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REFERENCE VALUES FOR ASSESSING THE NUTRITIONAL STATUS OF SOYBEAN CROPS IN MATO GROSSO

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ABSTRACT - Monitoring the nutritional status of the soybean crop, based on nutrient levels in the third trefoil with petiole, can help improve fertilization. The objective of this work was to determine the reference values of macro and micronutrient contents, to evaluate the nutritional status of soybean crops, regarding the degree of balance and to obtain the potential response to fertilization for nutrients. The work was carried out based on a database of foliar nutrient contents and grain yield of soybean crops in Mato Grosso, Campo Novo dos Parecis region, covering different agricultural years, cultivars, soil textures and times of use of the area. with the soybean crop. They were obtained from useful reference values for the evaluation of the nutritional status of soybean crops, regarding the degree of balance, plus limits of nutrient content in the normal range, according to the balance by the Kenworthy method. In low-yield soybean crops in the region studied, on average, for macronutrients, 69.7% of crops are in the normal class, while for micronutrients this percentage is lower, 60.9%. N is the nutrient most found in crops (83.2%), while Cu (49.8%) is the least found in the normal class. Of the low productivity soybean crops studied in this work, 78.3% have adequate nutritional balance. Mg, P and Ca and Cu, Mn and Zn are those for which there are greater expectations of crop productivity gains, in response to fertilization.
Keywords: Kenworthy, leaf analysis, nutrition.

VALORES DE REFERÊNCIA PARA AVALIAÇÃO DO ESTADO NUTRICIONAL DE LAVOURAS DE SOJA NO MATO GROSSO

RESUMO - O monitoramento do estado nutricional da cultura da soja, com base nos teores dos nutrientes no terceiro trifólio com pecíolo, pode subsidiar o aprimoramento das fertilizações. O objetivo do trabalho foi determinar os valores de referência de teores de macro e micronutrientes, avaliar o estado nutricional de lavouras de soja, quanto ao grau de balanço e obter o potencial de resposta à adubação para os nutrientes. O trabalho foi realizado com base em banco de dados de teores foliares de nutrientes e produtividade de grãos de lavouras de soja no Mato Grosso, região de Campo Novo dos Parecis, abrangendo diferentes anos agrícolas, cultivares, texturas do solo e tempos de uso da área com a cultura da soja. Foram obtidos a partir de valores de referência úteis à avaliação do estado nutricional das lavouras de soja, quanto ao grau de equilíbrio, acrescidos de limites de teores de nutrientes da faixa normal, conforme o balanço pelo método Kenworthy. Nas lavouras de soja de baixo rendimento na região estudada, em média, para macronutrientes, 69.7% das lavouras estão na classe normal, enquanto para micronutrientes esse percentual é menor, 60.9%. O N é o nutriente mais encontrado nas lavouras (83,2%), enquanto o Cu (49,8%) é o menos encontrado na classe normal. Das lavouras de soja de baixa produtividade estudadas neste trabalho, 78,3% apresentam balanço nutricional adequado. Mg, P e Ca e Cu, Mn e Zn são aqueles para os quais há maiores expectativas de ganhos de produtividades das lavouras, em resposta à fertilização.
Palavras-chave: Kenworthy, análise foliar, nutrição.

INTRODUCTION

One of the reasons for the success of the culture of soybean in Brazil is the savings in fertilizer, for account the fixing of N by soybean - symbiotic bacterium *Bradyrhizobium japonicum* and *Bradyrhizobium elkanii* (DOMINGOS et al., 2015) which makes unnecessary the addition of mineral N crop crops (SANTOS et al., 2008; KURIHARA et al., 2013). However, the conditions of high acidity in tropical and subtropical regions and low fertility, frequent in soils in areas generally used for cultivation of this crop, make liming and mineral fertilization necessary, and even essential (SILVA et al., 2020) to that plant growth and the ratio area/part of the root are adequate, not interfering with the genetic potential of soybean productivity (FREIBERGER et al., 2014).

To guide the management nutritional the culture of soybean is made using the analysis chemistry of the soil, whose results must be interpreted based on criteria diagnoses listed in the literature (CANTARUTTI et al., 2007) and used for calculation of nutrient supply by soil module in balance models (SANTOS et al., 2008) making it possible, by both these strategies, to determine the

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recommended doses of nutrients to be used in the fertilization of the crop. Performed the fertilization, the culture will grow and develop and, by the time of flowering is recommended to monitor the nutritional status of the crop which is made by collecting and chemical analysis as to the contents of macro and micronutrients in the third trifoliate with petiole.

