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Insights Into the Wild World of Major Millets

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Abstract

Sorghum and pearl millet are vital cereal crops for food security in arid and semi-arid regions, contributing significantly to livelihoods in resource-constrained environments. Wild relatives of these crops harbor a wealth of genetic diversity for biotic and abiotic stress resistance, grain quality, and yield enhancement. Systematic collection and conservation of wild germplasm have become critical to preserving this biodiversity, threatened by habitat loss and climate change. These collections, housed in global gene banks, serve as reservoirs of adaptive traits for modern crop improvement. This review underscores the importance of wild relatives in enriching sorghum and pearl millet breeding programs, ensuring crop resilience and sustainability in the face of global agricultural challenges.

Introduction

Sorghum (*Soghum bicolor*) and Pearl millet (*Pennisetum glaucum*) are the two major millets mainly grown in Rajasthan, Karnataka, Maharashtra, Uttar Pradesh, Haryana, Gujarat, Madhya Pradesh, Tamil Nadu, Andhra Pradesh, and Uttarakhand states of India. Millets are also known as nutri-cereals because they are rich in protein, fiber, vitamins and minerals. Millets are now gaining more attention for their amazing qualities like low glycemic index and free of gluten which are the making them healthy substitute to the staple cereals. These small grained cereals are a staple food in parts of Asia and Africa thrives well in the warm weather and infertile soils.

Millets can mitigate climate change and address food security challenge in several ways: (i) they are C4 crops that convert carbon dioxide into oxygen, which helps reduce the amount of greenhouse gases in the atmosphere, (ii) millets are drought tolerant, can grow in arid climates without irrigation, and are resistant to biotic stresses, (iii) Millets are a reliable source of food even in adverse conditions, and they can be grown in a variety of climates, (iv)

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Millets have retained a diverse genetic pool, which means they can be bred to produce varieties that are less vulnerable to disease and climate change and (v) millets can improve soil health.

Wild relatives in major millets are important for enhancing the climate resilience of crops by improving yield and quality and addressing emerging challenges like climate change, soil degradation and water scarcity as they possess novel genes and alleles providing valuable traits for breeding. This article showcases the collections and pre-breeding work done globally with the wild relatives of sorghum and pearl millet. Wild relatives of any crop are mostly reserved to their primary and secondary origins, from where those have to be collected, evaluated, conserved and tamed to be used in the crop improvement program. Pre-breeding deals with the principles and methods used to tame the wild relatives.

Wild relatives

Sorghum: According to Dillon *et al*. (2001), Sorghum consists of 25 species distributed across Australia, the Pacific Islands, Southeast, East and South Asia, and much of Africa. In Snowden's classification, sorghum was divided into two main sections, Eu-sorghum and Parasorghum, based on morphological traits such as color of grains and glumes and persistence of pedicellate spikelets (Snowden, 1955). However, five subgenera of Sorghum are now recognized: Eu-sorghum, Chaetosorghum, Heterosorghum, Parasorghum, and Stiposorghum based on morphological characters.

Pearl millet: The genus *Pennisetum* contains about 140 species. The important wild relatives of cultivated pearl millet include:

1. *P. glaucum* subsp. *monodii* (the progenitor)
2. *P. purpureum*; *P. pedicellatum*
3. *P. orientale*; *P. mezianum* and
4. *P. squamulatum*

Collections

- **Sorghum:** Based on crop diversity, availability of characterization and evaluation data, and accessibility and availability of material and related information, the National Bureau of Plant Genetic Resources in India, USDA-ARS, and ICRISAT are the three main germplasm collections identified by the global strategy for the ex-situ conservation of sorghum. Information on nearly 100,000 accessions, including those stored at the USDA-ARS genebanks and ICRISAT, is kept up to date by Genesys, an online global gateway.

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- **Pearl millet:** Nearly 90% of the approximately 26,000 accessions of pearl millet are in the CGIAR genebank, which is housed at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Hyderabad, India. Millets continue to be generally ignored in conventional agriculture, despite the significant work that plant breeders have put into them. As evidenced by genebank holdings, the majority of which are traditional cultivars and landraces, however some advanced lines and a few accessions of wild relatives are also present.

Pre-breeding

Pre-breeding efforts focus on unlocking the genetic potential of these wild relatives by introducing desirable traits into elite breeding lines. Techniques such as hybridization, backcrossing, and genomic-assisted breeding enable the transfer of traits like drought tolerance, pest resistance, and enhanced nutritional profiles. However, barriers like linkage drag, reproductive incompatibility, and limited genetic understanding of wild relatives pose challenges. Integrating advanced molecular tools with traditional methods accelerates the development of pre-breeding materials.

- **Sorghum:** The sorghum pre-breeding project aims to introduce valuable genetic variation from *Sorghum bicolor* (L.) Moench into two cultivated sorghum backgrounds, focusing on subspecies *verticilliflorum* and *drummondii*. These subspecies exhibit significant morphological and ecological diversity and harbor traits beneficial for global sorghum breeding, including resistance to *Striga*, anthracnose, grain mold, downy mildew, and rust.
- **Pearl millet:** The pearl millet pre-breeding project, conducted from 2015 to 2018, developed interspecific populations by crossing *Pennisetum glaucum* subsp. *violaceum* (*P. monodii*) with agronomically superior pearl millet lines. These populations are being advanced and evaluated for terminal drought and flowering-stage heat tolerance under controlled environments and field conditions at four locations in India. Heat- and drought-tolerant introgression lines will also be screened for blast resistance to identify promising candidates. Once developed, these lines will be made available to pearl millet breeders and researchers globally through the ICRISAT genebank in India.

Conclusion:

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Wild relatives of sorghum and pearl millet are invaluable for enhancing crop resilience and productivity. Their genetic diversity offers solutions to climate challenges and resource constraints. Effective collection, conservation, and pre-breeding efforts, combined with modern tools, are essential to harness their potential, ensuring food security and sustainable agriculture for future generations.

References

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