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Critical levels and nutritional evaluation of irrigated "Prata-Anã" banana

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ABSTRACT: The study was conducted aiming to determine nutritional critical levels in the soil and in irrigated banana plants (cv. "Prata-Anã"), in the northern region of Minas Gerais State. For this, it was used the yield data and nutrient concentrations in the soil and in the reference leaf from 14 commercial areas of banana production in 2013, 2014 and 2015, adopting the method of reduced normal distribution. The critical levels of soil chemical attributes were 6.6 for pH, 45.1 mg dm^{-3} for P, 132.9 mg dm^{-3} for K, 3.9 cmol$_c$ dm^{-3} for Ca, and 1.3 cmol$_c$ dm^{-3} for Mg. Regarding leaf nutrients, the concentrations were 23.8; 1.7; 35.6; 6.6; 2.9 and 1.7 g kg^{-1} for N, P, K, Ca, Mg and S, respectively, and 62.3; 17.9; 280.3; 12.3 and 7.1 mg kg^{-1} for Fe, Zn, Mn, B and Cu, respectively. The methodology of reduced normal distribution for obtaining critical nutrient levels in soil and plants resembles those used by other authors. The most limiting soil nutrients in the year 2013 were K and Ca, and in 2014 and 2015 were P and Ca, resulting in low yields.

Key words: leaf nutrients contents; *Musa* ssp.; soil fertility

Níveis críticos e avaliação nutricional da bananeira prata-anã irrigada

RESUMO: O trabalho foi realizado com o objetivo de definir níveis críticos nutricionais no solo e em plantas da bananeira, cv. Prata-Anã irrigada na região norte de Minas Gerais. Foram avaliados as produtividades e teores de nutrientes no solo e na folha diagnóstico de 14 áreas comerciais de produção de banana, nos anos de 2013, 2014 e 2015, adotando o método da distribuição normal reduzida. Os níveis críticos dos atributos químicos do solo nas áreas avaliadas foram de 6,6 para pH, 45,1 mg dm^{-3} para P, 132,9 mg dm^{-3} para K, 3,9 cmol$_c$ dm^{-3} para Ca e 1,3 cmol$_c$ dm^{-3} para o Mg. Para os teores foliares foram 23,8; 1,7; 35,6; 6,6; 2,9 e 1,7 g kg^{-1} para N, P, K, Ca, Mg e S, respectivamente, e 62,3; 17,9; 280,3; 12,3 e 7,1 mg kg^{-1} para Fe, Zn, Mn, B e Cu, respectivamente. A metodologia de distribuição normal reduzida para obtenção dos níveis críticos dos nutrientes no solo e nas plantas assemelha-se às utilizadas por outros autores. Os nutrientes mais limitantes no solo no ano de 2013 foram K e Ca, em 2014 e 2015 foram P e Ca, resultando em baixas produtividades.

Palavras-chave: teores de nutrientes foliares; *Musa* ssp.; fertilidade do solo

Introduction

Banana is one of the most produced fruit in the world and has a great socioeconomic importance in Brazil. In the country semi-arid region, the main banana production poles are Northern Minas Gerais, Bom Jesus da Lapa in Bahia, the São Francisco Submedium Valley, Açu Valley in Rio Grande do Norte and Jaguaribe Valley in Ceará (Coltro & Karaski, 2019).

The banana plant, besides being one of the most produced fruit, is also one of the most consumed in the world, due to its richness in vitamins and nutrients (Leite et al, 2010; Fingolo et al., 2012). On the other hand, for obtaining high yields, it demands adequate nutrient content in the soil and plants (Fontes et al., 2003; Weber et al., 2006; Hoffmann et al., 2010). Thus, economically viable yields are associated with a systematic monitoring of soil fertility and crop nutritional status, which must be under constantly evaluation.

