ISBN: 978-81-19149-19-3

7. Field Cultivation Practices for Different Types of Millets

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Abstract:

Millets are one of the oldest cultivated cereals in the world. Millets are a group of small grained cereals having nutritionally rich grains cultivated under poor soil fertility conditions and are low input demanding crops. They are staple crops in the semi-arid tropics and largely found in low rainfall receiving areas, and consequently assume larger position in sustainable agriculture and nutritional security in the drylands. Most of the millets complete their life cycle in 60 to 120 days, acclimatizing to the brief cropping periods that endure unpredicted climatic vagaries and shifting.

The broader classification of millets puts these crops into two groups – major and minor millets. It is rich in proteins, fibre, vitamins, minerals like iron and is a better option on the nutritional test. Seeing their health benefits, millets are also being called the super foods. Millets can play a huge role in taking India towards food and nutritional security. Millets are extremely beneficial for the consumer, the farmer and the climate. Today the craze for millets is increasing all over the world. On India's initiative, the United Nations has declared the year 2023 as the International Year of Millets.

Keywords:

Millets, nutritional security, sustainability, staple food, low input crops

7.1 Introduction:

Millets are recently recognized as *'Nutri-cereals'* due to their superiority in terms of dietary value to other cereals. India has the heritage to grow different kinds of millets since the ancient time (Gowda NAN, *et al.* 2022; Maitra S, 2020). The term *"millet"* comes from the French word *"Mile,"* which means *"thousand,"* suggesting that a small number of millets contains many thousands of grains. Millets are frequently produced in marginal or degraded lands with very low nutrient contents and semi-arid conditions with minimal rainfall.

The crops provide food for people in areas where hunger is a common occurrence, and millets produce a more consistent harvest than other crops in low rainfall areas (Tadele, 2016). Millets are C4 plants with very superior photosynthetic efficiency, short duration, higher dry matter production capacity, and a high degree of tolerance to heat and drought. They also easily adapt to degraded saline, acidic and aluminium toxic soils (Yadav and Rai 2013).

People are being encouraged to seek out healthy and nourishing diets due to the modern sedentary lifestyle's association with a number of health issues. Millets are good for those who cannot consume gluten because they are gluten-free, but millet flour cannot be used to make bread that is raised (Amadou et al., 2013; Santra, 2013).

Millets are a storehouse of nutrients, and finger millet grains in particular have a remarkable high calcium content (>350 mg/100 g); foxtail millet, barnyard millet, and proso millet are prosperous in protein (>10%); little millet and foxtail millet are rich in fat (>4.0%); little millet, barnyard millet, and foxtail millet are superior in crude fiber (6.7-13.6%) (Kam *et al*. 2016). Globally, India is the largest producer of millets accounting for about 41% of the world production in 2020 and 83% of Asia's millet cropping area. India produces around 12 million MT of millets annually, according to Ministry of Agriculture and Farmers Welfare data. In India, millets have been an integral part of tribal food in the states of Odisha, Madhya Pradesh, Jharkhand, Rajasthan, Karnataka, and Uttarakhand.

In India, millets are cultivated in an area of 12.45 million hectares, producing 15.53 million tonnes with a yield of 1247 kg/ha. The state of Rajasthan has the highest area under millets cultivation (29.05%) followed by Maharashtra (20.67%), Karnataka (13.46%), Uttar Pradesh (8.06%), Madhya Pradesh (6.11%), Gujarat (3.94%) and Tamil Nadu (3.74%) (ASSOCHAM 2022). Though India cultivates a large variety of millets, bajra contributes to more than 50 percent cultivation of millets in India. Further, it is interesting to note that, India is the topmost producer of Barnyard, Finger, Kodo, Little millet and pearl millet globally (ASSOCHAM, 2022).

7.2 Global Scenario of Millets:

Table 7.1: Millet's Area and Production Region Wise (2019)

Regions	Area (lakh ha)	Production (lakh ton)
Africa	489	423
America	53	193
Asia	162	215
Europe	8	20
Australia & New Zealand	6	12
India	**138**	**173**
World	**718**	**863**

