28. APPLICATIONS OF MUTATION BREEDING

Mutation breeding has been used for improving both oligogenic as well as polygenic characters. It has been employed to improve morphological and physiological characters, disease resistance and quantitative characters including yielding ability. The various applications of mutation breeding may be briefly summarized as under.

Induction of desirable mutant alleles, which may not be present in the germplasm or which may be present, but may not be available to the breeder due to political or geographical reasons. To some extent, mutation breeding relieves the complete dependence of breeders on the natural germplasm. But it should be remembered that mutation breeding cannot minimise the necessity of germplasm collections; it only serves as a useful supplement to the available germplasm.

It is useful in improving specific characteristics of a well adapted high Yielding variety. This is particularly so in the case clonal crops due to their highly heterozygous nature; in such a case, mutagenesis is the only method available to improve the specific characteristics of clones without changing their genetic make up.

In self-pollinated species, mutagenesis is useful in improving the specific characteristics of otherwise adapted and superior varieties. However, in such species mutagenesis may not be simpler or quicker than the standard backcross procedure if the characteristic is available in a variety. This is more so because the desirable mutations are often associated with undesirable side effects due to other mutations, chromosomal aberrations, sterility, etc. As a result, one or few backcrosses with the parent variety may be necessary to bring the desirable mutant allele in an acceptable genetic background.

Mutagenesis has been successfully used to improve various quantitative characters, including yie1d.Several varieties have been developed by this technique. However, there is no critical comparison available to show that the same improvement would not have been brought about by the conventional hybridization programmes.

F1 hybrids from intervarietal crosses may be treated with mutagens in order to increase genetic variability by inducing mutations and by facilitating recombination among linked genes. But this method has not been widely used.

Irradiation of interspecific hybrids has been done to produce translocations. This is done to transfer a chromosome segment carrying a desirable gene from the alien chromosome to the chromosome of a cultivated species. This illustrates another application of irradiation in crop improvement, but this does not constitute mutation breeding.

In developing countries, mutation breeding is widely used, but in Europe it is mainly confined to clonal and ornamental crops. For example, mutagenesis is the principal source of genetic variation in chrysanthemum and banana breeding programmes. This is because most breeders believe that the characteristics of mutation breeding, viz., (1) the need for large (10^5 to 10^6) M2 populations, (2) associated detrimental effects of mutations, and (3) the existence in germplasm of the so called 'novel' mutant alleles, mitigate against the incorporation of this technique into conventional breeding programmes. In addition, the yields of new varieties released over a period of years (developed through conventional breeding approaches) show an average increase of -1 % in case the major field crops. Development of a new variety using mutagenesis would require about 7 years; therefore the mutant variety must show an increase of -7% in yield over the parent variety. An increase of this magnitude is unlikely from modification of a single gene or trait unless it is critical for plant performance, e.g., disease or insect resistance.

LIMITATIONS OF MUTATION BREEDING

The experience with mutation breeding has brought out certain limitations of the technique; these limitations are summarized as under.

1. The frequency of desirable mutations is very low, about 0.1 per cent of the total mutations. Therefore, large M2 and subsequent populations have to be grown and carefully studied. This involves considerable time, labour and other resources.
2. The breeder has to screen large populations to select desirable mutations. Therefore, efficient, quick and inexpensive selection techniques are required to screen large populations. Mutation breeding is more easily applied to such characters where quick screening techniques are available, e.g., disease resistance. But in the case of characters where elaborate tests are required, e.g., quality characteristics, mutation breeding is virtually impractical. For this reason, mutation breeding has been more successful with those characteristics where the mutant phenotype is distinct and easily detectable.
3. Desirable mutations are commonly associated with undesirable side effects due to other mutations, chromosomal aberrations, etc. The mutant lines often have to be backcrossed to the respective parent varieties to remove these defects. This increases the time requirement of mutation breeding programmes and involves additional labour, time and

expenditure.

4. Often mutations produce pleiotropic effects. The chief procedure for reducing or eliminating pleiotropic effects is to transfer the gene into different genetic backgrounds by hybridizing the mutant with a randomly selected range of elite varieties. Alternatively, when the pleiotropic {effect is on a specific trait, e.g., delayed flowering, appropriate genes for correction of the defect, e.g., genes for early flowering, can be introgressed into the mutant strain.
5. Mutations in quantitative traits are usually in the direction away from the selection history of the parent variety; this conclusion was reached by Brock in 1965 and is generally regarded as valid. This may tend to limit the degree of improvement attainable in a quantitative trait that has been the object of selection for a long period of time, e.g., yield.
6. There may be problems in the registration of a mutant variety since it may be difficult to convincingly demonstrate the new variety to be distinct from the parent variety; the PBR laws, where they exist, require a new variety to be distinct, uniform and stable (the DOS requirement). Such a variety may also attract a royalty liability in case the PBR title of the parent variety was held by another breeder/organization.
7. Most of the mutations are recessive; detection of recessive mutations is almost impossible in clonal crops and is difficult in polyploidy species. Consequently, in polyploidy species, larger population have to be grown and larger doses of mutagens have to be applied. Mutagenesis has been most commonly applied to diploid species that reproduce sexually, more particularly to self pollinated species.

ACHIEVEMENTS

The year 1969 is widely regarded as the year of transition from mainly fundamental investigations to practical mutation breeding; upto this time, only 77 varieties had been developed through mutagenesis. In 1983, this number rose to 337, and by 1989, 1322 mutant varieties had been released. This number rose to 1542 by 1990, and to 1737 by 1992; at this rate, the number would be well over 2,000 by now. Of the 1542 varieties (up to 1990), 1019 varieties were in seed propagated crops (609 direct releases of mutants, and 410 varieties were derived from crosses involving mutants as, at least, one of the parents).

In contrast, only 523 varieties were developed in vegetatively propagated crops. Bulk of the varities (1029) were due to direct release of mutants and only a small proportion (Ca. 23%) were obtained by using mutants in hybridization programmes. Among seed propagated crops, the largest number of variety have been developed in rice (278), closely followed by barely (229) and wheat (113), etc. Of these, China has developed the largest number (281) of mutant varities, followed by India (116), USSR (82) and Japan (65).