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Nutritional diagnosis of sugarcane varieties in a Yellow Oxisol during three agricultural seasons

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Leaf analysis is one of the main methods used for the evaluation of nutritional requirements in sugarcane culture, contributing to a better management of fertilizers. This study aimed to evaluate the nutritional status of sugarcane varieties by quantifying the leaf content of macro and micronutrients of the +3 leaf. The varieties RB92579, RB867515, VAT90-212 and SP813250 were evaluated in a Yellow Oxisol at Fazenda Jequiá, Anadia, Alagoas (AL) state, during plant-cane, first and second regrowth cycles. The design was randomized blocks consisting of four varieties and five replications. Varietal differences were observed in leaf contents of macro and micronutrients. However, no variety had a higher leaf content regarding any element.

Key words: Macronutrients, micronutrients, nutritional status, production system, *Saccharum* spp.

INTRODUCTION

Sugarcane has a socio-economic importance for Brazil generating employment, income and exchange values (Zuanazzi and Mayorga, 2010; Marin and Nassif, 2013). Its average productivity is 76.9 t ha^{-1}, which corresponds to less than 25% of the biological potential of the crop. The low productivity is caused, among other factors, by inadequate fertilization in relation to culture requirements (Conab, 2016).

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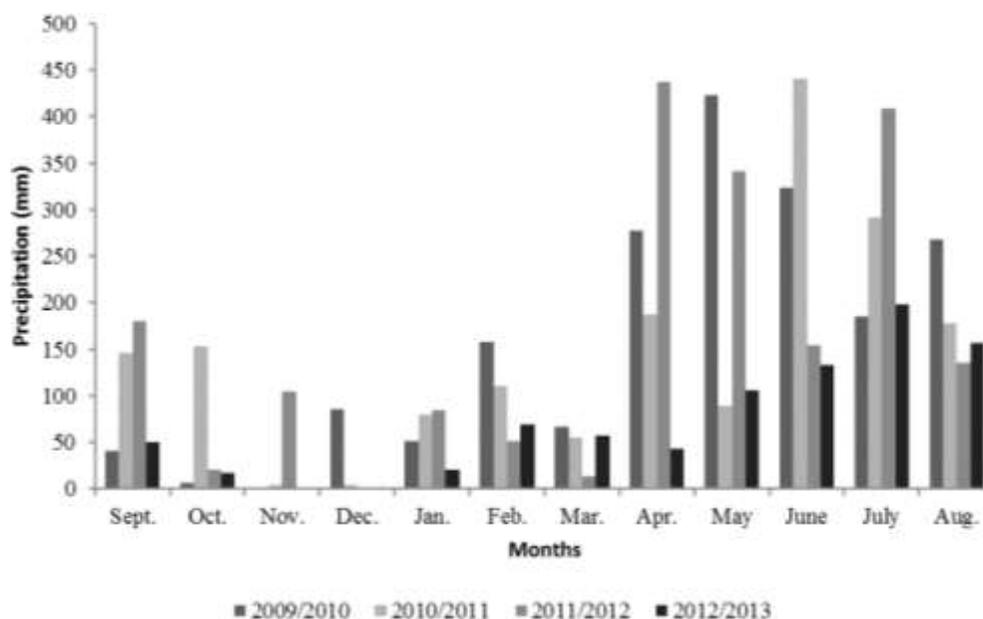
Figure 1. Monthly precipitation during the period studied.

Due to its high biomass production, sugar cane extracts and accumulates high amounts of soil nutrients (Calheiros et al., 2012; Mishra et al., 2014; Meena et al., 2015). Oliveira et al. (2010) evaluating the extraction and export of macronutrients by 11 sugarcane varieties in Ultisol, obtained averages of 0.91, 0.13, 1.71, 1.18 and 0.44 kg t^{-1} culm N, P, K, Ca and Mg, respectively. Thus, the accumulation of nutrients by sugarcane shows the need for an adequate fertilization for the crop to achieve high yields. Furthermore, fertilization represents a significant percentage of the production costs of sugarcane crops. Thus, it must follow strict optimization criteria to obtain a higher productivity and a lower cost (Otto et al., 2010).

