Environment and Ecology 40 (4D) : 2822—2828, October—December 2022
ISSN 0970-0420

Finger Millet: A Potential and Sustainable Crop for Hilly Region of Uttarakhand

Shivangi Negi

Received 2 August 2022, Accepted 2 November 2022, Published on 14 December 2022

ABSTRACT

Finger millet is an important crop among the small millets and third among millets in the area and production after sorghum and pearl millet in India. It is cultivated as a rainfed crop for its valued food grains and adaptability to a wide range of geographical areas and agro-ecological diversity in India. Finger millet occupies an important place in the agriculture of the Uttarakhand hilly regions. Apart from being a source of food, finger millet provides fodder for cattle which thereby reduces the pressure on rangelands and forests and helps to balance the delicate ecosystem of the Himalayas. Ragi is commonly called as "Nutritious millet" as the grain are nutritionally superior to other cereals providing a fair amount of proteins, minerals, calcium and vitamins in abundance to the people. Finger millet is an excellent source of methionine, Ca, Fe, Mn. It is appreciated by the people because it gets digested slowly thereby furnishing energy required for hard work throughout the day. The protein of finger millet has been reported to possess a fairly high biological value, which is needed for the maintenance of nitrogen equilibrium of the body. It has crude fiber content, which supply energy for a long time after consumption. There is a high demand for finger millet due to its high nutritional value with appealing flavor and taste. Finger millet possesses tremendous potential for product diversification. However, awareness about the inclusion of millets in our daily meals for healthy living is needed.

Keywords Diversification, Meal, Ragi, Rainfed, Small millet, Uttarakhand.

INTRODUCTION

Millets are one of the cereals besides the major cereals i.e. wheat, rice and maize. Millets are major food sources for millions of people, especially those who live in hot and humid areas of the world (Rani *et al.* 2017). They are grown mostly in marginal areas under those agricultural conditions in which major cereals fail to give substantial yields (Adekunle 2012, Wang *et al.* 2018). Millets are one of the oldest foods known to humans and possibly the first cereal grain to be used for domestic purposes (Maitra and Shankar 2021). Millets are small-seeded grasses that are hardy, thus grow well in dry zones as rain-fed crops under marginal conditions of soil fertility and moisture. Millets are unique from major cereals crops due to their short growing season (Michaelraj and Shanmugam 2013, Sarkar and Dutta 2014).

Shivangi Negi
Dept of Agriculture, Tula's Institute, Deheradun, Uttarakhand 248197, India
Email : shivanginegi002@gmail.com

Fig. 1. Field view of finger millet in hilly region of Uttarakhand.

Millets are small-seeded grasses and are distributed in about 10 genera and 20 species. Most of the small millets have their origin mainly in Asia and Africa (Shingane *et al.* 2018). The most important domesticated areas are East Asia, India sub-continent and Ethiopian high lands of Africa. It is cultivated mostly as a rainfed crop for its valued food grains, dry fodder and adaptability to a wide range of geographical areas (Ulaganathan and Nirmalkumari,2014, Negi *et al.* 2017a, Negi *et al.* 2017b). The term Millet (A Nutritional Crop) is applied to various grass crops whose seeds are harvested for human food or animal feed (Patil *et al*. 2018, Mubeena *et al*. 2019). Millets include five species, *Panicum*, *Setaria*, *Echinochloa*, *Pennisetum* and *Paspalum* (Beaglehole and Yach 2003). Small millets have a long history of cultivation in India and a large number of millets are grown in different parts of the country, making India a hub of small millets (Bisht and Singh 2009, Kujur *et al*. 2018). Among all the millets, Finger millet is the most common crop grown in different parts of the world including India (Ravi *et al.* 2016, Arshewar *et al.* 2018).