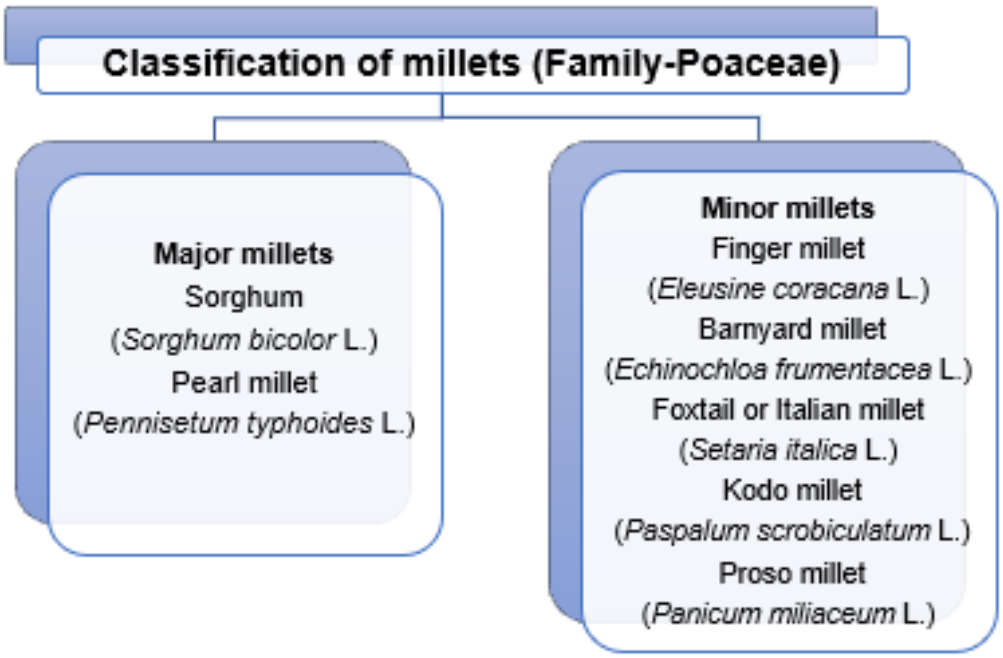
(Source: FAO Stat 2021)

According to ICMR-National Institute of Nutrition, the percentage of millet in the overall amount of cereal consumed during the day should be around 33%. For instance, 275 g of cereals, including Nutri Cereals, are advised for a reference man who engages in sedentary exercise. (Millets). Therefore, if an individual consumes millets, he can take in about 1/3 or 33% (90 to 100g of millets per day) of the recommended quantity.

Table 7.2: Nutritional content in 100 gm of dry grains

Crop	Protein (gm)	Carbohydrate (gm)	Fat (gm)	Minerals (gm)	Fiber (gm)	Calcium (mg)	Iron (mg)	Energy (Kcal)
Sorghum	10.4	70.7	3.1	1.2	2.0	25	5.4	329
Pearlmillet	11.8	67	4.8	2.2	2.3	42	11	363
Foxtail	12.3	60.2	4.3	4.0	6.7	31	2.8	351
Little	7.7	67	4.7	1.7	7.6	17	9.3	329
Kodo	8.3	65.9	1.4	2.6	5.2	35	2.9	353
Proso	12.5	70.4	1.1	1.9	5.2	8.0	2.9	354
Barnyard	6.2	65.5	4.8	3.7	13.6	22	18.6	300
Finger	7.3	72	1.3	2.7	3.6	344	3.9	336

(Mishra *et al.* 2021; NIN 2003)



(Muthamilarasan et *al*, 2019; Kumari *et al.* 2016; Goron and Raizada, 2015)

Figure 7.1: Classification of Millets (Family Poaceae)

- All India Coordinated Sorghum Improvement Project (AICSIP) - **New Delhi (1969)**
- International Crops Research Institute for Semi-Arid Tropics (ICRISAT) - **Hyderabad (1972)**
- National Research Centre for Sorghum – **Hyderabad (1987)**

7.3 Major Millets

Table 7.3: Major Millets

Crop	Origin	Seed rate	2n	Varieties
Sorghum	Africa	10-12 kg/ha Spacing- 45X12 cm^2 **Forage-** 40 kg/ha Spacing- 30x10-15 cm^2 row to row	20	**Hybrids-** (Kharif) CSH 1,5,6,9,10,11 (Rabi)-CSH 7R, CSH 14R, DSH 4 Mahalaxmi 296, CSH 15R **Composite-** (Kharif) CSV 10,11,13,15,17,20 (Rabi)- CSV 8R, 14R, 18 **Forage-** MP Chari, Jawahar chari 69 (JC 69), Pusa chari 23, Hara sona, PCH 106, CSH 20MF
Pearl millet	Africa	4-5 kg/ha Spacing- 45X15 cm^2	14	**Hybrids-** HB 2,3, BJ 104, CJ104, RHB 30, 90, GHB 15,27,32, NHB 3,4,5 **Composite-** Pusa 266, Pusa safed, PCB 15,164, HC 4, 10

(Bernji *et al*. 2011; Kimber 2000)

7.3.1 Sorghum:

Figure 7.2: Sorghum

Sorghum is one of the finest millet crops for food and forage (fodder for livestock). This offers staple foods in Asia's densely populated nations. In India, this grain is also referred to as *"Jowar" (*Kumari *et al.* 2016; Bantilan et al., 2004). The production of sorghum benefits the income and exports of the nation. Sorghum is a traditional staple food of the dry land regions of the world, a warm season crop intolerant to low temperatures, resistant to pests/ diseases and is highly nutritious. It ranks fifth in terms of cereals produced world-wide and fourth largest produced millet in India (Malabadi *et al.* 2022).

