RB0442 – drought tolerant sugarcane cultivar

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Abstract: *Sugarcane cultivar RB0442 has a high yield, late maturation and good drought tolerance. It is recommended for planting in restrictive environments, mainly with water-deficient soils, and is resistant to the major sugarcane diseases of the Northeastern region of Brazil.*

Keywords: *Saccharum spp., plant breeding, water stress.*

INTRODUCTION

Water is the main limiting factor for sugarcane productivity (Inman-Bamber and Smith 2005). In some regions of Brazil, lower mean yields in the last harvests were reported, due to water scarcity (Teodoro et al. 2017). Under the cultivation conditions for sugarcane in the state of Alagoas, where dry periods are quite common, the soil can become highly water deficient, consequently stress the plants with drought and cause significant yield reductions of sugarcane and by-products (Barbosa 2018).

The Inter-University Network for the Development of the Sugarcane Industry (RIDESA) is responsible for the development of sugarcane cultivars with improved traits, e.g., a high agro-industrial yield, resistance to the major pests and diseases, high sugar content in different growth periods and high suitability for mechanical planting and green cane harvesting (Barbosa et al. 2012, Barbosa et al. 2015, Carneiro et al. 2015, Carneiro et al. 2019, Daros et al. 2017 and Daros et al. 2018). To minimize yield losses due to water deficiency, the Sugarcane Breeding Program of the Center of Agricultural Sciences (CECA) of the Federal University of Alagoas (UFAL), member of RIDESA, has developed a series of cultivars tagged RB (Republic of Brazil), with high agro-industrial yield for harsh conditions (poor soils and water stress). This study describes cultivar RB0442 (*Saccharum* spp.), a highly promising cultivar with characteristics of high agro-industrial yield and drought tolerance, recommended for planting in extensive parts of the Northeastern region of Brazil.

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PEDIGREE AND BREEDING METHOD

The genetic origin of RB0442 (Figure 1) was a biparental cross performed in May 2004 at the Station for Flowering and Crossing of Serra do Ouro (lat 09° 13' S, long 35° 50' W, alt 500 m asl), Murici, AL, where the female RB72910 received pollen from the male parent RB931013. Parent RB72910 was chosen for its characteristics of drought tolerance and rusticity. In July of the same year, the caryopses from the crosses of the series RB04 were germinated in a greenhouse of CECA/UFAL (lat 09° 28' S, long 35° 49' W, alt 127 m asl), in Alagoas. The resulting 21,000 seedlings were transplanted to a field of the sugarcane mill Caeté, in São Miguel dos Campos (lat 09° 42' S, long 36° 06' W, alt 97 m asl), Alagoas in October 2004. The trial of the first selection stage (T1) was arranged in an unreplicated block design, with single-row plots (length 11.5 m) spaced 1.0 m and plants (seedlings) spaced 0.5m apart. Nine months later (July 2005), in the plant cane crop, mass selection

Figure 1. Pedigree of sugarcane cultivar RB0442.

was performed, based on the following phenotypic characteristics: growth habit, diameter and number of stalks per clump, sugar content (brix) and disease resistance. The selected clones (415) were then planted at the research station of the sugarcane mill Porto Rico (water-stressed region), constituting the first clonal stage (T2); this station is based in Campo Alegre (lat 09º 48' S, long 36º 12' W, alt 106 m asl), Alagoas. At this stage, the experiment was planted in plots of two 3.5-m rows, spaced 1 m apart. Mass selection was performed in August 2006, in the plant cane crop, based on the same traits as in the first selection stage (T1). The second clonal stage (T3) of 55 selected clones was then planted at the same research station, in a randomized complete block design with two replications, in plots of five 4-m rows. The selection was performed based on data collected in the plant cane (2007), first and second ratoon crops (2008 and 2009), mainly for the traits: tons of cane per hectare (TCH), total recoverable sugars (TRS), in kilogram of sugar per ton of cane, determined by the method described by Fernandes (2003), and tons of TRS per hectare (TTRSH).