Finger millet (*Eleusine coracana* (L.) Gaertn. 2n=4x=36) belongs to the family *Poaceae* and is widely cultivated in the arid and semi-arid regions of the world. The term *Eleusine* is derived from Eleusis, an old epic city sacred to Demater, the Greek deity presiding over agriculture. The term coracana is derived from kurukkan, the singhali name of the grain. The word Ragi is derived from Sanskrit word "Rajika" means red. Finger millet is important millet grown extensively in various regions of India and Africa, constitutes as a staple food for a large segment of the population in these countries. It ranks sixth in production after wheat, rice, maize, sorghum and bajra in India (Joshi and Katoch 1990, Devi *et al*. 2014, Bhatt *et al.* 2003). Finger millet is an important but underutilized crop in tropical and semiarid regions of the world. Finger millet has greater resistance to pests and diseases, good adaption to a wide range of environment and good yield of production. It can withstand significant levels of salinity and short growing season (Gebreyohannes *et al*. 2021). It is resistant to water logging, drought tolerant, requires little inputs during growth and with an increasing world population and decreasing water supplies makes it an important crop for future human use. The drought tolerance of finger millet may be attributed to an efficient antioxidant potential and increased signal perception (Wambi *et al.* 2020). Being a hardy crop, it is relatively easy to grow finger millet under stressful regimes, without hampering the net productivity. There is a vast potential to process millet grains into value-added foods and beverages in developing countries (Asharani *et al.* 2010). Furthermore, millets, as they do not contain gluten and therefore it is advisable for stomach (abdominal) patients (Chandrasekara and shahidi 2010, Chandra *et al.* 2016).

Uttarakhand state with diverse agro-climatic endowments, the plains and hills present differing scenarios for agriculture (Fig.1). The commercial agriculture is practiced in the plains while the hilly region farmers mainly practice subsistence farming. The hills practice mixed cropping, while in the plains in a given season single crops are grown mostly. In Uttarakhand more than 75% of the population depends on agriculture for their livelihood.

Scenario of finger millet production in Uttarakhand

Finger millet is an important small millet grown in India. It is a staple food in many hilly regions of the country. It is grown both as grain and forage. Finger millet is a crop of tropical and subtropical climate and can be cultivated up to an altitude of 2100 m. It is a heat-loving plant and for its germination, the minimum temperature required is 8–10°C. A mean temperature range of 26–29°C during the growth is the best for proper development and good crop yield. Finger millet can be grown on a wide range of soils as

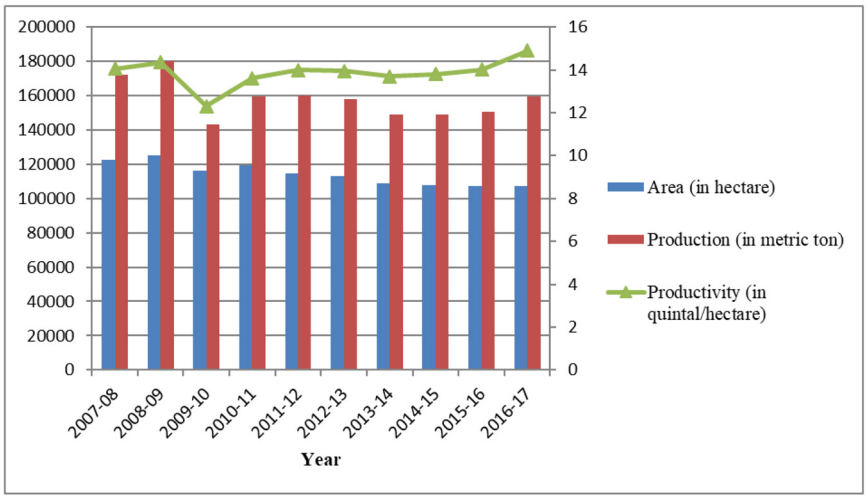

Fig. 2. Graphical representation of area, production and productivity of finger millet in Uttarakhand.

well, from very poor to very fertile and can tolerate a certain degree of alkalinity. The best soil is alluvial, loamy and sandy soil with good drainage. In *kharif* season ragi is grown in June–July and in *rabi* season September–October. Uttarakhand basically depends on dryland/rainfed farming system. In this practice of cultivating land, this derives water only through rains. Hence, an understanding of rainfall patterns and land characteristics is crucial for optimizing the use of available water for dryland crops. Finger millet one of the most important dryland crop among small millets which are being cultivated in larger parts of Uttarakhand from ancient times. Ragi is the most viable option in the dryland conditions as it requires minimum water and can withstand in adverse weather conditions.

