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A review on Bajra/ Pearl millet (*Cenchrus americanus* (L.) Morrone)

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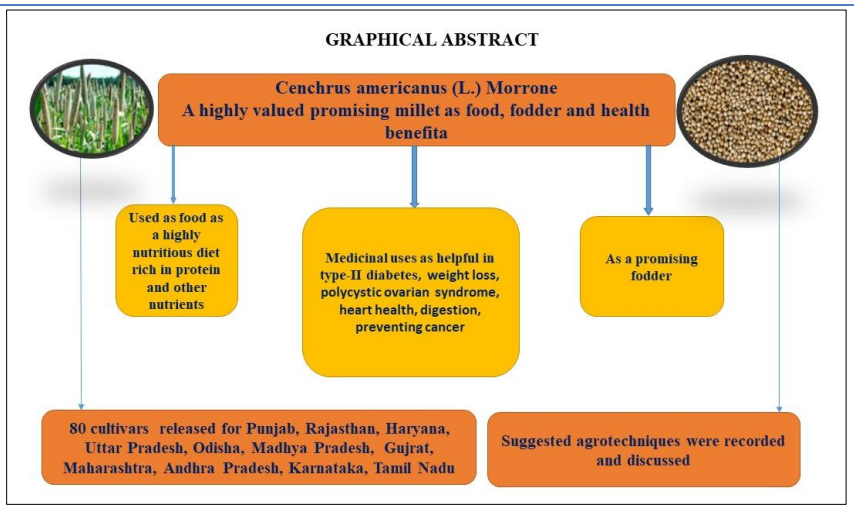
Abstract

The paper deals with a review of different aspects of Cenchrus americanus prominent millet found in different parts of India. It is widely cultivated in different states and seeks out the variable climatic conditions in universities as well as the Indian Agricultural Institute, PUSA, New Delhi.Various published literature and online available resources like Google Scholar, PubMed, Science Direct, Elsevier, etc., were consulted and the field visits of the cultivated areas were observed for taxonomic features and other field observations of the species. Literature surveys on various aspects of Bajra have been thoroughly analysed in the context of the status of varieties, which were released in different parts of India for cultivation along with their nutritional values of different varieties for emphasizing the values and promotion of including it in daily life. Approximately 80 varieties/cultivars were released for sowing and harvesting in the Kharif, Rabi, and Jayad seasons. Many of these are commonly cultivated in the Kharif and Rabi seasons but few are only in the Jayad season. It is recommended to cultivate this plant commercially and consumption by Madhumeh and Hriday Rog patients.



Keywords: Millet, *Cenchrus americanus*, Medicinal use, Nutrition value, Cultivars.

INTRODUCTION

The year 2023 is celebrated as the International Year of Millets. Millets are small-seeded hardy crops that grow well in dry regions or rain-fed regions. [1] Its ayurvedic properties as Madhura in Rasa, Ruksha, and UshnaVirya and pacifies Vata and Kapha Dosha.[2]

It is an erect, annual, ornamental grass with its native range from Benin to Tropical South Africa and well-adapted to poor, drought-stricken, and infertile soils.[3] The robust root system enables the plant to reach up to 3 m tall and 1 m wide.[4]

The gradual and continuous change in the rainfall pattern and climatic conditions does not bring adverse effect in thecrop production as pearl millet (*Cenchrus americanus* (L.) Morrone) is superior tolerant to high temperature. It is a C4 plant (2N=14) and thus is considered as an important crop in arid and semiarid

regionsof the world. [5-10] It is over 31.2 million hectares feeding over 90 million poor people so known to be a staple food crop. [11] Recently, 10 chromosomal genomes with a single assembly capturing 424,085 genomic structural variations have been developed[12].

The generic name comes from the Latin *penna* meaning "feather" and *seta* meaning "bristle"; refers to the flowers' long, feathery bristles. The species name *glaucum* means "having a bluish-grey cast"[13].

Synonym. *Panicum americanum* L. in Sp. Pl.: 56 (1753); *Pennisetumglaucum* (L.) R.Br.

Pennisetum americanum (L.) Leeke in Z. Naturwiss. 79: 52 (1907)

Vernacular names: Kandaja, Priyangu, (Sanskrit); Bajra (Bengali, Hindi, Oriya, Punjabi, Urdu); Bajree (Rajasthani, Gujarati, Marathi); Sajje (Kannada; Kambu (Tamil); Sijja (Telugu) Millet, Pearl Millet, Spiked millet, Yellow Bristle Grass (English).

Botanical description: Annual. Culms robust, up to 2-3 m tall, densely pubescent at nodes and below inflorescence. Leaf sheaths loose, smooth; leaf blades 25–100 × 1.5–5 cm, with scabrous margins and both surfaces; base subcordate; ligule short. Inflorescence cylindric to broadly elliptic, dense, 40-50 cm long with persistent involucre, enclosing 1–9 spikelets, base of the stipe pubescent, bristles usually shorter to spikelets, Spikeles short obovate; lower glume tiny; upper glume 3-veined; lower floret staminate, lemma with 5-veins, memberanous and ciliate margins, palea thinly membranous; upper lemma thinly membranous with 5–7-veins and obtuse tip; anthers hairy with a tuft of short hairs at tip [Figure 1].

Flowering and fruiting: September–October.

