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Nutrients optimum range (NOR) based on DRIS method to assess the nutritional status of the first ratoon sugarcane

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Abstract

The development of nutrients optimum range (NOR) is quite important for the ratoon sugarcane (*Saccharum* spp.) to help decision making of fertilizers management. The purpose of this study was to establish NOR from statistical models of relationship between leaf nutrient content (LNC) and DRIS indices. In this study, the nutritional status of the first ratoon sugarcane crop was assessed based on NOR. The study was performed using data from the first ratoon sugarcane obtained from commercial fields, in the southern region of Goiás State, in Brazil. Yield data from plots (average acreage 20 ha) and LNC of macro- and micronutrients in 2012/2013 cropping season were stored in a database. The procedure to define the reference population (high-yielding subpopulation) consisted of plots with above-average yield + 2/3 standard deviation (over 200.94 tonnes ha^{-1}). The average and coefficient of variation for each dual ratio between nutrient concentration (N/P, N/K, N/Ca, etc.) were measured in the high-yielding subpopulation, which was considered the DRIS norms. Based on DRIS norms at the first ratoon sugarcane, it was possible to develop NOR and assess the nutritional status of sugarcane crop. The evaluation of the nutritional status using the NOR indicated that K (87.36%), P (81.82%), Zn (67.27%) and Cu (76.36%) were the nutrients that showed the most deficiency among the plots assessed. On the other hand, N (69.09%), Ca (60%) and S (70.91%) were the most excess nutrients.

Keywords: Nutrients content; plant nutrition; macronutrients; micronutrients; diagnosis system.
Abbreviations: DRIS_Diagnosis and Recommendation Integrated System; TVD_Top Visible Dewlap; LNC_Leaf Nutrient Content; mmt_million metric tonnes.

Introduction

Brazil is the highest worldwide producer of sugarcane (*Saccharum* spp) crop. In 2013/2014 growing season the production of sugarcane was 640 mmt and 9.8 million hectares planted with sugarcane crop in Brazil (USDA, 2014). Nowadays, Brazil is held responsible for half of the sugar produced in the world and the second worldwide producer of ethanol (Marin and Nassif, 2013). Besides, sugarcane is considered an important supply to feed animals in Brazil, like beef cattle and dairy.

The average sugarcane yield in Brazil is approximately 65.31 t ha^{-1}; however, it is possible to achieve higher yield. According to Goldemberg et al. (2013), it is possible to achieve more than 80 t ha^{-1} in Brazil. Many factors are related to the sugarcane yield, like weather condition, cultivars, soil fertility, plant nutrition, etc. It is really important to control the production factors to maintain the soil fertility. In Brazil, problems are faced with the absence of Leaf Nutrient Content (LNC) diagnosis to support the soil analysis data for managing the input of soil fertilizer. Another point is related to the absence of soil analysis in the ratoon sugarcane crop. This problem is not specific in Brazil, as reported by Maccray et al. (2010), whose they faced similar problem with soil analysis and LNC diagnosis in ratoon sugarcane crop in California, USA.

Based on the above mentioned points, it is important to upgrade soil and leaf nutrient content diagnosis to improve the fertilizer management and to achieve higher yield in ratoon sugarcane crop. The soil analysis does not usually reflect a precise result of nitrogen and many micronutrients contents in soil. According to Marschner (1995), the extractor used to measure the nitrogen in the soil may not simulate the uptake by plants roots, because the nitrogen dynamic changes easily in the soil.

The problem is that the content of micronutrients in soil is very small. Thus, it is hard to measure the right content by the calibrated method being used in Brazil, which limits the precise evaluation by the laboratory methodology. Nitrogen and micronutrients are better diagnosed in the leaf tissue of the plants, because in Brazil there is no calibrated soil test for nitrogen. Therefore, it is important to have nutritional diagnosis systems well adjusted for this purpose.

The diagnosis and recommendation integrated system (DRIS) method was developed by Beaufils (1973). This diagnosis method uses the dual ratio between nutrients (N/P, N/K, etc.) based on the norms and DRIS indices. Using the DRIS to diagnose LNC, it is feasible to obtain the negative or positive value for each nutrient in diagnosis, which is called DRIS index. When this value is close to zero, it means that the nutrient is under nutritional balanced in comparison to others, and when this DRIS index is far from zero, it means that the nutrient is unbalanced, compared to others. Positive DRIS index means nutrient in excess and negative DRIS index means nutrient in deficiency.

