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Millets: A Climate-Resilient Solution to Global Food Security

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SUMMARY

Millets offer a climate-resilient solution to global food security due to their ability to grow in arid lands with minimal inputs, high nutritional value, and adaptability to various environmental conditions. They are rich in fibres, protein, key vitamins, and minerals, making them an ideal alternative to combat malnutrition. Millets are gluten-free, non-allergic, and have a low glycaemic index, providing protection against cardio-vascular and diabetic diseases. Their short growth cycles and efficient water use enable them to thrive in areas where other crops fail. Despite their ease of cultivation and numerous nutritional and therapeutic benefits, millets receive minimal attention in agricultural promotion. However, these often-overlooked crops hold significant potential to ensure food security and support sustainable agricultural practices.

INTRODUCTION

Millets (Shree Anna) are one of the oldest foods known to humans. The evidence of domestication and consumption of millets can be traced back to Indus Valley Civilization. The year 2023 was declared as international year of millets (IYoM 2023) by United Nations General Assembly, that was proposed by India and supported by 72 countries. As global agri-food systems grapple with the challenge of feeding a continuously growing population, resilient cereals such as millets offer an affordable and nutritious alternative to combat malnutrition. It is crucial to intensify efforts to promote their cultivation at extensive scale. Millets are group of small seeded grasses (*poaceae* or *gramminae* family) that can be grown on arid and semi-arid lands with minimal inputs and are climate resilient. They are categorized into two main categories (1) major millets which include sorghum, pearl millet, and finger millet and, (2) minor millets which include little millet, proso millet, barnyard millet, foxtail millet and kodo millet (Figure 1). Millets are often regarded as “Nutri-Cereals” and are rich in fiber, protein, key vitamins and minerals. Millets are gluten free, non-allergic and 3-5 times rich in nutrients than other cereals such as wheat and rice. Additionally, due to their low glycemic index they provide protection against cardio-vascular and diabetic diseases. They are hardy crops and can be grown in wide range of environments. For these reasons, millets provide an ideal solution for countries to increase self-sufficiency, combat hunger and malnutrition. Thus, paving the way for sustainable agriculture solution in a changing climate to sustain global food security. In this article we will discuss the status of millets in India, soil and climatic conditions, nutritional benefits, and government initiatives in order to promote millet cultivation.

Status of millets in India:

India is the largest millet producer in the world, with approximately 41% world share and 80% share in Asia. There are three major millets which occupies maximum sown area are sorghum, pearl millet, and finger millet. Rajasthan occupies first rank in terms of production followed by Karnataka and Maharashtra.

Climate and Soil requirements

Millet can be grown in a wide range of climatic conditions. However, a warm climate with 20-30 degrees Celsius is essential for germination and sprouting of millet seeds. Most millets are short duration in nature and can be grown in areas where other crops fail to grow due to moisture deficit conditions. For instance, sorghum and bajra can be cultivated in drought conditions, unlike other crops, because of their excellent water holding capacity. Millets have efficient water holding capacity and can complete their life cycle in minimum moisture availability condition. There are mainly 8 types of millets are being cultivated in India under rainfed conditions which require little or no irrigation. Millets require around 35-40cm of annual rainfall for a good harvest. Interestingly, most of the millets are resilient to climate and sustain production. Millet are adaptable to wide range of soil conditions from poor to very fertile soils, and various alkaline soils. Alluvial, sandy, and loamy soil with good drainage capacity are ideal for cultivations of millets.

