NUTRITIONAL DIAGNOSIS BY DRIS METHOD OF THE CULTIVARS COFFEE IN THE NORTHERN REGION OF PARANÁ, BRAZIL

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ABSTRACT: Due to the lack of knowledge on the nutritional status of the coffee shrub, DRIS method was introduced in coffee culture in the northern region of the state of Parana, Brazil. Current research aimed at establishing a data base for DRIS guidelines in coffee culture and introducing other parameters for the rational and balanced application of fertilizers. Assay was performed between February 2011 and February 2012 (Harvest 2011/201) in coffee plantations in the municipality of Pitangueiras PR Brazil, 23º 14' 03" S and 51º 35' 06" W; altitude 600 m. Leaf samples from 75 coffee shrub lots were retrieved from 69 plantations, featuring cultivars IAPAR 59, IPR 98, IPR 99, Catuaí, Mundo Novo and Tupi. DRIS norms were established for the nutritional diagnosis of the coffee shrub for the northern region of the state of Paraná through the criterion of productivity at 55 sacks ha^{-1}. Data revealed that potassium constituted the highest deficiency, followed by Cu and Zn. Fe, S and Mn had excessive rates with regard to parameters at regional level.

Index terms: Densely cultivated coffee, leaf analysis, soil fertility, fertilization, plants´ mineral nutrition.

DIAGNÓSTICO NUTRICIONAL DE VARIEDADES DE CAFEEIRO PELO MÉTODO DRIS NA REGIÃO NORTE DO PARANÁ, BRASIL

RESUMO: *Devido à falta de conhecimentos relativos ao estado nutricional do cafeeiro, procurou-se conhecer e estabelecer o método DRIS, nessa cultura, na região Norte do estado do Paraná. Objetivou-se, neste trabalho, formar um banco de dados para o estabelecimento das normas DRIS para a cultura do café, bem como estabelecer outros parâmetros para aplicação de fertilizantes de forma racional e equilibrada. O experimento foi realizado no período de fevereiro de 2011 a fevereiro de 2012 (safra 2011/2012), em propriedades rurais localizadas no município de Pitangueiras – PR, com coordenadas geográficas 23º 14' 03" S e 51º 35' 06" W, estando a uma altitude de 600 m. Foram coletadas amostras de folhas de 75 lotes de lavouras de café (Coffea arabica L.), presentes em 69 propriedades rurais com as cultivares IAPAR 59, IPR 98, IPR 99, Catuaí, Mundo Novo e Tupi. Obteve-se o estabelecimento das normas DRIS para a diagnose nutricional do cafeeiro para o Norte do estado do Paraná, utilizando como ponto de corte a produtividade de 55 sc* ha^{-1}*. Observou-se que o nutriente mais limitante foi o K, seguido do Cu e Zn. Quanto aos teores dos nutrientes excessivos, o Fe, S e Mn foram os mais representativos a nível regional.*

Termos de indexação: *Café adensado, análise de folhas, fertilidade do solo, adubação, nutrição mineral de plantas.*

1 INTRODUCTION

The cultivation of coffee shrubs (*Coffea arabica* L.), either in traditional or in the densely cultivated mode, occurs in several regions of the state of Paraná, Brazil. Up to the mid-1990s, the traditional mode, with larger spaces among plants and between rows, was predominant in the northern region of the state of Paraná. Henceforth, the dense cultivation of coffee shrubs coupled to the introduction of new cultivars was adopted by many planters for better income and as a form of diversification of production activities in the region´s family farms.

The state of Paraná has currently 74.854 ha of coffee shrubs (SECRETARIA DA AGRICULTURA E ABASTECIMENTO DO PARANÁ; DEPARTAMENTO DE ECONOMIA RURAL - SEAB/DERAL, 2012), 54.75 % cultivated in the densely cultivation mode. It should be underscored that in spite of the relatively small area for coffee plantation, production reaches 1,845,466.66 million sacks of 60 kg each.

In an experiment to evaluate the consequences on growth, productivity and biannuality of the coffee shrub after spacing between plants and between rows has been reduced, Pereira et al. (2011) concluded that productivity increased.

Information on the mineral nutrition of the coffee shrub for rational fertilization is one of the most relevant steps to be taken.

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However, this factor is frequently neglected and its due importance discarded. Techniques not recommended by research, with basic liming and fertilization assessment put aside, are practiced. Coffee shrub nutrition as a main factor in production is highlighted. In fact, the plants nutritional imbalance may cause considerable loss of productivity, coupled to diseases, susceptibility to insects and fungus and the indiscriminate use of nutrients with the consequent chemical imbalance of the soil.

