ISSN: 0975-8585

Research Journal of Pharmaceutical, Biological and Chemical Sciences

# Foxtail Millet a Fortifying Climate-Resilient Crop for Sustainable Agriculture and Nutrition.

**Nisha Choudhari[1], Shital Kadam[2]*, Kirti Nitnaware[3], Yogesh Jorapur[4], and Vinayak Lokhande[5].**

[1]Department of Botany, KES'S, Pratibha College of Commerce and Computer Studies, Chinchwad, Pune, Maharashtra, India,
[2] Department of Botany, Dr. D.Y. Patil Arts, Commerce and Science College, Pimpri, Pune, Maharashtra, India,
[3] Department of Botany, Hutatma Rajguru Mahavidyalaya, Rajgurunagar, Maharashtra, India.
[4]Department of Chemistry, KES'S, Pratibha College of Commerce and Computer Studies, Chinchwad, Pune, Maharashtra, India,
[5]J.T.S.S.P.M. Shri Shiv Chhatrapati College of Arts, Commerce and Science, Bodkenagar, Junnar, Pune, Maharashtra, India - 410502.

**ABSTRACT**

Foxtail millet (*Setaria italicaa* (L.) Beauv.) is an ancient cereal grain that has been cultivated for thousands of years, primarily in arid and semiarid regions of Asia and Africa. Despite its rich cultural heritage and potential as a environmentally adaptive crop, foxtail millet has been largely overshadowed by major cereal crops like rice, wheat, and maize in terms of research, investment, and global attention. This paper provides a comprehensive overview of the current status of foxtail millet as a underutilized crop, examining its historical significance, agronomic characteristics, nutritive profile, and its potential to address emerging challenges in agriculture and food security. The research underscores the distinctive environmental adaptations of foxtail millet, showcasing its ability to thrive in marginal and water-stressed environments, making it a promising candidate for eco-friendly farming practices in the face of climate change. While recognizing the potential benefits, the paper also discusses the existing constraints and challenges associated with foxtail millet cultivation, including limited genetic diversity, inadequate agronomic practices, and underdeveloped value chains. Furthermore, this exploration will unravel the nutritional ability of foxtail millet. Through this all-inclusive overview, this paper aim to shed light on the underappreciated grain that may well play a crucial role in shaping the future of eco-friendly farming practices and nutrition.

**Keywords:** foxtail millet, nutritive profile, challenges, eco-friendly farming practices, agronomic practices.

***Corresponding author***

ISSN: 0975-8585

## INTRODUCTION

Millet is a general term used to group together small-seeded grasses, commonly known to as Nutri-cereals or Dryland-cereals. This group includes a variety of small-grained cereal crops such as Pearl Millet (Bajra), Sorghum (Jowar), Finger Millet (Ragi), Little Millet (Kutki), Foxtail Millet (Kangani or Rala), Proso Millet (Cheena), Barnyard Millet (Sawa), Kodo Millet (Kodon), and various other millet varieties, [6,12].

According to agricultural data, foxtail millet holds the position of being the second most produced millet worldwide, after pearl millet [34]. Its significance is obvious in its well-known consumption as a staple food in various countries, including China, India, Korea, Japan, and Nepal. This millet variety is cultivated extensively for both grains and fodder across Asia, Europe, North America, Australia, and North Africa [34]. Nonetheless, over the previous 65 years, foxtail millet cultivation has significantly decreased in the particular setting of India. From 9.2 million hectares in 1949 to just 0.72 million hectares in 2014, the amount of arable land has drastically decreased, according to official figures (Government of India, 2022). Significant shifts in land use patterns and agricultural methods over a certain time span are reflected in this drop.

According to FAO, 2018 data, India is the leading Millet producing country in the world followed by Nigeria and China. In India, Rajasthan is the leading small-grained cereal crops producing state followed by Maharashtra and Gujarat [1]. In the world of traditional cereals, Foxtail millet stands as a robust and long-lasting cereal that has been cultivated across the arid and semiarid landscapes of Asia and Africa for periods. Foxtail millet is one of the ancient grown crop known for thousands of years, playing a vital role in the agriculture of various nations, dating back to around 8,000 to 10,000 years ago in China. The crop has been in India, approving ancient cultivation, was mentioned in many names in Sanskrit to as Bhavaja, Rajika, and Priyaguka etc. Traditionally, foxtail millet, a short-growing, warm-season plant, grow into an main food crop by second millennium BC as its ability to reduce agricultural risk and was grown as a Cost effective rain-fed summer crop, [21]. Its ability to flourish in different climates, to become this crop as a popular for cultivation in worlds various regions.

