CROP BREEDING AND APPLIED BIOTECHNOLOGY

CULTIVAR RELEASE

RB005014 – a sugarcane cultivar with high tillering and agroindustrial yield

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Abstract: *RB005014 was developed for the Brazilian central-south region, for harvesting between July and September and planting on soils that have moderate or higher fertility levels. It has high tillering, high sucrose yield, excellent ratooning ability after mechanical harvesting, resistance to the main diseases and carries the Bru1 gene of brown rust resistance.*

Keywords*: Saccharum spp., improvement, disease resistance.*

INTRODUCTION

Modern sugarcane cultivars have a complex genome, due to large genome size arround 10 Gb, a variable ploidy level and constant aneuploidy resulting in highly heterozygous hybrids (Vieira et al. 2018). Cultivated sugarcane is a vegetatively propagated crop, which takes approximately 8 to 12 years to improve and release more productive cultivars.

The Sugarcane Breeding Program of the Federal University of São Carlos – PMGCA/UFSCar (www.ridesaufscar.com.br) is part of the Inter-University Network for the Development of Sugarcane Industry – RIDESA (www.ridesa.com.br). In over 40 years, 94 RB sugarcane cultivars were released, currently planted on nearly 64% of the sugarcane growing area in Brazil (Daros et al. 2015, Chapola et al. 2016).

The RIDESA network aims to develop high-yielding cultivars with a high sucrose content, resistance to the main diseases and adapted to different climate and soil conditions (Carneiro et al. 2016, Daros et al. 2018). Furthermore, the stability of cultivar yields in mechanical planting and harvesting systems has been a challenge and concern for RIDESA (Daros et al. 2018). In this context, the high tillering and excellent ratooning ability of RB005014, even under mechanical harvesting, indicate the cultivar as promising. Moreover, this sugarcane cultivar is suitable for mechanized planting and has good resistance levels against the major sugarcane diseases.

PEDIGREE AND BREEDING METHOD

Cultivar RB005014 was derived from a biparental cross of the full-sib genotypes SP80-1816 x RB855536 (Figure 1). At the beginning of the year

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2000, the cross was carried out at the experimental site Estação de Floração e Cruzamento da Serra do Ouro (lat 9º 13' S, long 35º 50' W, alt 450 m asl), in the municipality of Murici, Alagoas, of the Federal University of Alagoas. Later in the same year, sugarcane caryopses were planted and germinated in a greenhouse at the experimental station of the Federal University of São Carlos (lat 22° 21' S, long 47° 23' W, alt 620 m asl), in the city of Araras, São Paulo. Thereafter the sugarcane plantlets were individualized and planted at an experimental field in order to establish the first selection stage (T1). In this phase, each genotype, represented by a single clump, was mass-selected in the first ratoon crop for general morphological criteria like as higher Brix, resistance to the main diseases, absence of flowering, stalk number and reduced bagasse pith (Morais et al. 2015).

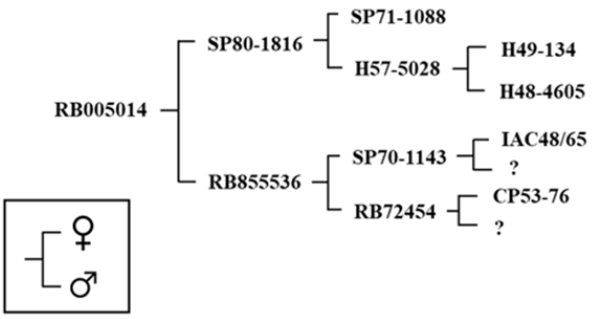

Figure 1. Pedigree of sugarcane cultivar RB005014.

