CROP BREEDING AND APPLIED BIOTECHNOLOGY

CULTIVAR RELEASE

RB961552 – Highly productive sugarcane cultivar with fast inter-row closure

Crop Breeding and Applied Biotechnology
21(2): e32992126, 2021
Brazilian Society of Plant Breeding.
Printed in Brazil
http://dx.doi.org/10.1590/1984-70332021v21n2c35

Paulo Pedro da Silva[1*], Geraldo Veríssimo de Souza Barbosa[1], Marcelo de Menezes Cruz[1], João Messias dos Santos[1], Carlos Assis Diniz[1], Iêdo Teodoro[1], Vera Lucia Dubeux Tôrres[1], Lailton Soares[1], Adeilson Mascarenhas de Oliveira Silva[1], Bruno Fernando Costa do Nascimento[1], Antônio José Rosário Sousa[1], Carlos Alberto Guedes Ribeiro[1], Antônio Jorge de Araújo Viveiros[1], Francisco Sampaio Filho[1] and Edjane Gonçalves de Freitas[1]

Abstract: *Sugarcane cultivar RB961552 was developed by the Sugarcane Breeding Program of the Federal University of Alagoas, a member university of RIDESA. It was selected for being highly productive, responsive to fertigation and for the high leaf biomass and excellent inter-row closure. It is resistant to brown and orange rust and moderately resistant to leaf scald and smut diseases.*

Keywords: *Saccharum spp., plant breeding, cultivar description, yield potential.*

INTRODUCTION

During their lifespan, sugarcane varieties tend to show signs of genetic degeneration, caused by several factors, resulting in significant losses in agro-industrial production. This can be attributed mainly to the cumulative effects of pests and diseases, resulting in an urgent need for a renewal of the currently cultivated varieties (Viswanathan 2018). In this context, sugarcane breeding has come to play a decisive role in the development of the sugar-energy sector (Santana et al. 2017). Half of the productivity gain is estimated to be a result of sugarcane breeding, due to the continuous replacement of cultivars by other more productive ones (Barbosa et al. 2012). The breeding process is long, requiring on average 8 to 12 years until a more resistant and high-yielding sugarcane cultivar can be released (Barbosa 2018, Carneiro et al. 2019).

The Sugarcane Breeding Program of the Federal University of Alagoas (PMGCA/UFAL) is part of the Inter-University Network for the Development of the Sugarcane Industry (RIDESA), i.e., an association of 10 Federal Universities that develop new improved sugarcane varieties in Brazil (Berton et al. 2020, Carneiro et al. 2020). This agreement allows the Universities to share the Flowering and Crossing Station of Serra do Ouro (Daros et al. 2017, Daros et al. 2018, Carneiro et al. 2019, Diniz et al. 2019).

In view of the high agricultural yield, positive response to fertigation, high leaf mass and excellent inter-row closure, cultivar RB961552 (*Saccharum*

***Corresponding author:**
E-mail: pps@ceca.ufal.br
ORCID: 0000-0002-2438-6601

Received: 17 June 2020
Accepted: 05 April 2021
Published: 31 July 2021

[1] Universidade Federal de Alagoas, Campus de Engenharias e Ciências Agrárias, 57.100-000, Rio Largo, AL, Brazil

spp.) was certified (20170279 - SNPC/MAPA) and released in Alagoas in 2015 (Oliveira et al. 2015). Due to its excellent performance in commercial areas in Alagoas, it has found widespread acceptance by growers in the State. According to data of the RIDESA sugarcane variety census in 2017/18 (www.ridesa.com.br), cv. RB961552 was among the 10 most planted varieties in Alagoas, occupying the ninth position in the planting ranking.

PEDIGREE AND BREEDING METHOD

Cultivar RB961552 is the progeny of a biparental cross made in May 1996 (RB96 series) between the female parent B4362 (pollen receptor) and male parent IAC68/12 (pollen donor) (Figure 1, at the Flowering and Crossing Station of Serra do Ouro (lat 09° 13' S, long 35° 50' W, alt 515 m asl), Murici, Alagoas. Parent IAC68/12 was chosen for its characteristics of early maturation and high sucrose content. Due to the high yield potential of B4362, the cultivar has been planted in several countries in North, Central and South America. In Cuba, the variety was planted on around 40% of the sugarcane area at the end of the 1970s (La O et al. 2018).