It is easy for growing with best germination occurring in warm soil above 21º-32º C. Mature plants have a robust root system holding plant is a fixed place in the soil by attaining the height up to 3m tall and width up to 1m. [14]

Cultivars: In India, 80 cultivars were released for Kharif, Rabi as well as fodder out of which Porogo 9443 was found suitable for 18 states; RHB 58 for 11 states; Pusa-444 for 10 states; GHB-558 for 9 states; GK-1004, Nandi-32, Nandi-35, and Nandi-52 for 8 states; GHB-526, GHB-744, Nandi-62, Progro No 1, and Pusa-605 for 6 states; Pusa-605, 7688, HHB-146, HHB-197, MLHB-267, PHB-2168, Pusa-415, Pusa composite-612, and RHB-121 for 5 states. The remaining cultivars are suitable for cultivation in lesser states (Figure 1)

Native range and distribution: The native range is Benin to South Tropical Africa. Cultivated in North and Eastern China and widely introduced in India and elsewhere with a short growing season. [14]

Plant diseases:

Downy mildew/green ear disease, ergot, leaf blight, rust, and smuts are the major diseases affecting the pearl millet in India. Susceptibility to damage by chinch bugs and stink bugs are also the cause of pearl millet health problem. [15]

Cultivation Details

Climate and rainfall:

Plant grows up to 1,800 m above sea level in regions of tropics and subtropics in semiarid to moist soil with annual temperature ranging from 25o-35o C also tolerating from 12o-40oCin several areas with variation in annual rainfall from 400-900 mm and 200-1,700 mm respectively.

Soil condition:

The crop requires light well-drained loamy soil in a sunny position and does not tolerate water logging. Acidic soil rich in aluminium content with a pH level of 4-5 is the best suitable soil for its growth. In general, the plant is tolerant of various soil conditions, especially of light and acid soils. Its large and dense root system allows it to succeed in dry infertile soil. [15,16]

Seed sowing and Crop care

The method of propagation is through seeds. Soil should be prepared before 4-5 days of sowing seeds by removing the weeds and ploughing well. Number of plants per hectare is recommended from 100000-175000 plants/ ha. At the blooming stage, maximum irrigation is required till grain establishment. [1]

Weed and Pest Management

The major insects and pests attacking the crop are chinch bugs, stink bugs, nematodes, and birds. A minimum application of insecticide reduces the damage caused by stinkbugs and chinchbugs with regular observation in the field at the glooming time. [17-19]

Uses

Food use: It was considered a new feed grain crop in the United States of America, [20] however, in India and other countries it is in regular use as one of the food grains in different ways like flour to prepare bread, soup, and stew, snacks, fermented dishes, and seeds as pilaf or Pullao, Khichdi, laddo, dumpling, kheer, sweet cakes (Pua), etc. The dishes are highly nutritious and good in taste. [21,22]

Medicinal and health benefits:

The plant is an appetizer and tonic. [23,24] It is commonly taken in heart diseases and type-II diabetes as is gluten free. [25-28] Fruits are applied on pimples[29] and also used against leprosy, poisoning blennorrhoea, chest problems. The grounded grain is used as an anthelmintic for children. For beating jaundice, root decoction is taken and vapours of inflorescence extract is inhaled in case of respiratory troubles of children. [30-31]

Its seed flour in a normal diet helps in weight loss, prevents polycystic ovarian syndrome, and makes the heart healthy, bone growth, celiac, diarrhea, stomach ulcers, respiratory diseases, gall stones, and anti-allergic actions. It is easy to digest and helps in the prevention of cancer. [32]

Fodder use: This millet is used as fodder in most of the parts of India.

Agricultural use: It is often intercropped with one to several crops. [33] Its cultivation helps to reduce the carbon footprint.[18] It suppresses root-lesion nematodes (*Pratylenchus penetrans*), and it is frequently being used as an alternative to soil fumigation in tobacco and potatoes. [34]

Other domestic uses: The straw of this species is used for thatching, fencing, and fire fuel as well and split stems are used for making baskets, and a dye for leather and wood is obtained from red- and purple-flowered types. [29]

Dietary use:

It uses in various types of culinary preparations. Pearl millet flour is used to make bread like bhakri, and bajra ki roti. Toast and sliced bread are prepared, either alone or mixed with wheat and other cereal flour. Seeds are roasted to make pop and are boiled to make corn pop and pearl millet flakes just like corn flakes, It is boiled in water, milk with jiggery or sugar to make a nutritious and filling porridge and flavoured with cardamom or cinnamon. It is cooked with vegetables, spices, to make stock pulao or pilaf. It is used as a thickening agent in soups and goulash tobe by adding to it. It is puffed or roasted for making crispy snacks, which may also be seasoned with spices and taken as a healthy alternative to fried snacks. It

is widely used to make fermented dishes like fermented batter for dosa or idli. Its leaves and stems are also used as a nutritious fodder for cattle and poultry.

Agro-technological studies

It prefers to grow in areas where frequent dry weather is observed during vegetative growth or fruiting periods. The crop is more tolerant to sandy and acidic soil. Numerous studies are conducted to identify the best representative/ discriminating locations for the evaluation of pearl millet Open-pollinated varieties (OPVs), to identify stable OPVs across locations and those suitable to specific zones, and to determine variation in grain Iron and Zinc contents across locations in the OPVs.[17]

Studies on crop tolerance to salinity are of high importance due to the extent and the constant increase in salt-affected areas in arid and semi-arid regions has been studied. [19] Identification of high-yielding iron-biofortified open-pollinated Fe/Zn-rich pearl millet varieties in West Africa were recorded. [22,35-38]. The Varietal identification and fingerprinting of its varieties and hybrid using morphological descriptors and Simple Sequence Repeats (SSR) markers was also performed.[39]

An important point to include is the sensory, physical, and nutritional qualities of cookies of West and Central Africa were recorded.[40] The performance and stability of pearl millet varieties for grain yield and micronutrients in arid and semi-arid regions of India have been studied. [41] Management of finger millet-based cropping systems for sustainable production has also been reported.[42,43]

Damage caused by insect attacks is managed through Crop rotation and timely harvesting controls to avoid the application of insecticides.

