

Commercialization of pearl millet:

Seed production and value addition

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Pearl millet (Pennisetum glaucum), is the sixth most important global cereal and the millet occupying largest area in India. As a versatile crop that provides food, feed and fodder, and survives in the arid and semi-arid tropics with minimum inputs, pearl millet is regarded as a promise for future farming. Good quality seed is a vital input for exploiting complete potential of crop production. This article elaborately describes the seed production programmes in pearl millet. The significance of value addition in the crop for food and other uses is also described.

Keywords: Malting, Pearl millet, Shelf-life, Seed production, Value addition

PEARL millet is a hardy crop, can be grown in areas which are very hot and dry, and on soils too poor for crops like maize and sorghum. The major pearl millet growing states in India are Rajasthan, Maharashtra, Gujarat, Uttar Pradesh and Haryana, which together account for more than 90% of pearl millet acreage in the country. Most of pearl millet in India is grown in rainy (*kharif*) season (June–September). It is also being increasingly cultivated during the summer season (February–May) in parts of Gujarat, Rajasthan and Uttar Pradesh; and during the post-rainy (*rabi*) season (November–February) at a small scale in Maharashtra and Gujarat. A majority of the subsistence farmers who typically cultivate this crop are unable to take advantage of its high yield potential due to lack of improved cultivars and application of improved management practices. A robust seed production programme is central to providing high quality seeds for agricultural development and food security.

Pearl millet is a highly cross-pollinated crop. Due to protogynous nature, it is more susceptible to contamination. The emergence of the panicle from the sheath takes about 4–6 days. Flowering starts after the emergence of the panicle out of the boot, but in some genotypes style exertion commences before completion of panicle emergence. The stigma remains receptive for 18–24 h after full emergence. Anther emergence begins one day after the emergence of the stigmas is completed on the panicle. Under rainfed conditions, first-flush anthesis of a plant may take place over 12 days, and it may continue on the tillers till seed formation. After pollination, the stigmas dry up in 24 h. Seed-set can be

seen in the panicle about a week after fertilization.

All the commercial grain hybrids of pearl millet are single-cross hybrids based on A_1 cytoplasmic-nuclear male sterility (CMS) system. Hybrid programmes in India accorded highest priority to grain yield and downy mildew resistance combined with maturity duration mostly in the range of 75–85 days, as per agro-ecological requirements. In pearl millet, seed is multiplied in four stages (Nucleus, Breeder, Foundation and Certified) called seed classes.

Nucleus seed production

Nucleus seed is the first stage in the chain of seed multiplication of a released variety or hybrid parents and is the only seed that can be used to produce its own seed class. The procedure for the production of nucleus seed is as follows:

Maintainer line (B-line): Initially in an isolation plot, about 1000 plants are selected and selfed at the time of flowering. Finally, 200 selfed plants conforming to the characters of the maintainer line are selected and divided into two lots. In the next season, using the seed from one lot, plant-to-row is grown and the progeny rows are studied for the diagnostic characters and rows not conforming to the characteristics of the line are rejected. The corresponding seed of the second lot for the progenies are bulked. In the third season, the bulk seed is grown in isolation and harvested to obtain nucleus seed bulk of B-line.

Male-sterile line (A-line): The A- and B-lines (nucleus seed bulk) are grown in alternate rows in isolation. The pollen shedders are rogued from A-lines. About 200–250

paired crosses between representative plants are made and labelled as A1 × B1, A2 × B2, etc. The harvested seed of each pair is kept separately. During next season, the paired crosses are sown in alternate rows retaining a portion of seed. Uniform pairs of A- and B-lines which conform to the standards of parental lines are identified. Remnant seed of the A-lines of the selected pure pairs is bulked. This forms Nucleus seed bulk of A-line.

Restorer line (R-line): This can be done in similar procedure as B-line multiplication.