Studies in the use of D*iagnosis and Recommendation Integrated System* (DRIS) have been successfully undertaken, even in Brazil (BATAGLIA et al., 2004; BATAGLIA; SANTOS, 1990; CAMPOS, 2009; CRESTE; ECHER, 2010; CRESTE; NAKAGAWA, 1997; FARNEZI; SILVA; GUIMARÃES, 2010; LANA et al., 2010; PARTELLI; VIEIRA; COSTA, 2005; PIPERAS; CRESTE; ECHER, 2009; WADT, 2005).

DRIS defines the deviation degree of nutrients in a determined sample, its place with regard to the nutritional state, adequateness (deficient or excessive) and the conditions of each situation (PARTELLI; VIEIRA; COSTA, 2005). Results derived from commercial research may be used for the development of the method and establishment of guidelines on condition that normal distribution of data is verified and they attend to the normalization of populations based on productivity (PIPERAS; CRESTE; ECHER, 2009).

DRIS may also reveal the most limiting nutrients for cultures at different places. For instance, it showed that P was the most limiting nutrient (18.6 %), followed by Fe (15.3 %), K and Mn (13.5 %) and Zn and B (10.2 %) in leaf samples, in Alto Paranaíba region, MG, Brazil. Co-relationships between DRIS indexes also demonstrated the antagonism and synergism among the nutrients (CAMPOS, 2009).

When a nutrients DRIS index is negative, the limitation of a nutrient (relative deficiency) may occur, whereas a positive DRIS index, that is, nutrient limitation (relative excess), or close or equal to zero, indicates balanced nutrition conditions (LANA et al., 2010). Farnezi et al. (2010) applied DRIS to evaluate the quality of coffee drink and the nutritional aspects of the coffee shrubs in Alto do Jequitinhonha, MG, Brazil and concluded that a high equilibrium of the nutritional state of coffee plantations caused the productivity of 65 sacks ha^{-1} of processed coffee, with a drinking quality qualified as soft and only soft. In fact, balance maintenance of the plantation´s nutritional status provided high productivity and quality drinks.

The aim of this study was to establish DRIS norms using a regional database, formed by leaf analysis results and productivity for coffee in Paraná, especially for the northern region of the state, in order to establish parameters that may contribute to improvements in the fertilization programs in coffee crops.

2 MATERIALS AND METHODS

The experiment was performed between February 2011 and February 2012 in plantations in the municipality of Pitangueiras, PR, Brazil, at 23º 14’ 03” S and 51º 35’ 06” W, altitude 600 m. The productivity of the coffee plantations during the period (of different ages) ranged between 15 and 90 sacks ha^{-1} of processed coffee obtained in the 2010/2011 harvest (July 2011).

According to Köppen, the climate of the municipality of Pitangueiras is Cfa – a subtropical climate with mean temperature 18 oC (mesothermal) in the coldest month and mean temperature over 22 oC in the hottest month, with hot summers, slightly frequent frost occurrences, with a trend in rainfall concentration during the summer months, without a defined dry season (Instituto Agronômico do Paraná - IAPAR, 2011). Soil of the coffee plantation sites is dystroferric Red Latosol. Table 1 shows the result of 10 soil analyses of the area under study in this work, with pH in CaCl2, organic matter, Al, P, K, Ca, Mg according to the methodology described by Pavan et al. (1992), and determination of the micronutrients B, Cu, Fe, Mn and Zn according to the methodology described by Empresa Brasileira de Pesquisa Agropecuária - Embrapa (1999), objective of to demonstrate the characteristics of the soil the coffee plants in the municipality.

Leaf samples from cultivar cultivars IAPAR 59, IPR 98, IPR 99, Catuaí, Mundo Novo and Tupi were harvested from 75 coffee lots in 69 plantations, showing the 3rd and 4th pair of leaves from branches at mid-height of plant and surrounding it, according to the methodology proposed in Malavolta (1993). Spacing in the lots varied between 0.7 and 1.0 m between plants and between 1.5 and 3.0 m between rows in a dense production system.

Leaf samples were placed in paper bags and taken to the Laboratory of Vegetal Tissues Analysis of the Oeste Paulista University, where they were washed, dried, ground and subjected to analyzed (MALAVOLTA; VITTI; OLIVEIRA, 1997) and results databased.

TABLE 1 - Result of soil analysis in the areas with coffee shrubs, at a depth between 00 and 20 cm.