Chemical analyzes of soil and plant tissues are essential tools for estimating nutrient availability and evaluating the nutritional status of the plants. Correlations between nutrient content in the soil and the plant tissues, as well as the crop yields, allow the establishment of standards as assisting tools in management of the fertilizations (Partelli et al., 2014). However, these already established standards in most recommendation bulletins of banana crops are generally developed in distinct production systems in terms of climate, management, difference-inducing species in the nutrient dynamics in soil, and in plants relative to the conditions where the standards have been set. These situations may promote differences between cultivars, which justify specific studies to obtain local data for adjusting regional standards, in order to adopt safer interpretations for banana production systems.

Due to the difficulties in obtaining experimental data, Maia et al. (2001) for coffee plantations, and Maia & Morais (2015) for banana plantations, proposed the method of reduced normal distribution. It allows finding critical soil and leaf levels without the needing field experiments, only using nutritional monitoring data from the commercial plantations.

Given the above, this study was conducted with the objective of evaluating the nutritional status and defining critical nutrient levels in the soil and in the banana plant, irrigated cv. "Prata-Anã", using the method of reduced normal distribution, in the northern region of Minas Gerais.

Materials and Methods

Chemical, soil, plant and yield analysis data for banana (cv. "Prata-Anã") were obtained from fourteen commercial irrigated plantations (identified as areas from 1 to 14) cultivated in northern Minas Gerais in 2013, 2014 and 2015.

The climate of the region is Aw by Köppen-Geiger classification (tropical with dry season). Mean annual precipitation over the three years in which the data were collected was 1,199 mm, with a rainy season from October to April. Annual mean temperatures were maximum of 32.5 °C; average of 25.5 °C and a minimum of 18.8 °C. The annual mean relative humidity was of 75.6% and radiation of 280.4 w/m.

Studied areas were irrigated with water without restriction for agriculture (electrical conductivity = 0.06 dS m^{-1} and Sodium Adsorption Ratio = 0.14) employing the method of localized application by using a micro-spray for four plants, with flow rate of 21.4 l h^{-1} and pressure of 80.5 kPa. The fertilizations were predominantly performed by fertigation and by manual application.

In the years of data collection, in each of the 14 studied areas, four soil composite samples were collected in the 0-20 cm deep layer, totaling 168 composite samples, which were then analyzed according to Teixeira et al. (2017). For the leaf analysis, four composite samples were collected in each of the areas during the evaluation years, totaling 168 samples. In leaf sampling, 15 cm were collected from the median inner part of the leaf limb, eliminating the central leaf vein.

The mean yield of the 14 areas, considering only the commercial fruit, was 30.5 t ha^{-1} in 2013; 25.7 t ha^{-1} in 2014 and of 25.6 t ha^{-1} in 2017. Considering the three years and all areas evaluated, the overall mean yield was of 27 t ha^{-1}. This value was adopted as a reference for the yield classification in each area and cultivation year, with it being low when less than 27 t ha^{-1} and high when equal to or above 27 t ha^{-1}.

Based on this classification criterion, four areas were classified as low and 10 areas with high yield in 2013; in 2014, there were nine areas of low yield and five areas of high and; in 2015, nine areas of low productivity and five areas of high. The mean yield of the 20 high areas was 33.1 t ha^{-1} in 2013; 30.5 t ha^{-1} in 2014 and 32.1 t ha^{-1} in 2015; the mean yield of low areas was 24.1 t ha^{-1} in 2013; 23 t ha^{-1} in 2014 and 22.1 t ha^{-1} in 2015.

For critical nutrient levels determination, the method of reduced normal distribution described by Maia et al. (2001) was employed. According to it, the relation (Q) between the yield (P) and the desired nutrient content for the critical level (Ni) calculation was estimated. The critical level was obtained through Equation 1.

$$NCRIz = \frac{1.281552s1 + x1}{1.281552s2 + x2} \tag{1}$$

in which:
    s1   - P standard deviation;
    x1   - P arithmetic mean;
    s2   - Q standard deviation; and,
    x2   - Q arithmetic mean.

