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REVIEW ARTICLE

ORIGIN, DOMESTICATION, TAXONOMY, BOTANICAL DESCRIPTION, GENETICS AND CYTOGENETICS, GENETIC DIVERSITY AND BREEDING OF BROWNTOP MILLET (*Brachiaria ramosa* (L.) Stapf.)

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ABSTRACT

Browntop millet belongs to the Family Poaceae, Subfamily Panicoideae, Genus *Urochloa* and Species *Urochloa ramosa* L. Stapf; *Panicum ramosum* L. In several parts of India, brown top millet is known by local names which translate to “illegal wife of little millet [*Panicum sumatrense*],” reflecting its tendency to grow within fields of little millet as a mimic weed. It is also known as *signal grass* or *Dixie signal grass* and is considered as one of the rare millet. It is named differently in Indian languages as bennakki, benne akki, korale, karlakki, and kadu-baragu, branched or chaduru korale, round panicle/dundu korale in Kannada; anda korra, eduru gaddi, pala pul, Kuthiravali in Tamil; chama pothaval, varagu in Malayalam; and makra, murat in Hindi; and pedda-sama, andakorra in Telugu. Browntop millet (BTM) is small-seeded annual grass cultivated as grain crop, primarily on the marginal lands in dry areas in temperate, subtropical and tropical regions. It is increasingly receiving attention of the scientific community. Amongst different small millets, browntop millet has drawn the attention of health conscious customers very lately and it's of high priced coarse cereals in the retail market. In India during the Neolithic age, brown-top millet was grown as a subsistence crop and used as a grain and forage. Historical evidence (archaeo-botanical researches from the Neolithic south Indian sites) indicates that the early occurrence or first domestication of BTM was during the pre-historical period. It grew on the Deccan of southern parts of India from where it traveled to other parts of the country. This millet was present in the staple-crop fields as a weed alongside other crops in southern India from beginning of the third millennium BCE. During the second millennium BCE it reached to Gujarat and Tamil Nadu. Browntop millet is a warm season annual grass that is a heavy seed producer. This millet seed is grown in a variety of soils and climates. Browntop millet is used as a wild life food plot crop, livestock summer grazing crop, for erosion control, hay production and as a food grain crop. Under ideal conditions seed will germinate within five days and forage or seed will be ready to harvest within two months time. Browntop millet is an effective nurse crop, much like oats, in stabilizing erosive hill slopes and providing cover for slower growing target species to become established. With the ability to easily reseed and that seed to remain viable in the soil profile for years, makes browntop millet an excellent regenerating food plot for wild life. It was reported that the grain yield of browntop millet without any fertilizer was only 3.95 q/ha. However, by using the combination of organic manure and inorganic fertilizer the grain yield of BTM increased to 7.38 q/ha. The cultivation of browntop is simple but processing is difficult due to the hard outer cover of the seed. As a result, farmers get only 40-50kg of rice from one quintal of browntop/korale seeds. Earlier grinding stones were used to separate the grain from the seed. Today, grinding stones have almost disappeared and korale seeds are processed in the flour mills that process finger millet. The size of korale rice is also very small and separation of stones is difficult. Hence, processing has become a bottleneck for farmers, and efforts are on to design improved processing machines. In this review article on Origin, Domestication, Taxonomy, Botanical Description, Genetics and Cytogenetics, Genetic Diversity, Breeding, Uses, Nutritional Value and Health Benefits of Browntop Millet are discussed.

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INTRODUCTION

Browntop millet belongs to the Family Poaceae, Subfamily Panicoideae, Genus *Urochloa* and Species *Urochloa ramosa* L. Stopf; *Panicum ramosum* L., *Brachiaria ramosa* L. Stapf) (Priya *et al.*, 2022; Wikipedia, 2023a; USDA, 2023; Naturalist, 2023). In several parts of India, brown top millet is known by local names which translate to “illegal wife of little millet [*Panicum sumatrense*],” reflecting its tendency to grow within fields of little millet as a mimic weed (Kingwell-Banham and Fuller, 2014). It is also known as *signal grass* or *Dixie signal grass* and is considered as one of the rare millet (Sheahan, 2014; Singh *et al.*, 2022; NCEG, 2023). It is named differently in Indian languages as bennakki hullu, benne akki hullu, korale, karlakki, and kadu-baragu, branched or chaduru korale, round panicle/dundu korale in Kannada; anda korra, eduru gaddi, pala pul, Kuthiravali in Tamil; chama pothaval, varagu in Malayalam; makra, murat in Hindi; and pedda-sama, andakorra in Telugu (Sheahan, 2014; Sujata *et al.*, 2018; Naturalist, 2023; Wikipedia, 2023a; Staff, 2023). Brown top millet or signal grass belong to the family poaceae. The majority of *Brachiaria* species is polyploid. (Basappa *et al.*, 1987). Two basic chromosome numbers have been reported along decades for several species in the genus *Brachiaria*, $x = 7$ and $x = 9$ (Basappa *et al.*, 1987). However, recently, a new basic chromosome number, $x = 6$, was reported for *B. dictyonera* (Risso-Pascotto *et al.*, 2006). There is a wide prevalence of polyploid forms in the genus *Brachiaria*, with a predominance of tetraploid accessions within species. Among several species studied, only a few hexaploid accessions ($2n = 6x = 54$) were recorded and only in *B. brizantha*. Browntop millet (*Urochloa ramosa*, Poaceae) is a warm season grass commonly used as a cover crop in pasture management systems. This species is inexpensive compared to other forage crops and its ability to easily reseed and to remain viable in the soil for years makes browntop millet an excellent regenerating food plot for wildlife (Manamgoda *et al.*, 2017).

Browntop millet is an introduced annual grass that originated in South-East Asia. It is grown in Africa, Arabia, China and Australia. It was introduced to the United States from India in 1915. In the US, it is mainly grown in the South-East for hay, pasture and game bird feed. The browntop millet, called korale in Kannada, is specially grown in rainfed tracts of Tumakuru, Chitradurga and Chikkaballapura districts of Karnataka state. The crop is popular in this region in terms of cultivation and consumption. This millet seed is grown in a variety of soils and climates. Like other millets, it is a hardy crop and well suited for dry land (Sujata *et al.*, 2018). Browntop millet is a warm season annual grass that is a heavy seed producer. This millet seed is grown in a variety of soils and climates. Browntop millet is used as a wild life food plot crop, livestock summer grazing crop, for erosion control, hay production and as a food grain crop. Under ideal conditions seed will germinate within five days and forage or seed will be ready to harvest within two months time. Browntop millet is an effective nurse crop, much like oats, in stabilizing erosive hill slopes and providing cover for slower growing target species to become established. With the ability to easily reseed and that seed to remain viable in the soil profile for years, makes browntop millet an excellent regenerating food plot for wild life (Sujata *et al.*, 2018). Browntop millet is a warm season annual grass that is a heavy seed producer. This millet seed is grown in a variety of soils and climates. Browntop millet is used as a wild life food plot crop, livestock summer grazing crop, for erosion control, hay production and as a food grain crop. Under ideal conditions seed will germinate within five days and forage or seed will be ready to harvest within two months time. Browntop millet is an effective nurse crop, much like oats, in stabilizing erosive hill slopes and providing cover for slower growing target species to become established. With the ability to easily reseed and that seed to remain viable in the soil profile for years, makes browntop millet an excellent regenerating food plot for wild life (Sujata *et al.*, 2018). Browntop millet is one of forgotten crop with very small grains which is mainly used as food and fodder. It is a climate resilient crop which can come well with limited water. It is highly valued for its high fiber and mineral content in grains (Anuradha *et al.*, 2020).

It is used as both a human food crop and fodder. It is drought-tolerant, early maturing and harvested in about 75–80 days earlier than other millets. This millet is well suited for dry land, grown under a variety of soils and climates. The key factors like suitable processing and salubrious alternatives determines the uses of this millet for either house hold consumption or further processing by having optimum nutrient content (Maitra 2020). Millets are recently recognized as ‘nutri-cereals’ due to their superiority in terms of dietary value to other cereals. India has the heritage to grow different kinds of millets since the ancient time. Different small millets have unique quality to combat with the extreme climatic conditions which are more relevant as adaptation option in the present scenario of issues related to global warming and climate change. The production sustainability is must considering the growing population of the world and it is a major concern in developing countries with more population (Maitra, 2020). The small millets can play important role in this regard as these are ecologically sound, belong to C_4 group of plants, tolerant to different adverse climatic conditions including drought and can produce a moderate yield for food and nutritional sustainability. Amongst different small millets, the importance brown-top millet has recognized recently as it has huge potential to make farming in resource-poor and fragile ecological conditions and thus can ensure economic and nutritional security as well as production sustainability of smallholders (Maitra, 2020). Amongst different small millets, browntop millet has drawn the attention of health conscious customers very lately and it's of high priced coarse cereals in the retail market. In India during the Neolithic age, brown-top millet was grown as a subsistence crop and used as a grain and forage (Maitra, 2020). Considering the developing interest in browntop millet amongst both the consumers and farmers, there could also be scope for expansion of area under cultivation targeting profitability as well as agricultural sustainability. Unlike other millets, brown-top millet has a unique quality as it can be grown within the partial shade which ensures wider choice of adoption even in fruit orchards (Maitra, 2020). Browntop millet is a warm season crop and it can produce heavy seeds compared to other millets. This crop grown on a variety of soils and climates. It can be used as a wild life food crop, livestock grazing crop, for erosion control, hay production and also as a food grain crop. Brown top millets provide nearly all essential nutrients. Brown top millet referred as miracle or positive crop for the dry and rainfed situations. The Brown top millet is known for its rapid forage production. It is grown for several other purposes like cover crop in plantation crop for soil erosion control and for high straw production. It suppresses root-knot nematode in the soil. This millet can be recommended in daily diet, there is a need to encourage the farming community to grow this crop thus contributing in achieving nutrition security. The nutrient content of browntop millet is on par with other millets and cultivation of this crop is also easier (Ashoka and Sunitha, 2020).

Browntop millet is one of forgotten crop with very small grains which is mainly used as food and fodder. It is a climate resilient crop which can come well with limited water. It is highly valued for its high fiber and mineral content in grains. Though it is a weed in many places, it is grown as feed for game birds in some parts of America and it is grown as crop for human consumption and fodder to animals in few parts of southern India. In the past it used to be a major staple crop in much wider areas. Recently it is gaining importance among public as nutritional grain because of its high fiber content in the grain. Its growing popularity among public made the Government sector working on small millets to include it as one of the small millet in AICRP system for conducting trials and developing varieties during 2018-19 (Anuradha *et al.*, 2020). It is also considered as illegal wife of little millet since it mimics little millet and is mostly seen in the little millet crop. In India, it is cultivated mainly in Karnataka, Andhra Pradesh and to some extent in Tamil Nadu.

It is drought resistant, heat tolerant and can be grown even in degraded soils with scarce water resources. It fits into any cropping system and it can also be used as a cover crop as it easily spreads like grass striking roots wherever it touches the ground covering the ground and holding the soil firmly, thus preventing soil erosion. The grain matures within 75-90 days, while for forage it is hardly 50 days duration with rapid forage production (Anuradha *et al.*, 2020).

In the recent past, there has been an increasing recognition of the importance of millets as a substitute for major cereals owing to their inherent health benefits apart from climate resilience. Among the small millets, browntop millet (*Brachiaria ramosa* (L.) Stapf, *Panicum ramosum* L., *Urochloa ramosa*), is one of the rarest crops commonly known as Dixie signal grass and locally as korale in Kannada and andukorralu in Telugu. It is drought-tolerant, early maturing and harvested in about 75–80 days. This millet is well suited for drylands, grown under a variety of soils and climates and can fit into different cropping systems as a catch crop. It grows well in the dryland regions of Tumkur, Chitradurga and Chikkaballapura districts of Karnataka and Ananthapur district of Andhra Pradesh. In view of the health benefits coupled with its hardy nature, short duration and rich nutrient profile, there is a huge demand for this millet in the recent past (Kishore *et al.*, 2021). Transition in consumer demand for health-promoting foods than hunger-satisfying foods is taking place. Millets are non-glutinous, non-acid forming and easy to digest loaded with high phytochemicals and antioxidant levels. Brown-top millet can be used as both the fodder and grain purposes. In Southern part of India, the consumption and production can be observed. Still, brown-top millet is still an emerging crop and its cultivation is limited to confined areas. Brown-top millet is a crop of versatile use as it is grown as food for human consumption, forage and food for birds and as raw material for industries. Domestic and wild/weedy forms of brown-top millet are found in agricultural systems, often within the same field (Priya *et al.*, 2022). Outside of India, it is grown in some parts of the USA as a fodder crop, largely to provide food for game birds, and was introduced from India around 1915 (Kingwell-Banham and Fuller, 2014). Brown-top millet is one of the nutritious minor millets. The other vernacular names of brown-top millet are markra or murat in Hindi, korle or pedda same in Kannada and kula samai or palapul in Tamil. Browntop millet is an annual/perennial warm-season grass which is used in forage/pasture management systems that originated in Southeast Asia. This crop is recently gained importance, familiar for climate resilience and its capacity to adapt to varied ecological circumstances, low water requirement, low incidence of insect pests and disease and low vulnerability to environmental pressures (Priya *et al.*, 2022). Currently, it is grown in a limited area due to the shift from traditional crops to commercial crops. The climate resilient aspects and increased interest among consumers regarding healthy consciousness necessitated more research and development in this crop. This millet has encountered minimal research attention in terms of the development of genetic and genomic resources and breeding for yield improvement. This might be due to low research priority for this crop and nearly all diverse genetic resources were lost in the shift to cash crops (Priya *et al.*, 2022).