Nutritional contents in pearl millet: Various nutritional contents described in the past are given in Table 1. [34,36,44]

Table 1: Nutritional contents in pearl millet (Bajra).

Common name	**Nutritional contents in Gram (gm)**				
	Protein (gm)	**Carbohydrates (gm)**	**Fat (gm)**	**Minerals (gm)**	**Fibers (gm)**
Pearl millet	11.8	67.0	**4.8**	2.2	2.3

Mineral contents in pearl millet (Bajra)										
Calcium (mg)	**Phosphorus (mg)**	**Iron (mg)**	**Zinc (mg)**	**Potassium (mg)**	**Sodium (mg)**	**Vitamins (mg)**				
						B-1	**B-2**	**B-3**	**B-5**	**B-12**
43	207	**16.9**	**9.0**	401	**19**	0.32	0.27	2.4	-	-

Source: https://healthyday.net/pearl-millet-health-benefits-and-nutritional-value/

Cultivars developed for different climatic zones in India: State-wise cultivars developed from different agricultural institutions in India for cultivation in different states as well as climatic conditions are as follows.[45]

Punjab:

Kharief: BHB-577, GHB-316, GHB-744, HHB-146, JKBH-26, JKBH-676. MLHB-267, Nandi-32, Nandi-52, PHB-2168, Proagro-9443, Pusa-444, Pusa-605, Pusa-415, RHB-58,

Hybrid varieties: BHB-577, GHB-316, GHB-744, HHB-146, JKBH-26, JKBH-676, MLHB-267, Nandi-32, Nandi-52, PHB-2168, Proagro-9443, Pusa-415, Pusa-444, Pusa-605, RHB-58,

Haryana:

Kharif: CZ-IC-923, GBH- 316, GHB-538, GHB-558, GHB-577, GHB-719, GHB- 732, GHB-744, GHB-757, 7886, GICKV-96752, HC-10, HC-20, HHB-67, HHB-94, HHB-117, HHB-146, HHB-197, HHB-216, HHB-223, Jawahar Bajra Variety-2, JKBH – 26, JKBH-676, MP-406, Nandi-32, Nandi-52, Proagro-9443, Proagro-9445, Pusa Bajri – 266, Pusa composite-334, Pusa composite-383, PHB-2168, Pusa composite-443, Pusa-444, MLHB-267, Pusa – 605, Pusa-415, RHB-58, RHB-121, , RHB-154, RHB-173, 7688.

Hybrid varieties: GBH- 316, GHB-538, GHB-558, GHB-719, GHB-744, GHB- 732, GHB-757, HHB-146, GHB-577, HHB-67, HHB-94, HHB-117, HHB-197, HHB-216, HHB-223, JKBH – 26, JKBH-676, MLHB-267, Nandi-32, Nandi-52, Pusa-415, PHB-2168, Proagro-9443, Proagro-9445, Pusa-444, Pusa – 605, RHB-121, RHB-154,7886, 7688.

(The popular varieties are HHB-67-2 HHB-94 HHB-117, HHB-146, HHB-197, RHB-58, and RHB-173)

Fodder: Proagro No.1, and Avika Bajra Chari are the popular hybrid varieties.

Rajasthan:

Kharif: GBH-316, GHB-538, GHB-558, GHB-577, GHB-719, GHB-744, GHB-757, GHB-732, HHB-67, HHB-94, HHB-117, HHB- 146, HHB-197, HHB-216, HHB-223, JKBH-26, JKBH-676, MLHB-267, Nandi-32, Nandi-52, PHB-2168, Proagro-9443, Proagro-9445, Pusa-444, Pusa-605, Pusa-415, RHB-154, RHB-58, RHB-121, RHB-173, 7688, 7886.

Hybrid varieties: GBH-316, GHB-538, GHB-558, GHB-577, GHB-732, GHB-719, GHB-744, GHB-757, HHB- 146, HHB-94, HHB-117, HHB-67, HHB-197, ICTP-8207, JKBH-26, JKBH-676, MLHB-267, Nandi- 32, Proagro-9443, Proagro-9445, Pusa-415, Pusa-444, Pusa-605, RHB-154, HHB-216, HHB-223, 7688, 7886.

(The popular varieties are ICMH-356, HHB-67-2, HHB-60, HHB-94, MH-169, Nandi-52, PHB-2168, RHB-58, RHB-90, RHB-58, RHB-121, RHB-173, Raj-171, P-334, CZP-9802)

Uttar Pradesh:

Kharif: GICKV-96752, GHB-558, GHB-577, GHB-744, HHB-146, HHB-197, HHB-223, Jawahar Bajra Variety-2, Nandi-32, Nandi-52, Nandi-62, PHB-2168, Proagro-9443, Proagro-9445, Pusa composite-383, Pusa-444, RHB-58, RHB-121, RHB-173, 7686, 7688.

Hybrid varieties: GHB-558, GHB-577, GHB-744, HHB-146, HHB-197, HHB-223, Nandi-32, Nandi-52, Nandi-62, Proagro-9443, Proagro-9445, RHB-121, PHB-2168. Pusa-444, RHB-58, RHB-173, 7686, 7688.

Rabi: Nandi-32, Nandi- 52, Nandi-62, Nandi-64.

Odisha:

Kharif: Proagro-9443, Pusa-44, RHB-58, (All hybrid varieties)

Fodder: Proagro No.-1.

