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Sugarcane and Its Wild Relatives Conservation and Sustainable Utilization on India

*Subhalaxmi Sahoo
M.Sc. Scholar, Department of Plant Breeding and Genetics, College of Agriculture, OUAT, Bhubaneswar, Odisha, India -751003
*Corresponding Author's email: subhalaxmisahoo263@gmail.com

Sugarcane is one of the most important commercial crops, forming the backbone of the sugar, ethanol, and bioenergy industries. Its long evolutionary history, complex genetic makeup, and close association with wild relatives have played a crucial role in shaping modern cultivated varieties. The genus *Saccharum*, along with related genera such as *Erianthus*, *Miscanthus*, *Narenga*, and *Sclerostachya*, together constitute the *Saccharum* complex, which represents the primary genetic resource for sugarcane improvement. Wild relatives contribute invaluable traits such as tolerance to drought, waterlogging, pests, diseases, and high biomass yield, making them essential for climate-resilient agriculture. India, being one of the centres of diversity for wild sugarcane relatives, holds immense genetic wealth that requires systematic collection, evaluation, and conservation. Institutions such as the National Bureau of Plant Genetic Resources (NBPGR), Sugarcane Breeding Institute (SBI), and Indian Institute of Sugarcane Research (IISR) play a pivotal role in conserving and utilizing these resources. This article highlights the origin, genetic diversity, wild relatives, uses, and conservation strategies of sugarcane germplasm, emphasizing the importance of wild relatives in ensuring sustainable sugarcane production under changing climatic conditions.

Keywords: Sugarcane, Saccharum complex, wild relatives, germplasm conservation, NBPGR, bioenergy

Introduction

Sugarcane (*Saccharum spp.*) is far more than a source of sugar. It is a crop deeply woven into human history, rural livelihoods, and modern energy systems. Today, sugarcane supports millions of farmers and fuels industries ranging from sugar and jaggery to ethanol, electricity, paper, and bio-based products. Behind this success lies an extraordinary genetic foundation shaped by domestication, natural hybridization, and human selection over thousands of years. Modern cultivated sugarcane did not evolve in isolation. Instead, it emerged from continuous interaction with wild species and related grasses, collectively known as the *Saccharum* complex. Understanding and conserving this genetic diversity is essential for future crop improvement, especially in the face of climate change, emerging pests, and the growing demand for renewable energy.

The Saccharum Complex

The basic genetic resources of sugarcane consist of six species of the genus *Saccharum* and several closely related genera, including *Erianthus*, *Miscanthus*, *Narenga*, and *Sclerostachya*. These taxa form a closely related interbreeding group known as the **Saccharum complex**, which has played a central role in the evolution of cultivated sugarcane. Among the *Saccharum* species, *Saccharum officinarum* (noble canes), *S. barberi* (North Indian canes), and *S. sinense* (Chinese sugarcanes) are the cultivated forms, while *S. robustum*, *S.*

spontaneum, and *S. edule* represent the wild species. The Indonesia–New Guinea region is recognized as the primary centre of diversity for *S. officinarum* and *S. spontaneum*, whereas genera such as *Erianthus, Narenga*, and *Sclerostachya* are abundantly distributed in the north-eastern regions of India. Traditional Indian (*S. barberi*) and Chinese (*S. sinense*) sugarcanes were largely replaced after the 1920s with the introduction of high-yielding interspecific hybrids. Today, these older cultivated types survive mainly in field gene banks, serving as valuable genetic resources for breeding programs.

Origin and Global Spread of Sugarcane

Sugarcane is believed to have originated in **New Guinea**, around **8,000–10,000 years ago**, where early humans selected canes with thick, juicy stems for chewing. From this region, noble canes spread to Southeast Asia, India, and China. Archaeological evidence indicates that sugarcane was cultivated during the **Indus Valley Civilization (4000–1500 BCE)**, primarily for its sweet juice and medicinal uses. Indian farmers and artisans were among the first to develop techniques for extracting and crystallizing sugar more than 2,000 years ago. From India, sugarcane spread to China, where further advances in cultivation and processing were made. Arab traders later introduced sugarcane to the Mediterranean region in the 9th century CE, and Christopher Columbus carried it to the Americas in 1493. Today, sugarcane is grown in more than 100 countries, with Brazil, India, and China leading global production.

