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CULTIVAR RELEASE

RB975242 and RB975201 - Late maturation sugarcane varieties

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Abstract: *The sugarcane varieties RB975201 and RB975242 were developed and released for harvest at the end of the season (late maturation) in the Central-South region of Brazil. In specific environments, these varieties were compared with commercial standards in sugar yield per area. They are resistant to major sugarcane diseases and present the Bru1 gene of resistance to brown rust.*

Key words: *Saccharum spp., high production, disease resistance.*

INTRODUCTION

Sugarcane (*Saccharum* spp.) originated from crosses between *Saccharum officinarum*, *S. barberi*, *S. sinense*, *S. robustum*, *S. edule* and wild species of *S. spontaneum*, forming the *Saccharum* complex (Sreenivasan et al. 1987). The cultivated sugarcane is predominantly allogamous, highly heterozygous, and maintained by vegetative propagation.

Currently, Brazil has three sugarcane breeding programs: Agronomic Institute of Campinas (variety abbreviation - IAC), Sugarcane Technology Center (variety abbreviation - CTC), and Inter-University Network for the Development of Sugarcane Industry, RIDESA (variety abbreviation - RB, that is Brazilian Republic).

RIDESA is a cooperation between IFES (Federal Institutions of Higher Education) to develop improved sugarcane varieties by taking advantage of researchers training and regional bases of the former IAA/PLANALSUCAR. RIDESA's creation was an important step in order to promote nationwide coordinated actions of technological support to one of the most important segments of the Brazilian economy. RIDESA consists of 10 federal universities (UFSCar, UFRPE, UFAL UFRRJ, UFV, UFG, UFPR, UFS, UFPI and UFMT) which share the experimental station of Serra do Ouro, based in Murici/AL, and experimental units installed in major producing regions, forming a national network of trials aimed at sugarcane breeding. RIDESA has produced, since 1990, 75 varieties, which summed to the varieties released by PLANALSUCAR constitute 94 RB varieties, produced in 45 years of research on sugarcane. Currently, RB varieties account for 68% of the total area of sugarcane cultivation in Brazil (Barbosa et al. 2015, Carneiro et al. 2015, Iaia et al. 2015;,Oliveira et al. 2015).

The Federal University of São Carlos (UFSCar) develops breeding studies in

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the states of São Paulo and Mato Grosso do Sul, both located in Central-South Brazil. This region has the largest cultivated area (58.9%) and the highest sugarcane production in Brazil. RB975201 and RB975242 varieties were developed and studied for 18 years, and were released in 2015 by the breeding program of UFSCar.

BREEDING PROGRAM

Figure 1 shows the pedigrees of RB975242 and RB975201 varieties. In 1997, crosses were carried out in the Flowering and Crossing Station Serra do Ouro, located in the municipality of Murici, Alagoas (lat 09° 18'S, long 35° 56' W, alt 450m asl). The seeds obtained were germinated and then seedlings were planted in the field, establishing the first selection stage (T1). At this stage, the genotypes in a single clump were selected based on mass selection method in ratoon cane cycle (Breaux et al. 1963). The general morphological criteria were agroindustrial traits such as Brix and number of stalks (Hogarth 1987, Berding et al. 2004), flowering, pith and reaction to major diseases (Matsuoka et al. 1999, Morais et al. 2015).

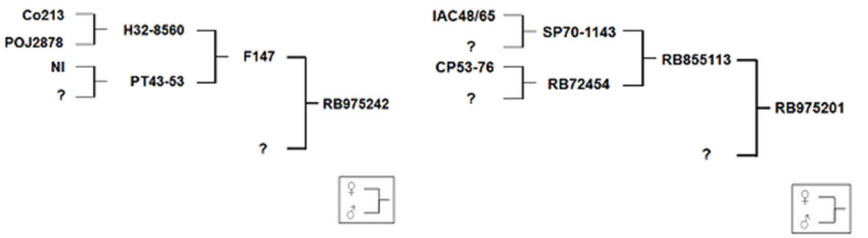

Figure 1. Pedigree of sugarcane varieties RB 975242 and RB975201.

