

Sorghum hybrid seed

production and quality maintenance

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Production of best quality seeds to meet the needs of the grower should be the main endeavour of sorghum improvement projects and seed agencies. Many limitations prevent or alter reproductive strategy of sorghum parental lines during hybrid seed production. Therefore, care must be taken for seed production that offer optimum climatic package during crop growth period. Seed certification agencies have an important role to play in certified hybrid seed production and distribution, because the crop performance is dependent on the quality of the certified seed used. Flowering behavior of the hybrid parents, productivity vs cost, and climatic conditions, particularly during the stages of flowering and seed filling should be important considerations to select an area for hybrid seed production. Good seed set in seed parent is possible by synchronization of flowering of pollen donor and pollen receptor, and adopting effective seed crop management practices. Regular guidance to seed growers by technical staff during the entire season of hybrid seed production facilitates the production of quality seeds of sorghum hybrid.

Keywords: Hybrids, Isolation, Seed quality, Sorghum

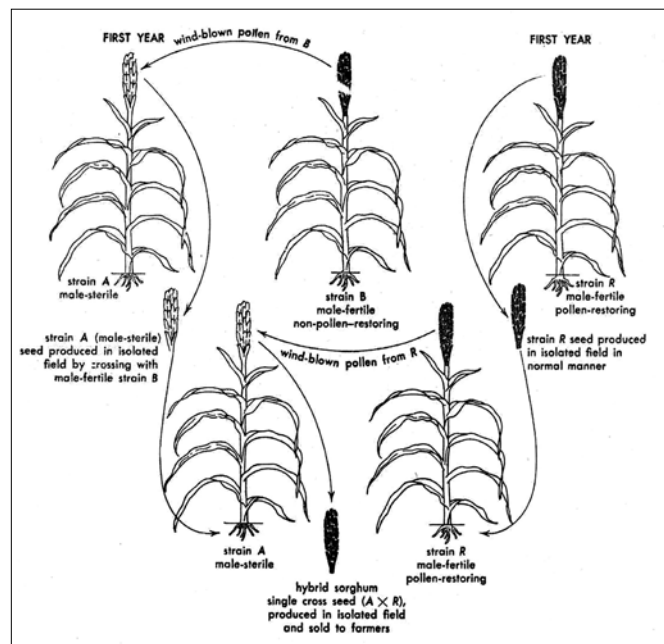
SORGHUM fits very well in a sustainable agricultural model with its ability to survive in water limiting conditions and provides an option for marginal farmers. It is a major dry land cereal and is grown primarily in Maharashtra, Karnataka, Madhya Pradesh, Andhra Pradesh, Rajasthan, Tamil Nadu, Uttar Pradesh and Gujarat for food, feed, fodder and fuel. Sorghum research in the country can be illustrated as a glaring example, which has significantly contributed towards the green revolution in drier areas. Sorghum has originated in East Africa with its secondary center of origin in India. The amount of genetic variability available in sorghum is very high because of its wide range of adaptation in tropical and temperate climates and free gene exchange among various races. In India, sorghum is grown in rainy and post-rainy seasons, and the requirement of varieties is different for two seasons. Besides grain sorghum genotypes, forage sorghum and sweet sorghum cultivars are being developed under AICSIP (All India Co-ordinated Sorghum Improvement Program). The cytoplasmic-genetic male sterility, induced by interaction of sterility-inducing factors in the cytoplasm with the genetic factors contained in the nucleus, forms the basis of hybrid seed production.

The successful development and spread of sorghum hybrids and varieties have made a significant impact on the productivity of this crop. The private sector gained considerably from the hybrid seed production and marketing of sorghum hybrids. In fact, the largest volume of hybrid seeds sold earlier was for sorghum and pearl millet hybrids. A country's advancement on the farm front is gauged by its efficiency in quality seed production and distribution. Without the use of good quality seed, the investments incurred on fertilizers, pesticides and water will not play dividend that ought to be realized. Seed is the key input in modern agriculture as the quality of seed determines the quantum output of a crop. The high quality seed in terms of high genetic and physical purity, healthiness, high germination, vigour and viability assures the potential of crop production under suitable and favourable agro-climatic conditions. The genetically pure seed of a variety is expected to have all the unique economic and diagnostic characters. In often cross pollinated species like sorghum inbred lines and varieties, the deterioration will be faster due to contamination with undesirable pollen of other genotypes. The quality of the certified seed class of a hybrid or variety depends on the maintenance of genetic

purity, physical purity, seed health, vigour, and viability potential during total seed production chain.