It was reported that the grain yield of browntop millet without any fertilizer was only 3.95 q/ha. However, by using the combination of organic manure and inorganic fertilizer the grain yield of BTM increased to 7.38 q/ha (Singh *et al.*, 2022). Browntop millet (BTM) is small-seeded annual grass cultivated as grain crop, primarily on the marginal lands in dry areas in temperate, subtropical and tropical regions. It is increasingly receiving attention of the scientific community. Aim of this systematic review is to study the physiochemical, sensory, functional and nutritional properties as well as health benefits of browntop millet (Singh *et al.*, 2022). This paper is based on quantitative and qualitative secondary data obtained from 71 out of 208 descriptive and scientific literature reviewed and analyzed from the national and international electronic platforms. The scientific literature based on browntop millet has been found scanty. According to the few studies available energy ranges from 338.0 kcal to 368.62 kcal. The carbohydrate, crude fiber and fat content of BTM is 71.32 gm, 8.06–16.08%, 1.89 gm, respectively. Protein is between 11.64% and 10.72%. Browntop millet contains phytochemicals such as flavonoids, quinones, tannins, and resin (Singh *et al.*, 2022). There is a scope for development and standardization of value added products made from browntop millets such as ready to eat foods (cookies, bars, desserts, etc) and ready to cook foods (idli mix, poha) in which the millet can be used in combination with other cereal grains. Thus, browntop millet holds great potential in alleviating food and nutrition insecurity. It has good nutritional value. It can be used for the prevention and management of several non-communicable diseases (Singh *et al.*, 2022).

Being good source of fiber, polyphenols and other biological active compounds, they are also considered to play an important role in lowering the rate of fat absorption, retarding the release of sugars (low glycemic index) and thus reducing risk of several non-communicable diseases such as heart disease, diabetes and high blood pressure. Amongst various small millets, the importance of browntop millet (BTM) has been recognized recently as it has huge potential to give high yield in resource-poor and fragile ecological conditions and thus can ensure economic and nutrition security as well as sustainability in production of small farm holders (Singh *et al.*, 2022). Amongst various small millets, the importance of browntop millet (BTM) has been recognized recently as it has huge potential to give high yield in resource-poor and fragile ecological conditions and thus can ensure economic and nutrition security as well as sustainability in production of small farm holders. The grains of browntop millet have been observed in scattered sites in Odisha and the Gangetic plains. However, literature does not provide any authentic information about commercial farming of this millet (Singh *et al.*, 2022). Up to the seventh century, existence of brown top millet was recognized at certain areas in Maharashtra (Paithan). However, with the passage of time cultivation of this crop got substituted by more productive millets, including pearl millet, sorghum, finger millet as well as foxtail millet (Singh *et al.*, 2022).

Brown top millet due to its exceptional nutritional profile and adaptability to hot and dry conditions with minimal water and other inputs, there is a growing demand for Brown top millet. It is predominantly cultivated in the rain-fed regions of Andhra Pradesh, Karnataka, and some parts of North-Central India. Notably, Brown top millet can thrive in coconut tree plantations and exhibits tolerance to drought. Moreover, it holds promise for combating soil erosion in hilly areas (BTP, 2023). Brown Top millet, also known as palapul in Tamil, korale in Kannada and andakorra in Telugu. It used to grow in the forest and was consumed by meat-eating wildlife and jungle inhabitants. Gluten-free, nutrient-dense whole grains have restored their place in our kitchen cabinets as a result of their essential therapeutic benefits. Brown top millets are widely grown in dry regions of Karnataka, Andhra Pradesh, and north-central India. These millets can be grown in dry soil with little water. They are drought and heat resistant crops, and their ability to tolerate shadows distinguishes them from other crops. Brown top millet is grown extensively in the United States, Asia, Africa, Australia, and China, in addition to India. In hilly areas, brown top millet is known to help stabilize soil erosion. Because the grass is tall, it provides a shield for slightly faster crops. The process of reseeded is very simple and easy, and the seed remains viable in the soil for years, making it an impressive regenerative food for wildlife (Bnboranics, 2023).

It can be found growing in fields, corn fields, and waste sites. Its primary use is as a forage crop for domestic animals and game animals and birds such as deer, turkey, duck, dove, quail, rabbit and pheasant. With ideal conditions provided, germination can occur within 5 days and the rapidly growing crop can be harvested in two months. Its fine stems and leaves allow the plant to dry sufficiently to create a dry hay product. It is also grown as a nurse crop, that is a crop that is planted to assist the establishment of a perennial crop such as grasses that may take a longer period of time to become established, especially on slopes. Its reseeded and long term viability also makes this an affordable regenerating food source for wildlife. Used in remediation projects, Browntop millet accumulates significant amounts of zinc and lead from the soil. The end

product will store these minerals for easy removal (NCEG, 2023). Unpolished Browntop millet is the rarest of all millet varieties and has great demands owing to its dense nutritional profile and its ability to adapt to climate change. Unpolished browntop millet is greenish in colour. Browntop Millet is warm season crop and is quickest maturing period of 70-75 days. Brown top millets are cultivated abundantly in dry regions of Karnataka, Andhra Pradesh, and parts of north-central India. These millets can be grown on hard soil with very little amount of water. They are drought and heat tolerant crops and their shadow tolerant nature makes them unique from other crops (Grandma, 2023)

In India, Browntop millets are grown in dry regions of Karnataka, Andhra Pradesh. Browntop millet are grown in the United States, Asia, Africa, Australia and China (Majumdar *et al.*, 2023). These seeds contain high levels of proteins, healthy fats, carbohydrates, and dietary fiber content. Browntop millet is rich in essential nutrients which includes calcium, iron, phosphorus, potassium, magnesium, manganese and zinc. Daily consumption of the millets lowers the threat of developing cardiovascular diseases, diabetes, and digestive problems. Browntop millet contains phytochemicals such as flavonoids, quinones, tannins, and resin. There is a huge potential for development of value-added products made from Browntop millets similar as ready to eat foods and ready to cook foods like idli blend, poha and many more where millets are mixed with other cereal grains. Therefore, Browntop millet holds great potential in alleviating food and nutrition insecurity. It has good nutritive value. Browntop millet prevents numerous non-communicable diseases. It can be used in many forms such as forage and staple food (Majumdar *et al.*, 2023). Brown top millet is one of the neglected small millets with moderately good demand in the market, and it can be cultivated in tropic and subtropics due to its wider adaptability. The crop is also of short duration that gives ample scope to fit into various cropping systems. Further, brown top millet does not require a sizable quantity of high energy input, and thus, it has the quality to lower carbon footprint in agriculture (Maitra *et al.*, 2023). Brown Top is one of the oldest cultivated crops in the world. It is a type of millet that is gaining popularity in India and other countries due to its high nutritional value and versatility. Brown Top Millet is an excellent substitute for rice and wheat and is known for its ability to grow in a variety of conditions. In recent years, it has gained attention as a superfood due to its numerous health benefits (Staff, 2023).

Brown top millet will come under minor millets which are still hidden even if it has a good nutrition profile. Brown top millet will grow in warm and dry areas and will give yield annually. Southern India's sparse and erratic rainfall and poor and marginal soils are ideal growing environments for brown top millet, which has its origins in Southeast Asia. It is well-known as a short-duration crop because of its higher yield per unit of time, lower input needs, and tolerance to drought and shade. It is also well-suited to a variety of soil types and can withstand extreme moisture stress. The biggest threat to agriculture and food security globally, particularly for the poor, is posed by challenges like climate change, water scarcity, increasing food prices, and other socioeconomic repercussions. As a result, other nutrient-rich dietary sources are required. Brown top millet is a small seeded grasses that are farmed as grain crops in dry areas of temperate, tropical, and subtropical climates are known as millets. However, it hasn't yet become popular because consumers aren't aware of it and food processing corporations aren't interested in it. Brown top offers a wide range of potential uses (Shaliha *et al.*, 2023). Browntop millet is a drought-tolerant, climate-resilient crop that contains abundant quantities of carbohydrates, protein, dietary fiber, minerals, and vitamins. Since it can be grown in varied soil types, it is highly fit for different cropping systems. It is tetraploid at the genetic level and has a basic chromosome number of four. The crop has its origins in South East Asia, and currently, it is cultivated across Western Asia, China, and Australia. In India, its cultivation is confined largely to south Indian states like Karnataka, Andhra Pradesh, and Tamil Nadu (Nagaraja *et al.*, 2023).

Browntop millet (BTM) is small-seeded annual grass cultivated as grain crop, primarily on the marginal lands in dry areas in temperate, subtropical and tropical regions. It is increasingly receiving attention of the scientific community. The scientific literature based on browntop millet has been found scanty. According to the few studies available energy ranges from 338.0 kcal to 368.62 kcal. The carbohydrate, crude fiber and fat content of BTM is 71.32 gm, 8.06–16.08%, 1.89 gm, respectively. Protein is between 11.64% and 10.72%. Browntop millet contains phytochemicals such as flavonoids, quinones, tannins, and resin (Singh *et al.*, 2022). The chemical properties of Browntop millet changes when it is subjected to various processing methods that is soaking, germination, fermentation, dry heating, hydrothermal treatment and extrusion cooking. Samples were analysed and found to have moisture in the range of 1.92 ± 0.05 to $8.99 \pm 0.06\%$, protein- $6.10 \pm 0.06\%$ to $17.31 \pm 0.25\%$; ash - $1.06 \pm 0.07\%$ to $5.80 \pm 0.15\%$; fat- $3.78 \pm 0.12\%$ to $7.08 \pm 0.03\%$; crude fiber - $2.22 \pm 0.07\%$ to $20.17 \pm 0.09\%$; carbohydrate- $58.0 \pm 1.06\%$ to $76.33 \pm 0.25\%$; energy- 306.8 ± 4.6 KCal/100 g to 396.5 ± 0.8 K Cal/100 g. (Majumdar *et al.*, 2023).

Seed germination can happen in up to 5 days and the rapidly growing crop can then be harvested in the next two months. Its fine stems and leaves allow the plant to dry sufficiently to be used as a dry hay product (Naturalist, 2023). Brown top millets are cultivated abundantly in dry regions of Karnataka, Andhra Pradesh, and parts of north-central India (Binu, 2021). These millets can be grown on hard soil with very little amount of water. They are drought and heat tolerant crops and their shadow tolerant nature makes them unique from other crops. Besides India, Brown top millet are widely cultivated in the United States, Asia, Africa, Australia, and China. Brown top millet is known to stabilize soil erosion in hilly regions. It offers a shield for slower-growing crops as their grass is tall. The reseeding process is very simple and easy, and the seed remains viable in the soil for years, thereby making it an impressive regenerative food for wildlife (Binu, 2021). Browntop typically grows only to 0.6 to 1.5 m tall. In India, the browntop millet is growing in the states of Karnataka, Tamil Nadu, Andhra Pradesh and parts of north central India referred as Bundelkhand region (Nagaraju *et al.*, 2020). The Browntop millet is grown in the districts of Tumakur, Chitradurga, Chikkaballapur and Mandya in Karnataka state and Ananthapur quarter in Andhra Pradesh state for the traditional food medications (Majumdar *et al.*, 2023). Being domestic in India, it grows well in the dryland tracts of Karnataka-Andhra Pradesh border areas, Tamil Nadu and Maharashtra, covering regions of Tumkur, Chitradurga, Mandya and Chikkaballapura districts in Karnataka and Ananthpur district in Andhra Pradesh and the crop is additionally grown and consumed in limited quantities in Bundelkhand region (north central India) (Sheahan, 2014).

Millets, often referred as smart food or smart crops, are the staple foods of people living in arid and semi-arid regions of the world. Especially in Asian and African countries. Minor millets are also referred as "coarse grains" or "poor man's crops" or "small millets" which include proso millet, finger millet, little millet, kodo millet, browntop millet, barnyard millet, and foxtail millet. They are not even traded in local markets in many countries. India has been the leading producer of millets followed by Nigeria and China. The production of millets has increased from 10.28 million tons in 2016 to 12.49 million tons in 2020. While in 2016 India contributed 37.34%, in 2020 the contribution was nearly 41% to the world's production of millets. Contribution to the pool of millets production in Asia by India has been most significant *i.e.*, 80.46% in 2016 and 79.36% in 2020 (Sheahan, 2014). The average grain yield of BTM is 12.13 g per plant; the highest grain yield being of IC 617961 variety *i.e.*, 20.38 g per plant. A study was conducted on growth and yield attributes of browntop millet (*Brachiaria ramosa*) in red sandy soils of Dharwad in Karnataka. The grain yield of browntop millet without any fertilizer was only 3.95 q/ha. However, by using the combination of organic manure and inorganic fertilizer the grain yield of BTM increased to 7.38 q/ha (Sheahan, 2014). The cultivation of browntop is simple but processing is difficult due to the hard outer cover of the seed. As a result, farmers get only 40-50kg of rice from one quintal of browntop/korale seeds. Earlier grinding stones were used to separate the grain from the seed.

Today, grinding stones have almost disappeared and korale seeds are processed in the flour mills that process finger millet. The size of korale rice is also very small and separation of stones is difficult. Hence, processing has become a bottleneck for farmers, and efforts are on to design improved processing machines (Sujata *et al.*, 2018). Browntop millet (*Urochloa ramosa* L.) known as 'korale' in Karnataka is an annual warm-season grass often used as a forage crop gaining importance because of its nutritional qualities. Very fewer researches have been done so far on the millet (Nagaraju *et al.*, 2020). In spite of having high micronutrient potentiality, storage stability and fodder quality browntop millet is grown in negligible parts of these states. The browntop millet is mainly grown in the districts of Tumakur, Chitradurga, Chikkaballapur and Mandya in Karnataka state and Ananthapur district in Andhra Pradesh state for the traditional food preparations (Nagaraju *et al.*, 2020). The brown-top millet has hard outer cover of the seed and processing is little difficult and for that reason only making rice from whole grain is not preferred, rather seeds are processed in the flour mills. There is enough scope for designing suitable machines for processing of seeds for making of rice from brown-top millet (Maitra, 2020).