In spite of its rich cultural heritage and proven adherence to difficult environmental settings, Foxtail millet is gaining compliments for its rich nutritional value and potential as a sustainable energy and protein source, seeds that possess health-promoting properties owing to its distinct protein composition containing a high content of essential amino acids. The mature foxtail seeds mainly consist of proline-rich, alcohol-soluble proteins (prolamin) called setarins, additionally there is vast potential for surely producing low-cost, protein-rich functional food products helpful in the prevention and management of lifestyle-related chronic diseases including essential micronutrients and dietary fiber, as a valuable resource for combatting nutritional deficiencies and improving human health. [21]. Purpose of this study is to focus on foxtail millet, taking consideration to its agronomic characteristics, historical significance, Genomic and nutritive profile.

### Botanical Characteristics

**Figure 1: Foxtail millet (in field & grains)**

Foxtail Millet (Setaria italica), an annual cereal crop plant belonging to family Poeacae, It is the earliest cultivated grass species and its inflorescence of spike look like the tail of Fox to its bushy panicum. The botanical characteristics of the foxtail millet are as follows:

**Taxonomical classification**

Kingdom: Plantae
Class: Monocotyledon
Order: Poales
Family: Poaceae
Genus: Setaria
Species: italica
Synonym: Panicum italicum L.
Common name: Foxatil millet (English)
Rala (Marathi, Hindi)
Navane (Kannada)
Korra (Telugu)
Thinai (Malyalam)

**Morphological Characteristics:**

The annual grass known as foxtail millet has a thin, upright, green stem. Usually, the plant grows to a height of 30 to 120 cm. The leaves are tiny, linear, and alternate along the stem. They can vary in length and are typically glabrous (hairless). The panicle-like inflorescence is distinguished by a thick spikelet cluster that is bristly. Along the panicle branches, the tiny spikelets are grouped in a spike like or cylindrical pattern. The tiny, ovate grains of foxtail millet are often yellow or brown in hue. Usually, one seed is present in each spikelet. In the case of grain seed production, it is self-pollinating and will yield seeds in 85 to 95 days. It is very adaptive to abiotic stressors, particularly poor soil and drought. According to Lata et al [14], foxtail millet seeds can be white, yellow, orange, brown, red, black, or gray.

**Agronomic Characteristics**

Foxtail Millet is well adapted to hot and arid regions. It is a drought-resistant crop suitable for rain-fed agriculture. It grows in various soils such as sand, loam and clay. Well-drained soil is preferred for good growth. Depending on the variety, millet's growing season is typically between 60 and 90 days. Foxtail millet is a short-duration cereal crop known for its adaptability, disease resistance and nutritional value. The Millet has vibrant adaptability to abiotic stresses, particularly in drought, and deprived soil. Foxtail millet have seeds with several colors, such as yellow, orange, white, brown, red, black and gray. Foxtail millet is rich in minerals, nutrients and bioactive compounds and its proper growth depend on manures, synthetic fertilizers, regular irrigation and pesticide and weedicide. They serve as an excellent resource material for abiotic stress related gene function dissection and elite allele mining.

**Table 1: Different varieties of foxtail millet grown in Indian states.**

| State | Millets Varities |
|---|---|
| Maharashtra | Krishnadevaraya; Prasad, SiA -3156, Surya Nandhi, Sri Lakshmi, and Narasimha Raya |
| Andhra Pradesh | SiA 2644, SiA 3085, SiA 3088, SiA 3156, SiA 3085, Lepakshi, SiA 326, Narasimharaya, Krishnadevaraya, PS-4, Srilaxmi |
| Karnataka | SiA 326, HMT 100-1, PS 4,Narasimharaya, SiA 3088, SiA 3156, SiA 3085, DHFt-109-3 |
| Tamil Nadu | TNAU 43, TNAU-186, TNAU 196, CO 1, CO 2, CO 4, CO 5, K2, K3, SiA 3088, SiA 3156, SiA 3085, PS-4 |
| Rajasthan | PrathapKangani (SR 1) and SR 51, SR 11, SR 16, SiA 3085, SiA3088, SiA-3156, |
| Uttarakhand | PS 4 and PRK 1, Sreelaxmi, SiA 326, SiA 3088, SiA 3156, SiA 3085, PS 4 |
| Bihar | RAU-1, SiA 3088, SiA 3156, SiA 3085, PS 4 |
| common to all States | Pratap (Kauni), M 145-1, Lepakshi, Kiran, Prasad, |