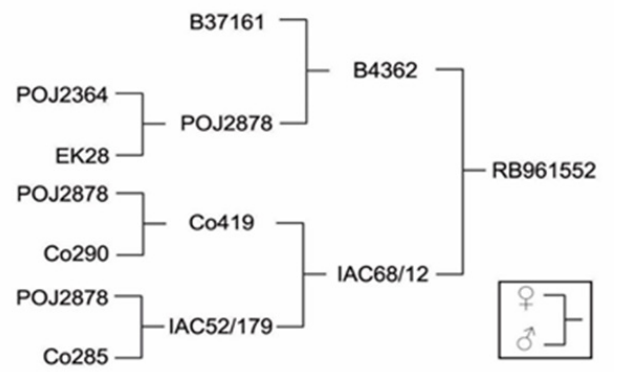

Figure 1. Pedigree of sugarcane cultivar RB961552.

The seedlings were grown from June to August 1996 at the Experimental Station of Rio Largo (lat 09° 28' S, long 35° 49' W, alt 127 m asl), Alagoas, where seedlings for the seven research bases of PMGCA/UFAL are produced. In September of the same year, 25,000 seedlings were planted in a field experiment in São Luiz do Quitunde (lat 09° 22' S, long 35° 32' W, alt 31 m asl), Alagoas. One of the most important breeding stages of sugarcane is T1, when the first plants or families are selected; T1 seedlings were planted (plant spacing 0.5 m) in single-row plots (length 11.5 m, row spacing 1.0 m). The clones were visually selected (mass selection) in the plant-cane crop in July 1997. For selection, the phenotypic traits number of stalks per clump (by counting all stalks), plant morphology, growth habit, sugar content (brix), flowering and disease resistance were taken into consideration. The standard commercial variety SP79-1011 was used for comparison (control).

A set of 694 clones of the series RB96 (2.8%) were selected and advanced to the first clonal stage (T2). The experiment of stage T2 was planted in July 1997 in double-row plots (3.5 m) spaced 1.0 m apart at the same location with the same control variety for performance comparison. Nine months later (April 1998), the clones were evaluated and selected in the plant-cane crop, for the same criteria as in stage T1, and stalk weight per plot (SWP) and kilogram of brix per plot (KBP) were estimated as described by Kang et al. (1983). At this stage, 55 clones were selected and advanced to the second clonal stage (T3), in September 1998.

Stage T3 was arranged in a randomized complete block design with two replications, in plots of five 4-m rows at the same locations as before and with the same control variety for performance comparison. In T3, selection was applied in the plant-cane (1999) and first and second ratoon crops (2000 and 2001), for the traits: cane yield in tons of cane per hectare (TCH), by weighing all stalks of the entire plot; total recoverable sugar (TRS) in kilogram of sugar per ton of cane, and tons of TRS per hectare (TTRSH). To this end, nine stalks from the central row of each plot were sampled and analyzed in the laboratory by the method described by Fernandes (2011). At this stage, 25 clones of series RB96 were selected and advanced to a final assessment trial (FAT).

The FAT trials were planted (2001) in a randomized complete block design, with four replications, in plots of six 6-m rows (15 buds per meter), to evaluate agro-industrial traits in three crop cycles: plant-cane (2002) and first and second ratoon crops (2003 and 2004). A total of 25 experiments were evaluated on 15 fields at different sites in the sugarcane region of Alagoas, whose locations and coordinates of the trials are given in Table 1.

At the FAT stage, the main traits TCH, TRS and TTRSH were measured and phenotypic adaptability and stability were estimated (Eberhart and Russell 1966). The environmental indices to differentiate favorable from unfavorable environments were defined based on the overall mean of all experiments. If the mean of an environment exceeded the overall mean it was considered favorable and an environment with a mean below the overall mean unfavorable.

