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SOIL PHYSICAL ATTRIBUTES AND PRODUCTION COMPONENTS OF SUGARCANE CULTIVARS IN CONSERVATIONIST TILLAGE SYSTEMS

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KEYWORDS

Saccharum spp., plant cane, soil management, reduced-tillage, no-tillage.

ABSTRACT

Machine traffic and conventional tillage can cause structural degradation of the soil, affecting the physical attributes and, consequently, the production and longevity of the sugarcane field. The objective of this study was to evaluate the production components of sugarcane cultivars (RB965902, RB985476, RB966928, RB855156, RB975201, RB975242, RB036066 and RB855536) and physical attributes of a Dystroferric Red Latosol (Oxisol) under no-tillage and reduced-tillage systems. The experiment was conducted using a completely randomized experimental design in an 8 × 2 factorial arrangement, with four replicates. The soil attributes evaluated were density, total porosity, macroporosity, microporosity and penetration resistance. The production components evaluated were stalk length and diameter, number of tillers (NT), tons of cane per hectare (TCH), sucrose content (Pol), tons of sucrose per hectare (TPH), soluble solids content (Brix), total recoverable sugars (TRS) and plant fiber. Cultivars RB965902, RB966928, RB855156 and RB985476 have productivity and technological attributes that are superior to the other cultivars, whereas these are lower for RB036066 in both soil tillage systems. Cultivars RB966928, RB855156, RB975242 and RB855536 exhibited higher TCH and TPH in the no-tillage system, and all cultivars displayed equal or higher performances than those observed in the reduced-tillage system. In the no-tillage system, which exhibits lower penetration resistance values between wheel tracks and in the subsurface layer of the planting row (0.20–0.40 m), cultivars RB985476 and RB975242 had a higher NT, and RB855156 had higher stalk lengths and NT.

INTRODUCTION

The growing demand for sugarcane byproducts has led to the growth of the Brazilian sugar-energy sector through expanding sugarcane plantations and investments in new plant construction in Brazil. Such demand in the industry requires intensive highly technical agricultural mechanization throughout the crop cycle, with modern and versatile machines that perform work at maximum efficiency and low cost to supply high-quality raw material to the agroindustry (Souza et al., 2012a).

Sugarcane is a semi-perennial crop whose cycle has an average duration of 5 years. For the planting of sugarcane, conventional soil tillage is performed via plowing and successive harrowing, which causes soil disturbance and alteration of its structure. During the management of the crop, there is traffic of machines/implements that promotes the compaction of the soil, mainly during the mechanized harvest season when heavy machinery operates, including harvesters and infield transporters. This generally leads to reduced soil quality in systems with intensive soil disturbance caused by changes in soil physical properties, such as increased density and, hence, penetration resistance and reduced macroporosity (Silva Junior et al., 2013; Marasca et al., 2015; Silva & Castro, 2015), which affects soil physical and hydraulic properties that are key for the maintenance of its productive potential, such as aeration and water and nutrient retention and availability, involved in the growth and root development of the plant (Valadão et al., 2015).

The continuous traffic of machines/implements also leads to soil compaction, especially in the sugarcane interrow, where there is significant development of the plant root system (Cury et al., 2014; Ohashi et al., 2015). Considering the impacts of such practices, questions have

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been raised about the use of successive soil preparation operations for establishing sugarcane plantations because they often occupy areas without fertility restriction and physical barriers, with higher energy demand (Carvalho et al., 2011).

The adoption of conservation systems, such as no-tillage and reduced-tillage systems, which offer minimal soil disturbance, maintenance of surface crop residues, conservation of the structure and reduction of energy expenditure, has been occurring in the sugarcane production system, albeit at a slow pace. Storino et al. (2010) reported that no-tillage sugarcane production comprises two successive phases: in the first phase, in an area cleared for replanting, the soil is physically and chemically corrected, and ratoons and weeds are chemically removed. In the second phase, soybeans are planted in a no-tillage system between rows of sugarcane ratoon, and after the soybeans are harvested, the ground is furrowed and sugarcane is planted.

However, few studies have assessed the impact of such systems on the physical quality of soils, especially those with high degradation potential, such as clayey Latosols cultivated with sugarcane (Silva & Castro, 2015), and there is also little information about the influence of these systems on the performance of different cultivars.