(Source: Chapke et al. [7])

**Growth and adaptability to different environments**

Foxtail millet is generally grow for food and forage in the arid and semi-arid regions of the world. With fluctuated environmental conditions this crop has potential to retain in minimal resources like poor soil quality, minimal water availability and high temperature, drought, pathogen and pest infection, and make them suitable for cultivation in challenging environments [5]. Foxtail millet reveals high efficiency in the usage of both nitrogen and water resources, leading to higher yields with lower inputs. This makes the crop well-suited for water-scarce and nitrogen-limited environments while maintaining productivity [27]. Foxtail millet is gained new attention due to its nutritive value and adaptability in different climatic conditions.

Foxtail millets show remarkable adaptability to different climates, ranging from tropical to temperate regions. They are known to thrive in arid and semi-arid conditions, making them a resilient crop in regions with water scarcity. Highlights the ability of foxtail small-grained cereal crops to withstand high temperatures and minimal water availability, making them suitable for cultivation in challenging environments.

Foxtail millets are known for their adaptability to various soil types, including sandy and loamy soils. They are less demanding in terms of soil fertility compared to some other cereals. Studies by Kumar et al. [13] emphasize the suitability of foxtail small-grained cereal crops for cultivation in marginal lands with poor soil quality. Foxtail millets are considered drought-tolerant and require less water compared to major cereal crops. Sehgal et al. [25] suggests that the efficient water use efficiency of foxtail small-grained cereal crops makes them suitable for rainfed agriculture, contributing to water conservation in agriculture. Foxtail millets are traditionally grown in tropical regions, where they serve as a staple food. Their ability to thrive in high-temperature conditions makes them suitable for cultivation in tropical climates.

**Climate Resilience**

Foxtail millet, a fast-maturing crop with a life cycle of 70–80 days, offers a significant advantage under climate change scenarios, particularly in arid and semi-arid regions. It thrives in regions with limited water availability, requiring less water than traditional cereals like rice, maize, and wheat [24]. Foxtail millet, like other millets, has adapted to survive drought and high-temperature stresses due to its C4 photosynthetic mechanism, efficient water and nitrogen use, and physiological traits such as small leaf area, thickened cell walls, and a dense, deep fibrous root system that stabilizes water availability [22]. Under moisture stress conditions, foxtail millet exhibits increased root length and enhanced antioxidant activity, including the accumulation of reactive oxygen species scavenging enzymes and amino acids, which help the plant tolerate environmental stresses [3]. Additionally, foxtail millet is resilient to high temperatures during its reproductive stage, withstanding temperatures up to 42°C during flowering, which makes it well-suited for cultivation in regions with rising temperatures due to climate change [9]. As temperatures are expected to rise significantly in South Asia by the end of the century, the resilience of foxtail millet to both drought and heat stress positions it as a valuable crop to replace more water-intensive cereals like maize in semi-arid regions [28].

**Nutritional Value**

Compared to rice and wheat, millets are a nutritious powerhouse. They boast higher protein levels, and their amino acid profile is more balanced. Additionally, small-grained cereal crops surpass some staple cereals in dietary fiber content. Millets are rich in phytochemicals, offering therapeutic benefits due to their anti-inflammatory and antioxidant properties. In major small-grained cereal crops list one of the millet is a Foxtail millet (Setaria italica) is a traditional cereal crop that has gained attention for its nutritional composition and potential health benefits. Here is an overview of the nutritional composition of foxtail millet based on existing literature. Because of its high carbohydrate content, foxtail millet is a strong source of energy. It contains complex carbohydrates, including dietary fiber, which contributes to its low glycemic index. Foxtail millet is a good source of plant-based proteins. The protein content is comparable to that of other cereals like rice and wheat but may vary depending on the specific variety. The high dietary fiber content of foxtail millet is well-known. Dietary fiber is essential for digestive health and can contribute to the management of conditions like obesity and diabetes, [30].

