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1. Agronomic Practices of Millet Cultivation: Crop Management Techniques

Abstract:

This chapter explores the agronomic practices associated with millet cultivation, focusing on crop management techniques, nutritional importance, health benefits, and monetary advantages. Millets are a group of small-seeded grasses that have gained significance due to their adaptability to diverse agro-climatic conditions and nutritional value. The study delves into the agronomic practices essential for successful millet production. Crop management techniques play a pivotal role in millet cultivation, encompassing aspects such as land preparation, seed selection, planting methods, irrigation, and pest control. Understanding and implementing these practices contribute to optimizing millet yields and ensuring crop resilience in varying environmental conditions. Millet grains are rich in essential nutrients, including proteins, fibers, vitamins, and minerals. The research emphasizes the nutritional importance of millets, underlining their potential to address dietary deficiencies and enhance food security. Additionally, millets offer diverse health benefits, such as promoting cardiovascular health, managing diabetes, and supporting weight management. Beyond their nutritional and health advantages, the abstract explores the monetary benefits associated with millet cultivation. Millets are cost-effective crops with lower input requirements compared to traditional staples. The study underscores the economic advantages for farmers, including reduced production costs, enhanced income potential, and improved resilience to climate variability. It provides a comprehensive overview of agronomic practices for millet production, highlighting the crop's nutritional, health, and monetary benefits. The findings underscore the potential of millets to contribute to sustainable agriculture, food security, and economic well-being for farmers.

Keywords:

Agro-Climatic, Crop Management, Pest Control, Crop Resilience, Food Security.

1.1 Introduction:

India cultivates a variety of millets, collectively known as 'Shree Anna,' including jowar, ragi, bajra, foxtail millet, barnyard millet, kodo millet, proso millet, little millet, sama, among others. These millets, which have been an integral part of the Indian diet for centuries, offer numerous health benefits. Currently, India stands as the world's largest millet producer, accounting for the highest share in 2021 at 43.90%, followed by China (8.97%), Niger (7.13%), Nigeria (6.39%), Sudan (4.99%), Mali (4.94%), Senegal (3.36%), Ethiopia (3.32%), Burkina Faso (2.39%), and Chad (2.07%). Collectively, these ten countries contribute to 87.56% of global millet production. Despite this, there has been a consistent reduction in the millet cultivation area in India, decreasing from 37.37 million hectares in 1960-61 to 10.92 million hectares in 2021-22. Production has also exhibited fluctuating trends, declining from 25.09 million tons (MT) in 1992-93 to 16.00 MT in 2021-22, with a target of reaching 45 MT by 2030. The share of millets in the total area and production of cereals has decreased from 39.90% and 25.51% in 1966-67 to 10.99% and

4.92% in 2021-22, respectively. The decline in millet cultivation is attributed to factors such as lack of profitability, limited input subsidies, inadequate price incentives, changes in consumer preferences, challenges in processing, shorter shelf life, and the greater emphasis on fine cereals (wheat and rice) (Meena *et al*., 2021), compounded by the low social status and the absence of public supply distribution facilities for millets. Despite these challenges, millets remain vital for the nutritional security of the country. Considering the shift towards sustainability and the unique characteristics of millets, such as carbon efficiency, low water requirements, heat resistance, and shorter crop duration, there is an urgent need to revitalize millet cultivation. NABARD Chairman, Shri Shaji K V, suggests that enhancing the per-unit yield of millets can address rural distress and contribute to nutritional security.

1.1.1 Trends in Area, Production and Yield of Millets in India:

India holds the title of being the world's largest producer of millets. In 2020, two prominent varieties of millets, namely Pearl Millet (Bajra) and Sorghum (Jowar), collectively contributed approximately 19% to global millet production. India's Pearl Millet production represented a substantial share at 40.51%, with Sorghum following at 8.09% of the world's millet production in the same year. The primary millet-producing states in India include Rajasthan, Karnataka, Maharashtra, Uttar Pradesh, Haryana, Gujarat, Madhya Pradesh, Tamil Nadu, Andhra Pradesh, and Uttarakhand. In the period of 2020-21 in Figure 1.1, these ten states collectively accounted for about 98% of millet production in India. Among them, Rajasthan, Karnataka, Maharashtra, Uttar Pradesh, Haryana, and Gujarat contributed significantly, making up more than 83% of the total millet production. Rajasthan alone contributed 28.61% to India's overall millet production. India boasts a diverse range of millet varieties, including Pearl Millets, Sorghum, Finger Millet, Foxtail, Kodo, Barnyard, Proso, Little Millet, and Pseudo Millets such as Buckwheat and Amaranths. Among these, Pearl Millet (Bajra), Sorghum (Jowar), and Finger Millet (Ragi) hold the largest share in India's total millet production and country wise production illustrated in Figure 1.2.