The hypothesis tested in this study was that conservation soil management systems are viable options for establishing sugarcane crops in no-tillage grain production areas. This study evaluated the performance of sugarcane cultivars and physical attributes of a Dystroferric Red Latosol under no-tillage and reduced-tillage systems.

MATERIAL AND METHODS

The study was conducted at the Experimental Farm of the Federal University of Grande Dourados, located in Dourados, Mato Grosso do Sul (MS), Brazil (22°13'58"S, 54°59'57W", altitude 418 m). The climate is type Am, monsoon, with dry winters, average annual rainfall of 1500 mm, and average temperature of 22°C (Alvares et al., 2013). In the plant cane cycle, cumulative average rainfall of 1400 m and an average temperature of 23°C were recorded. The soil is classified as Dystroferric Red Latosol (EMBRAPA, 2013) with a clay-like texture, and the layer down to 0.30 m deep is characterized by 603 g kg^{-1} of clay, 147 g kg^{-1} of silt and 250 g kg^{-1} of sand, based on the classification proposed by the United States Department of Agriculture (USDA). To chemically characterize the soil, samples were collected throughout the experimental area at depths from 0 to 30 cm, with the following results: pH (H_2O) of 4.5, 3.1 cmol$_c$ dm^{-3} of Ca^{2+}, 1.3 cmol$_c$ dm^{-3} of Mg^{2+}, 0.4 cmol$_c$.dm^{-3} of Al^{3+}, 4.9 cmol$_c$.dm^{-3} of $H+Al^{3+}$, 6.5 mg dm^{-3} of P, 0.1 cmol$_c$.dm^{-3} of K^+ and 30 g kg^{-1} of OM. In all plots, the planting furrows were fertilized with a formulation of 0.3 Mg ha^{-1} of 10-25-26 NPK, as recommended by the sugarcane producers in the region.

The experimental area, which was fallow for about two years, after 14 years of cultivation with soybean and corn under a no-tillage succession system, was subjected to the no-tillage and reduced-tillage systems. The reduced-tillage treatment consisted of heavy harrowing, whereas the no-tillage treatment consisted of mechanical weed control and subsequent soil furrowing, with tillage only in the planting furrow.

A completely randomized design with an 8 × 2 factorial arrangement (eight sugarcane cultivars and two soil tillage systems) and four replicates was used; each experimental unit consisted of 5 rows of sugarcane 5 meters in length spaced 1.50 m apart, with a total area of 37.5 m^2. Manual planting of eight sugarcane varieties (RB965902, RB985476, RB966928, RB855156, RB975201, RB975242, RB036066 and RB855536) was performed on July 21, 2016, at a density of 15 buds per meter.

To prepare the soil, the following were used: a straw grinder equipped with a steel curved blade rotor that operates at a high rotation speed, has a weight of 1.2 Mg and was mounted on a tractor; a two-row furrower; and an off-set disc harrow, with 16 discs of diameter 0.76 m (30") in each section, which operated up to 0.15 m with a weight of 2.0 Mg. For the tillage and furrowing operations, a 4 × 2 New Holland tractor, model 8030, with engine power of 89.79 kW (122 hp), 2200 rpm rotation speed, 3rd low gear, 14.9-58 front tires, 23.1-30 rear tires, and a weight of 4.51 Mg was used. For covering the furrows and crop management, a 4 × 2 TDA Massey Fergusson tractor, model MF292, with an engine power of 68.74 kW (92 horsepower), 2200 rpm rotation speed, 3rd low gear, 7.50-18 front tires, 18.4-34 rear tires, and weight of 3.40 Mg was used, together with a KO Cross 2000 sprayer, with 9.5-24 tires, 14 m spray boom and a weight of 1.4 Mg.

On September 16, 2016, and October 2, 2016, chemical control of weeds was performed with pre-emergence and post-emergence application, respectively. The tebuthiuron formulation used was Combine® 500 SC concentrated suspension (500 g a.i. L^{-1}), applied at a dose of 2.4 L ha^{-1}. The haloxyfop-methyl formulation was Verdict-R®, applied at a dose of 0.5 L ha^{-1}. Manual weeding was also performed during the sugarcane crop cycle in the experimental units.