The use of the leaf as the organ most suitable, usually to investigate the nutritional status of crops with base in analysis of tissue, it is due to be the body more physiologically active responsible for the production of assimilates and having higher correlation between the levels of nutrients and crop productivity (CANTARUTTI et al., 2007). According to Malavolta (1997), there are premises that must be met in order to properly use tissue analysis; in essence there must be a relationship between the availability of the nutrient in the soil and the content of the nutrient in the tissue and with the productivity of the crop.

Based on the interpretation of nutrient content in the leaf through univariate methods such as the Kenworthy Balanced Index (IBK), the nutritional status of the crop is evaluated (COELHO et al., 2013).. Thus, taking into account the results of the soil analysis, the amounts of correctives and fertilizers provided and the assessment of the nutritional status of the crop, the fertilization program for the next crop of the soybean crop to be planted can be refined tracts. Thus, leaf analysis is a valuable operational tool for reinforcing the fertilization recommendation. Thus, leaf analysis is a valuable tool for improving the recommendation of fertilization (CAMACHO et al., 2012), being effective for planning and monitoring fertilization projects for both perennial and annual crops (DIAS et al., 2013).

There are several methods for assessing nutritional status, with emphasis on the method of balanced indices of Kenwort h y (KW) for the assessment of the degree of balance of each nutrient involved in the diagnosis (KENWORTHY, 1961). This method analyzes nutrients in a pediatric way, being considered a univariate technique that makes it possible to relate fertilizer doses with nutrient concentrations in the tissue (GOTT et al., 2014).).

In order for the KW method to be used and inform the balance leaf indices (KW indices) there is a need to have reference values for the contents. These reference values are commonly referred to as standards, since they generally follow the normal distribution or close to it. However, the reference values vary with the edaphoclimatic conditions, with the genetic plant material and with the management of the culture, once they are influenced by all the factors that influence the nutrient absorption rate and the growth rate of the plant (FERNANDES, 2010). Thus, it is recommended that the reference values be obtained for each condition of soil and climate, of genetic material and management (SILVA et al., 2005).

The region of Campo Novo dos Parecis, state of Mato Grosso, stands out for the adequate conditions of climate, relief and soil (in terms of physical aspects) for the cultivation of soybeans. However, its soils, which vary in texture, are generally acidic and of low fertility, requiring the addition of correctives and fertilizers (LIMA, 2004). In addition, it is necessary to investigate whether the nutritional norms vary with the time of use of the area, that is, with the history of cultivation with soybean culture.

Thus, the objectives of this study were to determine reference values (standards) levels of macro and micronutrients, useful to the assessment of the balance leaf at Kenworthy method, Assess the nutritional status of low productivity soybean crops as the degree of balance and obtain the potential for response to fertilization for nutrients.

MATERIAL AND METHODS

The study was carried out based on a database of leaf nutrient content and grain yield of soybean crops in Mato Grosso, Campo Novo dos Parecis region, covering different agricultural years, cultivars, soil textures and time of use area with soybean culture.

To obtain nutritional standards for use in assessing nutritional status as to the degree of balance using the Kenworthy balanced index method (KENWORTHY, 1961), reference populations were initially established, according to different stratification criteria: a) not stratified, that is, considering the entire database, and integrated by crops with above average productivity, b) not stratified, but integrated by crops with above average productivity plus 0.5 standard deviation, c) not stratified, but integrated by crops with above-average productivity plus 1 standard deviation, d) by soil texture (clayey, medium and sandy, sandy), e) by cultivar (Pintado, Uirapuru, Tucano), f) by time of use of the area with soybeans (new areas, areas with 1 crop, areas with 2 or 3 crops, areas with 4 to 6 crops). For the reference populations referring to daf items, their crops were always those with higher than average productivity.

Considering the reference populations, the standards for use in the Kenworthy method (KW standards) consisted of the mean and standard deviation of the levels of N, P, K, Ca, Mg, S, Cu, Fe, Zn, Mn and B. With the rules in place, the nutritional status of low-productivity crops was diagnosed, considered as those that did not integrate the reference population.

