MILLETS: FUTURE CROP TO ENSURE THE HOUSEHOLD NUTRITIONAL SECURITY UNDER CLIMATE CHANGE SCENARIO

Abstract

Millets comprises a group crops and major crops grown in entire world are Pearl, Proso, Foxtail, Japanese Barnyard, Finger and Kodo millets *etc.* As evident from recent research and extension works, due to climate change scenario many issues in agricultural production system have raised, which causes major challenges to ensure food availability and accessibility in general and nutritional security of households are another genuine ground in particular. Aforesaid issues and challenges before agriculture compel the farmers, scientific and policy maker communities to rethink about restructure and revitalize new crop/cropping production system which can deal the problems effectively and efficiently. As millets are performed well even under diverse agro-climatic conditions under low agricultural input supply system especially under marginal land. Conclusively, millets not only meet the food demand of growing world population but also deals extreme weather situations due to increase in level of greenhouse gases in the atmosphere and also helpful in ensuring nutritional security. Changing the preference of food and fast spreading of chronic health worldwide are open the new approaches to adopt new technologies and rational practices with selection of hardy and well performing crops like millets.

Keywords: Millets Household Nutritional Scenario

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I. INTRODUCTION

Modern world is now passing through the major challenges that is meeting the food demand of increasing population; hence scientific and appropriate action and changes require. In recent trend, gap has been observed in respect to food supply and demand due to limited and low food production in general at global level and India at particular, even across the regions and seasons. Major issues of shortage of food production are limited water availability, essential plant nutrients, reduction in carbon content in the soil and also including environmental and social problems. Greenhouse gases are major culprit for hunger and malnutrition. Though, number of people who experienced hunger and malnutrition has decreased 15% from 1990-1992 to 2010-2012 but 850 million people is still suffering from same aforesaid issues (Naresh *et al.,* 2023 and FAO, 2012). On the other hand, two to three billion people has insecurity in respect to access of proper nutrition and factors responsible of this nutritional insecurity are reduction in food production, so that additional food is required in order to meet the increasing population, the total population of world will become 9 million in 2050. Hence, extra and judicious efforts in research and extension under shifting scenario and perspective of agriculture globally and locally will be required to meet the food requirement for expected aforesaid population (Naresh *et al.,* 2023; Wheelker and Braun, 2013 and Godfray, *et al*., 2010). Keeping above facts and figures in view, in world as well as Indian agricultural scenario, restructuring and revamping the future line of research and extension in current production system are seemed to be inevitable under changing climate change scenario and to tackle and address the related issues particularly environmental and social aspects.

II. RELEVANCE OF MILLET CULTIVATION

The averaged carbon equivalent emission from wheat, rice and maize are 1000, 956 and 935 kg C/ha, respectively, which looks considerably high (Jain *et al*, 2016), it means these crops are major contributor of carbon in atmosphere, which is responsible for rise in average temperature and thus leads to global warming. Moreover, these crops require more water for unit production. On the other hand, millet has peculiar characteristics, which can be grown with full potential under water limited conditions and found to be instrumental to decrease the decline in the global carbon footprint (Prasad and Staggenborg, 2009). Among millet group; Pearl, Proso, Foxtail, Japanese Barnyard, Finger and Kodo millets are commonly and largely grown crops across the world (Naresh *et al.,* 2023).

Millets are hardy and considered to be climate resilient crops, so they can be grown under even extreme and diversified climatic conditions. As they can cope up the issues like biotic and abiotic stress conditions, which is common phenomenon and occurrence in semi-arid and arid regions and giving high yield in such bad conditions even under marginal land and under back up small quantity of critical inputs (Prasad and Staggenborg, 2009 and Awika, 2011).