Based on these criteria, clones were selected and, together with standard commercial varieties, they constituted the second selection stage (T2). At this stage, clones were established in Araras (lat 22° 18' S, long 47° 23' W, alt 690m asl) and Valparaiso (lat 21° 13' S, long 50° 52' W, alt 390m asl), in São Paulo. The experiment consisted of augmented blocks design (Federer 1956), and plots consisted of two 2.5 m furrows with one replication. Clones were evaluated in plant cane, and ratoon, using the same criteria of T1stage, adding the variable weight per plot (WP) and kilos of brix per plot (KBP) (Kang et al. 1983).

Clones selected during the T2 stage advanced to the third selection stage (T3), and were also established in augmented blocks (Federer 1956). Plots consisted of two 5m furrows, spaced 1.40m apart, with two replications. Genotypes at T3 were tested in 10 locations with different climate and soil conditions. Selection was carried out based on the mean performance of both plant and ratoons in several environments. The selection criteria were similar to those used in stage T2, sucrose content (PC, in %) in sugarcane and kilos of pol per plot (KPP) were considered additional variables (Matsuoka et al. 1999).

After the T3 stage, the clones selected followed for experimentation stage (ES), in which they were evaluated in 10 trials distributed in regions with different soil and climatic conditions, considering the data of four cycles (plant cane and three ratoons). The experiments were established in a randomized block design with four replications, with standard commercial varieties of intermediate/late maturation distributed in the blocks as controls. The evaluated variables were ton of stalks per hectare (TSH), sucrose content (PC in %) in sugarcane, ton of pol per hectare (TPH), and % of fiber content. The coefficient of environmental variation, the effects of the genotype x environment interaction, and the adaptability and stability of clones (Eberhart and Russell 1966) were estimated from individual (each site) and joint (all sites) analyses of variance (Steel and Torrie 1960). The promising clones of ES were subjected to maturation curve, in order to identify the best harvest time, according to the amount of sugar per ton of stalks (kg t^{-1}). The genotypes with better performance were multiplied and evaluated in units which are partner of the breeding program of UFSCar, aiming to verify the behavior of genotypes in production conditions (Barbosa et al. 2001, Barbosa et al. 2004).

PERFORMANCE

RB975201

RB975201 has fast development and upright to semidecumbent growth habit. Its leaves (trash) are easily removed; its stalk diameter is medium, with yellowish green color under straw, and purple color when exposed to the sun. The sheaths are green with little wax. It has high tillering in plant and ratoons, with good canopy cover, great ratooning ability in mechanical harvesting, and sugarcane longevity (additional crops from one planting).

It presents high agricultural yield, with great production stability, medium fiber content, medium PIU, and late maturation. RB975201, under the conditions of the Central-South region, presents a very difficult flowering and little pith. These characteristics, in combination with its fast growth, enable the recommendation of RB975201 for harvest at the end of the season in the Central-South region, between the months of August and November (Figure 2).

RB975201 variety is responsive to improvement of soil and climatic conditions; in the experiments, it presented agricultural yield (TCH) higher than RB867515 in intermediate to favorable environments; in restrictive environments, yield of RB975201 was similar to that of RB867515 (Figure 3). This response of RB975201 to different production environments has been validated in pre-commercial areas; therefore, in production conditions of the Central-South region, RB975201's cultivation is recommended preferably in intermediate and favorable environments, according to the classification of Prado (2008).

With agricultural yield above 125t ha^{-1}, and sucrose content in stalks (PC in %) of about 15.0%, RB975201 variety