The optimization can be achieved by a proper application of nutrients regarding the quantity, timing and form of application. The diagnosis of plant nutritional status is a tool for planning, evaluating and calibrating the fertilization recommendations of a crop. Its use is essential to sugarcane production as the nutritional status of sugarcane influences photosynthetic rates and the metabolism of sucrose, directly affecting the productivity, longevity and profitability of crops (Malavolta et al., 1997; Raij, 2011).

The diagnosis can be performed by evaluating the results of chemical foliar analysis. It allows identifying and correcting deficiencies and nutritional imbalances in plants, and it monitors and evaluates the efficiency of a particular crop fertilization and soil fertility program (Deus et al., 2012). In this sense, the proper use of the results obtained from leaf analyses contribute to a rational use of

inputs, promoting the nutritional balance of plants, providing greater crop yield and increasing safety in the use of fertilizers (Souza et al., 2011; Santos et al., 2013).

The literature reports appropriate ranges for nutrients levels using a well-nourished +3 leaf of sugarcane. These values were between 16 and 21, 1.5 and 3.5, 6 and 16, 2 and 10, 1.0 and 3.6 and 1.3 to 3.0 g kg^{-1} for N, P, K, Ca, Mg and S, respectively. Regarding micronutrients, the leaf content ranges considered adequate for Cu, Fe, Mn and Zn are between 6 and 50, 8 and 17, 40 and 500, 25 and 250, and 10 and 50 mg kg^{-1}, respectively (Orlando Filho, 1983; Malavolta et al., 1997; Raij, 2011). These results were obtained under different soil and climatic conditions in Alagoas with varieties that are practically no longer cultivated in that state. This may hinder the use of leaf analysis as a tool for identifying and correcting deficiencies and nutritional imbalances.

In face of such considerations, this study was conducted to evaluate by leaf analysis the nutritional status of four varieties of sugarcane, representing more than 50% of the sugarcane crop area in Alagoas, during plant-cane, first and second regrowth cycles.

MATERIALS AND METHODS

The research was conducted in the municipality of Anadia, state of Alagoas (09°41'04" S and 36°18'15" W). The experimental area belongs to the Triunfo Plant located in the municipality of Boca da Mata, AL. The climate of the experiment area is rainy tropical with dry summers, according to the Köppen classification. The average annual rainfall is 1500 mm (Figure 1) and the average annual

Table 1. Results of chemical analyses of soil samples at the layers 0-20 cm and 20-40 cm.

Layers	pH	P	K	Ca	Mg	Al	H+Al	SB	T
cm	-	mg dm^{-3}				cmolc dm^{-3}			
00-20	5.9	103.0	40	1.8	0.8	0.0	3.80	2.70	6.5
20-40	5.0	21.6	20	0.6	0.3	0.6	4.62	0.95	5.57

Prof	T	V	m	MO	Zn	Fe	Mn	Cu	B
cm	cmolc dm^{-3}	%		Dag kg^{-1}	mg dm^{-3}				
00-20	2.70	42	0	1.8	2.5	75.6	9.7	1.1	0.4
20-40	1.55	17	39	0.8	0.4	53.4	0.3	0.2	0.3

pH in H_2O (Ratio 1:2.5). P K, Fe, Zn, Mn, and Cu: Mehlich extractor. Ca, Mg and Al: KCl extractor. H+Al: Calcium acetate extractor. B: Hot water extractor, S: Monocalcium phosphate in acetic acid extractor.

temperature is 29ºC. The relief varies from flat to gently rolling.

The soil of the experimental area was classified as a dystrophic Yellow Oxisol (Embrapa, 2013) with a medium texture. Before installing the experiment, soil chemical analyses were performed. The chemical characterization was carried out on samples collected at layers 0.0-0.2 m and 0.2-0.4 m (Table 1). The correction of soil acidity was performed using dolomitic limestone at 150 kg ha^{-1} calculated by increasing base saturation to 60%, according to Oliveira et al. (2007). After the application of limestone, the soil was plowed and meshed. Then, grooves were opened. The planting density was 15-18 buds per furrow meter.

