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Nota/Note

Diagnosis and Recommendation Integrated System – DRIS for nutritional diagnosis of Tahiti acid lime

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SUMMARY

The nutritional status of Tahiti acid lime (*Citrus latifolia* Tanaka) might changes according to soil classes and management, weed control methods between rows and interrows, climate conditions, and other biotic/abiotic factors. The purpose of this study was to assess the nutritional status of Tahiti acid lime plants on farms with Diagnosis and Recommendation Integrated System (DRIS). The leaves for tissues analysis were collect in February 2015 until July 2016 (seasons 2014/2015, 2015/2016) on farms in cities of Paraná State, Brazil: Santa Fé, Iguaraçu, Ângulo, Nova Esperança and Altônia. The soils where leaves samples were collected are classified as DISTROFIC RED LYSOSOL - (LVd) and ARGISSOLO DISM. (PVd). The DRIS was establishment for the standard productivity of 30 mg ha^{-1} (season 2014/2015). Based on the nutrients contents in leaves and DRIS norms, was observed that Boron was the nutrient most deficient (55% plots) and Potassium was the nutrient most excessive in 34% of the samples.

Index terms: Citrus, leaf analysis, soil fertility, fertilization, mineral nutrition of plants.

Sistema integrado de diagnóstico e recomendação - DRIS para diagnóstico nutricional em lima ácida de Tahiti

RESUMO

O estado nutricional da lima ácida de Tahiti (*Citrus latifolia* Tanaka) pode mudar de acordo com as classes e manejo do solo, métodos de controle de plantas daninhas entre as linhas e entrelinas, condições climáticas e outros fatores bióticos/abióticos. O objetivo deste estudo foi avaliar o estado nutricional das plantas de limão em fazendas com Sistema Integrado de Diagnóstico e Recomendação (DRIS). As folhas para análise de tecidos foram coletadas de fevereiro de 2015 até julho de 2016 (safras 2014/2015, 2015/2016) em fazendas de diferentes cidades do Paraná, Brasil: Santa Fé, Iguaraçu, Ângulo, Nova Esperança e Altônia. Os solos onde as amostras das folhas foram coletadas são classificados como LVd e PVd . O DRIS estabeleceu a produtividade padrão de 30 mg ha^{-1} (estação 2014/2015). Com base nos conteúdos de nutrientes nas folhas e nas normas DRIS, observou-se que o Boro foi o nutriente mais deficiente (55% de parcelas) e o Potássio mais excessivo em 34% das amostras.

Termos de indexação: *Citrus*, análise de folhas, fertilidade do solo, fertilização, nutrição mineral das plantas.

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INTRODUCTION

Brazil holds an area equivalent to 782.6 thousand hectares (ha) of citrus, with production in 2014 equal to 18.2 million tons, of which 43.6 thousand hectares are of lemon and lime (IBGE, 2014) proving the importance of this activity in the country.

Paraná state (PR) where lemon and lime occupies an area of 945 hectares, produces 18.1 tons (Paraná, 2015), which leads a Gross Value of Production (VBP) of R$ 18.9 million (1% of state fruit production). However, for this activity to keep profitable to farmers, there is a need to increase productivity and make the lime production more competitive than other citrus varieties.

Soil fertility needs to be better managed where the orchards are implanted, that is possible through the Integrated Diagnosis and Recommendation System (DRIS), which is a method of nutritional diagnosis of plants based on the comparison of Indices, calculated from the relationships between nutrients (Nachtigall, 2004). As an advantage, the DRIS allows an interpretation less dependent of samples variations relative to the development phase, age and origin of the analyzed material, also order the limiting factors of the production and the importance of nutrient balance.

The aim of this study was to develop a database with the results of leaf analysis and productivity to establish the DRIS standard for Tahiti acid lime (*Citrus latifolia* Tanaka) in the Northwest region of Paraná, Brazil.

The work was carried in February 2015 until July 2016 (seasons 2014/2015, 2015/2016), in farms located in the cities Santa Fé (538 m altitude), Ângulo (300 m), Iguaraçu (558 m), Nova Esperança (550 m), and Altônia (380 m), Paraná, Brasil (IPARDES, 2014).