In calculating Kenworthy balanced indices (KW indices), the following equations are used:

$$P = \frac{100\,\mathrm{yi}}{\bar{\mathrm{y}}} \qquad \text{(Equation 1)}$$

$$I = \frac{CV\ (y\,i - \bar{\mathrm{y}})}{\bar{\mathrm{y}}} \qquad \text{(Equation 2)}$$

$$IBKW = P - I \qquad \text{(Equation 3)}$$

Where:

P = proportion (%) between the nutrient content in the sample (yi) and the standard content ($\bar{\mathrm{Y}}$),

I = influence of variation (%) and

CV = coefficient of variation (%) of the nutrient content in the reference population.

The IBKW interpretation of nutrients was made according to the following diagnostic classes: deficient (IBKW <50%); below normal (50 ≤ IBKW <83%); normal (83 ≤ IBKW < 117%); above normal (117 ≤ IBKW <150) and excessive (150% ≤ IBKW). Also, based on the norms for use in the Kenworthy method, the reference values of leaf nutrient contents were calculated considering the limits for the values of the balanced indices (IBKW) of the Normal class regarding the degree of balance, according to Equation 4, as proposed by Fernandes (2010):

For the normal class:

$$\geq \frac{83\% - CV\%}{\frac{100}{\bar{y}} - \frac{CV\%}{\bar{y}}} \text{ and } < \frac{117\% - CV\%}{\frac{100}{\bar{y}} - \frac{CV\%}{\bar{y}}} \qquad \text{(Equation 4)}$$

RESULTS AND DISCUSSION

Norms for the assessment of the degree of balance by the Kenworthy method

The norms of contents of more general meaning, for the evaluation of the degree of balance by the Kenworthy method, and according to the stratification criteria adopted are presented in Table 1. It appears that the standards differ according to the stratification criterion adopted and with the nutrient considered, as to the mean and as to the variability around the mean, as indicated by the standard deviation and coefficient of variation (CV).

TABLE 1 - Reference values (norms) of leaf contents (macronutrients in g kg^{-1} and micronutrients, in mg kg^{-1}) of nutrients in soybean crops in the region of Campo Novo dos Parecis, Mato Grosso, according to several stratification criteria, for the assessment of the degree of balance by the Kenworthy method.