Now Millet shows its distinct impact to cope up the worst situation raised due to climate change and hence it is known as superfood because this group of crops are found to be efficient and effective to handle the challenges related to variability in rainfall pattern, erratic changing scenario in weather parameters *etc.*, thereby they regulate and handle the agricultural paradigm shift by accommodating them in crop production system easily and

conveniently. It not only ensures the nutritional and food security of Indian household but also combating the water scarcity situation as it grows at extreme conditions like very high temperature as well as deal the other issues *e.g.,* environmental and social issues (Naresh *et al.,* 2023). Though no. of millet species are grown worldwide as they require varying soil type and climatic conditions but if comparing with pearl millet, Sorghum and Maize are little efficient in utilizing the moisture at cultivation site. Millets have peculiar characteristics, which can cultivate better even under sandy and poor soils, besides thrives well under dry conditions also.

III. ABOUT MILLET CROPS

Pearl millet (*Pennisetum glaucum* L.) is sixth important crop globally FAO (2014) and successfully grown in areas where soil is marginal and received lesser annual precipitation that is in rang of 200 to 500 mm (Guigaz, 2002). It is traditionally grown in different countries *e.g.,* India, Pakistan, Central, Eastern, and Southern Africa and Western Africa *etc.* In some parts of Africa and India, pearl millet plays crucial role in food security (Passot *et al.,* 2016).

Eleusine coracana L. is a botanical and binomial nomenclature of Finger Millet (English Name) and this crop is known as different name in India in different regions *i.e,* Ragi, Madua and Nagli *etc* This crop is grown in various parts of Africa and India. In India, after wheat, rice, maize, sorghum, and bajra; finger Millet ranks sixth important and principal crop (Devi *et al.*, 2014). If comparative requirement will be made with other agronomical cereal crops, ragi can performed well even at higher temperatures and highly salinized soil conditions. For finger millet; Optimum temperature, soil pH and rainfall requirement is 11 to 27 °C, 5 to 8, and moderate, respectively (Upadhyaya *et al.*, 2008).

Centre of origin of Proso millet (*Panicum miliaceum*) was Central and Eastern Asia before migrating to Russia, India, the Middle East, and Europe (Roshevits, 1980 and Baltensperger, 1996). Major proso millet growing countries are China, India, and Russia. Proso millet is a short-season crop that can be matured in 60–75 days after sowing. Climatic requirement of this crop for average annual rainfall and ideal daily temperature are <600 mm and 17 ºC, respectively (Zarnkow *et al.,* 2010). Areas known and grown for this Middle East, including Iran, Iraq, Syria, and Turkey, as well as Afghanistan, Kazakhstan, Northwest China, Australia, Central and Southern India, Russia and USA (Zarnkow *et al.,* 2009).

During Neolithic and Bronze periods, seeds of Foxtail millet (*Setaria italica* L.) discovered from various parts of world and locations were throughout Europe, the Middle East, Eastern, and Central Asia. Presently, the Korean peninsula, China, India, Indonesia, Europe, and the former USSR produced marked quantity of this millet. As Foxtail millet has quick ripening mechanism and strong photosynthetic efficiency so that it can be grown as a catch crop under aberrant weather conditions. Foxtail millet is also useful in contingency plan (Leder, 2004). Moreover, it is highly nutritive and has strong resilience to biotic stresses (Vetriventhan *et al.,* 2012). For good yield, only one pre-sowing precipitation/irrigation requires (Dwivedi *et al.,* 2012). As far as water use efficiency is concerned, foxtail millet is better than sorghum and maize (Zhang *et al.,* 2007).

There are two varieties of Barnyard millet that are cultivated economical purpose *i.e., Echniochloa utilis* and *E. frumentacea* (Yabuno, 1987). Former species is commonly known as a Japanese barnyard millet, but latter is called as Indian barnyard millet, which is commonly known as sawan millet or billion-dollar grass. Moreover, sawan millet is cultivated largely counties *viz.* India, China, Japan, Pakistan, Africa and Nepal (Gomashe, 2017). In India, regarding area and production, barnyard millet has been ranked 2nd after finger millet (ragi) and its annual production has been reported in the tune of 87 thousand ton and productivity was 0.86tons/ha (Padulosi *et al.*, 2009). Under climate change scenario due to pollution particularly rise in level of greenhouse gases in the earth atmosphere, this crop has been found suitable because it has some very peculiar and suitable characteristic, those are - stands drought, matures fast and has high nutritive values (Wallace *et al.,* 2015).