The weather in the cities Santa Fé, Iguaraçu, Ângulo, Nova Esperança and Altônia has been classified according to Koppen as Cfa - Subtropical climate, average temperature in the coldest month below 18 °C (mesothermic) and average temperature in the hottest month above 22 °C, with hot summers, frosts infrequent and tendency of rainfall concentration in the summer months, but without defined dry season (IAPAR, 2016).

Leaves samples belonging to one hundred plots of Tahiti acid lime were collected in February 2015, repeating the procedures in the same plants in February 2016.

After collecting the material and obtaining the results of the laboratory analyzes, the following requirements were met according to Beaufils (1973): 1- All factors suspected of influencing production should be considered; 2- The relation between these factors and the production must be considered and studied; 3- The calibration of standards or reference data must be established. The calculation of the indices for each nutrient will be performed through the general formula proposed by Walworth & Sumner (1987). For nutrient X, the index will be: $IndiceX = \left(\frac{f(X/A) + f(X/B) + f(X/C) + ... + f(X/N)}{z} \right)$ at where: X = nutrient under study A, B, C ... N = nutrients that appear in the numerator or denominator of the relationships with element X, Z = is the number of functions involved in the calculation of the index, F (X / A) = is considered as an 'intermediate function', used to calculate the indices. Each intermediate function is a comparison of the relationship found in an individual sample with the standard for that relation.

The method that will be used to calculate the intermediate functions was the one proposed in Jones (1981), together with the method proposed by Hallmark et al. (1987), which includes the dry matter index in the calculations. Thus, considering a relationship between the nutrient X and the generic nutrient A, one has: $f(X/A) = \left(\frac{M(X/A) - m(x/a)}{s(x/a)} \right).K$ at where: M (X / A) = value of the nutritional relation X / A in the study population; M (x / a) = value of the nutritional relation X / A in the reference population; S (x / a) = standard deviation of the nutritional ratio in the reference population, K = sensitivity constant, adopted in this equation according to Bataglia & Santos (1990), to allow integer values of the calculated diagnosis indices. It has arbitrary value. In this work, the value of 1.0 will be used so that the values of the diagnostic indices and consequently of the IBN do not show magnitudes that are far from zero.

Table 1 shows the description of each sample aiming at a more detailed knowledge of the effects that occurred in the year 2015.

The results obtained are shown in Table 2. Number of the sample (column 1), index of the nitrogen (IN, column 2), phosphorus (IP, column 3), (Iq, column 4), calcium (ICa, column 5), magnesium (IMg, column 6), sulfur (IS, column 7), boron 9), iron (IFe, column 10), manganese (IMn, column 11) and zinc (IZn, column 12), dry matter (Ims, column 13), Nutrition Balance Index (IBN, column 14) and in columns 15 and 16 the elements diagnosed as the most deficient and most excessive, respectively, using the general standards established for DRIS at the levels of 30 t ha^{-1} in the year 2015.

When analyzing Table 2, we noticed that the values presented by the DRIS, through the norms originated