The basic assumption for obtaining the critical level through the proposed method was that the P and Q data must follow a normal distribution and, for this, the normality of the data was verified by using the Shapiro-Wilk test. In case of non-normality, the data were transformed using the logarithm. In this case, the critical levels were obtained through the estimator, according to Equation 2.

$$NCRIz = \frac{\exp(1.281552s1 + x1)}{\exp(1.281552s2 + x2)} \qquad (2)$$

in which:

s1 - P standard deviation;
x1 - P arithmetic mean;
s2 - Q standard deviation; and,
x2 - Q arithmetic mean.

Following Maia & Morais (2015) methodology, the soil fertility of low yield areas was evaluated through the Ii index, by using the estimator according to Equation 3.

$$Ii = \frac{Ai}{NCRIz} - 1 \qquad (3)$$

in which:

A_i - result of the soil or foliar analysis for each nutrient; and,

NCRIz - critical level calculated from the nutrient in the soil or leaf.

High yield areas, equal to or above 27 t ha^{-1}, were considered as a reference for defining critical levels, assuming that they were nutritionally balanced. Hence, for soil fertility evaluations, positive (+) I_i index values indicate equal or higher nutrient content and negative (-) values indicate lower content than the reference areas (critical level).

Results and Discussion

The critical levels of soil chemical attributes obtained by the method of reduced normal distribution for irrigated cv. "Prata-Anã" banana plant are displayed in Table 1. Recorded values were 45.1 mg dm^{-3} for P; 132.91 mg dm^{-3} for K; 3.99 and 1.35 cmol$_c$ dm^{-3} for Ca and Mg, respectively. The estimated critical levels for K, Ca and Mg are higher than those that were established by Alvarez et al. (1999): from 70 mg dm^{-3} to K; 0.90 and 2.40 cmol$_c$ dm^{-3} for Ca and Mg, respectively. Banana plants in this study are irrigated, high-yielding and periodically receiving high nutrient applications. On the other hand, pH and K, Ca and Mg contents are within the sufficiency range found by Silva & Carvalho (2005) also for the irrigated cv. "Prata-Anã" in northern Minas Gerais; however, they were estimated by the mean and standard deviation.

Obtained results show the importance of establishing regional sufficiency ranges, depending on the adopted production technologies. According to the results obtained by Silva & Carvalho (2005), for the cv. "Prata-Anã" banana with mean yield of 25 t ha^{-1}, the lower limits of the sufficiency range estimated for K (90 mg dm^{-3}) and Mg (0.6 cmol$_c$ dm^{-3}) were lower than the critical levels determined in the banana plants from this study, with mean yield of 27 t ha^{-1}. These results indicate that the lower the yield is, the lower the nutrient requirement also is and, thereby, the lower the critical level values are.

The cultivar can also influence critical nutrient levels. For example, Teixeira et al. (2001), while studying cv. "Nanicão" under irrigation, found critical level for P of 46 mg dm^{-3}; Maia & Morais (2015), studying the irrigated cv. "Pacovan" with mean yield of 27 t ha^{-1}, estimated a critical Ca level of 6.43 cmol$_c$ dm^{-3}, higher than those found for P (43 mg dm^{-3}) and Ca (3.9 cmol$_c$ dm^{-3}) for cv. "Prata-Anã" (Table 1).

Just as the cultivar, the pedological and climatic conditions must be taken into account when establishing critical nutrient levels. Maia & Morais (2015), in Chapada do Apodi, eastern Ceará State, also by the method of reduced normal distribution and for the "Pacovan" cultivar (same group as "Prata-Anã"), obtained different critical levels values from those of this study, mainly for phosphorus, 1.7 times lower (Table 1). However, Silva & Carvalho (2005), when evaluating the same plantation also in the northern region of Minas Gerais, found different results due to working with a larger sample, encompassing quite distinct areas regarding the technologies and yields use (Table 1).

In low yield areas, below 27 t ha^{-1}, soil fertility was evaluated by using the I_i index, where positive values indicate content equal to or greater than the critical level, and negative values show the lower content. In 2013, areas 5, 7, 8 and 11 were those with low yield.

It was found that in 50% of the areas, the pH, K and, or Ca values were below the critical level, while in 25% they had P or Mg content below the critical levels (Table 2).