On February 4, 2017, 180 days after planting (DAP), three soil samples with preserved structure were collected from each experimental unit using volumetric rings (0.0557 m in diameter and 0.0441 m in height) in the area between the tractor wheel tracks. In these samples, which were collected from the centers of the 0.00-0.10 and 0.10-0.20 m-deep layers, the soil moisture and density, total porosity, macroporosity, microporosity and penetration resistance were determined.

After the preparation of the samples in the laboratory, the soil moisture was determined using the gravimetric method to measure the wet soil mass. The soil density was calculated using the relationship between the soil weight after drying at 110°C for 24 hours and the volumetric ring volume with which the soil was collected (Donagema et al., 2011). The total porosity was determined from the difference between the saturated soil mass and the soil mass after drying at 110°C for 24 hours; the microporosity of the soil was determined via the suction table method with a water column 60 cm in height (Donagema et al., 2011). The difference between the total porosity and the microporosity was used to determine the macroporosity of the soil (Donagema et al., 2011). To achieve a pressure equilibrium corresponding to a water column of 6 kPa, the penetration resistance (PR) was determined using an electronic penetrometer MA-933 with a constant penetration rate of 10 mm min^{-1}, rod base diameter of 4 mm and conical tip with a 30° semi-angle, according to ASABE (ASABE, 2006). The samples from the top and bottom 5 mm of the sample were discarded to eliminate the sample border effect. Regarding the frequency of PR readings, a value was collected every 0.25 s, obtaining 800 readings per sample, and the mean value was used, following Bergamin et al. (2010).

The soil penetration resistance test was performed in each experimental unit using the PenetroLOG-PLG 1020 field penetrometer, with electronic capability for data acquisition (ASABE, 2006), to determine the mean PR and maximum PR stratified in the 0.00-0.10, 0.10-0.20, 0.20-0.30, 0.30-0.40 m-deep layers (Cortez et al., 2018a; Cortez et al., 2018b). Five sampling points were selected in each of the following the positions: sugarcane row, between the tractor wheel tracks and in the tractor wheel tracks.

The harvest was performed in August 2017 at 395 DAP. The measurements of stalk length and diameter were taken in 10 stalks in the three central rows of each experimental unit, discarding 1.0 m of the ends of each row as the border. The stalk length was measured using a tape measure, with a precision of 1.0 m, to measure the distance from the base of the stalk to the dewlap of leaf +1 (Abreu et al., 2013). The stalk diameter was measured with the aid of a caliper at the base of the stalks, 5 cm from the ground.

The number of tillers per meter (NT) was determined directly by counting the tillers of the five rows of the experimental unit (Abreu et al., 2013), considering 1 m of the ends of each row as the border.

Tons of cane per hectare (TCH) was determined at the time of harvest (395 DAP) by counting the number of tillers, collecting 10 industrialized stalks in the experimental unit and calculating the mass of the stalk bundle, which was then sent to the Chemical Laboratory of a sugarcane plant to determine the following variables: soluble solids content (Brix, %), total recoverable sugars (TRS), sucrose content (Pol, %) and plant fiber (Souza et al., 2012b). Tons of sucrose per hectare (TPH) was obtained using the equation proposed by Souza et al. (2012b), Silva et al. (2014) and Campos et al. (2014).

The data were evaluated for outliers and determined to be normally distributed using the Ryan-Joiner test. For the sugarcane production components and technological quality parameters, the treatments (cultivars and soil management) were compared using the Student-Newman-Keuls (SNK) test at 5% probability. For soil penetration resistance in the field, the treatments (soil management and sampling position) were compared using the SNK test at 5% probability. For the other soil physical attributes, the treatments (two soil managements) were compared using a t-test for independent samples at 5% probability.

RESULTS AND DISCUSSION

The Ryan-Joiner test indicated that the soil's physical attributes were normally distributed in the reduced-tillage and no-tillage treatments. There were changes in Ma in the 0.00-0.10 m-deep layer (Table 1), with higher values in the reduced-tillage system, resulting from the superficial soil inversion, than the no-tillage system. These values were considered low, less than 0.10 $m^3\ m^{-3}$, which, according to Rossetti & Centurion (2013), is the minimum level adequate for liquid and gas exchanges between the external environment and the soil and is considered critical for root growth in most crops.

TABLE 1. Mean of total porosity (Pt), macroporosity (Ma), microporosity (Mi), soil density (Ds) and soil penetration resistance in the ring (PR) per soil layer in the reduced-tillage and no-tillage treatments.

