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SUGARCANE PRODUCTIVITY AND GASEOUS EXCHANGES ARE NOT AFFECTED BY POTASSIUM FERTILIZATION IN HIGH K CONTENT SOIL

Igor Tenório Marinho da Rocha[1], Anibia Vicente da Silva[2], Djalma Euzébio Simões Neto[1], Alexandre Campelo de Oliveira[1], Edivan Rodrigues de Souza[1], Emídio Cantídio Almeida de Oliveira[1], Maria Betânia Galvão dos Santos Freire[1], Fernando José Freire[1]

[1]Universidade Federal Rural de Pernambuco (UFRPE), Pernambuco State, Brazil. E-mail: tenorio_igor@hotmail.com, djalmasimoesneto@gmail.com, alexandre_solos@hotmail.com, edivan.rodrigues@ufrpe.br, emidio.oliveira@ufrpe.br, maria.freire@ufrpe.br, fernando.freire@ufrpe.br
[2]Instituto Federal de Pernambuco (IFPE), Pernambuco State, Brazil. E-mail: anibia.vicente@vitoria.ifpe.edu.br

ABSTRACT

This study aimed to evaluate the effect of K_2O doses, as KCl, on physiological aspects and agricultural productivity of sugarcane in rainfed cultivation. The experimental design was in randomized blocks in a factorial arrangement (6x2) with 4 replications, with six K_2O rates (0, 25, 50, 100, 200 and 250 kg ha^{-1}) and two sugarcane varieties (RB92579 and RB962962). K_2O rates did not positively affected physiological characteristics and productivity of the sugarcane varieties. The productivity of the RB962962 variety was higher than that of the RB92579. The variety RB962962 had lower transpiration and stomatal conductance than the variety RB92579. Potassium fertilizers application is not recommended in soils with high soil exchangeable content, above 0.24 cmol$_c$ dm^{-3}, as it does not result in increased productivity or improved gas exchange characteristics in sugarcane.

Keywords: Nutritional status, *Saccharum* spp., gas exchange, water deficit

INTRODUCTION

Agribusiness accounts for approximately 27% of the Brazilian gross domestic product (CEPEA, 2021). Among the prominent agribusiness crops, sugarcane is one of the most important. In the 2019/2020 biennium, Brazil produced approximately 640,000 tons of sugarcane (CONAB, 2020) destined for the production of sugar and alcohol.

Despite this prominent role, sugarcane planting is mostly carried out with low application of agricultural technologies, such as soil acidity amelioration or fertilizer application. Especially in relation to fertility, the fertilization recommendations of the main manuals are outdated. This fact compromises the expression of the maximum productive potential of the sugarcane fields.

K (potassium) is one of the most abundant nutrients in the soil. Its concentration, in general, varies between 0.3 to 30 g kg^{-1} (approximately 0.76 to 76,000 $cmol_c$ kg^{-1}) (ERNANI et al., 2007). Soils cultivated with sugarcane in Brazil have contrasting fertility characteristics, with values ranging from 0.04 to 0.34 $cmol_c$ dm^{-3}. These values have been observed in the north/northeast soils (UCHÔA et al., 2009; SIMÕES NETO et al., 2015). Although, the critical level of K for sugarcane is 0.15 $cmol_c$ dm^{-3} for the state of Pernambuco (IPA, 2008).

In general, most Brazilian soils have low natural fertility. However, some soils have high natural contents, especially soils located in regions with low rainfall or with a long history of fertilization (LOPES & GUILHERME, 2007; LIMA JÚNIOR & LIMA, 2008). For soils with nutrients contents above the critical level, fertilization probability response is lower than the probability response that soils with low natural levels present.

The application of potassium doses in soils with low natural content has been reported to be beneficial to sugarcane productivity (OTTO et al., 2010; CAVALCANTE et al., 2016). However, studies on the efficiency of potassium fertilization in soils with high natural content are scarce.