Madhya Pradesh:

Kharif: GBH-316, GHB-557, GHB-558, GHB-732, GHB-744, HHB-146, Nandi-62, HHB-197, MLHB-285, JKBH-26, Nandi-8, Nandi-32, Nandi-52, PHB-2168, Proagro-9443, Proagro-9445, Pusa-415, Pusa-444, Pusa-605, 7688, RHB-58, RHB-121, RHB-173, 7886.

Hybrid varieties: GBH-316, GHB-557, GHB-558, GHB-732, GHB-744, HHB-146, HHB-197, JKBH-26, MLHB-285, Nandi-8, Nandi-32, Nandi-52, Nandi-62, Pusa-605, Proagro-9443, Proagro-9445, PHB-2168, Pusa-415, Pusa-444, 7688, RHB-58, RHB-121, RHB-173, 7886.

Gujarat:

Kharif: CZ-IC-923, GBH-316, GHB-538, GHB-558 GHB-577, GHB-719, GHB-744, GHB-757, GHB- 732, GICKV-96752, HHB-146, HHB-197, HHB-216, HHB-223, Jawahar Bajra Variety-2, JKBH-26, JKBH-676, MP-406, Nandi- 8, Nandi-32, Nandi-52, Nandi-62, 7688, Pusa composite-334, , Pusa composite-383, Pusa-444, Pusa-605, Pusa-415, Proagro-9445, , RHB-154, RHB-58, RHB-121, RHB-173, 7876.

Hybrid varieties: GBH-316, GHB-538, GHB-558, GHB-577, GHB-719, GHB-744, GHB-757, GHB- 732, HHB-146, HHB-197, HHB-223 JKBH-26, JKBH-676, 7876, Nandi- 8, Nandi-32, Nandi-62, Nandi-52, Proagro-9445, Pusa-415, Pusa-444, Pusa-605, RHB-154, HHB-216, RHB-58, RHB-173, RHB-121, 7688. (The popular hybrids are GHB-558, GHB-538, GHB-526)

Rabi: GHB-526.

Fodder: Proagro No.1.

Summer (Jayad): GHB-526, Guj-Hybrid, Nandi-32, Nandi-52. Nandi-62, Proagro-9444, Proagro-9555. (All are hybrid varieties).

Maharashtra:

Kharif: AIMP-92901, B-2301, B-2095, GHB-558, GK-1004, GK-1051, PAC-903, MLHB-267, MLBH-504, Nandi-30, Nandi-35, Prabhni Sampda, Proagro-9443, Pusa composite-612, Pusa-444, RHB-58, Saburi. (The popular varieties are ICTP-8203, Saburi, Sharadha, and Pratibha).

Hybrid varieties: B-2301, B-2095, GHB-558, GK-1004, GK-1051, MLHB-267, MLBH-504, Nandi-30, Nandi-35, PAC-903, Proagro-9443, Pusa-444, Saburi, RHB-58,

Rabi: GHB-526, GK-1004, Nandi-64, Nandi-35, Proagro-9444, Proagro-9555, Saburi, (All are the hybrid varieties, and ICTP-8203, Saburi, Sharadha, Pratibha are popular varieties used in the state).

Andhra Pradesh:

Kharif: Ananta, B-2301, B-2095, GHB-558, GK-1004, GK-1051, MLHB-504, Nandi-35, Nandi-360, PAC-903, Proagro-9443, Pusa composite-612, Pusa-444, RHB-58.

Hybrid varieties: B-2301, B-2095, GHB-558, GK-1004, GK-1051, MLHB-504, Nandi-35, Nandi-360, PAC-903, Proagro-9443, Pusa-444, RHB-58.

Rabi: Ananta.

Fodder: Proagro No 1.

Summer (Jayad): The hybrid varieties GK-1004, Nandi-35 (the popular varieties for all the three seasons are APS-1, ICMH-451, ICMV-221, ICTP-8203, WCC-75).

Karnataka:

Kharif: B-2095, B-2308, GHB-558, GK-1004, GK-1051, MLHB-267, MLHB-504, Nandi-35, Pusa composite-612, PAC-903, RHB-58, Proagro-9443, Pusa-444, (Except Pusa composite-612, all the varieties are hybrids.

Rabi: GHB-526 is a hybrid also.

Fodder: Proagro No.1.

Summer (Jayad): The hybrid varieties are GHB-526, GK-1004, Nandi-35.

Tamil Nadu

Kharif: B-2301, B-2095, COH (Cu)-8, CoCu-9, GHB-558, K-1051, Pusa composite-612, Pusa-444, GK-1004, PAC-903, Proagro-9443, Nandi-35, RHB-58, X-6, X-7. (All are hybrid varieties except CoCu-9, and Pusa composite-612,).

Rabi: COH (Cu)-8, GHB-526, GK-1004, GK-1051 Nandi-35, Proagro-9444, Proagro-9555, X-6, X-7, and all are the hybrid varieties. (The popular varieties from Tamil Nadu are Co Cu-9, CO-6, CO-7, CO-8, COCH-8, ICMS-7703, ICMV-155, ICMV-221, KM-1, KM-2, Raj-171, WCC-75 and X-7 for all the seasons).

Different cultivars are under cultivation in different states according to seasons as well as used for fodder in India as represented in Figures 2 and 3.