Hybrid (A × R) seed production

Sorghum hybrid seed production is a highly commercial venture. It is essential to maintain efficient level of crop management in order to maximize production at minimum cost. The hybrid seed is produced as certified seed under the vigilance of state seed certification agencies on a very large scale by private agencies, seed farms, experienced growers, and other extension organizations. Sorghum hybrids involve A × R seed production and are carried out according to the prescribed standards of production and processing in terms of isolation distance, genetic purity, and seed quality. Seed certification and seed law enforcement agencies have an important role to play in certified hybrid seed production and distribution, because the crop performance is dependent on the quality of the certified seed used. Although production of hybrid seed can be carried out by small individual growers, it is convenient to grow it in large compact blocks of 100–150 ha in a single or cluster of adjoining villages to avoid isolation problems. The quantities of hybrid seed required should be roughly estimated on an annual basis in advance, depending upon the projected demand for the commercial hybrid under cultivation. It is desirable to maintain significant quantities of carry-over seed as an insurance against unforeseen seed crop losses (normally an excess of 20% over the demand is produced).



Hybrid (A × R) seed production in Sorghum

Production environment

The area where the temperature during flowering ranges from 27–32°C is best suited for good seed production of sorghum. Night temperatures should not fall below 11°C for longer period since it affects the seed development. Flowering and seed development stages should not coincide with the rains, as the pollen

loss and grain mold deteriorate seed quality. The fields where sorghum was not grown during the previous season should be selected. In addition, there should be no Johnson grass in the seed field or within isolation distance. The field should be well levelled and drained. The saline, alkaline or very lighter soils are not suitable. Uniform and levelled piece of land with good drainage should be selected. The pH should be around 5.5–8.5, good irrigation facilities are essential for sorghum seed crop.

Selection of season

Sorghum seed production is mostly undertaken during rainy (*kharif*) season in Maharashtra, Madhya Pradesh, Rajasthan and Gujarat. In the other sorghum growing areas, it is taken in winter (*rabi*) or summer season. Seed produced in seasons other than *kharif* have good germination and vigour. During *kharif*, problems due to grain mold arise frequently. The savings should be carried out before the end of June and September in *kharif* and *rabi* seasons respectively. Early sowing culminates shoot fly attack and seed crop passes through its life cycle at the most optimum environmental condition for crop growth and seed development. The seed of commercial hybrids is produced during *rabi* and summer seasons both by public and private seed agencies and marketed in summer season itself. However, seed for *rabi* has to be stored till the next *rabi*. Consequently, there is some difficulty in the availability of seed for *rabi* leading to stagnant production of *rabi* sorghum. The seed production in *rabi* is predominantly concentrated in Andhra Pradesh and adjacent part of Karnataka due to favourable ecological conditions.

Sowing method

Seed should be placed at 3–4 cm depth. Maintenance of male sterile line (A-line) involves sowing of two parents, i.e. A-line (male sterile) and B-line (male fertile, non-pollen restores). Similarly, certified seed production of hybrids includes male sterile A-line and fertility restorer R-line. The border rows (4–6) should be sown with male line all round the seed production plot. To facilitate frequent rouging operation, a spacing of 60 cm (row to row) and 15–20 cm (plant to plant) is advisable.



Male sterile (A) and restorer (R) lines in sorghum sown in alternate strips of rows

Precautions should be taken to avoid admixing two parental lines at the time of sowing. For A-line seed production, the seed rate is 7.5 kg/ha of A-line and 5 kg/ha of B-line. The usual planting row ratio of A- and B-lines is 4:2 for breeder seed production. For certified hybrid seed production, the female and male lines in 4:2 can be sown, however, the proportion can be widened to 6:2. The general seed rate varies from 7–8 kg/hectare depending on spacing.

Planting ratio

Male sterile (A) and restorer (R) lines are sown in alternate strips of rows, normally in a ratio of 4A:2R, depending on the local experience of success and the ability of the R-line to disperse the pollen. The borders on all four sides of the hybrid seed production field are sown with the restorer (R) lines to ensure an adequate supply of pollen and guard against incoming stray pollen. The ideal planting ratio between male and female lines is two male rows alternated by 4–6 female rows. The male lines have smaller earheads and shorter span of flowering compared to the female ones, therefore, it is desirable to allow only four female rows for each pair of male rows. The female rows for each pair of male rows can be increased to six as in case of the male lines having larger panicle and longer span of flowering. A five row thick border all around the seed production plots must always be provided. Economizing on male lines, both within the plots and borders may affect the seed set and is not a wise step which many seed growers tend to do.