According to Malavolta (1980), to validate the fertilization recommendation, experiments with nutrient doses must be conducted in soils with low, medium and high content of the element. In this way, different response curves to fertilization will be obtained, which makes it possible to know the necessary doses to obtain the maximum agronomic and economic production of crops in soils with different levels of the nutrient.

K is an essential element for plants. Among its functions, K is responsible for promoting cell expansion and stomatal opening and closing, in addition to being an enzyme activator and responsible for cellular osmotic control (TAIZ & ZEIGER, 2004).

When K content in the cell is adequate, plants present homeostasis of physiological characteristics, such as: net photosynthesis (A), stomatal conductance (gs) and transpiration (E); and biochemical, such as: osmotic control and carbohydrate and protein metabolism (WANG et al., 2012; CAVALCANTE et al., 2015). This promotes greater tolerance to stress situations, such as water deficit (WANG et al., 2013).

Thus, the objective of this work was to evaluate the physiological characteristics and productivity of two sugarcane varieties in the first cropping cycle fertilized with K in a soil with high exchangeable potassium content.

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MATERIALS AND METHODS

The experiment was installed in the municipality of Carpina, Pernambuco, Brazil, with geographic coordinates 7º51'04" South Latitude and 35º14'27" West Longitude. The municipality is 178 m above sea level and has a rainy tropical "AS" climate with dry summer, according to the Köppen-Geigerem classification.

In the experiment field, five soil samples were collected up to 0.20 m deep to compose a composite sample and chemical analyzes were performed to evaluate fertility [pHwater (5.07), P (15.04 mg dm^{-3}), Na^{+} (0.07 $cmol_c$ dm^{-3}), K^{+} (0.24 $cmol_c$ dm^{-3}), $Ca^{2+}+Mg^{2+}$ (3.5 $cmol_c$ dm^{-3}), Al^{3+} (0.2 $cmol_c$ dm^{-3}), H+Al (3.1 $cmol_c$ dm^{-3})] (DONAGEMA et al., 2011). With the results of this analysis, the potential (potential CEC: 6.91 $cmol_c$ dm^{-3}) and effective (effective CEC: 4.01 $cmol_c$ dm^{-3}) cation exchange capacities, base saturation (V: 55.13%) and aluminum saturation (m: 4.98%) were calculated.

The experiment was implemented in June 2014 and harvested in November 2015 (17 months - year and a half sugarcane). The rainfall during the experimental was 1,152 mm (Figure 1).

Physically, the soil was characterized by granulometry (Loam-clay-sandy), particle density (2.70 Mg m^{-3}), soil density (1.65 Mg m^{-3}) and total porosity (39%) (DONAGEMA et al., 2011).

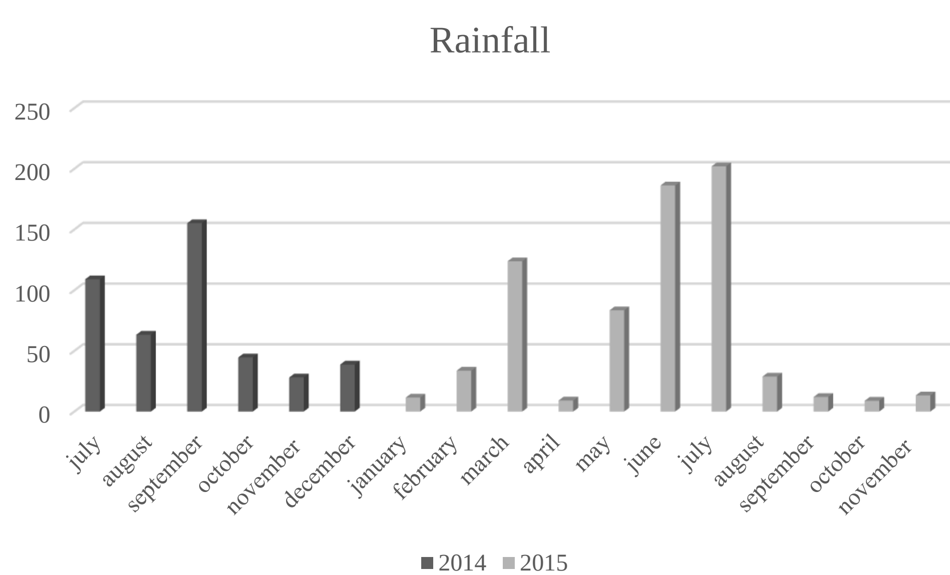

Figure 1. Rainfall during the experiment in the municipality of Carpina Carpina, Pernambuco State, Brazil.

