Tropical Plants

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LC05-136 originates from ROC22, green arising from blue and surpassing blue

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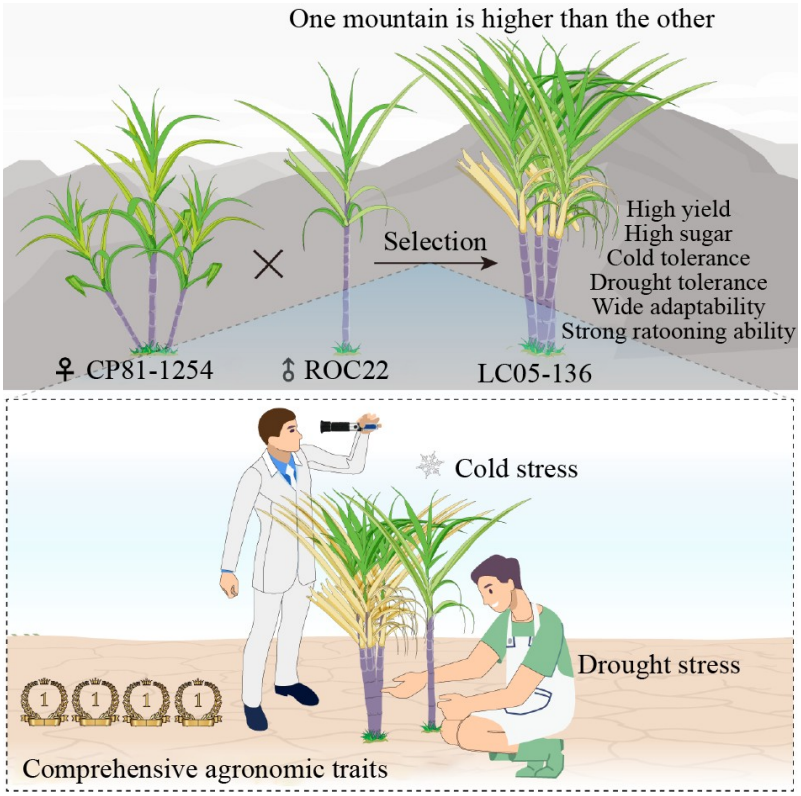
In Brief

LC05-136 originating from ROC22, was tailored to suit the specific conditions of Liuzhou City of the Guangxi province, China. It is characterized by high yield, high sugar, high tolerance to drought and cold stress, strong ratooning ability, and wide adaptability, and is recognized as the flagship of the fifth-generation sugarcane varieties in China. To date, LC05-136 has been accumulatively cultivated across more than 1.67 million hectares, occupying 38% of the sugarcane planting area in Guangxi, China.

Graphical abstract



Highlights

- The agronomic features of LC05-136 are described in detail.
- Breeding strategies and cultivation practices for LC05-136 are dissected.
- This variety won the first prize in the Science and Technology Awards issued by Guangxi province.

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LC05-136 originates from ROC22, green arising from blue and surpassing blue

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Abstract

Sugarcane plays a crucial role in the agricultural economy and people's livelihoods, and the seed industry is the key to maintaining a stable sugar supply. In China, sugarcane varieties have witnessed five rounds of improvement and renewal, which significantly drive the development of the sugar industry. Among the fifth-generation sugarcane varieties, LC05-136 was developed by Liucheng Sugarcane Research Units (LC-SRU), with reference to ROC22, and was tailored to suit the specific conditions of the region. This variety, which emerged as a flagship, is known for several significant advantages, including high yield, high sugar, high tolerance to drought and cold stress, strong ratooning ability, and wide adaptability. Up to 2023, LC05-136 has been accumulatively cultivated across more than 1.67 million hectares in China. We can reasonably deduce that in sugarcane breeding, the selection of 'marshals' with a well-balanced combination of desirable traits is far superior to 'generals' that excel in only one favorable trait. As it truly deserves, in 2022, the breeding and promotion of LC05-136 won the first prize in the Science and Technology Awards issued by the People's Government of Guangxi Zhuang Autonomous Region, China.

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Sugarcane, accounting for approximately 90% of total sugar output is the predominant sugar crop, which plays a crucial role in the agricultural economy and the livelihood of the people in China[1,2]. The primary sugarcane cultivation regions include Guangxi, Yunnan, Guangdong, and Hainan provinces (China). In 2023, sugarcane has been cultivated across roughly 1.11 million hectares, with Guangxi accounting for 0.75 million hectares, Yunnan for 0.26 million hectares, Guangdong for 80,000 hectares, and Hainan for 13,200 hectares. This has resulted in a sugar production of approximately 8.0 million tons. The seed industry, contributing up to 60% to its growth, is a key factor in maintaining a stable sugar supply. Since the establishment of the People's Republic of China, sugarcane varieties have completed five rounds of improvement and renewal, resulting in an average yield increase of approximately 1.0 ton per round and a 1.0% increase in sugar content[3,4]. These advancements have significantly driven the continuous, rapid, and healthy development of sugar industry in China. In this situation, Liuzhou city of Guangxi province, located in the northernmost sugarcane planting region in China faces challenges especially poor ecological conditions, including barren dry slopes, cold or frost, and drought. It is generally believed that, if sugarcane can grow well here, it may grow even better elsewhere[5]. Recently, Liucheng Sugarcane Research Units (LC-SRU) has developed a new and improved variety named LC05-136 with reference to ROC22, which was tailored to suit the specific conditions of the region (Fig. 1).