SOIL SAMPLES	pH	M.O.	P	H + Al	Al	K	Ca	Mg	Sat bases	B	Cu	Fe	Mn	Zn
	$CaCl_2$	g kg^{-1}	mg dm^{-3}			$mmol_c$ dm^{-3}			(V%)			mg dm^{-3}		
3	5.70	19.52	225.60	36.8	0.00	3.50	51.0	21.7	67.43	0.30	3.89	38.00	-	24.40
4	5.00	17.09	25.60	42.7	0.00	1.40	37.0	13.9	55.05	0.28	15.7	20.90	-	7.15
12	5.00	19.05	117.80	46.0	0.00	2.00	36.2	11.1	51.73	0.18	4.98	51.70	-	7.09
13	6.10	25.26	217.40	29.4	0.00	3.00	46.5	13.1	68.04	0.12	4.91	30.40	-	4.30
32	6.20	13.79	229.59	23.6	0.30	2.40	40.3	8.90	68.62	-	5.50	42.00	74.0	32.30
35	4.80	14.14	10.10	39.7	0.00	1.60	27.5	10.6	50.00	0.17	4.07	56.60	-	1.99
42	5.00	22.89	4.70	57.6	0.00	6.50	66.2	22.2	62.22	0.47	13.0	21.20	-	8.80
52	5.40	12.21	124.31	29.5	0.80	1.30	30.3	7.20	56.85	-	4.15	19.00	28.0	16.60
60	5.00	31.17	127.3	42.7	0.00	3.80	44.7	18.0	60.89	0.33	1.46	38.50	-	20.70
63	5.80	10.77	49.70	27.3	0.00	2.50	37.0	13.1	65.83	0.24	2.29	19.10	-	9.47
Mean	**5.40**	**18.59**	**113.21**	**37.5**	**0.11**	**4.00**	**41.7**	**14.0**	**60.67**	**0.26**	**6.00**	**33.74**	**51.0**	**13.28**

After collecting the material and obtain the results of laboratory analyzes, we sought to meet the following requirements (BEAUFILS, 1973): 1 – all factors that may have influenced production were taken into account; 2 – the relationship between these factors and production should be taken into account and studied; 3 – calibration of reference guidelines should be established.

The Interactivity among nutrients the N, P, K, Ca, Mg, S, B, Cu, Fe, Mn and Zn was investigated to determine which affected the productivity of the densely cultivated coffee shrub system and the variables that affected them and then their results were derived for the establishment of DRIS in this culture.

Five out of the 75 lots were discarded from collection procedures due to zero productivity (due to execution of trimming called skeleton with zeroed production for that particular year), taking into consideration the remaining 70 lots with 70 productivity rates and their respective chemical leaf analyses. The data were grouped and formed the database for current research and Data base was subdivided into 5 production levels. Randomized production levels within the score predefinition for the establishment of DRIS for coffee culture comprised over 35 sacks ha^{-1}; over 45 sacks ha^{-1}; over 55 sacks ha^{-1}; over 65 sacks ha^{-1} and over 75 sacks ha^{-1}.

It is noteworthy that the greater the deficiency of one nutrient will be more negative the index value in relation to other nutrients. An index and a high positive value indicates that the nutrient is in excessive amounts. Therefore, so that appropriate nutritional balance occurs all indices must be equal to zero.

3 RESULTS AND DISCUSSION

Variables that might affect to a greater or smaller degree the mineral composition of coffee leaves were verified by the introduction of the D*iagnosis and Recommendation Integrated System* (DRIS) and thus could be reflected in the diagnose by of the DRIS. The current analysis employed 70 leaf samples out of the 75 analyzed. The above was due to selection in production since 5 samples were retrieved from pruned ´skeleton´ plantation with zeroed production for that particular year.

Five productivity levels were established, namely, over 35 sacks ha^{-1}; 45 sacks ha^{-1}; 55 sacks ha^{-1}; 65 sacks ha^{-1} and 75 sacks ha^{-1}. Each level comprised high productivity, called sub-population A, and low productivity, called sub-population B.

For instance, level over 45 sacks ha^{-1} includes population A with productivity equal to or higher than 45 sacks ha^{-1} and sub-population B with all productivities lower than 45 sacks ha^{-1}, and so on for the other productivity levels.

Table 2 or shows chemical analysis results of leaves for all macro and micronutrients for high (A) and low (B) productivity sub-populations following productive stratification adopted.

The Data in Table 2 showed that production levels >35, >45, >55, >65 and >75 sacks ha-1 revealed similarities among nutrient rates with the highest rates in populations with the highest productivity (A) and lowest rates in populations with the lowest productivity (B). However, in some situations occurred alternations, sometimes with high rates in populations with the highest productivity (A) and sometimes in populations with the lowest productivity (B).

Following methodology by Beaufils (1973), the best co-relationships (r) were obtained between the Nutritional Balance Index (NBI) and the productivity of productive classes at score 55 sacks ha-1, serving the field for future use through the development of diagnostic coffee fields. Table 3 shows results of the chemical analyses of leaves from all samples whose productivity was equal to or higher than 55 sacks ha-1. It also demonstrates means, variance and standard deviations for sub-populations A and B (means and variance), relationship of variance between sub-populations A and B (establishing nutritional relationships that will be introduced in DRIS processing) and levels of significance in the relationships of variance of sub-populations A and B by test F.

Diagnosis indexes were calculated following Walworth and Sumner (1987) and thus the intermediate mathematic equations for DRIS were obtained (BEAUFILS, 1973), based on the highest relationship between two nutrients and taking sub-populations A and B into consideration.

