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8. Agronomic Practices for Enhancing Millet Productivity

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Abstract:

Millets are a group of small grained cereals, termed as "Nutri cereals" having nutritionally rich grains and can be cultivated under poor soil fertility and low moisture conditions. These crops assume a large portion of the nutritional security in the drylands.

They have a short life cycle and can adapt to harsh climatic conditions. Major millet crops cultivated in India include sorghum or jowar, pearl millet or bajra and minor or small millet include finger millet or ragi, barnyard millet or sawan, foxtail millet or kakum, kodo millet or koden, little millet or kutki and proso millet or cheena.

Despite the climate friendly cultivation and highly nutritious nature of millets, the area under millets cultivation is drastically declining. Thus, adoption of improved agronomic practices is the key to sustain millets productivity at desired levels and for ensuring long term ecological and economic sustainability in rainfed millet systems.

Keywords:

Agronomic, enhancing, millets, productivity.

8.1 Introduction:

The word millet is derived from the French word "mille" meaning a handful of millets contain thousands of seed grains. Millets are a group of small grained cereals belonging to the grass sub-family Panicoideae, generally termed as "Dryland cereals" or "Nutri-cereals" which were found to be domesticated around 8000 years ago in the highlands of central China [1]. Millets are low input requiring crops which are nutritionally rich and can be cultivated under poor soil fertility conditions. Life cycle of most of the millets is completed in 60 to 120 days and can endure unpredicted climatic conditions. Millets are staple crops in the semi-arid tropics, found in low rainfall areas and assume an important position for nutritional security in the dryland areas. Due to their inherent drought tolerance and pests and disease resistance mechanism, millets are well considered as the "crops of antiquity" [2]. In India different types of millets are grown and broadly millets are classified into two groups- major and minor millets. Major millets comprise sorghum and pearl millet and minor or small millet comprise finger millet or ragi, barnyard millet, foxtail millet, kodo millet, little millet, proso millet and brown top millet (Table 8.1). With the ever-increasing global population, agrifood systems in India are facing major challenges.

Millets being climate resilient, drought tolerant and eco-friendly crop provides an affordable and nutritious option and efforts are required to promote its cultivation and ensure sustainable income for resource poor and marginal farmers. According to FAO Director-General QU Dongyu, "Millets can play an important role and contribute to our collective efforts to empower smallholder farmers, achieve sustainable development, eliminate hunger, adapt to climate change, promote biodiversity and transform agrifood systems".

Table 8.1: General Information About Millets.

Sr. No.	Crop	Scientific name	Common name	Place of origin	Major growing states in India	Scientific name	Common name
1.	Pearl millet	*Pennisetum glaucum*	Bajra	Africa	Rajasthan, Maharashtra, Gujrat, Uttar Pradesh, Haryana, Karnataka, Madhya Pradesh, Tamil Nadu, and Andhra Pradesh.	*Pennisetum glaucum*	Bajra
2.	Sorghum	*Sorghum bicolor*	Jowar	Northeastern Africa	Maharashtra, Karnataka, Madhya Pradesh, Tamil Nadu, Andhra Pradesh, Rajasthan, Uttar Pradesh and Gujarat.	*Sorghum bicolor*	Jowar
3.	Finger millet	*Eleusine coracana*	Ragi/ Mandua	East Africa	Karnataka, Uttarakhand, Maharashtra, Tamil Nadu, Odisha, Andhra Pradesh and Gujarat.	*Eleusine coracana*	Ragi/ Mandua
4.	Foxtail millet	*Setaria italica*	Kangni or Kakum	Central Asia (India)	Andhra Pradesh, Bihar, Karnataka, Rajasthan, Tamil Nadu, Telangana, Uttarakhand and Uttar Pradesh.	*Setaria italica*	Kangni or Kakum
5.	Kodo millet	*Paspalum scrobiculatum*	Koden	India	Madhya Pradesh, Chhattisgarh, Maharashtra, Tamil Nadu, and Karnataka.	*Paspalum scrobiculatum*	Koden