Figure 1. Millets and their Common names in Indian Languages

Nutritional Powerhouses

The majority of the world's undernourished people live in India. Approximately 194.6 million individuals, or 15.2% of India's total population, suffer from malnutrition. India is ranked 111th out of 125 countries with enough data to create a 2023 Global Hunger Index score. India experiences a severe level of hunger, scoring 28.7 on the 2023 Global Hunger Index. Millets are nutri-dense, non-glutinous, easily digested, and allergy-free. The protein level of millets such as Jowar (10.4g), Bajra (11.6g), proso millets (12.5g), foxtail millet (12.3g), and barnyard millet (11.6g) is comparable to that of wheat (11.8g) and considerably higher than that of rice (6.8g). Finger millet contains less protein (7.3g) than wheat and rice, but it contains more calcium and mineral matters. In general, millets are higher in fibre than fine cereals. Small millets such barnyard millet 14.7g, kodo millet 9g, small millet 8.6g, and foxtail millet 8.0g are the highest in fibre when compared to wheat 1.2g and rice 0.2g. According to Senthilvel *et al.* (2008), millets are now known as "Miracle grains/Adbhut Anaj and nutria-cereals" as a result. Finger millet contains sixteen times the calcium level of maize, and because it contains essential minerals, some people think it may someday take the place of rice as a staple food (Hassan *et al.,* 2021). Compared to other cereals, millets contain nutrients like phosphorus, potassium, calcium, magnesium, and important amino acids (**Tables 1 and 2**). Millets are superior to wheat and rice in a few nutritional aspects. The calcium content of finger millet is noticeably higher than that of rice by a factor of thirty. Furthermore, several millet types have as least twice the calcium amount of rice. Little millet and pearl millet have much higher iron content compared to rice, making rice comparatively inferior in terms of iron concentration. Additionally, these grains are rich in dietary fiber, vitamins, folic acid, and significant amounts of lecithin, all of which support the neurological system. Millets also contain abundant beta carotene, an essential micronutrient that rice lacks despite its popularity. Notably, beta carotene is often obtained through pharmaceutical pills and capsules. Furthermore, millets are packed with phytochemicals such as polyphenols, tannins, and phytosterols, which have antioxidant properties.

Table 1 Proximate composition of millets and other cereals (per 100g)

Millet/Cereal	Calorific value(kcal)	Carbohydrate (g)	Protein (g)	Fat (g)	Crude fiber (g)	Minerals (g)
Sorghum	349	72.6	10.4	1.9	1.6	1.6
Pearl millet	361	67.5	11.6	5	1.2	2.3
Finger millet	328	72	7.3	1.3	3.6	2.7
Foxtail millet	331	60.9	12.3	4.3	8	3.3
Proso millet	341	70.4	12.5	1.1	2.2	1.9
Barnyard millet	307	65.5	6.2	2.2	9.8	4.4
Kodo millet	309	65.9	8.3	1.4	9	2.6
Little millet	341	67	7.7	4.7	7.6	1.5
Rice	345	78.2	6.8	0.5	0.2	0.6
Wheat flour	341	69.4	12.1	1.7	1.9	2.7
Maize	342	66.2	11.1	3.6	2.7	1.5

(Srivastava and Arya, 2021)

Table 2 Micronutrient composition of millets and other cereals (mg/100 g)

Millet/Cereal	Iron	Calcium	Zinc	Phosphorous	Potassium	Magnesium
Sorghum	4.1	25	1.6	222	131	171
Pearl millet	8	42	3.1	296	307	137
Finger millet	3.9	344	2.3	283	408	137
Foxtail millet	2.8	31	2.4	290	250	81
Proso millet	0.8	14	1.4	206	113	153
Barnyard millet	5	20	3	280		82
Kodo millet	0.5	27	0.7	188	144	147
Little millet	9.3	17	3.7	220	129	133
Rice	0.7	10	1.4	160		90
Wheat flour	4.9	48	2.2	3555	315	132
Maize	2.3	10	2.8	348	286	139

Source: (Gopalan, Ramashastri, & Balasubramanium, 2016)

Health benefits of millets

Millets provides variety of health benefits owing to their ability to provide vitamins, minerals, protein, fibers, phytochemicals etc. Millets are anti-acidic, gluten free that help in detoxification of body and helps in controlling type-II diabetes. Millets provide Niacin (Vitamin B3) that helps in lowering blood cholesterol, thus minimizing the risk of cardio-vascular diseases. Additionally, millets help in preventing breast cancer. Moreover, millets aid in treating respiratory illness and help to optimize kidney, liver, and immune system health. Furthermore, millets eliminate the risk of digestive problems such as constipation, excess gas, bloating and cramping. Interestingly, millets act as a prebiotic feeding micro-flora in your inner ecosystem. Additionally high in substances that protect cancer, such as antioxidants, are millet. Millets' dietary fiber supports general digestive health, encourages regular bowel movements, and wards off constipation (Saleh *et al.*, 2013). The grain is also rich in phytochemicals, such as phytate, which millets linked to a lower risk of disease, and phytic corrosive, which is thought to lower cholesterol (Coulibaly *et al.*, 2011). Millets' high fibre content makes them feel full, which aids in controlling hunger and weight. Because of their reduced calorie content and high nutrient density, millets are regarded as a healthy choice for diets aimed at losing weight.