Table 4 shows results for the 70 data sampled in coffee plants, with the number of sample), index for nitrogen (IN,), phosphorus (IP,), potassium (IK,), calcium (ICa,), magnesium (IMg,), sulfur (IS,), boron (IB,), copper (ICu,), iron (IFe,), manganese (IMn), zinc (IZn,), dry matter (Ims,), Nutritional Balance Index rate (NBI,) and factors diagnosed respectively as the most deficient and the most excessive, employing general guidelines established for DRIS at level 55 sacks ha-1 of processed coffee.

The analysis of data in Table 4 reveals that values by DRIS-given diagnosis through the employment of guidelines of sub-population with over 55 sacks ha-1 productivity mark predominance of relative deficiencies in plants of K (22.7 %) and Cu (17.3 %) in the producing region under analysis. On the other hand, K deficiency may be pinpointed as the probable cause of errors in fertilization or may have been caused by the extraction of the nutrient in high-productivity sites. The Cu should be supplemented in the coffee plantations of the northern region of the state of Paraná since its relative deficiency may be explained by the replacement of copper-based products in phytosanitary control. The same event has been reported by Farnezi, Silva and Guimarães (2009) who concluded that the imbalanced coffee plantations of the region Alto Vale do Jequitinhonha in the state of Minas Gerais were deficient in P, K, S, B, Cu, Mn and Zn. Similarly, Partelli et al. (2006) reported on the conventional Conilon coffee plantation with nutrients Mn, Cu and N having the highest negative DRIS indexes.

On the other hand, iron, Zn (21.6 %) and S (16.2 %) were nutrients diagnosed as excessive by DRIS. Study revealed nutritional imbalance which may have been caused by excessive iron and zinc in the region, coupled to excessive sulfur. The above may have been caused by management mistakes in the correction or in the fertilization of this culture. It may be explained by soil characteristics with high total rates of the nutrients inherent to dystrophic Red Latosol and its high rates of Fe_2O_2 and also by the results of soil analysis, where the average levels of Fe are high. Farnezi, Silva and Guimarães (2009) reported that coffee plantations of the Alto Vale do Jequitinhonha region in the state of Minas Gerais had excessive Ca, Mg and Fe, corroborating results in current analysis, given the fact that on average, the results of soil analysis showed medium to high ranges of Ca and Mg, respectively, due to periodic application of lime by farmers.

By employing absolute leaf standards provided by current research (Table 3) the standards were compared with the nutritional references given in Malavolta (2006) for coffee culture. Table 5 lists the sufficiency bands of all nutrients.

Data in Table 4 show the productivity of coffee culture over 55 sacks ha^{-1} for which the DRIS guidelines were established. With the exception of nutrients N and P with rates close to extant nutritional bands, the nutrients K, Ca, S, Cu, Fe, Mn and Zn were above extant standards, whereas nutrients Mg and B were below, when compared to the nutritional standards by Malavolta (2006).

TABLE 2 - Mean rates of macro and micronutrients in coffee leaves to differentiate sub-populations of high (A) and low (B) productivity.

Score Product. (sc ha^{-1})	sub-pop.*	N	P	K	Ca	Mg	S	B	Cu	Fe	Mn	Zn
		Macronutrients						Micronutrients				
		g.kg^{-1}						mg.kg^{-1}				
> 75	A	30.00	1.70	24.87	13.90	3.51	2.60	35.79	38.81	105.90	130.67	14.21
	B	26.42	1.54	19.46	14.45	4.09	3.30	42.63	8.07	111.68	186.01	22.13
> 65	A	29.14	1.59	23.18	13.34	3.38	2.60	37.05	34.03	97.98	126.43	13.68
	B	26.47	1.55	19.59	14.53	4.12	3.31	42.58	8.19	112.78	187.43	22.32
> 55	A	27.50	1.60	21.60	14.40	4.10	3.00	39.70	18.30	113.40	200.80	19.80
	B	26.60	1.60	19.50	14.40	4.00	3.30	42.60	9.00	110.40	174.70	21.80
> 45	A	27.35	1.60	21.78	14.37	4.01	3.00	39.60	16.77	113.25	194.50	21.43
	B	26.51	1.54	19.19	14.40	4.05	3.33	43.02	8.56	110.15	174.29	21.31
> 35	A	27.28	1.57	21.61	14.39	4.02	3.24	41.78	13.36	105.29	187.42	22.04
	B	26.42	1.55	18.87	14.40	4.05	3.22	42.08	9.54	115.13	175.82	20.87

TABLE 3 - Mean rates and possible relationships among nutrients, variance, coefficient of variation, variance relation between sub-populations A and B and Test F.

