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PEARL MILLET: A CLIMATE-RESILIENT CROP FOR FOOD AND NUTRITIONAL SECURITY

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ABSTRACT

Pearl millet (Pennisetum glaucum), commonly known as bajra, is a nutritionally rich and climate-resilient cereal widely cultivated in arid and semi-arid regions. Its exceptional tolerance to drought, heat, and poor soils makes it a lifeline crop under changing climatic conditions. Rich in dietary fiber, essential amino acids, iron, zinc, and B-complex vitamins, pearl millet contributes significantly to food and nutritional security. With expanding climate risks and resource constraints, pearl millet offers sustainable solutions for resilient farming systems, livelihood security, and diversified food systems, particularly in developing countries.

KEYWORDS: Climate resilience, food security, nutritional security, pearl millet, sustainable agriculture

INTRODUCTION

Pearl millet (*Pennisetum glaucum* [L.] R. Br.), popularly known as bajra, is one of the oldest cultivated cereal crops and a staple food for millions of people inhabiting arid and semi-arid regions of the world. It is a highly cross-pollinated diploid species (2n = 2x = 14) with an estimated genome size of approximately 1.79 Gb (Varshney et al., 2017). The crop is characterized by exceptional tolerance to drought, high temperature, salinity, and low soil fertility, making it uniquely suited to marginal environments where other cereals fail to perform.

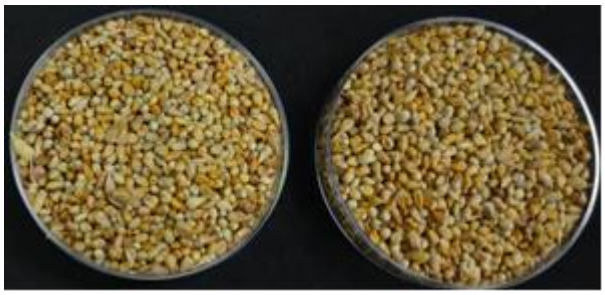
Pearl millet plays a critical role in global food security, particularly under the current scenario of climate variability and increasing frequency of extreme weather events. The crop possesses a deep and extensive root system that allows efficient extraction of soil moisture, enabling survival and grain production under severe water scarcity. Owing to its resilience and adaptability, pearl millet is considered a lifeline crop for resource-poor farmers in dryland ecosystems.

Globally, pearl millet is cultivated in more than 30 countries across Asia, Africa, the Americas, and Australia. India is the largest producer, contributing nearly 44% of global pearl millet production (FAO, 2016). The crop ranks fourth among cereal crops in India after rice, wheat, and maize. Major pearl millet-producing states include Rajasthan, Maharashtra, Uttar Pradesh, Gujarat, and Haryana, together accounting for about 90% of national production.

AGRO-CLIMATIC ADAPTABILITY AND CLIMATE RESILIENCE

Pearl millet exhibits remarkable adaptability to harsh agro-climatic conditions, including high temperatures exceeding 42°C, low and erratic rainfall, and nutrient-poor soils. Its short growth duration, rapid early vigor, and efficient photosynthetic system enable the crop to escape terminal drought stress. Compared to other cereals, pearl millet shows superior water-use efficiency and maintains productivity under limited irrigation or rainfed conditions.

The crop's resilience is further supported by its tolerance to soil salinity and acidity, making it suitable for cultivation in degraded and marginal lands. Pearl millet's genetic diversity provides a valuable resource for breeding climate-smart cultivars capable of withstanding abiotic stresses such as drought, heat, and emerging pest and disease pressures under climate change scenarios.



Pearl millet grain

Field view of Pearl millet

NUTRITIONAL AND HEALTH BENEFITS

Pearl millet is widely recognized as a "nutri-cereal" due to its superior nutritional profile and its role in diversifying diets. The grain is rich in complex carbohydrates, dietary fiber, and high-quality protein containing essential amino acids such as methionine and cysteine, which are limited in other cereals. Whole pearl millet grain has a higher energy content than most cereals, except maize.

Pearl millet is an excellent source of micronutrients, particularly iron and zinc, offering a cost-effective dietary intervention to combat micronutrient deficiencies such as anemia and zinc deficiency prevalent in developing countries. It also contains significant amounts of B-complex vitamins, including niacin, riboflavin, and thiamine, which support metabolic and neurological health.