Isolation requirement for hybrid seed plot

Getting required isolations (300–400 for foundation and 200–400 m for certified) is increasingly becoming difficult for sorghum seed production. Hence, it is necessary that the hybrid wise seed production is planned in few clusters of villages. Each cluster can have 2–3 contiguous villages with about 200 or more hectares. The number of clusters may depend on the total seed required based on demand and supply. Compact blocks are easy for the supervision, maintenance of quality, minimizing the nicking and isolation problems to a major extent and can also serve as demonstration blocks.

Plant height adjustment

Most of the parental lines of sorghum hybrids have matching heights in the *rabi* season facilitating easy pollination process. The problem of disparity of heights can be avoided to some extent by planting the short parent on the raised ridges and the taller parent in the furrows below. Selective urea sprays also enable to increase the height to some extent by elongating the peduncle.

Nicking/ensuring synchronization

It is essential that the parental lines chosen for hybrid seed production flower at the same time, i.e the viable pollen is available when stigmas are receptive. Therefore, a prior knowledge of the flowering patterns of both the parents in hybrid seed production is necessary. The male

and female parents of the various hybrids, with different degrees of photo and thermo-sensitivities may react variably under different day length and temperatures at various locations or seasons. Therefore, several methods are employed to ensure synchrony. Some important measures for synchronization of flowering of male and female parents are:

- The growth stages of male and female parents should be critically examined at 4 weeks stage or even later depending upon the length of their vegetative growth period.
- The flower primordia and the apex of male and female plants be sampled randomly and observed critically by stripping the leaves of stem. The difference in the time of initiation and the size of the panicle bud would indicate the difference in their time to 50% flowering.
- The parent lagging behind can be hastened by selective measures like supplementation of nitrogen in the soil (additional dose of 50 kg N/ha) followed by foliar spray of urea (2%), soaking of seeds in water and GA spray at primordial initiation stage.
- Alternatively, selective irrigation of one parent and delayed irrigation of the other will also help in synchronizing the flowering date of the parents.
- Careful manipulation of nitrogenous fertilizers, foliar spray of GA and irrigation can synchronize the flowering of parents that differs by up to one week.
- If the male is advanced in the early stage due to adverse seasonal conditions, alternate plants are cut to allow the tillers to come up and such tillers are boosted with additional doses of nitrogen.

In case of partial seed setting, sugary disease (ergot) may occur. In such cases, spray of Thiram/Captan is used to control the disease and avoid prolonged sowings in the same areas, since the disease may invade the late sown crop in epiphytotic proportion. However, making the available pollen to achieve good seed set ensures better control of ergot disease.

Pollen viability, production and dispersal

Sorghum ear heads flower from the top to downwards over 4–9 days. Flowering commences when the glume opens and the pollen sacks emerge and release the fine pollen powder which grows down the stigma tube and fertilizes the grain ovary. Fertilization normally takes place within 2 h of the pollen landing on the stigmas. This happens soon after sunrise in the coldest part of the day. Researchers find it difficult to nominate the exact temperature below which pollen production is affected and pollen becomes non-viable, but temperatures below 10°C and above 40°C definitely reduce pollen viability. Cold weather at flowering reduces pollen viability and causes erratic seed set in late planted crops. In conditions of high moisture and humidity, pollen sacks do not dry out fast enough, their skin becomes rubbery and they do not split and shed pollen. Breeding for high pollen production is one of the key breeding goals for sorghum research and development programmes. Pollen viability



Sorghum seed production



Sorghum dispersal

is also important, as large amounts of non-viable pollen are not useful. High levels of viable pollen also help to combat ergot disease infestation. In fact, the staggered planting of the two male rows ensures adequate and prolonged availability of pollen. It is not safe to rely entirely on natural winds to aid in pollen dispersal. It is desirable to use artificial aids of pollen dispersal like tapping the male plant or blowing air through empty duster over the male heads. It is also advisable to spray 2% borax to improve the pollen production and dispersal. If the pollen is not available in the same plot, the pollen in the morning is collected from neighbouring plots and instantly sprayed with water or dust on the ear heads of the female parent. If there is dew fall hampering spread of pollen, power duster is blow emptied on the male rows to disperse pollen towards female heads or the male heads are tapped.

Stigma receptivity

Generally, the stigma retains good receptivity up to 4–5 days (MS 2219A, MS 296A and AKMS 14A) after flower opening, although in some lines it extends beyond that period as in MS 2077A. However, during the hot summer months, the receptivity is lost faster owing to desiccation of stigmas.

