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Millets: A Promising Pathway in Combating Food Crisis

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Abstract

Millets are coarse grains whose cultivation on fertile as well as marginal lands dates back to 3500-2000 BC. Millets are classified as large millets and small millets on the basis of size of the grain. Millets, with low glycemic index act as a store house of nutrients prove propitious in combating various heath related issues. These are recognized as climate smart crops due to their adaptation to diverse agro-climatic conditions and presence of diverse pool of genes to perform under abiotic stress. Millets can also be called as "Miracle Grains" as they require less water, less dependence on synthetic fertilizers, provide sustainable food and fodder and fit well in contingent crop planning. Government of India celebrated the year 2018 as "National Year of Millets" to create greater awareness by addressing millets as nutricereals. Other ventures of GOI, like increase in MSP for millets, formation and promotion of self-help groups by civil societies etc. paved a way for successful adoption for cultivation of millets. The tribal community in the Bastar Plateau Zone of Chhattisgarh in India clearly demonstrates the ethno-medical uses of millets and by-products. In the times of sedentary lifestyle, less diversity in source of nutrition and demand for nutritious diet, an increase in awareness and knowledge regarding the millets by proper planning and execution of awareness campaigns, public education has become need of the hour.

1. Introduction

Millets are a diverse group of small-seeded annual grasses cultivated as grain crops, primarily in marginal and dry regions across temperate, subtropical, and tropical areas (FAO, 2021). The term "millet" originated from the French word "Mile," signifying a thousand, alluding to the abundant grains packed within a handful of millet. The cultivation of millets in the world dates back to 3500-2000 BC. Even Indian literature also shows description of millets in *Yajurveda* which depicts that cultivation of nutritious grains is an ancient concept in India. On the basis of grain size, millets are classified into two groups viz. large millets (sorghum and pearl millet) and small millets (finger millet, foxtail millet, proso millet,

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kodo millet etc.). The remarkable potential of millets extends to ensuring food security, nutritional well-being, economic stability, and promotion of good health.

Over the years, millet cultivation in India has witnessed a concerning decline, with a staggering 60% reduction since 1950, resulting in decreasing from 34.8 mha to 13.6 mha. The decline in millet cultivation gained momentum after the early nineties (Figure 1), although the magnitude of decline varies among different millet crops. For instance, sorghum, once the second most important crop in India after rice, covering over 17.9 mha in the 1950s, has seen a significant downturn, with its current area reduced to 4.9 mha in 2020 (Figure 1), marking a substantial decrease of 70% over seven decades. Likewise, small millets faced an alarming reduction of 90% in cultivation area with finger millet witnessing a decline from 2.25 mha to 1.0 mha. On the other hand, pearl millet exhibits relatively

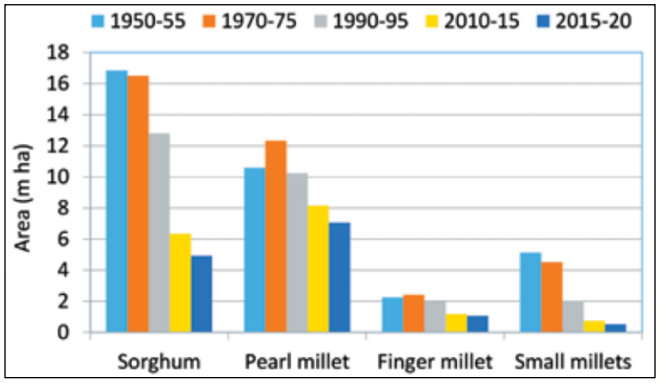

Figure 1: Dynamics of area under different millets in India

minimal decline in area, still being cultivated across 7.0 mha, mainly in the harsh and marginal environments of arid and semi-arid regions.

Currently, there are around 6,000 varieties of millets grown throughout the world. Millets are underutilized crops in many developed countries. There is an immense potential to process millet grains into value added foods. Till date, 154 varieties of millets have been released for cultivation throughout India (Table 1)

In India, production has increased from 164 lakh tonnes in 2017-18 to 176 lakh tonnes in 2020-21thereby contributing about 80% in Asia and 20% in global millet production. India is the largest grower (with 19% contribution) and producer (20% production) of millets in the world (NAAS, 2022). India has an average productivity of 1239 kg ha^{-1}as against 1229 kg ha^{-1} at global level (Table 2 and Figure 2).