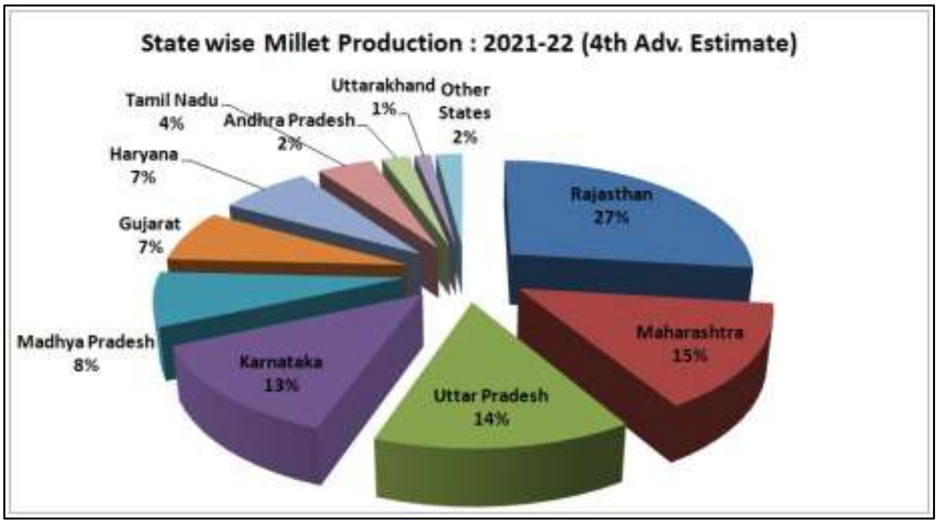

Figure 1.1: State Wise Millets Production. (Source: https://apeda.gov.in/milletportal/)

The trend in millet yields demonstrated an overall increase, with ragi exhibiting the highest growth, followed by bajra, jowar, and small millets. Across the nutri-cereal crops, the average decadal yield displayed a consistent upward trajectory, indicating positive Compound Annual Growth Rates (CAGR). The overall area and production of millets experienced negative growth during the study period, the positive CAGR in yields suggests a favorable outcome associated with improved farming practices. This underscores the importance of adopting and enhancing such practices to counteract the decline in millet cultivation and production.

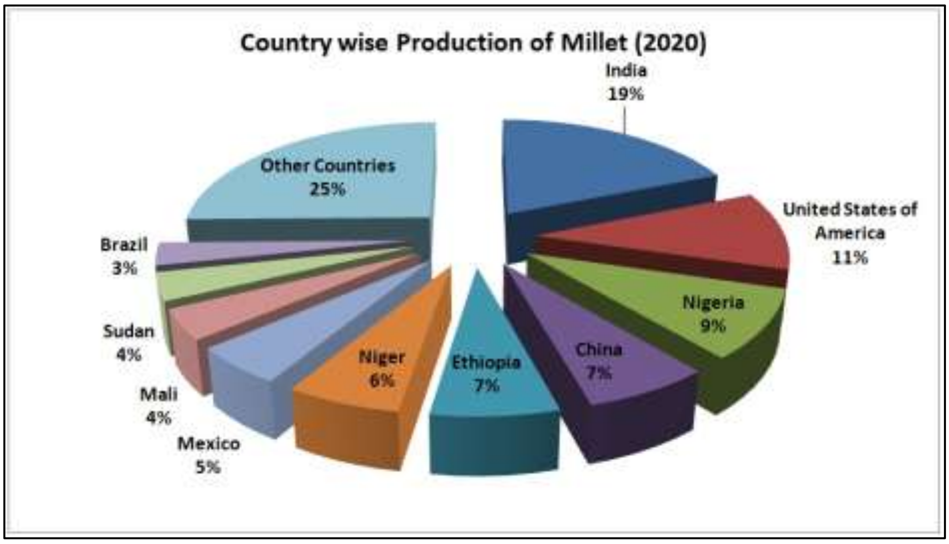

Figure 1.2: Country Wise Production of Millets (2020). (Source: https://apeda.gov.in/millets)

1.2 Indian Millet Production Scenario:

In recent years, millet production in India has witnessed a notable increase. As one of the leading millet producers globally, Indian farmers are favoring millet cultivation due to its resilience to drought conditions. The Indian government's promotion of millet production under the NFSM further contributes to this trend, indicating a continued growth trajectory for millet production in India. Rajasthan has the highest share in the total millets production at 32.76%, followed by UP (13.67%), Karnataka (11.73%), Maharashtra (10.96%), MP (7.24%) and Haryana (7.0%). These 7 states together account for 91.25% of total millets production.