Steps taken for promoting millets (since 2018)

Different steps have been proposed and planned for millets in recent years since 2018 to date. i. Millets are included under Poshan Mission Abhiyan by the Ministry of Women and Child Development. ii. Sub Mission on Millets" under the National Food Security Mission since 2018. iii., ICAR released one variety of Quinoa (Him Shakti). iv Quinoa – A new crop: The Indian Council of Agricultural Research (ICAR) has been referred to suggest declaring Nutri-cereals. The year 2018 declared as National year for millets. vi. The export of millet increased from $ 24 million (2017) to $ 26 million (2020).[30]

DISCUSSION

The guidelines for cultivation and processing methodologies for meeting nutritional needs as well as health benefits are being developed in India as well as the World as a whole.[30] Pearl Millet (Bajra) is a common Kharif crop in every part of India, a Rabi crop in Andhra Pradesh, Gujrat, Karnataka, Maharashtra, Tamil Nadu, and Uttar Pradesh, and a summer crop in Gujrat, Karnataka, and Rajasthan in India, and different African nations. It is also used as fodder in different parts of India particularly Andhra Pradesh, Karnataka, Tamil Nadu, Uttar Pradesh, and Uttarakhand from where several cultivars have been released by different Agricultural institutions. Due to its gluten-free and nutritious nature, it is gaining popularity as a grain. The benefits of Bajra as it helps control blood sugar spikes, prevents chronic conditions, and promotes heart health[23,24]

Due to its anti-inflammatory properties, consuming pearl millet in winter can boost the functioning of the respiratory tract, i.e., trachea and lung, which usually ease breathing. Basic methods of use of pearl millet by preparing different traditional dishes and others can be tried like Bajra roti and Bajre ki meethi poori, which are famous in Northern India.

However, consuming pearl millet for patients having thyroid issues is advised by the physician.[46] It is recommended to soak and cook bajra to avoid any digestive problems properly. Varieties of the pearl millet were developed with the concept of making disease resistant, high yield, seasonal adaptability, nutritional content increase, and for use as fodder. Fodder variety Proagro No.-1 has been developed and used in the states of Andhra Pradesh, Gujrat, Haryana, Karnataka, and Uttar Pradesh. Variety Avika Bajra Chari has been developed which is restricted as fodder in the state of Haryana only. Phylogeny and origin of pearl millet based on microsatellite loci has been described.[4]

Studies on genomic diversity derived from primary and improved with a comparative global acceptability, transcriptomic analysis under high temperature, for climatic acceptability, analysis of genome size to fulfil the hidden hunger along with nutritional security by the use of k-mer

frequency analysis based on Lander-Waterman algorithm, the genome size of pearl millet [8,47-52] shows the millet including pearl millet can come forward in respect of fulfilment nutritional requirement as well as meeting out food security to the people in the World.

Genomic diversity derived from primary and improved varieties, population genomics of pearl millet and comparative analysis of global accessions and senegalese landraces has been worked out.[47,48] Transcriptomic analyses under high temperatures were studied according to climate-resilient nutricereal for alleviating hidden hunger including nutritional security has been recorded in detail.[8,49] By the use of k-mer frequency analysis on the basis of Lander-Waterman algorithm, the genome size of pearl millet as well as use of flow cytometry to confirm the estimated genome size with the methodoly used in reference has been worked out.[50-54] Pearl millet is one of the most extensively cultivated cereals in the world, after wheat (*Triticum aestivum* L.), maize (*Zea mays* L.), rice (*Oryzasativa* L.), barley (*Hordeum vulgare* L.), and sorghum [*Sorghum bicolor* (L.) Moench]. In the arid and semiarid regions of Africa and southern Asia pearl millet is fulfilling the food requirement as the major component of traditional farming systems and a staple food.[55]

A graph-based pan-genome by assembling ten chromosomal genomes with one existing assembly adapted to different climates worldwide and capturing 424,085 genomic structural variations (SVs) has been developed which shows endoplasmic reticulum (ER)-related genes in heat tolerance.[11]

Figure 1: *Cenchrus americanus* (L.) Morrone: A. Habit of the plant; B. Seeds.

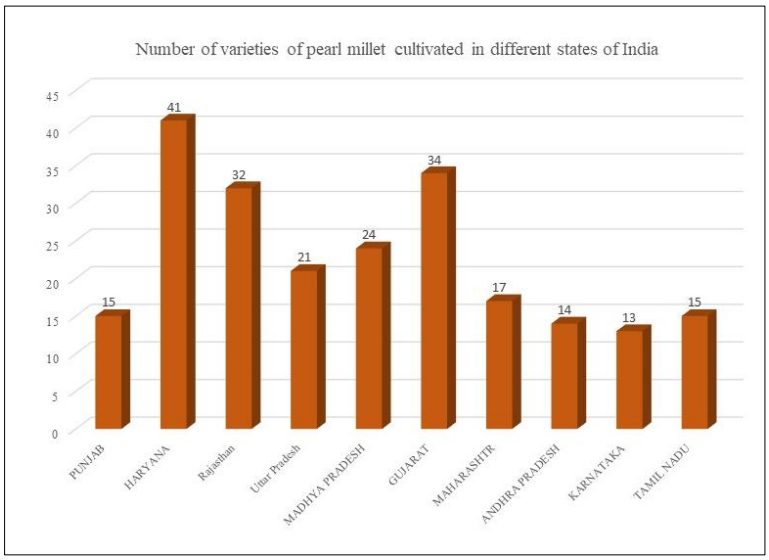


Figure 2: Graph showing the varieties cultivated in different states of India.