Table 1. Coordinates of 15 locations of final assessment trials (FAT) in the sugarcane region of Alagoas, where a total of 25 experiments was carried out

Counties of the studied plantations	**No. Trials**	**Latitude** (S)	**Longitude** (W)	**Altitude** (m asl)
Atalaia	1	09° 26′	35° 57′	156
Barra de São Miguel	1	09° 47′	35° 59′	95
Boca da Mata	1	09º 41′	36º 09′	148
Campo Alegre	1	09º 47′	36º 11′	135
Colônia Leopoldina	2	08° 54′	35° 39′	150
Coruripe	2	10° 08′	36° 11′	69
Maceió	2	09° 28′	35° 44′	106
Marechal Deodoro	1	09° 43′	35° 57′	93
Matriz de Camaragibe	2	09° 03′	35° 30′	130
Passo de Camaragibe	3	09º 15′	35º 33′	15
Penedo	1	10° 16′	36° 29′	61
São José da Laje	1	08° 58′	36° 02′	358
São Luiz do Quitunde	4	09° 22′	35° 32′	31
São Miguel dos Campos	1	09° 42′	36° 06′	132
Teotônio Vilela	2	09° 54′	36° 23′	166

To identify the ideal harvest time, maturation curves of RB961552 and SP79-1011 that show sucrose accumulation in sugarcane (PC, in %) were established, as proposed by Fernandes (2011). For this purpose, the sucrose content was sampled in plots of the two cultivars, each month from September to February, in the same production environments as the experiments.

Together with other genotypes, cv. RB961552 was subjected to tests of natural infection against the main sugarcane diseases, in areas where weather conditions were conducive to pathogen occurrence, under the high inoculum pressure of Alagoas. The following main sugarcane diseases were evaluated: brown rust (*Puccinia melanocephala*), orange rust (*Puccinia kuehnii*), smut (*Sporisorium scitamineum*) and leaf scald (*Xanthomonas albilineans*). The evaluation was based on the number of clumps infected with smut and scald (% incidence) and on the percentage of leaf area with brown and orange rust symptoms (% severity) (Amorim et al. 1987).

PERFORMANCE

The mean performance of cultivar RB961552 in 25 experimental crops confirmed better results than of control variety SP79-1011 in the mean of three crops (Table 2). Considering the TCH in the three crops (125.34 t ha^{-1}), the yield was 10.31% higher than that of SP79-1011. In the favorable environments, this difference in TCH was far greater, with a mean gain of 19.12 t ha^{-1} (14.77%). This shows the superiority in yield response to environmental improvements. Due to the high yield potential, gains may be even greater under fertigation, when water and fertilizers are provided simultaneously.

The maturation curve indicates that RB961552 had a higher medium sucrose content (PC in %) than that of control SP79-1011 at the end of the crop cycle (Figure 2). Therefore, cv. RB961552 was classified as medium to late-maturing. The best harvesting period would be between November and December (rainfed cultivation) in the Northeast of Brazil. By irrigation, this period could be extended until February, boosting the potential yield (Teodoro et al. 2017).

According to the methodology of Eberhart and Russell (1966), the results for TCH and TTRSH indicated high adaptability and stability of RB961552, as confirmed by the respective regression coefficients of 0.90 and 0.87, which exceeded those of control SP79-1011, where the regression coefficients for TCH and TTRSH were approximately the same (0.81) (Figure 3). This shows that RB961552 is responsive to improvements of soil and climatic conditions.