1.2.1 Trends in Area, Production and Yield of Nutricereals (Shree Anna):

- **Jowar (Sorghum):**

At all-India level, yield of jowar improved from 9.57 qtl/ha in 2013-14 to 11.10 qtl/ha in 2021-22, and grew at a CAGR of 3.41%. The highest average yield was reported in Andhra Pradesh (33.72 qtl/ha) Trends in Area, Production and Yield of Nutricereals (Shree Anna) followed by MP (19.19 qtl/ha) and Telangana (16.97 qtl/ha) in 2021-22. The highest annual growth in yield was observed in UP (8.0%) followed by Telangana (7.6%), Rajasthan (5.4 %) and Maharashtra (4.2%). The average yield of Maharashtra, Rajasthan, Tamil Nadu, Andhra Pradesh, Haryana and Odisha is lower than national average in 2021-22. Maharashtra has the highest share in total sorghum production at 34.4% followed by Karnataka (17.9%) and Rajasthan (12.9%) in 2022-23.

- **Bajra (Pearl Millet):**

Bajra yield at all-India level grew annually by 2.5 % from 11.84 qtl/ha in 2013-14 to 14.36 qtl/ha in 2021-22. Among major bajra producing States, MP, Andhra Pradesh, Telangana and Karnataka, registered the highest yield (in that order) at 19.19, 17.87, 16.97 and 16.17 qtl/ha in 2021-22. Further, in Telangana yield grew impressively with a CAGR of 9.0% followed by Karnataka (7.6%) and Andhra Pradesh (2.7%) whereas in other states bajra yield contracted in 2021-22. Rajasthan has the highest share in production at 44.7 % followed by UP (17.9 %), Gujarat (11.32 %) and Haryana (11.4 %) in 2022-23.

- **Ragi (Finger Millet):**

Bajra (Pearl Millet) At all-India level, ragi yield stood at 14.01 qtl/ha in 2021-22. Tamil Nadu is the largest producer of ragi, and it attained the highest yield of 30.56 qtl/ha in 2021-22 with annual growth of 1.4%. On the other hand, ragi yield in the largest producing State, Karnataka decreased from 17.59 q/ha in 2013-14 to 13.32 qtl/ha in 2021-22, showing a decline in CAGR of 2.0%. In case of Odisha, yield grew by 0.8% annually. At all-India level, area production and yield showed declining growth.

Therefore, there lies a huge yield gap between the two top producers of ragi and it indicates tremendous scope of yield improvement in Karnataka. Ragi is a highly nutritious crop and its demand is growing both in the domestic and international market. Thus, research institutions and State governments need to coordinate their efforts to bridge the yield gap and Karnataka State can take up targeted measures for enhancing yield. Further, Karnataka, Tamil Nadu, Uttarakhand and Maharashtra together contribute 92.2% of total ragi production.

- **Small Millets:**

There was a steady decline in the area and production of small millets in 2013-14 to 2021-22, with CAGR of (-) 6.0%) and (-) 2.2%, respectively. However, the yield grew with a CAGR of 4.3%. The highest growth in yield was observed in Karnataka (9.4%) followed by Chhattisgarh (8.7%), MP (8.7%) and Gujarat (3.6%) in the study periods.

The area under small millets cultivation is concentrated in MP (20.7%) followed by Maharashtra (14.0%), Chhattisgarh (12.2%) and Uttarakhand (11%).

However, MP has the highest share in production at 20.8 % followed by Uttarakhand (19.9%) and Arunachal Pradesh (7.6%). Hence, it can be concluded that reduction in area and production has been compensated by rise in their yield.

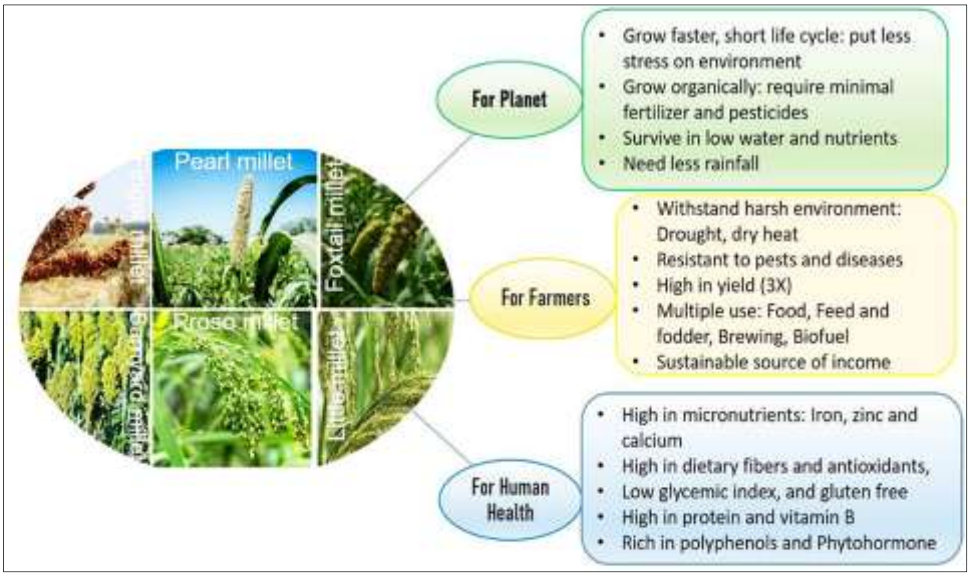

Figure 1.3: Millets for Planet, Farmers and Human Health. (Source: *Babele et al., 2022***)**

