

Lecture: - 17

MUTATION BREEDING

- Mutation is the sudden heritable change other than the Mendelian segregation and gene recombination in an organism.
- Mutation may be the result of a change in a gene, a change in chromosome that involves several genes or a change in plasmagene.
- There are three types of mutations based on genetic basis of heritable change :
 - **Gene mutations** : These are produced by change in the base sequence of genes. The change may be due to base substitutions, deletion or addition.
 - **Chromosomal mutation** : These arise due to change in chromosome number that may leads to polyploidy or aneuploidy or change in chromosome structure that result in deletions duplication, inversion and translocation.
 - **Cytoplasmic or plasmagene mutation** : These are due to change in the base sequence of plasma genes. The plasma genes are present in mitochondria or chloroplast. Here the mutant character occurs in buds or somatic tissues which are used for propagation in clonal crops.

17.1 Classification of mutations:

Based on origin, the mutations are classified as spontaneous and induced mutations:

- **Spontaneous mutations:** Mutations occur in natural populations at a low rate (10^{-6}) but different genes may show different mutation rates. Here the different genes show different mutation rate. For example : in maize R-locus mutates at the frequency of 4.92×10^{-4} i.e. (1 in 20000 population), when as Su locus at 2.4×10^{-6} (1 in 25 lakhs).The Wx locus considered to be highly stable. The difference in mutation rate may be due to a) Genetic back ground i.e. presence of mutator genes b) Genes themselves c) Environment
- **Induced mutation:** Mutations may be artificially induced by treatment with certain physical or chemical agents. Available evidence indicates that induced mutation rarely produce new alleles they produce alleles which are already known to occur spontaneously. Induced mutations are comparable to spontaneous mutations in their

effects and in the variability they produce. Induced mutation occur at a relatively higher frequency so that it is practical to work with them.

Based on magnitude of phenotypic effects mutation as classified as:

- **Macro mutations:** Oligogenic Mutation – Large phenotypic effect and recognizable on individual plant basis and can be seen easily in M2 generations – Eg. Ancon breed in sheep, pod maize to cob maize
- **Micro mutations:** Polygenic mutations – Small phenotypic effect which can not be recognized on individual plant basis but can be recognize only in a group of plants.
- Selection should be done in M3 or later generations.

17.2 Characteristic feature of mutations:

- Mutations are generally recessive but dominant mutations also occur
- Mutations are generally harmful to the organism. Most of the mutations have deleterious effects but small proportions (0.1%) of them are beneficial.
- Mutations are random i.e. they may occur in any gene. However some genes show high mutation rates than the others.
- Mutations are recurrent
- Induced mutations commonly show pleiotropy often due to mutation in closely linked genes.

17.3 Procedure for irradiation: The plant material may be treated in any of the following source. 1. Seeds 2. Seedlings 3. Flowers 4. Cuttings

- **Seeds:** Seeds are used after soaking to get greater frequency of induced mutations than air dried.
- **Seedlings:** At any stage of life cycle can be subjected to radiation but usually seedlings neither too young nor too old are irradiated due to their convenience in handling in pots transportation from nursery easily.
- **Flowers:** Meiotic cells have been found more sensitive than the mitotic cells and therefore plants are irradiated in the flowering stage in order to affect the developing gametes.
- **Cuttings:** In case of fruit tree when they are propagated by clones – the desirable cuttings are exposed to irradiation.

Dose of the Mutagen:-An optimum dose of the mutagen should be used. An optimum dose is the one which produces the maximum frequency of mutations and causes the minimum killing. Many workers feel that a dose close to LD50 should be optimum. LD50 is that dose of a mutagen, which would kill 50% of the treated individuals.

17.4 Mutation Breeding for oligogenic traits:-

The handling procedure described here is based on the selection for a recessive mutant allele of an oligogene.