The experimental design was randomized blocks with five replications consisting of four varieties of sugarcane: SP813250, RB867515, RB92579 and VAT90212. They were grown in plots with six grooves and 10-m length, spaced 1 m, totaling 60 m^2 of total area. The four central lines, six meters long, totaling 24 m^2, were considered as the useful area of each plot. The varieties were chosen because the sum of their cultivated areas was greater than 50% of the area planted with sugarcane in the state of Alagoas during the 2010/2011 season, one year before implementing the experiment.

The soil fertilization was based on the recommendation by the Triunfo Plant according to the results of soil analysis (Table 1), 60, 100 and 150 kg ha^{-1} of N, P_2O_5 and K_2O were applied. The sources were ammonium sulfate, simple superphosphate and potassium chloride, respectively. They were applied at the bottom of the grooves. The plant-cane cycle was harvested after 14 months. After the harvest, the research continued on the first and second regrowth cycles, each cycle during 12 months. In these cycles, all treatments received 500 kg ha^{-1} of the formula 20-05-25.

The leaf analysis was performed at the maximum growth stage of the plants, eight months after planting the plant-cane cycle and six months after cutting the plant-cane and the first regrowth. For the evaluation of nutritional status, the +3 leaf was sampled. 20 leaves were randomly collected within the useful area of each plot. The sampled leaves were washed in deionized water. Then, the median third of the leaf blades, discarding the midrib, was separated for chemical analysis. Then, the samples were dried at 65°C in a forced-air circulation oven until constant mass and ground in a Wiley mill. The leaf blade was analyzed for nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), sulfur (S), boron (B), copper (Cu), iron (Fe), manganese (Mn) and zinc (Zn), following the methods described by Malavolta et al. (1997). The nitrogen was extracted by sulfuric acid digestion following the Kjeldahl method. The boron was extracted by dry

digestion and determined by the muffle method. The other nutrients were extracted by nitric-perchloric digestion. The P was colorimetrically determined by the development of the blue color by reducing the phospho-molybdenum complex. K, Ca, Mg, Mn, Zn, Cu and Fe were determined by atomic absorption spectro-photometry and the S was obtained by turbidimetry of barium sulfate.

Statistical analyses were performed using the software Sisvar (Ferreira, 2011). The variables were subjected to analysis of variance by F test. For variables with a significant F, the means were compared by Scott Knott test at 5% probability.

RESULTS AND DISCUSSION

Tables 2, 3 and 4 show the mean squares of the analysis of variance and the mean test for nitrogen, phosphorus, potassium, calcium, magnesium and sulfur in the middle third of the +3 leaf of sugarcane varieties VAT90212, RB92579, RB867515 and SP813250 during the plant-cane, first and second regrowth cycles.

For leaf nitrogen contents, there was a significant difference by F test during the plant-cane and the first regrowth cycles (Table 2). The cane plant variety RB92579 showed a higher leaf content (15.16 g kg^{-1}). The other varieties did not show differences. Comparing the leaf N contents of the four varieties during the plant-cane cycle with those reported by Orlando Filho (1983), Malavolta et al. (1997) and Raij (2011), the values were below those considered as appropriate concentrations. During the first regrowth, the highest leaf contents (19.16 and 19.35 g kg^{-1}) were observed for the varieties RB92579 and SP813250, respectively. In this cycle, four varieties were at a suitable concentration according to the authors above.

During the second regrowth and similar to the plant-cane, the overall mean for leaf nitrogen content was below the appropriate as mentioned by Orlando Filho (1983), Malavolta et al. (1997) and Raij (2011). Oliveira et al. (2007) stated that the nutrient content in the limbo of the +3 leaf cannot be related to the quantity of

Table 2. Average macronutrient contents (N and P) in the +3 leaf of sugarcane during the maximum growth phase of plant-cane (PC), first regrowth (FR) and second regrowth (SR) cycles.