In 2005, Wenxiang Lu, director of LC-SRU, developed LC05-136 by selecting from over 100,000 sugarcane seedlings. This variety, originating from the crossing between CP81-1254 and ROC22[6], is characterized by tall, compact, and moderate growth, featuring medium to large, erect and uniform, and solid stems, cylindrical internodes, straight leaf posture, green leaf color, purple-red leaf sheaths, and easy defoliation[3,7]. During the national sugarcane variety regional trial in 2012−2013, LC05-136 exhibited an average yield of 100.74 tons per hectare (t/ha), surpassing the control ROC22 by 0.87%, of which the plant cane increased by 0.15% and the ratoon cane increased by 2.10%. Compared to ROC22, the sugar content averaged 15.16 t/ha, representing a 5.41% increase (Table 1). Surprisingly, LC05-136 is known for several significant advantages, including but not limited to high yield, high sugar, highly tolerant to drought and cold stress, strong ratooning ability, and wide adaptability (Table 1), making it suitable for cultivation in moderately fertile acreage across major sugarcane planting regions in China, mostly Guangxi, Guangdong, Yunnan, and Hainan provinces[3,7−9]. This variety is moderately resistant to sugarcane mosaic disease and sugarcane smut disease in the national sugarcane variety regional trial (2012−2013)[7,10]. The recommended row spacing is 100−120 cm, with a general seed amount of 120,000~150,000 buds/ha and the seeds in double or triple buds. On dry slopes, consider planting 3−4 buds in each section. To ensure root retention for over 3 years and enhance planting efficiency, the suitable fertilization time is in late May for plant cane but in mid-April for ratoon cane. As this variety grows rapidly, field management should be timely and thorough. Remember to remove plants infected with smut disease promptly and implement effective

Table 1. Comprehensive evaluation on variety traits for LC05-136 and ROC22.

Varieties	PH (cm)	SD (cm)	SSW (kg/stem)	ENS (stems/ha)	SY (t/ha)	SC (t/ha)	SMDR	SSDR	DT	CT
LC05-136	286.21	2.74	1.64	66573	100.74	15.16	MR	MR	HR	HR
ROC22	300.19	2.72	1.70	64586	99.87	14.39	HS	S	R	MR

The original data was extracted from Lu & Lu[7], Luo et al.[8] and You et al.[10]. PH, plant height (cm); SD, stem diameter (cm); SSW, single stem weight (kg/stem); ENS, effective number of stems (stems/ha); SY, sugarcane yield (t/ha); SC, sugar content (t/ha); SMDR, sugarcane mosaic disease resistance; SSDR, sugarcane smut disease resistance; DT, drought tolerance; CT, cold tolerance; MR, moderately resistant; HR, highly resistant; HS, highly susceptible. During the national sugarcane variety regional trial in 2012–2013, LC05-136 was moderately resistant to sugarcane smut disease. Unfortunately, the variety has been found to be susceptible to sugarcane smut in recent years.