Firstly, Kodo millet **(***Paspalum scrobiculatum*) is tropical and subtropical crop and it was originated in India and it has been reported that Kodo millet was cultivated in some 3000 years ago (Hulse *et al.,* 1980; House *et al.,* 1995 and Arendt and Dal Bello, 2011). It can be matured during 80 to 135 days. Among all minor millet, Kodo millet has been observed to be strongest drought resistance millet and it is capable to give a good yield.

IV. MILLETS ARE THE BEST TOOL/ANSWER TO FOOD, NUTRITIONAL AND ENVIRONMENTAL SECURITY

Food security means - at all the times (consistently and constantly), when all the human being or people have physical, social and economic access to safe, sufficient and nutritious food in order to meet their dietary needs and food choices for an active and healthy life (Tiwari *et al.,* 2022; Tiwari *et al.,* 2023).

There are four components of millets food security, which are as follows: -

- Food Availability,
- Food Accessibility,
- Proper Food Utilization &
- Food Security

Millets are a perfect and suitable crop for people's shifting dietary preferences and climatic conditions because of their following peculiar and salient characteristics (Vetriventhan *et al.,* 2012).

- Short lifespan,
- High photosynthetic efficiency,
- Nutritional richness, and
- Moderate Resistance to pests and diseases.

Not only in India but also in world, cereal crops are suffering from several challenges and issues due to shifting monsoon and variability in rainfall pattern from seasons to regions, hence millets have been proved a potential solution for guaranteeing food security and they are also an environment resilient crop.

Millets as food are beneficial due to following reasons

- Human Health
- Pro-environment (requiring less water to grow),
- Pro-farmer (as millets are being more tolerant of shifting weather patterns).

Millets contains high amount and good quality of proteins, niacin, fiber, thiamine, riboflavin, methionine, lecithin, and a meagre level of vitamin-E, besides this group of crops are rich in minerals *e.g.,* iron, magnesium, calcium, and potassium. They might also help in prevention of cancer, lower the risk of heart disease, limit the formation of tumors, lower blood pressure, slow down the rate at which fat is absorbed, postpone gastric emptying, and increase gastrointestinal bulk. Millets are a major and prime source of phytochemicals that are considered to be good for human health including the involvement of polyphenols, lignans, phytosterols, phytoestrogens, and phytocyanin. Furthermore, crops of this category are seemed to be considered as immune system regulators, detoxifying agents, antioxidants, and other roles, preventing age-related degenerative illnesses like cancer, diabetes, and cardiovascular diseases (CVD).

In addition to their established characters in avoiding diseases caused by nutritional deficiencies; some vitamins, minerals, and essential fatty acids have benefits in the inhibition of degenerative diseases. As Millets are non-glutinous, so that harmless for those with celiac disease and gluten allergies. Even they are found to be simple food to easily digest and being allergy-free too, besides do not produce acids. As far as age-related degenerative illnesses and diseases are concerned, millets have been found best and provides defense and protection against metabolic syndrome and Parkinson's disease. Millets also lower or protect from chronic diseases, which are very common now a days and others health issues like heart disease and diabetes, besides they improve the digestive system, lower the risk of cancer, detoxify the body, increase immunity in the respiratory system, increase energy levels, and improve the muscular and neural systems. Among the other essential elements, millets are rich in resistant starch, oligosaccharides, lipids, antioxidants such phenolic acids, avenanthramides, flavonoids, lignans, and phytosterols, which are considered to be helpful for a number of health benefits.