Varieties	Nitrogen (g kg^{-1})				Phosphorus (g kg^{-1})			
	PC	FR	SR	Average	PC	FR	SR	Average
VAT90212	13.2[b]	17.5[b]	14.8	15.1	1.6[b]	2.3[b]	1.6[b]	1.8
SP813250	13.7[b]	19.3[a]	14.2	15.7	1.8[b]	2.5[b]	1.5[b]	1.9
RB867515	13.9[b]	16.6[b]	14.3	14.9	1.4[a]	2.0[a]	1.4[a]	1.6
RB92579	15.1[a]	19.1[b]	15.4	16.5	1.4[a]	1.9[a]	1.4[a]	1.6
Average	14.0	18.1	14.7	15.6	1.6	2.2	1.5	1.7

Source of variation	DF	Mean squares							
Varieties	3	3.36**	9.07**	1.56[ns]	-	0.21**	0.39**	0.03**	-
Blocks	4	2.91	0.81	5.48	-	0.02	0.02	0.008	-
Residue	12	0.51	1.73	1.43	-	0.02	0.03	0.005	-
CV (%)		5.35	7.25	8.13	-	10.14	8.58	5.06	-

* and** - significant at 5 and 1% probability, respectively, by F test; [ns] = not significant at 1% probability. Means followed by the same letter do not differ statistically by Scott-Knott test at 5% probability.

Table 3. Average macronutrient contents (K and Ca) in the +3 leaf of sugarcane during the maximum growth phase of plant-cane (PC), first regrowth (FR) and second regrowth (SR) cycles.

Varieties	Potassium (g kg^{-1})				Calcium (g kg^{-1})			
	PC	FR	SR	Average	PC	FR	SR	Average
VAT90212	9.7[b]	8.8[a]	8.0[b]	8.8	3.0[a]	4.6[a]	3.3[b]	3.6
SP813250	8.4[a]	8.8[a]	8.0[b]	8.4	3.9[b]	4.8[a]	3.2[a]	3.9
RB867515	8.7[a]	8.9[a]	7.0[a]	8.2	3.4[a]	4.5[a]	3.5[b]	3.8
RB92579	8.4[a]	10.0[a]	7.9[b]	8.7	4.0[b]	4.8[a]	2.8[a]	3.8
Average	8.8	9.1	7.7	8.5	3.6	4.7	3.2	3.8

Source of variation	DF	Mean squares							
Varieties	3	1.97*	1.58[ns]	1.09*	-	1.00*	0.14[ns]	0.42**	-
Blocks	4	2.61	1.63	1.17	-	0.32	0.29	0.25	-
Residue	12	0.58	0.92	0.40	-	0.14	0.23	0.04	-
C.V(%)	-	8.84	10.49	8.27	-	10.62	10.29	6.89	-

* and** - significant at 5 and 1% probability, respectively, by F test; [ns] = not significant at 1% probability. Means followed by the same letter do not differ statistically by Scott-Knott test at 5% probability.

accumulated nutrients in the shoot biomass. When the plant grows and consequently accumulates more dry matter, there is a dilution of such elements in the biomass, including leaves. This effect has been called "dilution effect."

In sugarcane reform areas, the application of liming and the soil preparation (plowing and harrowing) increase soil microbial activity and there is a greater mineralization rate of the soil organic matter (Ferreira et al., 2015), especially residues and rhizomes of the previous crop. Thus, the nitrate content in the soil solution increases. This increase, combined with a high phosphorus availability in the soil resultant from fertilization, results in an increased efficiency of nitrate uptake by plants (Oliveira et al., 2007; Isaac et al., 2011). Magalhães (1996) showed that the absorption and translocation of nitrogen for corn plants are greatly influenced by the phosphorus endogenous availability: plants with a higher phosphorous endogenous availability have a lower Km (Michaelis-Mentem constant) and a higher inflow rate (Malavolta et al., 1997; Oliveira et al., 2007).

The leaf P concentration was influenced by the varieties during the three crop cycles (Table 2). VAT90212 and SP813250, both during plant-cane and first and second

Table 4. Average macronutrient contents (Mg and S) in the +3 leaf of sugarcane during the maximum growth phase of plant-cane (PC), first regrowth (FR) and second regrowth (SR) cycles.