1.3 Export of Millets:

India witnessed a 1.58% growth in millet exports, rising from Rs. 448 crores in 2013-14 to Rs. 608 crores in 2022-23. The primary destinations for India's millet exports include the UAE (17.8%), Saudi Arabia (13.7%), Nepal (7.4%), Bangladesh (4.9%), Japan (4.4%), USA (4.1%), Germany (3.8%), Libya (3.6%), Egypt (2.9%), and Oman (2.9%). These top ten countries collectively accounted for 65.4% of total millet exports. To boost exports, India can target key importing nations and conduct sensitization programs for millet startups. APEDA and the Indian Institute of Millet Research are developing a promotion strategy for millets and value-added products. The world's population is projected to reach 9.1 billion by 2050, necessitating urgent action for increased food supply and security amid limited land resources. Food security has become a critical global concern due to supply challenges, economic growth, and population rise in emerging countries. The impact of climate change on crop yields and overall food system sustainability is significant. Despite efforts to achieve food and nutrition security in India, challenges persist, requiring sustained efforts for improvement.

Millets, categorized as C4 plants, boast a more efficient photosynthetic system than C3 plants like rice and wheat. Recognized as "Nutri-cereals," millets offer higher protein, fiber, calcium, and mineral contents compared to widely consumed grains (Lenka *et al*., 2020). East Asia has cultivated millets for over 10,000 years, with pearl millet being the most widespread variety. Proso millet is utilized in developed nations, while foxtail millet is significant in China and Eastern Europe. Finger millet is popular in the higher-altitude regions of Africa and Asia. Other millet species, such as barnyard, kodo, and little millets, hold regional or international importance. Millets, due to their resilience and nutritional benefits, can play a vital role in preventing non-communicable diseases.

1.4 Nutritional Importance:

Numerous chronic diseases and health challenges prevail worldwide. According to the 2016 Global Nutrition Report, in 129 countries with available data, 44 percent of the population faces significant issues related to undernutrition, adult overweight, and obesity (IFPRI, 2016).

The root cause of many of these conditions lies in nutrient imbalances within diets. The United Nations Food and Agriculture Organization estimated that 7.9 percent of the global population, or 795 million people, experienced undernourishment in 2015.

In contrast, more than 1.9 billion adults under the age of 18, constituting 39 percent of the world's population, were reported to be overweight, with an additional 13 percent categorized as obese (FAO, 2015).

The World Health Organization has previously labeled obesity-related issues such as diabetes and cardiovascular diseases as an epidemic (WHO, 2015). India hosts the majority of undernourished individuals globally. Globally, protein-energy malnutrition (PEM) was linked to 469,000 deaths, while 84,000 deaths were attributed to deficiencies in other essential nutrients like iron, iodine, and vitamin A (Kumar *et al*., 2020).

With a prevalence incidence of 11 per cent for men and 15 per cent for women, obesity is a significant public health issue in India. Because millets are a great source of several essential elements, they offer an extra benefit in the fight against nutrient deficiencies in third-world countries.

Millets are equivalent to and occasionally have higher nutrient levels than conventional cereals in terms of calorie value, protein, and macronutrients. As a result of their high quantities of calories, calcium, iron, zinc, lipids, and high-quality proteins, they significantly contribute to the diets of both humans and animals.

They are also abundant providers of vitamins and dietary fiber. Here, is the nutrient composition of millets also illustrated in Figure 1.4:

- **Carbohydrates:**

The carbohydrates present in pearl millet grains encompass dietary fiber, starch, and soluble sugars. The endosperm of pearl millet contains glucose in the form of amylase and amylopectin, contributing to its recognized high starch content. Different genotypes of pearl millet grains exhibit starch content variations ranging from 62.8 to 70.5 percent, with soluble sugars ranging from 1.2 to 2.6 percent and amylose from 21.9 to 28.8 percent. The starch found in pearl millet serves various purposes, including functioning as bulking, thickening, and gelling agents for food texture. In contrast, finger millet has a total carbohydrate content ranging from 72 to 79.5 percent. Additionally, the detailed carbohydrate profile, indicates starch levels between 59.5 and 61.2 percent, pentosane ranging from 6.2 to 7.2 percent, cellulose from 1.4 to 1.8 percent, and lignin from 0.04 to 0.6 percent.