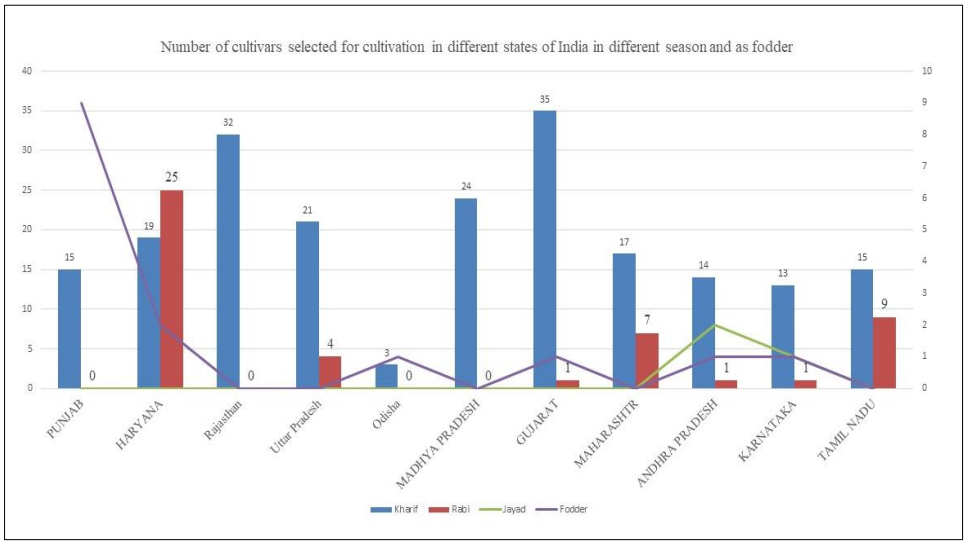


Figure 3: Graph showing the number of cultivars under cultivation in different seasons as well

CONCLUSION

Pearl millet provides various health benefits. It is rich in dietary fiber, which helps the digestive system. It is used as a good substitute for rice and wheat. It contains essential nutrients such as proteins, amino acids, insoluble fibre, etc., that lead to better health and weight loss. Being easy to cultivate, it is recommended for cultivation and consumption by the patients of Madhumeha and Hriday Rog.

Conflict of Interest

There is no conflict of interest amongst the authors.

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REFERENCES

1. Kumari P, Thakur A, Sankhyan NK, Singh U. Millets Production and Consumption in India. Just Agriculture 3277-283.
2. https://powo.science.kew.org/taxon/urn:lsid:ipni.org:names:318562-2
3. Lee RD, Hanna W, Buntin GD, Dozier, W, Timper P, Wilson JP. Pearl millet for grain.1216; Georgia: University of Georgia; 2009;03/24/2009 https://hdl.handle.net/10724/12185.
4. Oumar I, Mariac C, Pham JL, Vigouroux Y. Phylogeny and origin of pearl millet (*Pennisetumglaucum* [L.] R. Br) as revealed by microsatellite loci. TheorAppl Genet 2008 Aug;117:489-97. doi: 10.1007/s00122-008-0793-4. Epub 2008 May 27.PMID: 18504539
5. James D, Tarafdar A, Biswas K, Sathyavathi TC, Padaria JC, Ananda Kumar P. Development and characterization of a high-temperature stress responsive subtractive cDNA library in pearl millet *Pennisetumglaucum* (L.) R. Br. Indian J ExpBiol 2015;53:543-50.
6. Pucher A, Pucher, OusmaneSy, Ignatius I. Angarawai II, Gondah J, Zangre R, Ouedraogo M, Sanogo MD, Boureima S, Hash CT, Bettina I.G. Haussmann BIG. Agro-morphological characterization of West and Central African pearl millet accessions. Crop Sci, 2015;55: 737–48.
7. Jukanti A, Gowda CL, Rai KN, Manga VK, Bhatt RK. Crops that feed the world 11. Pearl millet (*Pennisetumglaucum* L.): an important source of food security, nutrition, and health in the arid and semi-arid tropics. Food Security, 2016;8:307-29.
8. Satyavathi, CT, Ambawat S, Khandelwal V, Srivastava RK. Pearl millet: a climate-resilient nutricereal for mitigating hidden hunger and providing nutritional security. Front. Plant Sci2021;12:1-18 (659938). Doi: 10.3389/fpls.2021.659938.
9. Varshney RK, Shi C, Thudi M, Mariac C, Wallace J, Qi P, Zhang H, Zhao Y, Xiyin Wang X, Rathore A, Srivastava RK, Chitikineni A, Fan G, Bajaj P, Punnuri S, Gupta SK, Wang H, Jiang Y, Couderc M, Katta MAVSK, Paudel DR, Mungra KD, Chen W, Harris-Shultz

KR, Garg V, Desai N, Doddamani D, Kane NA, Conner JA, Ghatak A, Chaturvedi P, Subramaniam S, Yadav OP, Berthouly-Salazar C, Hamidou F, Wang J, Liang X, Clotault J, Upadhyaya HD, Cubry P, Rhoné B, Gueye MC, Sunkar R, Dupuy C, Sparvoli F, Cheng S Mahala RS, Singh B, Yadav RS, Eric Lyons E, Datta SK, Hash CT, Devos KM, Buckler E, Bennetzen JL, Paterson AH, Ozias-Akins P, Grando S, Wang J, Mohapatra T, Weckwerth W, Reif JC, Liu X, Vigouroux Y, Xun X. Pearl millet genome sequence provides a resource to improve agronomic traits in arid environments. Nature Biotechnol, 2017;35:969-76.