Varieties		Magnesium (g kg^{-1})				Sulfur (g kg^{-1})			
		PC	FR	SR	Average	PC	FR	SR	Average
VAT90212		3.5[b]	3.6[b]	2.5[c]	3.2	1.2[a]	1.9[b]	1.7[a]	1.6
SP813250		3.4[b]	3.3[b]	1.9[b]	2.8	1.5[b]	1.7[a]	1.5[a]	1.5
RB867515		3.6[b]	3.8[b]	2.6[c]	3.3	1.5[b]	1.9[b]	2.1[b]	1.8
RB92579		2.4[a]	2.1[a]	1.4[a]	1.9	1.2[a]	1.6[a]	1.4[a]	1.4
Average		3.2	3.2	2.1	3.7	1.38	1.80	1.70	1.6

Source of variation	DF				Mean squares				
Varieties	3	1.62**	2.69**	1.52**		0.13*	0.08[ns]	0.47**	1.62**
Blocks	4	0.08	0.15	0.15		0.01	0.008	0.054	0.08
Residue	12	0.11	0.17	0.04		0.04	0.02	0.029	0.11
C.V(%)		10.30	12.83	9.81		15.36	9.03	10.09	10.30

* and **Significant at 5 and 1% probability, respectively, by F test; [ns] = not significant at 1% probability. Means followed by the same letter do not differ statistically by Scott-Knott test at 5% probability.

regrowth, showed a leaf P greater than RB867515 and RB92579. Averaging each cycle of leaf P of VAT90212 and SP813250 and comparing them with an average of leaf P of RB867515 and RB92579, it is observed that, during the plant-cane and the first regrowth, the leaf P of VAT90212 and SP813250 was about 20%, but in the second regrowth it decreased to 10%. The contents of phosphorus in leaf, during the plant-cane cycle, are of the similar as observed by Vasconcelos et al.(2014).

Considering the high availability of P in the soil, which in the layer 0-20 cm had 103 mg dm^{-3} of phosphorus extracted with Mehlich 1, the plants, particularly during the plant-cane cycle, should also have a high leaf P content. However, both in plant-cane and the second regrowth, leaf contents were at the limit established by Raij (2011) but lower than values advocated by Orlando Filho (1983) and Malavolta et al. (1997).

In a study conducted at the Triunfo Plant with RB867515 during the first regrowth cycle in a soil with a high P content (average values above 30 mg dm^{-3} of phosphorus extracted by Mehlich), Oliveira et al. (2011) found leaf P values lower than 1.6 g kg^{-1}, characterizing, according to Malavolta et al. (1997) and Orlando Filho (1983), an inadequate supply of this element, however, the productivity of RB867515 was 166 tonnes of culms per hectare. Considering this and other observations of high-productive sugarcane fields and leaf P levels lower than 2.0 g kg^{-1}, Oliveira et al. (2011b) pondered whether the reference values set by Orlando Filho (1983) and Malavolta et al. (1997) would be suitable for the evaluation of the nutritional state of Alagoas sugarcane fields.

Significant differences were found by F test for leaf potassium contents during plant-cane and second regrowth cycles (Table 3). During the plant-cane cycle, the leaf potassium content for VAT 90212 was approximately 15% higher than other varieties. However, during the second regrowth, the K content in the +3 leaf of RB92579 was 13% lower than the others. In the three crop cycles, leaf contents were below the sufficiency range mentioned by Malavolta et al. (1997) and Raij (2011), but at appropriate concentrations when the values reported by Orlando Filho (1983) are taken as a reference. For this author, the minimum adequate content would be 6.0 g of K per kg of dry matter. Potassium contents in the +3 leaf, during the plant-cane cycle, are of the similar as mentioned by Oliveira et al. (2016).

There was a variety effect in leaf calcium contents during plant-cane and second regrowth cycles (Table 3). The leaf contents during the three cycles were below the proper range reported by Malavolta et al. (1997). For the first sugarcane regrowth, the leaf contents were in a range considered adequate by Orlando Filho (1983) and Raij (2011): 2.0-8.0 g of calcium per kg of dry matter in the +3 leaf. Since the soil received dolomitic lime in a quantity sufficient to increase the base saturation to 60% (Oliveira et al., 2007) and because of soil analyses conducted in each plot after the implementation of the experiment (data not shown), it was found that the saturation increased to 60% or more. The inadequate supply of calcium should not have occurred.

