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EXPLOITING MILLETS IN THE SEARCH OF FOOD SECURITY : A MINI REVIEW

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ABSTRACT

Climate change is negatively influencing agricultural production, and there is an urgent need for a rational and cost-effective technique like crop diversification to develop resilience into agrarian systems. For diversifying against the monoculture of conventional staples, the proposed crops shall have essential nutritional advantages and also higher income perks for the farmers. Millets are the better options for the crop diversification. In India, millets are traditionally cultivated from pre-historic occasions. Millets because of their higher resistance against biotic and abiotic stresses, they are sustainable towards the climate. Nutritionally, millets are gluten-free and are with a micro-nutrients profile better than of conventional cereals like rice and wheat. But, millets have faced lots of neglect within the Indian subcontinent because the population is obtaining much more conscious from the challenges of food security and climate change. New methods for millet processing are essential to revert the dietary habits in favour of millet-based diets along with more economical initiatives for the farmers taking up the millet cultivation. In this review article, author have discussed the three millets namely foxtail millet, proso millet and finger millet with the hope of popularizing their cultivation in the Indian subcontinent. We hope that the information provided in this review will help in the better understanding of the minor millets.

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1 Introduction

The world population is continuously rising; this step rise causes a lot of pressure in terms of food security and deciding the means to feed the rising population (Dyson, 1996; Roy et al., 2006). Tackling the hidden hunger as a result of the deficiencies of macro and micronutrients is a notable challenge. However, a number of approaches, such as crop biofortification and yield improvement, were tried to overcome the hunger issue. But this problem still persists (Sharma et al., 2019; Saini et al., 2020;). Furthermore, the challenges imposed by climate change and global warming are also increasing. Climate change will affect the world population and agriculture productivity by threatening the overall ecosystem (DeFries et al., 2019; Kellogg, 2019). Also, the agriculture sector is among the primary producers of greenhouse gases like methane. Cereal crop production is contributing to a significant amount of global warming; additionally, cereals are deficient in important micronutrients (Soares et al., 2019). The cereal crops like wheat, rice and maize have a very high global warming potential (releases around 4 tons CO₂ eq/ha) whereas the carbon footprints of minor millets are far less (Singh et al., 2019; Adegbeye et al., 2020). Moreover, millets cultivation is recommended to reduce the world carbon footprint along with sustaining the food production (Jaiswal & Agrawal, 2020).

Millets cultivation is vital for developing countries like India. Besides, more than 90% of the global millets produce comes from the developing world (Taylor, 2019). Pearl millet is the most widely grown millet. In contrast, millets like foxtail millet, finger millet, little millet, barnyard millet, proso millet, and Kodo millet are also cultivated in India but to a lesser extent (Alavi et al., 2019). The cultivation of millet is undergoing from as far as 5000 year ago for Little millet (*Panicum sumatrense*) in South Asia and Kodo millet (*Paspalum scrobiculatum*) was cultivated for 3700 years before present (Tadele, 2016). India is the leading millet producing country followed by Niger and China. Efforts are being executed to increase the demand of millets in India (the Smart Food campaign) and the world, especially because they provide cheap and high nutrient options like high fibre content, magnesium, calcium, iron, potassium, phosphorus and Niacin

(Vitamin B3)(Rao et al., 2018) (Table 1). Millets are gluten-free and are rich sources of protein and also do not get destroyed easily, thus providing food security. Most of the millets grown in India are of short duration, taking 3-4 months from sowing to harvesting. In the metros and cities, these crops are sold at a premium (Saleh et al., 2013).

Millets are C4 plants they can work out photosynthesis more efficiently. Millets are rich in nutrients and are also gluten-free can be consumed by the people who are allergic to cereals (Thakur & Tiwari, 2019). Moreover, millets are easily digestible and possess numerous health benefits like anticancer, antidiabetic and anticholesterol. Furthermore, millets-based diet is recommended for the patients facing diabetes and even for patients with chronic diseases like cancer (Kam et al., 2016). Several mineral elements like iron, zinc and copper, etc. which are essential for human health and well-being are present in high quantities in the millets (Stein, 2010). Moreover, finger millet is known to possess ten times higher content of calcium than rice or wheat. Early maturing varieties of millets can be a good alternative for sustaining crop production under irrigated and also under the stress conditions (Council, 1996). Millets have a better storability than most of the cereals (Taylor & Emmambux, 2008). In this review, author have gathered information regarding the millets in a hope to improve the cultivation of millets in the Indian subcontinent.

2 Foxtail Millet

Foxtail millet (*Setaria italica*), also known as dwarf Setaria is an annual millet which is also the second-most cultivated species of millet next to pearl millet (Figure 1). It is extensively cultivated in the Indian subcontinent. Earliest record of about foxtail millet is from 8700 BC (Onziga, 2015). Similarly, it is also widely cultivated in India. The eco-friendly crop foxtail millet due to its health benefits, excellent yield potential, tolerance to biotic and abiotic stresses is gaining popularity in the Indian subcontinent (Jia et al., 2007).

Moreover, in recent years' foxtail millet has been tagged as a model plant because of its short life cycle, optimum seed

Table1 Nutrition status of Minor Millets *vis-à-vis* Cereals
(Compiled from a study published by National Institute of Nutrition, Hyderabad) (Rao et al., 2018).

