Short Research Article

MILLETS: A TASTY SOLUTION TO FOOD SECURITY CHALLENGES OVERCEREAL-BASEDCROPPING SYSTEMS

ABSTRACT

A heightened emphasis on augmenting millet production and accentuating their nutritional benefits is pivotal in mitigating reliance on conventional crops, fostering dietary diversity, and enhancing food security, particularly in times of natural calamities when food scarcity is prevalent. The United Nations General Assembly has designated the year 2023 as the International Year of Millet. Millets hailed as 'superfoods,' boast high levels of protein, fibre, vitamins, and minerals. India stands as a major contributor, producing 80% of Asia's millets and 20% globally, as reported by the Ministry of Agriculture and Farmers Welfare. Statistics reveal that over 90 million individuals in Africa and Asia incorporate millets into their diets, with Africa accounting for more than 55% of global production, followed by Asia at nearly 40%, while Europe constitutes approximately three per cent of the worldwide market. Specifically in India, West Bengal adheres to a predominantly monocultural cropping system, predominantly focused on rice. Monoculture systems are highly susceptible to blights and pests due to their lack of diversity, leading to reduced soil fertility and compromised soil structure. Cultivating millets not only offers a viable solution by diminishing reliance on synthetic fertilizers and pesticides but also facilitates a transition towards sustainable agriculture. This involves diversifying crop rotations and steering clear of the pitfalls associated with mono-cropping systems. Introducing various millet types into cropping systems can significantly enhance food security. Each millet variant possesses unique qualities that enable them to withstand extreme climatic conditions, making them particularly relevant as adaptive measures in the current context of global warming and climate change issues.

Keywords:*food security, mono-cropping, climate change, sustainable agriculture*

1. INTRODUCTION

Agriculture is undoubtedly the backbone of any developing country like India. It is the prime source of food-fodder-fibre-fuel-fruit-flower-fish and timber and provides raw materials to many large- and small-scale industries. A lion’s share of the country’s mammoth population depends directly or indirectly on agriculture. Being the largest private enterprise in India it contributes 17.4% of national GDP (G.O.I,2016).Tackling hunger and feeding the world population are two of the biggest challenges of the modern world. Reasons contributing to this issue range from deficiencies in the supply of micro- and macro-nutrients, shortages in the production of foods leading to supply–demand imbalances, and conflicts destabilising various parts of the world. Although several of these triggers for hunger can be addressed leading to a slight reduction in the population suffering from hunger and malnutrition from almost one billion in 1990–1992 to 850 million in 2010–2012, the threat of climate change and global warming still lingers” (FAO,2012).Millets – often called “Nutri-Cereals” due to their high nutritional

value – are a group of small-seeded grasses grown mainly in dry zones of Asia and Africa. These include sorghum (or great millet), pearl millet, finger millet, fonio, proso millet, foxtail millet, teff and other smaller varietals.Millets are one of the oldest foods known to humans & possibly the first cereal grain to be used for domestic purposes. Millets are small-seeded grasses that are hardy and Millets are hardy crops grown in arid and semiarid environments and are resilient to higher temperatures and drought-prone environments require 350 mm of water compared to 1200 mm for rice. They offer food, fodder, fuel, and nutrition security and can be grown in intercropping (or maybe under mixed cropping with pulses and oil seeds) (ACCII,2022). Millets are also unique due to their short growing season. They can develop from planted seeds to mature, ready-to-harvest plants in as little as 65 days. This is important in heavily populated areas. When properly stored, whole millets will be kept for two or more years (Michaelraj and Shanmugham,2013).India is one of the leading producers of millets in the world with an estimated share of around 41 per cent in the global production. As per FAO(2020), world production of millets in the year 2020 was 30.464 million metric tonnes (MMT) and India's share was 12.49 MMT, which accounts for 41 per cent of the total millet production. India recorded a 27 per cent growth in millet production in 2021-22 as compared to millet production in the previous year was 15.92Mmt.India's top five millet-producing states: Rajasthan, Maharashtra, Karnataka, Gujarat and Madhya Pradesh.In recent times, climate change has been one of the great constraints to crop production and productivity including cereals. Among the various adaptation strategies is the choice and diversification of crops (Sood et al., 2018). Climate change and increasing global average temperatures are reported to have a direct impact on crop yields, crop productivity and the overall sustainability of our food systems. Although some estimates show that a few regions could benefit from climate change due to increased productivity and yields, this will not be sufficient to feed the higher number of inhabitants globally (Kang et al.,2009). Furthermore, most of the scientific community agrees that the current rates of global warming and emissions of greenhouse gas would significantly reduce overall crop productivity. Thus, reducing greenhouse gas emissions to control global temperatures plays a crucial role in achieving food security. However, the agricultural sector is one of the primary contributors to greenhouse gases such as methane into the atmosphere. Higher emissions are generally caused by intensive agricultural practices which are being followed in different locations around the world (Downing et al.,2000 and Olesen et al.,2002). Millets possess several morpho-physiological, molecular, and biochemical characteristics which confer better tolerance to environmental stresses than major cereals (ACCII,2022).