Treatment	Layer (m)	
	0.00-0.10	0.10-0.20
	* Pt ($m^3\ m^{-3}$)	
No-tillage	0.45 a	0.44 a
Reduced-tillage	0.46 a	0.45 a
	Ma ($m^3\ m^{-3}$)	
No-tillage *	0.04 b	0.04 a
Reduced-tillage **	0.06 a	0.04 a
	* Mi ($m^3\ m^{-3}$)	
No-tillage	0.41 a	0.41 a
Reduced-tillage	0.40 a	0.40 a
	* Ds (Mg m^3)	
No-tillage	1.48 a	1.49 a
Reduced-tillage	1.41 b	1.48 a
	PR (MPa)	
No-tillage *	4.00 a	3,90 a
Reduced-tillage **	3.27 a	4.34 a

The letters compare the treatments, and, when different, indicate that the values differ according to Student's t test at 5% probability.
*Significant by the Ryan-Joiner test at 5% probability; **Significant by the Ryan-Joiner test at 1% probability.

The Pt and Mi did not differ between the soil treatments studied for the 0.00-10 and 0.10-0.20 m-deep layers (Table 1). Silva Junior et al. (2013) state that the soil inversion under reduced-tillage system leads to increased Pt compared to a no-tillage system because in a clayey Red Latosol, the authors could not find any porosity changes between systems with soil inversion and direct furrowing. Regarding Mi, according to Bergamin et al. (2010), in a Dystroferric Red Latosol, the mineralogical composition of the clay fraction conditions the behavior of this attribute to the detriment of the soil management, contrary to macroporosity. Araújo et al. (2013), evaluating two systems of sugarcane harvesting in a Dystrophic Red Latosol under conventional tillage, observed similar macroporosity values in the evaluated layers of less than 0.10 m^3 m^{-3}; however, the microporosity values were greater than 0.40 m^3 m^{-3}, which, according to the authors, may indicate greater soil compaction in this area. It should be noted that the lack of a difference between the treatments for Pt and Mi in the evaluated layers and for Ma in the 0.10-0.20 m-deep layer can be explained by the action of the implement used, which, because it operates up to a depth of 0.15 m, created denser layers in the subsurface.

The PR in the volumetric ring (Table 1) did not differ between the treatments in the two layers, but the Ds value was higher under the no-tillage system than under the reduced-tillage system in the 0.00-10 m layer. The higher Ds in this soil layer under the no-tillage system is attributed to the machine traffic combined with the lack of soil tilling; however, in high-water content (field capacity) conditions, the effect of Ds equating the PR values was reduced.

The values of Ds in the 0.0-0.20 m layer in both treatments do not indicate compaction in the plant cane cycle because they are less than the range of 1.51 to 1.59 Mg m^{-3} (Table 1) considered maximum by Sá et al. (2016) and Oliveira et al. (2012) when evaluating the compaction in clayey to very clayey Latosols. In general, the PR values in the soil surface layers do not indicate compaction and do not compromise the crop's root development because per Oliveira Filho et al. (2015) and Marasca et al. (2015), values greater than 4 MPa limit the growth and root development of sugarcane. This attribute depends on the soil moisture and density at the time of analysis (Silva et al., 2017). Thus, despite the difference between the densities obtained under the different treatments, this parameter did not affect PR due to the high soil moisture content.

The Ryan-Joiner test indicated normal distributions for the mean and maximum determined in the field as well as for moisture as a function of the soil management system and sampling position (Table 2). For the surface layers (0.00-0.10 and 0.10-0.20 m), both the mean PR and maximum PR were highest in the reduced-tillage system in the tractor wheel tracks, which was also observed in between the wheel tracks and in the planting row in the 0.20-0.30 and 0.30-0.40 m-deep layers (Table 2). These results can be explained by the lower values of soil moisture under reduced-tillage compared to no tillage, obtained in the 0.10-0.20, 0.20-0.30 and 0.30-0.40 m-deep layers (Table 2). According to Iamaguti et al. (2015), the non-inversion of the soil and the presence of plant residues under the no-tillage system provide higher values of soil moisture compared to the conventional system.