The clones selected in the T1 stage were taken to the second selection stage (T2), which also had standard commercial cultivars for comparison of yields. In this phase, the genotypes were grown at two locations in the state of São Paulo: Araras (lat 22° 21' S, long 47° 23' W, alt 620 m asl) and Valparaiso (lat 21° 13' S, long 50° 52' W, alt 439 m asl). The experiment in T2 stage was evaluated in an augmented randomized incomplete block design (Federer 1956), with plots consisting of two 2.5-m rows, with one replication. Genotypes in T2 stage were assessed in plant cane and ratoon crops likewise in T1 stage, plus the variables stalk weight per plot (WP) and kilogram brix per plot (KBP) (Kang et al. 1983). Clones selected during T2 stage advanced for the third selection stage (T3) as described by Carneiro et al., (2016). In T3, clones were evaluated at three sites under different climate and soil conditions, in different regions of Sao Paulo state (Tarumã-SP (lat 22° 44' S, long 50° 34' W, alt 429 m asl), Nova Europa-SP (lat 21° 46' S, long 48° 33' W, alt 502 m asl), Barra Bonita-SP (lat 22° 28' S, long 48° 33' W, alt 526 m asl). The selection in T3 stage was performed considering the performance of the clones across all evaluated environments and both plant and ratoon crops. The selection criteria were utilized sucrose content in sugarcane (PC, in %) and kilogram pol per plot (KPP).

The selected genotypes were planted in the experimentation stage (ES), in which they were assessed in 15 fields trials allocated in the diverse in regions of São Paulo and Mato Grosso do Sul: Tarumã-SP (lat 22° 44' S, long 50° 34' W, alt 429 m asl), Nova Europa-SP (lat 21° 46' S, long 48° 33' W, alt 502 m asl), Barra Bonita-SP (lat 22° 28' S, long 48° 33' W, alt 526 m asl), Guaíra-SP (lat 20° 19' S, long 48° 18' W, alt 518 asl), Pradópolis-SP (lat 21° 21' S, long 48° 4' W, alt 533 asl), Promissão-SP (lat 21° 32' S, long 49° 51' W, alt 425 asl), Valparaíso-SP (lat 21°13' S, long 50° 52' W, alt 439 m asl), Olímpia-SP (lat 20° 44' S, 48° 54' W, alt 480 asl), Tanabi-SP (lat 20° 37' S, long 49° 39' W, alt 521 m asl), Paraguaçu Paulista-SP (lat 22° 24' S, long 50° 34' W, alt 509 m asl), Piracicaba-SP (lat 22° 43' S, long 47° 38' W, alt 526 m asl), Orindiúva-SP (lat 20° 11' S, long 49° 21' W, alt 487 m asl), Guariba-SP (lat 21° 21' S, long 48° 13' W, alt 649 m asl), Sandovalina-SP (lat 22° 27' S, 51° 45' W, alt 383 m asl), Angélica-MS (lat 22° 9' S, long 53° 46' W, alt 366 m asl)), recording the data of three to four cycles. The fields tests were established in the randomized block (3 or 4 replicates), with standard commercial cultivars as controls, alocated in the blocks. The traits assessed were sucrose content in sugarcane (PC, in %), tons of stalks per hectare (TSH), tons of pol per hectare (TPH), and fiber content (in, %). The clone adaptability and stability were estimated according by Eberhart and Russell (1966). The selected genotypes of ES were evaluated to maturation curve, according to the sucrose content in sugarcane (PC, in %).

PERFORMANCE

Cultivar RB005014 has an intermediate development cycle and upright growth habit. The stalks have a medium diameter, a high amount of wax, a greyish green color and the leaf blades are green and waxy. The tillering capacity in plant and ratoon crops is high, with excellent canopy cover, high ratooning ability even under mechanical harvesting, and sugarcane longevity (several harvests from one planting). In addition, cultivar RB005014 has a high agro-

industrial yield, yield stability and good fiber content. Under the conditions of central-south region of Brazil, the recommended harvest time for RB005014 is the middle of the growing season, between July and September (Figure 2). Under these conditions, cultivar RB005014 rarely flowers and produces little or no pith.