2. LITERATURE REVIEW

Millets are a highly varied group of small-seeded grasses, widely grown around the world as cereal crops or grains for fodder and human food.They can grow in the harshest,most arid regions(Varshney et al., 2006).Millets are low-input intensive crops making them a marginal Farmer's first choice.In the future, millets can be our insurance in times of climate change. Millets are resilient to extreme conditions including high temperatures and drought. They can grow in the harshest, most arid regions. Currently, around 55% of millets are grown in arid regions of Africa,40% in Asia, and 3% in Europe. In India, the demand for millets has grown by 140% but the production is less than 50%(Kumar et al.,

~~2022).There are 9 types of millets grown in India, those are- sorghum(*Sorghum bicolor*), Pearl millet(*Pennisetum glaucum),*Fingermillet*(Eleusine coracana),*Barnyard millet*(Echinochloacolona),*Proso millet*(Panicum milaceum),*Foxtail millet*(Setariaitalica),*Little millet*(Panicum sumatrense),*Kodo millet*Paspalum scrobicultum),*Brown top millet*(Urochloaramosa).~~ *As shown in Figure 1,* 9 species of millets are grown in India: *Sorghum sorghum (Sorghum bicolor),* Millet *(Pennisetum glaucum),* Finger millet *(Eleusine coracana),* Barnyard millet *(Echinochloacolona),* Millet *(Panicum milaceum),* Foxtail millet *(Setariaitalica),* Small millet *(Panicum sumatrense),* Kodo millet *(Paspalum scrobicultum),* Brown millet *(Urochloaramosa).* *(The Indian Express- Please find this resource and put it in the reference list)*

