Review and Progress Open Access

Trait Basis and Breeding Strategies for the Coordinated Improvement of Yield and Sugar Content in Sugarcane

Jiong Fu, Zhongmei Hong
Hainan Provincial Key Laboratory of Crop Molecular Breeding, Sanya, 572025, Hainan, China
Corresponding email: jiong.fu@hitar.org

Plant Gene and Trait, 2026, Vol.17, No.1 doi: 10.5376/pgt.2026.17.0005
Received: 20 Jan., 2026
Accepted: 18 Feb., 2026
Published: 27 Feb., 2026

Preferred citation for this article:
Fu J., and Hong Z.M., 2026, Trait basis and breeding strategies for the coordinated improvement of yield and sugar content in sugarcane, Plant Gene and Trait, 17(1): 56-73 (doi: 10.5376/pgt.2026.17.0005)

Abstract This study explores the trait basis, genetic mechanisms, and breeding strategies for the coordinated improvement of yield and sugar content in sugarcane. Yield and sugar content are the two key traits determining sugar yield per unit area and industrial value, and their formation is jointly influenced by agronomic traits, physiological processes, and molecular regulatory networks. Cane yield is mainly determined by millable cane number, single stalk weight, plant height, and stalk diameter, while sugar content is characterized by quality traits such as Brix, Pol, CCS, juice purity, and fiber content. Photosynthetic efficiency, dry matter accumulation, source-sink relationships, and assimilate partitioning constitute the fundamental physiological basis linking biomass formation and sucrose accumulation. Genetically, the complex polyploid genome of sugarcane makes both traits typical quantitative traits controlled by multiple genes, allele dosage effects, and strong environmental interactions. This study further summarizes breeding strategies, including conventional hybrid breeding, marker-assisted selection, genomic selection, and gene editing, as well as the roles of agronomic management such as water and fertilizer regulation, population structure optimization, and proper harvesting time. Overall, achieving high yield and high sugar content relies on integrating yield- and quality-related traits and their underlying mechanisms within a genotype-environment-management framework to promote multi-trait coordinated improvement.

Keywords Sugarcane; Yield; Sugar content; Source-sink relationship; Coordinated improvement

1 Introduction

Sugarcane (*Saccharum* spp.) is one of the most important sugar crops globally, contributing approximately 80% of the world's sugar supply, and also serves as a major source of biomass energy and bio-based materials (Wu et al., 2024). In tropical and subtropical countries such as Brazil, India, and China, the sugarcane industry not only supports the sugar production system but is also closely linked to rural economic development, employment, and regional agricultural stability. With the advancement of biorefinery systems, sugarcane is no longer merely a traditional sugar crop, but has evolved into an integrated industrial feedstock capable of producing sugar, fuel ethanol, electricity, and various bio-based products. Its strategic importance in the circular economy and low-carbon bioeconomy continues to increase (Wang et al., 2025). Under the pressures of global population growth, limited arable land, and climate change, improving the efficiency with which sugarcane converts solar energy into fermentable sugars and structural biomass has become a key scientific challenge for sustainable agricultural and energy systems (Lu et al., 2024; Mehdi et al., 2024).

In sugarcane production systems, sugar yield per unit area is determined by both cane yield and sucrose content, making it a core indicator of cultivar value and cultivation efficiency. Theoretically, maximizing industrial benefits requires simultaneous improvement in biomass accumulation and sugar concentration. However, in practical breeding, increases in sugar yield have relied more on improvements in cane yield, while gains in sugar content have progressed more slowly. This is closely associated with the physiological and genetic trade-offs between the two traits: high-biomass genotypes tend to allocate more assimilates to structural carbon pools, whereas high-sugar genotypes may divert carbon toward storage tissues at the expense of sustained vegetative growth. Thus, although yield and sugar content jointly determine final sugar yield, their formation processes are not fully synchronized and often exhibit complex coordination and trade-offs. This carbon assimilation, transport,