

MILLETS SEED:

PRODUCTION TECHNOLOGY, HARVESTING & POST-HARVEST MANAGEMENT, PROCESSING & STORAGE- AN OVERVIEW

C Chandra Sekhar¹, B Dayakar Rao²

¹Research Assistant, ICAR - Indian Institute of Millets Research, Hyderabad

²CEO Nutrihub and PS ICAR - Indian Institute of Millets Research, Hyderabad



Seed

Seed refers to the fertilized, matured ovule that contains an embryonic plant, stored material and a protective coat.

Seed Technology

Seed technology is essentially an interdisciplinary science which encompasses broad range of subjects. In its broadest sense, 'seed technology includes the development of superior crop plant varieties, their evaluation and release, seed production, seed processing, seed storage, seed testing, seed certification, seed quality control, seed marketing and distribution and research on seed physiology, seed production and seed handling based upon modern botanical and agricultural sciences'.

Millets

Sorghum, Pearl Millet And Small Millets-Proso, kodo, barnyard, little, foxtail, finger Millet) are the important food and fodder crops in semiarid regions, and are predominantly gaining more importance in a world that is increasingly becoming populous, malnourished and facing large climatic uncertainties. These crops are adapted to wide range of temperatures, moisture-regimes and input conditions supplying food and feed to millions of dryland farmers, particularly in the developing world. Besides they also form important raw material for potable alcohol and starch production, in addition millets are the best candidates to address the millennium goal of "Zero hunger".

International Year of Millets -2023 aims to contribute to the UN 2030 Agenda for Sustainable Development, particularly SDG 2 (Zero Hunger), SDG 3 (Good health and well-being), SDG 8 (Decent work and economic growth), SDG 12 (Responsible consumption and production), SDG 13 (Climate action) and SDG 15 (Life on land). It is important to make available to Indian farmers superior quality seeds of all crops including Millets. Farmers as vital links in

seed production, distribution and exchange networks are in search of resultant profitability from the seed production activity. Due to the seed production problems compounding in relation to ecological, agronomic and genetic limitations; the seed set, yield and resultant quality are also affected. In the absence of relevant technological knowledge, the sustained profitable yields and quality traits are at real stake. Hence, strategies to improve seed production, quality and supply must begin with strengthening the public agricultural R&D sector on a long term, sustainable basis.

It was only during the mid 60's that a revolution took place in our concept of yield potential of the major cereals and millets due to the discovery of morphological factors such as the dwarfing.

The introduction, development and release of dwarf varieties of rice and wheat and hybrids of maize, jowar and bajra have helped to raise the sights as regards yield possibilities and consequently have stimulated interest among the farming community in a new agronomy revolving around the cultivation of high yielding varieties.