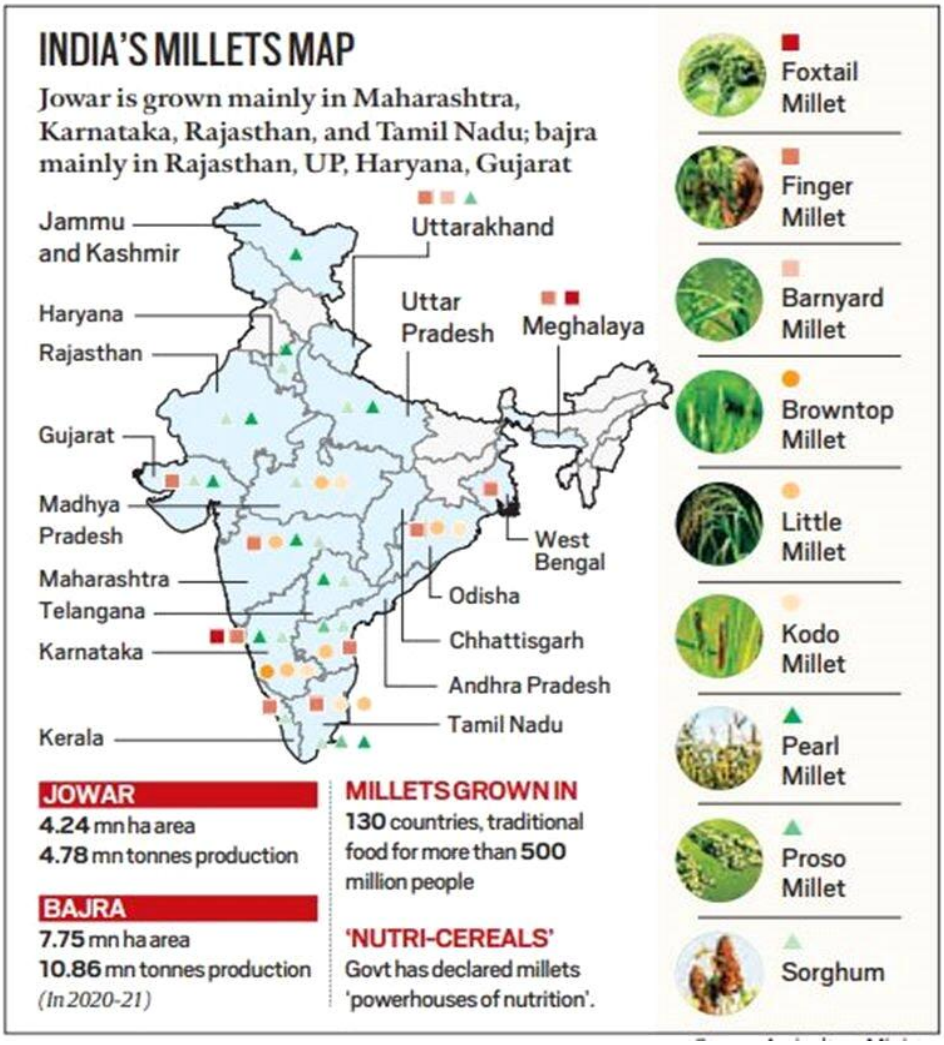

Fig.1. INDIA'S MILLETS MAP

3. AREA AND PRODUCTION

India is the largest producer of Millets in the world. In India, Millets are grown in about 21 States. There is a major impetus in Rajasthan, Maharashtra, Karnataka, Andhra Pradesh, Tamil Nadu, Kerala, Telangana, Uttarakhand, Jharkhand, Madhya Pradesh, Haryana, and Gujarat(Rao et al., 2019). In India, millets are cultivated in an area of 12.45 million hectares, producing 15.53 million tonnes with a

yield of 1247 kg/ha. Sorghum is the fourth most important food grain in India after rice, wheat, and maize in terms of area (3.84 Mn. ha) and production (4.31 Mn. MT). Bajra (7.05 m ha) is contributing more than 50 per cent of the country's area under millets with a nearly equal percentage of production. It is interesting to note that, India is the topmost producer of Barnyard (99.9%), Finger (53.3%), Kodo (100%), Little millet (100%) and pearl millet (44.5%), producing about 12.46 million metric tonnes from an area of 8.87 million ha (ACCII,2022). Rajasthan has the highest area under millet cultivation (29.05%) followed by Maharashtra (20.67%), Karnataka (13.46%), Uttar Pradesh (8.06%), Madhya Pradesh (6.11%), Gujarat (3.94%) and Tamil Nadu (3.74%). The states of Gujarat and Madhya Pradesh have increased their area under millets over the recent years. However, the highest yields were recorded in Andhra Pradesh (2626.58 kg/ha), Tamil Nadu (2153.22kg/ha), Haryana (1906.78 kg/ha), Gujarat (1762.05 kg/ha) and Madhya Pradesh (1729.70 kg/ha). The states like Gujarat and Andhra Pradesh have shown better productivity levels as compared to their counterparts (DES,Government of India,2021-22– It's not on the reference list).