However, in the subjacent layers (0.20-0.30 m and 0.30-0.40 m) and in the wheel tracks, the PR (mean and maximum) in the no-tillage system was equal to or higher than that obtained in the reduced-tillage system (Table 2). The soil tilling in the planting row in the no-tillage system may have increased the PR in the wheel tracks (Cortez et al., 2014), while higher PR values were observed in the surface layers (0.00-0.10 m and 0.10-0.20 m) of the reduced-tillage system due to the action of the disks of the soil tillage implement. This result, as reported by Moraes et al. (2018), is possible because the soil particles are rearranged, causing greater densification in the surface layers of the soil under reduced tillage.

In the 0.00-0.10 and 0.10-0.20 m-deep layers, higher values of mean and maximum PR were observed in the tractor wheel tracks, followed by in between the wheel tracks and in the planting row (Table 2). This finding is due to the traffic of machines in the crop interrow, which causes increased PR and Ds values relative to the positions where there was no pressure of the tractor wheels.

TABLE 2. Mean values of moisture and mean and maximum penetration resistance (PR) determined in the field per soil layer as a function of soil tillage system and sampling position.

		Mean PR (MPa)			Maximum PR (MPa)		
Soil treatment	Moisture*	In tracks*	Between tracks*	Planting row*	In tracks**	Between tracks*	Planting row*
				0.00-0.10 m			
Reduced-tillage	0.22 a	2.16 aA	1.18 aB	0.81 aC	4.19 aA	2.54 aB	1.87 aC
No-tillage	0.22 a	1.63 bA	1.29 aB	0.67 aC	3.32 bA	2.66 aB	1.69 aC
				0.10-0.20 m			
Reduced-tillage	0.21 b	3.36 aA	2.14 aB	1.57 aC	5.45 aA	3.31 aB	2.74 aC
No-tillage	0.22 a	3.00 bA	2.10 aB	1.29 aC	5.17 bA	2.90 bB	2.45 bC
				0.20-0.30 m			
Reduced-tillage	0.20 b	3.64 aA	2.40 aB	2.16 aB	5.28 bA	3.48 aB	3.15 aB
No-tillage	0.24 a	3.83 aA	2.07 bB	1.75 bC	5.59 aA	2.90 bB	2.73 bB
				0.30-0.40 m			
Reduced-tillage	0.20 b	3.45 bA	2.66 aB	2.42 aC	4.76 bA	3.59 aB	3.23 aC
No-tillage	0.24 a	3.88 aA	1.99 bB	2.06 bB	5.22 aA	2.68 bB	2.78 bB

Means followed by the same letters, where uppercase letters compare soil treatment and sampling location and lowercase letters compare sampling location and soil treatment, do not differ according to the SNK test at 5% probability. *Significant by the Ryan-Joiner test at 5% probability; **Significant by the Ryan-Joiner test at 1% probability.

A similar situation was observed by Cury et al. (2014) and Souza et al. (2014) when evaluating the compaction in the sugarcane row and interrow; those authors observed higher PR in the interrow and lower PR in the planting row in the 0.00-0.40 and 0.00-0.30 m-deep layers, respectively. This result was attributed to the furrowing, which creates an environment with less resistance to penetration, regardless of the soil tillage system.

In general, the evaluation of the maximum PR in the wheel tracks in all the evaluated layers, as shown in Sá et al. (2016), allows identifying limiting values for sugarcane root development in clayey soils; the values are greater than 3.8 MPa, which, for a clayey soil (600 g kg^{-1}), may result in a reduction of the sugarcane root mass.

Cury et al. (2014) observed that Ds had a higher negative correlation (48%) than PR (38%) with sugarcane root mass, with a limiting Ds value of 1.33 Mg m^{-3}, indicating the effect of other factors on root growth, such as the root system morphology, whose root mass tends to decrease with depth and distance from the plant. This fact raises concerns given that the authors observed that 90% of the root mass is located in and between the wheel tracks and in the surface soil layers.

The Ryan-Joiner test indicated a normal distribution of the sugarcane production components (Table 3 and Table 4) and technological quality parameters (Table 5). The experimental coefficient of variation values (CV, %) are considered low for the variables stalk length and diameter (Table 3) and average for NT (Table 3), TCH and TPH (Table 4). The CV values were also low for Pol, plant fiber, TRS and Brix (Table 5), demonstrating good precision of the experiment (Souza et al., 2012b; Fernandes Júnior et al., 2013).