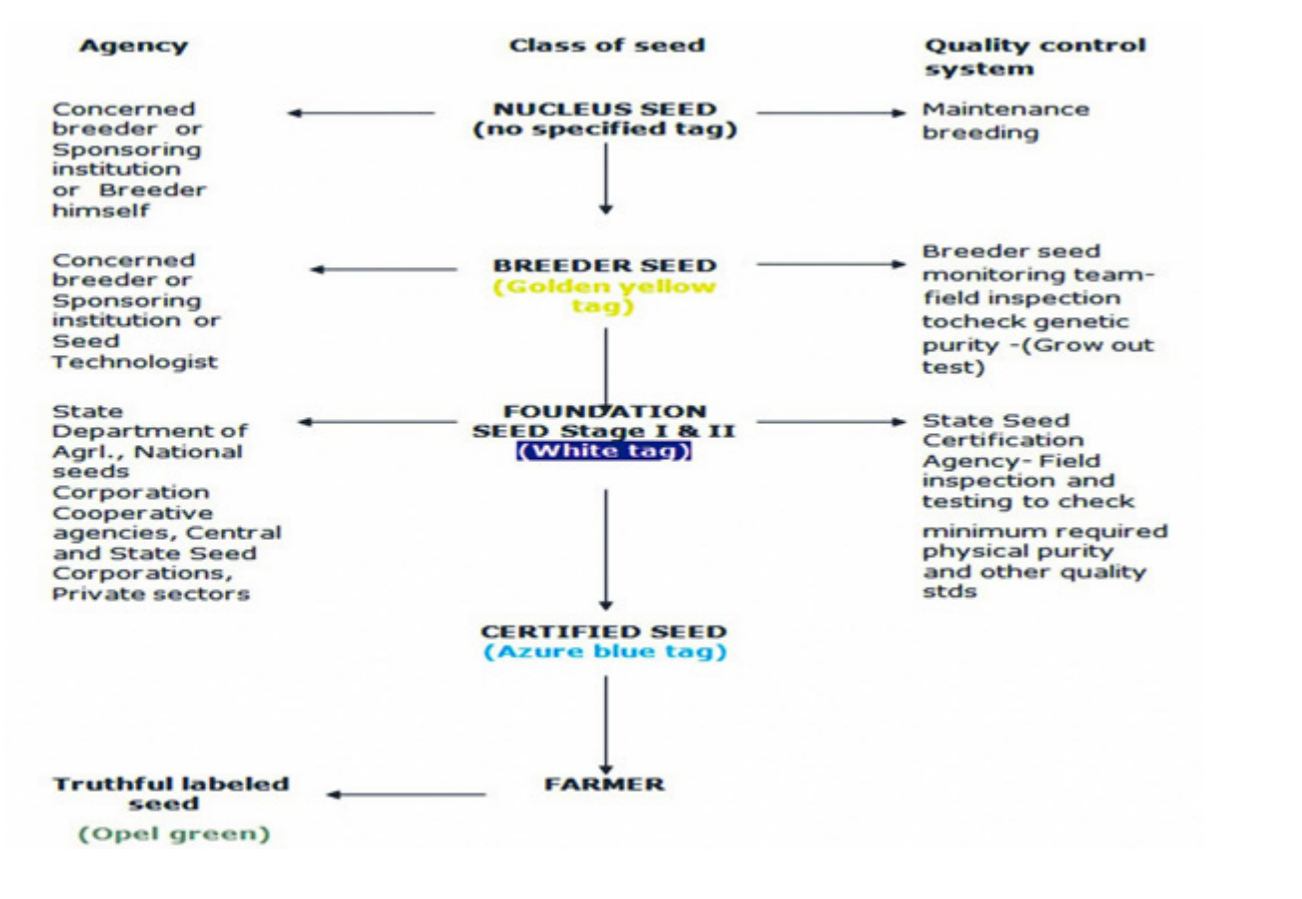


AREA, PRODUCTION AND YIELD OF MILLETS IN INDIA:

	Area (000 ha)			Production (000 ton)			Avg.Yield (kg/ha)		
	2009-2013	2014-2018	2019-2022	2009-2013	2014-2018	2019-2022	2009-2013	2014-2018	2019-2022
Sorghum	6684	4910	4355	4290	4404	4632	913	897	1064
Bajra	8480	7142	7415	7030	8738	10149	1065	1223	1369
Ragi	1211	1104	1097	985	1710	1807	1580	1549	1647
Small millets	773	570	436	435	403	349	554	707	800
Total millets	17149	13726	12680	12740	15255	16937	1019	1111	1273

(Based on estimations of Dept. of Economics & Statistics, DAC&FW, GoI, New Delhi)

SEED CLASS AND INSTITUTION INVOLVED IN SEED PRODUCTION:



1. Millets Seed Production Technology

SORGHUM(*Sorghum bicolor* L)

Method of seed production Sorghum is often a cross-pollinated crop and seeds are allowed to set by open-pollination in isolation. The crop should be raised in isolation of 200 metres for foundation and 100 metres for certified seed production to maintain the varietal purity. Time isolation is not permitted. The spacing between the plants should be 45 x 15 cm.