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Table 1. Area under cultivation, production, and yield of millets

Crop	Area (m ha)	Production (m tons) *	Yield (kg per ha)
Sorghum(kharif)	1.76	1.58	967
Sorghum (Rabi)	3.07	2.73	1002
Sorghum (total)	4.83	4.31	989
Bajra	7.55	9.22	1374
Ragi	1.01	1.67	1747
Small millets	0.459	0.33	809
Total millets	13.83	15.53	1248

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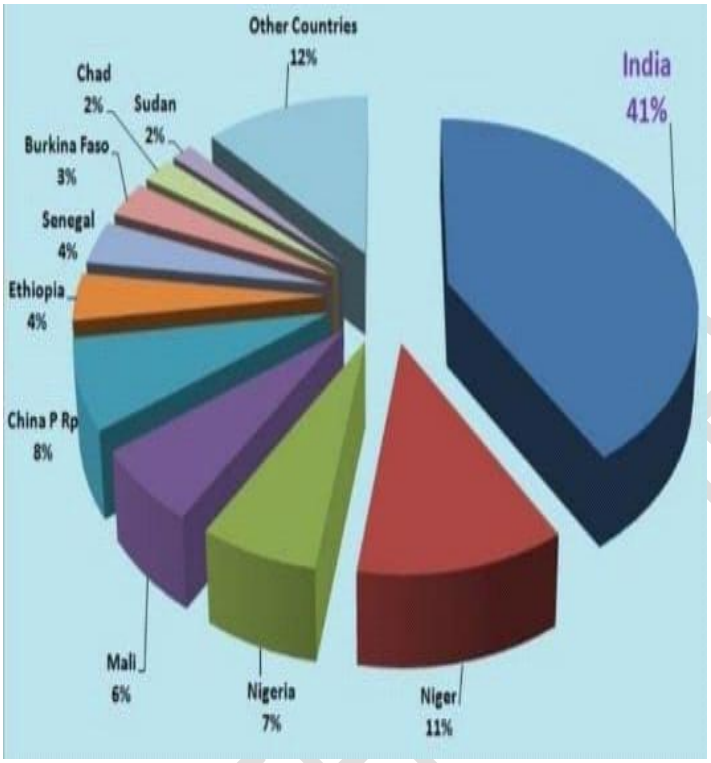

Fig.2. Country wise production of millet

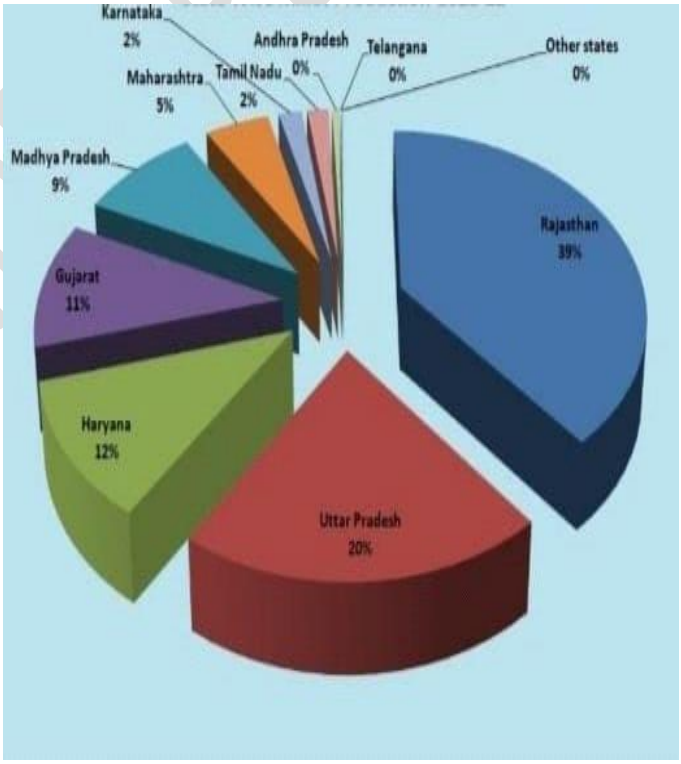

Fig.3. State wise millet production (2021-22)