A. Health Benefits:

- By lowering the amount of free radicals, one can lower their chance of developing a number of illnesses, such as cataracts, rheumatoid arthritis, inflammatory bowel disease, atherosclerosis, and cancer.
- Anti-inflammatory & anti-carcinogenic properties due to high riboflavin content.
- Helps in improving blood circulation as it is rich in folic acid.
- Aids in cell regeneration (Thakur *et al*. 2006)

B. Soil and Climate:

Sorghum is grown in the semi-arid tropics variable rainfall areas. Sorghum plants can tolerate high temperatures and dry conditions better than any other cereal crop because of its extensive root system (absorb moisture from deeper soil layer), waxy leaf surface, small leaf area, and ability to curl leaves (that reduces transpiration loss of water). In addition, during a growing season, sorghum can survive periods of moisture stress by becoming dormant and then resuming growth when conditions become favourable. That's why it is referred to as *"the camel"* crops.

Almost all types of soil can be used to produce sorghum, but in India, the soil types that can be used to grow sorghum are classified as vertisols and alfisols, respectively. Sandier soils are not ideal for it to grow. Best adapted are soils that have high levels of organic matter and have a high-water retention capacity and pH levels of 6.0 to 8.5 are ideal for growing crops. The finest soils for its cultivation are regarded as the central India's black cotton soils with good drainage.

C. Field Preparation:

The field is prepared by deep summer ploughing every year in shallow to medium deep soils, and once in 3 years in deep to very deep soils. This should be done soon after harvest of rabi crop in double cropped regions, immediately after cessation of S-W monsoon. This leaves the field cloddy, exposing weed and other pests to high temperatures. The cloddy field also helps in moisture conservation.

With the onset of monsoon, the field is prepared by one deep ploughing followed by 2-3 harrowing or ploughing with country plough. Planking should be performed after each ploughing to break the clods and to level the field. In heavy soils prone to water logging, levelling is necessary to facilitate easy drainage (Bhat *et al.* 2019).

D. Sowing Time:

Sorghum is sown thrice in a year. It is sown in kharif and summer in north. In south and west, it can be grown in kharif, rabi as well as in summer seasons. In kharif under rainfed situations, the onset of monsoons is the single most factors deciding sowing time. The sowing time of sorghum is important aspect in increasing the crop yield. Experiments conducted in major kharif sorghum tracts suggested that last week of June to first week of July (onset of monsoon) is the optimum time of sowing (Aruna *et al.* 2020).

Crop establishment prior to the start of the monsoon is ideal in cases where irrigation is present. Sowings before the monsoon are therefore done 1-2 weeks in advance. Crops that were planted late are similarly vulnerable to midge and shoot fly infestations. Additionally, extra early seeding in April or May causes plant roots to produce *Dhurin*, which is then transported to stems and leaves as hydrocyanic acid (HCN), which is extremely deadly if fed to cattle (Malabadi *et al.* 2022). In the states of Maharashtra and Karnataka, rabi sorghum is farmed. In Andhra Pradesh, it is called *Maghi* season. Under rainfed conditions, the second fortnight of September to mid-October is the best period to seed rabi sorghum. Under irrigated conditions, as in Dharwad (Karnataka), sowings can be delayed and second week of October is the optimum time.

E. Irrigation Management:

Due to its ability to efficiently use water and resilience to drought, sorghum is known as a water sipping crop. Critical stages of irrigation are 30-45 days (seedling elongation stage); 60-65 days (reproductive or heading stages); 70-75 days (panicle emergence); and 90-95 (grain development stage). However, if only one irrigation is available, this should be applied just before booting (40-50 days) from flowering at 10 days' interval or Dithane M 45 – 0.2 % + Bavistin 0.2 % twice at 10 days' interval after commencement of flowering (Solaimalai *et al.* 2001).

F. Fertilizer Management:

It is suggested to apply 10 tons/ha of FYM and 40 kg/ha of nitrogen fertilizer at the last ploughing. It is advised to apply 80 kg of N and 40 kg of P_2O_5 per hectare in the absence of FYM. At sowing, 40 kg of N and all of the P_2O_5 must be applied; the remaining 40 kg must be applied 30 to 40 days later. It is advised to use 60 kg of N and 30 kg of P_2O_5 on light soils with minimal rainfall (IIMR- Sorghum).

G. Weed Management:

Summer ploughing for destroying stubbles and perennial weeds. Timely sowing of crop to minimize crop weed competition. Two weeding with one shallow hoeing up to 3 weeks after sowing will keep the field free from weeds. To check severe weed infestation, apply Atrazine @ 0.25-0.50 kg a.i. per ha against broad leaves weeds and grasses. Pendimethalin @ 1 kg a.i. per ha is applied as per emergence to control grasses. 2,4-D is applied as post emergence at the plant height of 10-30 cm to control broad leaved weeds @ 0.5-0.75 kg/ha (Das TK. 2008). 2,4-D injury in sorghum is known as buggy whipping or onion leafing.