Table 2: Area and production of millets in the world

Region	Area (mha)	Production (lakh tonne)
Americas	48.9	423
Africa	5.3	193
Asia	16.2	215
Europe	0.8	20
Australia and New Zealand	0.6	12
India	13.8	173
World	71.8	863

(Source: FAO, 2021)

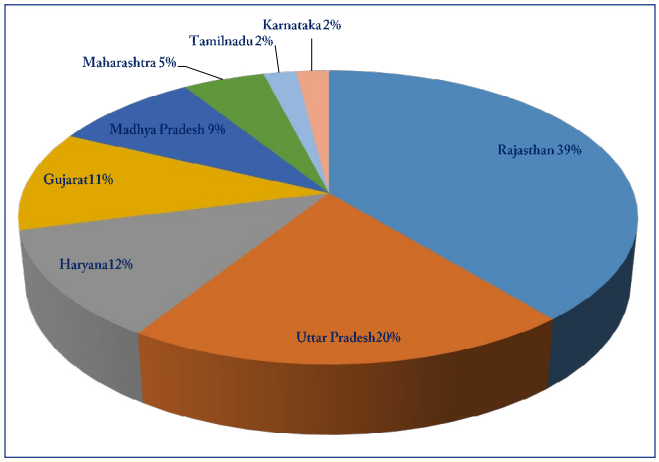

Figure 2: Percent contribution of states in millet production of India (Saini et al., 2023)

2. Millets as Sacs Full of Nutrients

Millets were historically perceived as a staple in the diet of the economically disadvantaged, leading the Indian government to recognize their significance by declaring them as "nutricereals" during the celebration of the national year of millets in 2018. Millets play a vital role in achieving sustainable development goals in agriculture due to their high input efficiency and exceptional

Table 1: Number of varieties of millets released in India till date

Sorghum	Pearl millet	Little millet	Proso millet	Kodo millet	Finger millet	Foxtail millet	Barnyard millet
43	52	11	4	4	28	8	4

nutrient composition, contributing to global nutritional security. Millets are rich source of essential vitamins such as riboflavin, thiamine, and minerals like calcium, phosphorus and zinc (Table 3). They are abundant in proteins, particularly prolamines and glutelins. The millets consist predominantly unsaturated fatty acids providing essential fatty acids which are very crucial for a healthy diet. Additionally, millets undergo processing that eliminates anti-nutritional factors like phytate and polyphenols primarily found in the seed coat resulting in processed millets free from these undesirable elements.

Compared to rice or wheat, millets boast superior nutritional properties with a low glycemic index, a higher proportion of unavailable carbohydrates and a gradual release of sugar making them a favorable choice for managing blood sugar levels. This unique nutritional profile of millets underscores their significance as a nutritious and sustainable grain option for fostering global health and well-being.

Table 3: Nutritional composition of millets (per 100 g)

Millet	Carbohydrate (g)	Protein (g)	Fat (g)	Dietary fibre (g)	Ca (mg)	P (mg)	Zn (mg)	Thiamin (mg)	Riboflavin (mg)
Sorghum	67.7	9.9	1.73	10.2	27.6	274	1.9	0.35	0.14
Pearl millet	61.8	10.9	5.43	11.5	27.4	289	2.7	0.5	0.20
Finger millet	66.8	7.2	1.92	11.2	364.0	210	2.5	0.37	0.17
Kodo millet	66.2	8.9	2.55	6.4	15.3	101	1.6	0.29	0.20
Proso millet	70.4	12.5	1.10	-	14	206	1.4	0.41	0.28
Foxtail millet	60.1	12.3	4.30	-	31	188	2.4	0.59	0.11
Little millet	65.5	10.1	3.89	7.7	16.1	130	1.8	0.26	0.05
Barnyard millet	65.5	6.2	2.20	-	20.0	280	3.0	0.33	0.10

(Source: Anonymous, 2017)

3. Millets with Therapeutic Advantage

The modern sedentary lifestyle has led to a rise in various health issues, prompting individuals to seek healthier and more nutritious options in their diet. Millets, being nutrient powerhouse, have emerged as a satisfying solution to meet the demands of contemporary society. With their potential health benefits, consuming millets can reduce the risk of heart disease, aid in diabetes management, promote digestive tract health, boost immunity, and enhance muscular and neural systems. Additionally, millets have shown to have protective mechanism against degenerative diseases like metabolic syndrome and Parkinson's disease. Millets are rich in essential nutrients, including resistant starch, oligosaccharides, lipids, and a variety of antioxidants such as phenolic acids, avenanthramides, flavonoids, lignans, and phytosterols. These compounds are believed to be responsible for numerous health advantages associated with millet consumption.