Brown top millet is particularly tolerant of drought and is well adapted to semiarid areas. It grows well at altitudes of 2,000–2,500 m, with 75–150 cm annual rainfall. Cultivation is more common in the dry areas of Karnataka and Andhra Pradesh at lower elevations, South India, than in other parts of the world. Brown top millet grows and matures over around 90 days, a shorter time than several other millets including pearl millet (*Pennisetum glaucum*). It is usually grown as a single crop and not incorporated into mixed field systems. Harvesting in the early morning while the dew is still on the crop reduces the amount of grain lost through panicle shattering. Shattering (dehiscence) is reduced compared to the wild forms, but it is still partially shattering. The crop tends to be cut at the base, then winnowed, dehusked, and polished. Because it is semi-shattering, its grains can become dislodged just by being dried which reduces the need to thresh, although it requires dehusking like most other millets. Straw and chaff is often used as animal fodder; however, the grain is reserved for human consumption and is said to be tastier than rice. Brown top millet tends to be ground into flour and used to make flatbreads (roti, dosa) or polished and boiled to make gruel (anna, kheer). Some of these foods are used in religious rituals, which may partly account for its persistence in cultivation (Kingwell-Banham and Fuller, 2014). In this review article on Origin, Domestication, Taxonomy, Botanical Description, Genetics and Cytogenetics, Genetic Diversity, Breeding, Uses, Nutritional Value and Health Benefits of Browntop Millet are discussed.

ORIGIN AND DOMESTICATION

The domestication of brown top millet probably occurred in South India, in the Deccan, and it spread during prehistory outward to other parts of India. Charred grains identified as "*Brachiaria ramosa* type" have been recovered from most Neolithic South Indian sites where systematic archaeobotanical work has occurred. On these sites brown top millet has a high ubiquity and relative frequency. Dating the time of domestication is complicated by the fact that little archaeobotanical work has been carried out on early Neolithic or preceramic period (Mesolithic sites); however, the evidence suggests that this crop, along with other South Indian crops (*i.e.*, *Macrotyloma uniflorum*, *Vigna radiata* and *Setaria verticillata*), developed from indigenous wild populations around the beginning of the third millennium BCE. During this period, local millets and legumes were incorporated into an agro-pastoral system, part of the ash-mound culture of the southern Neolithic of India, which employed both mobile cattle pastoralism and small-scale crop cultivation. Brown top millet spread out from the Deccan to Tamil Nadu in the south and Gujarat in the north by the end of the second millennium BCE. Small quantities of the grain have also been found from Chalcolithic (late second–early first millennium BCE) sites in Odisha (Orissa) in the east and some sites in the Ganges plains. However, the number of grains recovered does not suggest cultivation and may represent wild plants. Over time, brown top millet has seen reduced use, although it was still present at the site of Paithan in Maharashtra up to the seventh century CE. Its gradual reduction in use can be attributed to displacement by alternative, more productive millets, including the African millets (*Sorghum bicolor*, *Elausine coracana*), as well as foxtail millet (*Setaria italica*) that probably contributed to this. Today brown top millet is a relict cultivar but one with some important ritual uses (Kingwell-Banham and Fuller, 2014).

Brown top millet, which goes by the scientific name *Brachiaria ramosa* (L.) Stapf. or *Urochloa ramosa* (L.) R.D. Webster, is known locally as pedda-sama and korne, and has a limited cultivation largely confined to southern India. Domestic and wild/weedy forms of brown top millet are found in agricultural systems, often within the same field. It is used as both a human food crop and fodder. Although its distribution is highly relict today, restricted to parts remote parts of Andhra Pradesh, Karnataka, and Tamil Nadu states in southern India, it appears to have been a major staple crop in the late prehistory of the wider region of the Deccan. Outside of India, it is grown in some parts of the USA as a fodder crop, largely to provide food for game birds, and was introduced from India around 1915 (Kingwell-Banham and Fuller, 2014). The first domestication of brown top millet probably occurred within the Deccan of southern India and it had been reached to other parts of India during prehistory period (Kingwell-Banham and Fuller, 2014) as evidenced in the archaeo-botanical researches from the Neolithic south Indian sites (Fig.1).

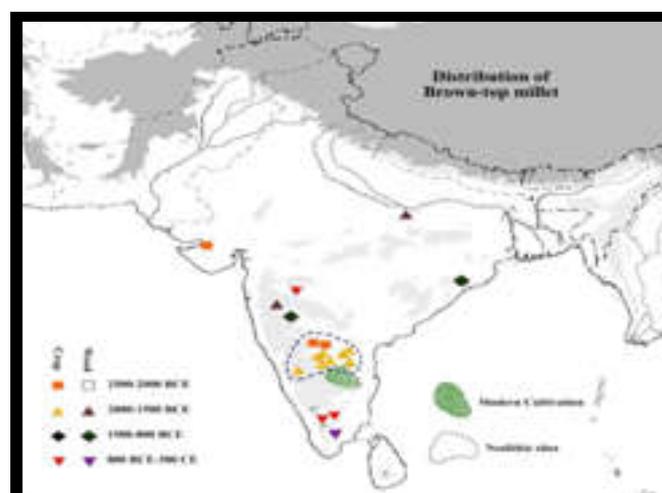


Fig.1. Distribution of brown-top millet from archaeological sites and modern cultivation

Browntop millet is an introduced annual grass that originated in South-East Asia. It is grown in Africa, Arabia, China and Australia. It was introduced to the United States from India in 1915. In the US, it is mainly grown in the South-East for hay, pasture and game bird feed (Sujata *et al.*, 2018). Browntop millet is also known as signalgrass and it is one amongst the rarest millets. Being native to India, it grows well in the dryland tracts of Karnataka-Andhra Pradesh border areas, covering regions of Tumkur, Chitradurga and Chikkaballapura districts in Karnataka and Ananthpur district in Andhra Pradesh. Further researchers suggested this millet was present in the crop fields alongside other crops of south India from beginning of the third millennium BCE. Agro-pastoral system was very common during Neolithic period and millet-legume mixed cropping was a standard feature of farming system. During the second millennium BCE from the Deccan it reached to Tamil Nadu and Gujarat (Maitra, 2020). The grains of browntop were observed in scattered sites in Odisha and the Gangetic plains. However, there was no evidence of commercial farming. Moreover, up to the seventh century CE presence of brown-top millet was noted at the location of Paithan in Maharashtra. But overtime this crop has been substituted by more productive millets, including sorghum, pearl millet, finger millet as well as foxtail millet. Brown-top millet was originated in south-east Asia and presently it is grown in Africa, western Asia, Arabia, Australia and China. In 1915, it was introduced to the United States from India. In the US, it is cultivated for hay, pasture and gamebird field. In India, its presence is noted as a common weed of little millet (Maitra, 2020). It originated from Southeast Asia and is presently grown in Africa, Western Asia, Arabia, China and Australia. It was introduced to the United States from India in 1915. In the US, it is mainly grown in the Southeast for hay, pasture and game bird feed (Nagaraju *et al.*, 2020).

Historical evidence (archaeo-botanical researches from the Neolithic south Indian sites) indicates that the early occurrence or first domestication of BTM was during the pre-historical period. It grew on the Deccan of southern parts of India from where it traveled to other parts of the country. This millet was present in the staple-crop fields as a weed alongside other crops in southern India from beginning of the third millennium BCE. During the second millennium BCE it reached to Gujarat and Tamil Nadu. The grains of browntop millet have been observed in scattered sites in Odisha and the Gangetic plains. However, literature does not provide any authentic information about commercial farming of this millet. Up to the seventh century, existence of browntop millet was recognized at certain areas in Maharashtra. Browntop millet got originated in south-east Asia and presently it is grown in Africa, western Asia, Arabia, Australia and China. It is grown in some parts of the USA as a fodder crop, largely to provide food for game birds, and was introduced by India at around 1915. In India, its existence is noted in the fields of little millet (Singh *et al.*, 2022). Being domestic in India, it grows well in the dryland tracts of Karnataka-Andhra Pradesh border areas, Tamil Nadu and Maharashtra, covering regions of Tumkur, Chitradurga, Mandya and Chikkaballapura districts in Karnataka and Ananthpur district in Andhra Pradesh and the crop is additionally grown and consumed in limited quantities in Bundelkhand region (north central India) (Singh *et al.*, 2022).

Browntop millet is distributed in India, Bangladesh, Bhutan, Cambodia, Malawi, Myanmar, Nepal, Senegal, South Africa, Yemen and Zimbabwe grown mostly in southern India and in some parts of the USA as a fodder crop and bird feed (Smart food, 2023). It is found in Afghanistan, Andaman Islands, Bangladesh, Benin, Burkina, Cambodia, Cameroon, Cape Verde, Chad, China, Djibouti, East Himalaya, Egypt, Eritrea, Ethiopia, Gambia, Guinea-Bissau, Gulf States, Hainan, India, Ivory Coast, Java, Kenya, Lesser Sunda Islands, Liberia, Malawi, Malaya, Mali, Mauritania, Mozambique, Myanmar, Nepal, New Guinea, Nicobar Islands, Niger, Nigeria, Northern Provinces (South Africa), Oman, Pakistan, Philippines, Saudi Arabia, Senegal, (island of) Socotra, Somalia, Sri Lanka, Sudan, Tanzania, Thailand, Vietnam, West Himalaya, Yemen and Zimbabwe. It has been introduced to parts of U.S.A. (Alabama, Arkansas, Florida, Georgia, Hawaii, Illinois, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, South Carolina, Tennessee, Texas and Virginia), South America (Peru), Africa (Madagascar, Mauritius and island of Réunion), and parts of Australia, (Christmas Island, Northern Territory, Queensland and Western Australia). In parts of America, it is now considered invasive weed, as it has been found to reduce yield and lower quality of cotton in the southeastern United States (Wikipedia, 2023a; Naturalist, 2023). It is a plant that is native to the tropics and has spread all across the southeastern U.S.A. In its native India it is often cultivated as a grain and a forage crop. The grain is also used as a bird seed (NCEG, 2023).

TAXONOMY

Small millets belong to nine different genera of the grass family *Poaceae*. Fig.2 shows the taxonomical classification of small millets, together with major cereals, and pseudo-cereals (Vetriventhan *et al.*, 2020).

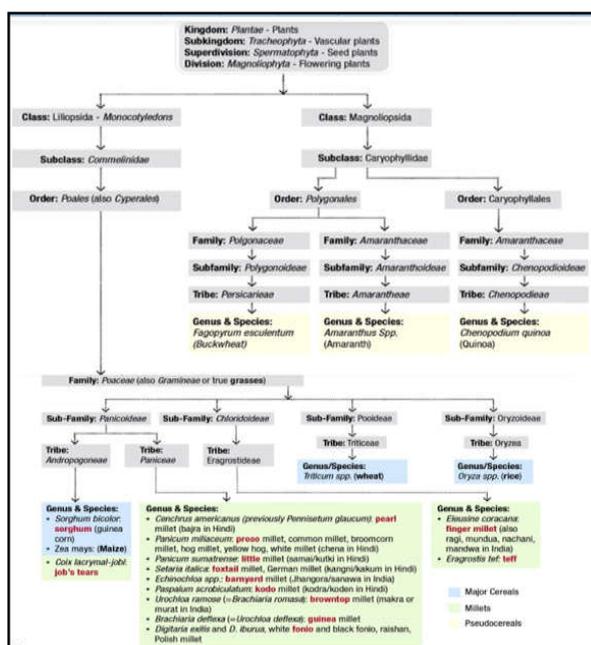


Fig. 2. Classification of millets

“Millet” is not a botanic term for a certain plant but rather an umbrella term for various small seeded grasses used for human consumption. All millets belong to the order of Poales, and there to the family of Poaceae (also Gramineae or true grasses). They belong to either of the two subfamilies of Panicoideae or Chloridoideae (TMP, 2023; MT, 2023):

Eragrostideae tribe (Chloridoideae subfamily):

- *Eleusine coracana*: finger millet, mawere (ragi, nachani or mandwa in India)
- *Eragrostis tef*: teff
- Paniceae tribe (Panicoideae subfamily):
- *Panicum miliacum*: proso millet, common millet, broom corn millet, hog millet, yellow hog, white millet
- *Pennisetum glaucum*: pearl millet (kambu or bajra in India)
- *Setaria italica*: foxtail millet, German millet (thinai, kang or rala in India)
- *Digitaria* spp.: white fonio, black fonio, raishan, Polish millet
- *Echinochloa* spp.: Japanese banyard millet, Indian banyard millet, sawa millet, burgu millet (kuthirai vaali, bhagar or varai in India)
- *Panicum sumatrense*: little millet (samai in India)
- *Paspalum scrobiculatum*: kodo millet (varagu in India)
- *Urochloa* spp. (also known as *Brachiaria*): browntop millet (*U. ramosa*, dixie signalgrass), Guinea millet Andropogoneae tribe (Panicoideae subfamily):
- *Coix*: Job’s tears.

It was originally published as *Brachiaria ramosa* (L.) Stapf. in 1919, before being renamed and published and described by botanist T.Q.Nguyen in Novosti Sist. Vyssh. Rast. in 1966. The specific epithet, *ramosa*, is a Latin adjective meaning "branched" which describes the plant as bearing branches. The reconstructed Proto-Dravidian name for *Brachiaria ramosa* is *conna-l*. (Wikipedia, 2023a; Naturalist, 2023). Browntop millet belongs to the Family Poaceae, Subfamily Panicoideae, Genus *Urochloa* and Species *Urochloa ramosa* L. Stapf; *Panicum ramosum* L., *Panicum arvense*; *Brachiaria ramosa* L. Stapf (Priya et al., 2022; Wikipedia, 2023a; USDA, 2023;) Naturalist, 2023. In several parts of India, brown top millet is known by local names which translate to “illegal wife of little millet [*Panicum sumatrense*],” reflecting its tendency to grow within fields of little millet as a mimic weed (Kingwell-Banham and Fuller, 2014). It is also known as *signal grass* or *Dixie signal grass* and is considered as one of the rare millet (Sheahan, 2014; Singh et al., 2022; NCEG, 2023).

87 species have been accepted by Plants of the World Online in 2023 (Wikipedia, 2023) and is given in Table 1.