Breeder/Foundation seed production

Breeder seed of hybrid parents is produced under the direct control of the sponsoring plant breeder. This class of seed is inspected by a monitoring team consisting of a breeder, seed certification officer, representatives of National Seed Corporation (NSC) and State Seed Corporation (SSC). Foundation seed is produced from Breeder seed, the production of which is carefully supervised or approved by the breeder and seed certification agency at the experimental station or recognized seed farms.

Male-sterile (A) line and maintainer (B) line: The A-line is multiplied by planting A- and B-lines in alternate set, usually in the ratio of 4:2. The B-line is planted in 4–8 border rows around the production block to ensure adequate pollen supply to the A-line. Careful and strict roguing is necessary in A- and B-lines. Pollen shedders should be removed in the A-line, if any. The B-line rows are harvested immediately after completion of flowering period. At maturity, the A-line rows are harvested and bulked. For breeder seed production of B-lines a separate production plot of 0.1 ha under isolation (1000 m) should be planted using the nucleus seed stock. Foundation seeds are produced by planting Breeder seed. The roguing and other procedures are similar to Nucleus seed production method.

Restorer (R) line: Breeder/Foundation seed production of R-lines is done by bulk planting under isolation (1000 m). Nucleus seed stock is used to produce breeder seed, and breeder seed is used to produce foundation seed (Table 1). Seed plots should be 0.1–0.2 ha for R-lines and at least 3000–5000 plants should be maintained.

The crop should be inspected at the following stages of growth to identify deviants for different characters:

- At 18 days after sowing: Deviants for early vigour
- At 30–35 days after sowing: Deviants for tillering, plant height and other traits
- Boot leaf stage: Deviants based on early flowering

- At 50% flowering: Deviants for late flowering, panicle exertion and panicle type (and pollen shedders in A-line)
- At Maturity stage: Deviants for panicle, seed type and seed colour

Identified off-type plants should be removed by uprooting as cutting of plants may lead to ratoon tillers.

Certified seed production

The stipulated isolation distance for certified seed production is 200 m. The pattern of planting and seed production is the same as for the breeder and foundation seed production. Production must be acceptable to seed certifying agency and should fulfill all the requirements of certification. Certified seeds are generally arranged through contract growers. Some private seed companies also undertake certified seed production programmes. The Certified seed of a hybrid is produced by growing A-line and R-line in 4:2 ratio in an isolated field. Synchronization of A- and R-lines is an important consideration for certified hybrid seed production. This can be manipulated by differential dates of sowing; controlling water and fertilizer application to one of the hybrid parents; and removal of extra-early tillers in A- or R-lines to synchronize the pollen shedding and stigma receptivity. Off-type plants in R-line and pollen shedders in A-line should be rogued out carefully to maintain genetic purity. A satisfactory certified seed production can be achieved if seed village concept is followed.

The calculations assume 1000 male row ratio of 4:1 kg/ha of seed yield in production plots, 4 kg/ha of seed rate and female:male ratio of 4:1.



Seed production plot of pearl millet

Table 1. Area and seed requirement for various seed classes to produce one tonne (enough to plant 250 ha) of certified pearl millet hybrid seed

Parental line	Year 1, Season 1		Year 1, Season 2		Year 2, Season 1	
	Breeder seed production		Foundation seed production		Certified seed production	
	Area (ha)	Nuclues seed (kg)	Area (ha)	Breeder seed (kg)	Area (ha)	Foundation seed (kg)
A-line	0.016	0.064	4	16	1000	4000
B-line	0.004	0.016	1	4		
R-line	0.004	0.016	1	4	250	1000
Total	0.024	0.096	6	24	1250	5000

Pearl millet value addition and commercialization

Pearl millet is a multi-purpose crop highly preferred by people living in arid regions in India as the crop survives well in such climatic conditions. The crop is used to feed livestock, poultry and fish. It is a source of high quality forage in seasons of forage scarcity. Both grain and stover of pearl millet have a better mineral profile than many other cereals. Grains are rich sources of fat, iron, calcium, essential amino acids and dietary fibre and are gluten-free.