Table 1. Area, production and productivity of finger millet.

Year	Area (ha)	Production (metric ton)	Productivity (kg ha^{-1})
2007-08	122498	172157	1405
2008-09	125399	179826	1434
2009-10	116162	142978	1231
2010-11	119207	159286	1362
2011-12	114511	160034	1398
2012-13	113210	157792	1394
2013-14	108656	148803	1370
2014-15	107904	149033	1381
2015-16	107427	150572	1402
2016-17	107175	159606	1489

In Uttarakhand, finger millet is locally called as Mandua and has been grown since times immemorial and successfully maintaining high productivity. Over time, they have developed diverse, locally suitable and beneficial varieties productivity has been gradually increasing in the last ten years on a sustainable basis, in spite of small and scattered land holdings, complex agriculture, low soil fertility, scarcity of human labor and poor economic viability of the farmers. Production technologies have been developed giving the highest emphasis to low and no-cost technologies (Joshi *et al.* 2021). Small millets occupy an important place in the agriculture of the Himalayan region of Uttarakhand state. Apart from being a source of food, they provide fodder for cattle which thereby reduces the pressure on grazing fields and forests and helps to balance the delicate ecosystem of the Himalayas. Small millets are grown up to an altitude of 3000 m above sea level in both pure and mixed stands and under *Jhuming* (shifting) cultivation. Pure stands of finger and barnyard millets are common in the mid-hills, while in the north-eastern hilly region, foxtail millet is largely grown as a mixed crop.

Finger millet holds a large share of agricultural output in Uttarakhand and grown in about all the

Table 2. District wise production of finger millet in Garhwal region of Uttarakhand.

Districts	Area (ha)		Production (Mt)		Productivity (kg ha^{-1})	
	2015–16	2016–17	2015–16	2016–17	2015–16	2016–17
Chamoli	9193	9212	13830	14446	1504.4	1568.0
Dehradun (Hilly)	551	677	824	1072	1495.5	1583.0
Dehradun (Plain)	197	175	280	280	1419.0	1600.0
Pauri	19369	21546	27048	29750	1400.0	1400.0
Rudraprayag	5685	5670	8576	9164	1508.5	1616.0
Tehri	10759	10538	16962	18173	1576.5	1725.0
Uttrakashi	4968	4951	9067	8167	1825.1	1650.0

districts. As it shown in Table 1 and Fig. 2, in the year 2015-16 and 2016-17, the coverage area of finger millet in Uttarakhand was 107.427–107.175 tha with a % decrease of 0.235. The total production in 2015-16 and 2016-17 was 150.572-159.606 tMt with a 6% increase. The average productivity of finger millet was 1402–1489 kg ha^{-1} in 2015-16 and 2016-17 and the increase in productivity was 6.205%.

Uttarakhand contributes a major part in the production of finger millet in the country. The finger millet is grown in both hilly and plain region of Garhwal and Kumaunthe. In the year 2016-17 Districts Chamoli, Tehri, Uttarkashi, Dehradun, Pauri, Haridwar and Rudrapryag of Garhwal Himalaya grow Ragi in the 53769 ha area with the production of 81052 Mt. In Almora, Champawat, Bageshwar, Udham Singh Nagar, Nainital and Pithoragarth districts of Kumaun region, Ragi is grown in the area of 54406 ha with the production was 78554 Mt in the year 2016-17. Districts wise production of finger millet in Garhwal and Kumaun is reviewed in Tables 2 – 3. The total area covered with finger millet in 2016-17 was 107175 ha.