Table 1. Species of Urochloa

1. <i>Urochloa adspersa</i> (Trin.) R.D.Webster
2. <i>Urochloa advena</i> (Vickery) R.D.Webster
3. <i>Urochloa albicoma</i> (Swallen & Garcia-Barr.) Morrone & Zuloaga
4. <i>Urochloa argentea</i> (R.Br.) Hughes
5. <i>Urochloa arida</i> (Mez) Rudov
6. <i>Urochloa arizonica</i> (Scribn. & Merr.) Morrone & Zuloaga
7. <i>Urochloa arrecta</i> (Hack. ex T.Durand & Schinz) Morrone & Zuloaga
8. <i>Urochloa atrisola</i> R.D.Webster
9. <i>Urochloa bovonei</i> (Chiov.) A.M.Torres & C.M.Morton
10. <i>Urochloa brachyura</i> (Hack.) Stapf - E + S Africa
11. <i>Urochloa brevispicata</i> (Rendle) Sosef
12. <i>Urochloa brizantha</i> (Hochst. ex A.Rich.) R.Webster - tropical + S Africa
13. <i>Urochloa burmanica</i> (Bor) Veldkamp
14. <i>Urochloa caboverdiana</i> (Conert & C.Kohler) Veldkamp, Potdar & S.R.Yadav
15. <i>Urochloa chusqueoides</i> (Hack.) Rudov
16. <i>Urochloa ciliatissima</i> (Buckley) R.D.Webster
17. <i>Urochloa clavipila</i> (Chiov.) Sosef
18. <i>Urochloa comata</i> (Hochst. ex A.Rich.) Sosef
19. <i>Urochloa deflexa</i> (Schumacher) H.Scholz
20. <i>Urochloa dictyoneura</i> (Fig. & De Not.) Veldkamp
21. <i>Urochloa distachyoides</i> (Stapf) Sosef
22. <i>Urochloa distachyos</i> (L.) T.Q.Nguyen
23. <i>Urochloa dura</i> (Stapf) A.M.Torres & C.M.Morton
24. <i>Urochloa echinolaenoides</i> Stapf - Zaïre, Tanzania, Malawi, Zambia
25. <i>Urochloa eminii</i> (Mez) Davidse
26. <i>Urochloa falcifera</i> (Trin.) Zon
27. <i>Urochloa foliosa</i> (R.Br.) R.D.Webster
28. <i>Urochloa fusca</i> B.F. Hansen & Wunderlin (browntop signalgrass) - southern USA to Argentina
29. <i>Urochloa fusiformis</i> (Reeder) Veldkamp
30. <i>Urochloa gilesii</i> (Benth.) Hughes
31. <i>Urochloa glumaris</i> (Trin.) Veldkamp (Thurston grass) - SE Asia, Indian subcon
32. <i>Urochloa holosericea</i> (R.Br.) R.D.Webster
33. <i>Urochloa jaliscana</i> (Santana Mich.) Espejo & López-Ferr.
34. <i>Urochloa jubata</i> (Fig. & De Not.) Sosef
35. <i>Urochloa kurzii</i> (Hook.f.) T.Q.Nguyen
36. <i>Urochloa lachnantha</i> (Hochst.) A.M.Torres & C.M.Morton
37. <i>Urochloa lata</i> (Schumacher) C.E.Hubb.
38. <i>Urochloa leersioides</i> (Hochst.) A.M.Torres & C.M.Morton
39. <i>Urochloa lorentziana</i> (Mez) Morrone & Zuloaga
40. <i>Urochloa megastachya</i> (Nees ex Trin.) Morrone & Zuloaga
41. <i>Urochloa meziana</i> (Hitchc.) Morrone & Zuloaga
42. <i>Urochloa mollis</i> (Sw.) Morrone & Zuloaga

43. *Urochloa multiculma* (Andersson) Morrone & Zuloaga
 44. *Urochloa mutica* (Forssk.) T.Q.Nguyen
 45. *Urochloa nigropedata* (Munro ex Ficalho & Hiern) A.M.Torres & C.M.Morton
 46. *Urochloa notochthona* (Domin) Hughes
 47. *Urochloa oblita* (Swallen) Morrone & Zuloaga
 48. *Urochloa occidentalis* (C.A.Gardner & C.E.Hubb.) B.K.Simon
 49. *Urochloa oligobrachiata* (Pilg.) Kartesz
 50. *Urochloa oligotricha* (Fig. & De Not.) Henrard - Africa
 51. *Urochloa olivacea* Sánchez-Ken - western Mexico
 52. *Urochloa ophryodes* (Chase) Morrone & Zuloaga
 53. *Urochloa orthostachys* (Mez) K.M.Ibrahim & P.M.Peterson
 54. *Urochloa ovalis* (Stapf) Zon
 55. *Urochloa panicoides* P.Beauv. (panic liverseed grass) - Africa, S. Asia
 56. *Urochloa pauciflora* Sánchez-Ken - W. Mexico
 57. *Urochloa paucispicata* (Morong) Morrone & Zuloaga
 58. *Urochloa piligera* (F.Muell. ex Benth.) R.D.Webster
 59. *Urochloa plantaginea* (Link) R.D.Webster
 60. *Urochloa platynota* (K.Schum.) Pilg.
 61. *Urochloa platyphylla* (Munro ex C.Wright) R.D.Webster
 62. *Urochloa platyrrhachis* C.E.Hubb. - Zambia, Zaïre
 63. *Urochloa polyphylla* (R.Br.) R.D.Webster
 64. *Urochloa polystachya* (Kunth) Mabb.
 65. *Urochloa praetervisita* (Domin) Hughes
 66. *Urochloa pubigera* (Roem. & Schult.) R.D.Webster
 67. *Urochloa ramosa* (L.) T.Q.Nguyen
 68. *Urochloa reptans* (L.) Stapf
 69. *Urochloa reticulata* (Stapf) Sosef
 70. *Urochloa rudis* Stapf - Somalia, Kenya, Tanzania
 71. *Urochloa rugulosa* (Stapf) Sosef
 72. *Urochloa sclerochlaena* Chiov - Ethiopia, Kenya
 73. *Urochloa semiundulata* (Hochst. ex A.Rich.) Ashal. & V.J.Nair
 74. *Urochloa serrata* (Thunb.) Sosef
 75. *Urochloa serrifolia* (Hochst.) Zon
 76. *Urochloa setigera* (Retz.) Stapf - Indian subcon, S. China, SE. Asia
 77. *Urochloa stigmatisata* (Mez) K.M.Ibrahim & P.M.Peterson
 78. *Urochloa subulifolia* (Mez) Torres Gonz. & C.M.Morton
 79. *Urochloa tanimbarensis* (Ohwi) Veldkamp
 80. *Urochloa texana* (Buckley) R.D.Webster
 81. *Urochloa trichopodioides* (Mez & K.Schum.) S.M.Phillips & S.L.Chen - Zaïre, Tanzania, Kenya, Ethiopia
 82. *Urochloa trichopus* (Hochst.) Stapf - Africa, Arabian Pen
 83. *Urochloa turbinata* (Van der Veken) Sosef
 84. *Urochloa villosa* (Lam.) T.Q.Nguyen
 85. *Urochloa whiteana* (Domin) R.D.Webster
 86. *Urochloa wittei* (Robyns) Sosef
 87. *Urochloa xantholeuca* (Hack.) H.Scholz

Synonyms of *Urochloa ramosa* are given in Table 2 (Wikipedia, 2023 a).

Table 2. Synonyms of *Urochloa ramosa*

1. *Brachiaria chennaveeraiana* Basappa & Munjy. in Proc. Indian Natl. Sci. Acad., B 49: 378 (1983)
2. *Brachiaria marselinii* Gawa & Gawa in J. Bombay Nat. Hist. Soc. 101: 291 (2004)
3. *Brachiaria multispiculata* H.Scholz in Willdenowia 12: 287 (1982)
4. *Brachiaria ramosa* (L.) Stapf in D.Oliver & auct. suc. (eds.), Fl. Trop. Afr. 9: 542 (1919)
5. *Brachiaria ramosa* var. *pubescens* Basappa & Munjy. in Proc. Indian Natl. Sci. Acad., B 49: 380 (1983)
6. *Brachiaria regularis* var. *nidulans* (Mez) Täckh. in Bull. Fac. Sci. Egypt. Univ. 17: 432 (1941)
7. *Echinochloa ramosa* (L.) Roberty in Fl. Ouest-Afr.: 398 (1954)
8. *Panicum arvense* Kunth in Révis. Gramin. 2: t. 109 (1831)
9. *Panicum bispiculatum* Chiov. in Annuario Reale Ist. Bot. Roma 8: 303 (1908 publ. 1907), pro syn.
10. *Panicum brachylachnum* Steud. in Syn. Pl. Glumac. 1: 62 (1853)
11. *Panicum breviradiatum* Hochst. in Flora 38: 195 (1855)
12. *Panicum canescens* Roth in J.J.Roemer & J.A.Schultes, Syst. Veg., ed. 15[bis]. 2: 457 (1817)
13. *Panicum cognatissimum* Steud. in Syn. Pl. Glumac. 1: 69 (1853)
14. *Panicum crus-galli* var. *petiveri* (Trin.) De Wild. & T.Durand in Ann. Mus. Congo Belge, Bot., sér. 2, 1(2): 72 (1900)
15. *Panicum grossarium* J.Koenig in Naturforscher (Halle) 23: 205 (1788), nom. illeg.
16. *Panicum nidulans* Mez in Bot. Jahrb. Syst. 34: 136 (1904)
17. *Panicum ozogonum* Steud. in Syn. Pl. Glumac. 1: 68 (1853)
18. *Panicum pallidum* Peter in Abh. Preuss. Akad. Wiss., Phys.-Math. Kl., n.f., 13(2): 45 (1928)
19. *Panicum petiveri* Trin. in Gram. Panic.: 144 (1826)
20. *Panicum petiveri* var. *puberulum* Chiov. in Annuario Reale Ist. Bot. Roma 8: 302 (1908 publ. 1907)
21. *Panicum ramosum* L. in Mant. Pl. 1: 29 (1767)
22. *Panicum sorghum* Steud. in Syn. Pl. Glumac. 1: 58 (1853)
23. *Panicum supervacuum* C.B.Clark in J. Linn. Soc., Bot. 24: 407 (1888)
24. *Setaria canescens* (Roth) Kunth in Révis. Gramin. 1: 47 (1829)
25. *Urochloa ramosa* var. *pubescens* (Basappa & Munjy.) E.A.Kellogg in PhytoKeys 163: 293 (2020)
26. *Urochloa supervacua* (C.B.Clark) Noltie in Edinburgh J. Bot. 56: 394 (1999)

BOTANICAL DESCRIPTION

The identification of browntop millet grain and spikelets can be difficult due to its similarity to *Setaria italica* (Fig. 3). Although the panicle is distinct from *Setaria* by being looser and non-bristly, the grains themselves are very similar. Grains are ovate to round and have a long embryo, roughly two thirds to three fourths of the length of the grain. They tend to be smaller than *Setaria italica* and squatter in cross section. The surface of well-preserved grains can be used for identification as these have a distinctive undulating pattern, although this again has similarities to *S. italica*. The husk has a fine beaded and rugose pattern, which again has some resemblance to that of *Setaria* spp., but it is somewhat coarser than *S. italica* and finer than *S. verticillata* (Kingwell-Banham and Fuller, 2014).

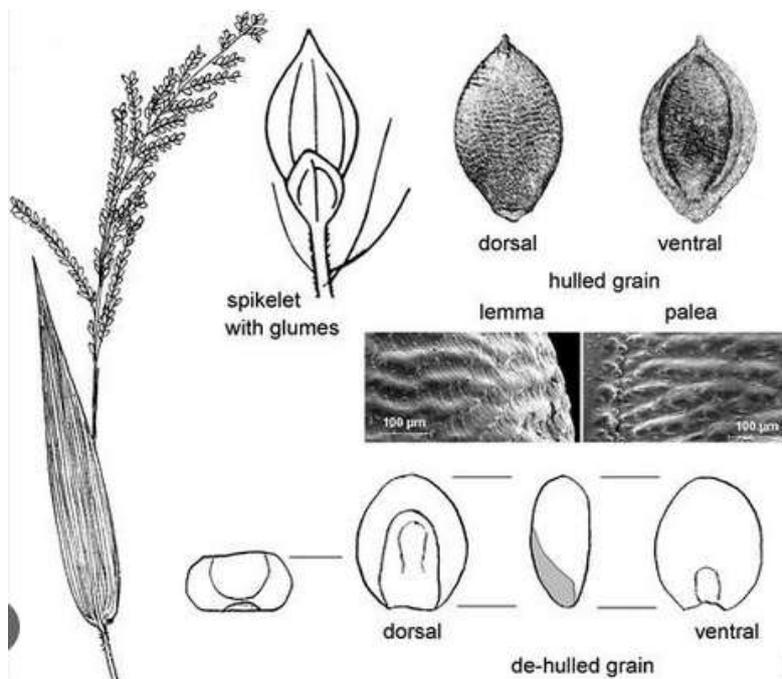


Fig. 3. Brown Top Millet (*Brachiaria ramosa*): panicles, spikelet, hulled and de-hulled grains, showing the rugose husk patterns of the lemma and palea

Browntop millet is an annual warm-season species that grows 30-90 cm tall. The smooth stems have pubescent nodes and may stand erect or ascend from a decumbent base. The leaves are 2.2 to 18cm long and 6-18mm wide; both surfaces are smooth. The inflorescence is indeterminate, open, spreading with simple axis and stalked flowers. It has 3-15 inflorescences and white flowers. Seeds are ellipsoid and tan in colour; they mature in approximately 60 days (Sujata *et al.*, 2018). Browntop millet is an annual/perennial warm-season grass of Poaceae family with erect or prostrate stem (culm) along the ground. When growing erect, it may reach up to 90 cm height at maturity. The nodes of browntop millet are minutely hairy; with lance-shaped and hairless leaf blades of 2-25 cm length and 4-14 mm width. The flowers are indeterminate in nature and stalked, however, the inflorescence is open and spreading, with a simple axis. The number of inflorescences ranges 3-15 of 1-8 cm long from a central axis. The flowers are white and ellipsoid seeds that are tan in colour. The fibrous roots of browntop millet can penetrate up to 60 cm deep. The duration of the crop is approximately 60 to 75 days (Maitra, 2020). Browntop millet (*Urochloa ramosa*) is an introduced, annual/perennial warm-season grass often used in forage/pasture management systems. The stem (culm) may be erect or prostrate along the ground. When growing erect, it may reach 1 m at maturity. Nodes will appear minutely hairy. The lance-shaped, hairless leaf-blades are 2–25 cm long and 4–14 mm wide. The inflorescence is indeterminate, open, spreading, with a simple axis and stalked flowers. It has 3–15 inflorescences, 1–8 cm in length, from a central axis. It has white flowers and ellipsoid seeds that are tan in color. It has fibrous roots that can grow to 60 cm deep. The grains of browntop millet are ellipsoid in shape. The seeds or grains are tan, tan white, white or light-colored, off white, brown, red, black in color. The size of the grains varies from 4-5 mm in length; they are classified as short, medium and medium long. Seed germination can happen in up to 5 days and the rapidly growing crop can then be harvested in the next two months. Its fine stems and leaves allow the plant to dry sufficiently to be used as a dry hay product (Fig. 4) (USDA, 2023; Wikipedia, 2023 a).