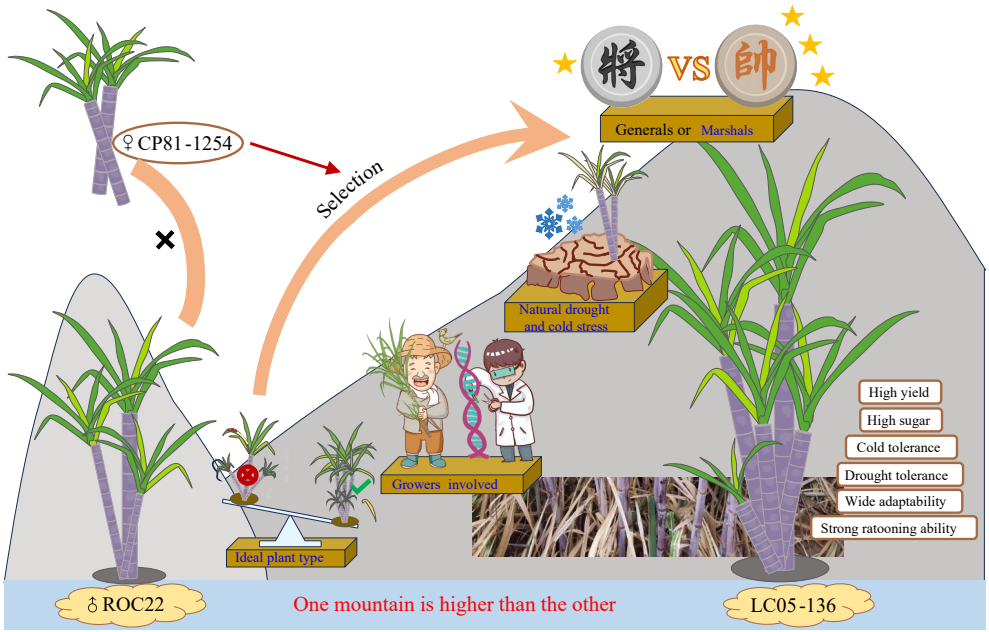

Fig. 1 Green LC05-136 originates from blue ROC22 and surpassing blue.

measures against thrips, aphids, and stem borers[10]. Collectively, LC05-136 has been well and widely accepted by sugarcane growers and sugar enterprises (Fig. 1).

Prior to 2013, there was a significant shortage of independently bred elite sugarcane varieties in mainland China[11]. ROC22, a variety introduced from Taiwan province, accounted for 55.54% of sugarcane planting areas nationwide and a striking percentage of 68.20% in Guangxi province[12]. In 2014, LC05-136 was successively certified by the China Committee for Crop Variety Registration and then by the Guangxi Committee for Crop Variety Registration. What excites us all is that, it was greatly promoted, with the rapid expansion of planting area. By 2021, LC05-136 reached 303,333 hectares in mainland China, with Guangxi contributing 278,200 hectares. Fortunately but not surprisingly, it was designated as the popular or mainly promoted sugarcane variety by the Ministry of Agriculture and Rural Development of the People's Republic of China in 2022. By 2023, LC05-136 emerged as a flagship of the fifth-generation sugarcane varieties, has been accumulatively cultivated across more than 1.67 million hectares in China, occupying 38.30% of the sugarcane planting area in Guangxi in 2021[4,13,14]. Despite the success, LC05-136 also exhibits some disadvantages, such as inadequate resistance to lodging and weak ratooning ability in specific regions. Especially, in recent years, the variety has been found to be susceptible to sugarcane smut, with incidence rates increasing with each subsequent ratooning year, opening up a new topic of disease resistance improvement. As the old saying goes, 'there is no perfect crop variety, but there are only those that are better'. We can reasonably deduce that LC05-136 will eventually be replaced by a new sugarcane variety, reflecting an inevitable progression. This is also the reason why the majority of sugarcane breeders insist on selection and breeding work.

A good sugarcane variety is a collection of traits such as high yield, high sugar, tolerant to abiotic stress, resistant to biotic stress, and strong ratooning ability[13,15]. As the cultivation area expands, a minor defect can be magnified indefinitely. Consequently, despite years of breeding efforts, some sugarcane varieties may still greatly suffer from those unfavorable traits such as easy to fall over, vulnerability to insect pests, or low sugar content. Regarding LC05-136, the breeding approach employed has demonstrated success by utilizing ROC22 as the type of ideal plant and subjecting it to natural local field conditions that well simulate drought and cold stress (Fig. 1). In sugarcane breeding, the selection of 'marshals' with a well-balanced combination of desirable traits is much better than or far superior to 'generals' that excel in only one favorable trait[3]. Furthermore, involving growers in the selection process well leverages their wealth of experience and ability to quickly identify promising sugarcane varieties. Since one end of sugarcane is connected to growers, while the other is linked to sugar enterprises, the collaborative approach for selection ensures

that the needs of growers and enterprises are perfectly combined and well fulfilled simultaneously. In 2022, the project 'Breeding and promotion of sugarcane variety LC05-136' led by Prof. Wenxiang Lu to win the first prize in the Science and Technology Awards issued by the People's Government of Guangxi Zhuang Autonomous Region. That is the highest confirmation on the acceptance of sugarcane growers, the satisfaction of sugar enterprises, and the increasing efficiency of the sugar industry which it truly deserves.

Author contributions

The authors confirm contribution to the paper as follows: conceptualization, supervision: Zhang Y, Que Y; formal analysis, methodology: Wu Q; visualization, writing–original draft: Wu Q, Li Z; resources, writing–review & editing, project administration: Lu W, Liang F, Zhang Y, Que Y; funding acquisition: Wu Q, Que Y. All authors reviewed the results and approved the final version of the manuscript.

Data availability

The raw RNA-Seq data of this study were deposited in the Genome Sequence Archive at the China National Center for Bioinformation (www.cncb.ac.cn). The original contributions presented in the study are included in the article. Further inquiries can be directed to the corresponding authors.

Acknowledgments

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Conflict of interest

The authors declare that they have no conflict of interest.

Dates

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