The plants present different responses as a function of soil tillage system and cultivar. Under reduced-tillage, cultivar RB855156 differed from the other cultivars, exhibiting the lowest value of stalk length (Table 3), whereas cultivar RB985476 differed from the other cultivars, exhibiting the highest value of stalk diameter. With respect to NT, the RB965902 cultivar had the highest value but did not differ from the RB966928 and RB855156 cultivars (Table 3). When analyzing the variables in the soil under the no-tillage system, it was observed that the cultivars did not differ statistically from each other for the variable stalk diameter (Table 3). The cultivar RB855156 exhibited the highest NT but was significantly different from only cultivars RB975201 and RB036066.

TABLE 3. Mean values of stalk length, stalk diameter and number of tillers per meter (NT) for sugarcane cultivars in Dystroferric Red Latosol under reduced-tillage (RT) and no-tillage (NTi) systems.

Cultivars	Variables					
	Length (m)		Diameter (mm)		NT (tiller m^{-1})	
	NTi *	RT *	NTi *	RT *	NTi *	RT *
RB965902	2.88 aa	2.92 aa	32.57 aa	29.30 bb	17 ABa	18.0 Aa
RB985476	3.10 aa	3.16 aa	32.10 Ab	35.64 aa	17 ABa	14.0 Bb
RB966928	3.20 aa	3.10 aa	32.36 aa	32.15 aa	17 ABa	16.0 ABa
RB855156	2.89 aa	2.64 bb	33.10 aa	32.66 aa	20 Aa	15.0 ABb
RB975201	3.00 aa	2.98 aa	33.51 aa	32.81 aa	13 Ba	13 Ba
RB975242	2.98 aa	2.92 aa	33.34 aa	31.57 aa	16 ABa	12 Bb
RB036066	2.85 aa	3.00 aa	32.00 aa	32.34 aa	12 Ba	14 Ba
RB855536	2.99 aa	2.94 aa	31.00 aa	30.90 aa	16 ABa	14 Ba
CV (%)	3.58	4.32	5.30	4.94	17.58	11.63

Means followed by the same letters, uppercase for the columns and lowercase for the rows, do not differ from each other according to the SNK test at 5% probability. CV: Coefficient of variation. *Significant by the Ryan-Joiner test at 5% probability.

At the end of the first cycle, Campos et al. (2014) did not find differences in tillering among 16 sugarcane cultivars. A similar result was also found by Morais et al. (2017) who, in a study performed in Rio Grande do Sul to evaluate the performance of 12 clones, including RB855156, observed very similar responses among clones with respect to the number of stalks because there was a large cluster of clones with no significant differences among themselves, mainly in plant cane.

In the soil under reduced-tillage, no significant differences were observed among the eight cultivars evaluated for TPH; these values varied between 16.60 and 25.60 Mg ha^{-1} (Table 4). In addition, the eight cultivars did not differ statistically from each other in the TCH, with the yields varying between 120.5 and 170.4 Mg ha^{-1}. TCH varied more under the no-tillage system than it did under the reduced-tillage system, with values between 130.35 and 196.52 Mg ha^{-1} (Table 4). These results were similar to those obtained by Campos et al. (2014), who observed a change in TCH between 108.6 and 170.26 Mg ha^{-1}; however, the study was performed under additional irrigation conditions for 16 varieties, which suggests that the soil and climatic conditions were satisfactory for the cultivars evaluated in this study.

TABLE 4. Mean values for tons of cane per hectare (TCH, Mg ha^{-1}), sucrose content (POL, %) and tons of sucrose per hectare (TPH, Mg ha^{-1}) for sugarcane cultivars in Dystroferric Red Latosol under reduced-tillage (RT) and no-tillage (NTi) systems.