Nutritional value

Nutritionally, finger millet is a good source of nutrients especially of calcium, other minerals and fiber. The total carbohydrate content of finger millet has been reported to be in the range of 72—79.5% (Joshi and Katoch 1990, Bhatt *et al.* 2003). Ragi is commonly called as "Nutritious millet" as the grain is nutritionally superior to many cereals providing a fair amount of proteins, minerals, calcium and vitamins in abundance to the people. It contains almost all the nutrients like protein (6–13%), carbohydrates (65–75%) and fat (1.29%). It is very rich in minerals (2.5–3.5%) such as calcium (452 mg 1000 g^{-1}), iron (3.90 mg 100 g^{-1}) and ash (3.90%) which are the core ingredients of normal human diet (Pandey and Kumar 2005). Millet also contains 3.6 % crude fiber, 19.1 mg/ 100 g. total dietary fiber, 102 mg/100 g total phenols and 72.6 g carbohydrates (Souci *et al.* 2000, Chandra *et al.* 2016). Finger millet is an excellent source of methionine, Ca, Fe, Mn. It is appreciated by the people because it gets digested slowly thereby furnishing energy required for hard work throughout the day. Many food preparations are made from ragi flour e.g. idlies, dosas, roties and uji. The protein of finger millet has been reported to possess a fairly high biological value, which is needed for the maintenance of nitrogen equilibrium of the body. It has crude fiber content (3–4%) to supply energy for a long time after consumption and thus whole day sustenance, high

Table 3. District wise production of finger millet in Kumaun region of Uttarakhand.

Districts	Area (ha)		Production (Mt)		Productivity (kg ha^{-1})	
	2015–16	2016–17	2015–16	2016–17	2015–16	2016–17
Almora	36696	36007	43743	49635	1192.0	1378.0
Bageshwar	5435	5364	7295	8698	1342.2	1622.0
Champawat	5171	4403	8220	6929	1589.6	1600.0
Nainital	2748	2264	4246	3348	1545.1	1479.0
Pithoragarh	6655	6368	10481	9944	1574.9	1562.0

Table 4. Mineral and vitamin composition of finger millet.

Minerals and vitamins	Composition (mg 100 g^{-1})
Ca	344
P	283
Fe	3.9
Mg	137
Na	11
K	408
Cu	0.47
Mn	5.49
Zn	2.3
Thaimine	0.42
Riboflavin	0.19
Niacin	1.1

cholesterol formation and intestinal cancer. Hence, people suffering from diabetics are advised to take finger millet and other small millets instead of rice (Malleshi and Hadimani 1993). Finger millet is important because of its excellent storage properties and nutritive value (Shashi *et al.* 2007). Its dietary fiber and mineral content are markedly higher than wheat, rice and a fairly well–balanced protein (Ravindran 1991). Millets have a hypoglycemic effect, which is attributed to high fiber content. The complex carbohydrates along with the fiber are slowly digested and absorbed thus bring a reduction in postprandial glucose (Geetha and Parvathy 1990).

The nutraceutical importance of finger millet lies in its high content of phytates (0.48%), tannins (0.61%), phenolic compounds (0.3–3%) and trypsin inhibitory factors and is recognized for its health beneficial effects, such as anti-diabetic, antitumorigenic, anti-diarrheal, antiulcer, anti-inflammatory, antioxidant and antimicrobial properties (Devi *et al.* 2014, Singh *et al.* 2019). The nutritional and mineral composition of finger millet is shown in Table 4 (Chandra *et al.* 2016). Earlier it was believed that polyphenols, phytates, tannins and dietary fiber contents of finger millet act as anti-nutrients because of their metal chelating and enzyme inhibition activities but now it has been confirmed that these constituents can contribute to antioxidant activity, which is an important factor in resisting aging and metabolic diseases (Thompson 1993). Millets possess unique nutritional characteristics specifically have complex carbohydrates, rich in dietary fiber as well as unique in phenolic compounds and phytochemicals having medicinal properties.