Due to its low glycemic index and high fiber content, pearl millet is recommended for individuals with diabetes, obesity, and cardiovascular disorders. Regular consumption has been associated with improved digestive health, better glucose regulation, and reduced risk of lifestyle-related diseases.

PEARL MILLET IN FOOD SYSTEMS AND CULINARY USES

Pearl millet is traditionally consumed in various forms such as flatbreads, porridges, fermented foods, and beverages across India and Africa. With increasing consumer awareness and policy support for millets, pearl millet is being incorporated into value-added products such as breakfast cereals, bakery items, snacks, and ready-to-eat foods.

The revival of millets under national and international initiatives has enhanced the market potential of pearl millet-based foods, creating opportunities for entrepreneurship, food processing industries, and nutritional interventions such as school feeding and public distribution systems.

ROLE IN LIVESTOCK FEED AND FARMING SYSTEMS

Beyond human nutrition, pearl millet serves as an excellent fodder crop due to its high biomass production, palatability, and nutritional quality (Daduwal et al., 2024). It contributes significantly to livestock productivity, especially in mixed crop–livestock farming systems prevalent in arid regions.

Pearl millet straw is widely used as dry fodder, while green fodder supports dairy and small ruminant production. Additionally, the crop residues are used for thatching, insulation, and rural housing, thereby enhancing its multifunctional value in farming systems.

INDUSTRIAL AND BIOENERGY POTENTIAL

Pearl millet is gaining attention as a potential bioenergy crop due to its high biomass yield and ability to grow on marginal lands without competing with food crops. It offers opportunities for bioethanol production, biogas generation, and renewable energy development in dryland regions.

The crop's adaptability and low input requirements make it suitable for integrated food–feed–fuel systems, contributing to sustainable rural livelihoods and energy security.

ADVANCES IN GENETIC IMPROVEMENT AND BIOTECHNOLOGY

The availability of the pearl millet genome sequence has accelerated molecular breeding and genomics-assisted crop improvement (Varshney et al., 2017). Modern breeding approaches, including marker-assisted selection, genomic selection, and gene discovery, are being employed to improve yield stability, nutritional quality, and stress tolerance.

Biofortification efforts focusing on iron and zinc enhancement have shown promising results, aligning pearl millet improvement programs with global nutrition and health goals.

CHALLENGES AND FUTURE PROSPECTS

Despite its advantages, pearl millet faces challenges such as low productivity in traditional systems, limited market integration, susceptibility to certain diseases, and declining consumer preference. Strengthening seed systems, improving value chains, promoting mechanization, and enhancing awareness about nutritional benefits are essential to unlock the full potential of the crop.

Future research should focus on developing climate-resilient, high-yielding, and nutritionally enriched varieties, supported by enabling policies and investments to mainstream pearl millet in sustainable food systems.

CONCLUSION

Pearl millet stands out as a climate-resilient and nutritionally superior cereal with immense potential to address food, nutrition, and livelihood security under changing climatic conditions. Its adaptability to drought, heat, and poor soils makes it a strategic crop for sustainable agriculture in arid and semi-arid regions. Rich in dietary fiber, essential amino acids, and micronutrients, pearl millet contributes significantly to combating malnutrition and lifestyle-related diseases. Beyond food, its value as fodder, industrial raw material, and bioenergy resource enhances farming system sustainability. Strengthening research, breeding, value addition, and policy support will be crucial to mainstream pearl millet as a key component of climate-smart and nutrition-sensitive agricultural systems.

REFERENCES

Daduwal HS, Bhardwaj R, Srivastava RK (2024). Pearl millet: a promising fodder crop for a changing climate. *Theoretical and Applied Genetics*, 137(7):169.

FAO (2016). The State of Food and Agriculture: Climate Change, Agriculture and Food Security. Food and Agriculture Organization of the United Nations, Rome.

Varshney, R.K., Shi, C., Thudi, M., Mariac, C., Wallace, J., Qi, P., Zhang, H., Zhao, Y., Wang, X., Rathore, A. and Srivastava, R.K., (2017). Pearl millet genome sequence provides a resource to improve agronomic traits in arid environments. *Nature Biotechnology*, 35(10):969–976.

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