H. Insect Pest Management:

Table 7.4: Insect Pest Management

Insect	Description	Management
Shoot fly (*Atherigona socata*)	Plants are more sensitive up to 4 weeks to this insect, Maggot feed on growing part of plant results in wilting followed by drying of central leaf, known as dead heart.	Early planting in kharif season avoids shoot fly attack. Only for crops sown late, apply spray Cypermethrin 10 EC @ 0.02% at the time of shoot fly oviposition Treat seeds with thiamethoxam 30 FS @ 3g/ kg seeds before sowing or treat seeds
Stem borer (*Chilo partellus*)	This attack on plant in entire growing season, Larvae feed on the upper surface of whorl leaves. Sometimes dead heart also appears on younger plant due to early attack.	Destroy thrashed sorghum ear heads before the onset of monsoon; use high seed rate and thin out the infected plants after 10-12 days of sowing, apply Endosulfan 4G/Carbonfurn 2 gm @ 8- 10 kg/ha in plant rows at 20th and 35th days after germination.
Sorghum midge (*Contarinia sorghicola*)	They attack at blooming Female midge lays eggs between the glumes of floret singly. Larvae destroy the seed causing blank or shrivelled seed coat.	Set up of light traps till mid night to monitor, attract and kill adults of stem borer, grain midge and ear head caterpillars. Neem seed kernel extract 5% (or) Spray malathion 50 EC @ 1600 ml/ha or phosalone 1150 ml/ha

(Aruna *et al.* 2020)

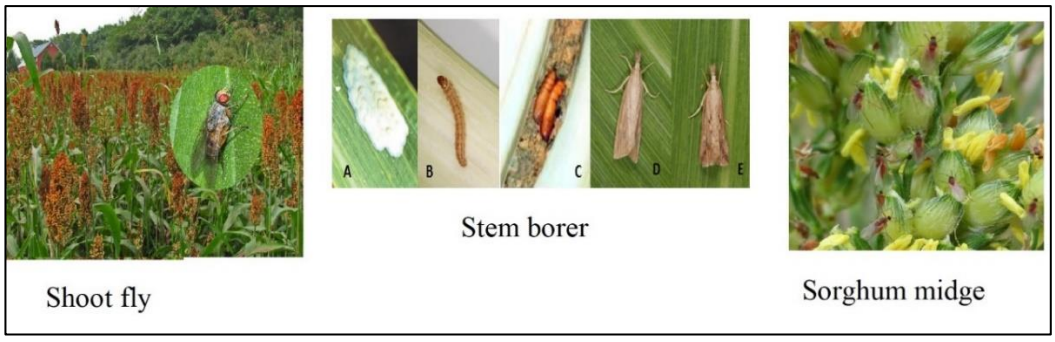


Figure 7.3: Insect Pest Management

I. Disease Management:

Table 7.5: Disease Management

Disease	Symptoms	Management
Loose smut (*Sporisorium cruenta)*	The ears come out much earlier than the healthy. The glumes are hypertrophied and the ear head gives a loose appearance than healthy. The sorus is covered by a thin membrane which ruptures very early, exposing the spores even as the head emerges from the sheath.	Seed treatment with Carboxin (Vitavax) @ 2g/kg or Captan/Thiram 4g/kg of seed. Collect smutted earheads in cloth bags and destruct by dipping in boiling water.
Head smut (*Sporisorium relianum*)	The entire ear head is either completely or partially replaced by a large whitish gall. The spores are blown away, exposing the dark filaments	
Long smut (*Tolyposporium ehrenbergii)*	Relatively small proportion of the florets are infected. The sori or spore sacs are cylindrical, elongate, usually slightly curved with a relatively thick creamy-brown covering membrane.	
Downy mildew (*Pernosclero sporasorghii*)	Green white strips on leaves and white patches of oospores, chlorotic plants.	Seed dressing with ridomil 25 @ 1 g a.i./kg seed.

(IIMR- Sorghum)