Finger millet is milled with the testa which is generally rich in dietary fiber and micronutrients to prepare flour and the whole meal is utilized in the preparation of traditional foods (Devi *et al.* 2014). On daily consumption of whole grain of finger millet and its products can protect against the risk of cardiovascular diseases, type II diabetes and gastrointestinal cancers and other health issues (McKeown *et al.* 2002). The dietary fiber, minerals, phenolics and vitamins concentrated in the outer layer of the seed coat form the part of the food and offer their nutritional and health benefits (Antony *et al.*1998). Finger millet grain also contains some amount of tannin and phenolic contents. Grains with light colored types contain much lower total phenolics and tannin compared to brick red pigmented types. Red colored varieties having pigmented testa are known to contain much tannin content and these are located in the said tissue of the grain (Siwela *et al.* 2007). Finger millet (*Eleusine coracana*), also known as ragi is a good source of carbohydrate, protein, dietary fiber and minerals and an important staple food for people under low socio-economic group and those suffering from metabolic disorders like diabetes and obesity (Mathanghi and Sudha 2012). It is important because of its excellent storage properties and nutritive value (Shashi *et al.* 2007). Its dietary fiber and mineral content is markedly higher than wheat, rice and have a fairly well-balanced protein (Ravindran 1991).

Finger millet contains amino acids in concentrations exceeding those of FAO/WHO recommended standards. It has high levels of methionine and lysine (Mbithi-Mwikya *et al.* 2000), which are lacking in the diets based on starchy foods. The finger millet grains are superior to rice and wheat as it contains essential amino acids such as methionine and tryptophan, (Fernandez *et al.* 2003). Finger millet is appreciated for its slow digestibility thereby furnishing energy throughout the day. The plant itself is reported to be diaphoretic, diuretic and vermifuge and its leaf juice has been given to women in childbirth. It has also been used as a folk remedy for various ailments including leprosy, liver disease, measles, pleurisy, pneumonia and smallpox (Dida and Devos 2006). The

high fiber content of finger millet helps in preventing constipation, high cholesterol formation, diabetes and intestinal cancer (Devi *et al.* 2014). Rich in carbohydrate, energy and nutrition thereby making finger millet an important ingredient of dietary and nutritional balanced foods. The regular use of finger millet as a nutrient and its products helps in managing different diseases (Chandra *et al.* 2016).

CONCLUSION

The high demand of finger millet is due to its high nutritional value with appealing flavor and taste. As finger millet is predominantly grown in marginal and submarginal lands by farmers, the fluctuations in production not only bring hardship to farmers but also create volatility in the total coarse cereal production. Millets are the last true agricultural crops and all steps must be taken by the state to conserve and promote them for food and nutritional security of the nation.

REFERENCES

Adekunle AA (2012) Agricultural Innovation in Sub-Saharan Africa: Experiences from Multiple Stake Holder Approaches. Forum for Agricultural Research in Africa, Ghana, 65. ISBN 978-99881.8373-2-4.

Antony U, Moses LG, Chandra TS (1998) Inhibition of *Salmonella typhimurium* and *Escherichia coli* by fermented flour of finger millet (*Eleusine coracana*). *World J Microbiol Biotech* 14 : 883—886.

Arshewar SP, Karanjikar PN, Dambale AS, Kawde MB (2018) Effect of nitrogen and zinc levels on growth, yield and economics of pearl millet (*Pennisetum glaucum* L.). *Int J Biores Stress Manage* 9 (6) : 729—732.

Asharani VT, Jayadeep A, Malleshi NG (2010) Natural antioxidants in edible flours of selected small millets. *Int J Food Properties* 13 (1) : 41—50.

Beaglehole R, Yach D (2003) Globalisation and the prevention and control of non-communicable disease : The neglected chronic diseases of adults. *Lancet* 362 : 903—908.

Bhatt A, Singh V, Shrotria PK, Baskheti DC (2003) Coarse grains of Uttaranchal: Ensuring sustainable food and nutritional security. *Ind Farmer's Digest* 7 (1) : 34—38.

Bisht BS, Singh DP (2009) Agriculture in Uttarakhand hills. Directorate of Experimental Station. GB Pant University of Agriculture and Technology, Pantnagar, pp 11—17.

Chandra D, Chandra S, Pallavi, Sharma AK (2016) Review of finger millet (*Eleusine coracana* (L.) Gaertn) : A power house of health benefiting nutrients. *Food Sci Human Wellness* 5 (3) : 149—155.