Between 2010 and 2017, 12 experiments were conducted at six different locations in the sugarcane region of Alagoas, at the research base of RIDESA/UFAL for final assessment trials. Each trial was arranged in a randomized complete block design, with four replications, planted in seven 6-m rows per plot (15 buds per meter); a total of 20 clones of the RB04 series were planted. Selection was carried out based on data of 12 locations in three crop cycles (plant cane, first and second ratoon crops), which enabled the evaluation of the agro-industrial yield and assessment of phenotypic adaptability and stability (Eberhart and Russell 1966); the main measured traits were TCH, TRS and TTRSH. In all selections stages, cv. RB0442 was compared to the standard cv. RB92579, an important commercial cultivar for the sugarcane sector in Brazil as well as for sugarcane breeding (Diniz et al. 2018).

The optimum harvest period of cv. RB0442 was also evaluated, in comparison with the standard cv. RB92579, based on maturation curves throughout the months of sugarcane harvesting in Alagoas; i.e., from September 2011 to March 2012. For the evaluation of the cultivar performance and recommendation for planting, data were collected in 31 experimental harvests (13 plant cane, 10 first ratoon crop and 8 second ratoon crops), as well as in other experiments and/or complementary evaluations, which confirmed the superior traits of cultivar RB0442.

In one of the trials, 1 m x 1 m x 1 m trenches were opened to evaluate the root system. The root dry weight of the genotypes was also evaluated in a greenhouse study, using cylindrical Rizotrons (glass wall thickness 10 mm, height 1 m, diameter 0.18 m) with a semicircle shape.

PERFORMANCE

The mean results of 31 experimental crops showed a superior agro-industrial yield of cv. RB0442 than of standard cv. RB92579, in three crop cycles (plant cane, first ratoon and second ratoon crops) (Table 1). The mean gain for TCH was
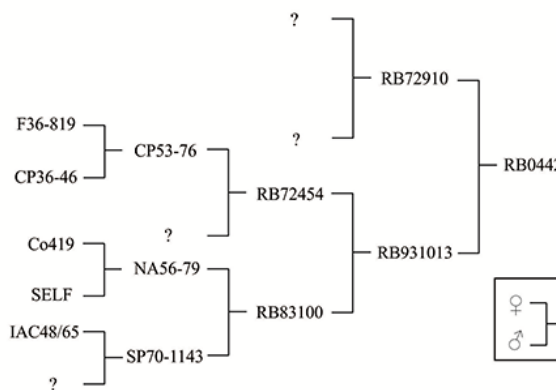
Table 1. Means of the characteristics tons of cane per hectare (TCH) and tons of TRS per hectare (TTRSH) of the cultivars RB0442 and RB92579, according to the type of environment and crop cycle. Estimation of yield gain of cv. RB0442 compared to cv. RB92579. Mean results of 31 harvests in Alagoas

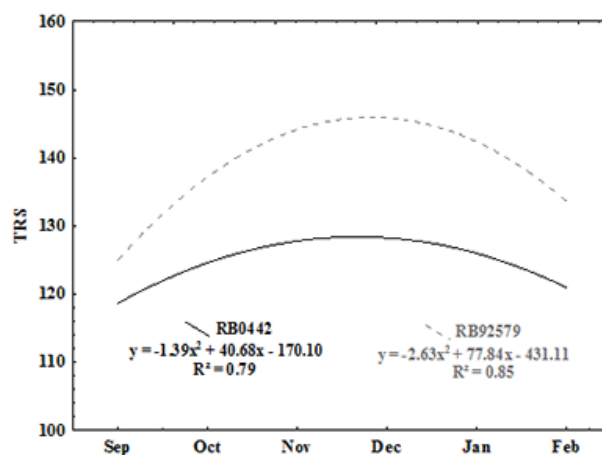| Environments	Crop cycle	TCH				TTRSH			
		RB0442	RB92579	Difference[+]	%	RB0442	RB92579	Difference[+]	%
All environments	Plant-cane	146.21	136.36	9.86	7.23	18.52	18.98	-0.46	-2.44
	First-ratoon	110.52	93.06	17.46	18.77	15.09	14.06	1.03	7.32
	Second-ratoon	124.54	99.46	25.08	25.22	15.60	13.95	1.65	11.81
	Mean	129.11	112.87	16.24*	14.39	16.66	16.09	0.56	3.50
Favorable environments	Plant-cane	165.12	154.56	10.56	6.83	20.97	21.24	-0.28	-1.31
	First-ratoon	140.87	131.29	9.58	7.30	19.10	20.43	-1.33	-6.50
	Second-ratoon	141.02	138.20	2.81	2.04	16.74	18.58	-1.84	-9.91
	Mean	157.68	148.46	9.22	6.21	20.03	20.71	-0.68	-3.28
Unfavorable environments	Plant-cane	103.68	95.41	8.27	8.67	13.00	13.88	-0.88	-6.34
	First-ratoon	102.93	83.50	19.43*	23.27	14.08	12.46	1.62	12.99
	Second-ratoon	119.05	86.55	32.50*	37.55	15.22	12.41	2.81	22.65
	Mean	108.47	87.16	21.31*	24.45	14.22	12.76	1.46	11.45