Table 1. Results of chemical analyzes of Tahiti acid lime leaves

Lots	N	P	K	Ca	Mg	S	B	Cu	Fe	Mn	Zn
	g kg^{-1}						mg kg^{-1}				
1	22.90	1.41	8.80	57.10	2.60	2.00	52.50	51.30	120.90	46.40	39.00
2	25.00	1.41	9.10	53.70	2.60	2.00	57.50	42.80	129.00	49.10	34.30
3	18.60	1.37	9.20	63.20	2.70	1.90	57.00	36.00	130.90	47.10	26.00
4	21.40	1.61	7.20	64.80	3.20	2.10	57.00	51.90	128.80	50.00	34.80
5	23.70	1.33	11.00	56.00	2.40	2.10	59.50	51.00	154.50	49.40	29.40
6	22.50	1.19	10.20	59.00	2.30	2.00	57.00	42.10	138.80	50.30	30.10
7	19.10	1.44	10.70	54.60	2.10	2.00	60.50	54.80	138.10	48.50	39.60
8	25.30	1.38	7.70	61.50	3.40	1.90	59.00	34.00	134.60	58.20	28.60
9	21.60	1.47	9.20	59.90	2.30	1.90	53.00	45.60	136.50	59.10	23.10
10	23.40	1.31	10.10	47.60	2.30	1.60	55.50	66.90	144.80	45.00	35.90
11	17.70	1.19	9.30	49.30	1.70	1.70	63.50	53.50	104.70	35.40	32.10
13	25.60	0.94	7.90	52.90	1.60	1.60	57.00	50.60	111.30	35.00	41.70
14	20.80	1.15	5.70	61.90	2.30	1.20	64.50	31.30	156.00	44.50	37.00
15	23.00	1.46	8.90	57.60	2.30	1.80	62.50	48.50	134.50	40.70	41.50
16	23.10	1.22	10.40	63.60	3.30	1.90	60.50	38.90	116.90	46.20	34.70
17	19.40	1.30	9.30	55.70	1.90	2.10	51.00	45.20	219.80	39.10	36.00
18	24.80	0.72	9.80	37.80	2.50	1.70	68.00	28.10	60.90	28.90	26.30
19	24.20	1.24	9.10	50.40	1.40	1.90	68.00	51.10	99.30	37.30	37.30
20	21.30	1.14	11.30	53.80	2.40	1.90	66.00	56.10	124.70	45.10	40.60
21	23.30	1.29	7.60	59.50	2.60	1.80	47.50	47.70	137.50	48.20	34.40
22	20.40	1.36	10.10	39.80	2.90	1.70	52.50	35.60	205.30	47.70	17.50
23	18.20	0.66	12.60	19.00	2.70	1.30	53.00	10.20	72.50	20.60	7.60
24	21.80	1.27	12.10	35.30	2.50	1.50	62.50	18.50	120.80	34.90	9.00
25	24.10	1.26	10.60	45.00	4.40	1.10	70.00	47.50	20.80	49.90	16.00
26	21.90	1.45	16.20	42.90	3.70	1.70	49.50	24.30	124.80	37.50	12.20
27	19.30	1.44	17.50	33.40	2.20	1.60	57.00	23.60	152.00	36.30	11.10
28	21.70	1.84	23.60	38.70	2.20	1.60	48.00	34.10	175.50	43.50	13.30
29	24.40	1.68	26.30	35.60	2.80	1.60	44.00	38.60	187.50	40.90	12.10
30	21.10	0.71	22.50	31.00	8.40	1.70	54.50	23.60	97.70	23.10	5.40
31	21.40	0.75	13.00	19.40	1.40	1.70	48.50	13.70	35.80	24.30	8.10
32	21.60	1.74	16.00	33.30	2.90	1.80	53.00	20.00	99.10	47.70	13.50
33	19.80	0.65	10.60	15.50	1.70	1.40	62.00	14.70	44.40	28.80	10.40
34	18.80	1.66	15.70	42.10	3.40	2.00	42.50	41.90	115.00	60.50	13.60
35	20.20	1.59	10.80	41.60	3.30	2.00	61.00	16.20	156.10	48.70	14.90
36	19.50	1.27	9.60	43.70	2.50	2.00	84.50	19.80	177.30	57.40	12.30
39	22.90	1.35	10.90	54.70	2.60	2.20	64.00	49.10	115.00	53.90	36.60
40	20.80	1.12	13.30	35.60	3.00	2.10	74.50	17.40	35.90	42.60	13.20
41	22.50	1.84	13.90	53.50	5.30	2.10	54.00	21.50	144.00	87.00	18.40
42	19.60	0.79	11.80	21.20	1.30	1.70	68.50	8.90	68.30	27.50	20.60
43	18.00	3.23	11.10	51.40	2.40	1.90	47.00	12.50	168.90	51.00	14.90
44	19.00	3.25	11.10	52.50	1.90	1.80	195.50	17.90	153.00	49.50	14.50
45	16.60	2.33	13.10	53.90	2.90	2.10	200.00	10.90	57.10	44.90	13.80
46	18.00	1.56	14.00	25.50	1.40	2.10	225.00	17.60	101.20	30.20	9.50
47	21.10	3.65	13.40	47.90	2.90	1.80	185.50	10.50	98.30	43.20	17.90
48	16.90	2.65	14.90	52.80	3.10	1.60	237.00	12.30	147.90	44.60	8.10
49	18.90	3.95	13.90	64.80	2.90	1.60	214.00	13.80	162.90	47.60	15.10

Table 1. Continued...