Cultivar RB005014 had responsiveness to improvements soil and climatic conditions. Considering the standard commercial cultivar (RB867515), the cultivar RB005014 had greater agricultural yield (TSH) in the intermediate to favorable environments, whereas in restricted environments presented TSH lower yields than standard commercial (Figure 3). The RB005014 was evaluated in pre-commercial areas, and RB005014 cultivar recommendation is for favorable and intermediate soil and climatic conditions, according to the classification of Prado (2008).

Cultivar RB005014 produced an agricultural yield (TSH) of more than 119 T ha^{-1} and a cane sucrose content (PC, in %) of approximately 15.5%. The performance of this cultivar with regard to the agroindustrial yield (in tons of pol per hectare - TPH) was excellent, higher to that of commercial standard cultivars of intermediate/late maturation, considering the mean data of 13 field tests with three to four harvests each (Figure 4).

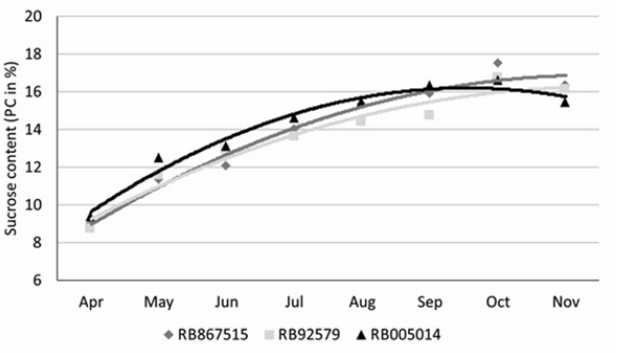

Figure 2. Maturation curve of sugarcane cultivar RB005014 in comparison with the commercial standard cultivars RB867515 and RB92579.

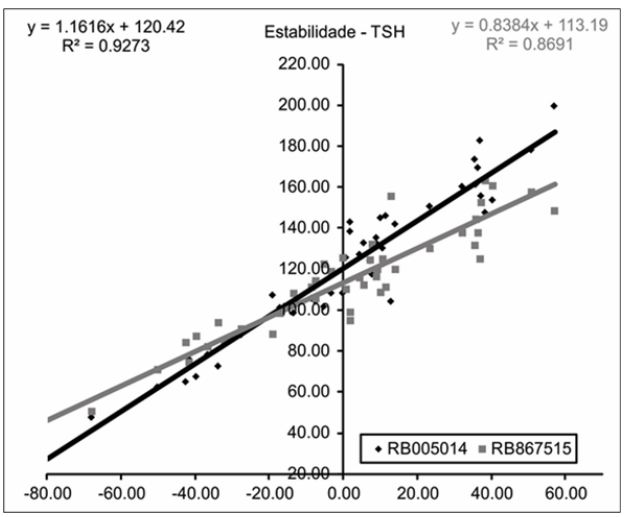

Figure 3. Adaptability and stability of cultivar RB005014 in comparison with the commercial standard cultivar RB867515. The mean data of tons of stalks per hectare (TSH) were adjusted based on regression analysis (Eberhart and Russell 1966). The points indicate the dataset of 13 experiments, with four harvests each.

OTHER CHARACTERISTICS

Disease reaction

Cultivar RB005014 was subjected to tests of artificial inoculation and natural infection with the main sugarcane diseases, together with other genotypes. These tests assessed the reaction of clones and cultivars against these diseases under the conditions of central-south region of Brazil.

Disease evaluation under natural infection conditions were performed in areas with weather conditions to pathogen occurrence and, consequently, with high inoculum pressure. Thereby, we evaluated under natural infection conditions the main sugarcane diseases; orange rust (*Puccinia kuehnii*), brown rust (*Puccinia melanocephala*), smut (*Sporisorium scitamineum*), leaf mosaic (sugarcane mosaic virus) and leaf scald (*Xanthomonas albilineans*). The evaluation is based on the number of infected clumps (% incidence) for smut, mosaic and scald, and based on the leaf area percentage with symptoms (% severity) for orange and brown rusts (Amorim et al. 1987).