Recognizing the unparalleled attributes of millets, India celebrated the year 2018 as the 'National Year of Millets' to raise awareness about their significance. Further urged the United Nations to declare 2023 as the '**International Year of Millets**' a resolution supported by 70 countries during the 75th assembly session in March 2021. The primary objective is to promote millet production, value addition and consumption at global level thereby contributing to food security and increasing the overall production of millets worldwide.

Health Benefits of Millets

Cardio-vascular diseases- The millet grains are the powerhouse of nutrition that help in improving heart health and effectively trim down the coronary blockage. They are enriched with magnesium, potassium, and plant lignin, which effectively reduce blood pressure by acting as a vasodilator and decrease heart attack and other cardiovascular risks. The high fiber content of millets lowers the cholesterol level thus eliminating LDL (Low Density Lipoprotein) from the system and increases the positive effects of HDL (High Density Lipoprotein) in the body.

Gastrointestinal Disorders- Regulating digestive process can increase nutrient retention and reduce chances of more serious gastrointestinal conditions

like gastric ulcers or colon cancer. Fiber content in millets helps in eliminating disorders like constipation, bloating and cramping. Being gluten free, millets can meet the growing demand for gluten free foods for the individuals suffering from celiac disease.

Antidiabetic properties-Millet consumption lowers blood glucose response and glycosilated hemoglobin thus, rendering low glycaemic index (Figure 3). It helps in reducing the risk of diabetes mellitus. Millets are a rich source of magnesium that helps in stimulating the level of insulin in the body and thus increase the glucose receptors' efficiency in the body.

Reduction in oxidative stress- Free radicals, are removed by the phenolic compounds present in millet grains which reduces oxidative stress.

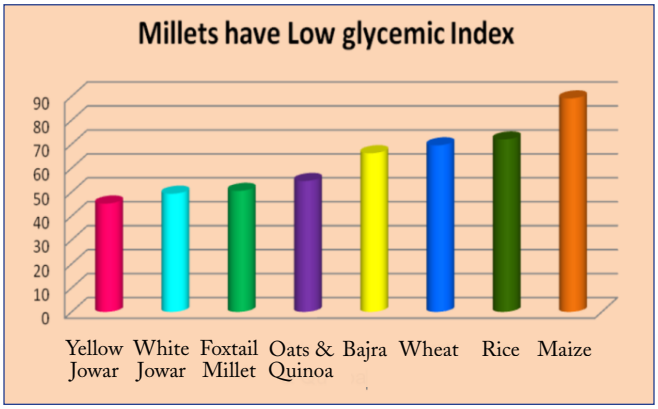

Figure 3: Glycemic index of different millets (Source: Rao et al., 2017)

4. Millets as Climate Smart Crops

Millets are **"Miracle grains"** as they require less water vis-a-vis other crops (Figure 4) and can be grown in harsh environment and therefore, can certainly act as foremost option in development of climate resilient agriculture. Millets are smart crops and highly suitable for conservation agriculture because:

- Having less water requirement than other cereals
- Require lesser fertilizer and other farm inputs
- Provide more nutrients
- Provide sustainable feed and fodder
- Promising contingency crops

Considering inevitable health benefits and nutritional composition, the need of the hour is to develop millet-based government policies to recognize their contributions

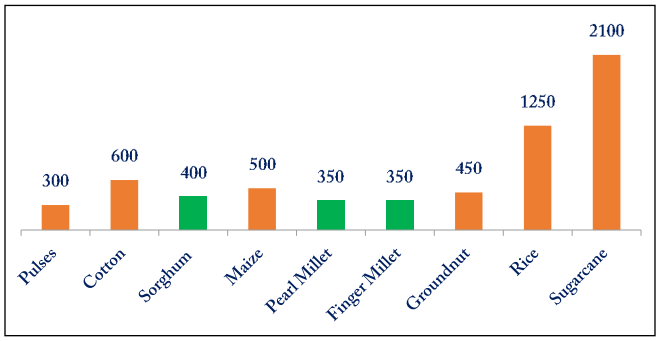

Figure 4: Water requirement of millets and other crops in mm (http://mcrhrdi.gov.in)

in achieving nutritional security and including them into agricultural production to formulate climate resilient cropping systems. Millets contain diverse pool of genes (Table 4) that confer tolerance to abiotic stresses such as drought, salt, dehydration etc.