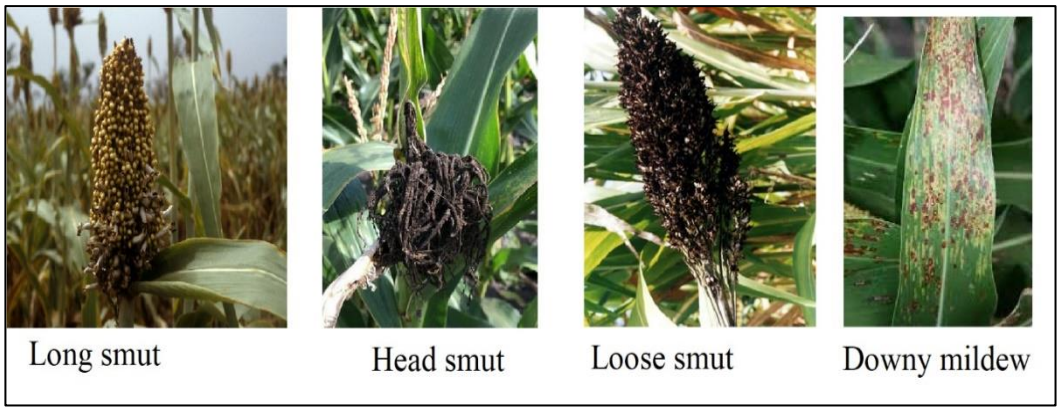


Figure 7.4: Disease Management

J. Harvesting and Yield:

The yield of sorghum crop varies from variety to variety and soil to soil. It also depends on other factors such as climate, irrigation and crop management practices. The grain yield of improved sorghum varieties under assured water supply ranges between 25-40 quintals / ha and 150-180 quintals / ha of hay can be obtained.

7.3.2 Pearl Millet:

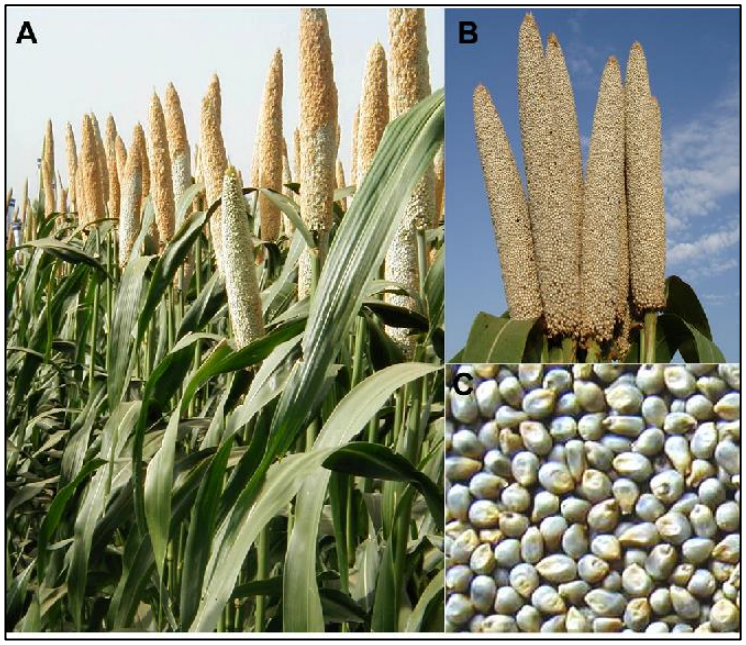


Figure 7.5: Pearl Millet

Pearl Millet is an annual grass which is grown widely in Africa and India for its grain which can be used to make flour and other foodstuffs. Pearl millet is an upright bunch grass that tillers from the base and has an extensive root system that provides drought tolerance (Satyagopal *et al*., 2014). Pearl millet is used by livestock producers for grazing, silage, hay, and green chop (Newman *et al.*, 2010). When compared to other warm-season millets including Japanese, and proso millet, it is the best option for forage. Pearl millet is safe to feed because it does not produce prussic acid or contain tannins like sorghum does.

In India, pearl millet is the fourth-most significant cereal after rice, wheat, and sorghum and a major source of dietary energy (360 kcal/kg) for the rural population (Nambiar *et al*. 2014). It contains a lot of iron, calcium, phosphorus, and protein.

Thiamine, riboflavin, and niacin are present in pearl millet grain in quite high concentrations. Moreover, pearl millet grain is utilised for non-food applications such the production of ethanol and animal feed. (Basavaraj *et al*. 2010). For a prolonged period of time, diabetes patients can effectively maintain their blood sugar levels with pearl millet (Dayakar Rao *et al.* 2017).

A. Time of Sowing: Sowing of *kharif* pearl millet should be done with the onset of monsoon i.e. first fortnight of July in north and central parts of the country. First fortnight of October is appropriate time for rabi season in Tamil Nadu. Gap filling should be done by transplanting seedlings after 2-3 weeks of sowing if scanty population exists.

B. Soil and Climate: Pearl millet is widely cultivated in India's semi-arid and arid regions in lighttextured red sandy, red loamy, alluvial, and coastal alluvial soils, as well as on mixed black, red, and medium black soils. It can be grown as well on medium-black soils, deep alluvial loams, and sandy and gravelly soils with low organic matter, but the yield is low. When the atmospheric temperature is between 30-34 ℃, pearl millet thrives.

Compared to other significant grown cereals, it is more resistant to higher temperatures. Pearl millet seed germinate best at temperature between 23-32 °C. If seeds are planted before soil reaches 23°C, they may not emerge properly. At the time of flowering and grain filling stage there should be no rainfall and weather should be dry and clear (Khairwal *et al.* 2007).