Based on balance among the nutrients, researchers have already used this methodology to develop NOR for commercial crops, like soybean (Urano et al., 2006, 2007) and cotton (Serra et al., 2010, 2012, 2013, 2014). The advantage of using NOR based on DRIS methodology is the possibility in developing the nutrient ranges in a specific region and with information of commercial field of sugarcane crop.

These NOR can be developed in each farm with the database of LNC and yield. According to Serra et al. (2012), the use of DRIS methodology to create this NOR showed less variability in the nutrient range, what could be more precise than the use of sufficient range, developed in different regions than the specific region where the crop is growing.

With the development of NOR based on DRIS method, it is possible to create NOR from nutritional balanced plant collected in the farm with low cost of implementation, because just the LNC and sugarcane yield data is necessary. One of the most advantages of DRIS method is the indication of nutritional balance, because of the relationship among all nutrients inside the plant, where the conventional methods are not capable to do so. The purpose of this study was to establish NOR from statistical models of relationship between leaf nutrient content and DRIS indices to assess the nutritional status of the first ratoon sugarcane crop.

Result and Discussion

Relationship between LNC and DRIS index in high-yielding subpopulation of the first ratoon sugarcane crop

Based on DRIS method, the NOR was determined for the first ratoon sugarcane crop. The relationship between DRIS index for each nutrient and LNC was used for this determination. This relationship fits with the linear regression equation for all evaluated LNC (Fig. 1 and 2). This relationship showed that the increase of nutrient content in leaves increases the value of DRIS index, as well. The DRIS index value ranges from -1.5 to +1.5 for the most nutrients evaluated, with the exception of Mg^{+2} that showed the range -2.5 to +2.5.

As recorded by Beaufils (1973), the DRIS index close to zero indicates that the nutrient is in balance and when the nutrient shows the value far from zero it means unbalance. The negative DRIS index (below zero) means deficiency and positive (above zero) means limitation for excess. These results were observed by Serra et al. (2014) that evaluated the values of DRIS indices by the order of plant requirement.

The relationship between LNC and DRIS index was observed by Reis et al. (2002), Urano et al. (2006, 2007) and Serra et al. (2012). These authors observed that the leaf nutrient content increases in the same proportion that the value of DRIS index changes from negative to positive value. This, may affirm the lower value of LNC is related to lower DRIS index as it was reported in this work (Fig. 1 and 2). With the exception of N and P, the values of R^2 in the adjusted equation were above 0.72 that indicates high relationship between these two variables (Fig. 1 and 2). Reis (2002) and Serra et al. (2012) reported low values of R^2 by N, as well. Santos et al. (2013) still reported lower values of R^2 for N and P in relation to the other nutrients in ratoon sugarcane.

Table 1. Nutritional balance point obtained with equation of relationship between DRIS index and LNC.

Nutrients	Nutritional balance point
N ($g\ kg^{-1}$)	16.2
P ($g\ kg^{-1}$)	2.04
K ($g\ kg^{-1}$)	14.71
Ca ($g\ kg^{-1}$)	2.74
Mg ($g\ kg^{-1}$)	1.7
S ($g\ kg^{-1}$)	1.32
B ($mg\ kg^{-1}$)	12.9
Zn ($mg\ kg^{-1}$)	19.3
Cu ($mg\ kg^{-1}$)	7.2
Mn ($mg\ kg^{-1}$)	94.02
Fe ($mg\ kg^{-1}$)	138.7

As reported by Serra et al. (2012), the lower values of R^2 for N and P indicated that other factors might be influenced in the DRIS index of these nutrients.

