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Methods of Hybrid Seed Production in Crop Plants

*Hari Kesh
College of Horticulture & Forestry, CAU (Imphal), Pasighat, Arunachal Pradesh
*Corresponding Author's email: harikeshkaul55v2@gmail.com

The hybrid (F1) is defined as the first filial generation, produced by crossing two genetically diverse parents (pure lines and inbreds). Hybrids are heterozygous genetically and uniform phenotypically. Till now, many hybrids are developed in field crops, vegetables and flower crops having higher productivity, better quality and wider adaptability etc. The important factors to be considered for hybrid seed productions are mode of pollination, flower morphology and agronomic conditions like soil, season, planting ratio, isolation requirement, rogueing etc. Hybrid seed production is cumbersome and expensive in self-pollinated crops compared to cross pollinated crops due to low percentage of natural outcrossing. Further, flower morphology like cleistogamy, chasmogamy, bisexuality and homogamy promote self-pollination and makes the crossing difficult whereas, dicliny, dichogamy (protandry and protogyny), heterostyly, male sterility and self-incompatibility promote cross pollination and make the hybrid seed production easy and cheaper.

Types of Hybrids

1. Single cross hybrid: When two diverse parents say A and B are crossed to produce F1 or hybrid, it is called single cross (SC). E.g. A (♀) × B (♂) → F1

2. Double cross hybrid: When two single crosses involving four diverse parents, say SC 1 (A × B) and SC 2 (C × D) are crossed to produce hybrid, it is called double cross (DC). E.g. SC 1 (♀) × SC 2 (♂) → Double cross.

3. Three-way cross hybrid: When a single crosses between two diverse parents say A and B is crossed with third parent to produce hybrid, it is called three-way cross (SC). E.g. (A × B) (♀) × C (♂) → F1

4. Top cross hybrid: When an inbred say I_1 is mated with an open-pollinated variety say V_1, it is called a top cross hybrid. E.g. $I_1 \times V_1$.

Basic requirements for hybrid seed production

For the hybrid seed production in sexually propagated crops, it is better to use homozygous lines as compared to any population with broad genetic base, firstly because homozygous lines can be maintained by selfing, secondly the hybrids developed using these hybrids are homogenous. Therefore, the important consideration for hybrid seed production is (i) development of homozygous breeding material like pure lines or inbred (ii) evaluation and identification of inbred for desired traits and combining ability (iii) production of hybrid seed.

Methods of Hybrid Seed Production

1. Manual Emasculation and Pollination: The male and female rows (blocks) are planted in recommended male to female row (blocks) ratios. In this method male flowers are manually removed from the female line or the stamens are removed from the bisexual flower of a female plant with the help of forceps. This step of removing stamens from flowers is known as emasculation. Emasculation is usually done in the evening hours, one day prior to anthesis to prevent the self-fertilization in flowers used as female parent. Therefore, flowers selected for removing stamen are those that are likely to open the next morning. In the next day,

pollens are collected from the male rows (blocks) having the desired features and dusted on the stigma of the emasculated female flower for pollination and fertilization.

2. Male Sterility system: The male sterility is an important genetic tool for hybrid breeding that excludes the tedious and expensive activity like manual emasculation and facilitates the large-scale seed production. Male sterility is characterized by absence of functional pollen grains in flowers while the female part functions normally. It may be caused by mutation or by environmental factors.

i) Genetic Male Sterility (GMS): GMS is controlled by a single recessive gene present in the nucleus. However, there are reports of dominant genes controlling the male sterility. A male sterile line (msms) is maintained by crossing it with heterozygous male fertile (Msms) line (maintainer line). This crossing produces 50% sterile plants and 50% fertile plants. In hybrid seed production plots, the fertile plants are removed before the anthesis to maintain genetic purity. Hybrid seed is produced by crossing the male sterile line (msms) with a homozygous male fertile line (MsMs).

ii) Cytoplasmic-Genetic Male Sterility (CGMS): Cytoplasmic genetic male sterility is governed by both nuclear and cytoplasmic genes (mitochondrial genome). This system uses three parental lines viz., cytoplasmic male sterile line (A line), maintainer line (B) and fertility restorer line (R) lines for developing hybrids. Hybrid seed production using the CMS system involves the following two steps.

1. Maintenance of Male sterile (A) line: The male sterile line (A line) is maintained by crossing it with a maintainer line (B line) that has the same genome as that of the male sterile line but carries normal fertile cytoplasm. This crossing produces 100% sterile plants.

2. Production of hybrid seed: Hybrid seeds are produced by crossing the male sterile line (A line) with the fertility restorer (R-line). The seeds obtained from the A-line are used as commercial hybrid seeds.

The B line and R lines are maintained and multiplied by selfing.

3. Self-incompatibility

It refers to the inability of the pollen to fertilize the same flower or other flowers on the same plant. This method eliminates the need to emasculate of the flowers and therefore ease the production of hybrid seed. For hybrid seed production, two self-incompatible lines but cross compatible lines are planted in alternate rows, seed obtained from both the lines would be hybrid seed. Alternatively, a self-incompatible line may be planted in inter-row with a self-compatible line, in this case, seed from only the self-incompatible line would be hybrid.

4. Gynoecious sex form

The gynoecious line has been commercially exploited for hybrid seed production in cucurbitaceous crops like cucumber, sponge gourd, bitter gourd and muskmelon. The gynoecious lines produce only female flowers. For hybrid seed production, the gynoecious lines are crossed with a monoecious male parent in a specific row ratio (4:1) to produce the F1 hybrid. The male parent line is maintained by selfing and rouging out undesirable plants before contamination may take place. The female lines are maintained by inducing the staminate flowers with the application of silver nitrate at two to four true leaf stages and followed by selfing.

References

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