Niacin, thiamine, folic acid, and other B vitamins are among the several vitamins found in foxtail millet. Energy metabolism and general health are significantly impacted by these vitamins. Iron, magnesium, phosphorus, and zinc are among the essential minerals that are abundant in it. Numerous bodily processes, such as immunity, oxygen transport, and bone health, depend on these nutrients. Antioxidants found in foxtail millet aid in the body's defense against free radicals, improving general health and lowering the risk of chronic illnesses.

With high levels of essential micronutrients and dietary fiber, this traditional cereal emerges not just as a resilient crop but also as a potential solution to combat nutritional deficiencies and promote human health. With low glycemic index, Foxtail millet helps to control diabetes. This feature makes it a suitable choice for people with diabetes or diabetes management goals. Since foxtail millet does not naturally contain gluten, it is a good product for people with gluten sensitivity or celiac disease [33]. Small-grained cereal crops offer health advantages in addition to their remarkable nutritional characteristics. According to research, foxtail millet is a good source of protein, crude fiber, fat, carbohydrates, minerals (selenium, calcium, phosphorus, copper, magnesium, iron, potassium), fatty acids (palmitic acid, stearic acid, oleic acid, linoleic acid, linolenic acid, and arachidic acid), and vitamins (A, niacin, thiamine, riboflavin, E). [11].

**Genetic transformation in foxtail millet**

Millet is an ancient crop with high yields that can survive in adverse conditions. C4 photosynthesis and rich nutrient supply make it a good model to study plant stress. It is the best applicant due to its small genome (~515 Mb), short lifespan, and inbred traits. The release of the genome in 2012 accelerated research efforts and revealed genetic stress [21]. The genetic diversity and phenotypic diversity of foxtail millet enrich research. Advances in sustainable transformation and gene therapy promise to bring stress tolerance to important crops. The first *Agrobacterium*-mediated gene transfer study in millet was conducted in 2005 by Liu et al [17], and the transfer efficiency was 6.6%. Liu et al. [18] examined various factors affecting *Agrobacterium*-mediated transformation of millet, including genotype, explant source, inoculation time, and co-culture time. Pardo et al [23] developed a millet Si401 seed transgenic line using *Agrobacterium*-mediated transformation of ear-derived callus. Lost pollen grains, fibrous bands in endothelial cells, and premature tapetum degeneration are abnormalities during anther formation observed in silenced Si401 transgenic lines.

Liu et al. [16] used floret-derived embryogenic callus to examine SiPf40 overexpression and RNAi lines. The function of SiPf40 in auxin homeostasis and tillering is highlighted in this study. By improving the millet transformation process, Wang et al. [32] improved plant recovery results from immature flowers. An SBgLR transgenic line was generated using this modified technique with 5.5% efficiency. This method has also been used to evaluate the activity of SiARDP and SiASR4 genes in response to abiotic stress and SiLEA14 studies in extreme salt/long stress condition [31,15].

Mature seeds were used as explants to create a transformation system that was quite effective (~27%) [26]. The optimized protocol emphasized the superiority of secondary embryogenic calli, with factors like the LBA44404 strain and specific additives significantly enhancing transformation efficiency.

**Table 3: Genetic transformation studies reported in Foxtail millet**

| Method of transformation | Type of explant | Gene used | Cultivar | Application | Reference |
|---|---|---|---|---|---|
| Agrobacterium Tumefaciens LBA4404 | Callus from inflores cence | - | - | Optimization of transformation protocol | Liu et al., 2005 [17] |
| Agrobacterium Tumefaciens LBA4404 | Callus-panicle | Si401 | Cv.Jigu11 | Regulation of anther development process | Qin et al., 2008 [23] |
| Biolisitic | Florets | Sipf40 | Var. 3661 | Functional characterization of SiPf4 gene | Liu et al., 2009 [16] |

| | | | | | |
|---|---|---|---|---|---|
| Agrobacterium tumefaciens strain LBA4404 | Immature inflorescence - Callus | SBgLR | Cv.Jigu11 | Optimization of transformation protocol | Wang et al., 2011 [32] |
| | Callus | SiLEA 14 | Cv.Jigu11 | Drought and salinity tolerance | Wang et al., 2014 [31] |
| | Callus | SiARDP | Cv.Jigu11 | Drought and salinity tolerance | Li et al., 2014 [15] |
| tumefaciens strain LBA4404 | Callus | pCAMBIA1304 pB4NU binary vector | IC-403579 IC-487110 | Optimization of transformation protocol | Sood et al., 2019 [27] |

**Breeding strategies**

Foxtail millet is spherical, has small flowers and faces problems in crossbreeding and hybridization [29]. The main purpose of foxtail millet breeding is to produce varieties that have excellent nutritional properties and are important in terms of yield, disease resistance and stress. Various breeding methods such as hybridization, genetic modification, line selection, and size selection can help achieve these goals.

