MALE STERILITY

Male sterility is characterized by non-functional pollen grains, while female gametes function normally. It occurs in nature sporadically, perhaps due to mutation. Male sterility is classified into three groups: (1) genetic, (2) Cytoplasmic, and (3) Cytoplasmic - genetic.

Genetic Male Sterility

Genetic male sterility is ordinarily governed by a single recessive genes, ms, but dominant genes governing male sterility are also known, e.g., in safflower. Male sterility alleles arise spontaneously or may be artificially induced. A male sterile line may be maintained by crossing it with heterozygous male fertile plants. Such a mating produces 1:1 male sterile and male fertile plants.

Utilization in Plant Breeding

Genetic male sterility may be used in hybrid seed production. The progeny from ms ms x Ms ms crosses are used as female, and are inerplanted with a homozygous male fertil(Ms Ms) pollinator. The genotypes of ms ms and Ms ms lines are identical except for the ms locus, i.e., they are isogenic ; they are known as male sterile (A) and maintainer (B) lines, respectively. The female line would, therefore, contain both male sterile and male fertile plants ; the latter must be identified and removed before pollen shedding. This is done by identifying the male fertile plants in seedling stage either due to the pleiotropic effect of the ms gene or due to the phenotypic effect of a closely-linked gene. Pollen dispersal from the male (pollintor) line should be good for a satisfactory seed set in the female line. however, generally pollen dispersal is poor and good, closely-linked markers are rare. Rouging of male fertile plants from the female lines is costly as a result of which the cost of hybrid seed is higher. Due to these difficulties, genetic male sterility has been exploited commercially only in a few countries. In USA, it is being successfully used in Castor. In India, it is being used for hybrid seed production of arhar by some private seed companies, e.g., Maharashtra Hybrid Seed Co. Ltd., India, produced and sold 50 Q seed of a hybrid variety of arhar, Suggestions have been made for its use in several other crops, e.g., Cotton.,barley, tomato, sunflower, cucurbits etc., but it is not yet practically feasible.

Cytoplasmic Male Sterility

This type of male sterility is determined by the cytoplasm. Since the cytoplasm of a zygote comes primarily from egg cell, the progeny of such male sterile plants would always be male sterile. Cytoplasmic male sterility is known in many plant species, some of wihc are crop plants

Nuclear genotype of male sterile line would be almost identical to that of the recurrent pollinator strain. The male sterile line is maintained by crossing it with the pollinator strain used as the recurrent parent in the backcross programme since its nuclear genotype is identical with that of this new male sterile line. such a male fertile line is known as the maintainer line or B line as it is used to maintain the male sterile line is also known as the A line, there is considerable evidence that the gene or genes conditioning Cytoplasmic male sterility, particularly in Maize, reside in mitochondria, and may be located in a plasmic like elements.

Utilization in Plant Breeding

Cytoplasmic male sterility may be utilized for producing hybrid seed in certain ornamental species, or in species where a vegetative part is of economic value. But in those crop plants where seed is the economic part, it is of no use because the hybrid progeny would be male sterile.

Cytoplasmic -Genetic Male Sterility

This is a case of Cytoplasmic male sterility where a nuclear gene for restoring fertility in the male sterile line is known. The fertility restorer gene, R, is dominant and is found in certain strains of the species, or may be transferred from a related species, e.g., in wheat. This gene restores male fertility in the male sterile line, hence it is known as restorer gene. The cases of Cytoplas mic male sterility would be included in the Cytoplasmic-genetic system as and when restorer genes for them would be discovered. It is likely that a restorer gene would be found for all the cases of Cytoplasmic male sterility if a thorough search were made. This system is known in Maize, Jowar, bajra, sunflower, rice, wheat, etc.

Plant would be male sterile in the presence of male sterile cytoplasm if the nuclear genotype were rr, but would be male fertile if the nucleus were Rr or RR. New male sterile lines may be developed following the same procedure as in the case of Cytoplasmic system. But the nuclear genotype of the pollinator strain used in such a transfer must be rr, otherwise the fertility would be restored. The development of new restorer strains is somewhat indirect. First, a restorer strain (say R) is crossed with a male sterile line (A). The resulting male fertile plants are used as the female parent in repeated backcrosses with the strain (C) (used as the recurrent parent), into which the transfer of restorer genes(s) is desired. In each generation, male sterile plants are discarded, and the male fertile plants are used as females for backcrossing to the strain C. This acts as a selection device for the restorer gene R during the backcross programme. At the end of backcross programme, a restorer line isogenic to the stain C would be recovered.

For the production of hybrid seed, removal of anthers before fertilization is essential to avoid selfing. Manually removing of anthers is very te dious and time consuming process in almost all the crops except in Maize and Castor which are monoecious. The pre-requisites for successful hybrid seed production in large quantities are:

1. Existence of male sterility or self-incompatibility through which ha nd emasculation can be avoided.
2. Sufficient cross-pollination should be there to get good seed set.