Sr. No.	Crop	Scientific name	Common name	Place of origin	Major growing states in India	Scientific name	Common name
6.	Barnyard millet	*Echinochloa frumentacea*	Sawan	India	Karnataka, Madhya Pradesh, Uttarakhand, Uttar Pradesh and North-eastern India.	*Echinochloa frumentacea*	Sawan
7.	Proso millet	*Panicum miliaceum*	Cheena	Central Asia (India)	Bihar, North-eastern India and Maharashtra.	*Panicum miliaceum*	Cheena
8.	Little millet	*Panicum sumatrense*	Kutki	India	Karnataka, Madhya Pradesh, Andhra Pradesh, Tamil Nadu, Jharkhand, Odisha, Maharashtra and Chattisgarh.	*Panicum sumatrense*	Kutki

8.2 Nutritional Importance of Millets:

Millets play an indispensable and significant role in traditional diets of many Indians. When compared to nutritional content of rice and wheat, millets are three to five times higher, making it yield of agricultural security.

Millets are treated as nutri-cereals due to the presence of different antioxidants and detoxifying agents in millet grains.

These are also rich in different minerals and dietary fibres and used as a livestock feed both grain and forage. There are multiple health benefits of millets:

- Millets contain copper and iron, which are required for improving blood oxygen level by producing more blood cells.
- Phosphorus in millets also helps in maintaining blood pressure. Millets when consumed in large quantities also helps in reducing triglyceride content in the body, thereby reducing the risk of coronary artery diseases.
- Millets contain vitamin B which helps in easy breakdown of carbohydrates and fats in body. Niacin in millets helps in increasing the HDL level of blood streams. They contain no saturated fats and are gluten free grains.
- They are also good source of essential fatty acids like linoleic acid, oleic acid and palmitic acid. Being gluten free, millets are perfect food for people suffering from celiac disease.
- Millets contain an amino acid Tryptophan and high fibre content which helps in maintaining body weight by lowering the appetite and helps in weight management. The fiber content in millets is higher than rice and wheat. Nutritive value of various millets has been summarized in **Figure 8.1**.

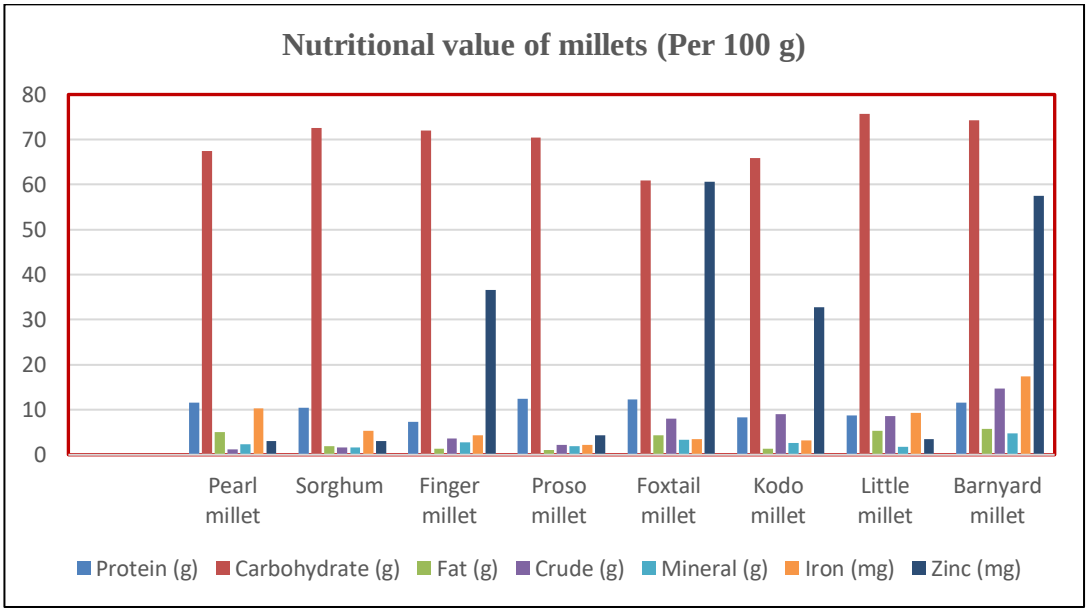

Figure 8.1: Nutritional Value of Different Millets.