Pedigree selection has been beneficial to foxtail millet breeding worldwide, particularly in China, where significant progress has been made in increasing yields and producing disease-free males [31]. Recombinant breeding and hybridization techniques are important to increase the yield of this adaptable, nutrient-rich crop [10]. Exploitation of diseases requires strict evaluation of the mass, disease, and agricultural diseases [20]. Wide selection purifies and multiplies original diversity; On the other hand, the choice of lines based on the cross is still important in the Chinese house.

Hybridization is an important breeding method for millet followed by selection into separate groups. To promote hybrid vigor, crossbreeding began producing disease-free males. In India, approximately 60% of rice production is introduced to the market through local variety selection, approximately 30% through line selection and 5% through translocation [2]. However, the use of hybrid vigour in small small-grained cereal crops faces limitations due to the difficulty of hybridization.

**Exploring Omics Approaches for Gene Detection and Crop Improvement**

Genetics and genomics have made great progress in our understanding of small-grained cereal crops, but other omics technologies are not yet widely available, especially in foxtail millet. A recent study by Bandaophadhay and colleagues [4] used a genome-wide association study (GWAS) which revealed a significant set of nucleotide polymorphisms (SNPs) associated with good results such as number of nuclei per plant. They also developed indicators to measure differences in nitrogen response. Quantitative proteomic study on foxtail millet under drought stress reveals major changes. Of the proteins found, 252 showed upregulation of 1.5-fold or more, and 69 showed upregulation of less than 0.67-fold.

**Exploring Ecological Benefits**

Investigating the ecological benefits of foxtail millet cultivation, such as its contribution to biodiversity conservation, soil health improvement, and climate change mitigation, will be critical for promoting its adoption in sustainable farming systems. Research should assess the socioeconomic impacts of foxtail millet cultivation on farmers' livelihoods, rural communities, and nutritional security. This includes analyzing income generation potential, gender dynamics, and dietary diversity outcomes associated with foxtail millet production. Facilitating collaboration among researchers, policymakers, farmers, and industry stakeholders at the global level is essential for advancing foxtail millet research and adoption.

**Future Prospects**

Foxtail millet, an traditional cereal with significant nutritive profile, has long been neglected in agricultural practices. However, recent research has highlighted its potential as a sustainable and

nutritious crop, especially in the face of climate change and food security challenges. Investigating optimal agronomic practices, such as planting density, irrigation management, and nutrient application, will be crucial for maximizing foxtail millet yields while minimizing environmental impacts. Additionally, exploring intercropping and crop rotation systems can enhance soil health and overall farm resilience.

Future research should explore value addition techniques and processing technologies to increase the marketability of foxtail millet products. This includes developing novel food products, fortification strategies, and storage methods to prolong shelf life and enhance consumer acceptance. Efforts to establish efficient market access and value chains for foxtail millet products are essential for incentivizing farmers to cultivate this crop. Research should focus on market demand analysis, supply chain optimization, and policy interventions to promote the adoption of foxtail millet in mainstream diets.

Knowledge sharing platforms, capacity building initiatives, and research networks can adopter innovation and accelerate progress in this field. Governments and international organizations should provide policy support and investment incentives to promote foxtail millet cultivation. This includes research funding, extension services, market infrastructure development, and policy frameworks that prioritize the integration of foxtail millet into agricultural development agendas.

## CONCLUSION

This paper explores the future research scope and prospects for foxtail millet, aiming to shed light on its role in shaping the future of agriculture. Future research should focus on unraveling the genetic diversity of foxtail millet to identify traits associated with stress tolerance, yield enhancement, and nutritional quality. This knowledge will aid in the development of improved varieties suited to diverse agro-ecological regions. In conclusion, foxtail millet holds immense potential as a vigorous, nutritious, and sustainable crop for agriculture's futures. By addressing the outlined research scope and prospects, stakeholders can contribute to revealing the full potential of foxtail millet and realizing its role in transforming global food systems towards greater resilience and nourishment.