Male sterility is characterized by non-functional pollen grains while female gametes functions normally. It occurs in nature sporadically due to mutations. MS can be classified into three groups:

1. Genetic 2. Cytoplasmic 3. Cytoplasmic genetic

I. Genetic male sterility: GMS is mostly governed by single recessive gene ms, but dominant genes governing male sterility are also known eg: Safflower, MS alleles arise spontaneously or can be induced artificially. A GMS line can be maintained by crossing it with heterozygous male fertile plant. Such mating produces 50% m.s. & 50% MF plants

msms x Msms
(Male sterile) (Male fertile)
↓
msms : Msms (1:1)
(Male sterile) (Male fertile)

Identifying the male fertile plants from the above progeny is difficult and time consuming. Hence GMS is not commonly used in hybrid seed production.

In USA it is used in Castor. In India it was being used in Redgram, but presently it is being used in safflower.

Marker genes which are linked to male sterility/fertility can be used to identify the male fertile plants before flowering stage. For example in Maize there is a gene, pigmented hypocotyl(P) and green hypoc otyl (P) which is closely linked with sterility locus

P S - Pigmented & Sterile

PF – Green & Fertile

At seedling stage all the green plants are to be removed and pigmented plants are retained, as they are sterile.

II. Cytoplasmic Male Sterility: In crops like Maize, Bajra and Sorghum, two types of cytoplasms were noticed. One is normal cytoplasm and the other is sterile one which interferes with the formation of normal pollen grains. This follows maternal inheritance therefore all the off springs will be male sterile.

As the F_1 is male sterile, this system cannot be used in crops where the seed is economic part. Hence its utility is confined to certain ornamental species or where a vegetative part is of economic importance. Eg: Onion, Fodder Jowar, Cabbage, Palak etc.

III. Cytoplasmic Genetic Male Sterility System: This is a case of cytoplasmic male sterility where a nuclear gene for restoring fertility in MS line is known. The fertility restorer gene 'R' is dominant and is found in certain strains of species or may be transferred from a related species. This gene restores fertility in the MS line hence it is known as restorer gene. The cytoplasmic MS can be included in CGMS system as and when restorer genes for them are discovered. Restorer genes can be found for all the cases of cytoplasmic MS if thorough search is made. This system is used in almost all seed crops.

This system involves

1. Cytoplasmically determined MS plants known as A line in the genetic constitution.
2. Fertile counter parts of A line known as maintainer line or B line with the genetic constitution.
3. Restorer plants used to restorer the fertility in commercial seed plots known as R lines in the genetic constitution.

Transfer of Male Sterility from Exotic lines to Nature lines:

Most of the times the MS lines obtained from other countries may not be suitable to our condition. Examples are:

Crop	Source of cytoplasm	Drawbacks
Maize	Texas Cytoplasm	Susceptible to *Helminthosporium* leaf blight
Sorghum	Combined kafir	Black glumes and cha lky endosperm
Pearlmillet	Tift 23 A (Tifton)	Susceptible to Green ear & downy mildew
Rice	Wild abortive	Incomplete panicle exertion
Sunflower	*H petiolaris* *H gigantis*	
Tobacco	*Microcephalan*	Reduced vigour in F_1 hybrids
Wheat	*Aegilops caudata*	Susceptible to pistiloidy

Due to these drawbacks, the well adapted local lines should be converted into male sterile lines. This can be done by repeated back crossing of the local lines to the exotic MS lines.

Transfer of Male Sterility to a New Strain

Maintenance of Male Sterile Line or A line: Since A line does not produce pollen, seed is not formed for maintaining A line. It has to be crossed with its fertile counter part having similar nuclear genes with fertile cytoplasm which is known as B-line.

Production of Hybrid seed: For production of hybrid seed, A-line has to be kept as female parent and the pollen parent should posses the restorer genes in order to induce fertility and seed development in the next generation. Such line is known as restorer line and denoted as 'R'line. The A line & R line should be of different genetic constitution and should be able to give maximum heterosis.

Limitations in using Male Sterile Systems:

1. Existence and maintenance of A, B & R Lines is labourious and difficult
2. If exotic lines are not suitable to our conditions, the native/adaptive lines have to be converted into MS lines
3. Adequate cross pollination should be there between A and R lines for good seed set.
4. Synchronization of flowering should be there between A & R lines.
5. Sterility should be stable over the environments.
6. Fertility restoration should be complete otherwise the F_1 seed will be sterile
7. Isolation is needed for maintenance of parental lines and for producing hybrid seed

HARDY WEINBERG LAW – FACTORS AFFECTING EQUILIBRIUM FREQUENCIES IN RANDOM MATING POPULATIONS

Cross-pollinated crops are highly heterozygous due to the free intermating among their plants. They are often referred to as random mating populations because each individual of the population has equal opportunity of mating with any other individual of that population. Such a population is also known as Mendelian population or panmictic population. A Mendelian population may be though of having a gene pool consisting of all the gametes produced by the population. Thus gene pool may be defined as the sum total of all the genes present in a population. A population, in this case, consists of all such individuals that share the same gene pool, i.e., have an opportunity to intermate with each