8.3 Millet's Cultivation in India:

Millets are gaining massive attention due to their nutritional advantage and gluten free nature. They are low input requiring crops and at the same time eco-friendly and they provide food security to the dryland agricultural communities.

They are considered as the most secure crop for small and marginal farmers as millets are adaptable to harsh, hot and drought climatic conditions.

India is the leading producer and consumer of various millet crops and their products. Pearl millet and Sorghum together constitutes approximately 19 percent in world production in 2020. The major millets producing states in India are Rajasthan, Maharashtra, Karnataka, Gujarat, Uttar Pradesh, Tamil Nadu and Uttarakhand. Area for small millets is maximum in Madhya Pradesh, Uttarakhand and Chattisgarh (Figure 8.2).

A total of about 16.9 million tonnes of millets food grains are produced in India from nearly 12.7 million ha area, which constitutes about 6% of the national food grain basket (Table 8.2). 95% of the total area under millets is constituted by pearl millet, sorghum and finger millet whereas less than 5% of the area is constituted by small millets (barnyard millet, foxtail millet, little millet, kodo millet and proso millet) (Directorate of Economics and Statistics, DA&FW 2021). Millets are highly suitable for contingency crop planning due to their fast growth and short crop cycle.

The area under millets is shrinking due to lack of high-quality seeds and confinement to poor and marginal farmers only.

Table 8.2: Millet Crops Area and Yield During 2009-22

Millet	Area ('000 ha)			Yield (kg/ha)		
	2009-13	2014-18	2019-22	2009-13	2014-18	2019-22
Sorghum	6684	4910	4355	913	897	1064
Bajra	8480	7142	74151	1065	12231	13691
Ragi	1211	1104	1097	1580	1549	1647
Small millets	773	570	436	554	707	800
Total millets	17149	13726	12680	1019	1111	1273

(Source: Estimations of Dept. of Economics & Statistics, DAC&FW, GoI, New Delhi)

(Source: agricoop.nic.in)

Figure 8.2: Millets map of India

8.4 Agronomic Practices for Enhancing Yield of Millets:

8.4.1 Sowing Dates, Sowing Methods and Improved Varieties:

One of the most important inputs influencing the crop yield is sowing time. Sowing of millets during appropriate time improves its productivity as it provides suitable environment to millets at all the growth stages.

There has been observed a reduction in grain yield with delayed sowing. Millets are grown during all the seasons of the year. *Kharif* crop should be grown from last week of June to first week of July depending on the onset of monsoon. Whereas *Rabi* crop should be grown during the month of October-November and summer crops during January – February. Optimum spacing and seed rate also enhances yield of millets. Optimum line to line distance at the time of sowing should be 20-30 cm and plant to plant distance should be 10-15 cm. The recommended seed rate for finger millets under line sowing should be 5-6 kg/ha and under transplanted conditions, it should be 4 kg/ha. For other small millets, it should be 5-6 kg/ha under line sowing and 8-10 kg/ha under broadcasted conditions. Direct sowing of millets offers some advantages like easier and faster planting, crop matures earlier, efficient utilisation of water. In case of direct seeded millets, time of sowing plays a vital role in enhancing the productivity of crops. The use of transplanting method of planting in millets is helpful for late maturing and high yielding varieties. It improves the establishment of seedlings in the field and affects the growth cycle of millets. As millets are confined mostly to marginal lands, less attention is given to the crop improvements in comparison to cereals. After the launch of AICRP-Small millets, several high yielding varieties of millets with tolerance to various insects, pests and diseases have been released for cultivation across the country (Table 8.3).