Average	Set of standards										
	N	P	K	Ca	Mg	S	Cu	Fe	Zn	Mn	B
Generic (prodt > average) n=426	50.38	2.90	17.46	8.86	3.65	2.66	10.20	123.7	51.5	55.9	42.7
Generic (prodt > average +0.5 detour) n=219	50.82	2.98	17.01	9.21	3.69	2.70	10.97	124.1	53.5	59.9	42.9
Generic (prodt > average + 1 detour) n=80	51.38	3.05	16.80	10.08	3.73	2.71	10.49	128.3	52.1	58.8	42.2
Grow crops Pintado n=86	54.29	3.11	18.73	8.42	3.79	2.93	9.48	134.4	52.4	49.5	44.7
Grow crops Tucano n=50	49.04	2.91	18.00	8.35	3.38	2.52	10.14	110.6	54.4	57.7	48.7
Grow crops Uirapurú n=136	49.84	2.86	17.63	9.06	3.74	2.63	10.64	123.1	50.9	54.4	41.3
Clay texture n=90	50.56	2.84	17.97	8.95	3.61	2.64	11.09	132.0	50.9	55.9	41.6
Medium and sandy texture n=46	49.54	3.07	16.14	9.60	4.00	2.60	9.79	106.3	53.5	54.0	39.2
Sandy Texture n=29	48.89	3.09	16.64	9.77	4.14	2.65	9.80	104.6	51.4	50.7	39.9
New Areas n=8	48.19	2.58	13.55	7.54	4.10	2.44	6.63	105.8	48.1	107.5	32.3
Crops 1 n=17	51.14	3.02	11.52	11.28	3.52	2.46	11.06	102.5	52.9	76.4	34.9
Crops 2 e 3 n=18	50.65	3.00	15.23	9.44	4.12	2.62	12.50	90.2	53.9	54.6	38.9
Areas with 4 to 6 crops n = 90	50.12	2.94	15.94	9.59	3.38	2.41	9.99	100.8	52.6	46.6	37.2
..........standard deviation..........											
Generic (prodt > average) n=426	7.03	0.51	3.74	2.07	0.80	0.59	3.66	65.5	14.4	26.5	9.4
Generic (prodt > average +0.5 detour) n=219	6.29	0.44	4.05	2.29	0.83	0.62	4.28	76.5	15.1	29.3	9.9
Generic (prodt > average + 1 detour) n=80	5.65	0.36	4.46	2.57	0.91	0.57	4.18	49.9	13.2	25.0	9.4
Grow crops Pintado n=86	5.57	0.39	3.59	1.74	0.83	0.58	2.42	95.6	12.4	19.2	8.9
Grow crops Tucano n=50	4.97	0.46	2.96	1.93	0.64	0.42	2.91	43.6	12.9	22.7	12.9
Grow crops Uirapurú n=136	8.04	0.54	3.52	1.90	0.75	0.62	4.00	45.4	15.5	27.2	9.0
Clay texture n=90	8.23	0.56	3.16	1.82	0.69	0.66	4.40	50.3	16.0	26.6	9.2
Medium and sandy texture n=46	6.91	0.48	4.44	2.24	0.74	0.52	2.85	27.4	13.9	27.6	8.1
Sandy Texture n=29	7.22	0.41	4.50	2.07	0.74	0.58	2.01	23.6	13.8	20.5	9.3
New Areas n=8	8.02	0.56	1.42	1.22	1.19	0.51	2.07	49.5	24.2	72.6	9.7
Crops 1 n=17	4.56	0.27	2.84	3.53	0.73	0.30	5.84	17.2	9.2	30.8	6.2
Crops 2 e 3 n=18	4.21	0.30	4.02	1.51	0.96	0.37	5.62	13.5	17.6	30.4	8.1
Areas with 4 to 6 crops n = 90	4.04	0.35	3.07	1.86	0.69	0.41	4.17	50.5	13.0	21.1	7.4
..........CV (%)..........											
Generic (prodt > average) n=426	13.9	17.7	21.4	23.4	21.9	22.1	35.9	52.9	27.9	47.4	22.0
Generic (prodt > average +0.5 detour) n=219	12.4	14.7	23.8	24.9	22.4	22.8	39.0	61.7	28.3	48.9	23.0
Generic (prodt > average + 1 detour) n=80	11.0	11.8	26.5	25.5	24.5	21.2	39.9	38.9	25.3	42.5	22.3
Grow crops Pintado n=86	10.3	12.5	19.2	20.6	21.8	19.8	25.5	71.1	23.6	38.8	20.0
Grow crops Tucano n=50	10.1	15.9	16.4	23.1	19.0	16.5	28.7	39.4	23.8	39.3	26.5
Grow crops Uirapurú n=136	16.1	19.0	20.0	21.0	20.0	23.7	37.6	36.9	30.5	49.9	21.8
Clay texture n=90	16.3	19.8	17.6	20.4	19.2	24.9	39.7	38.1	31.4	47.7	22.1
Medium and sandy texture n=46	13.9	15.5	27.5	23.3	18.6	19.9	29.1	25.8	26.1	51.1	20.7
Sandy Texture n=29	14.8	13.1	27.1	21.2	17.9	21.8	20.5	22.6	26.8	40.5	23.3

Continuation of Table 1 – References values…

New Areas n=8	16.6	21.7	10.5	16.1	29.0	20.8	31.2	46.8	50.3	67.6	30.2
Crops 1 n=17	8.9	8.8	24.7	31.3	20.6	12.1	52.8	16.7	17.4	40.3	17.7
Crops 2 e 3 n=18	8.3	10.1	26.4	16.0	23.2	14.2	44.9	15.0	32.6	55.7	20.8
Areas with 4 to 6 crops n = 90	8.1	11.9	19.3	19.4	20.4	16.9	41.7	50.1	24.6	45.3	19.8

N = nitrogen, P = phosphorus, K = potassium, Ca = calcium, Mg = magnesium, S= súlfur, Cu = Copper, Fe = iron, Zn = zinc, Mn = manganese, B = boron, n = number of crops.

Regarding the numerical value of the mean, that is, the magnitude of the value of the norm, in relation to macronutrients, N is the one with the highest content and P the one with the lowest content, according to the sequences: macronutrients: N> K> Ca> Mg> S> P and micronutrients: Fe> Zn> Mn> B> Cu. It can be observed in relation to the KW standard for P that its magnitude is lower for crops grown in clayey soils compared to other textures (Table 1) which can be explained based on the different capacities - P buffer in the soil.