Nutritional balance point obtained with the relationship between DRIS index and LNC

Based on the criterion defined by Beaufils (1973), the plant is considered nutritional balanced when the DRIS index is zero. According to relationship between DRIS index and LNC, it was feasible to obtain the nutritional point of balance for each nutrient defined in the analysis of sugarcane crop in the southern region of Goiás State, in Brazil (Table 1). The NOR observed in this research was over than the values obtained by Reis and Monnerat (2003), for the most evaluated nutrient, except for Mg^{+2} and S. Beside the exception of P, for the rest of nutrient evaluated, the nutritional balanced point did not adjust the sufficient range defined by Malavolta et al. (1997). These differences emphasize the importance of developing NOR in specific regions instead of the use of none specific NOR to diagnose the ratoon sugarcane crop. The development of specific NOR has shown that the results of diagnosis are much better than NOR developed in different regions (Dias et al., 2010; Serra et al., 2014). With the development of specific DRIS norms for each region, it is feasible to develop NOR based on the DRIS principles. These NORs are developed from DRIS and have shown better results than the traditional method of sufficiency range.

Nutritional diagnosis of the first ratoon sugarcane crop based on NOR established

The NOR is shown in Table 2. Using these NORs as reference, the diagnosis for sugarcane at the first ratoon sugarcane was accomplished. The database used for assessment of nutritional status was obtained at the same region that the NOR were developed. The diagnosis frequency in each sufficient range of NOR is showed in Table 3.

The hypothesis of randomness of the results diagnosed as deficient and excess were tested by chi-square ($p<0.01$) (Table 4). According to chi-square test, it was feasible to reject the possibility that the NOR, defined based on DRIS method, is not able to be used as reference for nutritional