Table 8.3: High Yielding Varieties of Millets and Their Characteristics

Sr. No.	Crop	Some of the improved and high yielding varieties and hybrids of millets	Special features of the improved varieties and hybrids
1.	Sorghum	CSH 1, CSH 5, CSH 6, CSH 9, CSH 14, CSH 16, CSH 35 and CSH 4, CSV 1 to CSV 41	Resistance against major pests and diseases, superior quality grain and fodder yield.
2.	Pearl millet	MPMH 21, RHB 223, MBC 2, ICTP 8203, GB 8735, ICMV 221, Pusa 1201	high grain Fe content, highly resistant to downy mildew, smut and rust and highly resistant to pests
3.	Proso millet	PMV 442, DHPM-2769, TNAU 202, TNAU 151, PRC 1, TNAU 164	Resistance to brown spot, sheath blight, leaf blight, rust, non-lodging and non-shattering.
4.	Barnyard millet	Phule Barti-1, DHBM 93-3, MDU-1, Co 2, DHBM-23-3	non-lodging and non-shattering, Resistance to shootfly, suitable for contingency planting.
5.	Foxtail millet	Renadu, Garuda, Hagari, Suryandi, RAU-2	High yielding, tolerant to blast and downey mildew, rust and smut.
6.	Kodo millet	ATL 1, Gujarat Kodo millet 4, CKMV 1, Chattisgarh Kodo-03, Jawahar Kodo-137	Tolerant to shoot fly, grain smut, sheath blight, brown smut and shootfly, lower incidence of diseases.

Sr. No.	Crop	Some of the improved and high yielding varieties and hybrids of millets	Special features of the improved varieties and hybrids
7.	Finger millet	Phule Kasari, Birsa Marua, Dapoli 3, CFMV-1, CFMV-1, VR-988, VL Mandua-348	Resistant to finger blast, neck blast, brown spot, foot rot, ear head caterpillars and aphids, suitable for organic cultivation
8.	Little millet	Kalinga Suan 217, CLMV 1, GNV-3, DHLM-14-1, BL 6, Jawahar Kutki 4	Resistant to rust and grain smut, tolerant to shoot fly, leaf blight and brown spot disease, reisitant to drought and lodging

(Source: Hariprasanna 2023[3] and Aruna *et al*. 2023[4])

8.4.2 Intercropping System:

Due to unpredictable weather conditions, growing of millets in their pure stands is quite risky. Under such conditions, to achieve sustained productivity from a land, diversification of crops is mu st. Among the various options of crop diversification, intercropping is the most suitable method. Intercropping is a system of crop production which is aimed at maximizing production and profits over time and space [5].

It is the practice of growing more than one crop on the same field simultaneously in a definite row pattern. Advantages of intercropping includes effective utilization of water, nutrients, land, increased profitability, maximize resource use efficiency, better exploitation of sunlight, risk reduction of insects and pests, maintenance of soil health and ultimately increased profitability, productivity and leading agriculture towards sustainability.

It also checks runoff of water. Complementarity among the species is very important for improving crop yield under intercropping system. Also intercropping provides natural insurance against total crop failure under unfavourable conditions. Different crops which are grown under intercropping system must require dissimilar agronomic practices (Figure 8.3).

A. Some of The Millet-Based Intercropping System Includes:

a. Finger millet-legume (pigeon pea/black gram)
b. Finger millet-groundnut
c. Finger millet + soybean
d. Foxtail millet + pigeonpea
e. Soybean + foxtail millet
f. Groundnut + foxtail millet
g. Little millet + Sesamum
h. Proso millet + black gram
i. kodo millet + soybean
j. Foxtail millet + Castor

Under millets + legume intercropping system, millet component gets additional benefits due to legume effect. It also provides benefit in terms of total productivity of crops, maintenance of soil fertility, requirement of less chemicals for enhancing crop production and control of erosion. Ultimately it provides better ecosystem services which leads agriculture towards sustainability [6].

Use of legumes in the intercropping system had an added advantage of higher soil fertility by Biological Nitrogen Fixation (BNF), low soil and nutrient losses, efficient use of soil moisture and deep-rooted system, enhancement of microbial biodiversity and leaf fall. Development of Sorghum hybrids with erect leaves and greater yield potential will help decrease the competition among intercrops and improve productivity of the system. Combining improved and early maturing Sorghum hybrids with photosensitive pigeon pea has been found to be successful across Karnataka and Maharashtra [7]. Intercropping also enhances the resource use efficiency under millet based cropping system which is depicted in the higher LER (Land Equivalent Ratio).