## REFERENCES

[1] Adekunle, A., Lyew, D., Orsat, V., &Raghavan, V. 2018. Helping agribusinesses—Small small-grained cereal crops value chain-To grow in India. Agriculture, 8(3), 44.

[2] AICSMIP. Report on compendium of released varieties in small small-grained cereal crops Banglore, India; 2014. small small-grained cereal crops/docs/report/Compendium of_Released_Varieties_in_Small small-grained cereal crops.pdf. Accessed 13 Mar 2019.

[3] Ajithkumar, K., & Panneerselvam, P. (2014). Morphological and biochemical responses of little millet (Panicum sumatrense Roth) to moisture stress. Environmental and Experimental Botany, 104, 72–79. https://doi.org/10.1016/j.envexpbot.2014.03.005

[4] Bandyopadhyay, T., Swarbreck, S.M., Jaiswal, V., Maurya, J., Gupta, R., Bentley, A.R., Griffiths, H. and Prasad, M., (2022). GWAS identifies genetic loci underlying nitrogen responsiveness in the climate resilient C4 model Setaria italica (L.). Journal of Advanced Research, 42, pp.249-261.

[5] Bhaskar, P., Gnanamalar, R. P., & Indra, A. S. (2017). Foxtail Millet: A Potential Crop under Changing Climate. Advances in Plants & Agriculture Research, 6(4).

[6] Bouis, H. E. 2000. Enrichment of food staples through plant breeding: a new strategy for fighting micronutrient nutritional deficiencies. Nutrition, 16, 701-4.

[7] Chapke et al. (2018) and others, Improved small-grained cereal crops production technologies and their impact, Publisher: ICAR-Indian Institute of Millets Research, Hyderabad 500 030, India, ISBN: 81-89335-69-3.

[8] Fuller, D. Q., et al. (2009). The domestication process and domestication rate in rice: spikelet bases from the Lower Yangtze. Science, 323(5921), 1607-1610.

[9] Gupta, S. K., Rao, P. S., & Deshmukh, S. K. (2015). High temperature tolerance during reproductive stage in pearl millet and sorghum. Crop Science, 55(3), 1189–1197. https://doi.org/10.2135/cropsci2014.07.0450

[10] Hariprasanna, K., Jacob, J., Patroti, P., Visarada, K.B.R.S. (2017). Breeding Strategies in Foxtail Millet. In: Prasad, M. (eds) The Foxtail Millet Genome. Compendium of Plant Genomes. Springer, Cham.

[11] Hassan ZM, Sebola NA, Mabelebele M. The nutritional use of millet grain for food and feed: A review. Agriculture & Food Security. 2021;10:1-14.