4. MILLETS FOR NUTRITIONAL IMPORTANCE

Millets are a smart food because they are good for your health, and the environment because they require less water to grow and have a low carbon footprint, and for the farmers as well because they are more tolerant of changing weather patterns. Millets are a source of food for more than 90 million people in Asia and Africa(Saleh et al., 2013). Wheat, rice, and maize, in contrast, are staple foods for 4 billion people(Kumar et al., 2022).The millets contain as high as 13-38 % of total dietary fibre that could be considered in the management of disorders like diabetes mellitus, obesity, hyperlipidaemia, etc. The glycaemicload-lowering effects of barnyard millet arethe highest among all millets(Kumari and Thayumanavan,1998).Foxtail millet exhibits antihyperglycemic and antilipidemic activities. An aqueous extract of 300 mg of foxtail millet per kg body weight of rats exhibited a 70% reduction in blood glucose level in streptozotocin in induced diabetic rats(Sireesha et al., 2011).Millets are also a good source of carotenoids (78-366mg/100g) and possess higher antioxidant capacity(Devi et al., 2014).

5. NUTRITIONAL COMPOSITION OF DIFFERENT MILLETS: ~~1~~

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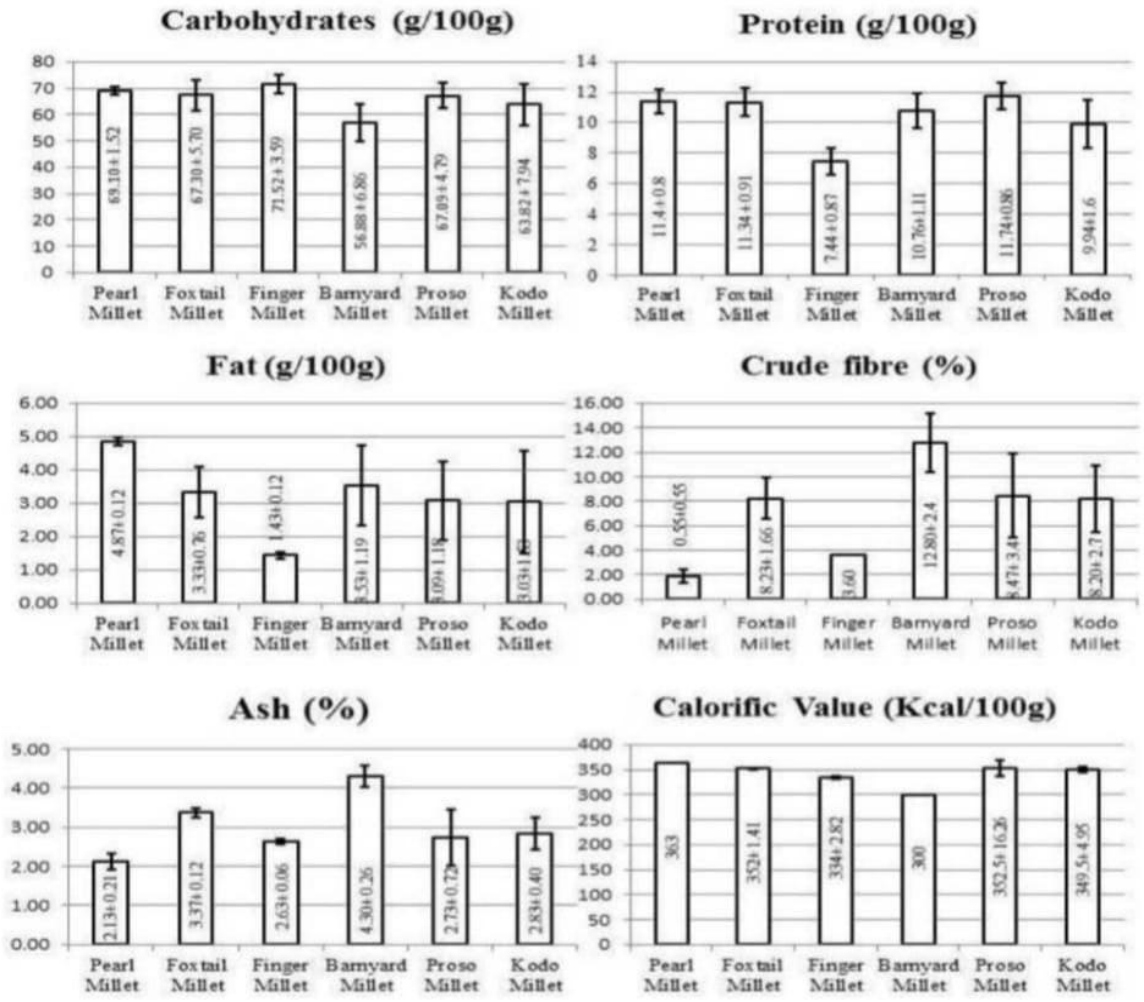