Although the yield of area 5 (five) in 2013 was slightly lower than the banana plantations mean (27 t ha^{-1}), it was higher than the obtained in low yield areas (7, 8, and 11) and did not show negative I_i value (Table 2).

In addition to the deficiency of K, Ca and Mg in low yield areas in 2013, positive and negative interactions between these nutrients should be considered in the management of banana fertility to maintain balance between them. Similar situations to this study were found by Silva & Rodrigues (2001), where K and Ca saturation in CEC were low and Mg was high, a low K/Mg ratio indicative; therefore, the authors

Table 1. Critical levels for soil chemical attributes for banana cv. "Prata-Anã" estimated by reduced normal distribution and critical ranges obtained by other authors.

pH	P	K	Ca	Mg	
	(mg dm^{-3})		(cmol$_c$ dm^{-3})		
6.6	45.1	132.9	3.9	1.3	
-	-	70	2.4	0.9	Alvarez et al. (1999)
5.5 − 7.5	-	90 − 240	3.5 − 9.5	0.6 − 1.8	Silva & Carvalho (2005)
7.1	25.7	140.4	6.4	1.1	Maia & Morais (2015)

Table 2. Ii index, critical levels and mean values of soil chemical attributes from low yield areas of irrigated banana in northern Minas Gerais in 2013.

Area	Yield (Mg ha⁻¹)	pH	P	K	Ca	Mg
				I_i index		
5	25.73	0.01	0.20	0.42	0	0.41
7	22.58	-0.02	0.96	-0.07	-0.10	0.04
8	23.21	0.01	-0.12	0.30	-0.10	0.11
11	25.15	-0.08	0.02	-0.26	0.13	-0.52
			Critical levels			
			(mg dm⁻³)		(cmol$_c$ dm⁻³)	
		6.6	45.1	132.9	3.9	1.3
			Mean values			
5	25.73	6.7	54.2	189.3	4.0	1.9
7	22.58	6.5	88.2	123.1	3.6	1.4
8	23.21	6.7	39.9	172.3	3.6	1.5
11	25.15	6.1	45.8	98.8	4.5	0.6

Table 3. I_i index of soil chemical attributes from low yield areas of irrigated banana plants in northern Minas Gerais in 2014 and 2015.

Area	Yield (t ha⁻¹)	pH	P	K	Ca	Mg
			2014			
4	23.68	0.00	0.03	0.83	-0.05	0.41
5	25.8	0.04	0.35	0.96	0.05	0.63
7	22.87	-0.03	-0.12	0.55	-0.12	0.11
8	21.47	-0.02	0.01	0.21	-0.05	0.11
9	23.77	-0.02	-0.16	0.71	-0.02	0.19
10	22.97	-0.06	-0.25	0.02	-0.06	-0.26
11	23.89	-0.06	-0.55	0.41	0.02	-0.30
12	21.31	-0.04	-0.27	0.91	-0.12	-0.31
14	21.73	-0.01	-0.72	-0.37	0.24	-0.39
			2015			
5	20.85	0.03	-0.05	1.05	-0.02	0.41
7	18.46	-0.02	0.01	0.14	-0.20	0.04
8	26.60	-0.03	-0.58	0.41	-0.25	0.04
9	25.32	-0.02	-0.50	1.08	-0.02	0.26
10	20.47	-0.10	-0.15	0.74	-0.17	0.03
11	17.08	-0.10	-0.11	0.57	0.09	0.10
12	22.90	-0.09	-0.41	1.16	-0.12	-0.15
13	25.17	-0.14	0.28	0.76	-0.19	0.00
14	22.36	-0.14	-0.15	0.31	-0.14	-0.09

recommended the K application. Another interesting fact was that in eutrophic alluvial soil, despite it containing satisfactory K values (120 mg dm⁻³), a deficiency of this element occurred when Ca and Mg contents were high (Silva & Rodrigues, 2001).