- **Protein:**

Protein stands as the second significant component in millets. Pearl millet, boasting an 11.6 percent protein content, surpasses the protein levels found in rice (7.2 percent), barley (11.5 percent), maize (11.1 percent), and sorghum (10.4 percent). It also noted a protein content of 9.79 percent in pearl millet. In comparison, finger millet contains about 5-8 percent protein, the highest protein level for finger millet at nearly 11 percent, while a proportion of 6.32 percent in finger millet. Furthermore, the amino acid profile of pearl millet is comparable to that of wheat, barley, and rice, but it contains more lysine, threonine, methionine, and cysteine than sorghum and maize proteins.

The distribution of proteins in pearl millet grain is believed to be similar to that of maize, particularly true prolamins that are soluble in alcohol. Additionally, arginine, threonine, valine, isoleucine, and leucine were found to have greater digestibility in pearl millet than in maize. Finger millet, containing more lysine, threonine, and valine than other millets, exhibits a somewhat balanced concentration of essential amino acids.

- **Dietary Fiber:**

Fiber is recognized for its positive impact on gut health, and maintaining a diet with moderate fiber-rich foods is believed to support overall gut health. The role of fiber extends to preventing conditions such as diabetes, colon cancer, and heart disease. Pearl millet, boasting a high dietary fiber content ranging from 8 to 9 percent, contributes to enhanced bowel movements (Shukla and Bhise, 2023). Its slow digestion extends transit time, reducing glucose absorption into the bloodstream, which proves beneficial for individuals with non-insulin-dependent diabetes and contributes to a lower incidence of diabetes among millet consumers. Furthermore, the fiber in millet may aid in lowering bad cholesterol levels while increasing good cholesterol. It hinders the production of bile acids, thereby reducing the risk of gallstones. The abundant fiber content in pearl mill*et al*so slows the passage of food from the stomach to the intestines, creating longer intervals between meals and contributing to obesity prevention.

- **Lipids:**

The fat content of pearl millet is estimated to range between 5 and 7 percent, whereas maize displays a fat content varying from 3.21 to 7.71 percent. Recent findings suggest that finger millet contains 1 percent lipids, while pearl millet contains 5 percent lipids. Pearl millet is characterized by a notable concentration of fatty acids, including palmitic, stearic, and linoleic acids, with a lower percentage of oleic acid compared to maize (Tomar *et al*., 2021). Notably, pearl millet surpasses other millet species in overall lipid content, ranging from 1.5 to 6.8 percent. Specifically, pearl millet's lipid composition consists of 5.6 to 6.1 percent free lipids and 0.6 to 0.9 percent bound lipids. In contrast, finger millet possesses an overall lipid content of 5.2 percent, comprising 2.2 percent free lipids, 2.4 percent bound lipids, and 0.6 percent structural lipids. The primary fatty acids identified in finger millet are oleic, palmitic, and linoleic acids. Notably, unsaturated fatty acids constitute 74.4 percent of finger millet's total fatty acid production, with saturated fatty acids comprising the remaining 25.6 percent.

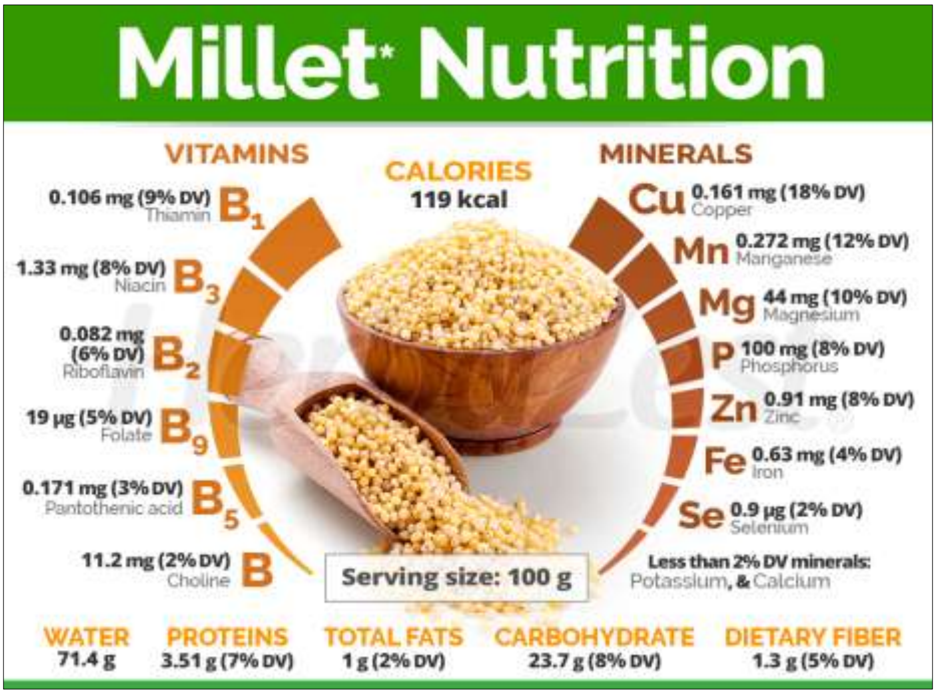

Figure 1.4: Nutritional Values of Millets (Source: USDA Food data center)