Table 5: Differentially expressed abiotic stress-related genes in millets

Gene	Source	Role
SiLEA	Foxtail millet	Increases drought tolerance
SiARDP	Foxtail millet	Increases drought tolerance
Argonaute protein 1 encoding gene	Foxtail millet	Regulate stress response
Late embryogenesis abundant protein (LEA)	Foxtail millet	Confers tolerance to salt, osmotic, and drought stress
Ec-apx1	Finger millet	Expression increased under drought
NAC transcription factor	Finger millet	Confers tolerance to salinity and drought stress in rice
bHLH transcription factor	Finger millet	Confers tolerance to salinity, oxidative, and drought stress
β-Carbonic anhydrase (PgCA)	Pearl millet	Up-regulated when exposed to drought
Voltage-dependent anion channel (VDAC)	Pearl millet	Tolerance to several abiotic stresses

(Source:Paschapur et al., 2021)

5. Ethno-Medical use of Minor Millets

Tribal life in Indian subcontinent harvests beneficial aspects of millets. They not only use millets as food but also for certain other purposes. The following are some of the uses of millets effectively fetched by tribal community in Bastar Plateau Zone of Chhattisgarh in India (Sahu and Sharma, 2013).

1. The wall of the houses are made by mixing the straw of the kodo millet with mud, the resulting mud wall becomes very strong and moreover resistant to termites. At the same time they reported that when the straw of the kodo millet is burnt and the ash is spread in the field of onion, it results in higher yield of the crop.

2. The tribal people usually mix and store the husk of the finger millet with the green gram and pigeon pea seeds which helps in protecting against pests during storage. The tradition of using kodo millet straw for baking earthen pots by tribal people is also very common as they believe that the pots become stronger and bake better by burning the kodo millet straw.

3. Kodo millet straw is used by Bastar tribals to provide immediate relief in cattle for **Tympany** disorder, which is a fatal disease in which the animal's stomach swells enormously and the cattle may die if adequate care is not given in time. They also use 3–4 year old kodo millet grains as an instant-relief medicine for poultry *Ranikhet* disease which is again a very contagious and dangerous foul disease leading to heavy toll if not effectively and timely managed.

4. Kodo straw is also used in paddy fields by tribal people to control leaf folders and blast diseases while mixing millet grains in cattle feed helps to increase milk production and reduce feed costs.

5. Minor millets are also associated with lots of faiths among tribal people. Gaadi is a major Bastar tribe festival, where the Prasaad given is finger millet grains and if those finger millet grains received as the Prasaad of Gaadi festival are sprinkled on the nonbearing mango and/or tamarind trees, the very next season they begin to bear fruit.

6. Initiatives of Government of India and Civil Societies to Promote Millets

Government of India is consistently in the process of promoting millets not only on national but also at International level. Major breakthrough started in the year 2018, when GOI took initiative to say millets as Nutricereals or super foods (Sandhu and Nidhi, 2022). Following are some of the milestones achieved in promoting the millets in India:

1. Millets have been included in the Public Distribution System (PDS) of India in the year 2018 at Rs. 1 kg^{-1} under the National Food Security Mission (2013).

2. Declaration of the year 2023 as "**International Year of Millets (IYoM)"** on the call of GOI by the United Nations (Sen et al., 2023).

3. In 22nd Shikhar Sammelan of Shanghai Cooperation Organization held in September, 2022 in Samarkand, Uzbekistan, Shri Narendar Modi, Hon'ble Prime Minister, GOI addressed that "The world is going through an unprecedented food crisis. Increase in cultivation and production of millets is a possible solution to this crisis. Millets are super foods which are cultivated from 1000 of years all over the world including SCO members. Millets are conventional, nutritional and cost effective alternate to tackle the food crisis" (Saini et al., 2023).

4. Millet Network of India (MINI) is a pan India alliance of over 65 institutions supporting different millet varieties. More than 50,000 farmers are part of the alliance that has spread activities to Uttarakhand, Nagaland, and Odisha.

5. In Odisha, a volunteer organization named "**Nirman**" restored 12 varieties of traditional millets with the aid of the Kutia Kandha community, which were almost extinct and preserved in seven villages in Kandhamal district involving tribal members.

7. Conclusion

Smart biofortified millets developed by using biotechnological techniques can be used in nutraceutical industry. Region specific and farmer oriented research and development, resource conservation technologies, congenial government policies, better infrastructure for processing and storage of millets are major future thrusts that need to be considered to bring climate resilience in millet ecosystems.

8. Future Thrust

Capacity building of researchers, extension personals, farmers, and rural agro-service providers about the basics of climate information such as mitigation and adaptation strategies, is essential in developing millet-based climate

smart cropping system. There is a need to develop index-based insurance schemes to cover risks associated with changes in rainfall, temperature, and floods to benefit the farming community. The nutritional and health benefits need to be communicated efficiently to consumers through print and electronic media to increase the market demands for millets. Space should be created to place millets in the food menus of schools, welfare hostel programs, and public gatherings.

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