Lots	N	P	K	Ca	Mg	S	B	Cu	Fe	Mn	Zn
	g kg^{-1}						mg kg^{-1}				
50	15.50	3.90	14.10	56.90	2.70	1.40	222.50	13.10	113.30	49.40	10.90
51	19.70	4.13	12.90	45.20	2.40	1.60	171.00	12.60	103.80	45.70	21.30
52	18.90	4.05	16.10	49.60	2.30	1.80	225.00	20.50	139.50	48.90	14.50
53	24.40	1.88	18.80	39.90	3.30	2.50	56.50	37.20	199.00	169.70	96.40
54	24.40	1.86	16.10	30.60	2.60	1.90	58.00	38.20	163.80	197.90	38.30
55	29.30	2.29	19.40	29.90	3.10	2.80	48.50	53.20	182.60	141.40	38.60
56	25.10	1.91	22.30	36.20	3.30	2.50	56.00	52.60	190.90	153.80	35.20
57	24.90	1.80	13.40	41.50	3.40	2.40	55.50	41.10	229.40	111.70	35.50
58	22.10	1.78	15.80	32.40	2.70	2.00	48.50	49.40	214.50	70.10	23.50
59	26.00	1.93	19.80	35.60	2.90	2.40	51.50	49.00	217.40	102.90	23.40
60	21.80	2.00	23.00	31.70	2.80	2.60	57.00	67.90	317.10	80.50	108.50
61	26.30	1.92	20.50	26.60	2.00	2.80	57.50	62.10	207.50	114.80	43.90
62	23.20	2.22	25.20	33.10	3.20	2.40	57.50	51.70	260.70	105.50	54.30
63	22.60	2.17	15.30	22.30	2.90	1.70	23.50	47.70	106.60	27.60	48.10
64	24.10	2.10	12.20	32.50	3.30	1.90	48.00	45.00	189.70	25.10	27.80
65	26.90	2.37	18.90	20.60	3.10	2.00	22.00	33.10	123.20	25.00	44.00
66	22.10	1.91	13.50	16.00	2.50	1.60	33.00	41.10	98.00	28.10	20.50
67	25.00	2.06	16.20	18.90	2.70	1.70	34.00	25.20	135.50	42.30	102.40
68	30.70	1.83	12.60	19.10	2.50	1.30	36.00	36.20	81.90	21.70	30.80
69	27.20	2.25	14.50	32.10	3.10	1.70	38.50	60.50	129.00	40.80	36.60
70	29.20	2.18	17.10	20.60	2.60	2.00	37.00	47.00	155.20	29.90	33.10
71	25.00	1.74	19.10	18.00	2.80	1.50	21.50	61.50	103.10	22.50	48.20
72	26.50	2.52	19.20	20.90	3.10	2.00	35.50	36.80	159.00	36.90	52.60
73	21.10	1.72	8.00	40.60	3.80	1.50	75.50	7.50	186.30	76.30	26.00
74	19.50	2.33	12.60	46.30	4.10	2.10	92.00	22.70	300.40	113.40	47.30
75	18.70	2.46	6.80	48.60	4.30	2.30	100.50	18.10	327.40	76.70	120.50
76	20.20	2.46	10.00	65.20	5.00	2.90	116.00	19.30	284.90	103.30	91.50
77	18.60	2.48	7.90	47.10	4.00	1.80	94.00	25.10	233.40	80.50	76.70
78	18.7	1.35	7.9	36	3	1.6	85.5	16.6	210.3	84.5	25.1
79	16.7	1.95	8.7	57.1	3.7	2.2	100	8.1	221.8	95	48.6
80	17.1	2.2	8.4	59.5	4.4	2.1	90	10.8	205	81	49.7
81	16.6	2.38	7.6	64.2	5.3	2.2	91.5	19	285.8	91	84.7
82	18.9	1.14	8.1	28.7	1.7	1	101	24	159.6	40.1	18.9
83	20.2	2.16	9.2	42.7	4	2.3	91.5	12.4	312.7	62.7	93.9
84	16.7	1.99	7.5	57.7	4.8	1.8	99.5	13.5	275	89.6	40.6
85	16.9	1.53	6.7	45.4	3.6	1.5	90	21.6	275.3	71	61.3
86	19.6	2.11	7.8	52.2	4.2	2.4	90	21.1	271.8	64.4	105.1
87	20.1	2.11	9.4	46.8	3	2.2	98.5	24.4	283	52.3	49
88	19.8	2.23	8.6	60.9	3.9	2.3	100.5	16.3	253.7	55.8	88.7
89	16.5	1.63	9.2	42.6	3.7	1.8	94.5	15.5	267.3	69.3	47.9
90	18.1	2.15	9.6	55.7	4.6	2.2	95.5	21.2	386.7	95.3	47.2
91	20.7	1.71	13.9	39.8	2.9	2.1	53.5	15.1	176.6	51.5	19
92	17.3	1.23	9.8	19.7	2.4	1.1	30.5	8.2	134.8	27.7	15.6
93	13.3	1.97	9	36.6	2.7	1.5	30	10.5	134.1	38.1	20.8
94	22.4	1.49	8.3	27.9	3	1.3	39	8.9	124.3	36.4	17.3
95	17.1	1.89	14.5	41	2.8	2	51.5	23.5	123.5	57.3	28.9