Greenhouse tests of artificial inoculation with smut fungus spores and contamination with mosaic virus suspension were carried out, as described by Matsuoka (1979). The evaluation was followed by scale for each disease, which considers the amount of infected plants (% incidence) and the clones were categorized as resistant, intermediate or susceptible. The results in both tests indicated RB005014 as highly resistant to the diseases evaluated (Table 1); therefore, it is recommended for planting without restriction.

The brown rust resistance in modern sugarcane cultivars is largely due to the *Bru*1 gene presence. Thereby, to verify if cultivar RB005014 has this resitance gene, the genomic DNA was extracted as described by Aljanabi et al. (1999)

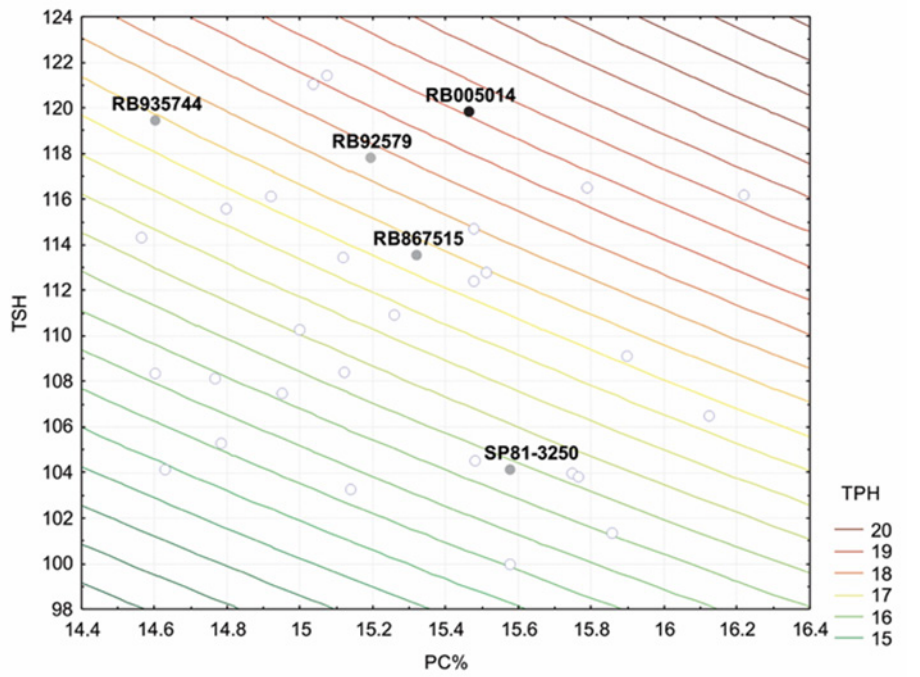

Figure 4. Isoquants of mean tons of pol per hectare (TPH) in function of sucrose content (PC in %), in sugarcane and tons of stalks per hectare (TSH) in 13 experiments. In the black circle, cultivar RB005014 is compared with standard commercial cultivars (gray circles) and clones (void circles).

and after that the presence of the *Bru*1 gene was detected using the molecular markers R12H16 and 9O20-F4-*RsaI* (Costet et al. 2012). The PCR reactions and amplification conditions were carried out as proposed by Costet et al. (2012). The result showed that *Bru*1 gene was present in cultivar RB005014, attested by the positive diagnosis of the two molecular markers evaluated (haplotype 1).

Table 1. Reaction of sugarcane cultivar RB005014 to diseases in the central-south region of Brazil

Disease	Cultivar RB005014
Smut	R
Brown rust	R^{+}
Orange rust	R
Mosaic	R
Leaf Scald	R

R = resistant; + = Presence of molecular markers *Bru*1 (haplotype 1: presence of the two markers R12H16 and 9O20-F4-RsaI)

BASIC SEED MAINTENANCE AND DISTRIBUTION

The samples of cultivar RB005014 are keepting and distributed by the Sugarcane Breeding Program (https://www.ridesaufscar.com.br/) of the *Department of Biotechnology, Plant and Animal Production, Center of Agricultural Sciences, Federal University of São Carlos,* Araras, São Paulo, Brazil.

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