Seed production stages:

Breeder seed > Foundation seed > Certified seed
The best season for seed production is November – December.

Roguing

Roguing should be done often to remove the offtypes, volunteer plants and diseased plants from the seed production field to avoid the genetic contamination. Off-types and volunteer plants should be uprooted and removed before they start shedding pollen.

Field inspection:

A minimum of three field inspections should be done between vegetative and harvesting stages by the Seed Certification Officer, to check the isolation and off-types, designated diseases, true nature of plants, head and seed.

Some important Hybrids and Varieties:

- **Kharif Hybrids:** CSH 45, CSH 42, CSH 41, CSH 35, CSH 30, CSH 18, CSH 16, CSH 14
- **Kharif Varieties:** Palamuru Jonna (CSV 31), CSV 39, CSV 36, CSV 27, CSV 23, CSV 20
- **Rabi Hybrids:** CSH 39R, CSH 19R, CSH15R
- **Rabi Varieties:** CSV 29R, CSV 26R, CSV 22R, CSV 18R
- **Forage Varieties/Hybrids:** CSV 47F, CSV 32F, CSV 33MF, CSH 24MF

In rice-fallows of coastal Andhra Pradesh, sorghum cultivation is gaining popularity among farmers due to its high productivity (5.66 t/ha in 2017-18) whereas, the national productivity is very low (average yield is below 1.0 t/ha). The farmers are commercially motivated and selected to grow sorghum instead of maize on residual



moisture of rice-harvested field without tillage operation after comparing economic benefits. CSH 16 - Suitable hybrid with high yield potential

PEARL MILLET (*Pennisetum glaucum*)

Bajra is a highly cross-pollinated crop with 80% of cross-pollination. The crop should be raised in isolation and seeds should be allowed to set by open-pollination. The isolation distance maintained between the varieties is 400 metres for foundation seed and 200 metres for certified seed production.

Seed production stages:

Breeder seed > Foundation seed > Certified seed. The best season for seed production is October - December.

Rouging:

Intensive rouging should be done at three growth stages like seedling, tillering and seed setting. To maintain genetic purity of the crop, off-types and diseased plants are rogued out periodically.

Field inspection:

A minimum of three field inspections should be conducted between pre-flowering and harvesting stages by the Seed Certification Officer to check isolation, volunteer plants, off-types, downy mildew etc.

Some important Hybrids and Varieties:

- **Kharif Hybrids:** MP 7366 (MSH 346), BHB-1202 (Bikaner Hybrid Bajra-1202), RHB 223 (MH 1998), HHB 299 (MH 2076), AHB 1200, MP 535 (Pusa Composite 701), MP 7872, MP 7792, HHB 272 (MH1837), HHB 67, MPMH-21, MPMH 17, KBH 108, GHB 905, 86M89, 86M86, 86M66, Kaveri Super Boss, Bio 448, RHB-173
- **Kharif Varieties:** MBC-2, PC-443, JBV-3, PC-383, ICMV-221, Raj 171
- **Summer Hybrids:** Nandi 72, Nandi 70, 86M64

FINGER MILLET (*Eleusine coracana*)

Ragi and other minor millets is a self-pollinated crop and should be raised in isolation. The isolation distance maintained between the varieties is 3 metres for both foundation and certified seed production to maintain the varietal purity.

Seed production stages:

Breeder seed > Foundation seed > Certified seed
The best season for seed production is December – January

Rouging:

Rouging should be done should be done upto the flowering stage. Maximum percentage of off-type permitted at the final inspection is 0.05% for foundation and 0.10% for certified seed production.



Field inspection:

A minimum of two inspections should be done between flowering and maturity stages by the Seed Certification Officer to check the isolation, off-types and estimate the yield

Some Important varieties:

CFMV 3, CFMV 2, SiA 3088, SiA 3156, SiA 3085, Lepakshi, SiA 326, Narasimharaya, Krishnadevaraya, PS 4.