Elements & parameters	Mean A	Standard deviation A	Coefficient of variation A	Variance A	Mean B	Variance B	Test F
N	28.82	3.46	12.02	11.99	26.34	7.13	0.59
P	1.59	0.37	23.52	0.14	1.55	0.14	1.04
K	23.37	5.93	25.39	35.20	19.44	33.05	0.94
Ca	13.32	2.78	20.84	7.71	14.57	9.22	1.20
Mg	3.51	0.66	18.87	0.44	4.13	0.77	1.76
S	2.63	0.68	25.67	0.46	3.34	2.02	4.42
B	38.14	10.24	26.84	104.80	42.74	170.93	1.63
Cu	30.97	43.04	138.97	1852.25	15.09	315.25	0.17
Fe	91.99	43.67	47.47	1907.26	115.88	2886.11	1.51
Mn	160.49	108.57	67.65	11786.39	185.05	11968.47	1.02
Zn	14.89	7.27	48.79	52.79	22.65	302.36	5.73
P/N	0.10	0.01	24.15	0.00	0.10	0.00	1.10
N/K	1.30	0.37	28.74	0.14	1.50	0.18	1.27
Ca/N	0.50	0.10	22.41	0.01	0.60	0.01	1.48
Mg/N	0.10	0.02	20.47	0.00	0.20	0.00	2.48
S/N	0.10	0.03	34.60	0.00	0.10	0.00	2.62
B/N	1.40	0.46	34.49	0.22	1.60	0.23	1.07
N/Cu	2.70	1.97	72.07	3.88	3.30	5.22	1.34
N/Fe	0.40	0.11	32.15	0.01	0.30	0.04	3.14
N/Mn	0.20	0.07	35.83	0.00	0.20	0.01	2.98
Zn/N	0.50	0.28	53.01	0.08	0.90	0.40	5.07
P/K	0.10	0.01	17.24	0.00	0.10	0.00	3.47

Elements & parameters	Mean A	Standard deviation A	Coefficient of variation A	Variance A	Mean B	Variance B	Test F
Ca/P	8.60	1.71	19.86	2.94	9.70	4.81	1.63
Mg/P	2.30	0.59	25.83	0.35	2.80	0.50	1.42
P/B	0.00	0.01	36.42	0.00	0.00	0.00	0.83
P/Cu	0.20	0.13	86.45	0.01	0.20	0.02	1.48
P/Fe	0.00	0.00	38.72	0.00	0.00	0.00	2.14
P/Mn	0.00	0.00	53.49	0.00	0.00	0.00	1.66
Zn/P	9.60	4.28	44.52	18.32	14.80	140.89	7.68
Ca/K	0.60	0.11	18.88	0.01	0.80	0.06	5.42
Mg/K	0.20	0.03	22.38	0.00	0.20	0.00	5.80
S/K	0.10	0.04	39.27	0.00	0.20	0.00	1.84
B/K	1.80	0.86	48.68	0.74	2.30	0.76	1.02
Cu/K	1.50	2.33	151.82	5.44	0.90	0.83	0.15
Fe/K	4.00	1.74	43.09	3.04	6.70	18.53	6.08
Mn/K	7.10	4.53	63.43	20.54	10.50	58.97	2.86
Zn/K	0.60	0.26	41.99	0.07	1.20	0.71	9.77
Mg/Ca	0.30	0.04	15.95	0.00	0.30	0.00	1.63
S/Ca	0.20	0.06	33.31	0.00	0.20	0.00	1.49
Ca/B	0.40	0.10	27.95	0.01	0.40	0.01	1.65
Ca/Cu	1.40	1.18	84.76	1.39	1.90	1.99	1.43
Ca/Fe	0.20	0.06	40.11	0.00	0.20	0.00	2.10
Ca/Mn	0.10	0.05	52.84	0.00	0.10	0.00	1.46
Zn/Ca	1.10	0.53	47.36	0.28	1.50	1.25	4.34
S/Mg	0.80	0.25	32.47	0.06	0.80	0.12	1.88
Mg/B	0.10	0.02	24.45	0.00	0.10	0.00	2.97
Mg/Cu	0.40	0.28	79.73	0.08	0.50	0.15	1.89
Mg/Fe	0.00	0.01	37.66	0.00	0.00	0.00	2.50
Mg/Mn	0.00	0.01	46.11	0.00	0.00	0.00	1.84
Zn/Mg	4.30	1.98	46.50	3.95	5.60	19.28	4.87
B/S	15.10	4.19	27.84	17.59	14.00	22.50	1.27
S/Cu	0.30	0.20	77.43	0.04	0.50	0.18	4.23
S/Fe	0.00	0.02	56.35	0.00	0.00	0.00	3.89
Mn/S	62.00	32.02	51.62	1025.80	63.90	2646.30	2.57
Zn/S	5.60	2.38	42.83	5.69	6.80	23.35	4.09
B/Cu	4.40	4.16	94.28	17.37	5.70	20.26	1.16
B/Fe	0.50	0.32	61.93	0.10	0.50	0.18	1.78
Mn/B	4.50	2.80	62.90	7.87	4.80	13.95	1.77
Zn/B	0.40	0.19	50.11	0.03	0.50	0.11	3.02
Fe/Cu	7.70	5.05	65.56	25.52	12.80	103.93	4.07
Mn/Cu	15.90	16.20	102.20	262.74	22.60	429.58	1.63
Zn/Cu	1.70	1.63	96.24	2.66	3.10	10.36	3.89
Fe/Mn	0.70	0.32	47.21	0.10	0.90	0.51	4.74
Zn/Fe	0.20	0.12	65.85	0.01	0.20	0.04	2.56
Zn/Mn	0.10	0.09	79.06	0.00	0.20	0.02	2.66