The experiment was implemented in randomized blocks in a factorial arrangement, using two sugarcane varieties (RB92579 and RB962962) and applying six doses of K_2O (0; 25; 50; 100; 200; and 250 kg ha^{-1}) as KCl, that corresponded to approximately the following K doses (0; 21; 41.5; 83; 166; and 207.5 kg ha^{-1}) with four replications, totaling 48 experimental plots.
The varieties were chosen because of their tolerance to water stress. The RB962962 variety is considered tolerant, while the RB92579 variety is poorly tolerant, but with rapid recovery after stress (RIDESA, 2010).

The experimental plots comprised seven planting lines 10.0 m long, with 1.0 m spacing between rows, corresponding to a total area of 70 m^2. For the useful area, 1.0 m of each side of the plot was eliminated, totaling a useful area of 36.0 m^2.

Soil preparation was carried out with chemical weeds control, subsoiling, harrowing and, later, soil plowing. The planting was carried out on June 30, 2014, being harvested in November 2015 (year and a half sugarcane). The sugarcane was planted by distributing the stalks in the furrow so that the end of one stalk coincided with the base of the other. Approximately 18 Mg ha^{-1} of stems were distributed, with subsequent sectioning in order to obtain, on average, 24 buds per meter.

The experimental field soil was amended using 1.2 Mg ha^{-1} of dolomitic limestone, with a PRNT of 85%. The liming requirement was calculated using the base saturation method, raising the saturation up to 70% (IPA, 2008). Lime was hand applied in a total area without incorporation. Foundation fertilization was carried out in the planting furrow with 40 kg ha^{-1} of N in the form of urea (IPA, 2008) and 90 kg ha^{-1} of P_2O_5 with triple superphosphate (SIMÕES NETO et al., 2015). K was applied according to the experiment treatments, using potassium chloride, KCl, as a source. There was no application of micronutrients or chemical pesticides at planting.

At seven months after planting (water deficit period for sugarcane, which corresponded to the month of January/2015), net photosynthesis (CO_2 assimilation rate) (A), stomatal conductance (gs) and transpiration (E) were evaluated in an infrared gas analyzer (IRGA) (LI-6400xt LI-COR bioscience®). The evaluations were carried out in the morning between 08:00 and 11:00.
Agricultural productivity was evaluated by harvesting all plants from each useful plot. Harvest took place in November 2015 (17 months after planting). After harvesting, the plants were weighed in a dynamometer and their values estimated per hectare (10,000 m^2).

The experiment data were submitted to analysis of variance (ANAVA) and when the main effects and/or interactions were significant, regression analysis was performed ($p<0.05$). The

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coefficients of the regression parameters were tested using the t test ($p<0.05$). The SISVAR software version 5.8 (FERREIRA, 2011) was used.

RESULTS AND DISCUSSION

Regarding sugarcane production, when soil K content is below the critical level, there is a positive response by potassium fertilization application (CAVALCANTE et al., 2016). However, in this experiment there was no response of productivity to fertilization (Table 1) probably due to the K content higher than the critical level established in the Fertilization Manual for the State of Pernambuco, 0.15 $cmol_c\ dm^{-3}$, (IPA, 2008), while in this experiment, the soil had a K content of 0.24 $cmol_c\ dm^{-3}$.

Furthermore, the varieties did not show significant differences ($p>0.05$) for productivity (Table 1). This same behavior among varieties was also observed by Silva et al. (2018) in a study with four sugarcane varieties. This shows that, under similar conditions, the agronomic potential of current sugarcane varieties is similar.