Figure 8.3: Intercropping of finger millet with soybean (4:1) and intercropping of finger millet with field bean (8:1).

8.4.3 Nutrient Management:

Nutrient stress is one of the greatest constraints in millet productivity. To cope with this stress, recommended doses of fertilizers for the various millets should be given (Table 4). Nitrogen fertilizers are more prone to volatilization, leaching and denitrification loses.

Therefore, should be applied in 2-3 split doses. At planting, half dose of nitrogen and full dose of P and K are applied and are placed below the seed. Remaining nitrogen is used as side dressing. In general, the recommendation of nutrients for crops also depends on soil type, crop type and nutrient source. Nutrient management for millets should be realistic and environmental friendly. Integrated Nutrient Management (INM) can also help to sustain crop productivity, enhance quality of crops and maintain profitability of the system. Integrated Nutrient Management refers to the maintenance of soil fertility and of plant nutrient supply at an optimum level for sustaining the desired productivity through optimization of the benefits from all possible sources of organic, inorganic and biological components in an integrated manner. INM practices are more effective and widely used in millet crops.

Table 8.4: Recommended doses of fertilizers for different millets.

Sr. No.	Crop	Recommended Doses of Fertilizers (N: P_2O_5:K_2O) (kg ha^{-1})
1.	Sorghum	80-100:40-50:40
2.	Pearl millet	60-100:40-50:40-50
3.	Finger millet	40-60:20:20
4.	Other millets	40:20:00

A. Use of Compost and Combined Application of Inorganic and Organic Sources of Nutrients:

Several research has concluded that application of compost in millet has a beneficial effect on crop yield due to

- Improvement in soil microbial activity as compost acts as a source of carbon for the microbes. Also, it provides congenial conditions required for microbial growth.
- Compost application provides plants with all the essential nutrients required for crop growth.
- It also improves the physical condition of soil like water holding capacity, soil structure, soil aeration, soil temperature which is optimum for root growth and plant development.
- Use of compost has also enhanced nutrient uptake in plants.
- Use of organics in nutrient management also enhances photosynthetic activity of millets resulting in higher accumulation of photosynthates ultimately leading to improved yield of millets.
- The presence of vermicompost in soil also acts as a soil conditioner by supplying nutrients to plants, lowering C to N ratio, improving the soil fertility, increasing soil porosity and water holding capacity, thereby requiring less tillage and irrigation (Figure 8.4). The average nutrient content of vermicompost is 0.6-1.2% N, 0.13-0.22% P_2 O_5, 0.4-0.7% K_2O, 0.4% CaO and 0.15% MgO.
- Combined application of organic and inorganic sources of nutrients helps in balanced supply of macro and micronutrients and will maintain the growth, yield and yield attributes of the crop. It also has a positive effect on the physiological process of plant metabolism thereby influencing shoot and root growth enhancing absorption of water and other nutrients.

B. Use of biofertilizers:

Biofertilizers are defined as biological products containing living microorganisms that, when applied to seed, plant surfaces or soil promote growth of plants by several mechanisms such as enhancing the supply of nutrients, increasing root area or root biomass, and enhancing nutrient uptake capacity of plants [8].

Most of the biofertilizers either belongs to Nitrogen fixers, phosphorus solubilizers, potassium solubilizers or PGPR (Plant Growth Promoting Rhizobacteria). Biofertilizers can be considered as an alternative source of plant nutrition as these acts as bioinoculants which on application improves the growth and yield of crop plants.

C. Advantages of Use of Biofertilizers Under Millets Are:

- It can contribute to higher yield and substitute 20-25% of RDF leading to increased sustainable and environmental friendly productivity and soil fertility.
- Inoculation of nitrogen fixing and phosphate solubilising microbes alone or in combination increases plant height, number of tillers in plants and ultimately the yield of plants.
- Use of biofertilizers also leads to enhanced availability of the primary nutrients nitrogen, phosphorus and potassium that promoted growth and development of the crops.
- Biofertilizers also releases phytohormones which are similar to plant hormones like gibberellic acid and Indole acetic acid which stimulates nutrients absorption and plant growth. Use of phosphate solubilizing bacteria improves solubilization of the fixed phosphorus, enhancing the availability of phosphorus for plants.
- Use of biofertilizers narrows down the C: N ratio, thus enhancing carbon and nitrogen mineralization and promoting soil microbial activity.