Chandrasekara A, Shahidi F (2010) Content of insoluble bound phenolics in millets and their contribution to antioxidant capacity. *J Agricult Food Chem* 58 (11) : 6706—6714.

Devi PB, Vijayabharathi R, Sathyabama S, Malleshi NG, Priyadarisini VB (2014) Health benefits of finger millet (*Eleusine coracana* L.) polyphenols and dietary fiber : A review. *J Food Sci Technol* 51 (6) : 1021—1040.

Dida MM, Devos KM (2006) Finger millet. In : Kole C. (ed). Cereals and Millets. Springer, New York, pp 333—343.

Fernandez DR, Vanderjagt DJ, Millson M, Huang YS, Chuang LT, Pastuszyn A (2003) Fatty acid, amino acid and trace mineral composition of *Eleusine coracana* (Pwana) seeds from northern Nigeria. *Pl Foods Human Nutrition* 58 : 1–10.

Gebreyohannes A, Shimelis H, Laing M, Mathew I, Odeny DA, Ojulong H (2021) Finger millet production in Ethiopia : Opportunities, problem diagnosis, key challenges and recommendations for breeding. *Sustainability* 13 : 13463. DOI https://doi.org/ 10.3390/su1323—1346.

Geetha C, Parvathi EP (1990) Hypoglycemic effect of millet incorporated breakfast items on selected non-insulin dependent diabetic patients. *Ind J Nutrition Dietetics* 27 (11) : 316—320.

Joshi DC, Sood S, Gupta A, Khulbe RK, Pandey B, Pal R, Lakshmi Kant MSB (2021) VL Mandua 382 : The first early maturing, white seeded finger millet cultivar suitable for rainfed organic agro-ecology of the Himalayan region. *Elect J Pl Breed* 12 (4) : 1308—1313.

Joshi HC, Katoch KK (1990) Nutritive value of millets : A comparison with cereals and pseudocereals. *Himalayan Res Develop* 9 : 26—28.

Kujur S, Singh VK, Gupta DK, Tandon A, Ekka V, Agrawal HP (2018) Influence of weed management practices on weeds, yield and economics of finger millet (*Eleusine coracana* L. Gaertn). *Int J Bio-res Stress Manage* 9 (2) : 209—213.

Maitra S, Shankar T (2021) Agronomic management in little millet (*Panicum sumatrense* L.) for enhancement of productivity and sustainability. *Internat J Biores Sci* 6 (2) : 91—96.

Malleshi NG, Hadimani NA (1993) Nutritional and technological characteristics of small millets and preparation of value-added products from them. In : Proceedings of the Second International Small Millet workshop. Bulawayo, Zimbabwe, 23 August.

Mathanghi SK, Sudha K (2012) Functional and phytochemical properties of finger millet (*Eleusine coracana*) for health. *Int J Pharmac*, *Chem Biol Sci* 2 (4) : 431—438.

Mbithi-Mwikya S, Ooghe W, Van Camp J, Nagundi D, Huy-ghebaert A (2000) Amino acid profiles after sprouting, autoclaving and lactic acid fermentation of finger millet (*Eleusine coracana*) and kidney beans (*Phaseolus vulgaris* L.). *J Agric Food Chem* 48 (8) : 3081—3085.

McKeown MN, Meigs JB, Liu S, Wilson PW, Jacques PF (2002) Wholegrain intake is favorably associated with metabolic risk factors for type 2 diabetes and cardiovascular disease in the Framingham Offspring Study. *Am J Clinical Nutrition* 76 (2) : 390—398.

Michaelraj PSJ, Shanmugam A (2013) A study on millets-based cultivation and consumption in India. *Int J Marketing, Financial Services & Manage Res* 2 (4) : 2277—3622.

Mubeena P, Halepyati AS, Chittapur BM (2019) Effect of date of

sowing and nutrient management on nutrient uptake and yield of foxtail millet (*Setaria italica* L.). *Int J Bio-res Stress Manage* 10 (1) : 92—95.