Cultivar RB961552 has rare flowering, no pithy stalks, a semi-erect growth habit, medium plant height and no lodging, which facilitates mechanical harvesting. Additionally, sprouting and tillering are medium-strong and inter-row closure is fast, which reduces the negative interference of weed plants and consequently the production costs, as a result of the

Table 2. Mean cane yield or tons of cane per hectare (TCH, in t ha^{-1}) and total recoverable sugar yield in tons per hectare (TTRSH) of the sugarcane cultivars RB961552 and SP79-1011, in 25 experiments, evaluated in favorable and unfavorable environments and plant-cane, first-ratoon and second-ratoon crop cycles, at 15 locations, in the sugarcane region of Alagoas

Environments	Crop cycle	Cane yield (TCH)				Sugar yield (TTRSH)			
	Harvest‡	RB961552	SP79-1011	Difference+	%	RB961552	SP79-1011	Difference+	%
All environments	Plant-cane	133.94	117.19	16.75*	14.29	18.15	16.40	1.75	10.65
	First-ratoon	121.62	112.41	9.20	8.19	17.18	16.35	0.83	5.06
	Second-ratoon	116.89	109.56	7.34	6.70	16.31	16.34	-0.03	-0.19
	Mean	125.34	113.63	11.71*	10.31	17.36	16.37	0.99	6.06
Favorable environments	Plant-cane	160.23	133.04	27.19	20.44	20.28	17.53	2.74	15.64
	First-ratoon	137.98	117.88	20.11	17.06	21.08	18.87	2.21	11.70
	Second-ratoon	142.91	129.99	12.92	9.94	19.50	18.63	0.87	4.67
	Mean	148.53	129.41	19.12*	14.77	20.42	18.56	1.86*	10.02
Unfavorable environments	Plant-cane	122.25	110.15	12.11	10.99	17.03	15.81	1.22	7.72
	First-ratoon	114.34	109.98	4.36	3.96	15.11	15.01	0.10	0.64
	Second-ratoon	103.89	99.34	4.55	4.58	14.19	14.82	-0.63	-4.26
	Mean	110.64	103.62	7.02	6.77	15.42	14.98	0.44	2.94

‡ Crops: 26 plant-cane, 26 first-ratoon and 15 second ratoon crops. + Gain in sugar yield of cv. RB961552 over SP79-1011 (reference). * Significant at 5% by the t test.

reduced application of chemical products (Barbosa 2018). Planting cv. RB961552 can optimize the profitability of sugarcane for growers in Alagoas and other States in the Northeast of Brazil.

OTHER TRAITS

Reaction to diseases

The plant health of cv. RB961552 is strong and it is resistant to the sugarcane diseases brown (*Puccinia melanocephala*) and orange rust *(P. kuenii*) and moderately resistant to leaf scald (*Xanthomonas albilineans*) and to smut (*Sporisorium scitaminea*).

Morphology

The botanical descriptors for sugarcane (International Union for the Protection of New Varieties of Plants - UPOV)

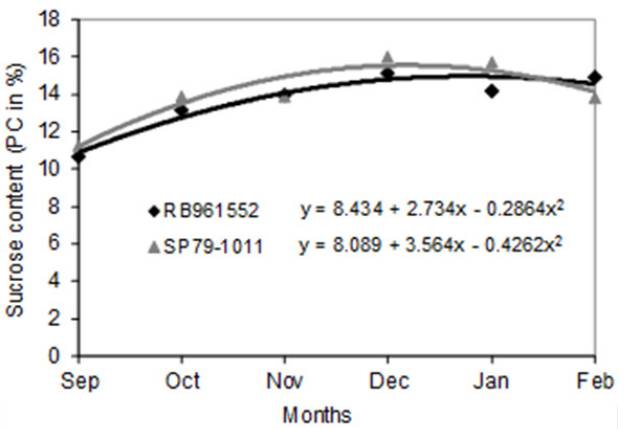

Figure 2. Maturation curve of sugarcane cultivar RB961552 in comparison with the standard cultivar SP79-1011 (reference) for sucrose content in sugarcane (PC, in %).

