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Compositional nutrient diagnosis in two oil palm genetic materials

Oil palm is a hybrid formed from different genetic materials, where different genetic varieties possibly have different nutritional demands. The O x G hybrid is supposed to need more nutrient than the Africana palm. The diagnosis of nutritional composition is made by the method of diagnosis of compositional nutrients, which uses nutritional standards in cormercia plantations, this method also supports the recommendation of fertilization. The objective was to generate standards for the diagnosis of nutritional composition (CND) in oil palm for N, P, K, Ca, Mg, S and B leaf and to perform diagnoses in tenera and interspecific hybrids (O x G). The CND and Sufficiency Ranges (FS) method was used in 240 samples of plantations in Pará, up to 6 years old, as well as data on the yield of dried fruit cluster (FFB) and chemical analysis of leaves for N, P, K, Ca, Mg, S and B. Oil palm plantations are located in the Moju municipality, in the north of the state of Pará. Reference values were obtained based on the multivariate relationships between CND indices and nutrients. Comparing leaf contents and degree of agreement (DA) with sufficiency ranges (SR). In both methods, the nutrient with the highest deficiency was S. The plots with tenera and O x G presented, respectively, more cases of B and S deficiency by CND. This method points out different nutritional needs among genetic materials, as well as may help better fertilization recommendations.

Keywords: Plant Nutrition; Leaf Diagnosis; Elaeis oleífera x E. Guineenses (O x G).

Diagnose da Composição Nutricional em dois materiais genéticos de palma de óleo

A palma de oléo é um hibrido formado a partir de diferentes matérias genéticos, em que as diferentes variedades geneticas possivelmente possuem diferentes demandas nutricionais. O híbrido O x G supostamente necessita de mais nutriente do que a palma afriacana. A diagnose da composição nutricional é realizada pelo método de diagnóstico de nutrientes composicionais, que utiliza padrões de nutricionais em plantios cormercias, este método também apóia a recomendação de fertilização. O objetivo foi gerar normas da diagnose da composição nutricional (CND) em palma-de-óleo para N, P, K, Ca, Mg, S e B foliares e realizar diagnósticos em híbridos tenera e interespecíficos (O x G). Utilizou-se o método CND e Faixas de Suficiência (FS) em 240 amostras de plantios no Pará, com idade de até 6 anos, além de daos sobre a produtividade do cacho de frutas secas (FFB) e aqnálise química das folhas para N, P, K, Ca, Mg, S e B. Os plantios da palma de oléo ficam localizados no monicipio de Moju, no norte do estado do Pará. Valores de referência foram obtidos com base nas relações multivariadas entre os índices de CND e os nutrientes. Comparando os conteúdos foliares e o grau de concordoância (DA) com as faixas de suficiência (SR). Nos dois métodos utilizados, o nutriente com mais casos de deficiência foi o S. Os talhões com tenera e O x G apresentaram, respectivamente, mais casos de deficiência de B e S pelo CND. Este método aponta necessidades nutricionais diferentes entre os materiais genéticos, bem como pode auxiliar melhores recomendações de adubação.

Palavras-chave: Nutrição de Plantas; Diagnose Foliar; Elaeis oleífera x E. guineenses (O x G).

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INTRODUCTION

The commercial oil palm uses different genetic materials. Tenera hybrid or African palm, resulting from the crossing between the plants with dura type and psifera type fruits, which are classified according to the thickness of the endocarp (MAIA, 2016), and the O x G interspecific hybrid results from the *Elaeis oleifera x Elaeis guineenses* crossing (CHIA et al., 2009).

Different genetic materials may have different nutritional requirements. Apparently, O x G requires more nutrient than African palm because it often exhibits typical symptoms of magnesium and boron deficiency (FRANZINI et al., 2012; RINCÓN et al., 2012). The compositional nutrient diagnosis (CND) method (PARENT et al., 1992) is a tool that provides accurate diagnoses using nutritional standards or norms established in commercial or experimental plantations.

The CND used exclusively or in addition to the ranges of sufficiency support the recommendation of fertilization, therefore, allowing the optimization of costs with fertilizers. The objective of this study was to generate reference CND values in commercial palm oil cultivation for leaf N, P, K, Ca, Mg, S, and B and to perform nutritional diagnoses in two different genetic materials of this species, which allows a better recommendation for fertilization.