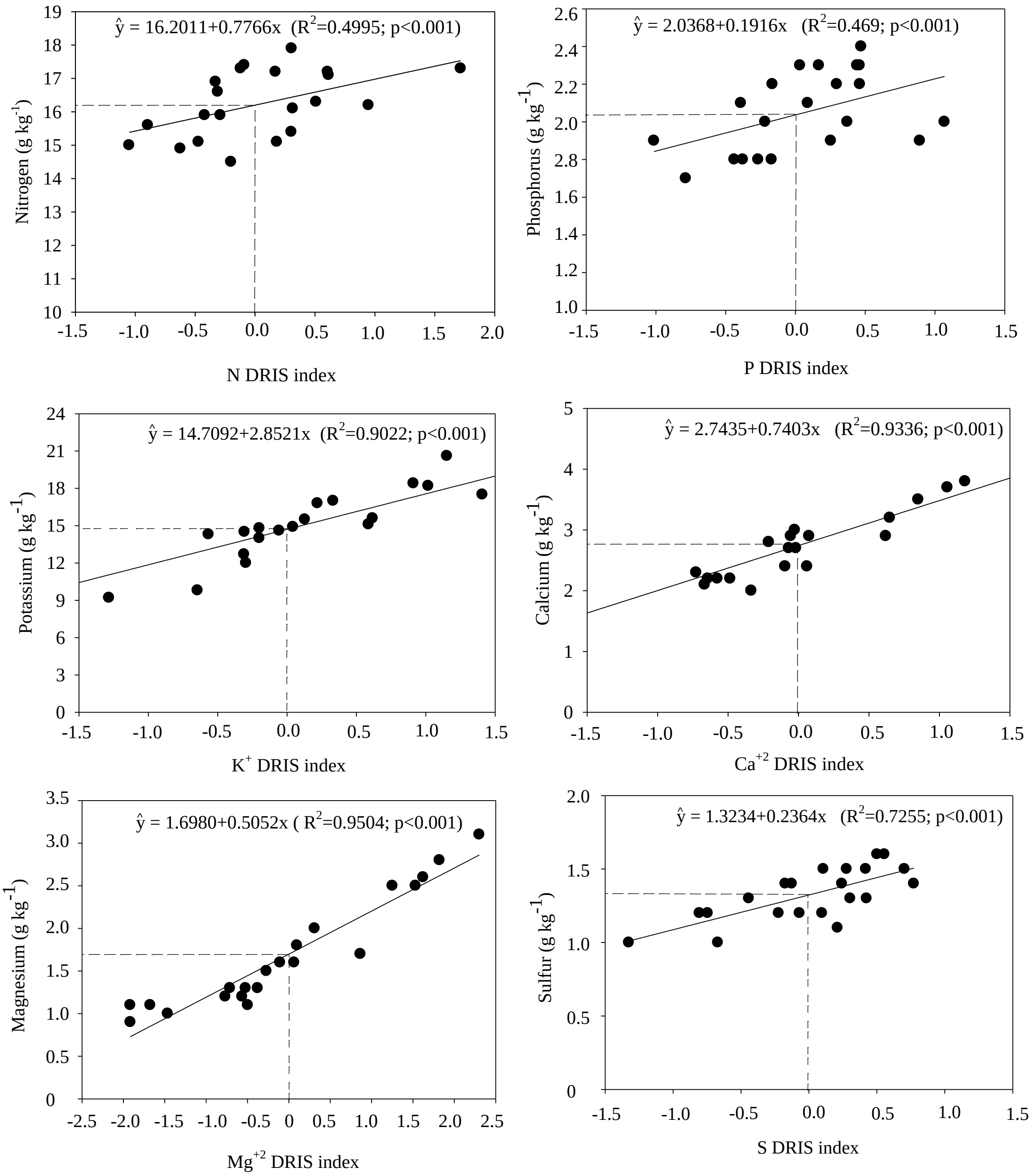

Fig 1. Relationships between the leaves macronutrients contents in high-yielding subpopulation of the first ratoon sugarcane crop and DRIS index.

diagnosis. The chi-square test has already been applied in the DRIS system to prove the efficiency of the system of nutritional diagnosis in crops such as soybean (Urano et al., 2007) and cotton (Serra et al., 2012; Serra et al., 2014). The results obtained by these authors were effective to prove that this test is efficient to be used in this procedure.

The NOR showed in this research were different from those proposed for sugarcane by Raij et al. (1996), Malavolta et al. (1997) and Santos et al. (2013). It reassures that specific NOR for sugarcane is quite important because, nowadays, the use of downgraded NOR and/or developed in regions far from the locality where the sugarcane crop is growing is not efficient to offer trustful results in nutritional diagnosis of plant.

As reported by Santos et al. (2013), the use of local NOR to diagnose the nutritional status of sugarcane must be accomplished to improve the nutritional diagnosis which guides the recommendation of fertilizers. Another important aspect is the narrow NOR, when it is developed in specific region (Table 2). When the NOR is wide, the possibility to obtain the LNC of a sample inside this range is very high. On the other hand, when the NOR is narrow this possibility decreases and the result is more precise. The procedure used in this research is based on DRIS norms developed in region, where the ratoon sugarcane crop in growing. Therefore development of DRIS norms in specific region is more efficient, because when the irrelevant region database is being used (far from where the crop is growing), it may develop

Table 2. Nutrients' Optimal Range (NOR) developed for nutritional diagnosis of the first ratoon sugarcane crop.

Nutrient	Deficiency	Deficiency-prone	Sufficient	Excess-prone	Excess
			g kg^{-1}		
N	<15.5	15.5 – 15.9	15.9 - 16.5	16.5 – 16.9	>16.9
P	<1.9	1.9 – 2.0	2.0 – 2.1	2.1 – 2.2	>2.2
K	<10.8	10.8 - 12.7	12.7 – 16.7	16.7 – 18.6	>18.6
Ca	<1.9	1.9 - 2.3	2.3 – 3.2	3.2 – 3.6	>3.6
Mg	<1.0	1.0 - 1.3	1.3 – 2.1	2.1 – 2.5	>2.5
S	<1.1	1.1 - 1.2	1.2 – 1.4	1.4 – 1.5	>1.5
			mg kg^{-1}		
B	<9.7	9.7 - 11.3	11.3 – 14.4	14.4 – 16.1	>16.1
Zn	<11.1	11.1 - 15.2	15.2 – 23.5	23.5 – 27.5	>27.5
Cu	<5.4	5.4 – 6.3	6.3 – 8.1	8.1 – 9.0	>9.0
Mn	<76.7	76.7 – 85.3	85.3 – 102.7	102.7 – 111.3	>111.3
Fe	<96.5	96.5 – 117.5	117.5 – 160.0	160.0 – 180.9	>180.9