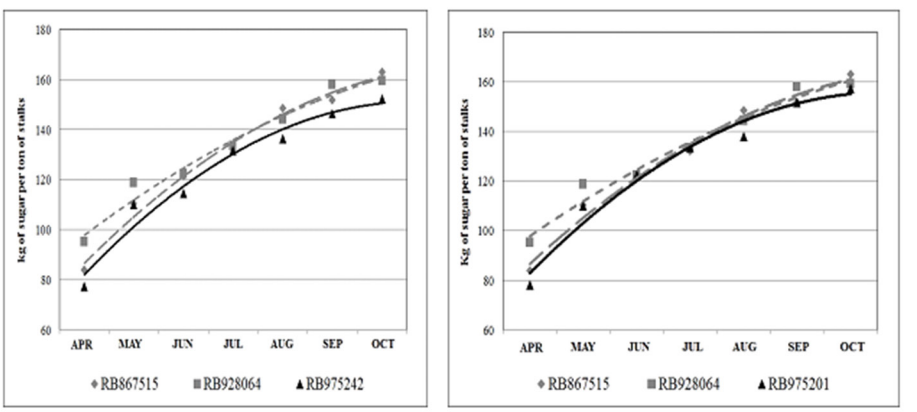

Figure 2. Maturation curves for RB975242 and RB975201 sugarcane varieties when compared with standard commercial varieties RB867515 and RB928064.

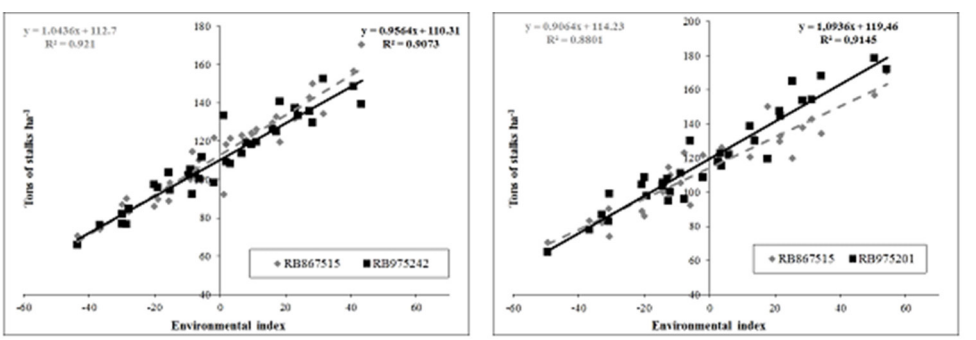

Figure 3. Adaptability and stability of RB975242 and RB975201 varieties when compared with the standard commercial variety RB867515. The mean data of tons of cane per hectare (TCH) were adjusted based on the regression method (Eberhart and Russell 1966). The points refer to the data of the 2nd, 3rd and 4th cuttings in a set of 10 experiments.

is placed in yield components agro-industrial productivity line, in tons of pol per hectare (TPH), superior to standard commercial varieties of intermediate/late maturation, considering the mean data of 10 experiments carried out by three to four cuttings (Figure 4).

RB975242

RB975242 has intermediate growth speed and upright growth habit. Its leaves (trash) are easily removed; its stalk diameter is medium, with green purplish color under straw, and purple color when exposed to the sun. The sheaths are light green and waxy. It has high tillering in plant and ratoons, with excellent closing between lines, great ratooning ability in mechanical harvesting, and sugarcane longevity.

It presents high agricultural yield, high production stability, medium fiber content, medium PIU, and late maturation. RB975242 does not flower nor does it pith, which are characteristics that allow its recommendation for harvest at the end of the season in the Central-South region, between the months of August and November (Figure 2).

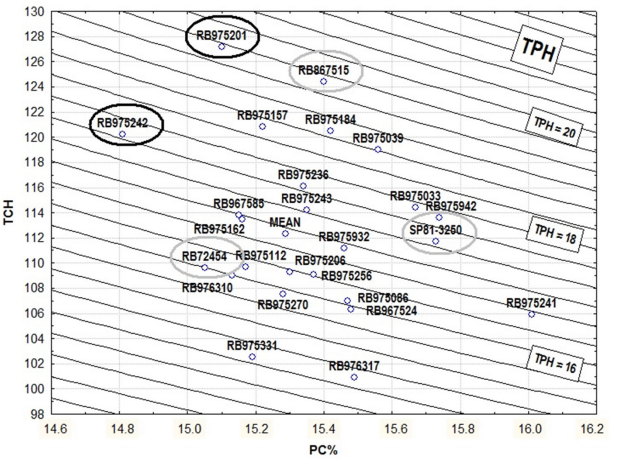

Figure 4. Isoquants of mean of tons of pol per hectare (TPH) in function of sucrose content (PC in %). in sugarcane (PC) and tons of cane per hectare (TCH) in different production environments. In the black circles, RB975242 and RB975201 varieties are compared with standard commercial varieties (gray circles) and clones.