Fig 4: - Charts describing the nutritional composition of different millets (Kumar et al., 2018)(fix the font and make a mention in the text,)

Foodgrain	Carbohydrates (g)	Protein (g)	Fat (g)	Energy (Kcal)	Calcium (mg)	Iron (mg)
Sorghum	72.6	10.4	1.9	349	25	4.1
Bajra	67.5	11.6	5	361	42	8
Finger millet	72.0	7.3	1.3	328	344	3.9
Foxtail millet	60.9	12.3	4.3	331	31	2.8
Kodo millet	65.9	8.3	1.4	309	27	0.5
Proso millet	70.4	12.5	1.1	341	14	0.8
Barnyard millet	65.5	6.2	2.2	307	20	5
Little millet	67.0	7.7	4.7	341	17	9.3
Wheat (whole)	71.2	11.8	1.5	346	41	5.3
Rice (raw, milled)	78.2	6.8	0.5	345	10	0.7

GRAPHIC: VIPUL SHARMA/MINT

Source: National Institute of Nutrition Hyderabad

Table 2: - Table describing the Nutritional component of different Millets (fix the font and make a mention in the text,)

6. ~~List 1:~~BENEFITS OF MILLETS CONSUMPTION

Similar corrections with section 5, need to add description

Table3. Benefitsofmilletsconsumption

FOOD SECURITY	NUTRITIONAL SECURITY	SAFETY FROM DISEASES	ECONOMIC SECURITY
Sustainable food source for combating hunger in changing world climate	Rich inmicronutrients like Ca, Zn, Fe and Iodine etc. Rich in bioactive compounds	Millets have low water requirements and are drought-resistant. They have a short growing season and require less water during growth. Millets can grow in regions with <50 cm annual rainfall	Millets offer farmers a stable source of income as they are drought-resistant and less susceptible to failure due to weather-related events
Resistance to climate stress, pest and diseases	Better amino acid profile	They can be grown in dry land areas using farmyard manures, thus reducing the dependence on synthetic fertilisers.	Millet production requires a low initial capital investment.

Kumar et al., 2018

7. HEALTH BENEFITS OF MILLETS

- Lower bad cholesterol level.
- Helps in weight loss,decrease high blood pressure.
- Optimizes immune system (Kaveeshwar et al., 2014).

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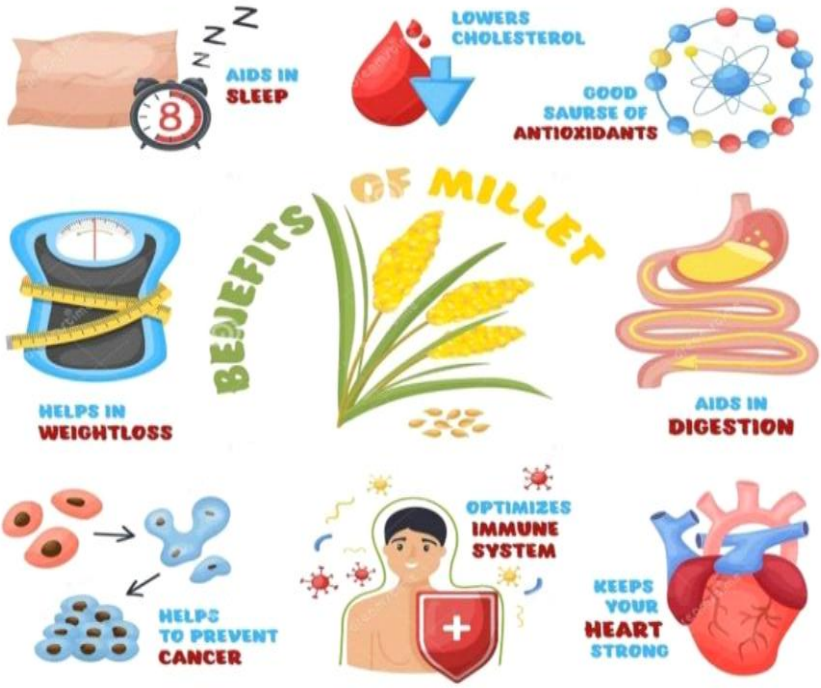