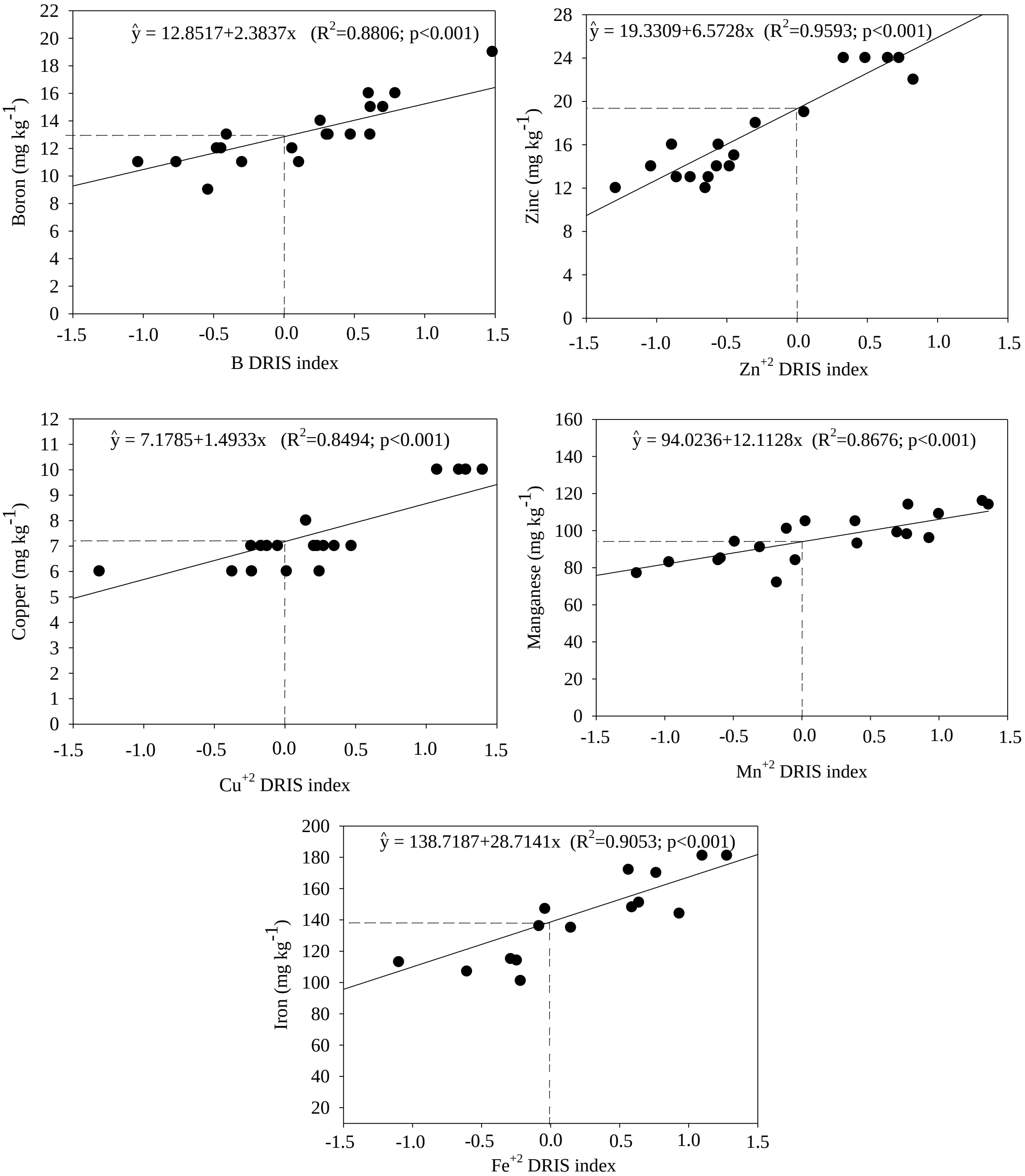

Fig 2. Relationships between the foliar micronutrients contents in high-yielding subpopulation of the first ratoon sugarcane crop and DRIS index.

Table 3. Plots percentage (%) diagnosed by NOR as deficiency, deficiency-prone, sufficient, excess-prone or excess, leaf samples from the first ratoon sugarcane crop.

