Agri Articles
(e-Magazine for Agricultural Articles)
Volume: 02, Issue: 02 (MAR-APR, 2022)
Available online at http://www.agriarticles.com

Male Sterility in Cotton and Their Role in Hybrid Development

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Male sterility refers to a condition in which nonfunctional pollen grains are produced in flowering plants. In flowering plants, the first case of male sterility was reported by Koelreuter in 1763. This condition is gift for our breeders to develop the hybrids without following any emasculations procedure. The different type of male sterility is available in different crop plants. Whereas the first report of male sterility is revealed by Justus and Leinweber with worked on upland cotton in 1960. Since cotton having the often cross pollination mechanism male sterility is highly useful for hybrid development.

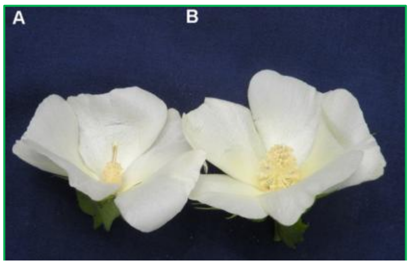
Male sterility is of three types, *viz*. (1) genetic male sterility, (2) cytoplasmic male sterility, and (3) cytoplasmic genetic male sterility. In cotton, all three types of male steriles are found.

Genetic Male Sterility (GMS): The pollen sterility that is caused by nuclear genes is termed as genic or genetic male sterility. In cotton, GMS has been reported in upland, Egyptian and arboreum cottons. In tetraploid cotton, male sterility is governed by both recessive and dominant genes.

Cytoplasmic Male Sterility (CMS): It occurs due to the involvement of non-nuclear genes. This type of male sterility is determined by the cytoplasm. Since cytoplasm of the zygote comes from the egg cell, the progeny of such male sterile plants will always be male sterile.

Cytoplasmic Genetic Male Sterility (CGMS): Such type of sterility arises from the interaction of nuclear gene (s) conditioning sterility with sterile cytoplasm. This type of male sterility has provision for restoration of fertility, which is not possible in cytoplasmic male sterility. The fertility is restored by the R gene (s) present in the nucleus. Thus, the combination of both nuclear genes and cytoplasmic factors determines the fertility or sterility in such plants.

A total of 18 GMS gene were identified in different species of cotton. Among these 13 genes was identified in *G. hirsutum*. In this most of the genes are controlled by recessive genes but dominant gene action is identified namely MS4, MS7, MS10, MS11 and MS12. The ms5ms6 and ms8ms9 were reported as duplicative gene action. The different male sterile genes are listed in the table 1. Apart



Male sterility

from this diploid GMS sources namely Hisar was derived from the spontaneous mutant of arboreum variety DS5 and Akola & HAU were obtained by crossing of *anomalum* and *arboreum* cross. *G. hirsutum* line Gregg (MS 399) is utilized from USA is one of the basic sources of GMS having ms5ms6 GMS gene. The chromosome number 12 having the different male sterile gene namely dominant MS11 and recessive ms5, ms5, ms8, ms15. The ms15 was flanked with SSR markers NAU2176 and NAU1278 and ms5 is flanked by NAU3561, NAU2176 and NAU2096 and ms6 is present in the chromosome 26 flanked by BNL1227 and NAU460 SSR markers. The ms5 and ms6 gene cause the male sterility by non-dehiscent and by unviable pollen grains. The ms3 and ms9 also mapped in the chromosome 16 and 26 respectively. Cytoplasmic male sterility (CMS). It is due to the non-nuclear gene derived male sterility. The available MS *G. hirsutum* lines are originally derived from introgression of *G. harknessii* species and it also has the single dominant fertility restorer gene (Rf). Another one species *G. aridum* also having the CMS source and fertility restorer. M Recessive gene Dominant gene Species Gene Species gene *G. hirsutum* ms1, ms2, ms3, ms5 ms6, ms8 ms9, ms13, ms14 (Dong A), ms15 (Long A), ms16 (81 A) *G. hirsutum* MS4, MS7, MS10, *G. arboreum* ar.ms, ams1 *G. barbadense* MS11, MS12.

G. barbadense

Different Sources of Male Sterility

1. Wild species

- *G. harknessii*: It is diploid species having the D genome and source for potential CMS source.
- *G. aridum*: It is diploid CMS source and having good fibre strength.
- *G. anomalum:* It is diploid with B genome and having rust, mites, jassid, bollworm, and bacterial blight resistance.

Wild Cotton

Temperature sensitive genetic male sterility (TGMS)

This type of sterility is caused by the higher temperature. The *arboreum* species line Ga TGMS - 3 is a sterile line shows male sterility at greater than 18^{0}C and fertile at low temperature. The mechanism underlying this due to increased callase enzyme is observed during the tetrad stage of anthers. NAU2176, NAU2096 and BNL1227 are markers which are tightly linked with these TGMS trait.

Achievements

- Suguna (CPH2) is the first GMS based hybrid developed and released y CICR, Coimbatore in 1978. It is intra hirsutum hybrid developed using the parentage of Gregg MS 399 x K3400 – 7 and is resistance to jassids.
- PKV Hy 3 (CAHH 468) is the first CGMS based intra *hirsutum* cotton hybrid developed by using CAK 32 x DHY 286-1R lines and released for cultivation in 1993 at Cotton Research Station of Punjabrao Deshmukh Krishi Vidyapeeth (PDKV), Akola. It highly resistance to jassids.
- GMS based hybrids: G. Cot MDH 11, AKDH 7, CICR HY 2, CSHH 198, Raj DH 7, AAH 1
- CGMS based hybrids: PKV Hy 4, MECH 4

Male sterility has important application in the development of hybrids. All the three types of male sterility are used in crop improvement programme. In India, several hybrids have been developed in cotton using the GMS system. CPH2 (Suguna) was the first male sterility based hybrid released in as early as 1975 from CICR Regional Station, Coimbatore. However, this GMS based hybrid did not spread much for lack of seed production efforts. The *G. harknessii* cytoplasmic male sterility with fertility restoration gene sources was used in developing the hybrid CAHH 468 (PKV Hy-3). Few private seed company hybrids also represent this category.

The future research work on male sterility needs to be directed towards following thrust areas:

1. In GMS, 50% population is male fertile and the same is identified after flower initiation. There is need to use marker genes in GMS for early identification and removal of fertile plants.
2. The GMS is sensitive to temperature which sometimes become fertile at low temperature (below 16°C). Efforts are needed to identify temperature insensitive and highly stable GMS lines.
3. Male sterility has been developed through genetic engineering in various crops. Efforts should be made to develop male sterile lines in cotton through genetic engineering.
4. There are only two sources of CGMS at present, viz. *G. harknessii* and *G. aridum*. Efforts should be made to identify additional sources of male sterility to avoid danger of uniformity.
5. In CGMS system, the male sterile cytoplasm has some adverse effects on insect resistance and fibre quality. Hence, efforts should be made to eliminate undesirable effects of sterile cytoplasm.

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