10. Mohammed R, Gangashetty PI, Karimoune L, Ba, NM. Genetic variation and diversity of pearl millet [*Pennisetumglaucum* (L.)] genotypes assessed for millet head miner, *Heliocheilusalbipunctella* resistance, in West Africa. Euphytica2020;216:1-14. (158).
11. Yan H, Sun M, Zhang, Z, Jin Y, Zhang A, Lin C, Bingchao Wu, He M, Xu B, Wang J, Peng Qin P, Mendieta JP, Nie G, Wang J, Jones CS, Feng G, Srivastava RK, Zhang X, Bombarely A, Luo D, Jin L, Peng Y, Wang X, Ji Y, Huang L. Panogenomic analysis identifies structural variation associated with heat tolerance in pearl millet. Nature Genet 2023;55:507-18. https://doi.org/10.1038/s41588-023-01302-4.
12. Navarange S, Wasnik V, Jain S. Millets an ayurvedic approach. International Ayurvedic Medical Journal 2023;1101-8. Doi: 10.46607/iamj1411052023; www.iamj.co.
13. Balkrishna A. World Botanical Dictionary, Haridwar: DivyaPrakashanMandir; 2022.
14. https://www.fondazioneslowfood.com/en/ark-of-taste-slow-food/bulrush-millet/
15. Singh R, Tomer A, Chandel SS, Moraj D, Chauhan S. Pearl millet (Bajra): Common diseases. in Diseases of Nationally Important Field Crops; Edit: MR Khan, Z Haque, F. Ahamad. New Delhi: Today & Tomorrow's Printers and Publishers; 2021. p. 189-200.
16. Protabase. Plant resources of Tropical Africa. http://www. Prota.org.
17. Grounds R. Ornamental Grasses Christopher Helm (Wonder Crops). Natural Food Institute, 1987.
18. Jennings E, Vendramini J, Blount A. Pearl Millet (*Pennisetumglaucum*): Overview and Management. Florida: University of Florida, Institute of Food and Agricultural Sciences. 2020; SS-AGR; 337 (EDIS https://edis.ifas.ufl.edu/publication/AG347).
19. Krishnamurthy L, Serraj R, Rai KN, Hash CT, Dakheel, AJ. Identification of pearl millet [*Pennisetumglaucum* (L.) R. Br.] lines tolerant to soil salinity. Euphytica, 2007;158:179-88.
20. Andrews DJ, Rajewski JF, Kumar KA. Pearl millet: New feed grain crop. In: Janick, J.Simon, J.E., editors, New crops. New York: John Wiley & Sons, 1993. p. 198-208.
21. https://pharmeasy.in/blog/12-nutritional-benefits-of-bajra-Pearl-millets.
22. Yadav HP, Gupta SK, Rajpurohit BS, Pareek N. Pearl Millet. In Broadening the Genetic Base of Grain Cereals edited by: Mohar Singh, Sandeep Kumar), 2016. p. 205-224. doi: 10.1007/978-81-322-3613-9.
23. Chopra RN, Nayar SL, Chopra IC. Glossary of Indian Medicinal Plants (Reprint, 2009). New Delhi: NISCAIR, CSIR, 1956.
24. Obidike J. Pearl Millet: 10 Surprising Health Benefits and Nutrition. Healthful Wonders. 2021;1-10. https://www.healthfulwonders.com › pearl-millet.
25. Nambiar VS, Dhaduk JJ, Sareen N, Shahu T, Desai R. Potential functional implications of pearl millet (*Pennisetumglaucum*) in health and disease. Journal of Applied Pharmaceutical Science 2011; 01 (10): 62-67.
26. Selladurai M, Manivannan, PulivarthiMK, Suprabha Raj A, Iftikhar M, Vara Prasad PV, Siliveru K. Considerations for gluten-free foods - pearl and finger millet processing and market demand.Grain & Oil Science and Technology 2023; 6(2): 59-70.
27. Fajardo V, González MP, Martínez M, Samaniego-VaeskenMdL, Achón M, Úbeda N, Alonso-Aperte E. Updated Food Composition Database for Cereal-Based Gluten Free Products in Spain: Is Reformulation Moving on? Nutrients. 2020;12(8):2369. https://doi.org/10.3390/nu12082369
28. El Khoury D, Balfour-Ducharme S, Joye IJ. A Review on the Gluten-Free Diet: Technological and Nutritional Challenges. Nutrients. 2018;10(10):1410. https://doi.org/10.3390/nu10101410
29. Moerman D. Native American Ethnobotany, Oregon: Timber Press, 1998.
30. Anonymous.Millets The Nutricereals of India. FSSAI, New Delhi: Min. Health & FW, Government of India, 2023.
31. Nambiar VS, Dhaduk JJ, Sareen N, Shahu, T, Desai R. Potential functional implications of pearl millet (*Pennisetumglaucum*) in health and disease. Journal of Applied Pharmaceutical Science, 62-67- japsonline.com
32. Malik S. Pearl millet-nutritional value and medicinal use. IJARIIE 2015; 1:414-418.
33. Craufurd PQ. Effect of plant density on the yield of sorghum–cowpea and pearl millet–cowpea intercrops in northern Nigeria. Experimental Agriculture 2000; 36:379-95.
34. Bélair G, Dauphinais N, Fournier Y, Dangi OP. Pearl Millet for the Management of *Pratylenchuspenetrans*. Flue-Cured Tobacco in Quebec 88:989-92. doi: 10.1094/PDIS.2004.88.9.989.
35. Yakubu H, Ngala AL, Dugje IY. Screening of millet (*Pennisetumglaucum* L.) varieties for salt tolerance in semi-arid soil of Northern Nigeria. World J AgricSci 2010; 6:374-80.
36. Ndjeunga J, Umar J, Ahmed B, Aba A, Ibro A, Abdoulaye, A Gwadi K. Adoption and impacts of modern sorghum and pearl millet varieties in Northern Nigeria; Working Paper Series no 40. Patancheru, India: International Crops Research Institute for the Semi-Arid Tropics. 2011.
37. Okeke-Agulu KI, Onogwu GO. Determinants of farmers' adoption decisions for improved pearl millet variety in Sahel savanna zone of northern Nigeria. Journal of Development and Agricultural Economics 2014;6:437-42.
38. Izge AU. Song IM. Pearl millet breeding and production in Nigeria: problems and prospects. Journal of Environmental Issues and Agriculture in Developing Countries, 2013;5:25-33.
39. Natesan S, Kali S, Venkateswaran K, Selvam K, Krishnamoorthy I, Rajasekaran R, Geetha S. Varietal identification and fingerprinting of Pearl Millet (*Pennisetumglaucum* L.) varieties and hybrid using morphological descriptors and SSR markers. Current Botany 2021;12:105-09. doi 10.25081/cb.2021.v12.7022.
40. Gangashetty PI, Riyazaddin M, Sanogo MD, Inousa D, Issoufou KA, Asungre PA, Ignatius AI. Identification of high-yielding iron-biofortified open-pollinated varieties of pearl millet in West Africa. Frontiers in Plant Science 2021;12:1-10. (688937) doi: 10.3389/fpls.2021.688937.
41. Reddy S P, Satyavathi, CT, Khandelwal V, Patil HT, Gupta PC, Sharma LD, Tonapi VA. Performance and stability of pearl millet varieties for grain yield and micronutrients in arid and semi-arid regions of India. Frontiers in Plant Science 2021;12:1-16. (670201).
42. Meena DS, Gautam C, Patidar OP, Singh R, Meena HM, Vishwajith, Prakash G. Management of Finger Millet based Cropping Systems for Sustainable Production. Int J CurrMicrobiol Applied Sci2017;6:676-86.
43. Florence SP, Uroo A, Asha MR, Rajiv J. Sensory, physical and nutritional qualities of cookies prepared from pearl millet (*Pennisetumtyphoideum*). Journal of Food Processing and Technology 2014; 5(10):2-6.
44. Anonymous. International year of millets (IYoM)-2023. National Conference on Kharif Campaign, 19th April, 2022.
45. Satyavati, CT, Ambawat S, Beniwal BR, KamleshK, Sushil B, Shripal S, Mahesh CK, Yadav SL. Pearl millet Hybrids and varieties, ICAR All India Coordinated Research Project on Pearl millet; Mandor, Jodhpur (India); 2018. P.1-142. http://www.aicpmip.res.in › pearl millet hybrids.
46. Gaitan E, Lindsay RH, Reichert RD, Ingbar SH, Cooksey RC, Legan J, Meydrech EF, Hill J, Kubota K. Antithyroid and goitrogenic effects of millet: role of C-glycosylflavones. J ClinEndocrinolMetab. 1989;68:707–14. Doi: 10.1210/jcem-68-4-707.
47. Kanfany G, Serba DD, Rhodes D, St Amand P, Bernardo A, Gangashetty PI, Kane NA, Bai G. Genomic diversity in pearl millet inbred lines derived from landraces and improved varieties.