TABLE 4 - Nutritional diagnosis of coffee plants following guidelines developed for productivity over 55 sacks ha-1.

Samples	I_N	I_P	I_K	I_{Ca}	I_{Mg}	I_S	I_B	I_{Cu}	I_{Fe}	I_{Mn}	I_{Zn}	I_{MS}	NBI	Deficient	Excessive
1	-0.5	1.0	-3.1	0.3	0.8	-0.7	0.1	0.3	2.0	-0.2	-0.3	0.3	9.5	K	Fe
2	0.4	0.1	-0.6	-0.7	0.0	-0.3	0.0	0.5	0.6	-0.3	-0.9	1.2	5.6	Zn	Fe
3	-0.6	-0.1	-0.9	-1.5	-0.3	-0.5	-0.9	0.2	0.6	-0.7	4.7	0.1	11.1	Ca	Zn
4	-1.0	0.0	-1.8	0.1	1.2	-0.7	-0.8	0.5	1.6	0.6	-0.4	0.5	9.2	K	Fe
5	-0.7	-0.1	-2.4	-0.6	2.6	-0.1	1.0	0.8	-0.4	0.2	-0.8	0.4	9.9	K	Mg
6	-0.9	-0.3	-2.1	-0.2	0.7	-0.6	1.1	0.7	2.7	-0.6	-0.6	-0.1	10.5	N	Fe
7	0.7	-1.2	-2.2	0.5	-0.1	-0.5	0.8	0.7	0.8	0.2	-1.1	1.4	10.3	K	Fe & B
8	-0.7	-0.7	-3.1	0.4	1.5	-1.4	-0.7	0.3	1.4	3.5	-0.5	0.0	14.3	K	Mn
9	-0.5	0.2	-1.3	0.7	1.1	-0.5	-2.0	0.2	1.0	1.3	-0.4	0.1	9.4	B	Mn
10	-0.4	-0.7	-0.4	-0.3	0.4	-0.4	-0.7	0.5	0.9	1.3	-0.6	0.2	6.7	P & B	Mn
11	-0.6	-0.4	-2.2	0.7	1.9	-0.5	-1.4	0.3	1.0	2.3	-0.9	-0.1	12.2	K	Mn
12	0.5	0.5	0.8	0.4	-0.6	-0.2	-0.1	0.1	0.0	-0.3	-1.2	0.1	4.8	Zn	K
13	0.5	0.5	0.8	0.4	-0.6	-0.2	-0.1	0.1	0.0	-0.3	-1.2	0.1	4.8	Zn	K
Samples	I_N	I_P	I_K	I_{Ca}	I_{Mg}	I_S	I_B	I_{Cu}	I_{Fe}	I_{Mn}	I_{Zn}	I_{MS}	NBI	Deficient	Excessive
14	-1.2	0.0	-0.5	0.0	2.1	-0.1	-0.6	0.4	0.0	0.7	-0.6	-0.3	6.5	N	Mg
15	0.0	-0.9	-1.8	0.1	1.0	-0.8	0.2	0.6	-0.1	1.3	-0.3	0.6	7.7	K	Mn
16	-0.7	-0.5	-3.6	1.1	2.0	-0.6	-0.9	0.1	2.0	0.8	0.3	0.0	12.5	K	Mg & Fe
17	0.2	-0.2	-0.3	0.2	0.7	-0.3	0.0	1.2	1.6	-1.7	-1.2	-0.2	7.8	Mn	Fe
18	-1.0	-0.8	-2.2	2.0	1.2	-0.2	-0.9	0.3	0.8	0.5	0.6	-0.2	10.6	K	Ca
19	-0.3	0.3	-1.2	0.4	0.0	-0.3	0.0	0.7	0.0	-0.4	0.2	0.6	4.4	K	Cu
20	-0.9	-0.6	-2.5	1.8	1.5	-0.6	-0.8	0.5	0.8	0.2	0.4	0.2	10.8	K	Ca
21	-0.9	-0.2	-0.8	1.2	1.1	-0.1	-1.8	0.6	0.4	1.2	-0.7	-0.1	9.0	B	Ca & Mn
22	-0.4	0.1	-0.8	0.2	1.1	0.0	-0.3	0.5	0.2	-0.5	-0.5	0.4	5.0	K	Mg
23	-1.6	-2.2	-1.1	-0.4	-0.9	0.6	0.4	-0.6	0.0	-0.4	7.8	-1.6	17.7	P	Zn
24	-1.5	-0.8	0.7	-0.2	0.5	1.5	1.5	0.0	-1.4	-0.3	1.0	-0.9	10.5	N	S & B
25	-0.3	-1.4	-0.7	-0.1	-0.2	1.8	1.2	-0.1	-1.2	-0.1	1.1	0.0	8.3	P	S
26	-0.3	-0.6	0.1	-0.7	0.3	0.6	0.0	-0.4	-1.0	1.9	0.4	-0.2	6.5	Fe	Mn
27	-1.2	-1.0	-0.4	0.9	1.4	1.3	0.7	-1.7	-0.4	0.9	0.3	-0.8	11.2	Cu	Mg
28	-0.4	0.1	-0.8	0.2	1.1	0.0	-0.3	0.5	0.2	-0.5	-0.5	0.4	5.0	K	Mg
29	-1.3	-1.4	-0.6	-0.8	-0.3	1.7	-0.4	-2.2	0.9	1.6	3.8	-1.0	15.9	Cu	Zn
30	-1.1	-0.8	-0.6	1.1	1.1	0.8	0.6	-1.7	-0.7	1.6	0.4	-0.7	11.0	Cu	Mn
31	0.0	0.4	0.7	0.5	-0.6	-0.2	-0.9	0.2	0.1	0.6	-0.7	-0.2	5.1	B	K
32	-0.9	-0.6	0.4	-0.4	0.5	2.3	-0.4	-1.8	-0.8	0.6	2.0	-0.9	11.6	Cu	Zn
33	-0.9	0.3	-1.6	0.2	2.1	3.2	0.8	-2.5	-2.5	0.6	1.5	-1.0	17.3	Fe & Cu	S
34	-0.6	0.5	-0.1	-0.4	-0.5	1.1	-0.8	0.6	-0.4	-0.8	1.2	0.0	7.0	Mn & B	Zn
35	0.2	-1.9	-1.7	-0.7	0.3	0.8	0.8	-1.2	2.0	0.8	0.2	0.4	11.1	P	Fe
36	-0.7	-1.3	-3.8	0.7	-0.6	0.2	1.2	-1.8	2.0	-0.6	5.4	-0.6	19.0	K	Zn
37	-0.6	0.8	-0.8	0.4	0.7	1.9	-0.4	-1.4	-1.4	-0.1	1.3	-0.4	10.2	Cu & Fe	S
38	1.5	-0.1	-1.1	-0.4	-0.8	1.7	1.4	-0.5	-2.3	0.2	-0.3	0.9	11.2	Fe	S