The CV of each standard indicates the precision of the standard: a lower value of CV indicates greater precision and vice versa. It appears in a joint assessment that, in general, macronutrient standards are more accurate than micronutrient standards. The nutrient whose norm is the most accurate is N and Mn and Fe are the nutrient whose norms are, almost always, the least accurate. More precise rules result in greater sensitivity and accuracy of diagnoses. Thus, Rocha (2008) found that the Kenworthy method is less sensitive as to the diagnoses produced for nutrients whose standards have a CV greater than 30%, especially for detecting deficiency situations. In this work it is seen in Table 1, considering the sets of norms obtained, that the nutrients whose norms have CV greater than 30% are Mn (47.3%), Fe (39.7%), Cu (35.9%).

Based on the values of the norms, the levels of leaf macro and micronutrients corresponding to the limits of the diagnostic classes proposed in the Kenworthy method (Table 2) were obtained, as proposed in Fernandes (2010). The levels thus obtained are very useful, allowing quick and easy assessment of the nutritional status of crops in terms of balance. As a consequence of the different degree of precision of the standard, it is observed, that the relative amplitude of the content ranges corresponding to the diagnostic classes is also different.

TABLE 2 - Values of macronutrient (g kg^{-1}) and micronutrient (mg kg^{-1}) contents corresponding to the limits of the Normal class, that is, from IBKW 83 to IBKW 117.

Set of Standards	IBKW	N	P	K	Ca	Mg	S	Cu	Fe	Zn	Mn	B
Generic (prodt > average) n = 426	83%	40.43	2.30	13.69	6.89	2.86	2.08	7.49	79.03	39.35	37.84	33.39
	100%	50.38	2.90	17.46	8.86	3.65	2.66	10.20	123.73	51.48	55.89	42.69
	117%	60.33	3.50	21.24	10.82	4.45	3.24	12.90	168.42	63.62	73.94	52.00
Generic (prodt > average + 0.5 detour) n = 219	83%	40.96	2.38	13.21	7.12	2.88	2.11	7.91	69.05	40.79	39.97	33.39
	100%	50.82	2.98	17.01	9.21	3.69	2.70	10.97	124.10	53.47	59.88	42.86
	117%	60.68	3.57	20.80	11.29	4.50	3.30	14.02	179.15	66.14	79.79	52.33
Generic (prodt > average + 1 detour) n = 80	83%	41.56	2.47	12.91	7.78	2.89	2.12	7.52	92.63	40.27	41.42	33.00
	100%	51.38	3.05	16.80	10.08	3.73	2.71	10.49	128.33	52.14	58.83	42.24
	117%	61.19	3.64	20.69	12.38	4.57	3.29	13.45	164.02	64.01	76.23	51.48
Grow crops Pintado n = 86	83%	43.63	2.37	14.48	6.49	2.76	2.19	6.05	72.88	40.68	34.78	34.63
	100%	53.77	2.96	18.28	8.36	3.56	2.79	10.20	135.28	53.92	54.38	44.56
	117%	63.91	3.56	22.08	10.24	4.36	3.38	14.35	197.69	67.15	73.99	54.49
Grow crops Tucano n = 40	83%	39.07	2.11	14.15	5.92	2.49	1.96	6.86	85.14	36.69	34.74	36.37
	100%	48.33	2.69	17.74	7.72	3.18	2.48	9.14	114.48	48.27	50.73	46.85
	117%	57.59	3.27	21.33	9.51	3.87	3.01	11.42	143.82	59.85	66.72	57.32
Grow crops Uirapurú n = 136	83%	39.61	2.15	13.60	6.85	2.81	2.00	7.36	90.68	38.96	34.96	32.70
	100%	49.83	2.75	17.26	8.77	3.58	2.57	10.10	124.34	51.07	52.37	41.68
	117%	60.05	3.35	20.91	10.69	4.35	3.15	12.83	158.00	63.18	69.77	50.66
Clay texture n = 90	83%	39.25	2.11	13.86	6.66	2.76	1.98	7.55	92.74	38.22	35.98	32.55
	100%	49.34	2.71	17.45	8.50	3.51	2.55	10.49	127.33	50.30	53.76	41.42
	117%	59.43	3.31	21.05	10.35	4.27	3.12	13.42	161.91	62.38	71.55	50.29
Medium and sandy texture n = 46	83%	40.42	2.22	13.05	7.28	2.92	2.05	7.05	86.42	40.59	32.84	33.05
	100%	50.91	2.83	16.82	9.35	3.71	2.63	9.25	117.81	52.76	49.31	42.25
	117%	61.40	3.43	20.59	11.42	4.51	3.20	11.44	149.20	64.93	65.78	51.46
Sandy Texture n =29	83%	40.54	2.28	12.91	7.39	3.01	2.08	7.24	84.80	40.30	35.22	32.79
	100%	51.00	2.90	16.76	9.50	3.82	2.66	9.29	117.03	52.19	48.51	42.10
	117%	61.47	3.51	20.61	11.60	4.63	3.23	11.34	149.27	64.07	61.80	51.40