Cultivars	Variables					
	TCH		POL		TPH	
	NTi *	RT *	NTi *	RT *	NTi *	RT *
RB965902	176.5 Aa	166.7 Aa	15.0 ABa	15.0 ABa	26.4 ABa	24.9 Aa
RB985476	179.1 Aa	170.4 Aa	15.2 ABa	15.1 ABa	27.2 ABa	25.6 Aa
RB966928	175.0 Aa	158.5 Ab	15.63 Aa	15.2 ABa	27.3 ABa	24.1 Ab
RB855156	196.5 Aa	149.3 Ab	15.57 Aa	15.7 Aa	30.7 Aa	23.4 Ab
RB975201	145.5 Aa	134.7 Aa	13.72 Ca	14.2 ABa	20.0 BCa	19.1 Aa
RB975242	172.8 Aa	127.2 Ab	14.3 ABa	14.5 ABa	24.8 ABa	18.5 Ab
RB036066	130.4 Aa	146.9 Aa	12.12 Da	12.1 Ca	15.7 Ca	17.9 Aa
RB855536	142.7 Aa	120.5 Ab	14.15 BCa	13.5 Ba	20.2 BCa	16.4 Ab
CV (%)	18.54	17.46	4.64	5.63	18.92	18.66

Means followed by the same letters, uppercase for the columns and lowercase for the rows, do not differ from one another according to the SNK test at 5% probability. CV: Coefficient of variation. *Significant by the Ryan-Joiner test at 5% probability.

Cultivar RB036066 exhibited lower values for the variable Pol (Table 4) than the other cultivars under both the reduced-tillage and no-tillage systems. In both soil tillage systems, cultivars RB965902, RB985476, RB966928, RB855156, RB975201 and RB975242 did not differ in terms of Pol (Table 4).

However, in the soil under the no-tillage system, higher TPH was observed for RB855156 than for RB975201, RB036066 and RB855536 (Table 4), which can be explained by the late maturation of these cultivars; however, such genetic variability was not expressed in the soil under the reduced-tillage system. Such evidence was also observed by Silva et al. (2014) when evaluating the productive potential of different sugarcane varieties fully irrigated by drip irrigation during two crop cycles; in addition to identifying differences in TPH responses due to the genetic differences of materials, those authors found cultivar RB855536 to be less productive than cultivars SP85-1115, IACSP96-3060, RB867515 and IAC91-1099 in the first crop cycle.

Cultivar RB036066 exhibited lower values for the variables TRS and Brix (Table 5) than the other cultivars under both the reduced-tillage and no-tillage systems. Under reduced-tillage, cultivars RB965902, RB985476, RB966928, RB855156, RB975201 and RB975242 did not differ in terms TRS and Brix (Table 5), whereas under the no-tillage system, that was true for cultivars RB965902, RB985476, RB966928 and RB855156. In this system, RB975201 and RB975242 exhibited lower Brix values, while for RB855536, the values were only greater than those exhibited by RB036066. Veríssimo et al. (2012), when evaluating fifteen early varieties in the 2009/2010 and 2010/2011 harvests, found for RB966928 high Brix richness and yield, moderate stability and wide adaptability, whereas the standard cultivar RB855156 exhibited specific adaptation and moderate stability. The authors noted that adaptability refers to the ability of genotypes to respond positively to environmental stimuli, while stability is associated with the ability of genotypes to respond predictably to environmental stimuli.

Notably, the excellent sprouting of cultivar RB966928 in plant cane in environments with medium to high soil fertility favors high production stability in different production environments whose yield values can be up to 11% higher relative to the standard variety, RB855156, in an average of four cycles (Daros et al., 2010).

TABLE 5. Mean values of total recoverable sugars (TRS, kg Mg^{-1}), soluble solids content (Brix, %) and fiber (%) for sugarcane cultivars in Dystroferric Red Latosol under reduced-tillage (RT) and no-tillage (NTi) systems.

Cultivars	Variables					
	TRS		Brix		Fiber	
	NTi *	RT **	NTi **	RT *	NTi *	RT *
RB965902	148.3 ABa	148.4 Aa	17.1 Aa	16.6 Aa	11.8 ABa	12.1 Aa
RB985476	150.9 ABa	149.4 Aa	17.0 Aa	16.6 Aa	11.6 ABa	12.4 Aa
RB966928	154.2 Aa	151.1 Aa	16.9 Aa	16.8 Aa	12.0 ABa	11.6 Aa
RB855156	153.9 Aa	155.0 Aa	17.0 Aa	17.0 Aa	11.3 Ba	11.6 Aa
RB975201	135.5 Ca	140.8 ABa	15.6 Ca	15.8 ABa	11.4 Ba	11.4 Aa
RB975242	142.5 ABa	144.2 ABa	16.0 Ca	16.2 Aa	11.6 ABa	12.4 Aa
RB036066	121.3 Da	121.0 Ca	13.6 Da	13.7 Ca	11.9 ABa	12.0 Aa
RB855536	140.6 BCa	134.1 Ba	15.8 Ca	15.0 Ba	12.3 Aa	11.9 Aa
CV (%)	4.34	5.06	3.49	3.75	2.93	5.10

Means followed by the same letters, uppercase for the columns and lowercase for the rows, do not differ from each other by the SNK test at 5% probability. CV: coefficient of variation. *Significant by the Ryan-Joiner test at 5% probability; **Significant by the Ryan-Joiner test at 1% probability.