Millets can address the various issues up to greater extent in relation to ecological and climatic conditions as they have peculiar and special characteristics, hence these crops can be categorized under best climate-resilient crops because millets have high level of adaptability to a wide range of variation in ecological and weather conditions particularly temperature and rainfall pattern as well as soil water regimes, through which current agriculture is passing through. These crops give optimum and higher growth, development and productivity even under lesser irrigation needs, lower nutrient input supply circumstances, curtail the dependance on synthetic and chemical fertilizers, and show minimal susceptibility to biotic and abiotic environmental (Tiwari *et al.,* 2022).

Historically, millets were grown to protect and safeguard the interest of poor farmers' family and also provided the protection from the vagaries of Indian monsoon. Under climate shift scenario, millets can provide insurance and guarantee in the present and future agriculture.

Millets can withstand against the extreme weather conditions, currently which is happening very frequently or in common phenomenon *e.g.,* drought and high temperatures. These group of crops can survive and thrive as well as give best result in various bad situations like driest and roughest environments. Comparative study in relation to other cereal crops like rice and wheat, millet has a high nutritional value and has good drought-resistant character, so that it requires less water for optimum growth, development and yield, thereby we can say overall performance of crop (Saxena *et al.,* 2018; Wang *et al.,* 2018). Millets, which are cultured for both food and fodder, help millions of people, especially small/marginal farmers in rain-fed areas, practice efficient farming by supplying food and a stable source of income. (Kumar *et al.,* 2022) [67] . Millets are grains for the future in a context of climate change and global warming because they are drought, temperature, and pest tolerant. (NAAS 2013).

1. **Nutrition and Value Addition of Millets:** Finger millet (***Eleusine corocana L.,***) is not only a staple and important food crop in the majority of drought prone areas of India but even in the entire world. It is grown in areas from sea level to an altitude of 2100 meters on hill slopes as well as on plains, which are by and large poor and marginal for cultivating other crops. This crop sustains poor and disadvantaged people too.

   Finger millet is also known by different local names in various parts of India as Ragi, Maduwa, Nachani or Nagli. The major finger millet cultivating states are Karnataka, Tamil Nadu, Andhra Pradesh, Orissa, Jharkhand, Maharashtra, Uttaranchal and Gujrat. Finger millet has outstanding properties as a subsistence crop. Its small seeds can be stored safely for many years without insect damage, which makes it a traditional component of farmers risk avoidance strategies in drought prone regions.

2. **Nutritional Importance:** Finger millet may be considered an important key component of the food security strategies and planning, attributed to its medicinal and nutritional values. It is nutritious, non-glutinous and easy to digest. Finger millet is superior to rice and wheat in many constituents (Table 1). The 100 g of finger millet will provide 7.3 g of protein, 1.3 g of fat, 2.7 g of minerals, 3.6 g of fiber, 72.0 g of carbohydrate, 344 mg of calcium, 283 mg of phosphorus, 3.9 mg of Iron and 191 mg of Magnesium.

Table 1: Nutrient composition of finger millet, rice and wheat (per 100 g edible matter)

Food grain	Protein (g)	Fat (g)	Mineral (g)	Fibre (g)	Carbohydrate (g)	Calcium (mg)	Phosphorus (mg)	Iron (mg)	Magnesium (mg)
Finger Millet	7.3	1.3	2.7	3.6	72.0	344	283	3.9	191
Rice	6.8	0.5	0.6	0.2	78.2	45	160	1.8	-
Wheat	11.8	1.5	1.5	1.2	71.2	41	306	3.5	138

The protein content of finger millet is comparable to many of the existing finer cereal grains. Though, it is moderately deficient in lysine but has adequate amount of other essential and related amino acids required by human beings. Finger millet is an excellent dietary source of Methionine- a Sulphur containing amino acid that is usually lacking in the diets of hundreds of Millions of the poor, who lived on starchy foods such as Cassava, polished Rice and Maize. Finger millet has good lipid picture with more free

fatty acid. And like any other cereal, finger millet is low in fat and free from cholesterol content. The release of energy from carbohydrate present in finger millet is being slow. Thereby, there would suddenly be lesser accumulation of glucose in the blood, which might be good for diabetic patients.