RB975242 variety is rustic; in the experiments, it presented agricultural yield (TCH) similar to that of RB867515 in intermediate to restrictive environments and, in favorable environments, RB975242 yield was slightly lower than that of RB867515 (Figure 3). This behavior of RB975242 in different production environments has been validated in pre-commercial areas; therefore, in production conditions of the Central-South region, RB975242's cultivation in recommended preferably in the intermediate and restrictive environments, according to the classification of Prado (2008).

With agricultural yield above 120 t/ha and sucrose content in stalks (PC, in %) between 14.5% and 15.0%, RB975242 is placed in an agro-industrial productivity line, in tons of pol per hectare (TPH), superior to the standard commercial varieties of intermediate/late maturation, considering the mean data of 10 experiments carried out with three to four cuttings (Figure 4).

OTHER CHARACTERISTICS

Reaction to diseases

RB975201 and RB975242 varieties were subjected, together with other genotypes, to testing for artificial inoculation and natural infection of diseases. These tests were carried out in order to verify the reaction of clones and varieties against the major diseases of sugarcane in the Central-South region of Brazil.

Natural tests were carried out in areas favorable to infections by several diseases, both by weather conditions and by high inoculum pressure. The main diseases evaluated under natural conditions of infection are: Orange Rust (*Puccinia kuehnii*), Brown Rust (*Puccinia melanocephala*), Smut (*Sporisorium scitamineum*), Mosaic (Sugar cane mosaic virus) and Leaf Scald (*Xanthomonas albilineans*). RB975201 and RB975242 varieties, as well as others, were evaluated based on the number of infected clumps (% incidence) for Smut, Mosaic and Leaf Scald, and based on the percentage of leaf area with symptoms (% severity) of Orange and Brown Rusts (Amorim et al. 1987).

Table 1. Reaction to diseases and presence (+) or absence (-) of *Bru*1 gene in RB975242 and RB975201 sugarcane varieties in Central-South Brazil

Disease	Cultivar RB975242	Cultivar RB975201
Smut	R	R
Brown rust	R	R
*Bru*1	+	+
Orange rust	R	R
Mosaic	R	R
Leaf Scald	R	R

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

Artificial tests were carried out in a greenhouse with inoculation of the fungus spores of the Smut disease, and suspension contaminated with mosaic virus, according to methods described by Matsuoka (1979). RB975201 and RB975242 varieties were evaluated based on the grading scale established for each disease, which considers the amount of infected plants (% incidence) and classifies the genotypes into resistant, intermediate and susceptible. The results obtained in the tests of natural infection and of artificial inoculations indicated that RB975201 and RB975242 have adequate resistance levels for the diseases evaluated; therefore, in this regard, both are recommended without restriction for planting.

To determine the presence of *Bru*1 gene, which confers resistance to Brown Rust, the genomic DNA was extracted according to the CTAB method described by Aljanabi et al. (1999). The two molecular markers for diagnosis to *Bru1*, R12H16 and 9O20-F4-*RsaI*, strongly associated with the *Bru*1 gene (Costet et al. 2012), were used to evaluate the presence of the gene. All PCR reactions were carried out following the protocol: 20 µL final volume containing 50 ng DNA, 0.4 M of each primer, 0.4 mM of each dNTP, 2.5 mM MgCl2, 0.5 unit Taq DNA Polymerase (Invitrogen), with 1 X PCR buffer supplied with the enzyme.

Amplification conditions and restriction steps using the *RsaI* enzyme were carried out according to Costet et al. (2012). RB975201 and RB975242 were classified regarding the simultaneous presence (haplotype 1) or absence (haplotype 4) of both molecular markers. Results obtained using the two molecular markers associated the presence of the *Bru*1 gene in RB975201 and RB975242 varieties (Table 1).

MAINTENANCE AND DISTRIBUTION OF BASIC SEEDS

RB975201 and RB975242 varieties were produced and are available for research purposes in the Sugarcane Breeding Program of UFSCar, located in the Agricultural Sciences Center, in Araras, São Paulo state, where they will be kept for at least 5 years from the date of this publication.

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