Young plant

Young plants

Field

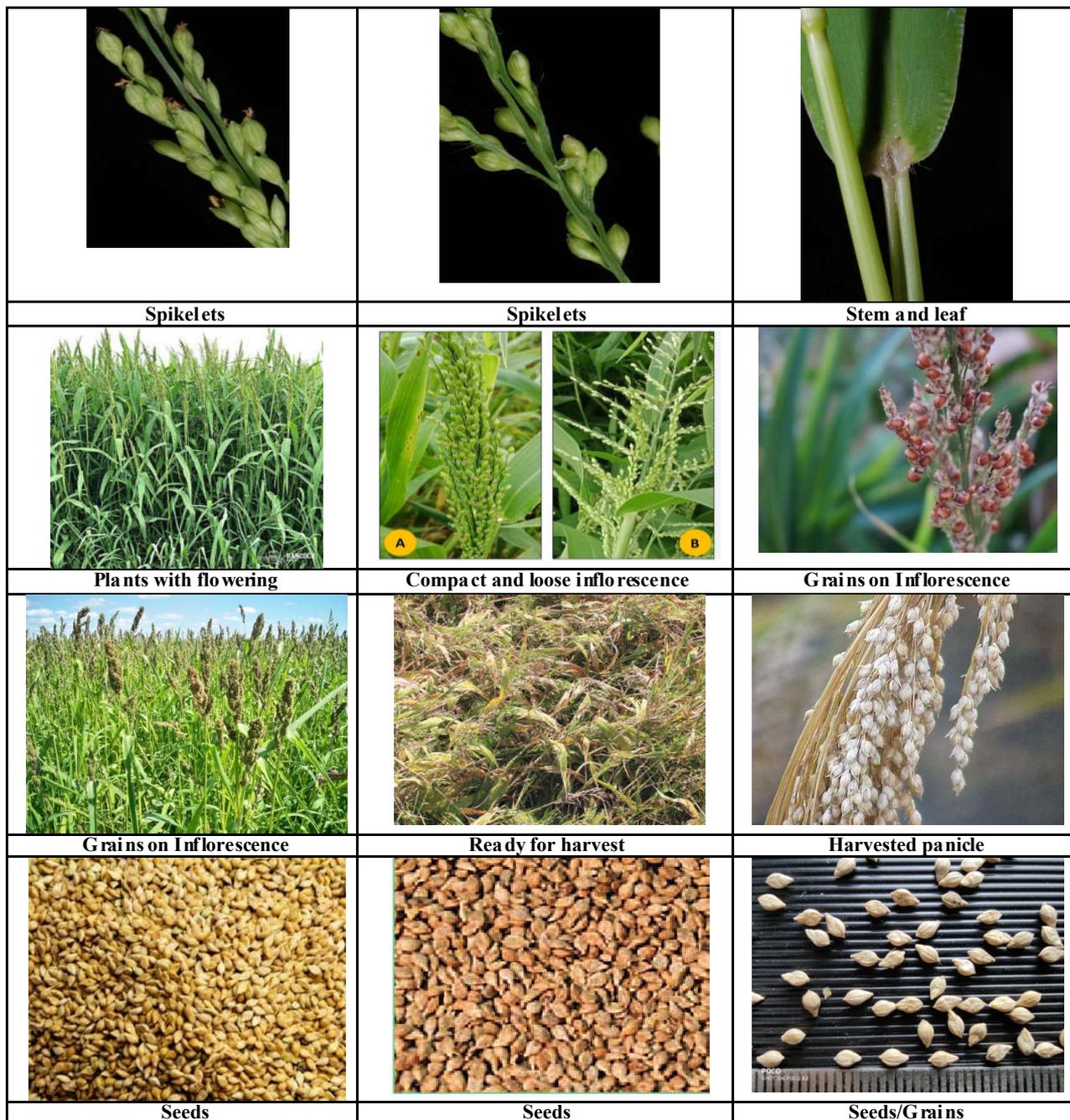


Fig. 4. Botanical Description

A warm-season annual plant, browntop millet has a height range of 30-90 cm. The smooth stems' pubescent nodes enable them to stand upright or climb from a decumbent base. The leaves are 0.6 to 1.8 cm wide, 22 to 180 mm long, and smooth on both surfaces. The inflorescence has stalked flowers on a single axis and is open, spreading, and indeterminate. It has white blooms and 3-15 inflorescences. The ellipsoid, tan seeds need around 60 days to reach maturity (Shaliha *et al.*, 2023). Browntop millet is a short day (<12 hour) plant that will begin to set seed in 60 days. It can produce 140,000 seeds/lb and 1,500 lb of seed/acre. Seed should be stored at 13% moisture or less (USDA, 2023). Browntop millet has glabrous (hairless) spikelets, are about 3.3 mm long, the upper of each pair on a pedicel (stalk) about as long as the spikelet. The spikelets are more often slightly or distinctly pubescent and pedicels are often shorter. Plants found in Malesia (Malesia is a biogeographical region straddling the Equator and the boundaries of the Indomalayan and Australasian realms, and also a phytogeographical floristic region in the Paleotropical Kingdom.) and Australia always have shorter spikelets (only up to 3 mm long) (Wikipedia, 2023a). Browntop millet has glabrous (hairless) spikelets, are about 3.3 mm long, the upper of each pair on a pedicel (stalk) about as long as the spikelet. The spikelets are more often slightly or distinctly pubescent and pedicels are often shorter. Plants found in Malesia and Australia always have shorter spikelets (only up to 3 mm long) (Naturalist, 2023). Browntop Millet is a loosely clustered annual grass, with stems 10-70 cm high. Leaf-blades are broadly linear, 2-25 cm long, 4-14 mm wide. Inflorescence of 3 racemes are borne on an axis 3-10 cm long; racemes are 1-8 cm long, simple or the longest with branchlets at the base, bearing mostly paired loosely contiguous spikelets appressed to the triquetrous rachis; flower-stalks shorter than the spikelets, 1-2 mm long. Spikelets are elliptic to broadly elliptic, 2.5-3.5 mm long, hairless or velvet-hairy, pointed to cuspidate, with or without a stipe up to 0.5 mm long. Browntop Millet is widely found in the Tropical world, at altitudes of 200-1800 m. Flowering: July-October (Shivaprasad, 2023). Browntop Millet is an annual. Culms 20-70 cm long, decumbent; nodes glabrous or softly villous. Leaves 3-14 x 0.5-2.3 cm, linear-lanceolate, shallowly cordate or rounded at base, acuminate at apex, softly villous, stiff-scabrid along margins; sheaths 2-5 cm, densely pubescent; ligule a row of hairs. Racemes 5-14 in number, pseudopaniculate, each 2-6 cm long; rachis angular. Spikelets 2.5-3 mm, broadly elliptic or ovate-elliptic, acute to cuspidate, pubescent or glabrous. Pedicels with or without long colourless hairs. Lower glume 1-1.5 x 2 mm, ovate or obovate, chartaceous, 7-nerved, softly hairy or glabrous. Upper glume 2.5-3 x 1.5-2 mm, ovate, chartaceous, 7-nerved, softly hairy

or glabrous. Lower floret empty. Upper floret bisexual. First lemma 2.5-3 x 2 mm, ovate, chartaceous, 5-nerved. Palea c. 2 x 0.5 mm, oblong-lanceolate, hyaline, 2-keeled. Second lemma 2-2.5 x 1.5-2 mm, ovate, mucronate, crustaceous, rugose. Palea c. 2 x 1 mm, ovate, crustaceous, 2-keeled. Stamens 3; anthers c. 1 mm long. Ovary c. 0.5 mm long; stigmas c. 1 mm long. Flowering and fruiting: March-September (Indiabiodiversity, 2023).

Floral biology, anthesis, and hybridization techniques: Small millets are highly self-pollinated and relatively low level of improvement in small millets appears to be the consequence because of difficulties in emasculation and hybridization. Hence, inducing male sterility is one of the ways for effective hybridization and enhancing out-crossing for improvement in these crops (Gupta *et al.*, 2012). Two types of inflorescence, *viz.*, open and compact, are present (Fig. 5). It has a branching panicle. The flower is bisexual with three anthers. In the center of the leaf blade, an evident vein is noticed in some cultivars. The flowering is basipetal. On the fourth or fifth day of flower initiation, maximum flowering occurs (Fig. 6). The research on browntop millet is scanty, especially on floral biology and anthesis in this crop. The contact method of crossing is employed in browntop millet, but the success rate of true hybrids is meager. To the best of the authors' knowledge, there are no reported attempts on crossing techniques in browntop millet (Nagaraja *et al.*, 2023).



Fig. 5. Brown top millet: A. Compact and B. Open inflorescence



Fig. 6. Blooming in browntop millet

Nature has favored a high magnitude of self-pollination in small millets, making the process of generating variability arduous. The intricate floral biology of millets hampers the process of artificial hybridization. Although, to some extent, few artificial hybridization methods have yielded successful results, it is essential to identify a method that produces 100% crossed seeds to harness the genetic potential of these mighty small millets (Nagaraja *et al.*, 2023).

GENETICS AND CYTOGENETICS

Determinations of chromosome number and morphological studies of 260 populations, belonging to 32 taxa, of the genus *Brachiaria* from the Indian subcontinent reveal that all sexually reproducing taxa have no chromosome races. Six agamic taxa, *viz.*, *B. brizantha* var. *brizantha* (n = 27), *B. brizantha* var. *ciliata* (n = 18), *B. decumbens* (n = 18), *B. hybrida* (n = 27), *B. mutica* (n = 18), and *B. setigera* var. *albistyla* (n = 14), have consistently shown uniformity in chromosome numbers, based on x = 7, 8, and 9. *Brachiaria setigera* var. *setigera*, a genetically unstable apomict, is the only taxon that tends to have a heteroploid series (n = 16, 17, 18, 21, and 32). The population of *B. setigera* var. *setigera* with n = 17 is based on a secondary base number of x = 17. There are 6 diploids, 20 tetraploids, 5 hexaploids, and 3 octoploids in the genus. Aneuploidy and triploidy are characteristically absent in the genus, although their plausible existence in the *B. setigera* complex cannot be ruled out. In several species certain previously reported chromosome numbers that deviate from the present study are found to be the result of erroneous identifications or the result of taxonomically complex situations such as those found in *B. brizantha*, the *B. distachya* complex, and the *B.*

ramosa complex (Basappa *et al.*, 2011). Morphotypes or races are not known in browntop millet (BTM). It is reported that $2n=36$ chromosomes in this species from India. The somatic chromosomes are small in size ranging in length between 1 and 1.25 micron. This species was found to show two cytological races, which are morphologically indistinguishable. Diploid, tetraploid and hexaploid status has been reported in BTM with basic chromosome number of 9 ($2n=18$; $2n=4x=36, 72$) (Yadava *et al.*, 2022).

GENETIC DIVERSITY

Genetic variability of a crop plays an important role in crop improvement. Genetic variation is a term used to describe the variation in the DNA sequence in each of our genomes. Genetic variation is what makes us all unique, whether in terms of hair colour, skin colour or even the shape of our faces. Genetic variability of a crop plays an important role in crop improvement (Anuradha *et al.*, 2020). Brown top millet can grow with either a compact or open panicle and can have either shattering or indehiscent spikelets. The domestic form, however, tends to act like other domestic cereals and is both compact and partially indehiscent (Kingwell-Banham and Fuller, 2014). The seeds or grains are tan, tan white, white or light-colored, off white, brown, red, black in color. The size of the grains varies from 4-5 mm in length; they are classified as short, medium and medium long (Fig. 7) (USDA, 2023).



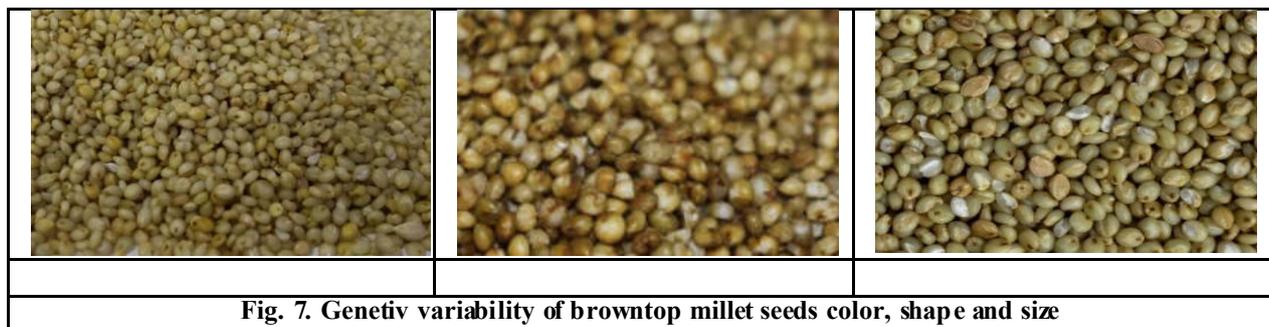


Fig. 7. Genetic variability of browntop millet seeds color, shape and size

Study was attempted to assess the genetic variability and associations of various economic traits at Agricultural Research Station, Vizianagaram. Significant differences for all twelve traits studied were noticed among 10 browntop millet genotypes. GCV ranged from low (4.63 for plant height) to moderate (12.99 for days to 50% flowering) indicating low to moderate variability. The difference in GCV and PCV was very narrow (less than 0.2) for days to 50% flowering and days to maturity indicating least influence of surrounding environment which was further supported by high value of broad sense heritability (more than 95%) while grain and fodder yield recorded moderate heritability with moderate GAM indicating the presence of both additive and non additive gene action. Selection for high grain and fodder yield can be relied upon selection for more number of days to 50% flowering and days to maturity as grain and fodder yield are significantly associated in positive direction with days to 50% flowering and days to maturity (Anuradha *et al.*, 2020).