Among all cultivars, only RB036066 exhibited a Pol lower than 13% (Table 4), which is a value that makes industrial processing viable; however, when evaluating Brix (Table 5), for all cultivars, values less than 18% during harvest were considered adequate (Silva et al., 2015). Regarding the TRS, values between 121.00 and 155.00 kg Mg^{-1} were observed under reduced tillage, and values between 121.26 and 154.21 kg Mg^{-1} were observed under tillage. Silva et al. (2014) report that among the technological parameters of sugarcane quality, TRS is key for the industry and for the producers since the industrial plants determine the price paid to the producers based on this variable. In this sense, the technological quality of the stalks resulting from the better expression of the TRS attribute is partly due to the better performance of the early and intermediate varieties (RB965902, RB985476, RB966928 and RB975201), in addition to RB975242, in both soil systems. However, the opposite can be observed for RB036066, which exhibited the lowest TRS.

Under no-tillage, the cultivars differed in regard to plant fiber (Table 5), with the highest value exhibited by RB855536, whereas the lowest values were exhibited by RB855156 and RB975201. The plant fiber ranged from 11.44 to 12.39% and 11.31 to 12.27%, under the reduced-tillage and no-tillage systems, respectively. Similar values were observed by Campos et al. (2014). The plant fiber values found in this study were less than those found by Silva et al. (2014) in a study performed with different cultivars, including RB855536, whose mean values ranged from 13.6 to 12.8% in the first and second evaluation cycles, and they were also less than those found by Simões et al. (2015), who reported increasing values of 13.8, 14.9 and 16.6% from plant cane to first and second ratoons, respectively.

Silva Junior et al. (2013) studied the agronomic performance of the cultivar SP81-3250 in clayey Dystrophic Red Latosol under different conventional tillage and minimum-tillage systems in the Rio Brilhante region of Mato Grosso do Sul state. In contrast to the values obtained in this study, the authors found lower values of TCH (145.05 Mg ha^{-1}) and TPH (17.41 Mg ha^{-1}) under a no-tillage system than under the other conventional tillage and reduced-tillage systems, especially in the plant cane cycle. These results were attributed to higher bulk density (1.55 Mg m) in the 0.20-0.40 m-deep layer and penetration resistance in the layer up to 0.40 m, also responsible for reducing the Brix relative to other systems. Thus, this study helps explain the better results obtained for growth, TCH and TPH under no-tillage compared with reduced-tillage because in the reduced-tillage, higher values of mean PR and maximum PR were observed between the wheel tracks and in the subsurface layers of the planting row (0.20-0.30 and 0.30-0.40 m). This result should be highlighted because more than 90% of sugarcane roots develop in the layers between 0.00-0.20 and 0.20-0.40 m, according to Cury et al. (2014), and according to Sá et al. (2016), PR values greater than 3.8 MPa can lead to root mass reduction. Moreover, the cultivars most suitable for planting are RB965902, RB966928, RB 855156 and RB985476, whereas RB036066 is not recommended.

CONCLUSIONS

The cultivars RB965902, RB966928, RB855156 and RB985476 exhibited yield and technological attributes superior to those of the other cultivars, whereas for RB036066, these attributes were inferior in both soil tillage systems.

The cultivars RB966928, RB855156, RB975242 and RB855536 exhibited more TCH and more TPH in the no-tillage system, while all cultivars displayed similar or higher performances than those observed in the reduced-tillage system.

In the soil under the no-tillage system, in which there were lower values of soil penetration resistance between the wheel tracks and in the subsurface layer of the planting row (0.20-0.40 m), cultivars RB985476 and RB97524 had more tillers, and RB855156 had a higher stalk length and more tillers.

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