The various biofertilizers which can be used with millets includes *Pseudomonas fluorescens*, *Azotobacter chroococcum*, *Azospirillum lipoferum* and *Acetobacter diazotrophicus* along with *Trichoderma viride*.

Figure 8.4: Seed treatment with biofertilizers in millets and vermicompost as a source of organic nutrient for plants.

8.4.4 Management of Abiotic and Biotic Constraints:

Abiotic constraints associated with millets production are environmental factors which includes climate, temperature, rainfall, sunlight and soil factors which includes acidity, alkalinity, drought, salinity, nutrient stress, moisture stress flooding or water logging stress.

Drought is considered as one of the most important stresses for millet production [9]. Terminal drought stress in Sorghum post rainy season leads to its low productivity. In pearl millet, the estimated yield loss due to drought was about 51 percent [10]. Drought stress in millets impacts the crop growth, crop yield, membrane integrity, osmoregulation, pigmentation and photosynthetic activity of crops. During the seedling emergence stage, poor drainage and soil salinity affects the crop growth.

Heat stress in millets induces various physiological alterations and affect photosynthetic and respiration in crops. As millets are usually grown on marginal lands, low nutrient status and low organic carbon content of the soil also leads to low productivity. Crop more sensitive to salinity is finger millet when compared with other millets. Millets are grouped into glycophytes which are destroyed by the application of high amount of salts. Salinity restricts plant growth, productivity and injurious to most plants at all the growth stages.

The most common biotic constraints associated with the millets are diseases, insects and pests, birds, parasitic plants and weeds. Though millets have less incidence of pests and diseases, the most common insects are shoot fly and stem borer in sorghum. The important diseases of millets are downey mildew in sorghum and pearl millet, blast in finger millet, smut in foxtail millet, barnyard millet and sorghum, rust in sorghum and foxtail millet and ergot in pearl millet and sorghum. Nymphs and adults of sucking pests like aphids and bugs sucks the sap from leaves causing yellowing, distortion and wilting of plants leading to less productivity. Pests like white grub are specific to certain regions. Yield losses in millets due to insects and pests attack in India have been reported to be 10-20%. More than 29% of the reduction in millets yield is due to weed infestation only. The initial vigour of the millets is poor, resulting in more growth of weeds and competition for nutrients, sunlight, space and resources during early growth stages resulting in low productivity of millets [11].

A semi root parasitic weed, Striga also causes yield losses in millets especially sorghum and pearl millet [12]. Bird damage is also a major biotic constraint affecting crop productivity.

A. Some of The Practices for Management of Abiotic and Biotic Constraints Are:

- Deep ploughing before planting should be done to expose the immature stages of insects. Burn the stubbles and diseased ear heads to prevent carryover of the pests.
- Development of stress tolerant and high yielding varieties. Application of Plant Growth Promoting Rhizobacteria (PGPR) can help to improve yield of millets and provide stress tolerance.
- Crop rotation with non-host plants is recommended to break the cycle of insects and diseases. It also helps in managing weeds and soil borne diseases of millets like wilt, foot rot and downy mildew of millets.
- Intercropping of millets with legumes reduces damage by stem borers in sorghum.
- Light traps can be used to attract and kill adults of insects and reduce incidence of stem borers, grain midge and other moth pests.
- Integrated nutrient management and balanced fertilization helps to promote growth of millets resulting in reduced damage by insects and pests.
- Neem seed kernel suspension can be used for management of sucking pests.