Twenty five genotypes of brown top millet were considered for genetic divergence, association and path analysis during *Kharif*, 2019. Among the eight yield components studied panicle length (23.67 %) contributed the maximum for divergence followed by fodder yield (14.33 %) and harvest index (13.67%). Divergence studies grouped twenty five genotypes into seven clusters. Among seven clusters, cluster I was the largest having 11 genotypes after which came cluster II with 5 genotypes, cluster III with 3 genotypes, clusters IV and V with 2 genotypes and clusters VI and VII with one genotype each. The maximum intra cluster distance was noticed in cluster IV (8.0788) indicating the highest variability. The maximum inter cluster distance was observed between cluster VI and cluster VII (54.086). Understanding the results obtained from trait association and path analysis revealed positive association and high positive direct effects by fodder yield and harvest index on grain yield (Priya *et al.*, 2022).

BREEDING

Germplasm

In the browntop millet crop a very limited number of germplasm lines (< 1000) are conserved worldwide. Diversity in crop cultivars is very important for sustainable agriculture. Germplasm provides the needed variability for crop development. A very few number of germplasm lines and inadequate information regarding the genetic diversity of browntop millet limit their effective utilization (Priya *et al.*, 2022). ICAR-IIMR maintains about 30 genotypes of BTM (Yadava *et al.*, 2022).

Breeding objectives of browntop millet (Mamo and Singh, 2016).

- High grain yield with compact head, more tillers, earliness and reduced plant height;
- High forage yield with high biomass and good digestibility;
- Resistance to diseases, insect pests and striga;
- Tolerance to drought, heat and acid soils.

Breeding Methods

Mass selection: This is the most common type of cultivar development method being used in several African and Asian countries. In this method a group of pearl millet plants are selected from open pollinated population and the seeds from selected plants are mixed and planted to begin the next cycle of selection. Mass selection in pearl millet has helped to improve traits with high heritability. The main criteria that have been taken in to consideration to improve grain yield in pearl millet are head characteristics such as compactness, length of ear, weight of grain and uniform maturity (Mamo and Singh, 2016).

Synthetic cultivar development: Synthetic varieties are developed in open pollinated crops by mixing several hundred elite genetic stocks/germplasm with one or more important traits in common. The synthetic cultivar developed in the first generation or cycle exhibits considerable heterosis (Mamo and Singh, 2016).

Hybrid breeding: The hybrid breeding program at ICRISAT and West Africa includes development of inbred lines and pure line selection, and the use of cytoplasmic male sterility. Cytoplasmic male sterility in pearl millet has been used to produce hybrid for grain production in India and for forage production in USA. Several sources of male inducing cytoplasm have been discovered in pearl millet including A1, A2, A3, A4, and A5. A1 is the most commonly used male sterile line for hybrid grain production in India. The CMS system involves the development of three line systems (A, B and R) in order to produce hybrid seeds. Line A is male sterile and serves as seed parent, line B has the recessive form of the fertility restorer gene in the nucleus and does not have the capacity to restore fertility in A system; it maintains sterility. The R line has the dominant form of the fertility restorer genes, and so reverses the effects of the CMS cytoplasm of the A line, therefore resulting in fertile hybrid seeds when used as a male parent. B and R lines should be multiplied in separate and isolated fields to maintain Purity (Mamo and Singh, 2016).

Pureline selection from the available germplasm appears to be a feasible strategy for improvement and release of cultivars in browntop millet crop (Yadava *et al.*, 2022).

Varieties: The scientific literature based on browntop millet has been found scanty (Singh et al., 2022). The variety IIMR AK 2 is recommended for all States (Chapke et al., 2020). UAS Bengaluru has also released GPUBT-2 for growing in Karnataka (UASB, 2022).

USES

Forage/grain: Compared to other warm season forage grasses, browntop millet is relatively low yielding. Its strength is that it is a rapidly maturing grass, often used as a catch crop, cover crop or nurse crop. Browntop millet can accumulate toxic/lethal levels of nitrate and should not be fed to livestock if the plant has been stressed by droughty or cold conditions. There is evidence of the cultivation of browntop millet as a subsistence crop in Neolithic India and it continues to be used as a grain and forage crop in India today. Grains from taller non-shattering varieties are used as a boiled whole grain, porridge or unleavened bread. Browntop millet produces large quantities of seeds. These millet seeds are used in food plots for game birds that are highly attracted to the nutritious seed. Browntop millet is one of the few types of millet that can be planted and flooded for ducks or planted in dry areas for deer, quail, dove, turkey and other wild life (Sujata et al., 2018). Compared to other warm season forage grasses, browntop millet is relatively low yielding. Its strength is that it is a rapidly maturing grass, often used as a catch crop, cover crop or nurse crop. Browntop millet can accumulate toxic/lethal levels of nitrate and should not be fed to livestock if the plant has been stressed by droughty or cold conditions. There is evidence of the cultivation of browntop millet as a subsistence crop in Neolithic India and it continues to be used as a grain and forage crop in India today. Grains from taller non-shattering varieties are used as a boiled whole grain, porridge or unleavened bread. Browntop millet is used to suppress root-knot nematode populations in tomato and pepper crops in the South-East. It is grown as a fast-growing catch crop between commodity crops and is not known to be allelopathic. Browntop millet is used as a fast growing cover for erosion control. It is used as a nurse crop in the South-East until a perennial grass cover is established. It also has the ability to accumulate significant amounts of lead and zinc in shoot and root tissues making it an important plant for remediation of contaminated soils. Browntop millet produces large quantities of seeds. These millet seeds are used in food plots for game birds that are highly attracted to the nutritious seed. Browntop millet is one of the few types of millet that can be planted and flooded for ducks or planted in dry areas for deer, quail, dove, turkey and other wild life (Sujata et al., 2018).

Brown-top millet is a crop of versatile use as it is grown as food for human consumption, forage and food for game birds. Grains of brown-top millet from non-shattering varieties are used as a boiled whole grain (like rice), porridge or unleavened bread. Brown top millet is generally ground into flour and breads (roti, dosa) are made or polished and boiled to make gruel (rice, *anna*, *kheer*). Besides, it has significance in some rituals, probably for that reason only it is persisting in farming in some locations. For human consumption, there is enough scope for value addition in the form of idli mix or making of biscuit by proportionately mixing brown-top millet with other flours of major cereals, namely, rice and wheat. Because of its short duration, it can be cultivated as catch crop, cover crop or nurse crop and as cover crop it can check soil erosion. But under drought and cold stressed conditions the nitrate level reaches to toxic or lethal level and the forage obtained should not be fed to animals. In plant protection aspect, the crop has greater importance as it suppresses root-knot nematode populations in tomato and pepper. The crop, however, does not show any allelopathic effects. The crop has the capacity to accumulate lead and zinc in plant tissues and so considered for remediation of contaminated soils. Brown-top millet can be considered for supporting the wild life. As a nutritious grain, seeds are used in food plots for game birds and as green forage it is grown for deer, dove, turkey and other wildlife (Maitra, 2020). Brown top millet was used widely to make traditional sweets, but nowadays with the advancement of technology, they are used for making ready to eat products, breakfast cereals, healthy snacks, and snack bars. Furthermore, they are also used for making value-added products including gun puffing, hot and cold mixing, baking and instant mixes with the application of conventional food technologies (Binu, 2021). In countries like India and Africa, small millets are consumed as whole or in form of flour. They are mainly used as food and for allied purposes, whereas in Japan they are mainly used as birds feed.

According to some authors, the grains from non-shattering varieties are consumed as boiled whole grain (like rice), porridge, kheer or unleavened bread and dosa in Southern parts of India. It can also be ground to make flat breads like roti or dosa in the form of flour. Various ready-to-eat (RTE) and ready-to-cook (RTC) value-added products have been developed by University of Agricultural Science, Dharwad like laddu, cookies and dosa mix by using BTM as a core ingredient. BTM has been mixed with other ingredients like coconut, chocolate, drumstick (Priya et al., 2022). Brown top millet was typically used to produce classical sweet treats, however with the rise of technology, it is used to render effectively utilised cereal bars, cookies, and snacks. They are also used to create value-added items like gun puffing, cold and hot blending, cooking, and immediate mixtures using traditional food techniques. Despite all of its advantages and rising popularity, millets persist as a less crop in the world on the brink of extinction. Brown Top Millet can allow farmers to safeguard their living standards while dealing with issues such as malnourishment, food production, global warming, and others. Steps towards its own required preservation, elevating awareness, and the implementation of specific and comfy equipment to handle plants can all make a contribution to the reinstatement of millet (SHB, 2022).

There is a large scope for development and standardization of value added products made from browntop millets such as ready to eat foods (cookies, bars, deserts) and ready to cook foods (idli mix, poha) in which the millet can be used in combination with other cereal grains. Thus, browntop millet holds great potential in alleviating food and nutrition insecurity (Singh et al., 2022). Browntop millet is a crop of versatile use as it is grown as food for human consumption, forage and food for birds and as raw material for industries. In countries like India and Africa, small millets are consumed as whole or in form of flour. They are mainly used as food and for allied purposes, whereas in Japan they are mainly used as birds feed. Studies report that under drought and cold stressed conditions the nitrate level reaches to toxic or lethal level and the forage obtained should not be fed to animals. In Southern part of India the grains of browntop millet from non-shattering varieties are consumed as boiled whole grain (like rice), porridge, kheer or unleavened bread and dosa (Singh et al., 2022). BTM can be used to prepare a variety of dishes. Its grains are used in preparing at least nine traditional foods in southern India such as *anna*, *dosai*, *kheer*, *nuchina mudda*, *roti*, *nippattu*, *chakkulli*, *haralu*, *kodubale* and *kadabuappe*. Browntop millet is usually ground into flour and used to make flat breads like roti or dosa or polished and boiled to make gruel (*kheer*). Some of these foods are used in religious rituals, which may partly account for its persistence in cultivation (Singh et al., 2022). For human consumption, there is enough scope for value addition in the form of idli mix or making of biscuit by proportionately mixing browntop millet with other flours of major cereals, namely, rice and wheat. BTM is an effective crop, much like oats. Various ready-to-eat (RTE) and ready-to-cook (RTC) value-added products have been developed by University of Agricultural Science, Dharwad like laddu, cookies and dosa mix by using BTM as a core ingredient. BTM has been mixed with other ingredients like coconut, chocolate, drumstick. BTM is drought-tolerant, early maturing and harvested in about 75–80 days earlier than other millets. This millet is well suited for dry land, grown under a variety of soils and climates (Singh et al., 2022).

Brown top millet is a nutritious and versatile grain that has culinary uses in various cuisines around the world. Remember to rinse and soak Brown top millet before cooking to remove any bitterness and improve its digestibility. The cooking time and liquid ratio may vary, so follow specific recipes or package instructions for the best results (BTP, 2023). There is evidence of the cultivation of browntop millet as a subsistence crop in Neolithic India and it continues to be used as a grain and forage crop in India today. Grain from taller non-shattering varieties is used as a boiled whole grain, porridge, or unleavened bread (USDA, 2023). Browntop millet is an annual, warm season small grain or cover plant that grows to a height of 60-90 cm. It is adapted to most upland soil types and can be grown in all regions of Texas. Browntop millet is an excellent cover crop for use with native seed mixes on highly erodible soils, or for areas that must be planted in summer, outside of typical spring or autumn planting windows for most native seeds. Doves, quail, waterfowl, and monkeys relish the seed of browntop millet, making it an excellent choice for game bird food plots and hunting areas. Browntop millet makes grain in as little as 55 to 60 days depending on the weather conditions. Best time to plant is March through August. It is low-yielding forage, but has value in forage systems as a nurse crop or to quickly revegetate denuded areas. For dove food plots, browntop millet should be planted in mid-summer (DKS, 2023). The biscuits prepared from 50% Browntop millet and 50% refined wheat flour were packed in LDPE and PP and were stored at $(30 \pm 4^\circ\text{C})$ for 90 days to check their storage feasibility. Chemical composition of the fresh biscuits were moisture content was 4.05 %, protein 11.40%, crude fat 24.76 %, crude fiber 4.36 %, carbohydrates 59.03 %, calcium 24.84 mg/100g, iron 5.77 mg/100g and 176.48 $\mu\text{g}/100\text{g}$ beta carotene. Monthly sensory evaluation was carried out during the storage of three months (Majumdar *et al.*, 2023).

The following products are prepared from browntop millet (**Fig. 8**) (BTP, 2023):

Porridges and Pilafs: Brown top millet can be cooked with water or broth to make a delicious and nutritious porridge or pilaf. Adding herbs, spices, and veggies increases its flavour.

Flatbreads: Brown top millet flour is used for flatbreads in various cultures. Flour, water, salt, and occasionally yoghurt or oil are combined to make a dough that is rolled out and fried on a griddle or skillet.