Chromosome Number and Genetic Complexity

Sugarcane is one of the most genetically complex crop plants. It is a highly polyploid species with a basic chromosome number of **x = 10**, while commercial cultivars possess **100–130 chromosomes (2n = 100–130)**. Its genome, estimated at around **10 gigabases**, is a mosaic derived mainly from *S. officinarum*, *S. spontaneum*, and *S. barberi*. This complexity provides enormous genetic variability, which breeders exploit to improve yield, quality, and stress tolerance.

Wild Relatives

Wild relatives of sugarcane are invaluable sources of adaptive traits. *Saccharum spontaneum*, widely distributed across India, is particularly important due to its tolerance to drought, flooding, salinity, pests, and diseases. It has played a key role in the development of modern hybrid sugarcane varieties. *Saccharum robustum*, native to New Guinea, is considered a progenitor of *S. officinarum* but is less commonly used in breeding due to disease susceptibility. Species of *Erianthus* are gaining increasing attention for their high biomass yield, multi-ratooning ability, and tolerance to biotic and abiotic stresses. These traits make *Erianthus* an ideal candidate for energy cane development and cellulosic ethanol production.
Other related genera such as *Miscanthus* and *Narenga* also contribute valuable genes and are used globally as bioenergy crops or breeding materials.

Uses of Sugarcane and Its Wild Relatives

Sugarcane is a true multipurpose crop. It is the world's leading source of sucrose and a major feedstock for **ethanol**, which is increasingly blended with petrol as a renewable fuel. By-products such as **bagasse** are used for electricity generation through cogeneration, paper and particleboard manufacturing, and bio-based chemicals. **Molasses** serves as a raw material for ethanol, yeast, rum, and organic acids, while **filter mud** is used as fertilizer and animal feed.
Wild relatives also have diverse traditional and modern uses. *S. spontaneum* provides thatching material, ropes, mats, paper pulp, and medicinal products. *Erianthus* species can produce nearly **100 t/ha of biomass** and are highly suitable for energy generation, even under sub-optimal growing conditions.

Collection and Conservation of Sugarcane Germplasm in India

India holds a strategic position in sugarcane genetic diversity, particularly for wild relatives. The **National Bureau of Plant Genetic Resources (NBPGR)** plays a central role in the collection, conservation, characterization, and documentation of sugarcane germplasm across

the country. Field gene banks, in vitro conservation, and cryopreservation techniques are employed to ensure long-term preservation. The **Sugarcane Breeding Institute (SBI), Coimbatore**, and the **Indian Institute of Sugarcane Research (IISR), Lucknow**, are major contributors to germplasm evaluation and varietal development. At the global level, the **International Sugarcane Germplasm Collection Centre** at USDA-ARS, Florida, conserves and distributes sugarcane genetic resources worldwide.

Importance for Sustainable Agriculture

With climate change posing serious challenges to sugarcane cultivation, wild relatives offer solutions through traits such as drought tolerance, flood resistance, pest resistance, and high biomass productivity. The integration of these traits into commercial varieties has already led to the development of **energy canes** and stress-resilient cultivars. Conserving and utilizing wild relatives is therefore not an option, but a necessity for sustainable sugarcane production.

Conclusion

Sugarcane's success as a global crop is rooted in its rich genetic heritage and close relationship with wild relatives. The *Saccharum* complex represents a treasure trove of genetic diversity that must be conserved and wisely utilized. India, with its vast diversity of wild sugarcane relatives and strong institutional support through NBPGR, SBI, and IISR, is uniquely positioned to lead efforts in sugarcane germplasm conservation and improvement. Protecting this genetic wealth today will ensure resilient, productive, and sustainable sugarcane cultivation for generations to come.

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