List of Latest released High-yielding Varieties/Hybrids of Millets

Crop	Varieties/ Hybrids	Area of Adoption	Characters
Sorghum	CSH 42 (SPH 1883)	Karnataka, Andhra Pradesh, Madhya Pradesh, Gujarat	Sorghum hybrid suitable for rainfed ecology during kharif, average grain yield 4.0 tonnes/ha, early maturity (98–105 days), moderately resistant to grain moulds.
Pearl Millet	MP 7366 (MSH 346)	Rajasthan, Gujarat, UP, Maharashtra, Tamil Nadu	Suitable for summer, average grain yield 5.1 tonnes/ha, maturity 89 days, highly resistant to downy mildew, smut and ergot diseases, tolerant to terminal stress condition, bio-fortified variety with high iron (69 ppm) and zinc (43 ppm).
Finger Millet	CFMV 2 (FMV 1118)	Andhra Pradesh, Chhattisgarh, Gujarat, Maharashtra, Odisha	Suitable for rainfed condition during kharif, average grain yield 2.95 tonnes/ha, dry fodder yield 8.6 tonnes/ha, medium maturity (119–121 days), rich in calcium (454 mg/100 g), iron (39 ppm) and zinc (25 ppm), resistant to leaf blast, foot rot, brown spot, grain mould.
Little millet	CLMV 1 (Jaicar Sama 1)	Maharashtra, Andhra Pradesh, Telangana, Tamil Nadu, Puducherry	Suitable for rainfed condition during kharif, average grain yield 1.58 tonnes/ha, dry fodder yield 4.4 tonnes/ha, medium maturity (98–102 days), rich in iron (59 ppm) and zinc (35 ppm), tolerant to shoot fly, banded blight, leaf blight and brown spot diseases.
Kodo Millet	Gujarat Anand Kodra 3 (GAK3)	Gujarat	Suitable for rainfed organic ecology of hilly and tribal region of Dahod and Panchmahal districts of middle Gujarat, average grain yield 2.46 tonnes/ha, medium maturity (114 days), good nutritional properties, high protein content and minerals, milling recovery 53.4%, highly resistant to shoot fly, moderately resistant to head smut.

SEED MULTIPLICATION AND SEED REPLACEMENT RATIO

Seed multiplication ratio

The number of seeds to be produced from a single seed when it is sown and harvested. Sorghum -(1:100); Bajra -(1:200); Ragi -(1:80)

Seed replacement ratio

Seed Replacement Rate (SSR) or Seed Replacement Ratio is a measure of how much of the total cropped area was sown with certified seeds in comparison to farm saved seeds. SRR of Sorghum (40), Bajra (57)

2. Harvesting and Post-Harvest management

SORGHUM

- **Stage of harvest:** Harvest the crop 40-45 days after 50% flowering. At that time, seed moisture would be around 25-30 per cent. A black layer will be visible at the base of the seed is the visible symptom of seed maturity.
- **Harvesting:** First, the male rows including the border rows are to be harvested and the earheads removed from the field. Then, harvest the female rows. Seeds harvested from the female rows are the hybrid seeds.
- **Threshing:** Seeds can be threshed either by manual method or by using mechanical threshers. During threshing, if seed moisture is kept at 15-18%, mechanical injury to the seed will be less.
- **Seed drying:** Seed can be dried either under sun or by using mechanical driers. If you dry the seeds under sun, avoid the noon hot sun. During the noon time, temperature will be very high and exposing the seeds to such high temperature will

affect viability. If mechanical drier is used, ensure that the drying temperature does not exceed 40°C.