Genomics, 2020;21:1-12. 469. doi:10.1186/s12864-020-06796-4.PMID: 32641069.
48. Hu Z, Mbacké B, Perumal R, Guèye MC, Sy O, Bouchet S, Prasad PV, Morris GP. Population genomics of pearl millet (*Pennisetumglaucum* (L.) R. Br.): Comparative analysis of global accessions and Senegalese landraces. Genomics, 2015;9;16:1-12,1048. doi: 10.1186/s12864-015-2255-0.PMID: 26654432.
49. Sun, M. Huang D, Zhang A, Khan I, Yan H, Wang X, Zhang X, Zhang J, Huang L. Transcriptome analysis of heat stress and drought stress in pearl millet based on Pacbio full-length transcriptome sequencing. BMC Plant Biol, 2020;20:1-12. (323).
50. Liu B, Shi Y, Yuan J, Hu X, Zhang H, Li N, Li Z, Chen Y, Mu D, Fan W. Estimation of genomic characteristics by analyzing k-mer frequency in de novo genome projects, v2. Preprint at arXiv. doi: 10.48550/arXiv.1308.2012 (2013).
51. Zhang, Q, Chen W, Sun L, Zhao F, Huang B, Yang W, Tao Y, Wang J, Yuan Z, Fan G, Xing Z, Han C, Pan H, Zhong X, Shi W, Liang X, Du D, Sun F, Xu Z, Hao R, Lv T, Lv Y, Zheng Z, Sun M, Luo L, Cai M, Gao Y, Wang J. The genome of Prunusmume. Nature Commun2012;3:1-8. (1318). https://doi.org/10.1038/ncomms2290
52. Dolezel J, Greilhuber J, Suda J. Estimation of nuclear DNA content in plants using flow cytometry. Nat Protoc 2007;2; 2233–2244 (34589092)
53. Li H, Durbin R. Fast and accurate short read alignment with Burrows–Wheeler transform. Bioinformatics 2009;25:1754–1760. doi: 10.1093/bioinformatics/btp324.
54. Li D, Li Y, Li M, Che T, Tian S, Chen B, Zhou X, Zhang G, Gaur U, Luo M, Tian K, He M, He S, Xu Z, Jin L, Tang Q, Dai Y, Xu H, Hu Y, Zhao X, Yin H, Wang Y, Zhou R, Yang C, Du H, Jiang X, Zhu Q, Li M. Population genomics identifies patterns of genetic diversity and selection in chicken. BMC Genomics. 2019;20:(263):1-12. doi: 10.1186/s12864-019-5622-4.
55. Serba DD, Muleta KT, Amand PS, Bernardo A, Bai G, Perumal R, Elfadil Bashir E. Genetic diversity, population structure, and linkage disequilibrium of pearl millet. Plant Genome 2019;12:1-12. doi: 10.3835/plantgenome2018.11.0091