Rouging

Regular rouging should be followed after the commencement of flowering. Apart from off-types, pollen shedders can also be a problem in A-lines. Shedders are plants that look similar to the A-line, but exhibit fertile anthers and shed pollen. Such plants can only be identified at anthesis and should be uprooted immediately. Shaders can also arise from a partial breakdown of sterility in the A-lines due to high temperatures (>38°C). Delay in identifying shedders will result in out crossing to male-steriles and subsequently contaminate the hybrid causing genetic deterioration. Therefore, it is recommended that rouging be carried out in the early morning hours before pollen shedding takes place. The R-line should also be rouged periodically.

Harvest of hybrid seed

All possible precautions against seed contamination should be taken during harvesting of hybrid seed production plots and threshing of panicles from the A-line rows. Usually, the R-line is harvested first and the

harvest is removed from the field. Later, the A-line rows are carefully inspected for off-types and other chance admixtures and then harvested. Harvesting should be done at physiological maturity stage when the black layer formation appears at the point of attachment of seed with the caryopsis. In general, the seeds harvested 35–45 days after flowering have superior seed quality.



Seed contamination in hybrid seed production of sorghum

Threshing of hybrid seed

Threshing can be done by clean machine threshers at proper seed moisture content (13–14%). Seed should be dried to 10–12% moisture content before storage. Care should be taken to avoid mechanical mixtures while threshing. Hybrid seed yield (on the A-line) depends upon the yield potential of the A-line, per cent seed set, and environmental conditions.

Seed processing

As per Indian minimum seed certification standards (2013), the threshed seeds of sorghum should be physically pure and should not contain weed seeds, disease and pest infested seed, other crop seed, other cultivar seed, undesirable seed, and damaged seeds. Seed processing is an integral part of sorghum seed technology, which encompasses steps such as drying, cleaning, grading, treating and bagging. Seeds of sorghum harvested and threshed properly can often be cleaned to the desired purity on the air screen cleaner alone. The sieve aperture sizes of top and bottom screens of air screen cleaner differ with genotypes. Generally, the top screen may be around 12/64" or 4.75 mm with round holes and the bottom screen at 9/64" or 3.5 mm with round holes. The specific gravity separator helps in upgrading the quality of seeds by rejecting the seed that is inferior in specific gravity. The seed should to be dried to a uniform moisture level of 11–12% for storage. The seed companies train supervisory staff who in turn advise and assist the seed growers in hybrid seed production across critical crop growth stages. Close communication between seed growers and the company supervisory staff during the entire season facilitates quality seed production of sorghum hybrids. The requirements of isolation distance must be satisfied by a negotiated contract between a contract grower or group of farmers living in a community (seed village) and the seed firm.

Seed certification

Genetic purity in seed production is maintained through a system of seed certification. The main objective of seed certification is to make available the seeds of good quality to farmers. To achieve this qualified and trained personnel from SCA carries out field inspections at appropriate stages of crop growth. They also make a seed inspection by drawing samples of seed lots after processing. The SCA verifies seed standards in which the seed lot must confirm to get approval as certified seed. Hybrid seed production plot should ensure field standards (general and specific requirements) of the produce for foundation and certified seed classes as per the Indian minimum seed certification standards (2013) prescribed for sorghum.

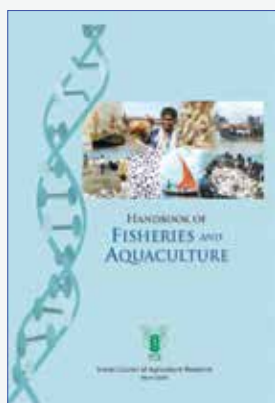
SUMMARY

Commercial hybrid seed production of sorghum must be carried out in a systematic manner. Selection of areas and seasons free from disease and pests is very

important before planning hybrid seed production of sorghum. Seed production agencies have to identify suitable areas with ideal agro-climatic conditions for efficient hybrid seed production through preliminary experimentation. Areas with temperature extremities, endemic to serious disease, pest, and obnoxious weed like *Sorghum halepense* and Striga are not suitable. Areas that are prone to natural disasters such as floods, excessive rains or high humidity during the grain filling stages of sorghum could cause grain molds, discolouration, weathering, and pre-harvest sprouting, all of which affect seed germination and seed quality. The chronological adjustments of the two parents ensuring coordination of pollen shedding and stigma receptivity facilitated by prolongation of effective flowering period is vital in hybrid seed production.

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TECHNICAL SPECIFICATIONS

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