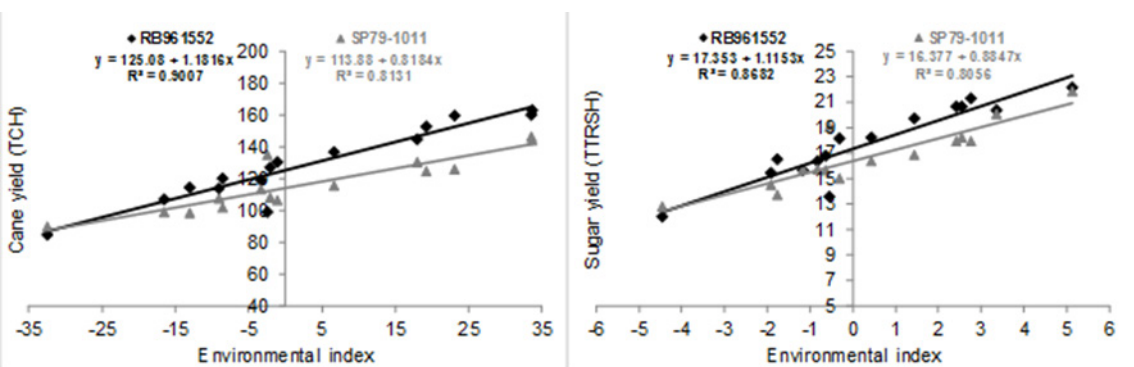

Figure 3. Adaptability and stability of variety RB961552 in comparison with the control variety SP79-1011. The mean data of cane yield (TCH) and total recoverable sugar yield in tons per hectare (TTRSH) in plant-cane and first and second ratoon crops were adjusted by the regression method (Eberhart and Russell 1966).

Table 3. Botanical descriptors* of 10-month-old sugarcane plants that differentiate cultivar RB961552 from SP79-1011 (reference) assessed in the field in Rio Largo, Alagoas, Brazil

Trait	RR961552	SP79-1011	Trait	RR961552	SP79-1011
Leaf canopy	Dense	Medium	Internode: shape	Cylindrical	Curved
Leaf blade: width	Broad	Medium	Internode: expression of zigzag alignment	Absent or very weak	Strong
Leaf blade: pubescence on margin	Absent or very sparse	Sparse	Internode: color where not exposed to sun	Yellow green	Grey yellow
Leaf blade: curvature	Curved tips	Straight	Internode: waxiness	Strong	Weak
Leaf sheath: shape of overlapping auricle	Dentoid	Transitional	Internode: depth of growth crack	Shallow	Absent or very shallow
Leaf sheath: size of overlapping auricle	Medium	Small	Node: growth ring color	Yellow green	Grey orange
Leaf sheath: color of dewlap	Green purple	Purple	Node: width of root band	Medium	Narrow
Cane top: shape of cross-section	Ovate	Circular	Node: shape of bud, excluding wings	Ovate	Obovate
Cane top: length	Medium	Short	Node: position of the pubescence on the bud	Lateral	Apical
Cane top: color	Yellow green	Grey purple	Node: position of bud tip in relation to growth ring	Clearly below	Clearly above
Cane top: waxiness	Weak	Medium	Node: bud cushion (space between base of bud and leaf scar)	Narrow	Absent or very narrow

* International Union for the Protection of New Varieties of Plants - UPOV (www.upov.int).

regarding the characteristics that differentiate RB961552 from the reference cultivar SP79-1011 were assessed in the field in a DHE (Distinction, Homogeneity and Stability) trial, in Rio Largo (lat 09° 28' S, long 35° 49' W, alt 127 m asl), Alagoas (Table 3). Among these descriptors, leaf blade curvature proved to be the clearest and most easily detected phenotypic differentiator between these cultivars, in that RB961552 had curved and SP79-1011 straight leaf tips. Another differentiating trait was waxiness on the internodes, in that RB961552 has strong and SP79-1011 weak waxiness.

Germplasm maintenance and basic seedling distribution

Plants of the variety RB961552 are maintained and distributed by the Breeding Program of RIDESA/UFAL (BR 104, Norte, km 85 - 57.100.000, Rio Largo, Alagoas), and every year seedlings are propagated at research bases to be distributed among growers.

REFERENCES

Amorim L, Bergamin-Filho A, Sanguino A, Cardoso CON, Moraes VA and Fernandes CR (1987) Metodologia de avaliação da ferrugem da cana-de-açúcar (*Puccinia melanocephala*). Copersucar, São Paulo, 65p. (**Boletim Técnico, 39**).