- **M1.** Several hundred seeds are treated with a mutagen and are space planted. In general, the number of treated seeds is so adjusted as to give rise to -500 fertile M1 plants at the harvest. Care should be taken to avoid outcrossing; this can be achieved either by planting the M1 population in isolation or by bagging the inflorescences of M1 plants or even the whole M1 plants. M1 plants will be chimeras for the mutations present in heterozygous state. About 20 to 25 seeds from each M1 spike are harvested separately to raise the M2 progeny rows.
- **M2.** About 2,000 progeny rows are grown. Careful and regular observations are made on the M2 rows. But only distinct mutations are detected in M2 because the observations are based on single plants. All the plants in M2 rows suspected of containing new mutations are harvested separately to raise individual plant progenies in M3. If the mutant is distinct, it is selected for multiplication and testing. However, most of the mutations will be useless for crop improvement. Only 1-3 per cent of M2 rows may be expected to have beneficial mutations. Individual plants are then selected in M2 and individual plant progenies are grown in M3.
- **M3.** Progeny rows from individual selected plants are grown in M3. Poor and inferior mutant rows are eliminated. If the mutant progenies are homogeneous, two or more M3 progenies containing the same mutation may be bulked. Mutant M3 rows are harvested in bulk for a preliminary yield trial in M4.
- **M4.** A preliminary yield trial is conducted with a suitable check, and promising mutant lines are selected for replicated multilocation trials.
- **M5-M7.** Replicated multilocation yield trials are conducted. The out-standing line may be released as a new variety. The low yielding mutant lines, however, should be retained for use in hybridization programmes.

17.5 Mutation breeding for polygenic traits:-

- **M1 and M2.** are grown in the same way as in the case of oligogenic traits. In M2, vigorous, fertile and normal looking plants that do not exhibit a mutant 120 phenotype are selected and their seeds are harvested separately to raise individual plant progeny rows in M3.
- **M3.** Progeny rows from individual selected plants are grown. Careful observations are made on M3 rows for small deviations in phenotype from the parent variety. Inferior rows are discarded. Selection is done in M3 rows showing segregation; a majority of M3 rows would show segregation. Intensive and careful evaluation of a large number of M3 progeny rows allows identification of mutants with altered quantitative traits, e. g., partial or horizontal disease resistance. Such mutants occur in high frequencies that approach 1% or even high, so that their isolation becomes quite cost effective.
- **M4.** Bulk seed from homogeneous M3 rows may be planted in a preliminary yield trial with a suitable check; superior progenies are selected for replicated multilocation yield trials. Individual plant progenies from M3 are critically observed. Progenies showing segregation may be subjected to selection only if they are promising. Superior homogeneous progenies are harvested in bulk for preliminary yield tests in M5.
- **M5-M8.** Preliminary yield trials and / or multi-location trials are conducted depending upon the stage when the progenies become homogeneous. Outstanding progenies may be released as new varieties.

17.6 Applications of Mutation Breeding:

- Induction of desirable mutant alleles which may not be available in the germplasm
- It is useful in improving specific characteristics of a well adapted high yielding variety.
- Mutagenesis has been successfully used to improve various quantitative characters including yield.
- F1hybrids from intervarietal crosses may be treated with mutagens in order to increase genetic variability by inducing mutation and to facilitate recombination of linked genes.
- Irradiation of interspecific (distant) hybrids has been done to produce translocations.

17.7 Advantages:

- Mutation creates inexhaustible variation.
- When no improvement is possible this method has to be adopted.

17.8 Limitations:

- Frequency of desirable mutations is very low about 0.1 percent. To detect the desirable one in M2 considerable time, labour & other resources are to be employed.
- To screen large population, efficient quick and inexpensive selection techniques are needed.
- Desirable mutations may be associated with undesirable side effects due to other mutations thus extending the mutation breeding programme.
- Detection of recessive mutations in polyploid and clones is difficult and larger doses of mutagen have to be applied and larger populations are to be grown.

17.9 Achievements:

❖ Natural mutants:

- **Rice** : GFB 24 – arose as a mutant from Konamani variety , Dee – Gee – Woo – Gen – Arose as a mutant from rice in China, MTU 20 – arose as a mutant from MTU 3
- **Sorghum** : Co. 18 – arose as a mutant from Co.
- **Cotton** : DB 3- 12 from G. heroaccum variety Western 1

❖ Induced mutants :

- **Rice** : Jagannath-gamma ray induced mutant from T.141
- **Wheat** : Sarbati Sonora Gamma radiation from Sonora 64 , NP 836 mutants through irradiation from NP 709
- **Cotton** : Indore 2-Induced from Malwa upland 4, MLU 7-gamma ray induced mutant from culture 1143 EE, MLU 10-gamma ray induced mutant from MLU 4
- **Mustard** : Primax white (1950) Summer Pope seed Regina I (1953)
- **Sugarcane** : Co.8152 gamma ray induced mutant from Co. 527
- **Groundnut** : NC 4
- **Castor** : Aruna (NPH1) – Fast neutrons induced mutant from HC 6.