Calcium levels in the +3 leaf, during the plant-cane cycle, are of the same order of magnitude as mentioned by Faroni et al. (2009), Oliveira et al. (2011b) and Omollo et al., (2016). During the first regrowth, an average content of 4.72 g kg^{-1} was observed. It was lower than that obtained by Rozane et al. (2008), who obtained a content of 5.6 g kg^{-1} for the first harvest of SP791011. In

Table 5. Average micronutrient contents (Zn and Fe) in the +3 leaf of sugarcane during the maximum growth phase of plant-cane (PC), first regrowth (FR) and second regrowth (SR) cycles.

Varieties		Zinc (g kg^{-1})				Iron (g kg^{-1})			
		PC	FR	SR	Average	PC	FR	SR	Average
VAT90212		15.2[b]	14.0[a]	15.0[a]	14.7	45.4[a]	56.6[a]	47.2[a]	49.7
SP813250		12.4[a]	13.2[a]	12.8[a]	12.8	99.4[a]	58.6[a]	49. 0[a]	69.0
RB867515		15.8[b]	13.8[a]	14.2[a]	14.6	48.0[a]	55.8[a]	49.0[a]	50.9
RB92579		13.8[a]	12.6[a]	12.6[a]	13.0	46.2[a]	62.2[a]	55.4[a]	54.6
Average		14.3	13.4	13.6	13.7	59.7	58.3	50.1	56.0
Source of variation	**DF**				**Mean squares**				
Varieties	3	11.53*	2.00[ns]	6.58[ns]		3499.51[ns]	40.73[ns]	64.85[ns]	11.53*
Blocks	4	9.67	2.32	2.70		5202.25	131.42	67.07	9.67
Residue	12	2.57	0.62	8.66		3327.68	65.19	57.97	2.57
C.V(%)		11.22	5.90	21.57		96.55	13.93	15.18	11.22

* and **Significant at 5 and 1% probability, respectively, by F test; [ns] = not significant at 1% probability. Means followed by the same letter do not differ statistically by Scott-Knott test at 5% probability.

the second regrowth, leaf calcium contents were similar to those obtained by Prado and Pancelli (2008).

The magnesium contents in the +3 leaf differed among varieties during the three cycles (Table 4). The values are within the range considered adequate by Orlando Filho (1983). The average levels during plant-cane and first regrowth cycles, compared to values mentioned by Raij et al. (1996) and Malavolta et al. (1997), are above the indicated concentration range.

The RB92579 variety had the lowest concentrations during plant-cane, first and second regrowth cycles. During plant-cane, the results obtained were higher than those observed by Píperas et al. (2009). In the first regrowth, leaf contents were 28% higher than those observed by Mendes (2006). In the second regrowth, the average leaf Mg content was similar to that obtained by Prado and Pancelli (2008).

There were significant differences in plant-cane, first and second regrowth cycles regarding leaf sulfur contents (Table 4). The average levels in the three cycles were below the levels indicated by Malavola et al. (1997), but within the range recommended by Orlando Filho (1983). The leaf S content during plant-cane was similar to that observed by Faroni et al. (2009), but, during regrowth, the levels increased. A "dilution effect" may have occurred on the plant-cane.

The average levels of macronutrients in the middle third of the +3 leaf of the varieties VAT90212, RB92579, RB867515 and SP83250 during plant-cane, first and second regrowth cycles showed the following descending order of concentration: nitrogen, potassium, calcium, magnesium, phosphorus and sulfur, coinciding with that mentioned by Prado and Pancelli (2008) and Oliveira et al. (2011a). However, for the plant-cane cycle, there are

reports of a potassium leaf content higher than nitrogen (Mendes, 2006).

Tables 5, 6 and 7 show the mean squares of the analysis of variance and the mean test for zinc, iron, manganese and boron in the middle third of the +3 leaf of sugarcane varieties VAT90212, RB92579, RB867515 and SP813250 during the plant-cane, first and second regrowth cycles.