[+] Difference between sugar yield of cv. RB0442 and reference RB92579; * significant at 5% by the t test.

16.24 tons (14.39%). According to the maturation curve of cv. RB0442, in spite of a lower sugar content, it has a 0.56 TTRSH (3.5%) higher sugar yield than the standard cultivar. Moreover, the data with most pronounced advantages over cv. RB92579 were observed under harsh conditions, with mean gains of 21.21 TCH (24.45%) and 1.46 TTRSH (11.45%) (Table 1). In these limiting environments, the rainfall of the season varied from 881 to 1,175 mm, i.e., insufficient to meet the crop water demand. The differences in performance were greatest in the experimental harvests of 2012, when Alagoas was affected by the most severe drought recorded in the last 100 years (Teodoro et al. 2017). The performance improvement of cv. RB0442 throughout the ratoon crops is also noteworthy, indicating good sprouting ability and longevity (Table 1). For the cultivation conditions of Alagoas, the maturation curve suggested an inferior performance of cv. RB0442 than of standard cv. RB92579, due to the lower sugar content. Consequently, for being a late-maturing cultivar, harvesting is recommended at the end of the crop cycle (Figure 2).

Figure 2. Maturation curves of cultivars RB0442 and RB92579 for total recoverable sugars (TRS).
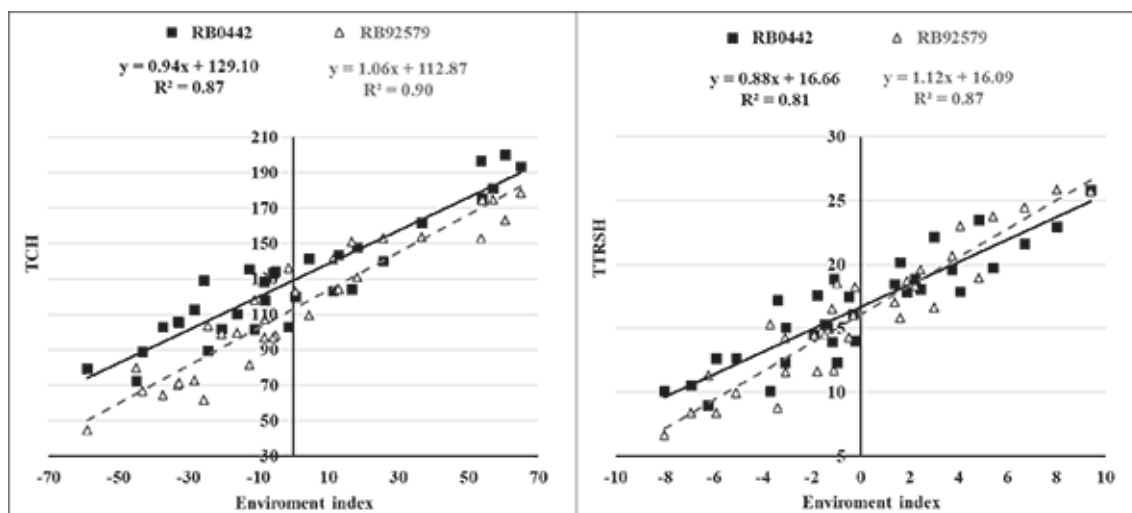
According to the results for TCH and TTRSH by the methodology of Eberhart and Russell (1966), cv. RB0442 has high adaptability and stability (Figure 3). In addition, a better performance of cv. RB0442 under unfavorable environments (harsh conditions) was observed, evidenced by the regression coefficients of < 1, for both TCH (0.94) and TTRSH (0.88).