METHODOLOGY

This study used the results of 240 foliar samples for the years 2011 to 2016 of plants up to 6 years of age, from a database owned by company MARBORGES SA, which included data on productivity of fresh fruit bunch (FFB) and leaf chemical analysis for N, P, K, Ca, Mg, S and B for the Tenera-type and O x G interspecific hybrid type plants. The plantations are located in the municipality of Moju, in Tomé-Açu micro-region in the north of the state of Pará. The leaflet collection for the chemical analyzes and the general pattern of fertilization in the sampled plots was described by Matos et al. (2018).

In order to obtain the norms, the reference subpopulation was first defined as FFB productivity > 9 t ha^{-1} $year^{-1}$, resulting in a total of 20 samples, similar to the value used by Matos et al. (2016). For the non-reference subpopulation, the productivity values were less than those established for the reference subpopulation, totaling 220 samples.

The reference values for calculation or CND norms (mean and standard deviation) were obtained from the multivariate relationships between the nutrients and the CND indexes. They were calculated using the log-centered multivariate relation method according to Parent (2011). The CND indexes were used in the diagnosis of the samples for each nutrient according to Beaufils ranges (SERRA et al., 2012), using standard deviation (s) values: deficient nutritional status < -4/3 s; sufficient = -2/3 to 2/3 s; excessive > 4/3 s.

Besides the CND diagnosis, the leaf contents of each plot were compared with the sufficiency ranges of (SR) of Fairhurst et al. (2003). These SRs contain a range of ideal nutrient values that were obtained from healthy plants and with a productive level equal to or greater than 90% of the maximum productivity. In addition, the degree of agreement (DA) of the diagnoses generated by the CND was calculated in comparison

to the SR.

RESULTS AND DISCUSSION

Considering the CND norms established for planting, all multi-nutrient variables showed normality (Table 1). These results demonstrate that the process of logarithmization inherent to the CND method is important for data normalization, therefore, providing more reliable nutritional diagnoses.

Table 1: Descriptive statistics of leaf contents and productivity and Mean, Standard Deviation (s), coefficient of variation (CV) and p-value for CND norms for nutrients and dry matter (DM) in commercial plots of high productivity oil palm population (reference) in northeastern Pará.

High productivity (Reference)						CND norms			
Nutrients	Mean	Minimum	Maximum	CV (%)			Mean	S	P value*
Prod. (t ha^{-1})	17.56	11.61	31.49	28.65		VMs	5.302	0.06	> 0.05
N (g kg^{-1})	26.2	22.5	31.4	8.93		VN	1.31	0.08	> 0.05
P (g kg^{-1})	1.7	1.5	2	8.97		VP	- 1.40	0.07	> 0.05
K (g kg^{-1})	8.4	7.1	10.7	13.03		VK	0.17	0.12	> 0.05
Ca (g kg^{-1})	9.5	7.1	11.7	15.52		VCa	0.28	0.15	> 0.05
Mg (g kg^{-1})	2.6	1.8	3.6	20.53		VMg	-1.03	0.2	> 0.05
S (g kg^{-1})	1.34	1	2,55	26.86		VS	-1.69	0.2	> 0.05
B (mg kg^{-1})	23.51	13.51	34.69	24.97		VB	-5.73	0.28	> 0.05

*p > 0.05 is not significant neither normal by the Shapiro-Wilk normality test.

By taking into account the number of evaluated samples, the most frequent nutrients in O x G deficiency status were S> P> Ca> N> Mg> K> B, in the CND method, and S> N> K> P> Mg> Ca> B by evaluating the sufficiency ranges of Fairhurst et al. (2003) (Table 2). For the Tenera hybrid, the frequency order of deficiency was B> P> S> Ca> N> K = Mg in the CND method, and S> K> N> P> Mg> B> Ca by the ranges of the sufficiency of Fairhurst et al. (2003).

Table 2: Percentage of plants with deficient (D), adequate (A), excessive (E) and nutritional status and degree of agreement (DA) between the performed diagnoses, according to the sufficiency ranges shown in the literature and from the diagnosis method of the nutritional composition (CND), in commercial plots of young palm oil plants, in northeastern Pará.