PEARL MILLET

Harvesting and drying:

The appropriate time of harvest to ensure maximum seed yield and quality is of great significance. Fully mature seed is easily harvested and cleaned with minimal harvest losses. Delayed harvesting may result in increased losses due to lodging and seed shattering. Sun drying of seeds on clean threshing floor may be necessary to reduce moisture content, preserve viability and vigour and improve storage quality. Drying of seed to recommended moisture level of 12% is necessary to preserve its viability and vigour.



Precautions:

- In certified seed production, R-line should be harvested first.
- Field should be thoroughly checked before harvesting A-line to avoid mixture
- Ensure that the drying yard is clean and free from any pearl millet or other crop seed
- Avoid making big heap at high moisture as it may deteriorate seed vigour.
- Panicles should be dried to 12% moisture level.
- Harvested material should be double checked properly.

Threshing:

Care must be taken during threshing operations to avoid any chance of mechanical mixture. Threshing should be done lot wise. Checking and cleaning of threshers before use is a must to keep seed free from other seeds and Seeds should be cleaned before dispatching to processing plant by winnowing /using screens to remove chaffy /unwanted materials.

FINGER MILLET

Harvest is done once the earheads are physiologically mature. Physiologically mature earheads will turn from green to brown colour. Harvesting is done in two pickings since, the maturation of the earheads are not uniform because of the tillering habit of the crop. Second harvesting should be done seven days after the first one. Mature earheads should be harvested and threshed with bamboo sticks. Threshed grains are further cleaned by winnowing.

Drying and storage

The cleaned seeds should be sun dried to attain a safe moisture level of 12%. Care should be taken while drying to avoid mechanical injury to the seeds and contamination. Seeds can be stored upto 13 months under proper storage conditions.

3. Processing & Storage of Sorghum & Pearl Millet Seeds

SORGHUM

- **Seed processing:** Seed processing is an operation by which all immature, wrinkled, broken and small seeds as well as all physical impurities such as sand, stones, dust, other crop sees and week seeds are removed. For processing sorghum seeds, sieve of 9/64" diameter can be used so as to get uniform size seeds.
- **Safe seed storage methods:** Processed seeds should be protected and stored so as to maintain the seed quality up to the next sowing season.
- **Seed moisture content:** If seed moisture is more, the germination ability of the seed will decrease. For storage of one year, the seeds have to be dried to 12 per cent and longer storage period it has to be dried below 8% moisture content and stored in moisture vapour poof containers.

- **Seed treatment:** Seeds dried to safe level of moisture should be treated with captan 75% WP @ 70 gm in 500 ml water for 100 kg of seeds. After seed treatment, the seed can be stored for one year in cloth bags and if the seeds need to be stored beyond one year, they should be dried to 8% moisture, treated and then stored in moisture vapour proof container like 700 guage polythene bag.
- These seeds could be stored upto 1 ½ years. Instead of poisonous chemicals, use a safe and non-poisonous chemicals like Halogen mixture is recommended for treating sorghum seeds @ 3 g kg-1 of seeds.
- Halogen mixture can be prepared by mixing bleaching power (calcium oxy chloride) + calcium carbonate + arappu leaf powder (*Albizia amara*) 5:4:1 proportion respectively and then storing in moisture vapour poof container for a week before use.
- **Storage methods:** Always, new bags have to be used for packing the seeds. Seeds are hygroscopic in nature which means they have the tendency to absorb moisture from the atmosphere. In sea shore and deltoic areas where relative humidity of the atmosphere is normally more, seeds stored in cloth or gunny bags, loose viability fast. In such places, moisture vapour proof containers like polythene (700 guage thickness) bags can be used.
- Sorghum seed packed in 700 polybag.
- **Attention:** Seed Moisture should be lowered below 8%, when the seeds are stored in moisture vapour poof container. Otherwise they will deteriorate much faster.
- Direct contact of seed bags with the floor or wall is to be avoided. Seed bags should be stacked above the wooden pallet. While stacking, number of bags per row should not exceed 8, otherwise seeds in the lower bag will deteriorate due to pressure.