Nutrients	Deficiency	Deficiency-prone	Sufficient	Excess-prone	Excess
Plots percentage (%)					
N	12.73	3.64	14.55	0.00	69.09
P	81.82	7.27	7.27	1.82	1.82
K	87.27	5.45	7.27	0.00	0.00
Ca	1.82	0.00	20.00	18.18	60.00
Mg	0.00	3.64	34.55	16.36	45.45
S	0.00	0.00	18.18	10.91	70.91
B	18.18	16.36	21.82	5.45	38.18
Zn	67.27	30.91	1.82	0.00	0.00
Cu	76.36	14.55	7.27	1.82	0.00
Mn	21.82	5.45	14.55	7.27	50.91
Fe	40.00	45.45	12.73	1.82	0.00

Table 4. Chi-square test and values of observed and expected frequencies (%) for N, P, K, Ca, Mg, S, B, Zn, Cu, Mn, and Fe as deficient and excess.

Nutrients	--------------Deficient-----------------			-----------------Excess-------------------		
	OF[†]	EF[†]	$(OF-EF)^2/EF$	OF	EF	$(OF-EF)^2/EF$
N	12.73	9.09	1.45	69.09	9.09	396.00
P	81.82	9.09	581.82	1.82	9.09	5.82
K	87.27	9.09	672.36	0.00	9.09	9.09
Ca	1.82	9.09	5.82	60.00	9.09	285.09
Mg	0.00	9.09	9.09	45.45	9.09	145.45
S	0.00	9.09	9.09	70.91	9.09	420.36
B	18.18	9.09	105.09	38.18	9.09	9.09
Zn	67.27	9.09	372.36	0.00	9.09	9.09
Cu	76.36	9.09	497.82	0.00	9.09	9.09
Mn	21.82	9.09	17.82	50.91	9.09	192.36
Fe	40.00	9.09	105.09	0.00	9.09	9.09
Chi-square			2377.82**			1490.55**

[†]OF and EF: observed and expected frequencies, respectively. ** $p \leq 0.01$.

very wide NOR that compromises the diagnoses results (Serra et al., 2012).

The results of nutritional diagnosis showed that more limited macronutrients by deficiency were K and P, 87.36% and 81.82% of all the evaluated plots, respectively. On the other hand, N, Ca^{+2} and S were the macronutrients that showed the highest frequency as more limited by excess, 69.09%, 60% and 70.91%, respectively. It is important to note that uptaken K was not enough to supply the plant requirement in 87% of the evaluated plots.

The sugarcane crop requires high quantity of K. It is the second more uptaken nutrient by sugarcane (Coleti et al., 2006 and Oliveira et al., 2010). Most of the evaluated plots (81.82%) showed P deficiency in leaves. The sugarcane in Brazil is growing in soil with low fertility; most of these soils are located in Brazilian savannah, which is predominated of Oxisol. Therefore, the presence of P deficiency is expected if the application of P fertilizer in the furrow was not adequate to supply the plant requirement. The efficiency of P fertilizer in Oxisol is very low, due to adsorption of P with Fe oxides, Al^{+3}, etc. In fertilizing procedure of the first ratoon sugarcane crop, the use of N and K fertilizers are very common because both of them are highly required for plant growth. In the case of N, it was observed that 69.09% of plots showed N excess. This information may aid the management of N fertilizer because if the N content in the leaf tissue is in excess, it means that the uptake of N is over than the plant requires, which indicates luxury consumption. The NOR diagnosis showed quite important to assess the nutritional diagnosis of the first ratoon sugarcane crop, but the recommendation must be directed by an agronomist to be possible the increasing of fertilizer efficiency.

It is possible to observe that Ca^{+2} was in excess in 60% of the plots. On the other hand, Cu^{+2} and Zn^{+2} were lower. This result may be explained because of the need to apply lime to correct the soil pH in Brazilian savannah. The result is the decrease of micronutrient availability in the soil because of the increasing of soil pH. Beside the lime application in the whole area, the gypsum was applied in all plots to increase the Ca^{+2} and S contents in the soil. As reported in the fertilizer history of the farm, the dose of gypsum was 1,250 kg ha^{-1}. This application may result in the excess of Ca^{+2} and S in nutritional diagnosis of 60% and 70.91% of the plots, respectively.