Nutrient	Method	Nutritional Status								
		O x G					Tenera			
		DA	D	A	E	%	DA	D	A	E
N	CND	42.5	38.1	33.6	28.3		48.03	25.2	38.6	36.2
	Fairhurst		85.0	14.2	0.9			36.2	58.3	5.5
P	CND	63.7	46.9	43.4	9.7		53.54	37.0	42.5	20.5
	Fairhurst		69.0	31.0	0.0			29.9	70.1	0.0
K	CND	19.5	19.5	24.8	55.8		22.83	22.8	28.3	48.8
	Fairhurst		81.4	18.6	0.0			70.1	29.9	0.0
Ca	CND	24.8	44.2	33.6	22.1		37.01	31.5	33.1	35.4
	Fairhurst		0.9	31.9	67.3			0.0	15.0	85.0
Mg	CND	78.8	21.2	43.4	35.4		77.17	22.8	35.4	41.7
	Fairhurst		28.3	71.7	0.0			15.7	84.3	0.0
S	CND	60.2	59.3	36.3	4.4		37.01	36.2	59.8	3.9
	Fairhurst		96.5	2.7	0.9			97.6	1.6	0.8
B	CND	50.4	17.7	50.4	31.9		40.9	37.8	35.4	26.8
	Fairhurst		0.0	100.0	0.0			2.4	94.5	3.1

It can be seen that nutrient S presented a high deficiency frequency in the stands, regardless of the genetic material and the method used. Sulfur is a very important macronutrient for oleaginous crops such as palm because it is related to oil biosynthesis and formation of storage organs of saturated fatty acid (SABIR

et al., 2015).

The lack of S in the oil palm can be attributed to the losses caused by the reduction of this nutrient through FFB and leaching. Losses caused by sulfur leaching are related to sandy soils and the high S mineralization rate in organic matter (GERENDAS et al., 2009; SABIR et al., 2015), common factors in crops in the state of Pará. In addition, sulfate fertilization sources such as organic and magnesium sulfate, as described by Matos et al. (2016), and possibly ammoniacal N sources used in these plantations may not have been sufficient in the case of losses and the rate of extraction in the studied crop.

Regarding the CND diagnosis, Tenera hybrid presented more plots poor in B and P while O x G showed more cases of S and P deficiency. In relation to B deficiency in Tenera plants, using the DRIS and CND methods, Matos et al. (2016) found B as the micronutrient with greater frequency of deficiency in young and adult plants. The symptoms of B deficiency occur first in the younger leaves causing a decrease in the apical meristems, and the leaves are brittle with reduced foliar expansion and mainly writhing and thick. Boron deficiency is commonly found in oil palm plantations and is significantly aggravated in regions of acidic, sandy soils and areas subjected to high annual rainfall, as the nutrient is easily leached (GUTIÉRREZ-SOTO et al., 2013).

It is interesting to note that in the range of Fairhurst et al. (2003), O x G presented twice as many cases of Mg deficiency in relation to Tenera, a very recurrent situation in field conditions in Pará by means of visual diagnosis. This fact meets the information of Franzini et al. (2012), which report the O x G requires more Mg. Magnesium deficiency is one of the most common for oil palm, especially in soils with low clay content. Deficiency in Mg begins with yellowing at the apexes of the leaflets at the extremities of the older leaves and in the most intense cases, all the leaves of the palm display this pattern, and the most affected part of the leaflet tends to dry (FAIRHURST et al., 2003).

For both genetic materials (O x G and Tenera), the percentage of agreement in the nutritional diagnoses was generally low, especially those of K (21.3%) and Ca (31.3%). This divergence occurred in palm plantations in Moju, in the state of Pará (MATOS et al., 2016), when diagnosis obtained from ranges generated by DRIS, CND and ChM were compared. Differences between methods of foliar diagnosis are expected, but in this case, it is important to observe the several tools used for decision making in crop fertilization, as it is done in the eucalyptus crop, which has interpretive software, such as NUTRICALC (BARROS et al., 1995) and FERTICALC (NOVAIS et al., 1999).

CONCLUSIONS

A higher frequency of S deficiency was found in the plots both for the ranges of sufficiency and for the CND. This method highlighted S as it displayed more cases of deficiency for O x G and B for the Tenera. The use of CND foliar diagnosis allows to observe a differentiated pattern in the nutrition of these palm oil hybrids as well as to generate reliable information for the fertilization recommendation.

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