C. Land Preparation: For the cultivation of millet, one ploughing should be done with a soil turning plough. After this, do 2 to 3 ploughing with country plough or harrow, keeping in mind that planking must be applied after each ploughing. If there is a problem of termite pest in the field, then neem cake should be used at the rate of 20 to 30 kg per hectare.

D. Irrigation: Pearl millet is generally grown during the kharif season under rainfed conditions in areas of low rainfall. It is given supplemental irrigation when long dry spell prevails. Water requirement of this crop is much lower (250- 350 mm) than maize, sorghum, finger millet (500-600 mm) (IIMR- Pearlmillet). Though pearl millet is rainfed crop, irrigation at anthesis or flowering is beneficial.

E. Nutrient Management: Application of 40 kg N + 20 kg P_2O_5/ha for arid regions and 60 kg N/ha + 30 kg P2O5/ha for semi-arid regions is recommended for sole pearl millet as well as intercropping system. In light soils (sandy loams) the applied nitrogen may be lost due to leaching with heavy rains. So, only about half of the recommended nitrogen dose should be applied at seedbed preparation.

The remaining half of nitrogen dose is side-dressed when the crop is 25 days old. On soils which do not leach easily like black soils, all of the nitrogen may be applied during seedbed preparation (IIMR- Pearlmillet).

G. Weed Management: The herbicidal weed control achieved by pre-emergent application of atrazine @ 0.5 kg ha^{-1} combined with one hand weeding is similar to the effectiveness of two hoeing and weeding at 15 and 30 days after sowing. Atrazine is more efficient for weed control as compare to simazine in dryland areas.

To preserve soil hydration, do a second round of weeding. Pendimethalin apply for the control of annual grasses and some broad leaves weeds @ 0.75-1.0 a.i. kg ha^{-1} (Das TK. 2008).

H. Insect Management:

Table 7.6: Insect Management

Insect	Description	Management
Shoot fly (*Atherigona approximate*)	Pest of N-India, attack up to 3-week plant, lays eggs singly on either lower side of leaf or base of plant, cut the apical points results in dead heart cut off panicles.	Early plantig. Two dusting of 5% malathion @ 25 kg/ha at 10 & 20 DAS
Grain midge (*Geromyia penniseti*)	Attack on developing grains, lays egg in flower, grain less glumes with white purple case on tip of spikelet	Spray metacide 250 cc or thiodan 625cc
White grub (*Holotrachia spp*.)	Feed on roots of young seedling results in wilting like appearance, maximum damage in July august	Intercropping with legumes Seed treatment with chlorpyriphos 20 EC @ 12.5 ml/kg seed.

I. Disease Management:

Table 7.7: Disease Management

Disease	Symptoms	Management
Downy mildew or green ear disease *(Sclerospora graminicola*)	Downey growth on lower leaf surface wrinkled and split leaves profuse the tillering, ears either not produced or abnormal ear which transferred into twisted leafy structure,	Use of hybrid and composite varieties, seed treatment with Apron 35D @ 8 gm per kg seed.
Smut (*Tolyposporium penicillariae*)	Grains are replaced by powdery material, initially these are green later become dark black that cause secondary infection	Spray Vitavax or Plantavax 0.25% on panicle at booting stage
Ergot (*Claviceps fusiformis*)	Small droplets of pinkish or light honey-like fluid exuding from infected spikelet of ear, which dried at become hard	Use 105% salt solution remove sclerotia, Use a mixture of ziram 2 g/liter (0.1%) + benlate (0.1%).

Source : AESA; IIMR- Pearlmillet)

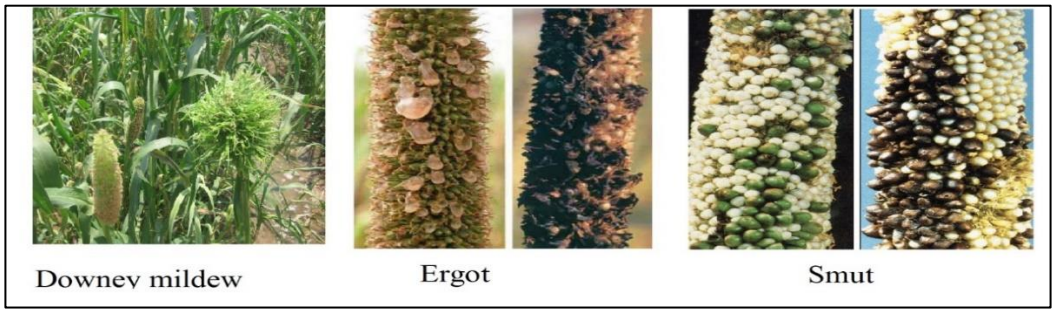


Figure 7.6: Disease Management

J. Harvesting:

The best stage to harvest pearl millet is when the plants reach physiological maturity determined by the black spot at the bottom of the grain in the hilar region. When the crop matures, the leaves turn yellowish and present a nearly dried up appearance.