Materials and Methods

Site description and soil

This study was performed with data from commercial sugarcane fields in 2012/2013 growing season, located in the southern region of Goiás State, in Brazil, (approximately 18° 26’ S, 50° 26’ W, average altitude 540 m asl). The LNC and yield samples were obtained from the first ratoon sugarcane crop, with the following varieties; RB86-7515, IAC87-3396 and SP81-3250, with the data stored in a database. The soil of the study area was predominantly dystroferric Red Latosol (Santos, 2013).

Plant material

To constitute the database to develop the DRIS norms and NOR, 30 single leaves per plot was collected to compose each sample. The total number of plots collected was 106. The leaves samples were collected randomly in each plot in average of 20 ha. The leaves samples consisted of the top visible dewlap (TVD) leaf blade. Right after collecting, the midrib from the leaves blades was removed. All the samples were stored in paper bag and dried in a forced-air oven at 65 °C to a constant weight, ground and sieved (60 mesh cm^{-2}). In the leaf samples, the total contents of N, P, K^{+}, Ca^{+2}, Mg^{+2}, S, B, Zn^{+2}, Cu^{+2}, Mn^{+2} and Fe^{+2} were determined by the method described by Malavolta et al. (1997).

Evaluation of yield

The sugarcane yield was evaluated following the procedure suggested by the Technological Center of Sugarcane (TCS), in Brazil. This way, it was weighed 20 tillers and counted the number of tillers in 10 meters. Based on these data, the average number of tillers per meter and the average weight of each tiller were obtained. From these data and the space among rows, the yield of each plot (t ha^{-1}) was estimated, using the following equation 1:

$$Y = ANTMxTAMx\left(\frac{AWT}{1{,}000}\right) \qquad (1)$$

Y=yield (t ha^{-1}); ANTM=average number of tillers by meters; TAM=total amount of meters in one hectare (10,000/space among rows); AWT=average weight of tillers (kg).

DRIS norms

The information that stored in the database and used for DRIS were the total leaf contents of macronutrients (g kg^{-1}) and micronutrients (mg kg^{-1}) and the first ratoon sugarcane crop yield (t ha^{-1}). A specific DRIS norms was developed based on the database of the first ratoon sugarcane crop. The procedure to define the reference population (high-yielding subpopulation) consisted of plots with above-average yield + 2/3 standard deviation (over 200.94 t ha^{-1}), as recommended by Serra et al. (2013). The normality distribution of the yield data used to compose the DRIS norms was tested by the Kolmogorov-Smirnov test (Campos, 1983).

To determine the DRIS norms, it was necessary to calculate the average and coefficient of variation of all dual ratio between nutrients, considering nutrient dual ratio in direct (A/B) or inverse form (B/A). These dual ratios were applied for all nutrients in the database. To select the nutrient dual ratio (A/B or B/A) to compose the DRIS norms, the proceeding named F-value was used, which already applied by Beaufils (1973), Jones (1981), Serra et al. (2014). To be feasible the accomplishment, the variance of the dual ratio between nutrients in the high- and low-yielding subpopulation was calculated. The criterion to select the dual ratio was the highest value of variance ratio, as following in the equation 2. If, we consider the following formula

$$\left[\frac{S^2\left(\frac{A}{B}\right)\ low-yielding}{S^2\left(\frac{A}{B}\right)\ high-yielding}\right] > \left[\frac{S^2\left(\frac{B}{A}\right)\ low-yielding}{S^2\left(\frac{B}{A}\right)\ high-yielding}\right] \qquad (2)$$

Then: the dual ratio chosen to compose the DRIS norms is A/B. On the contrary, it will be B/A. S^2 = variance of the dual ratio between nutrients.