Nutritional content in 100 gms of dry grain	Protein (gms)	Carbohydrates (gms)	Fat (gms)	Minerals (gms)	Fiber (gms)	Calcium (mgs)	Phosphorus (mgs)	Iron (mgs)	Energy (Kcal)	Thiamin (mgs)	Niacin (mgs)
Finger millet	7.3	72.0	1.3	2.7	3.6	344	283	3.9	336	0.42	1.1
Proso millet	12.5	70.4	1.1	1.9	5.2	80	206	2.9	354	0.41	4.5
Foxtail millet	12.3	60.2	4.3	4.0	6.7	31	290	2.8	351	0.5	3.2
Rice (paddy)	6.8	78.2	0.5	0.6	1.0	33	160	1.8	362	0.41	4.3
Wheat	11.8	71.2	1.5	1.5	2.0	30	306	3.5	348	0.41	5.1

production, and small genome size (around 400 Mb) (Zhang et al., 2012). Also, foxtail millet is a C4 plant and is used to provide valuable information regarding the C4 photosynthesis (Doust et al., 2009). Botanically, foxtail millet produces leafy stems with height upto 200 cm. Foxtail produces a seed head with a hairy panicle of 5-30 cm long. The seeds are small approximately 2mm in diameter with a seed colour that varies from greenish to whitish. In the Indian subcontinent, its cultivation stretches in arid and semi-arid regions. It is planted in late spring and usually has a crop duration of 65-70 days for hay production and 75-90 days as a grain crop. The grain yield typically varies between 800–900 kg/ha (Austin, 2006).

3 Proso Millet

Proso millet (*Panicum miliaceum*) was first domesticated before 10,000 BCE in Northern China (Sakamoto, 1987). Whereas, the weedy wild relatives of proso millet are distributed throughout central Asia. It cultivated in South East Asia, middle east, Europe and also in the United States (Lu et al., 2009). Proso millet takes upto 60 days from the seed to grain production (Figure 2). It is a drought-tolerant millet. Proso millet is cultivated as an allotetraploid resulted from the wide hybridization of the two ancestors. Proso millet has been recently sequenced, and it has a genome size of 920 Mb (Zou et al., 2019). Proso millet is well customized to plateau and the regions with high elevation. Additionally, proso millet production can be sustained under unirrigated conditions. Whereas, under temperature that is high as well as with drought conditions, proso millet prevents its vegetative growth (Habiyaemye et al., 2017). Botanically, proso millet is an upright grass with a height of approximately 1.5 m tall and is cultivated as an annual. Proso millet produces tillers and possesses a shallow root system. The stem is cylindrical with simple alternate and hairy leaves. The inflorescence of proso millet is a panicle. The grains are ovoid, up to 3 mm × 2 mm, and are usually white coloured. Proso millet have anti cholesterol properties. The determination of the harvesting time for proso millet grains is not easy as the grains mature at different times (Gomeshe, 2016).

4 Finger Millet

Finger millet (*Eleusine coracana*) also known as kodo, is a millet that is cultivated annually in arid and semi-arid regions of the world (Chandra et al., 2016). Finger millet is a self-pollinating tetraploid plant (Figure 3). It

Figure 1 Plants of foxtail millet with their inflorescence (Rao et al., 2018).

Figure 2 Plants of proso millet with their inflorescence (Rao et al., 2018).

Figure 3 Plants of finger millet with their inflorescence (Rao et al., 2018).

is believed to be the native of Ethiopian highlands. Finger millet can be cultivated in the high altitudes of over 2000 m furthermore, has a high degree of drought tolerance (Chandrashekar, 2010). The optimal growth temperature for finger millet production is about 27 °C, with a minimum temperature of 18 °C. Finger millet can be cultivated from 500 to about 2400 m above mean sea level. It is also highly tolerant to soil salinity. But finger millet is sensitive to waterlogging. Finger millet is also tolerant of acidic soils (pH 5), and alkaline soils (pH 8.2). This crop produces tillers with erect and light green coloured stems around 1.7 m in height (Prasad & Staggenborg, 2010), smooth leaves which are hairy along the margins. The inflorescence is comprised of fingers with a cluster of 3–26, it has dense spikelets (Thapa & Tamang, 2004). Finger millet crop doesn't mature uniformly, and therefore its maturity is taken up when the earhead on the main shoot as well as 50% earheads on the crop turn brown. The later process like cutting, drying, threshing and cleaning is carried out in the same order. Finger millet produces grains of size 1–2 mm diameter, with colour usually from the light brown or dark brown (Brar et al., 2019; Udeh et al., 2018).

Conclusions and Future Roadmap

Climate change will negatively impact agricultural production, but a rational and cost-effective method to build resilience into agrarian systems is the implementation of crop diversification. This would enable farmers to increase their crop portfolio so that they are not dependent on a single crop to generate their income. Besides, depleting water resources and smaller landholdings calls

for the judicious utilisation of these resources for the sustainability of agricultural growth. Diversifying from the monoculture of traditional staples shall have critical nutritional benefits as well as augment farmers' income in developing countries. In India, these are considered to have been cultivated since pre-historic times.

Although millets are gluten-free with a micro-nutrients profile much better than rice and wheat, millets have faced a lot of neglect in the Indian subcontinent as the population is getting more aware of the challenges of food security and climate change the growers and even projects are now favouring them are also getting funding. The points that favour the millets cultivation is the tolerance to biotic and abiotic conditions, and their ability to delay climate change. Previously, in the last several decades Indian farmers have ignored the millets for rice, wheat, oilseeds and pulses. As compared to the 5000 litres of water requirement for one-kilogram rice, there is 250–300 litres of water required for the production of the equivalent amount of millets. New ways of food processing are necessary to revert the dietary habits in favour of millet-based diets. There should be more economical initiatives for the farmers taking up the millet cultivation. Likewise, advertising strategy is actually required for targeting the growers facing the problems in marketing their products based on minor millets.

Conflict of Interest

The authors declare no conflict of interest

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