[12] Kaur, K.D, Jha, A, Sabikhi, L, Singh, A.K. 2012. Significance of coarse cereals in health and nutrition: a review. Journal of Food Science and Technology, DOI: 10.1007/s13197-011-0612-9.
[13] Kumar, A., Datta, A., Singh, D., & Ramakrishnan, S. (2019). Sustainable Agriculture: Foxtail Millet as a Smart Food Crop. International Journal of Current Microbiology and Applied Sciences, 8(5), 2316-2325.
[14] Lata C, Gupta S, Prasad M. Foxtail millet: a model crop for genetic and genomic studies in bioenergy grasses. Critical reviews in biotechnology. 2013; 33(3):328-343.
[15] Li C, Yue J, Wu X, Xu C, Yu J (2014) An ABA-responsive DRE-binding protein gene from Setaria italica, SiARDP, the target gene of SiAREB, plays a critical role under drought stress. J Exp Bot 65:5415–5427.
[16] Liu Y, Feng X, Xu Y, Yu J, Ao G, Peng Z, Zhao Q (2009) Overexpression of millet ZIP-like gene (SiPf40) affects lateral bud outgrowth in tobacco and millet. Plant Physiol Biochem 47:1051–1060.
[17] Liu Y, Yu J, Zhao Q, Zhu D, Ao G (2005) Genetic transformation of millet (Setaria italica) by Agrobacterium-mediated. Chin J Agric Biotechnol 13:32–37.
[18] Liu, Y., YU, J., AO, G. and Zhao, Q., 2007. Factors influencing Agrobacterium-mediated transformation of Foxtail millet. Chinese Journal of Biochemistry and Molecular Biology, pp.531-536.
[19] Lu, H., et al. (2009). Earliest domestication of common millet (Panicum miliaceum) in East Asia extended to 10,000 years ago. Proceedings of the National Academy of Sciences, 106(18), 7367-7372.
[20] Moharil, M.P., Ingle, K.P., Jadhav, P.V., Gawai, D.C., Khelurkar, V.C., Suprasanna, P. (2019). Foxtail Millet (Setaria italica L.): Potential of Smaller Millet for Future Breeding. In: Al-Khayri, J., Jain, S., Johnson, D. (eds) Advances in Plant Breeding Strategies: Cereals. Springer, Cham. .
[21] N Sachdev, S Goomer, LR Singh (2020). Foxtail millet: A potential crop to meet future demand scenario for alternative sustainable protein. The Journal of the Science of Food and Agriculture, 100(14), 5224–5235 (wileyonlinelibrary.com) DOI 10.1002/jsfa.10716.
[22] Panchal, A., Singh, R.K. & Prasad, M. (2023) recent advancements and future perspectives of foxtail millet genomics. Plant Growth Regul 99, 11–23.
[23] Pardo, J., & VanBuren, R. (2021). The drought resilience of millets: An overview of physiological and genetic adaptations. Agricultural Systems, 186, 102962. https://doi.org/10.1016/j.agsy.2020.102962
[24] Qin FF, Zhao Q, Ao GM et al (2008) Co-suppression of Si401, a maize pollen specific Zm401 homologous gene, results in aberrant anther development in foxtail millet. Euphytica 163:103–111.
[25] Saxena, K. B., Shyam, N., & Saini, H. S. (2018). Millets and climate change: A strategy for sustainability. Agricultural Research, 7(3), 295–302. https://doi.org/10.1007/s40003-018-0312-7
[26] Sehgal, D., Vikram, P., Sansaloni, C. P., Ortiz, C., & Saint Pierre, C. (2020). Crop Science, 60(6), 3155-3167.
[27] Singh, R.K., Muthamilarasan, M. and Prasad, M. 2017. Foxtail millet: an introduction. Prasad, M. (Ed.), The Foxtail Millet Genome, Springer, pp. 1-9.
[28] Sood, P., Singh, R.K. & Prasad, M. (2020). An efficient Agrobacterium-mediated genetic transformation method for foxtail millet (Setaria italica L.). Plant Cell Rep 39, 511–525.
[29] Sood, P., Singh, R.K. & Prasad, M. Millets genetic engineering: the progress made and prospects for the future. Plant Cell Tiss Organ Cult 137, 421–439 (2019). .
[30] Sultan, B., Roudier, P., & Courty, R. (2013). The impact of climate change on cereal crop yield in tropical and semi-arid regions. Global Change Biology, 19(7), 2100–2115. https://doi.org/10.1111/gcb.12121
[31] Vetriventhan, M., Azevedo, V.C., Upadhyaya, H.D., Nirmalakumari, A., Kane-Potaka, J., Anitha, S., Ceasar, S.A., Muthamilarasan, M., Bhat, B.V., Hariprasanna, K. and Bellundagi, A., (2020). Genetic and genomic resources, and breeding for accelerating improvement of small small-grained cereal crops: current status and future interventions. The Nucleus, 63, pp.217-239.
[32] Vetriventhan, M., et al. (2015). Nutritional and antinutritional traits of foxtail millet varieties. Journal of Food Science and Technology, 52(3), 1851-1860.
[33] Wang M, Li P, Li C, Pan Y, Jiang X, Zhu D, Zhao Q, Yu J (2014) SiLEA14, a novel atypical LEA protein, confers abiotic stress resistance in foxtail millet. BMC Plant Biol 14:290.
[34] Wang M, Pan Y, Li C, Liu C, Zhao Q, Ao GM, Yu JJ (2011) Culturing of immature inflorescences and Agrobacterium-mediated transformation of Foxtail millet. Afr J Biotechnol 10:16466–16479.

[35] Yadav, A. K., & Arya, P. S. (2014). Foxtail millet: a review on its nutritional properties, utilization and health benefits. Journal of Food Science and Technology, 51(8), 1633–1640. doi:10.1007/s13197-013-1225-3
[36] https://www.fao.org/india/fao-in-india/en/
[37] https://www.smartfood.org/smart-food-foxtail-millet/