If the content of these nutrients remain below the reference value, as pointed out by the I_i index, disturbances in the plant may occur, such as decreased yield, decreased fruit quality and pseudostem diameter (Silva et al., 2008). Therefore, in order to increase the yield and guarantee the fruit quality of these low yield areas, according to the obtained results, it would be necessary to adjust the contents and relations of these nutrients. Silva & Rodrigues (2001) cite that the quantities of K, Ca and Mg must correspond to 10%; 50% and 40% of base saturation, i.e., a K:Ca:Mg ratio of 0.5:2.5:2 to 0.3:2:1, respectively.

Besides deficiency of K, Ca and Mg in low yield areas in 2013, interactions with synergistic and antagonistic responses between these nutrients should be considered in the fertility management of planted soils.

Similar situations to those of this study were obtained by Silva & Rodrigues (2001), where K and Ca saturation in CEC were low and the Mg was high, hence, low K:Mg ratio; therefore, the authors recommend the application of K and Ca.

According to the respective I_i index values (Table 2), nutrient content in the soils from the low yield banana plants in 2013 are below the critical levels (Table 2), reinforcing the occurrence of problems in the adopted fertilization program, which may have contributed to the lower yield of these banana plants.

In the nine areas that presented low yield in 2014, the nutrients P, Ca and Mg were the most limiting, as indicated by the negative values of I_i indexes (Table 3). However, it was found that the K value in areas 7 and 11 that were below the critical level in 2013 and thus presented negative I_i indexes (Table 2), were corrected through fertilizations and these indexes were positive in 2014 (Table 3).

Corroborating this study, Maia & Morais (2015), using the same methodology for obtaining critical levels for the "Pacovan" banana cultivar in Chapada do Apodi – CE, verified

that phosphorus was also the main limiting nutrient. According to the authors, the results obtained are explained by the low natural P fertility and the high Ca content of the soils from this region, since these elements can form stable compounds, reducing their availability to the plants.

Silva et al. (2011) emphasize that phosphate fertilization is fundamental in the early stages of banana plants, so that they develop with greater vigor, especially when cultivated in soils with low content of this element. These authors found that the content of available phosphorus in the soil and leaves increased linearly with the increasing doses of phosphorus applied to the soil. Silva & Rodrigues (2013) also verified that the "Prata-Anã" banana grown in soils with low P content responds to the application of this nutrient only in the first production cycle. Hence, in cases of eventual deficiencies after the initial stage of formation, P fertilizations with may have low efficiency, as verified in the present study, where, in 2014, the banana plants were with more than five production cycles.

Regarding Ca and Mg, negative I_i indexes found in low yield areas in 2014 (Table 3) can be attributed to the imbalance of these elements in relation to K, since both Ca and Mg are essential for increasing the banana yield (Silva & Rodrigues, 2001).

In 2015, for the chemical attributes of the soil, in the nine areas that presented low yield, negative indexes for P and Ca were observed again (Table 3).

In the three evaluated years, despite being deficient in areas 7 and 11 in 2013 and in area 14 in 2014, K was the soil nutrient that most often presented a positive I_i index, or in other words the one that presented more content above the

critical level. On the other hand, P and Ca were the nutrients that had negative I_i index in the majority of low productivity banana plants. Due to the nutrient dynamics in the soil and the banana plant demands, there is a emphasis in the importance of application of correctives with higher Ca contents, the adequate P fertilization in the banana plantations and in the initial stage of the plants, and the direct relation between potassium fertilization and cultivation yield.

Obtained critical levels for leaf nutrient contents in irrigated cv. "Prata-Anã" banana plant from the studied areas using the method of reduced normal distribution are displayed in Table 4.

Estimated critical levels of leaf nutrient contents by the method of reduced normal distribution are within the sufficiency ranges found by Silva & Carvalho (2005) for the "Prata-Anã" banana plant in northern Minas Gerais, estimated by the mean and standard deviation, except for N and Fe that were slightly below (Table 4).

Differences in critical levels values were verified when comparing the nutritional survey conducted in the banana crops of northern Minas Gerais, with a irrigated cv. "Prata-Anã" predominance, made by Silva & Rodrigues (2001) using the mean and standard deviation method, and with the results obtained by Borges & Caldas (2004), in the regions of Petrolina-PE/Juazeiro-BA, with the "Pacovan" cultivar (Table 4). These are attributed to the used methodologies, the banana evaluated varieties and the edaphoclimatic conditions, evidencing the importance of these factors and technological level for a safer interpretations of the results of plant tissue analysis.