Fig 5: - Health Benefits of Millets(fix the font and make a mention in the text)

8. ADAPTABILITY OF MILLETS IN DIFFERENT CLIMATIC ZONES

Future agriculture will face some common environmental changes like enhanced temperature, uncertainties in rainfall, elevated CO2 and GHG levels, and more frequency in natural calamities. Under these conditions, climate-resilient agriculture should be adopted in which cultivation of climate-smart crops will play a pivotal role. There is no doubt that millets are climate-smart crops which can simultaneously mitigate the ill effects of climate change and adapt to the changed and wider agro-climatic conditions(Bandyopadhyay et al., 2017). Different millets have a unique quality to combat extreme climatic conditions which is more relevant as an adaptation option in the present scenario of issues related to global warming and climate change (Reynolds et al., 2020). Being C4 plants, millets can utilize more atmospheric CO2 and by the process of photosynthesis can produce more assimilates, even under elevated CO2 levels into the atmosphere (Aubry et al., 2011). Furthermore, “water use efficiency (WUE) of millets is higher than major cereals and, in the future, under the crucial situation of water deficit in a major portion of the world, millets will automatically be chosen to combat water shortage(Saxena et al., 2018). In semi-arid and arid regions, abiotic stress such as drought, extreme temperature (cold, frost and heat), flooding, salinity etc. are the major yield-limiting stressors. Millets encompass numerous morpho-physiological, molecular, and biochemical

properties that confer better tolerance to environmental stresses than major cereals(Simmons et al., 2020).The rainfall requirement of pearl and proso millet is 20 cm, which is many folds lower than rice as they require more than 120–140 cm (Kumar et al., 2018). The short life cycle of millets(~10–12 weeks) as compared to other major crops (20–24 weeks) also supports them in stress mitigation. Millets have enhanced photosynthetic rates at warm conditions and confer immediate water and nitrogen use efficiency, which is ~1.5- to 4-fold higher than C3 photosynthesis Wang et al., 2012).Compared to maize, pearl millet can modulate their membrane dynamics better for water permeability to attain better water status during osmotic stress (Bandyopadhyay et al., 2017). An increase in leaf tensile strength and root length was reported in teff and little millet under drought(Balsamo et al., 2006).

CONCLUSION AND FUTURE PROSPECTS

In India, diversifying crop production to include more coarse cereals, such as millets andsorghum,can make food supply more nutritious, reduce resource demand and greenhouse gasemissions, and enhance climate resilience without reducing calorie production or requiringmore land. Millets can support to sustainable food systems under climate change. Theirresilient nature and outstanding potential to survive under low water availability and stressfulenvironments serve as the bestalternative to staple cereal crops.In India and especially in West Bengal generally mono croppingsystem is followed (rice-rice-rice). By offering a reduced dependence on synthetic fertilizers andpesticides and improving soil fertility,millet cultivation may also help promote a shift towardssustainable agriculture,diversifying crop rotations and avoiding the promotion of mono-croppingsystems.

The UN-FAO has announced the year 2023 as the ‘International Year of Millets’, recognizing the potential of this crop. By that time, the intervention of government and non-governmental bodies in initiating or reviving millet farming may be expected to incentivize increased millet production. This could achieve success in combating hunger and malnutrition among the vulnerable population in any future aberrant conditions.

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