- **Storing:** Seed lots have to be stored with separate and clear identity. Storage go down has to be thoroughly cleaned before storing seeds.

PEARL MILLET

- **Seed processing:** Process of removing undesirable material from the desired seed lot and various steps in preparation of seed for marketing is called seed processing. The objectives of seed processing include ensuring high germination/seedling vigour, maintaining good appearance of seed, ensuring high physical purity and minimizing deterioration during storage. Types of materials removed during seed processing include inert materials, common weed seeds, noxious weed seeds, deteriorated seeds, damaged seeds, other crop seeds, other variety seeds and unacceptably small-sized seeds.
- **Cleaning:** Seed is passed through an air screen cleaner to remove inert material. Precautions have to be taken to ensure that machine is cleaned before using, desired screen is selected and samples are taken to essertian that seeds are well cleaned.
- **De-stoning:** It separates heavy impurities, such as stones, metallic particles etc. from the seed. Gravity separators are used for grading of seeds to the highest standards of physical purity. Near-size grains are separated according to the differences in their specific weight. It helps in removing damaged seed (insect and mechanical) and premature light weight seeds.
- **Chemical Treatment:** Seed is treated with chemicals to protect it from pests and diseases. Seed-treaters suitable for liquid/dry chemical products are used. Calibration is important for uniform seed coating. Slurry volume and dump speed are calculated for uniform coating. Seed is treated with metalaxyl 35% WS @ 2 g a.i./kg seed for controlling downy mildew when the seed is used for planting. K-Obiol 2.5 WP (Deltamethrin) @ 0.04

g/kg seed is used for controlling stored pests. Care should be taken in metalaxyl treatment of seed that is likely to be stored at room temperature for a longer time as metalaxyl-treated seed stored at 40°C has been reported to show phytotoxic effects.

- **Packing:** After the treatment, the seed is transferred from the holding bin into the packing machine to pack it into the pouches. Samples are taken during bagging to ensure the seed meets quality assurance standards. Care is taken to ensure that each primary seed bag contains the proper quantity of seed, is sealed properly and final seed moisture doesn't exceed 12%. The samples are again tested for warm germination test and accelerated aging test.
- **Labelling:** Information on the label should be as per country seed laws. Pearl millet bag size in India is usually of 1.5 kg and 3.0 kg. Label on each bag specifies name of crop and cultivar, seed class, seed lot number, year of production and date labeled, expiry date of validity, germination percentage, purity, seed treatment and appropriate danger signs and warnings.



- **Storage:** Storage conditions for nucleus seed include temperature of 4°C and relative humidity (RH) of 20% as the seed is stored for use in next few seasons. For breeder seed, temperature is 10°C and RH is 20%. Foundation and certified seeds are stored at room temperature if intended to be used within one year and at -20°C if stored for two years. Stacking procedure is very important during storage for ease of handling within the store. Information on quality and quantity of stock.

CONCLUSION

Millets can easily thrive in extreme conditions like drought, and some wild varieties can even prevail in flooded areas and swampy grounds. These extraordinary traits make them nutritious and climate change compliant crops. These can not only serve as an income crop for farmers but also improve the health of the community as a whole.

Replace low yielding varieties with high yielding varieties/hybrids. An effective means of improved seed distribution is farmer-to-farmer seed exchange. This may be primed to a limited extent by supplies of improved seed from public agencies, agricultural research stations and non-governmental organizations to farmers in easily accessible villages. However, such a system is very slow. To speed up the flow of adapted improved varieties to farmers, there is a need to form a network, formal and informal or integrated seed systems between community-based organizations and research institutes, public and private seed multiplication agencies, involved in various aspects of seed production.

However, to the farmer all this scientific research would be of little value unless he gets seeds, which are genetically pure (true to type) and possess other desired qualities namely, high germination percentage and vigour, high purity, sound health, etc. When the farmers do not get seeds possessing these qualities the yields they obtain may not be as expected.