- **Macronutrients:**

Environmental stresses, such as high salt concentrations, limited water accessibility, and extreme temperatures, have been demonstrated to impact the mineral content of food. The overall mineral and trace element composition of pearl millet is influenced by soil types. Comparing ash concentrations, pearl millet and maize range from 1.6 to 3.6 percent and 0.86 to 1.35 percent, respectively. Pearl millet outperforms maize in mineral content, containing higher amounts of calcium, phosphorus, magnesium, manganese, zinc, iron, copper, and being recognized for its richness in fat-soluble vitamin E (2 mg/100 g) and vitamin A. Pearl millet boasts a calcium content ranging from 45.6 to 48.6 mg per 100 g, contributing significantly to bone development and healing. Substances such as phytates, oxalates, may hinder the bioavailability of iron in pearl millet and polyphenols found in high concentrations. On the other hand, finger millet, with calcium levels varying from 162 mg/100 g to 487 mg/100 g depending on the genotype, is reported to have 344 mg of calcium per 100 g. Additionally, finger millet is recognized for its significant magnesium content, ranging from 84.71 mg/100 g to 567.45 mg/100 g, contributing to the body's defense against diseases like cancer and promoting bone growth to reduce fracture incidence.

- **Polyphenols:**

The body's immune system is believed to be strengthened by the presence of the primary polyphenols, which are abundant in millet and include phenolic acids and tannins (Samtiya *et al*., 2023). The enzymatic hydrolysis of complex carbs can be somewhat inhibited by millet phenolic, which also inhibit malt amylase, -glucosidase, and pancreatic amylase, all of which lower postprandial hyperglycemia. Similarly, to this, ferulic and p-coumaric acids, which are present in whole pearl millet, are thought to have the ability to reduce cancer cells. The phenols found in millets have been shown to offer several health benefits, including the ability to serve as an antioxidant, anti-inflammatory, and antiviral. In addition, celiac disease is a genetically predisposed condition brought on by consuming gluten. Millets help to prevent celiac disease by minimizing the discomfort brought on by typical cereal grains that contain gluten because they are gluten-free. Millets contain phenolic acids, which occur (60%) in bound and free forms. The most prevalent phenolics in millets are hydroxycinnamic acids, which are primarily located in the phenolic acids' insoluble-bound regions. Ferulic acid, an antioxidant, is the most prevalent form of hydroxycinnamic acid. Antioxidants are well-known substances that reduce the body's exposure to free radical damage and have anti-inflammatory properties. Additionally, millet grains have been discovered to contain ferulate dimers, which exhibit considerable antioxidant activity. Further, the flavonoids found in millet grains include anthocyanin’s, chalcones, amino phenolics, flavanols, flavones, and flavanones. Proanthocyanidins, also known as condensed tannins, are thought to be present in certain millet cultivars. Significant amounts of tannin are primarily found in colored millet types. This finding was linked to the presence of condensed tannins because they significantly contribute to the color of the grain. However, a high concentration of condensed tannins may negatively impact the bioavailability of minerals and proteins.