Pearl millet flour develops a rancid odour and taste within a few days of milling due to a high lipid content which leads to fat acidity and lipolytic activity during storage. Though the polyphenolic content in endosperm restricts the efficient absorption of nutrients by the body, several processing techniques have been developed to enhance food value and shelf-life of pearl millet products and to improve the availability of starch, protein and minerals. Blanching and heat treatment are found to improve the storability and stability of flour. Acid treatment of grain is found effective in removing anti-nutritional factors and improving digestibility and shelf-life of pearl millet flour. Malting of pearl millet also increases the shelf-life. A wide range of value-added products can be prepared from processed pearl millet flour for both home consumption and commercial purpose. Pearl millet is suitable to prepare products like puffs, extruder snacks, upma, laddu, chapathi, pasta, noodles, pizza base, cookies, bread/bun, cake, instant idli mix and millet flour.

The major use (almost 70%) of pearl millet is for food purpose. Apart from this, the grains are also used as a cattle feed, alcohol industry, poultry industry and for seed. Pearl millet is an excellent cattle and poultry feed and it is nutritionally either superior to, or as good as corn. Most of pearl millet production currently is used for poultry, livestock and bird feed. The fodder from pearl millet and sorghum is preferred as livestock feed due to its superior quality with high energy and protein levels. Pearl millet-supplemented poultry feeds are

generally superior to sorghum and equivalent to maize in broiler diets.

Pearl millet grains are used in the production of potable alcohol and biofuel. In India, broken rice is used as a viable feedstock for alcohol industry followed by pearl millet grain (lower grade grain quality) and sorghum. Even though, the use of pearl millet in alcohol industry is not huge at present, there is much potential in future and increasingly many distilleries are shifting now to pearl millet from sugarcane molasses. A significant portion of pearl millet, especially lower quality, and blackened grain is used in Haryana and Rajasthan for manufacturing potable alcohol. Cellulose and hemicellulose, which are the main components for cellulosic biofuel production, are found abundantly in Pearl millet (bajra) biomass making it amenable for the production of biofuel. Pearl millet has every potential to be used for commercial scale-up of ethanol production in coming future because of its suitability as a rain-fed and low-input crop, short period of crop rotation, adaptation to poor soils, high biomass yield per unit area, energy yield potential and market price.

SUMMARY

Standardized seed production technology is essential for tapping the full potential of crop production. Several hybrids and varieties of pearl millet suited to different agro-climatic zones have been developed in India by both private and public sectors. Development of pearl millet based ready-to-eat and ready-to-cook products that are storable being developed strengthening the commercial value chain of the crop. The crop is also being explored for novel uses such as potable alcohol and bio-ethanol production. Strong seed production systems and commercial exploitation of the crop helps in ensuring enhanced and assured returns to the pearl millet farmers.

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Impact assessment of "Low Tunnel Technology" of vegetable cultivation during off season

An intensive survey was conducted in Jaipur bypass, Pemasar village, Jaipur road, Narangdesar, Sagar, Raysar, Ridmalsar, Napasar, Gardwala, Kilchu, Kalyansar, Gigasar, Ambasar, Sujasar, Palana, Swarupsar, Kolsar, Bachhasar, Meghasar, Naiyo ki Bast, Jaisalmer bypass, Ganganagr Highway, Khara, Sarahkunjiya villages and surrounding areas of Bikaner in Bikaner district to collect basic data/information about the impact of adoption of "Low Tunnel Technologies" for cultivation of vegetables during off season (winter). The study revealed that the local farmers grow various vegetables (specially cucurbits) under "Low Tunnel Technologies (LTT)" during the winter for advance production to fetch more price and earning from the vegetable market/*Mandies*. "Low Tunnel Technologies (LTT)" for vegetable production has spread over 1,200 ha in Bikaner, Rajasthan and farmers get/earn ₹ 2–3 lakh net profit from one ha of land per season depending on type of vegetable, seed quality, climatic conditions, marketing demand etc.

Source : ICAR Annual Report 2021-22