Calculation of DRIS function

The DRIS functions were calculated according to Beaufils (1973), using an adjustment factor (K) = 1. It was compared the nutrient dual ratio (A/B) of each sample from the database selected to nutritional diagnosis with the same dual ratio in the DRIS norms [average value of dual ratio (a/b) and coefficient of variation (CV)]. For these purposes the following procedure was applied (equation 3, 4 and 5):

For A/B < a/b: $f\left(\frac{A}{B}\right) = \left[1 - \frac{a/b}{A/B}\right] . \frac{100.K}{CV\%}$ (3)

For A/B = a/b: 0 (4)

For A/B > a/b: $f\left(\frac{A}{B}\right) = \left[\frac{A/B}{a/b} - 1\right] . \frac{100.K}{CV\%}$ (5)

Calculation of DRIS index

The DRIS indices were calculated following the general formula proposed by Beaufils (1973) (equation 6), where for nutrient A:

$$DRIS\ index\ for\ nutrient\ A = \frac{\sum f\left(\frac{A}{B}\right) - \sum f\left(\frac{B}{A}\right)}{n+m} \qquad (6)$$

n = number of DRIS functions involved in the analysis, in direct form (A/B); m=number of DRIS function included in the analysis, in the inverse form (B/A).

Establishment of NOR based on DRIS method

The data of LNC of the high-yielding subpopulation was used to define the DRIS norms for the first ratoon sugarcane crop. I was also used to establish the NOR to interpret the LNC. First, it was adjusted analytical model between the LNC and the DRIS index for each nutrient. After this analysis, the NOR for each nutrient in the analysis was established.

The balanced point of LNC was adjusted based on the equation between the DRIS index and LNC. The value named balanced point is the one, in which the DRIS index is zero. It means that this is the value that there is no deficiency or excess of nutrient in the plant, according to Beaufils (1973). The following step defined the five ranges of LNC, according to the standard deviation range (s) of DRIS indices from the high-yielding subpopulation, where, deficiency nutritional status < -4/3 s; deficiency-prone = -4/3 to -2/3 s; sufficient = -2/3 to 2/3 s; excess-prone = 2/3 s 4/3 s; excess > 4/3 s (Beaufils, 1973).

Database selected for nutritional diagnosis by NOR

The database selected for assessments was collected from a farm with the first ratoon sugarcane crop growing at the same region, where the DRIS norms and the following NOR were established. The database basically was compiled for LNC and yield. The total of samples evaluated on this farm was 60 plots. The whole database was collected in 2012/2013 growing season.

Statistical analysis

The hypothesis that the frequency of each nutrient appeared as deficiency or excess attributed was randomly tested. For this purpose, the chi-square test ($\chi 2$) of Pearson was applied at 1 % probability, with n-1 degrees of freedom (n = number of analyzed nutrients). If the hypothesis was true, the observed frequencies for all nutrients would be statistically equal to each other (Urano et al., 2006; Serra et al., 2010). The chi-square test ($\chi 2$), expected (*EF*) and observed frequencies (*OF*) were calculated as followed (equation 7, 8 and 9):

$$\mathrm{EF}(\%) = \left[\left(\frac{\text{Total number of plots evaluated}}{\text{Number of nutrients evaluated}}\right) / (\text{Total number o} \quad (7)$$

$$\mathrm{OF}(\%) = \left(\frac{\text{Total number of plots evaluated}}{\text{Number of nutrients evaluated}}\right).100 \quad (8)$$

$$\chi^2 = \sum_{i=1}^{k} [\frac{(\mathrm{OFi} - \mathrm{EFi})^2}{\mathrm{EFi}}] \quad (9)$$

Statistical analysis was performed using the program SPSS for Windows, version 11.0.0. The other DRIS calculations were performed with Excel ® (2010) spreadsheets (Microsoft Corporation, 2010).

Conclusions

Based on DRIS norms at the first ratoon sugarcane, we were able to develop nutrient optimum range (NOR). The evaluation of the nutritional status using the NOR revealed that K (87.36%), P (81.82%), Zn^{+2} (67.27%) and Cu^{+2} (76.36%) were those nutrients that showed the most frequency as the most deficient among the plots assessed. On the other hand, N (69.09%), Ca^{+2} (60%) and S (70.91%), were the most limited by excess. The developed NOR according to DRIS method showed high capability to be applied on specific farms, because with the database of LNC and yield, it is possible to develop this NOR. The excess of Ca^{+2} and S may be occurred because of gypsum (calcium sulfate) application in the whole area on the farm, which proved the efficiency of the NOR to inferior the nutrition status. The analysis following the NOR may support the management of fertilizer application. It is possible to recommend the upgrade of this NOR in the future and develop it in other stages of plant development to guide the recommendation of fertilizer for sugarcane crop.

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