The grains are hard and firm. The usual practice of harvesting pearl millet is cutting the ear heads first and the stalks later. The stalks (straw) are cut after a week, allowed to dry and then stacked. Grain at or below 14% moisture is considered dry. For long-term storage (more than 6 months), grain moisture content should be less than 12%.

7.4 Minor Millets:

Table 7.8: Varieties

Crop name	Origin	2n	Seed rate kg/ha		Sowing time	Spacing (cm)
			Line sowing	Broadcasting		
Finger millet	Africa	40	6-8	5-5 (Transplanting)	June-July	22.5x7.5-10
Foxtail millet	Eastern Asia	18	8-10	15	TN- Aug.-Sep. UP, BH – Mid June AP - 1st fortnight of July	25-30x10
Kodo millet	India	40	10	15	June-July	22.5x10

Crop name	Origin	2n	Seed rate kg/ha		Sowing time	Spacing (cm)
			Line sowing	Broadcasting		
Proso millet	Egypt	36	10	15	TN- Sep.-Oct. KR, AP- July UK- May-June	25x10
Barnyard millet	India	54	8	10-12	Sept.-Oct. & Feb-March	22.5x10
Little millet	India	36	8	10	June-July	22.5x10

(Hatakeyama *et al*. 2017; Saha *et al*. 2016; Jia *et al*. 2013; Bennetzen *et al,* 2012)

7.4.1 Varieties:

Table 7.9: Varieties

Crop	Varieties
Finger millet	GPU 67, 48, VR 847 (Chaitanya), PRM 1, ML 365, MR 6 (Divya), VL 315, VR 762 (Bharathi), Vegavathi (VR 929), CFMV 1 (Indravathi), CFMV 2, Dapoli 1, Phule Nachani,
Foxtail millet	PS 4, Sri Lakshmi, SR 16 (Meera), 51, PRK 1, TNAU 43
Kodo millet	KK2 Jawahar kodo 48,13,65,439, RMV 20
Proso millet	Pratap chena 1, TNAU 145, 164, 151, PRC 1
Barnyard millet	Pratap sanwa 1, VL Madira 172, 181, 207, PRJ 1
Little millet	Paiyur 2, OLM 20, 36, 203, 208, Co 4, CLMV 1, Sree Neelima

7.4.2 Description:

Among millets, ragi or finger millet has a unique place and is the only millet which has been able to touch an average productivity level of more than a tonne per hectare. About 60% of finger millet is produced by the state of Karnataka which account for about 34% of global production (Chandra *et al.*, 2016; Upadhyaya *et al.*, 2007). Finger millet is a dwarf, highly tillering plant with characteristic finger like terminal inflorescences.

A minor millet called barnyard millet has a calcium concentration that is about ten times higher than that of rice or wheat. The millet that contains the most carbohydrates is finger millet (Gulla *et al.* 2014). Micronutrients like magnesium, calcium, manganese, serotonin, phosphorus, fiber, and B vitamins are also abundant in minor millets. These micronutrients act as antioxidants which are essential to human body.

Minor millets also have the advantage of requiring very little water for cultivation and being able to endure harsh climatic conditions. To attain nutritional security and maintain rain-fed farming in the nation, new high-yielding crops are required. Promotional strategies and policies are also required (Singh *et al.* 2020).

Proso millet's common name, "*broom corn,"* derives from the compact panicle's top, which droops like an old broom (Changmei and Dorothy, 2014). It is well suited for many soil types and climate conditions. Proso millet is highly drought resistant, which makes it of interest to regions with low water availability and longer periods without rain.

Little millet but the plant is generally shorter in stature, has smaller panicles and seeds, and is grown on a limited scale voluntarily or with minimum care on poor lands. Little millet matures quickly and withstands both drought and water logging. It is generally consumed as rice and any recipe that demands staple rice can be prepared using little millet (Prasad and Staggenborg, 2009).