Continuation of Table 1 – Values of macronutrient…

New Areas n = 8	83%	40.40	1.98	12.41	5.28	3.37	2.04	4.64	75.93	33.68	52.13	28.16
	100%	50.13	2.50	15.75	6.76	4.27	2.54	10.16	100.24	50.08	94.72	36.88
	117%	59.85	3.02	19.08	8.24	5.17	3.05	15.68	124.55	66.48	137.31	45.60
Crops 1 n =17	83%	42.07	2.30	9.77	7.12	2.84	2.04	-22.87	79.28	40.05	42.62	27.51
	100%	51.57	2.87	12.69	9.81	3.61	2.52	13.56	99.92	55.52	78.96	39.60
	117%	61.06	3.44	15.60	12.51	4.38	3.00	49.99	120.56	70.99	115.30	51.69
Crops 2 e 3 n =18	83%	40.27	2.35	12.23	7.36	2.78	2.01	7.48	77.39	40.70	32.01	29.73
	100%	49.47	2.93	15.87	9.29	3.68	2.52	11.07	98.82	53.54	49.68	37.79
	117%	58.67	3.51	19.50	11.22	4.59	3.03	14.66	120.25	66.37	67.34	45.84
Areas with 4 to 6 crops n = 90	83%	41.56	2.32	13.25	7.40	2.56	1.94	6.74	54.64	41.58	34.62	30.25
	100%	51.06	2.88	16.80	9.44	3.26	2.44	9.51	120.22	54.27	50.15	38.44
	117%	60.56	3.44	20.35	11.49	3.96	2.94	12.29	185.80	66.96	65.68	46.63

N = nitrogen, P = phosphorus, K = potassium, Ca = calcium, Mg = magnesium, S = sulfur, Cu = Copper, Fe = iron, Zn = zinc, Mn = manganese, B = boron, n = number of crops.

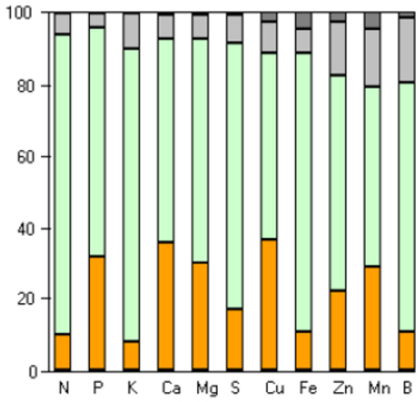
Diagnosis of the soybean nutritional status

The diagnosis of the nutritional status of crops that were not part of the reference population, here called low productivity crops, was made only based on the use of the set of generic standards derived from a reference population with higher than average productivity. However, it is considered relevant, for the purposes of this work, an analysis in terms of the nutritional status of the set of diagnosed crops. Thus, this analysis is presented below based on frequency statistics as shown in Figure 1.

Middle Kenworthy balanced index classes		
Strongly unbalanced	Unbalanced	Balanced
1	70	256

Kenworthy balanced index class											
Classes	N	P	K	Ca	Mg	S	Cu	Fe	Zn	Mn	B
Deficient	0	0	0	0	1	1	0	0	0	0	0
Below normal	34	105	27	119	101	58	123	39	72	95	38
Normal	272	208	265	184	199	239	163	249	197	165	223
Above normal	21	14	35	23	26	29	32	25	51	53	60
Excessive	0	0	0	1	0	0	9	14	7	14	6

Total number of plots = 327



Plots frequency (%) in relation to the nutritional balance classes by nutrient

FIGURE 1 - Frequent statistics involving Nutritional Balance. Source: Silva (2014).