- Clean cultivation practices should be followed which includes activities that keeps the field clean and removal of crop residues, weeds, alternate hosts from the field. Incidence of diseases like downy mildew, rust, sheath blight and bacterial diseases can be minimised using clean cultivation.
- Disease suppressive properties can be improved by treatment of soil with green manures, animal-based soil amendments or other manures. Downy mildew, root and stalk rot can be managed by soil treatment with manures.
- Seed treatment can also be done using organic products like beejamrit. Bio control agents like Trichoderma and Pseudomonas are useful for sheath rot and foot rot in millets.
- Timely or early sowing and proper spacing, seed rate and use of resistant cultivars will also help in managing insects, pests and diseases.
- Weed management using manual methods will also help in weed control.

8.4.5 System of Millet Intensification (SMI):

Crop production is affected by various biotic and abiotic factors which is made adverse by changing and unpredictable climatic factors. Improved agronomic practices can help in sustaining agricultural productivity under such adverse conditions. System of Millet Intensification (SMI) is one such agro-ecological innovative approach whose basic objective was to enhance productivity and production in finger millet contributing to food and nutritional security of the tribal households of Koraput in the Indian states of Odisha even under extreme weather conditions.

This innovative method depends more on endogenous processes than on external inputs. Millets are staple food for tribal people of Odisha. As per the traditional method land is ploughed and seeds are directly broadcasted, due to which production is less.

So, to enhance the yield of finger millet, SMI was developed. This method was developed on the lines of System of Rice Intensification (SRI) for paddy. SMI leads to lower seed requirement, easier intercultural operations, more tillers and panicles and ultimately higher yield. SMI includes raising nursery, transplanting young seedlings, weeding by weeders and application of organic manures (Figure 8.5).

A. The Various Steps Involved Are:

- 400 to 500 grams of seeds are required per acre of land. For selection of seeds, they are soaked in 10% salt solution. Remove the seeds that will float.
- Seed treatment is done using manures/ Jeevamrut and then spread the seeds in shade to drain water. To make the seedlings more vigorous and resistant to insects, pests and diseases microbes and nutrients are also used.
- Soil and compost are used in the ratio 2:1 for preparation of raised seed bed. Seeds are put into nursey seed bed with spacing of about 3 to 4 inches and depth of 1/2 inch.
- Vermicompost or powdered FYM is spread over the seed bed in a thin layer and then it is covered with straw. Watering of the seed must be done once in a day. Seedlings are ready for transplanting in about 15 days or when two leaves come out.

- Properly plough the main transplanting land and mix cow dung powder or neem cake into top layer of soil. Maintain 25 cm distance from plant to plant and line to line when transplanting. Plant one or two saplings in each mark along with soil. While transplanting drain water completely from land. Manures are applied in the pits at the time of planting. Roller weeder or cycle hoe is used for weeding. Vermicompost/ pot manure/ Jeevamrut is applied after each weeding. To control pests, neem oil solution is sprayed.

B. Few Things Should Be Kept in Mind While Adopting Smi Technique.

- Transplanting of seedlings should be done within 15 minutes of taking it out from the nursery bed.
- While transplanting make sure roots of the saplings do not come out of the soil.
- Always clean the boundary of the transplanted field so that attack of insect, pests and diseases is minimum.

The average yield in SMI comes out to be 12-14 quintals per hectare which is double as compared to traditional methods. SMI is emerging as a solution to enhance the productivity of millets and to address the climatic change conditions.

Figure 8.5: SMI being practised in the field.

8.4.6 Adaption to Modern Agroecosystems and Mechanization:

Agricultural mechanization is the use of different machinery ranging from basic hand tools to motorized machinery and equipments to reduce human labour use and aid in agricultural operations. Mechanization is common in cereals like rice, wheat, sugarcane but it is still lacking in millets. Mechanization in millets has encouraging outcomes as briefed below:

- Use of multi crop seed cum fertilizer drill, tractor drawn seed drills and bullock drawn planter for millets have been observed to enhance the millet grain and straw yield.
- Intercultivation operation such as hoeing has been found to replace weeding in rainfed finger millets.
- Superior performance of petrol engine reaper in finger millets lead to high field efficiency, lesser fodder and low shattering losses.
- Studies on finger millet cultivation has indicated that use of tractor drawn seed drill along with machine harvesting proved to be a better option than manual operations.