Negi S, Bhatt A, Kumar V (2017a) Character association and path analysis for yield and its related traits in finger milllet *Eleusine coracana* (L.) Gaertn genotypes. *J Appl Natural Sci* 9 (3) : 1624—1629.

Negi S, Kumar V, Bhatt A (2017b) Morphological characterization and genetic analysis of finger millet (*Eleusine coracana* (L.) Gaertn) germplasm. *Int J Bio-res Stress Manage* 8 (3) : 8 (3) : 469—472.

Pandey PK, Kumar GS (2005) Finger millet : A flair for human nutrition in Uttaranchal. *Ind Farmers Digest* 38 (9) : 28—30.

Patil AH, Dubey M, Sao A, Chandel G (2018) Characterization of minor millets (*Panicum sumatrense* and *Eleusine coracana*) for trait related to moisture stress tolerance. *Int J Biores Stress Manage* 9 (2) : 224—230.

Rani YS, Triveni U, Patro TSSK (2017) Integrated nutrient management for enhancing the soil health, yield and quality of little millet (*Panicum sumatrense*). *Int J Biores Stress Manage* 8 (1) : 26—32.

Ravindran G (1991) Studies on millets : Proximate composition, mineral composition, phytate and oxalate content. *Food Chem* 39 (1) : 99—107.

Ravi SC, Umesh KB, Bellundagi V (2016) Economic analysis of yield gap and its implication on profitability of finger millet (*Eleusine coracana* L.) production in Karnataka. *Int J Bio-res Stress Manage* 7 (2) : 286—290.

Sarkar S, Dutta SC (2014) Influence of fertilizer loaded nanoclay superabsorbent polymer composite (NCPC) on dynamics of P and N availability and their uptake by Pearl millet (*Pennisetum glaucum*) in an inceptisols. *Int J Bio-res Manage* 5 (2): 221—227.

Shashi BK, Sunanda S, Shailaja H, Shankar AG, Nagarathna TK (2007) Micronutrient composition, antinutritional factors and bio-accessibility of iron in different finger millet (*Eleusine coracana*). *Karnataka J Agric Sci* 20 (3) : 583—585.

Shingane S, Patil JV, Gomashe S, Chand D (2018) Assessing genetic diversity among foxtail millet (*Setaria italica* (L.) P. Beauv.) accessions using RAPD and ISSR markers. *Int J Bio-res Stress Manage* 9 (1) : 1—6.

Singh RB, Khan S, Chauhan AK, Singh M, Jaglan P, Yadav P (2019) Millets as functional food, a gift from Asia to Western world. In: Singh RB, Watson RR, Takahashi T (eds). The Role of Functional Food Security in Global Health. Academic Press, Elsevier, Amsterdam, pp 457—468. DOI 10.-10.101610.101610.1016/C2016-0-04169-4.

Siwela M, Taylor JRN, De Milliano WAJ, Duodu KG (2007) Occurrence and location of tannins in finger millet grain and antioxidant activity of different grain types. *Cereal Chem* 84 (2) : 169—174.

Souci SW, Fachmann W, Kraut H (2000) Food composition and nutrition tables (8th edn). Stuttgart wissenschaft verlags Gmb H, Stuttgart, pp 1182.

Thompson LU (1993) Potential health benefits and problems associated with antinutrients in foods. *Food Res Int* 26 (2) : 131—149.

Ulaganathan V, Nirmalakumari A (2014) Genetic variability and correlation studies for quantitative traits in finger millet [*Eleusine coracana* (L.) Gaertn] germplasm. *The Ecoscan* 5 (6) : 21—25.

Wambi W, Otienno G, Tumwesigye W, Mulumba J (2020) Genetic and genomic resources for finger millet improvement : Opportunities for advancing climate-smart agricult ture. *J Crop Improvem* 35 (2) : 204—233.

Wang J, Vanga S, Saxena R, Orsat V, Raghavan V (2018) Effect of climate change on the yield of cereal crops : A review. *Climate* 6 (2) : 41—47.