As noted, almost 80% of crops, more precisely 78.3%, have balanced nutrition. This considering the set of nutrients. However, in an analysis by nutrient based on Figure 1, it appears that N is the most frequently normal nutrient in crops (83.2%) whereas Cu (49.8%) is the least frequently in the normal class. As for macronutrients, on average, 69.7% of crops are in the normal class, whereas for micronutrients this percentage is lower (60.9%). Considering that, as already discussed, the accuracy of the KW standards is greater for macro compared to micronutrients in the normal range, indicating that, from the point of view of balance, the situation of micronutrients is worse than for the group of macronutrients.

It can be seen, that N is the nutrient that is most frequently balanced, an explanation for this fact is the occurrence of biological nitrogen fixation, which occurs through the soybean-*Bradrhizobium* symbiosis, at levels adequate to meet the needs of N from the crops. It can also be proposed that any imbalances in the balance of other nutrients did not significantly affect the fixation of N.

The relative frequency of crops in the various diagnostic classes, regarding the balance, can provide valuable subsidies with a view to improving the fertilization of the crop. Thus, in this work, the relative frequency in the normal class can be considered as the first indicator of the degree of nutritional adequacy. A higher frequency in the normal class would indicate greater nutritional adequacy. For example, for P, Ca and Mg, the nutrients for which, in the group of macronutrients, there are the lowest relative frequencies of crops in the normal class, namely 63.6%, 56.3% and 60.8%, respectively, as calculated based on Figure 1, there are more opportunities to improve the fertilization program.

The question is: should the doses of these three nutrients being used be increased or decreased? In order to answer this question, the limiting-for-lack (LF)/excess-limiting (LE) quotient was calculated, in which limiting by lack is obtained by adding the relative frequency of crops in the deficient and below normal class, and limiting by excess is obtained by adding the relative frequency of crops in the class above normal and excessive. For P, Ca and Mg, in this work, the LF/LE indices are equal to 7.50, 4.95 and 3.92, respectively. Thus it can be concluded that for them the adjustments in the fertilization program must be in the sense of increasing the doses. By this same line of reasoning for the other macronutrients supplied from fertilizations, that is, P, K and S, the adjustments should be oriented towards a small reduction in the dose of K and a certain increase in the doses of S. As for the micronutrients, making use of the same reasoning, it concludes that the fertilization program can be improved aumentando- the doses of Cu, Mn and Zn and reducing - the dose B.

CONCLUSIONS

They were obtained from reference values (standards) working to assess the nutritional status of crops soybeans in the degree of balance, grown in the state of Mato Grosso, region of Campo Novo dos Parecis, plus d limits indicative nutrient content of the normal range as to the balance by the Kenworthy method.

In low-yield soybean crops in the studied region, on average, for macronutrients, 69.7% of the crops are in the normal class, while for micronutrients this percentage is lower, 60.9%.

N is the most frequently found nutrient in crops (83.2%) while Cu (49.8%) is the least frequently found in the normal class. 78.3% of the low productivity soybean crops studied in this work have an adequate nutritional balance.

Mg, P and Ca in the group of macronutrients and Cu, Mn and Zn in terms of micronutrients are those for which there are greater expectations of gains in crop productivity in response to fertilization.

REFERENCES

CAMACHO, M.A.; SILVEIRA, M.V.; CAMARGO, R.A.; NATALE, W. Faixas normais de nutrientes pelos métodos ChM, DRIS e CND e nível crítico pelo método de distribuição normal reduzida para laranjeira-pera. **Revista Brasileira de Ciências do Solo**, v.36, n.1, p.193-200, 2012.

CANTARUTTI, R.B.; BARROS, N.F.; MARTINEZ, H.E.P.; NOVAIS, R.F. **Avaliação da fertilidade do solo e recomendação de fertilizantes.** In: NOVAIS, R.F.; ALVAREZ, V.V.H.; BARROS, N.F.; FONTES, R.L.F.; CANTARUTTI, R.B.; NEVES, J.C.L. (Eds.). Fertilidade do Solo. Viçosa, Sociedade Brasileira de Ciência do Solo. 2007. p.769-872.