There was a difference ($p<0.05$) in gs and E as a function of the varieties, and for A there was a significant effect ($p<0.05$) for the K_2O dose x varieties interaction. However, A's data did not fit the regression models ($p>0.05$) (Table 1).

The variety RB92579 showed higher gs and T than the variety RB962962 (Table 1). The RB962962 variety is considered drought tolerant, while the RB92579 has a good recovery capacity after short periods of stress (RIDESA, 2010) and, although there were no significant differences ($p>0.05$) between the varieties for productivity, the RB962962 variety showed higher productivity than RB92579 (Table 1). Differences between physiological parameters in sugarcane varieties are reported in the literature and indicate different genotypic potentials, such as the ability to tolerate abiotic stresses (SIMÕES et al., 2019).

The variety RB962962 showed better efficiency in maintaining water status through better regulation of stomatal conductance and transpiration, lower values than RB92579 (Table 1) and, thus, was able to produce more under rainfed conditions than the variety RB92579 (Table 1). According to Inman-Bamber and Smith (2005), one of the ways that sugarcane can reduce water loss and tolerate water stress/deficit is to reduce its stomatal conductance.

Table 1. Net photosynthesis (A), stomatal conductance (gs) and transpiration (E) as a function of the application of increasing amounts of potassium in two sugarcane varieties at seven months after planting, analysis of variance, regression, mean and coefficient of variation.

Potassium (K_2O)	Physiological characteristics							
	(*A*)		(g_s)		(E)		Productivity	
	579(1)	2962(2)	579	2962	579	2962	579	2962
kg ha^{-1}	µmol CO_2 m^{-2} s^{-1}		mol H_2O m^{-2} s^{-1}		mmol H_2O m^{-2} s^{-1}		Mg ha^{-1}	
0	14,15	16,18	0,08	0,08	80,28	41,04	76,24	80
25	20,32	13,70	0,12	0,07	74,91	51,10	80,41	81,66
50	12,85	17,87	0,08	0,09	72,90	43,72	77,08	78,33
100	15,90	11,20	0,08	0,05	54,85	55,19	80,41	92,91
200	16,94	12,55	0,09	0,07	60,21	66,19	79,58	88,75
250	14,90	16,68	0,08	0,09	72,80	55,18	88,33	84,58
Mean	15,84	14,70	0,09a	0,07b	69,32a	52,07b	80,34	84,37
F of the variance analysis								
Dose of K	0,83^{ns}		1,13^{ns}		1,17^{ns}		1,37^{ns}	
Variety	1,25^{ns}		6,85*		6,16*		2,09^{ns}	
Dose x Var(3)	3,50*		2,47^{ns}		2,10^{ns}		0,75^{ns}	
F regression								
Linear	0,015ns	0,13ns	--	--	--	--		
Quadratic	0,087ns	4,06ns	--	--	--	--		
C.V. (%)(4)	23,20		24,74		18,67		11,70	

(1) Variety RB 92579; (2) variety RB 962962; (3) Variety; (4) coefficient of variation = (standard deviation/mean) x 100. Equal letters on the line do not differ by the scott-knott test at the level 5% probability. *significant to 5% probability. ^{ns} not significant.

CONCLUSION

Due to the high exchangeable K content, potassium fertilization did not increase productivity or improved physiological aspects of sugarcane varieties. Therefore, it is not recommended to apply potassium fertilizer in soils with high levels of exchangeable K (above 0.24 $cmol_c$ dm^{-3}). Significant differences were observed between the varieties RB92579 and RB962962 for transpiration and stomatal conductance. In this context, the variety RB962962 was more agronomically efficient than the variety RB92579, as it presented better regulation of gas exchange (lower values of transpiration and stomatal conductance), and higher productivity. This confirms its greater tolerance to water deficit than RB92579. In soils with texture and K content similar of the present experiment, potassium fertilization is not recommended.

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