1.5 Other Health Benefits:

The aqueous extract of foxtail millet (*Setaria italica*) has been shown to have anti-hyperglycemic and anti-lipid emic effects in streptozotocin-induced diabetic rats. According to the study, diabetic rats received a dose of 300 mg of Setaria italica seed aqueous extract per kilogram (kg) of body weight, which led to a significant decline (70%) in blood glucose levels after 6 hours. As evidence of the hypolipidemic effect of the aqueous extract, they also discovered higher levels of HDL (high-density lipoproteins) cholesterol and lower levels of triglycerides, total LDL (low-density lipoproteins), and VLDL (very low-density lipoproteins) cholesterol in diabetic treated rats compared to diabetic untreated rats (Dar *et al*., 2024). Korean foxtail millet's dietary protein has a positive impact on cholesterol and insulin sensitivity. This experiment showed that rats fed foxtail millet had a substantial decrease in insulin levels. The impact of consuming millet on lipid levels and C-reactive protein concentration, they discovered that, contrary to their earlier studies, hyperlipidemia rats fed foxtail millet had lower levels of triglycerides. In rats fed foxtail millet, the levels of C reactive protein, a sign of inflammation, were also shown to be lower. Kodo millet aqueous and ethanoic extracts have been shown to cause a dose-dependent decrease in fasting blood glucose. Dual use of millets as food and feed: Due to their abundance in essential minerals like calcium, dietary fiber, polyphenols, and protein, millet grains are regarded as one-of-a-kind crops. Many Asian and African nations rely on them as a primary food supply. A larger portion of the millet produced is mostly used for human use, and a smaller portion is used to make beer, livestock, and bird feed. In some regions of Africa, millet is prepared as a porridge with a thin or thick consistency, whereas in other regions, it is prepared as couscous. The effectiveness of pearl millet as a feed item for poultry production was confirmed by research utilizing whole grain or crushed grain that was used in chicken diets. The primary goal of pearl millet production in Africa and Asia is thought to be grain, while the forage is a significant secondary product used for construction, fire, and animal feed. While all-season millets ensure food security, fodder, nutrition, health, and sustainable livelihood, in contrast to season-specific crops like wheat and rice. Because they are free of gluten and have a higher level of nutritional fiber than rice, pearl millet grains have a great deal of promise as a source of nourishment for people. Additionally, they have the same amount of fat as maize cereal and more critical amino acids like leucine, isoleucine, and lysine than traditional cereals like wheat and rye (ICRISAT, 2016). In India, where millet is frequently used, it is converted into the dense bread known as dosa, which is formed from a combination of millet and other grains. Additionally, it is used to make roti, sushi, no-yeast pizza, biscuits, and couscous. Another item manufactured from millet is Madua, a popular finger millet-based beverage in India. Additionally, millet is used to make Oshikundu, a traditional alcoholic or non-alcoholic drink in Namibia.

1.6 Monetary Benefits of Using Millet:

The cost of millet is thought to be 40% lower than that of maize, making it an economical and gluten-free cereal. The trade value of pearl millet was less than or equal to 77.78% of the price of maize grain. Pearl millet grain contains more protein per unit than maize, potentially allowing diets to be formulated without protein supplements, thereby reducing the cost of food and feed. Additionally, millet is more cost-effective to produce compared to other cereals such as sorghum and maize. For example, Brazilian pearl millet cultivars exhibit more efficient water use than sorghum and maize grown in semi-arid regions of the country. A separate study revealed that the cost of feed required to achieve one kilogram of live weight gain in chickens fed on maize was higher than that for chickens fed on pearl millet, finger millet, and sorghum. Millet grain feed presents the lowest cost per kilogram of feed and the lowest cost of feed per unit weight gain, making broiler chicken production more affordable. The annual net profit from using pearl millet as the sole feedstock was $25,175,000 compared to $23,758,000 for maize feedstock's, representing a difference of nearly $1.4 million. Addressing food security challenges in developing nations involves recognizing the complexity of factors beyond just increasing agricultural supplies.

Urbanization, accessibility, economic structures, institutional shortcomings, and other elements contribute to food insecurity. Successful interventions require multispectral strategies, combining indicators of food insecurity with relevant socioeconomic and environmental variables. Despite the challenges, the significance of locally grown and underutilized grains like millet cannot be overlooked. Millets, particularly minor varieties like finger, kodo, foxtail, tiny, porso, and barnyard, possess genetic adaptability and resilience to diverse soils and climatic conditions. These qualities position millets as suitable alternatives to staples like wheat and rice in challenging climate zones, contributing to food security. However, millet is often overlooked in agro-biodiversity discussions, despite its potential to enhance food security for disadvantaged populations in developing countries.

1.7 Agronomic Practices for Millets Production:

Millets are hardy and resilient crops that can be grown in diverse agro-climatic conditions, including in the regions of Jammu and Kashmir. The agronomic practices for successful millet production are discussed in this chapter.

A. Selection of Seed and Variety: Seeds should be taken from a reliable source. Proper varietal selection ensures higher yield and prevents susceptibility to biotic and abiotic stresses. Development of high yielding varieties with wide adaptability resulted in increased production despite the decline in area under cultivation Important varieties of millets are given in Table 1.1.

Table 1.1. Promising Varieties of Millets

Millet	Varieties
Pearl millet	PCB 164, ICMV 221, Raj171
Sorghum	Raj Vijay Jowar 1862 (RVJ 1862), CSV 34, CSV 15,CSV 17, JJ 741, JJ 938, Palamurujonna (CSV31)
Finger millet	VL Mandua 379 (VL 379), VL Mandua 376 (VL 376), VL Mandua 352 (VL 352),GPU 28, PR 202
Foxtail millet	S 4, PRK 1, Sreelaxmi, SiA 326, SiA 3156, SiA 3085
Barnyard millet	VL 172, VL 207, PRJ 1, VL 29, PRS 1, DHBM93-3
Little millet	BL-6, Jawahar Kutki 4 (JK 4), JK 8, JK 36, JK137,DHLM 36-3
Proso millet	PRC 1, TNAU 145, TNAU 164, TNAU 151
Kodo millet	Jawahar Kodo137 RBK 155, Indira Kodo 48, Indira Kodo1, GPUK 3, JK 439, JK98, JK 65, RK 390-25, TNAU 86
Browntop millet	IMRAK 2

B. Optimum Time of Sowing: Millets are grown in almost all the seasons of the year but in Jammu and Kashmir they are cultivated in *Kharif* season. The best time for sowing *kharif* crop is from last week of April to ending May in Kashmir region and for Jammu region June – July.