Barbosa GVS (2018) **Inovações tecnológicas desenvolvidas em Alagoas para o setor canavieiro**. FAPEAL/Imprensa Oficial Graciliano Ramos, Maceió, 136p.

Barbosa MHP, Resende MDV, Dias LAS, Barbosa GVS, Oliveira RA, Peternelli LA and Daros E (2012) Genetic improvement of sugar cane for bioenergy: the Brazilian experience in network research with RIDESA. **Crop Breeding and Applied Biotechnology S2**: 87-98.

Berton GS, Oliveira RA, Daros E, Zambon JLC, Bespalhok Filho JC, Brasileiro BP, Ido OT, Ruaro L and Weber H (2020) RB036091 – an early-maturing sugarcane cultivar for the Central South of Brazil. **Crop Breeding and Applied Biotechnology 20**: e28852029.

Carneiro MS, Chapola RG, Fernandes Junior AR, Cursi DE, Balsalobre TWA and Hoffmann HP (2020) RB985476 – a sugarcane cultivar with high agroindustrial yield and disease resistance. **Crop Breeding and Applied Biotechnology 20**: e304020210.

Carneiro MS, Chapola RG, Fernandes Junior AR, Cursi DE, Balsalobre TWA and Hoffmann HP (2019) RB005014 – a sugarcane cultivar with high tillering and agroindustrial yield. **Crop Breeding and Applied Biotechnology 19**: 230-234.

Daros E, Oliveira RA, Zambon JLC, Bespalhok Filho JC, Brasileiro BP, Ido OT, Ruaro L and Weber H (2018) RB036066 – a sugarcane cultivar with high adaptability and yield stability to Brazilian South-Central region. **Crop Breeding and Applied Biotechnology 18**: 325-329.

Daros E, Oliveira RA, Zambon JLC, Bespalhok Filho JC, Brasileiro BP, Ido OT, Ruaro L and Weber H (2017) RB036088 – a sugarcane cultivar for mechanical planting and harvesting. **Crop Breeding and Applied Biotechnology 17**: 84-88.

Diniz CA, Ferreira, VM, Barbosa GVS, Cruz MM, Silva JV, Santos JM, Teodoro I, Tôrres VLD, Soares L, Silva AMO, Nascimento BFC, Sousa AJR, Ribeiro CAG, Viveiros AJA, Sampaio Filho F and Freitas EG (2019) RB0442 – drought tolerant sugarcane cultivar. **Crop Breeding and Applied Biotechnology 19**: 466-470.

Eberhart SA and Russell WA (1966) Stability parameters for comparing varieties. **Crop Science 6**: 36-40.

Fernandes AC (2011) **Cálculos na agroindústria da cana-de-açúcar**. Sociedade dos Técnicos Açucareiros e Alcooleiros do Brasil, Piracicaba, 416p.

Kang MS, Miller JD and Tai PYP (1983) Genetic and phenotypic path analysis and heritability in sugarcane. **Crop Science 23**: 643-647.

La O M, Perera M.F, Bertani RP, Acevedo R, Arias ME, Casas MA, Pérez J, Puchades Y, Rodríguez E, Alfonso I and Castagnaro AP (2018) An overview of sugarcane brown rust in Cuba. **Scientia Agricola 75**: 233-238.

Oliveira RA, Daros E and Hoffmann HP (2015) **Liberação nacional de variedades RB de cana-de-açúcar**. Graciosa, Curitiba, 72p.

Santana PN, Reis AJS and Chaves LJ (2017) Combining ability of sugarcane genotypes based on the selection rates of single cross families. **Crop Breeding and Applied Biotechnology 17**: 47-53.

Teodoro I, Ferreira Junior RA, Lyra GB, Cantarelli ALD, Soares MAS, Santos JMD and Serqueira ACF (2017) Análise agrometeorológica de safras de cana-de-açúcar no estado de Alagoas. **STAB Açúcar, Álcool e Subprodutos 36**: 40-43.

Viswanathan R (2018) Changing scenario of sugarcane diseases in India since introduction of hybrid cane varieties: path travelled for a century. **Journal of Sugarcane Research 8**: 01-35.