness are eliminated.
- **Second year:** Clones from the selected plants are grown separately, generally without replication. This is because of the limited supply of propagating material for each clone, and because of the large number of the clones involved. Characteristics of the clones will be more clear now than in the previous generation. Based on the observations the inferior clones are eliminated. Fifty to one hundred clones are selected on the basis of clonal characteristics.
- **Third year:** Replicated preliminary yield trial is conducted. A suitable check is included for comparison few superior performing clones with desirable characteristics are selected for multi location trials.
- **Fourth to eighth years:** Replicated yield trials are conducted at several locations along with suitable check. The yielding ability, quality and disease resistance etc. of the clones are rigidly evaluated. The best clones that are superior to the check in one or more characteristics are identified for release as varieties.
- **Ninth year:** The superior clones are multiplied and released as varieties.

Advantages:-

- Varieties are stable and easy to maintain
- Avoids inbreeding depression
- Clonal selection, combined with hybridization generates necessary variability for several selections.
- Only method to improve clonal crops
- Hybrid vigour is easily utilized selection may be used in maintaining the purity of clones.

Disadvantages:-

- Selection utilizes the natural variability already present in the population.
- Sexual reproduction is necessary for creation of variability through hybridization.
- Applicable only to the vegetatively propagative crops.
- Problems in Breeding asexually propagated crops
- Reduced flowering and fertility
- Difficulties in genetic analysis
- Perennial life cycle.

Genetic variation within a clone:-

It may arise due to: Mutation, Mechanical mixture, Sexual Reproduction.

- **Mutation:** The frequency is generally very low (10^{-5} to 10^{-7}). Ordinarily dominant mutations would be expressed in the somatic tissue. A mutant allele would be homozygous only when:-
 - Both the alleles in a cell mutate at the same time producing the same mutant allele or
 - The mutant allele is already in heterozygous condition in the original clone. Though rare, both these events are possible. Bud mutations may often produce chimeras i.e. an individual containing cells of two or more genotypes. Bud mutations make possible selection of buds to establish new desirable clones, the process being known as Bud selection. It is of some importance in improvement of perennial crops like fruit trees or of those crops where flowering does not take place.

- **Mechanical mixtures:** Mechanical mixtures produce genetic variation within a clone much in the same way as in the case of pure lines.
- **Sexual reproduction:** Occasional sexual reproduction would lead to segregation and recombination. The seedlings obtained from sexual reproduction would be genotypically different from the asexual progeny. It is evident that only clones would tend to become variable at least in annuals and biennials. Eg. Potato

Clonal degeneration: The loss in vigor and productivity of clones with time is known as clonal degeneration and results due to:

1. Mutation
2. Viral diseases
3. Bacterial diseases

Achievements:

▪ **Through clonal selection :**

Potato : 1. Kufri Red from Darjeeling Red Round, Kufri Safed from phulwa, Bombay Green banana is a bud selection from dwarf Cavendish : pidi monthan from Monthan

▪ **Through hybridization:- Potato** : Kufri Alankar, Kufri Kuber, Kufri Sindhuri, Kufri Kundan, Kufri Chamatkar Kufri Jyothi (late blight resistant), Kufri Sheetman (frost resistant)

Sugarcane : Co 1148, Co 1158, CoS 510, Co 975, Cos 109, Co 541

Mango : Pedda Neelam, Chinna Suwarnarekha Bana : High gate from Gross Michel

Citrus : Robertson Navel Orange Sweet oranges : Yuvaraj blood Red

Turmeric : Kesari, Kasturi.