C. Land Preparation: Millets require fine tilth for crop establishment, initial root and shoot development. One ploughing followed by 2–3 harrowing and cross plantings is necessary to obtain fine tilth (Table 1.2). Levelling of fields is necessary for adequate drainage.

Table 1.2: Practices of Land Preparation in Millets

Millet	Land Preparation
Pearl millet	The field should be ploughed once or twice followed by harrowing to create fine tilth.
Sorghum	Ploughing is required once in summer followed by 2-3 harrowing’s.
Finger millet	One deep ploughing with mould-board plough is recommended. Followed by, ploughing with wooden plough twice is necessary. Before sowing,

Millet	Land Preparation
	secondary tillage with cultivator using multiple tooth hoe to prepare smooth seed bed is necessary.
Foxtail millet	The field should be ploughed once with mold board plough. The field should be harrowed or plough with local plough twice.
Barnyard millet	The field should be ploughed once or twice followed by harrowing to create fine tilth.
Little millet	The field should be ploughed once or twice followed by harrowing to create fine tilth.
Proso millet	The field should be ploughed once or twice followed by harrowing to create fine tilth.
Kodo millet	The field should be ploughed once or twice followed by harrowing to create fine tilth.
Brown top millet	The land should be harrowed two or three times and then finally levelled.

D. Seed Rate, Spacing and Method of Sowing: Optimum seed rate and spacing ensures higher yield in millets. Seed rate depends on the method of sowing and seed size. The recommended seed rate to achieve the required plant population along with spacing and method of sowing is given in Table 3. Mostly line sowing or broadcasting is followed in millets but transplanting is also done in finger millet.

1.8 Nursery Management:

An area of 150 m^2 is required to raise seedlings for 1.0 ha. Apply 2-3 baskets of well decomposed farm yard manure (FYM) along with 1.0 kg super phosphate, half kg muriate of potash and half kg ammonium phosphate and 750 g zinc sulphate per bed. Sow the seeds by opening rows at every 3 inch uniformly. Cover the seed with well decomposed FYM and soil/ sand/ water every bed. Top dress with urea 500 g per bed when the seedlings are 12-14 days old. Seedlings of 21-25 days old are ideal for transplanting in rows of 22.5-25 cm with 2 seedlings/hill with 10 cm between hills.

Table 1.3: Seed Rate, Spacing and Method of Sowing

Millet	Seed rate (Kg/ha)	Spacing (cm x cm)	Sowing method
Pearl millet	3 – 4 for line sowing and 10-12 for broadcasting	45 × 10-15 (L-L x P-P)	Three systems of pearl millet sowing are followed: (i) on a flat surface, (ii) using ridge and furrow system, (iii) on a broad-bed and furrow system.
Sorghum	9-10 for line sowing and 15-16 for broadcasting	45 x 12-15	

Millet	Seed rate (Kg/ha)	Spacing (cm x cm)	Sowing method
Finger millet	8-10 (line sowing) and 4-5 (transplanting).	22-30 x 7.5	Line sowing, transplanting is done in irrigated conditions.
Foxtail millet	8-10 (line sowing) and 15 for broadcasting	25-30 x8-10	Line sowing or broadcasting.
Barnyard millet	8-10 in line sowing and 15 for broadcasting	25 x 10	Broadcasting and line sowing
Little millet	6-8 for line sowing and for broadcasting 10-12	22.5 x 8-10	Broadcasting and line sowing is recommended.
Proso millet	Line sowing is 10 and for broad casting is 15	22.5 x 10	Broadcasting or line sowing is recommended.
Kodo millet	10 for line sowing and for broad casting is 15.	22.5 x 10	Broadcasting or line sowing is recommended.
Brown top millet	10-12 for line sowing and 20-22 for broadcasting	22.5 x 8-10	Broadcasting and line sowing is recommended

1.9 Conclusion:

The intricacies of millet cultivation, exploring diverse agronomic practices and crop management techniques. By examining the contributions of key millet-producing states in India and the global significance of varieties like Pearl Millet and Sorghum, the chapter highlights the importance of informed agricultural practices for optimal millet yield.

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