Table 1. Continued...

Lots	N	P	K	Ca	Mg	S	B	Cu	Fe	Mn	Zn
	g kg^{-1}						mg kg^{-1}				
96	15.5	1.58	12.6	43.8	3	1.7	33	17.8	175	56.1	27.8
97	17.5	2.04	13.4	47.3	3.5	2.4	32	14.3	191.5	66.2	27.9
98	16.9	2.17	14.4	38.3	2.8	1.9	31.5	22.8	211.6	58.9	27.5
99	14.3	1.5	12.9	37.9	2.1	1.5	26	15.8	166.2	50	42.2
100	18.2	1.76	14.1	50.2	2.9	2.3	38.5	29.1	190.9	64.1	30.4

Table 2. Nutritional diagnosis of Tahiti acid lime plants according to standards developed for yields above 30 t ha^{-1}

Lots	I_N	I_P	I_K	I_{Ca}	I_{Mg}	I_S	I_B	I_{Cu}	I_{Fe}	I_{Mn}	I_{Zn}	I_{MS}	IBN	Deficient	Excessive
1	1.9	-1.2	1.1	2.1	-0.8	2.1	-4.7	3.3	-2.4	-2.5	0.8	0.3	23.3	B	Cu
2	2.3	-1.2	1.2	1.6	-0.8	2.1	-4.0	2.4	-1.9	-2.1	0.2	0.2	19.8	B	Cu
3	0.7	-1.4	1.5	3.2	-0.4	1.8	-3.4	1.9	-1.6	-2.0	-0.9	0.6	19.2	B	Ca
4	1.2	-0.7	0.0	2.6	0.0	1.8	-3.9	3.2	-2.1	-2.3	0.0	0.3	18.2	B	Cu
5	1.7	-1.8	1.9	1.8	-1.3	2.5	-4.0	3.0	-1.1	-2.1	-0.6	0.0	22.1	B	Ca
6	1.7	-2.5	1.8	2.8	-1.3	2.3	-3.9	2.4	-1.5	-1.7	-0.3	0.3	22.5	B	Ca
7	0.4	-1.1	1.9	1.6	-1.9	2.1	-3.5	3.5	-1.8	-2.2	0.8	0.2	21.0	B	Cu
8	2.4	-1.6	0.4	2.7	0.5	1.1	-3.6	1.5	-1.6	-1.1	-0.7	0.2	17.3	B	Ca
9	1.5	-0.8	1.3	2.6	-1.3	1.6	-4.4	2.8	-1.5	-0.7	-1.5	0.4	20.5	B	Cu
10	1.8	-1.4	1.6	1.1	-1.2	0.5	-4.5	4.8	-1.3	-2.3	0.6	0.1	21.1	B	Cu
11	0.4	-1.5	1.9	2.1	-2.2	2.3	-2.4	4.1	-2.7	-3.3	0.6	0.7	24.1	Mn	Cu
12	3.1	-3.4	1.0	3.1	-2.4	1.9	-3.7	3.8	-2.3	-3.4	1.8	0.5	30.4	B	Cu
13	1.3	-2.1	-0.6	3.8	-0.6	-1.3	-2.1	1.6	-0.1	-1.5	1.0	0.8	16.9	P e B	Ca
14	1.6	-0.9	1.0	2.2	-1.2	1.3	-3.3	2.9	-1.7	-3.1	1.2	0.2	20.7	B	Cu