Finger millet has high fibre content and the highest calcium content among all the food grains. High fibre content appears to prevent high cholesterol formation and intestinal cancer. The study showed that replacement of rice in rice- based diet with finger millet not only maintained positive nitrogen balance but it improves the calcium retention. Thus, this can also be used to overcome the Calcium deficiency of a rice rich diet.

Finger millet grain in rich in important vitamins *viz.*, Thiamine, Riboflavin and Foline. It is especially known for its characteristic of providing energy for long time as it consumes. Hence, this can be consumed by the people who have jobs that require hard manual work.

Finger millet is usually converted into flour and made into cakes, puddings or porridge. Malting of its grains has been a traditional process in certain parts of India. Malted grains are mostly used for feeding young children. Among the cereals, finger millet develops highly agreeable flavour on popping. Popped grains find extensive usage as snacks. Popped finger millet flour is often consumed after mixing with jaggary and milk.

Beer prepared out of finger millet is an important drink and sometimes it is served in ceremonial function. It can also be used in bakery products like bread, biscuits, candies, cakes etc.

There is great need for small scale industries to take up finger millet as raw materials to encourage better utilization of finger millet products in the present-day food system of rural and urban society to achieve the nutritional security goal.

Table 2: Nutrient content in different millet crops produce (based on per 100 g grains)

Sl. No.	Millet crops	Energy (Kcal)	Protein (g)	Carbohydrate (g)	Crude Fibre (g)	Calcium (mg)	Iron (mg)
1.	Pearl Millet	361	11.6	65.5	1.2	42	8.0
2.	Sorghum	349	10.4	72.6	1.6	25	4.1
3.	Finger Millet	328	7.3	72	2.6	344	8.9
4.	Foxtail millet	331	12.30	60.9	14.0	31.0	3.6
5.	Barnyard Millet	341	7.7	67.0	7.6	17	9.3

6.	Kodo Millet	302	8.03	69.9	8.5	22.0	9.9
7.	Proso Millet	309	8.3	65.9	9.0	27.0	0.5
8.	Little Millet	314	10.13	65.55	7.72	32.0	1.3

Source: Nutritive value of Indian food, NIN, ICMR 2018

V. CONCLUSIONS

Globally and locally, in some parts, millets are a predominant crop and they are commonly grown in diverse agro-climatic conditions under marginal land with meagre input supply system. In India, there are a lot of scope to produce more millets in order to secure food and nutritional security of Indian households, besides earn more foreign currency in international market after fulfilling our internal demand of growing population with considering and well managing current social and environmental issues which was left during successful story of "Green Revolution". The major challenges before agriculture are to meet the food demand of growing global and Indian population under extremes weather conditions, which is common occurrence under changing climatic conditions. It is well known and well documented that millets are hardy crop and performed well under diverse climatic situations and vagaries of weather parameters particularly temperature and rainfall pattern, besides they can be cultivated under marginal land with meagre supply of agricultural critical inputs including irrigation and fertilizers *etc.* and also least susceptible to abiotic and biotic stresses. They can also thrive and survive and even performed best as compared to other cereal crops. So that these crops are considered to be pro-poor, pro-environmental and pro-health. Keeping these facts in view, flexible and adequate government programmes and policies are required to strengthen and revitalizes the research and extension machinery for promoting the millet crops under climate shift paradigms. Public and private partnership on the concept of win-to-win situation is an important approach, which may be further seemed to be instrumental in bringing out India as a competitive player globally after securing own food and nutritional security of Indian households through millet cultivation.

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