As for the chemical attributes of the soil, in the low yield areas, those below 27 t ha^{-1} had their leaf contents evaluated through the I_i index, where positive values indicate contents above the critical level and negative values lower contents.

In 2014, the areas of low yield were 4; 5; 7; 8; 9; 10; 11; 12 and 14 and the nutrient that showed leaf indices below the critical level in the largest number of areas was N, observed in five areas (5, 10, 11, 12 and 13) (55.56%), and followed by K, deficient in four areas (10, 11, 12, 13 and 14) (44.45%) (Table 5).

When evaluating the nutritional status of banana plants in the northern region of Minas Gerais, using 1099 leaf samples of banana plants with predominance of "Prata-Anã" cultivar, Silva & Rodrigues (2001) observed N and K deficiency in 57%

and 66% of the samples, respectively, a result very similar to this study. These authors also found that 36% of the leaf samples had some deficiency type of macronutrient and 95% micronutrient and, in general, 97% of the evaluated banana plants showed some kind of deficiency. Silva & Carvalho (2005), when evaluating the nutritional status of the irrigated "Prata-Anã" banana plants in 56 commercially exploited areas in northern Minas Gerais, also found N and K deficiencies in 31% and 46%, respectively, of the banana plantations.

Negative values of I_i index for N in these results indicate the need to review the nitrogen fertilization program in the low yield banana plants of this study. On the other hand, there are divergent results in the literature regarding the response of banana plantations in the application of nitrogen fertilizers. Silva et al. (2012) found no effect of N application on the banana development and production variables, while Silva et al. (2003) obtained significant effect of N application on the banana production in the second and third production cycles.

In 2015, the areas of low yield were 5; 7; 8; 9; 10; 11; 12; 13 and 14 and the nutrient that showed values below the critical level in the largest number of areas was K, observed in eight areas (7, 8, 9, 10, 11, 12, 13, 14) (88.89%) and followed by Cu, which was deficient in seven areas (77.78%) and Zn (66.67%) (Table 3).

From 2014 to 2015, it was observed that the areas that had leaf contents for K below the critical level increased from four to eight mg dm^{-3}; however, the values of this nutrient in the soil were satisfactory, being equal or higher than the critical level, as previously discussed. This can be explained by the dilution effect, where the nutrient absorption occurs by the plant, however, a proportionally greater growth and development happens, not allowing the increase of its leaf content in the same magnitude (Fernandes et al., 2008).

Cu and Zn that were deficient in 77.78% and 66.67%, respectively, of the low yield areas were not measured in the soil analysis, so it cannot be stated that their leaf contents are deficient because they have low content in the ground. Despite the Cu and Zn input as much from restitution for the plantation remains as from fertilization carried out in the studied areas, it seems not enough to increase these nutrients content in the leaf, which generated the negative values of I_i index.

Table 4. Critical levels for leaf contents due to reduced normal distribution.

		Silva & Carvalho (2005)	Silva & Borges (2008)	Borges & Caldas (2004)
N	23.8	25.0 − 29.0	25.0 − 26.0	22.0 − 24.0
P	1.7	1.5 − 1.9	1.68 − 1.72	1.7 − 1.9
K	35.6	27.0 − 35.0	27.0 − 28.0	25.0 − 28.0
Ca	6.6	4.5 − 7.5	5.9 − 6.1	6.3 − 7.3
Mg	2.9	2.4 − 4.0	3.35 − 3.44	3.1 − 3.5
S	1.7	1.7 − 2.0	1.85 − 1.89	1.7 − 1.9
Fe	62.31	72.0 − 157.0	98.5 − 106.4	71.0 − 86.0
Zn	17.94	14.0 − 25.0	18.7 − 19.7	12.0 − 24.0
Mn	280.32	173.0 − 630.0	514.3 − 566.3	315.0 − 398.0
B	12.36	12.0 − 25.0	33.5. − 34.2	13.0 − 16.0
Cu	7.10	2.6 − 8.8	7.2 − 8.0	6.0 − 7.0

*Values of N, P, K, Ca, Mg and S are in g kg^{-1} and Fe, Zn, Mn, B, Cu in mg kg^{-1}.