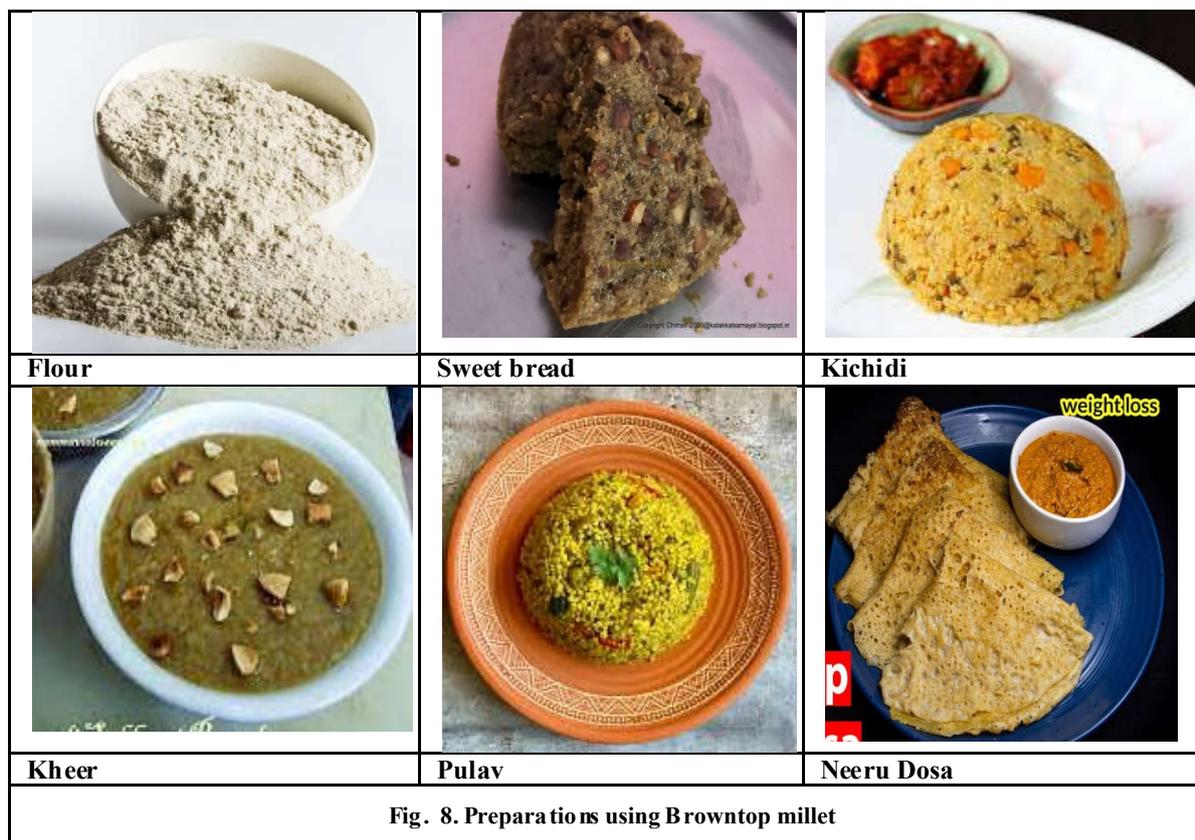
Stuffings: Brown top millet can fill bell peppers, zucchini, and tomatoes. Before stuffing veggies and baking or grilling, cooked millet is combined with herbs, spices, onions, garlic, and chopped vegetables.

Salads and Side Dishes: Salads can utilize cooked and chilled Brown top millet. It gives the salads a chewy, nutty texture. Like rice or couscous, it goes well with curries, stews, and grilled meats.

Soups and Stews: Brown top millet can be added to soups and stews to add thickness and texture. It absorbs the flavours of the broth and adds a hearty element to the dish. It can be cooked directly in the soup or stew or separately and then added.

Breakfast Cereals: Brown top millet can be cooked with milk or water and sweetened to form a healthful and substantial breakfast cereal. Fruits, nuts, seeds, honey, and maple syrup can flavour it.

		
Idli	Upama	Dosa
		
Bajji	Upama	Chips
		
Lad du	Lad du	Parata



Baked Goods: Brown top millet flour can be used as a gluten-free alternative in baking. It adds flavour, texture, and nutrition to bread, muffin, pancake, and cookie recipes. Compared to other warm season forage grasses, browntop millet is relatively low yielding. Its strength is that it is a rapidly maturing grass, often used as a catch crop, cover crop, or nurse crop. Browntop millet can yield 1,800–4,000 lb/ac dry matter. These yields are 60–70% of pearl millet or sorghum x Sudangrass hybrids. Browntop millet can accumulate toxic/lethal levels of nitrate and should not be fed to livestock if the plant has been stressed by droughty or cold conditions. Plantings in Minnesota have produced low yields and did not successfully compete with weeds (USDA, 2023). Browntop millet is used to suppress root-knot nematode populations in tomato and pepper crops in the Southeast. It is grown as a fast-growing catch crop between commodity crops, and is not known to be allelopathic. Browntop millet can represent 10–25% of the diet of terrestrial and water birds. It is a prolific seed producer that is planted to attract wild game like pheasants, turkeys, and ducks. 50% of ingested seed found in mourning doves' crops was browntop millet. It is also used in deer food plots and as exotic bird feed (USDA, 2023). In South Asia, it is traditionally cultivated as a cereal crop. It is used because it has potential to give high yield in resource-poor and fragile ecological conditions. In the southern parts of India, the grains of browntop millet from non-shattering varieties are consumed as boiled whole grain (like rice), porridge, kheer or unleavened bread and dosa. The grain is also used as a birdseed, and forage crop (in the US) for domestic animals and game animals (such as deer and rabbit) and for birds such as turkey, duck, dove, quail and pheasant. Browntop millet can represent up to 10–25% of the diet of terrestrial and water birds. Also 50% of ingested seed found in mourning dove's crops was browntop millet. *Urochloa ramosa* is also used to suppress root-knot nematode populations in tomato and pepper crops in south-eastern states of America. *Urochloa ramosa* also has the ability to accumulate significant amounts of metals such as lead and zinc in its shoot and root tissues making it an important plant for remediation of contaminated soils (Wikipedia, 2023a).

Brown top millet has a wide range of uses in the food and other bioenergy industries. Brown top millet is used to make fuel pellets, biogas, bioethanol, and biofuel. There are several uses for it in the food business, such as gluten-free bread dough, milk made from this millet, which is very nutritious, dosa and idly batter, and rotis. Different standard food processes, such as explosive or cannon puffing, hot and cold extrusion, mixing, and baking, are suitable for brown top millet value-added goods. Additionally, instant mixtures in powder form are made. Commercial products available in the market are vermicelli, noodles, cookies, sooji, brown top ghee biscuits, bars, flakes, flour, and brown top millet mixed with other seeds for example pumpkin seeds and flax seeds to increase both the nutrition and commercial value of the products (Shaliha *et al.*, 2023). In southern region of India the grains of Browntop millet from non-shattering kinds are consumed as boiled whole grain (like rice), porridge, kheer or unleavened bread and dosa. Browntop millet is generally base into flour and used to make roti or dosa or polished and boiled to make gruel. Browntop millet is an effective crop, much like oats. Millets are principally C4 cereals which means it takes take further carbon dioxide (CO₂) from the atmosphere and convert it to oxygen (O₂), requires low input, have high efficiency of water use, and hence, they are environment friendly. They reduce carbon dioxide from atmosphere, and can contribute in modifying the climate change (Majumdar *et al.*, 2023). In South Asia, it is traditionally cultivated as a cereal crop. It is used because it has potential to give high yield in resource-poor and fragile ecological conditions. In the southern parts of India, the grains of browntop millet from non-shattering varieties are consumed as boiled whole grain (like rice), porridge, kheer or unleavened bread and dosa. The grain is also used as a birdseed, and forage crop (in the US) for domestic animals and game animals (such as deer and rabbit) and for birds such as turkey, duck, dove, quail and pheasant. Browntop millet can represent up to 10–25% of the diet of terrestrial and water birds. Also 50% of ingested seed found in mourning dove's crops was browntop millet. *Urochloa ramosa* is also used to suppress root-knot nematode populations in tomato and pepper crops in south-eastern states of America. *Urochloa ramosa* also has the ability to accumulate significant amounts of metals such as lead and zinc in its shoot and root tissues making it an important plant for remediation of contaminated soils (Naturalist, 2023).

NUTRITIONAL VALUE

Millets are rich in nutrients and have higher dietary value and brown-top millet contains 8.98, 1.89, 3.9 and 71.32% of protein, fat, minerals and carbohydrate, respectively. Each 100 g of brown-top millet provides 338 Kcal of energy. Further, it is a rich source of macro and micro nutrients. 100 g of brown-top millet was comprised of 28 mg of calcium, 276 mg of phosphorus, 60 mg of potassium, 94.5 mg of sodium, 7.72 mg of iron, 2.75 mg of zinc and 1.23 mg of copper. Such superior nutritional value of brown-top millet has kept it as an automatic choice of health conscious consumers and created higher market price. The residual stock is also considered as animal feed as it contains 56.7 g/kg of crude protein and 594.2 g/kg of total digestible nutrient (Keating and Broderick, 2018) along with higher level of minerals like phosphorus (1.5 g/kg), magnesium (5.9 g/kg) and calcium (9.0 g/kg) (Maitra, 2020). Brown top millet like all other millets is a storehouse of nutrition that is essential for optimal health and well-being. These tiny seeds can deliver you a daily dose of proteins, healthy fats, carbs, and dietary fibre content. Apart from this, they are also a treasure trove of essential nutrients including calcium, iron, phosphorus, potassium, magnesium, manganese, copper, sodium, and zinc. Regular addition of this nutrient-rich grain lowers the risk of developing cardiovascular disease, diabetes, and digestive problems (Binu, 2021).

Brown top millet is gluten-free, rich in essential nutrients, a good source of zinc, iron, fibre and provides 338 kcal of energy. The mineral composition constitutes 28 mg of calcium, 7.72 mg of iron, 276 mg of phosphorus, 60 mg of potassium, 94.5 mg of magnesium, 1.99 mg of manganese, 7.60 mg of sodium, 2.5 mg of zinc, 1.23 mg of copper and a rich source of natural fibre (8.5%) due to which it serves as an excellent option for dealing with lifestyle diseases (Kishore *et al.*, 2021). The brown-top millet is highly nutritious food and for 100 grams of brown-top millet consisting of protein (11.5 grams), fiber (12.5 grams), minerals (4.2 grams), iron (0.65 milli grams) and calcium (0.01 milli grams). Among all the millets, brown-top millet is having higher fiber content (Priya *et al.*, 2022). Brown top millet, like all millets, is a powerhouse of nutrients that is critical for proper nutrition and well-being. These small seeds can give you a regular dose of proteins, good fats, carbs, and soluble fibre. They are also high in nutrients, iron, potassium, magnesium, manganese, sodium, copper, and zinc. The regular intake of this nutrition grain lessens the risk for cardiovascular disease, obesity, and digestive problems (SHB, 2022).

Brown Top millet nutritional value per 100 grams is given in **Table 3** (BTP, 2023).

Table 3. Browntop millet nutritional value per 100 g

Nutrients	Content
Carbohydrates(g)	71 g
Protein (g)	8 g
Fibre(g)	9 g
Fat	65 g
Potassium	188 mg
Sodium	10 g

Browntop millet nutritional value per 100 g is given in **Table 4** (Bnborrganics, 2023).

Table 4. Nutritional value of browntop millet Per 100g

Energy (kcal)	338
Fat (g)	1.89
Protein (g)	8.89
Carbohydrate (g)	71.32
Crude Fibre (g)	8.2
Sodium (mg)	71.6
Calcium (mg)	28
Magnesium (mg)	94.5
Phosphorus (mg)	276
Potassium (mg)	60

Brown top millets are a great source of fiber and protein when compared to other minor millets next to proso and foxtail millet. Brown top millet is considered to have a low caloric value because it only contains 338 kcal of energy, is gluten-free, has a good nutritional profile, and is a good source of fiber, zinc, and ferrous content. The nutrition composition of brown top millet is given in **Table 5**. This comparison has clearly shown that brown top millet has a considerably high amount of nutrients like protein as 3rd in millets, lowest fat content, high mineral content, and stands first in the fiber content than other millets. Brown top millet is nutritionally richer than other millet (Shaliha *et al.*, 2023).

Table 5. Nutritional contents of browntop millet

Nutritional composition	Amount of nutrients per 100g of grain
Fiber	8.5%
Protein	8.8g
Iron	7.72mg
Calcium	28mg
Phosphorous	276mg
Potassium	60mg
Magnesium	9.45mg
Manganese	1990µg
Sodium	7600µg
Zinc	2500µg
Copper	1230µg
Fat	1.89mg
carbohydrates	71.3g

Browntop millet nutritional value per 100 g is given in Table 6 (Grandma, 2023).

Table 6. Nutrients Per100 g

Nutrients	Amount
Carbohydrates	69.7 g
Fibre	12.5 g
Protein	11.5 g
Niacin	18.5 mg
Riboflavin	0.027 mg
Thiamine	3.2 mg
Iron	0.65 mg
Calcium	0.01 g
Phosphorus	0.47 g
Minerals	4.21 g

The present study aims to investigate the physicochemical properties of Browntop millet, comparing it with refined wheat flour and evaluation of its suitability in product formulation. The proximate composition (moisture, ash, protein, fat and crude fiber) and functional properties (solubility, swelling power, water absorption capacity, oil absorption capacity and bulk density) were studied using AACC standard methods. The product bread was formulated by replacement of refined wheat flour of different levels of Browntop millet (10.20, 30%). The results of the functional properties of Browntop millet flour and refined wheat flour are analysed. The bulk density of the Browntop millet flour and refined wheat flour are (0.7 ± 0.04) g/ml and (0.82 ± 0.02) g/ml respectively. The water absorption capacity of the Browntop millet flour and refined wheat flour are (2.15 ± 0.02) g/g and (2.00 ± 0.01) g/g respectively. The oil absorption capacity of the Browntop millet flour and refined wheat flour are (2.30 ± 0.01) g/g and (2.59 ± 0.01) g/g respectively. The solubility percent of the Browntop millet flour and refined wheat flour are (11.06 ± 0.05) % and (13.22 ± 0.02) % respectively. The solubility power of Browntop millet flour and refined wheat flour are (7.7 ± 0.04) g/g and (6.97 ± 0.02) g/g respectively. Sensory analysis of bread formulated seems to be reduced with increased level of fortification (Majumdar *et al.*, 2023). While browntop millet provides little calcium or iron, it is a powerhouse for protein and fibre. However, the millet requires much preparation and is less palatable to its alternatives. This protein and fibre-rich millet helps deal with several lifestyle diseases, she says as she discusses the several benefits of browntop millet. Like other millets, browntop millet is also gluten-free and rich in nutrients. Those who suffer from gluten intolerance or wish to have a gluten-free diet can opt for this alternative to rice (Iyer, 2023). Browntop millet is one of the rarest millets found. It is native to India (Karnataka and Andhra Pradesh). This millet is a rich source of protein, fiber, iron, calcium (Tripathi, 2023). Brown top millet contains protein, fibre, and B vitamins, including niacin, thiamin, and riboflavin. It also contains magnesium, phosphorus, and iron. These nutrients improve health. Finally, Brown top millet supports energy generation, cognitive health, immune system function, and red blood cell creation in our body (BTP, 2023).