During the plant-cane cycle, there was a significant difference only for leaf zinc levels (Table 5). During the first regrowth, there was a variety effect for copper, and during the second regrowth there were significant differences for manganese and boron. Based on the compilation by Oliveira et al. (2007), the lowest values of leaf micronutrients considered adequate are 6.0, 9.0, 40.0, 25.0 and 10.0 mg kg^{-1} for boron, copper, iron, manganese and zinc, respectively. Thus, the sugarcane varieties of this study, during the plant-cane cycle, would have an adequate supply of boron, iron and zinc (Tables 5 and 6). However, only the variety VAT90212 was not deficient in Mn (Table 7). In the first and the second regrowth cycles, there was a general micronutrient deficiency according to the reference values established by Malavolta et al. (1997).

Copper deficiency has been widespread in many sugarcane fields: from the northeast of Minas Gerais state to Rio Grande do Norte (Oliveira et al., 2011b). In the vast majority of these soils, the copper content extracted by Mehlich is lower than 0.80 mg dm^{-3}, a critical value according to Marinho and Albuquerque (1981) based on studies conducted in Alagoas.

The availability of micronutrients in the soil, estimated by chemical extractors, varied widely in terms of methods and extractors used for the chemical analysis of the soil.

Table 6. Average micronutrient contents (Cu and B) in the +3 leaf of sugarcane during the maximum growth phase of plant-cane (PC), first regrowth (FR) and second regrowth (SR) cycles.

Varieties	Cooper (g kg^{-1})				Boron (g kg^{-1})			
	PC	FR	SR	Average	PC	FR	SR	Average
VAT90212	2.2[a]	6.6[b]	3.8[a]	4.1	7.1[a]	9.8[a]	4.4[b]	7.1
SP813250	2.2[a]	7.4[b]	4.4[a]	4.6	7.1[a]	9.4[a]	3.4[a]	6.6
RB867515	2.2[a]	6.6[b]	3.8[a]	4.2	6.3[a]	8.1[a]	3.4[a]	5.9
RB92579	1.8[a]	5.8[a]	4.0[a]	3.8	7.3[a]	9.8[a]	3.4[a]	6.8
Average	2.1	6.6	4.0	5.9	6.9	9.2	3.7	6.6

Source of variation	DF	Mean squares							
Varieties	3	0.20[ns]	2.13*	0.400[ns]	-	1.01[ns]	3.19[ns]	1.07*	0.20[ns]
Blocks	4	0.70	0.57	0.250	-	1.18	64.34	1.42	0.70
Residue	12	0.36	0.34	0.316	-	0.45	3.90	0.18	0.36
C.V(%)	-	28.83	8.86	14.07	-	9.63	21.28	11.72	28.83

* and **Significant at 5 and 1% probability, respectively, by F test; [ns] = not significant at 1% probability. Means followed by the same letter do not differ statistically by Scott-Knott test at 5% probability.

Table 7. Average micronutrient contents (Mn) in the +3 leaf of sugarcane during the maximum growth phase of plant-cane (PC), first regrowth (FR) and second regrowth (SR) cycles.

Varieties	Manganese			
	PC	FR	SR	Average
VAT90212	28.0[a]	38.6[a]	28.0[b]	31.53
SP813250	22.8[a]	39.0[a]	22.2[a]	28.0
RB867515	22.6[a]	31.8[a]	29.6[b]	28.0
RB92579	20.0[a]	33.0[a]	19.0[a]	24
Media	23.3	35.6	24.7	27.8

Source of variation	DF	Mean squares			
Varieties	3	56.18[ns]	69.60[ns]	122.73**	-
Blocks	4	166.70	420.20	170.42	-
Residue	12	18.93	69.43	17.85	-
CV (%)	-	18.63	23.41	17.11	-

* and **Significant at 5 and 1% probability, respectively, by F test; [ns] = not significant at 1% probability. Means followed by the same letter do not differ statistically by Scott-Knott test at 5% probability.

analysis should be associated to the history of the area, especially to the record of their deficiency in previous crops (Oliveira et al., 2007, 2011b; Raij, 2011).

Conclusions

The varieties RB92579, RB867515, VAT90212 and SP813250 show differences in leaf contents of macro and micronutrients, but no variety has a higher content regarding any element.

Conflict of interests

The authors have not declared any conflict of interests.

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