8.5 Other Production Constraints in Millets:

Millet productivity is mainly concentrated in the developing nations where markets system is not well developed resulting in less economic returns to the farmers. Also, there is less availability of improved and high yielding varieties of millets.

Grain size is also an issue for small millets. Due to very small seeds of small millets, it causes difficulty in mechanical planting. Due to changing food habits and preferences of consumers, it has led to more cultivation of high value cereals and thus lowered the production of millets. Lack of policy support is also a major factor affecting millets productivity.

8.6 Conclusion:

By virtue of their high nutritional content and ability to adapt to harsh climatic conditions, millets should become an integral part of subsistence agriculture. Also, millets can easily thrive under stress conditions like drought and some varieties can even prevail under flooded areas and swampy grounds.

Despite this, area under millets have been decreasing drastically over the years. So, it is important to make use of improved agronomic practices, technologies and high yielding varieties to enhance the productivity and profitability from cultivation of millets.

Millet nutrition future research should be focused for enhancing the nutrient use efficiency of millets by using various INM practices, gadgets and tools.

Millets are now considered as nutri-cereals under National Food Security Mission the United Nations has decided to commemorate 2023 as the International Year of Millets and increase awareness about millets across the world. This would help increase or expand the area under millets cultivation and enhance their productivity.

8.7 References:

1. Louhar, G., Bana, R. S., Kumar, V. and Kumar, H. 2020. Nutrient management technologies of millets for higher productivity and nutritional security. *Indian Journal of Agricultural Sciences* 90 (12): 2243–50.
2. Devi, P.B., Vijayabharathi, R., Sathyabama, S., Malleshi, N.G. and Priyadarisini, V.B. 2014. Health benefts of finger millet (Eleusine coracana L.) polyphenols and dietary fiber: A review. *J Food Sci Technol* 51(6):1021–40.
3. Hariprasanna, K. 2023. High yielding varieties for enhancing the production of small millets in India. *Indian Farming 73*(1): 42–46.
4. Aruna, C., Madhusudhana, R., Bhat, B. V., & Umakanth, A. V. 2023. Improved varietal technology for enhanced productivity in sorghum. *Indian Farming 73*(1): 22–29.
5. Manjunath, M.G., Salakinkop, S.R. and Somanagouda, G. 2018. Productivity and profitability of soybean-based millets intercropping systems. *Research on Crops* 19: 43-47.
6. Maitra, S., Hossain, A., Brestic, M., Skalicky, M., Ondrisik, P., Gitari, H., Brahmachari, K., Shankar, T., Bhadra, P., Palai, J.B., Jena, J., Bhattacharya, U., Duvvada, S.K., Lalichetti, S. and Sairam, M. 2021. Intercropping—A Low Input Agricultural Strategy for Food and Environmental Security. *Agronomy* 11(2):343.
7. Aruna, C., Madhusudhana, R., Bhat, B. V., & Umakanth, A. V. 2023. Improved varietal technology for enhanced productivity in sorghum. *Indian Farming, 73*(1): 22–29.
8. Vessey, J.K. 2003. Plant growth promoting rhizobacteria as biofertilizers. *Plant and Soil* 255: 571–586.
9. Gebretsadik, R., Shimelis, H., Laing, M.D., Tongoona, P., Mandefro, N. 2014. A diagnostic appraisal of the sorghum farming system and breeding priorities in striga infested agro-ecologies of Ethiopia. *Agric Syst* 123:54–61.
10. Ashok, S., Senthil, A. Sritharan, N., Punitha, S. Divya, K. and Ravikesavan, R. 2018. Yield Potential of Small Millets under Drought Condition. *Madras Agric. J.*, 105 (7-9) (2): 370-372.
11. Meena, R. P., Joshi, D., Bisht, J. K. and Kant, L. 2021. Global Scenario of Millets Cultivation *in* book: Millets and Millet Technology (pp.33-50).
12. Ejeta, G. 2007. Breeding for Striga resistance in sorghum: exploitation of an intricate host–parasite biology. *Crop Science* 47, S-216–S−227.