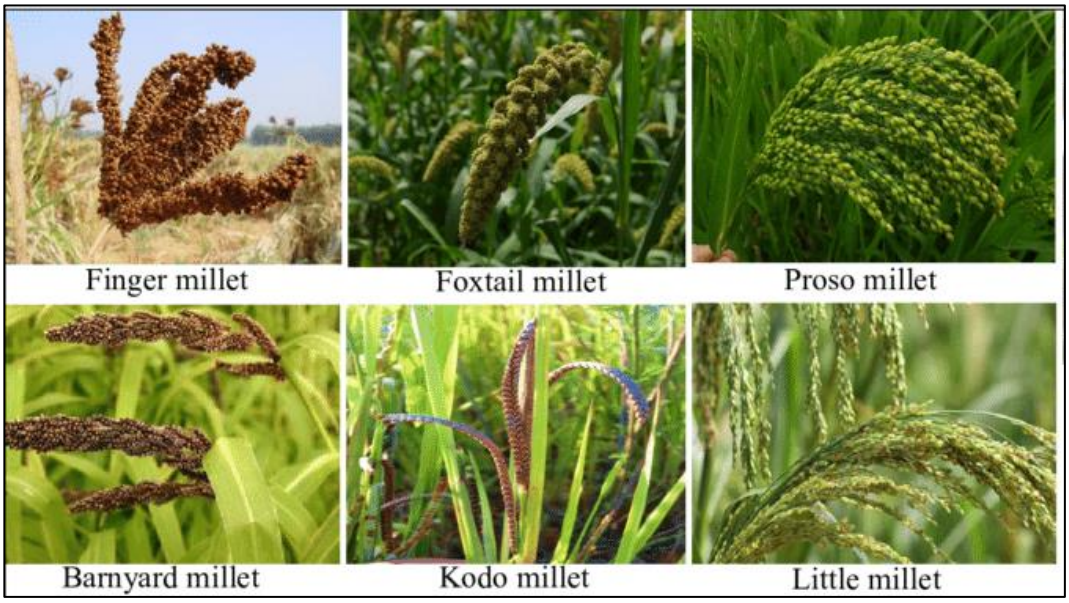


Figure 7.7: Description

Kodo is known to be extremely hardy, drought resistant and grows on stony or gravelly soils which do not support other crops. It is relatively long in duration requiring four to six months to mature compared with two to four months for the other millets. It has the highest dietary fiber among stall the millets (Prasad and Staggenborg, 2009).

7.4.3 Climate and Soil:

These crops have a wide range of seasonal adaptation and is grown in varying soil and temperature conditions. These can be grown throughout the year if moisture is adequate and if temperatures are above 15°C. Alluvial and black soils are also suitable provided the soils are well drained.

7.4.4 Tillage:

Fall ploughing is advantageous for moisture conservation. In the month of April or May, one deep ploughing should be done with a soil turning plough. Followed by country ploughing twice is necessary. Before sowing secondary tillage with cultivator and multiple tooth hoe to prepare smooth seed bed is necessary.

7.4.5 Manures and Fertilizers:

Adequate application of FYM, 7.5 to 10 tonnes per hectare help in better development of root growth. The general recommendation in finger millet is 40, 20, 20 kg N, P_2O_5 and K_2O for rainfed and 60:30:30 N, P_2O_5 and K_2O for irrigated conditions. All P_2O_5 and K_2O are to be applied at sowing whereas, nitrogen is applied in split doses. And recommended N, P_2O_5 and K_2O dose for remaining millets is 40:20:0. The small millets respond well to moderate application of N and P_2O_5. The response to K has not been observed. (Source: IIMR).

7.4.6 Weed Control:

Weed free condition throughout the crop growth period was essential for obtaining significantly higher grain yield in small millets. The critical period for crop with competition is initial 45 days in all the small millets. Two manual weeding at 15-20 days and 30-35 after sowing are sufficient to control the weeds. Isoproturon @ 0.5-0.75 kg a.i./ha applied as pre-emergence spray or mixed with sand or soil along with one hand weeding 30-45 days after sowing has been found effective in controlling weeds in finger, kodo, foxtail and barnyard millet (AICSMIP, 2005).

A. Pre-emergence spray: Oxyflurofen @ 0.1 lt a.i /ha (Irrigated areas)

B. Post-emergent spray: 2, 4-D sodium salt @ 0.75 kg a.i./ha Spraying around 20-25 days after sowing effectively control weeds.

7.4.7 Water Management:

Foxtail millet is grown in dry areas as a rainfed kharif crop, but if water is available, irrigation that can save lives can be provided during intermittent dry periods between rainy spells. Chapke et al. (2018) suggested providing two irrigations, at 25–30 and 45–50 days after sowing. Proso millet- Kharif crop does not require any irrigation. During prolonged dry spells, protective irrigation at tillering, flowering and grain formation stage need to be given.

Summer crop require 4 to 6 irrigations depending upon soil type and climatic conditions (Prabhakr *et al*. 2017). Kodo millet - Irrigations are necessary during dry spells depending on the soil type and the severity of the drought, first irrigation should be done at 25–30 days after sowing and after 40–45 days of sowing second irrigation should be done. When it rains heavily and continuously, drain the excess rainwater from the field (Prabhakar *et al*. 2017; Dwivedi *et al.*, 2012).

Barnyard millet - During kharif season, the crop does not require irrigation but at the time of long dry spells, first irrigation at 25-30 days after sowing (tillering stage) and second irrigation at 45-50 days after sowing (panicle initiation stage) needs to be given.

7.4.8 Harvesting and Threshing:

Harvesting should be done when the ear head colour starts fading or grains at low portion of ear head mature. Grain maturity is not uniform in proso millet. Delayed harvesting causes considerable yield losses due to shattering and bird damage. Well dried gains can be stored for long period. All the small millets (except finger millet) have outer tough seed coat layer. The separation of seed coat from endosperm is usually done by repeated ponding in mortar.

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