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Climate Resilient Characteristics of Millets for Sustainable Agricultural at Molecular Level

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Introduction

Millets are coarse grains of the Poaceae family that have been farmed since the dawn of civilisation. Little or minor millets are considered neglected crops due to their limited yield potential when compared to large millets (sorghum and pearl millet) and fine cereals (rice, wheat and maize). Despite their versatility, tiny millets have been underused due to institutional encouragement of fine cereals. Because of their composition and nutritional significance, these coarse cereals have recently been re-evaluated as "nutri-cereals." Little millets have piqued the interest of growers and policymakers in the aftermath of the negative effects of climate change since they require fewer external inputs, are drought-tolerant, and have a lower carbon footprint than other cereals. These positive effects ensured the resurgence of small millets after decades of institutional neglect in poor countries. Because of their ecological soundness and potential to mitigate climate change, tiny millets have risen to the forefront of developing health consciousness and food demand for the future (Maitra *et al.*, 2022).

The two main kinds of small-seeded grains, major and minor millets, are referred to collectively as millet. Sorghum and pearl millet (*Pennisetum glaucum*) are two common millets (*Sorghum bicolor*). On the other hand, minor or small millets include finger millet (*Eleusine coracana*), foxtail millet (*Setaria italica*), proso millet (*Panicum miliaceum*), barnyard millet (*Echinochloa crus-galli*), kodo millet (*Paspalum scrobiculatum*), little millet (*Panicum sumatrense*), teff (*Urochloa ramosa*). Tiny millets are noted for their ability to survive harsh weather conditions like heat, drought, salt, and cold. They are also less susceptible to diseases and insect pests than big grains. Little millets are nutritionally five to seven times better than main cereals since they include a higher amount of protein, fibre, vitamins, bioactive substances, and both micro- and macronutrients. These characteristics highlight little millets as one of the finest crops to grow in the context of climate change. Despite these benefits, research on small millets has lagged behind that of other crops. The biotechnological approaches like molecular cloning of useful gene, identification of marker or QTLs, GWAS and other omics-based approaches could be utilized for unravelling the important traits of millets and can be used in crop improvement. Tolerance against adverse climate or abiotic stress like high soil temperature, cold stress, salinity, etc have already been reported in various millets. These traits from the small millets have to be harnessed and introduced into other millets crops or any food crop to attain nutritional and climate resilient sustainability in food crops (Muthamilarasan and Prasad, 2021).

Properties of millets

From the Neolithic era, millets, one of the ancient domesticated crops, have been a fundamental dietary supplement. Millets' nutritional profile is far superior to that of widely grown cereal crops like rice, wheat, and maize. They serve as a storehouse of nutrients due to their high nutritional qualities in terms of carbs, proteins, antioxidants, dietary fibre, phytochemicals, vitamins, and minerals. The proteins found in millet are a great source of several necessary amino acids that also contain sulphur. Millets also differ from other cereals in terms of their starch quality; millet flour contains about twice as much resistant starch (13–15%) as rice. The millet-based food products have been identified as a healthy diet for type II diabetic patients due to their high dietary fibre content and low glycaemic index. Gluten-free millet grains lessen the likelihood of developing celiac disease as a result of gluten intolerance. As a rich source of antioxidants, the diverse polyphenols found in millet grains-including ascorbic acid, catechol, gallic acid, caffeic acid, gentisic acid, p-coumaric acid, vanillic acid, p-hydroxybenzoic acid, syringic acid, sinapic acid, salicylic acid, chlorogenic acid, and kaempferol-provide significant benefits (Ofosu *et al.*, 2020).

Millets are inherently abiotic stress-tolerant crops, in addition to having good nutritional properties. Most millet cultivars still have the ability to withstand high temperatures, salt, drought, insect and pathogen infestation, and poor soil fertility despite being grown in semi-arid to desert areas with few resources. Millets don't need regular irrigation, chemical fertiliser application, or precise pest control measures like big crops like rice do. Millets are physiologically sustainable in harsh environmental circumstances without sacrificing production because to their high water and nitrogen usage efficiency.

Insight the millet's genome

The foxtail millet, finger millet, pearl millet, and broomcorn millet draft genome sequences are currently accessible. Foxtail millet (2n = 2x = 18) and pearl millet (2n = 2x = 14) are the only diploid species of millet that are commonly grown. Tetraploid species include finger millet (2n = 4x = 36), kodo millet (2n = 4x = 40), little millet (2n = 4x = 36), proso millet (2n = x = 36), and barnyard millet (2n = 6x = 36). Foxtail millet is the smallest millet crop genome, measuring about 400 Mb, followed by broomcorn millet (923 Mb), finger millet (1.2 Gb), and pearl millet (1.7 Gb).Foxtail millet has been established as an experimental model crop for the study of the genetics and genomics of abiotic stress tolerance, the biochemistry of C-4 photosynthesis, and the biomass production of panicoid biofuel crops due to its low genome complexity, inbreeding nature, short life cycle, and accessibility to high-throughput genomic resources (Kumar *et al.*, 2020).

Approaches to utilize climate resilient features of millets for crop improvement

Millets have been found very much tolerant to abiotic stress prevailing at current climatic conditions and also reported as good source of stress resistance traits for crop improvement. Here are the list of techniques/methodology through which we can use the climate resilient traits of millets to improve the other cereal crops:

1. Identification of molecular marker and QTLs related to abiotic stress tolerance, it is the first and most important step to understand molecular mechanism behind the tolerance.
2. Transcriptomic approach for candidate gene selection, here the expression of gene could be analysed to ensure the credibility of gene identified for resistance.
3. Application of genome-wide study of abiotic stress-related gene families in millets, genome wide studies can be used to assess the available germplasm to find the novel candidate gene/QTL.
4. Integrative omics approach to harness potential candidate genes in millets, in the present omics-era, the use of different omics like genomic, transcriptomics, proteomics in collaboration could be a better choice.

Above mentioned points leads to identification of genes/QTL responsible for tolerance mechanism in millets. After identification, theintrogression of targeted gene/QTL could be done trough the molecular breeding approach, conventional breeding, transgenic

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approach, and the gene correction/deletion of genes with negative effect could be done through genome editing (Singh *et al*., 2021).

Conclusion

Millets are regarded as being resistant to abiotic stress, a storehouse of nourishment, and having significant medicinal benefits. Unfortunately, after the green revolution, their cultivation and consumption were neglected, and this underutilization continued into the first decade of the twenty-first century. With foxtail, finder, and pearl millet, significant strides have been made in biotechnological interventions and exploration of the availability of genomic resources. Broomcorn millet's genome sequence is already available, although molecular research has not advanced enough at the genome level. The accelerated crop development procedures, such as speed breeding, are not currently used in millets; nonetheless, this has the potential to reduce breeding timetables and allow for the early introduction of varieties. The UN-FAO has designated 2023 as the "International Year of Millets," acknowledging the crop's potential. By then, the involvement of government and non-governmental organisations in establishing or revitalising millet cultivation may be expected to promote higher millet production. And use of millets for crop improvement for climate resilient is the need of the hour. In the event of any future anomalous events, this could lead to success in battling hunger and malnutrition among the vulnerable population.

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