39	-0.2	-0.2	0.4	-0.7	0.3	-0.4	1.5	0.3	0.9	-0.4	-1.2	-0.2	6.6	Zn	B
40	-0.9	0.2	-0.5	0.5	0.6	1.1	0.8	-1.4	-0.8	-0.3	1.2	-0.4	8.8	Cu	Zn
41	-0.3	0.9	0.2	0.8	0.4	1.8	1.3	-1.3	-2.8	-1.0	0.5	-0.4	11.6	Fe	S
42	-0.9	1.0	-3.1	1.5	-0.2	1.6	1.1	-1.7	-0.6	1.2	1.0	-0.9	14.8	K	S
43	-1.2	-0.3	-1.0	-0.3	-0.4	1.1	-0.4	1.0	-0.2	0.2	1.9	-0.5	8.4	N	Zn
44	-0.8	0.9	0.0	1.2	0.4	1.3	0.3	-1.6	0.2	-3.3	2.6	-0.8	13.5	Mn	Zn
45	-0.3	-0.6	0.1	-0.7	0.3	0.6	0.0	-0.4	-1.0	1.9	0.4	-0.2	6.5	Fe	Mn
46	-1.0	0.3	-1.3	-0.2	0.7	2.5	0.3	-1.6	0.4	0.6	0.7	-1.3	11.0	Cu	S
47	-0.7	0.1	-0.7	0.7	1.3	1.6	0.7	-3.9	0.4	0.9	0.4	-0.5	11.9	Cu	S
48	-1.1	0.5	0.4	0.0	0.8	2.3	0.4	-1.7	-0.9	0.8	-0.4	-0.9	10.3	Cu	S
49	-1.6	0.5	-1.1	-0.1	-1.1	2.2	0.2	0.6	1.0	-0.9	1.6	-1.5	12.4	N	S
50	0.5	0.5	0.8	0.4	-0.6	-0.2	-0.1	0.1	0.0	-0.3	-1.2	0.1	4.8	Zn	K
51	-1.4	0.2	-2.0	0.1	-0.3	0.7	-0.2	0.4	-0.1	0.7	2.3	-0.6	9.0	K	Zn
52	-1.3	1.2	-1.9	0.9	0.3	1.2	-0.4	-2.0	1.2	-1.9	4.1	-1.1	17.5	Cu	Zn
53	-1.2	1.0	0.0	0.8	0.4	2.2	-0.6	-1.7	-1.9	-0.4	2.4	-1.0	13.7	Fe	Zn
54	-0.6	0.5	-0.1	-0.4	-0.5	1.1	-0.8	0.6	-0.4	-0.8	1.2	0.0	7.0	B & Mn	Zn
55	0.2	-0.2	-0.3	0.2	0.7	-0.3	0.0	1.2	1.6	-1.7	-1.2	-0.2	7.8	Mn	Fe
56	-1.2	-0.3	-1.0	-0.3	-0.4	1.1	-0.4	1.0	-0.2	0.2	1.9	-0.5	8.4	N	Zn
57	0.6	-0.5	-0.1	0.1	-0.5	3.2	1.4	-0.9	-4.2	-0.4	1.1	0.3	13.3	Fe	S
58	0.4	0.2	-0.7	-0.2	-0.4	-0.5	-0.2	1.2	0.5	0.2	-0.9	0.1	5.6	Zn	Cu
59	0.4	0.2	-0.7	-0.2	-0.4	-0.5	-0.2	1.2	0.5	0.2	-0.9	0.1	5.6	Zn	Cu
60	1.2	0.9	-0.6	-0.3	1.0	-0.1	-1.1	0.3	1.6	-2.4	-0.8	0.2	10.6	Mn	Fe
61	0.5	0.5	0.8	0.4	-0.6	-0.2	-0.1	0.1	0.0	-0.3	-1.2	0.1	4.8	Zn	K
62	0.2	1.7	0.3	0.0	1.0	0.0	-0.4	-2.8	2.2	-1.2	-0.9	0.1	10.8	Cu	Fe
63	0.7	0.0	-0.5	-0.2	0.4	-0.8	0.2	-0.3	2.1	-2.8	1.1	0.3	9.3	Mn	Fe
64	0.0	0.4	0.7	0.5	-0.6	-0.2	-0.9	0.2	0.1	0.6	-0.7	-0.2	5.1	B	K
65	-0.4	-1.5	-2.0	-0.5	-0.7	-1.6	0.2	0.4	1.5	-0.1	5.5	-0.9	15.3	K	Zn
66	0.2	0.0	0.3	0.9	0.2	-0.4	0.2	-0.2	1.1	-1.7	-0.9	0.4	6.4	Mn	Fe
67	-0.3	-0.4	0.1	-0.4	-0.7	-0.6	0.1	-0.5	0.9	1.0	1.5	-0.5	7.0	Mg	Zn
68	0.2	-0.7	0.2	-0.7	-0.4	-0.4	-0.4	0.3	1.5	-0.1	0.5	-0.2	5.4	P & Ca	Fe
69	0.5	-0.1	0.1	-0.2	-0.6	-0.4	-0.6	0.6	1.3	-0.2	-0.7	0.3	5.6	Zn	Fe
70	0.3	0.2	0.6	-0.2	0.3	-0.3	1.0	-1.5	1.1	-0.6	-0.5	-0.4	6.9	Cu	Fe