Cultivar RB0442 has an abundant, deep and vigorous root system, with 16.13% higher dry weight than cv. RB92579 (Figure 4a and 4b). The deepening of the root system is one of the physiological drought tolerance mechanisms of plants (Endres et al. 2010) and is essential for a good performance of sugarcane cultivars in soils with low water availability.

In view of the high agricultural yield, rusticity and drought tolerance, cv. RB0442 is recommended for planting in restrictive environments, especially those subject to water deficit and medium to low fertility soils.

Figure 3. Means of tons of cane per hectare (TCH) and tons of TRS per hectare (TTRSH) of the cultivars RB0442 and RB92579, with linear regression fitting, based on the environmental index of 12 experiments (31 harvests), in Alagoas.
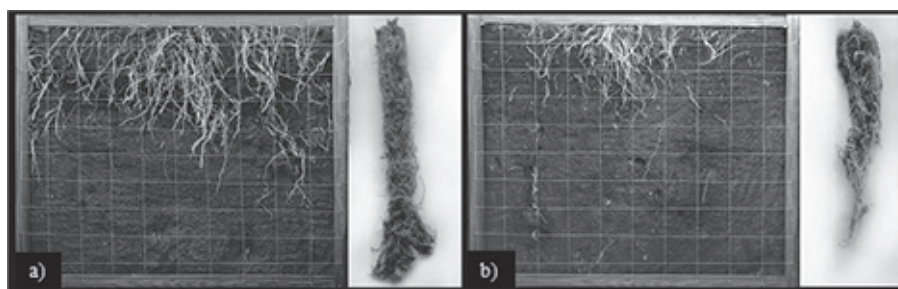
Figure 4. Depth, distribution and dry weight of the root system of the cultivars RB0442 (a) and RB92579 (b).

OTHER TRAITS

Morphology

Cultivar RB0442 has good sprouting and medium tillering capacity in plant cane and high tillering in the early ratoon crops, moderate growth speed and rapid inter-row closure; flowering can occur in years with favorable weather; the growth habit is semidecumbent and detrashing easy; the leaf canopy has a regular volume and is intermediate green; the medium width leaves have curved tips and poor edge serration; the ligule is ascending, the auricle transitional small and symmetrical; the dewlap is triangular and purple-green; the hairless leaf underside is purple-green and has a low amount of wax; the canopy is short with little wax; the stalk has cylindrical internodes with a circular section, arranged in a slight zigzag, with no bud groove; stalk length and diameter are average, the appearance stained, green-purple where exposed and purple-green under drying leaves, with shallow cracks with little wax and no hollow spaces in the stalks; the growth ring is yellowish/medium purple, with little protrusion; the root area has a medium width without aerial rooting and greenish yellow root primordia; the round, medium prominent bud never exceeds the growth ring and the bud cushion is narrow, with hairs at the apex and on the sub apical germ pores.

Reaction to diseases

Cultivar RB0442 is resistant to the two major sugarcane diseases in Alagoas, i.e., orange rust (*Puccinia kuehnii*) and leaf scald (*Xanthomonas albilineans*). Under natural infection and in disease-favorable years, the cultivar was classified as intermediate resistant to brown rust (*Puccinia melanocephala*), although the agro-industrial yield losses were not

significant. Moreover, the cultivar was also classified as intermediate resistant to smut (*Sporisorium scitamineum*, synonym of *Ustilago scitaminea*), a low-incidence disease in Alagoas and in the Northeastern region of Brazil.

GERMPLASM MAINTENANCE AND DISTRIBUTION OF BASIC SEEDLINGS

Plants of cv. RB0442 are maintained in clonal nurseries of the Breeding Program of RIDESA/UFAL (BR 104, Norte, km 85, 57100-000, Rio Largo, Alagoas) and seedlings are propagated from the basic plant registered by the National Register of Seeds and Seedlings (RENASEM) of the Brazilian Ministry of Agriculture, Livestock and Supply (MAPA).

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