HEALTH BENEFITS

Lower incidence of cardiovascular diseases, duodenal ulcer and hyperglycaemia (diabetes) is reported among those who regularly consume browntop millets (Kishore *et al.*, 2021).

The following health benefits are reported by Binu (2021):

Regulates diabetes: Brown top millet is a great substitute for rice as it keeps you satiated and delays the gastric emptying time, thereby serving as a perfect grain for all diabetic patients. Being low in glycaemic index and carbs brown top millet prevents unwanted hunger pangs and avoid a sudden spike in sugar levels. Add this tiny grain to the daily diet to stabilize blood sugar and promote insulin sensitivity

Promotes digestion: Good gut health is an indication of overall well-being and robust immune health. Brown top millet being gluten-free is a great alternative for those suffering from celiac disease and irritable bowel syndrome. It strengthens the digestibility and absorption of starch in the body and reduces bloating and cramping. Aside from this, help alleviate constipation by regularising bowel movements.

Augments cardiac health: Millets are famed for optimising heart health and lowering the risk of developing cardiovascular disease. Being imbued with protein, dietary fibre and low on carbs these tiny wonders diminish bad LDL cholesterol, avert the build-up of clots in the arteries besides improving heart functions. Consume it daily to shield the heart from ailments.

Fortifies bones: Blessed with an impressive source of calcium, phosphorus and magnesium brown top millet plays a key role in strengthening bones and muscles. Include Brown top millet in your regular meal plan to meet the demands of calcium and phosphorus for fighting brittle bones, fractures, inflammation and averting the risk of developing osteoporosis and other debilitating bone disorders.

Supports weight loss: Millets are boon for all fitness enthusiasts who are wanting to shed those extra kilos. Adding Brown top millet flour in the meal plan can help in lowering the BMI and burning fat. Substituting rice with millets daily can reduce the accumulation of fat, improve the gut microbiome, and attain your weight loss goals.

Millets have been recognized as smart foods in view of their health benefits by International Crops Research Institute for the Semi-Arid Tropics. BTM is also rich in fiber *i.e.*, 12.5 g per 100 g and fiber helps to detoxify the body by removing the waste from the intestine. Fiber gets fermented in the colon and act as a prebiotic in the colon. Due to its high fiber content, if consumed regularly, BTM can help in the prevention and management of several non-communicable or lifestyle related diseases such as constipation, diverticulosis, dyslipidemia, metabolic syndrome to name a few. Millets have low glycemic index (GI). Because of the low GI, millets help in gradual increase in the post-prandial blood glucose levels. This is particularly helpful for patients suffering from impaired glucose tolerance as well as diabetes. BTM contains good amount of minerals. It has significant levels of magnesium which is 94.5 mg/100 g. Magnesium is a vital mineral which aid in increasing the efficiency of insulin and glucose receptors by supporting many carbohydrate digesting enzymes, which manages insulin action and it also helps to reduce the pressure on blood vessels which make it capable of reducing the effects of myocardium infarction and migraine. BTM is gluten free and an excellent choice for people suffering from celiac disease. BTM contain 276 mg per 100 g phosphorous. Phosphorous is involved in the

structure of every cell in the body, forming the mineral matrix of bone and essential component in molecule *i.e.*, adenosine triphosphate (ATP) also known as energy currency of the body. Besides fiber and minerals, millets are also rich in health-promoting phytochemicals like polyphenols, lignans, phytosterols, phyto-estrogens, phytoacyanins, phenolic compounds, tannins and flavonoids like, anthocyanins, carotenoids, and tocopherols. They are natural antioxidants that protect the phospholipid membrane around heart, nerves, muscles, and red blood cells from the attack of free radicals and thus prevent carcinogenesis, and aging. Carotenoids are reported to prevent cardiovascular diseases like atherosclerosis, maintain normal functioning of immune system, and retina of eyes. These also function as, immune modulators and detoxifying agents. BTM being rich in secondary metabolites (phytochemicals) can help to reduce the risk for gastric ulcers and colon cancer (Singh *et al.*, 2022).

The following health benefits are reported by SHB (2022):

- Brown top millet is an amazing rice replacement since it keeps you satisfied and calms down stomach emptying, making it the perfect grain for diabetes patients. Brown top millet's low GI and carbs prevent future food cravings and a rapid sharp rise in sugar intake. Including this small grain in your everyday diet can help with blood glucose binding and insulin acuity.
- Digestive health is a measure of overall well-being and a healthy immune system. Brown top millet is an allergen, making it a great choice for celiacs and inflammatory bowel disease. It enhances digestibility and uptake in the body while also lowering fluid retention and stomach cramps. Aside from that, it can relieve digestive problems by controlling intestine motion.
- Millets are well-known for enhancing cardiovascular fitness and lessening the risk of developing heart disease. Since they are full of fibre, and protein, and low in carbohydrates, these little miracles lessen bad cholesterol, inhibit blood clotting in the arteries, and strengthen cardiac function. Devour it on an everyday level to maintain your heart beating.
- Brown top millet is an excellent source of calcium, phosphorus, and magnesium, and it reinforces bones and muscles. Eat Brown top millet in your everyday order to meet phosphorus and calcium requirements for combating weak bones, broken bones, inflammatory processes, and reducing your risk of osteoporosis and other crippling musculoskeletal diseases.

The following health benefits are reported by BTP (2023):

Manages diabetes: If you are diabetic and looking to manage your diet, Brown top millet serves as an excellent rice substitute, providing a sense of fullness and delaying gastric emptying, thus making it ideal for you. Brown top millet glycemic index and carbohydrate content curb appetite and control blood sugar. This healthy grain can stabilise blood glucose, lower HbA1C, and improve insulin sensitivity, helping you manage diabetes. Don't hesitate to include this tiny powerhouse in your meals for improved overall health.

Good for digestion: Gut health is essential for your overall health and immunity. This is one of the well-known Brown top Millet benefits. Brown top millet is gluten-free, making it a good choice for all you diagnosed with Celiac disease and IBS. It reduces bloating, cramps, and starch digestion. Additionally, Brown top millet helps regulate bowel movements, offering relief from constipation and promoting a healthy digestive system. Including this millet in your diet can contribute to better gut health and overall digestive well-being.

Improves cardiac health: Brown top millet, like all other millet, is known for promoting heart health and lowering cardiovascular disease risk. These grains decrease LDL cholesterol, avoid arterial clots, and improve cardiac function due to their protein, fibre, and low carbohydrate content. Incorporating Brown top millet into your daily diet acts as a protective shield for your heart, safeguarding it from various ailments. Embrace the Brown top millet benefits for a healthy heart.

Strengthens bones: Another Brown top millet benefit is that it strengthens bones. Brown top millet is a remarkable source of calcium, phosphorus, and magnesium, which are essential for strong bones and muscles. By incorporating Brown top millet into your regular meal plan, you can fulfil your body's calcium and phosphorus requirements, combatting issues like brittle bones, fractures, and inflammation & reducing the risk of conditions like osteoporosis. Don't disregard the Brown Top Millet benefits in maintaining healthy bones and warding off debilitating bone disorders.

Supports weight loss: Brown top millet is a boon for fitness enthusiasts aiming to lose weight. Incorporating Brown top millet flour into your meal plan can effectively lower your BMI and aid in fat burning. By substituting rice with millet on a daily basis, you can prevent fat accumulation, enhance the gut microbiome, and achieve your weight loss goals. Experience these Brown top Millet benefits and step towards a healthier lifestyle.

The following health benefits are reported by Bnboranics (2023):

- Brown Top millet is an excellent rice alternative because it keeps you satiated and slows down stomach emptying, making it an ideal grain for diabetics.
- Brown Top millet is gluten-free, making it an excellent choice for people with celiac disease and digestive problems.
- Because they are high in protein, fibre, and low in carbohydrates, these little millets lower bad LDL cholesterol, prevent clot formation in the airways, and improve heart function.
- Include Browntop millet in your regular meal plan to meet calcium and phosphorus requirements for fighting brittle bones, fractures, inflammation, and lower your rate of bone loss and other disabling bone disorders.
- Replacing millets for rice on a daily basis can help to reduce fat storage and improve digestion.

The following health benefits are reported by Shaliha *et al.* (2023):

- Consumption of brown top millet regularly leads to a lower risk of cardiovascular diseases, duodenal ulcers, and hyperglycemia or diabetes.
- It has a good source of natural fiber as compared to other food grains.
- It is gluten-free and rich in nutrients that are essential for the body.
- Due to the presence of fiber in large quantities it helps to cure several lifestyle diseases.

- Antioxidants in Brown top millet prevent gastric ulcers and colon cancers.
- Brown top millet acts as a Probiotic for the respiratory system.
- It is very useful for bronchitis and Asthma.
- It hydrates our skin and can look younger
- It helps to boost immunity.
- Taste of the brown top millet is better when compared to rice.

The following health benefits are reported by Grandma (2023):

- It detoxifies each part of the body from head to Toe and Entire Body System
- Cleanses entire Digestive System from Mouth to the rectums
- Relieves Gastritis
- Relieves Constipation
- Cures Piles/ Haemorrhoids
- Cures Fissures
- Cleanses metabolic Waste from the body
- Useful in Nerve Related Issues such as Alzheimer's, Parkinson's, Autism, Paralysis etc.
- Useful in Brain Related Issues such as Forgetfulness, Loss of Memory, Loss of Recognition etc.
- Very beneficial in Lung Related issues.

Browntop millet rich in fiber that is it contains 12.5 g fiber per 100g. Fiber helps in detoxification of the body by removing the waste from the intestine. Fiber act as a prebiotic in the colon as it gets fermented. Browntop millet is gluten free. Browntop millet contain 276 mg per 100 g phosphorous. It is also a good source of minerals. Sufficient amount of magnesium is present which is 94.5 mg/100g. Magnesium is a vital mineral which increases the effectiveness of insulin and glucose receptors by supporting numerous carbohydrates digesting enzymes which manages insulin action. It also helps to reduce the pressure on blood vessels which make it able of reducing the effects of myocardium infarction and migraine (Majumdar *et al.*, 2023).

The following health benefits are reported by Iyer (2023):

Relieves constipation: It is an enriching source of fibre and magnesium, both of which play important roles to relieve constipation. While the fibre adds heft to the meals, adding pressure to your colon, magnesium allows for smooth relaxation and contraction of the muscles when it is time to pass the faeces.

Diabetic-friendly: Fibrous foods have a low glycemic index, raising one's blood sugar slower than other foods, hence beneficial for diabetics.

Balance your weight: Fibre-rich foods add weight to your meal and thus, you reach satiety faster. This ensures that the person does not feel hunger pangs. "When we plan a diet for one to lose weight, we restrict calories and ensure a good amount of fibre. You could call this a miracle millet, in that sense," adds Dr Preeti.

Treats dyslipidemia: Dyslipidemia refers to a condition when cholesterol and triglycerides are high in the body. Fibre plays a crucial role to help the body recover. Our body tends to eat more if the GI of a food is high. Since browntop millet has a low GI, it provides satiety faster, ensuring you don't overeat. When you eat less, triglycerides are burnt.

Heals gastric ulcers: Our gut has good microorganisms called probiotics. However, they need to be in a specific colony in a specific area of your body. If one is growing at a faster speed than the other, the other bacteria will travel elsewhere in your body, much like a tiger migrating in a forest when it can't find food. This migration is called dysbiosis which can lead to gastric ulcers and irritable bowel syndrome. The fibre in browntop millet ensures that the bacteria grow naturally in its native area.

The following health benefits are reported by Staff (2023).

Rich in nutrients: Brown top millet is an excellent source of various essential nutrients. It contains high levels of protein, dietary fiber, vitamins, and minerals, making it an excellent addition to a healthy diet. This millet is particularly rich in iron, calcium, magnesium, and potassium, all of which are essential for maintaining good health. Iron is important for the formation of red blood cells, while calcium and magnesium are necessary for maintaining strong bones and teeth. Potassium plays a crucial role in maintaining fluid balance in the body and regulating blood pressure.

Helps manage diabetes: Millet Brown top is a good option for people with diabetes or those at risk of developing the disease. This millet has a low glycemic index, which means that it is slowly digested and absorbed by the body, resulting in a gradual increase in blood sugar levels. This slow release of glucose into the bloodstream helps maintain steady blood sugar levels, making it an ideal food for people with diabetes. Additionally, brown top millet contains high levels of dietary fiber, which can further help regulate blood sugar levels by slowing down the absorption of glucose in the bloodstream.

Good for digestion: Brown top millet is high in dietary fiber, which is important for maintaining good digestive health. Regular intake of dietary fiber aids in maintaining bowel regularity and prevents the condition of constipation. It also aids in the growth of healthy gut bacteria, which can help to improve overall digestive function. Additionally, brown top millet contains a good amount of magnesium, which has been shown to have a beneficial effect on digestive health.

Boosts immunity: Brown top millet is a good source of various vitamins and minerals that are essential for supporting a healthy immune system. It contains high levels of antioxidants such as polyphenols, which help to fight against free radicals and prevent oxidative stress. These antioxidants can help to boost immunity by protecting cells from damage and supporting healthy cell function. Brown top millet is also rich in

vitamins B6, C, and E, all of which are important for a strong immune system. Vitamin C, for example, helps to promote the production of white blood cells, which are vital for fighting off infections and diseases.

Good for heart health: It contains high levels of magnesium, which is essential for maintaining heart health. Regulating blood pressure and reducing the risk of heart disease are among the benefits of magnesium. Brown top millet also contains fiber, which can help lower cholesterol levels and reduce the risk of heart disease. Additionally, the presence of antioxidants in brown top millet helps in preventing oxidative damage, which is linked to heart diseases.

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