COELHO, F.S.; FONTES, P.C.R.; CECON, P.R.; BRAUN, H.; SILVA, I.R. Value and prediction of critical content-level to assess the nitrogen status of the potato, **Revista Ciência Agronômica**, v.44, n.1, p.155-122, 2013.

DIAS, J.R.M.; WADT, P.G.S.; TUCCI, C.A.F.; SANTOS, J.Z.L.; SILVA, S.V. Normas DRIS multivariadas para avaliação do estado nutricional de laranjeira ‘Pera’ no estado do Amazonas. **Revista Ciência Agronômica**, v.44, n.2, p.251-259, 2013.

DOMINGOS, C.S.; SILVA, L.L.H.; BRACCINI, A.L. Nutrição mineral e ferramentas para o manejo da adubação na cultura da soja. **Scientia Agraria Paranaensis**, v.4, n.3, p.132-140, 2015.

FERNANDES, L. **Normas e determinação de faixas de suficiência para diagnose foliar com base no crescimento relativo de eucalipto.** 2010. Dissertação (Mestrado em Agronomia) - Universidade Federal de Viçosa, Viçosa, 94p., 2010.

FREIBERGER, M.B.; GUERRINI, I.A.; CASTOLDI, G. PIVETTA, L.G. Phosphorus fertilization on the early growth andnutrition of physic nut seedlings. **Revista Brasileira de Ciência do Solo**, v.38, n.1, p.233-239, 2014.

GOTT, R.M.; AQUINO, L.A.; CARVALHO, A.M.X.; SANTOS, L.P.D.; NUNES, H.M.P.; COELHO, B.S. Índices diagnósticos para interpretação de análise foliar do milho. **Revista Brasileira de Engenharia Agrícola e Ambiental**, v.11, n.18, p.1110-1115,2014.

KENWORTHY, A.L. **Interpreting the balance of nutrient-elements in leaves of fruit trees.** In: REUTHER, W. (Ed.). Plant analysis and fertilizers problems. Washington. American Institue of Biological Science, 1961. p.28-43.

KURIHARA, C.H.; VENEGAS, V.H.A.; NEVES, J.C.L.; NOVAIS, R.F. Acúmulo de matéria seca e nutrientes em soja, como variável do potencial produtivo. **Revista Ceres**, v.60, n.5, p.690-698, 2013.

LIMA, R.O. **Sustentabilidade da produção de soja no Brasil central: características químicas do solo e balanço de nutrientes no sistema solo-planta.** 2004. Dissertação (Mestrado em Solos e Nutrição de Plantas) - Universidade Federal de Viçosa, Viçosa, 65p, 2004.

MALAVOLTA, E. **Avaliação do estado nutricional das plantas:** princípios e aplicações, 2a. ed., Piracicaba, POTAFOS, 319p., 1997.

NEVES, J.C.L.; BARROS, N.F.; NOVAIS, R.F.; LEITE, R.A.; ALVAREZ, V.V.H.; SILVA, I. In: ENCONTRO BRASILEIRO DE SILVICULTURA, 2008. **Anais...**Curitiba. v.1, p.51-60, 2008.

ROCHA, J.B.O. **Diagnose nutricional de plantios jovens de eucalipto na região litorânea do Espírito Santo e Sul da Bahia.** 2008. Dissertação (Mestrado em Agronomia) - Universidade Federal de Viçosa, Viçosa, 56p., 2008.

SANTOS, F.C.; NEVES, J.C.L.; NOVAIS, R.F.; ALVAREZ, V.V.H.; SEDIYAMA, C.S. Modelagem da recomendação de fertilizantes para a cultura da soja. **Revista Brasileira de Ciência do Solo**, v.4, n.32, p.166-1674, 2008.

SILVA, C.S. **Valores de Referência e Diagnóstico do Estado Nutricional de Lavouras de Soja no Mato Grosso.** 2014. Trabalho de Conclusão de Curso - Universidade Federal de Viçosa, Viçosa, 66p., 2014.

SILVA, G.G.C.; NEVES, J.C.L.; ALVAREZ V.V.H.; LEITE, F.P. Avaliação da universalidade das normas DRIS, M-DRIS e CND. **Revista Brasileira de Ciência do Solo**, v.29, n.5, p.755-761, 2005.