Table 5. Yield and I$_i$ index of leaf contents of low yield areas of irrigated banana crop in northern Minas Gerais in 2014 and 2015.

Area	Yield (Mg ha⁻¹)	N	P	K	Ca	Mg	S	Fe	Zn	Mn	B	Cu
						I$_i$ index						
2014												
4	23.68	0.00	0.06	0.00	0.03	0.03	0.06	0.20	0.24	0.22	0.13	0.17
5	25.87	-0.02	0.06	0.01	0.02	0.00	0.06	0.09	0.11	-0.05	0.19	0.11
7	22.87	0.00	0.06	0.00	0.11	-0.03	0.06	0.28	0.12	0.17	0.05	0.26
8	21.47	0.00	0.06	0.00	0.11	-0.03	0.06	0.28	0.12	0.68	0.05	0.26
9	23.77	0.00	0.06	0.00	0.11	-0.03	0.06	0.28	0.12	0.68	0.05	0.26
10	22.97	-0.06	0.00	-0.15	0.33	0.17	0.06	0.12	0.09	0.03	0.04	0.08
11	23.89	-0.06	0.00	-0.15	0.33	0.17	0.06	0.12	0.09	0.03	0.04	0.08
12	21.31	-0.06	0.00	-0.15	0.33	0.17	0.06	0.12	0.09	0.03	0.04	0.20
14	21.73	-0.06	0.00	-0.15	0.33	0.17	0.06	0.12	0.09	0.03	0.04	0.08
2015												
5	20.85	0.05	0.06	0.01	-0.02	0.00	0.12	0.17	0.08	0.12	-0.04	-0.08
7	18.46	0.01	0.06	-0.03	0.09	0.00	0.06	0.06	0.04	0.22	0.08	0.09
8	26.60	0.00	0.00	-0.04	0.06	-0.03	0.06	0.03	-0.05	0.26	0.10	-0.06
9	25.32	0.01	0.06	-0.03	0.09	0.00	0.06	0.06	0.04	0.22	0.08	0.09
10	20.47	0.00	0.06	-0.09	0.23	0.03	0.06	0.02	-0.09	-0.13	0.11	-0.06
11	17.08	0.00	0.06	-0.09	0.23	0.03	0.06	0.02	-0.09	-0.13	0.11	-0.06
12	22.90	0.00	0.06	-0.09	0.23	0.03	0.06	0.02	-0.09	-0.13	0.11	-0.06
13	25.17	0.00	0.06	-0.09	0.23	0.03	0.06	0.02	-0.10	-0.13	0.11	-0.06
14	22.36	0.00	0.06	-0.09	0.23	0.03	0.06	0.02	-0.09	-0.13	0.11	-0.06

Silva & Carvalho (2005), when evaluating the nutritional status of irrigated "Prata-Anã" banana plants in the north of Minas Gerais also observed that Cu, together with Mn, were the micronutrients that were deficient in most banana plants. Silva & Rodrigues (2001), also in banana crops in northern Minas Gerais, with predominance of "Prata-Anã" cultivar, observed severe Zn deficiencies in 72% of samples, adequate content in 26% of samples and excess in 2% of the samples evaluated. However, it should be noted that some soils in northern Minas Gerais are originated from limestone rocks and some banana plants are irrigated with groundwater with high Ca^{+2}, CO_3^{-2} and HCO_3^{-} concentrations, which raise the soil pH, decreasing the availability of cationic micronutrients to plants (Fernandes et al, 2008; Silva & Carvalho, 2005).

Conclusions

The methodology of reduced normal distribution for obtaining critical nutrient levels in soil and plants is similar to those used by other authors.

The most limiting nutrients in the soil in 2013 were K and Ca, in 2014 and 2015 were P and Ca, resulting in the low yields.

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