TABLE 5 - List of nutrients under analysis, bands of extant standards and DRIS guidelines established for coffee culture.

NUTRIENT	N	P	K	Ca	Mg	S	B	Cu	Fe	Mn	Zn
			g.kg^{-1}						mg.kg^{-1}		
Exantant standards (MALAVOLTA, 2006)	26 - 31	1.5 – 1.9	19 - 24	15 – 18	3.6 – 4.0	2.1- 2.4	60 - 80	10 - 15	110 – 300	100 - 200	12 – 20
Standards by coffee DRIS	25 - 32	1.2 – 1.9	17 - 29	10 - 16	2.8 – 4.1	1.9 – 3.2	27 - 48	12 - 74	49 – 135	52 - 269	8 - 22

4 CONCLUSIONS

DRIS guidelines for the nutritional diagnosis of coffee (*Coffea arabica* L.*)* were established for the northern region of the state of Paraná by taking standard productivity the level of over 55 sacks ha^{-1} of processed coffee.

Samples data of the selected score (over 55 sacks ha^{-1}) showed that nutrient K had the highest deficiency, followed by Cu. Nutrients Zn and Fe with excessive nutrient rates.

It is necessary to apply fertilizer based on Potassium in crops studied, based on demonstrated by DRIS results, taking into account the results of soil analysis and productivity level of each batch.

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