Climate resilience and sustainability

Increasing temperatures, elevated atmospheric CO2 levels, and unpredictable rainfall patterns are just a few of the major obstacles that climate change presents to agriculture. Among the common cereal crops, there is a 50% reduction in yield due to abiotic stressors in the current climate change scenario, which pose a significant risk to plant growth and development. Merely 10% of the entire agricultural land is unaffected by abiotic pressures, whereas the remaining 90% of cultivable land is impacted by various abiotic stresses worldwide (Dita *et al.*, 2006). Of all the environmental factors that exist, heat and drought rank as the most significant productivity constraints. All the major abiotic stresses brought on by climate change, such as increasing heat and drought, could result in higher annual losses, which would have an impact on agricultural productivity. Climate-smart agriculture strategies must be used in order to solve these issues and guarantee sustainable food production. Cultivating climate-resilient crops is one such method, and millets have become a viable contender. Millets are backbone for dry land agriculture. Millets exhibit efficient morphological, physiological, molecular, and biochemical traits that enable them to withstand abiotic stresses. Due to their short growth cycles, millets can complete their life cycle quickly, allowing them to avoid environmental stress during early or late sowing periods. Additionally, millets have a smaller leaf area, thickened cell walls, and a dense fibrous root system, all of which enhance their tolerance to abiotic stress. As C4 plants, millets can utilize more atmospheric CO2 and, through photosynthesis, produce more assimilates even under elevated atmospheric CO2 levels (Aubry *et al.*, 2011). For these reasons, millets can be termed as the 'miracle grains' or 'crops of the future'. Additionally, millets have a higher water use efficiency (WUE) than major cereals and will automatically be chosen to combat water shortage in the future under the crucial situation of water deficit in a major portion of the world. Rice has low growth and production on soil with salinity higher than 3 dS/m, whereas millets like finger millet and pearl millet can grow up to 11–12 dS/m (Rathinapriya *et al.,* 2020). Since they significantly improve the diet of a people with little resources, they are regarded as a poor man's crop and have numerous potential for cultivation in developing nations. The rainfall requirement for pearl and proso millet is approximately 20 cm, significantly lower than the 120-140 cm required by rice (Kumar *et al.*, 2018). The short life cycle of millets, around 10-12 weeks compared to 20-24 weeks for other major crops, aids in stress mitigation. Millets exhibit enhanced photosynthetic rates in warm conditions and demonstrate superior water and nitrogen use efficiency, which is approximately 1.5 to 4 times higher than that of C3 photosynthesis (Wang *et al.,* 2012). For example, *Setaria italica* needs only 257 grams of water to produce 1 gram of dry biomass, whereas maize and wheat require 470 grams and 510 grams, respectively (Nadeem *et al.,* 2020). Additionally, C4 photosynthesis provides millets with secondary benefits, including improved growth and ecological performance in warm temperatures, more flexible biomass allocation patterns, and reduced hydraulic conductivity per unit leaf area.

Millet Initiatives

Several initiatives have been taken at world level and in India to promote the production and consumption of millets. To celebrate the IYoM-2023, FAO has released millet recipes book from the Global Chefs Challenge by chefs and hobby cooks across the world. In India also, several major initiatives have been taken such as millet start-up innovation challenge, inclusion of millets under 'Poshan Mission Abhiyan', by ministry of women and child development. Further, government has hiked the minimum support price (MSP) for millets. Additionally, government has strengthened the marketability of millets by building value chains through farmer producer organization. The initiative for nutritional security through intensive millet promotion (INSIMP) was launched to encourage the millet production to ensure nutritional security in India.

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