15	1.8	-2.6	2.0	3.3	0.5	1.5	-3.6	2.0	-2.8	-2.5	0.3	0.2	23.0	B	Ca
16	0.9	-1.8	1.2	1.9	-2.2	3.2	-4.5	2.8	0.8	-3.4	0.5	0.4	23.7	B	S
17	3.6	-4.5	3.6	1.6	0.9	4.4	-1.5	1.8	-6.8	-4.3	0.4	0.7	34.1	Fe	S
18	2.3	-1.4	1.6	1.9	-3.5	3.3	-2.4	3.6	-3.5	-3.3	1.1	0.2	28.2	Mg e Fe	Cu
19	1.0	-2.8	2.4	2.0	-1.1	1.9	-3.0	3.6	-2.4	-2.6	1.0	0.0	23.9	B	Cu
20	2.3	-1.8	0.5	2.9	-0.6	1.2	-5.3	3.1	-1.3	-1.9	0.4	0.5	21.7	B	Cu
21	3.4	-3.6	9.8	-2.8	-0.2	5.5	-2.4	-0.1	-5.9	-5.4	-0.3	1.3	40.7	Fe	K
22	1.3	-0.5	1.7	-0.1	0.5	1.8	-4.0	2.0	0.8	-1.5	-2.6	0.6	17.3	B	Cu
23	2.7	-2.5	7.1	-2.9	4.1	6.0	-2.3	0.0	-3.7	-5.0	-5.8	1.6	43.9	Zn	K
24	2.3	0.5	4.0	0.1	1.0	3.0	-2.4	0.6	-1.5	-2.5	-6.1	0.8	24.7	Zn	K
25	5.0	1.7	9.4	4.5	6.0	0.2	-0.1	5.7	-31.2	0.5	-2.1	0.3	66.8	Fe	K
26	2.1	0.2	6.2	0.5	2.6	2.6	-5.2	1.0	-2.3	-3.2	-5.2	0.4	31.5	Zn e B	K
27	1.1	0.8	6.7	-0.9	-0.3	3.0	-3.7	1.0	-0.9	-2.7	-5.1	0.5	26.7	Zn	K
28	1.5	1.6	9.6	-0.6	-1.0	1.6	-6.7	1.9	-1.2	-2.2	-4.9	-0.3	33.0	B	K
29	2.5	1.0	11.2	-1.4	0.4	1.8	-8.4	2.4	-1.1	-2.8	-5.9	-0.7	39.6	B	K
30	2.8	-6.5	13.6	-2.1	19.1	7.7	-5.1	1.7	-5.1	-9.6	-17.1	-0.1	90.4	Zn	Mg
31	5.0	-1.1	10.4	-3.1	-0.9	10.7	-2.8	0.8	-12.0	-3.7	-5.4	1.5	57.5	Fe	S
32	2.0	1.9	6.2	-1.6	0.8	3.3	-4.3	0.6	-3.9	-1.4	-4.4	0.5	30.9	Zn	K
33	3.5	-2.1	6.4	-4.8	0.5	7.2	-0.8	0.8	-7.9	-1.9	-3.1	1.6	40.5	Fe	S
34	1.1	0.9	6.0	-0.3	1.3	3.2	-6.8	2.8	-3.2	-0.6	-5.0	0.4	31.7	B	K
35	1.2	0.6	2.2	-0.3	1.1	3.3	-2.8	0.0	-0.5	-1.7	-3.8	0.6	18.1	Zn	S
36	0.7	-0.9	1.3	0.4	-0.3	3.6	-0.6	0.4	0.2	-0.6	-4.6	0.3	13.8	Zn	S

Table 2. Continued...

Lots	I_N	I_P	I_K	I_{Ca}	I_{Mg}	I_S	I_B	I_{Cu}	I_{Fe}	I_{Mn}	I_{Zn}	I_{MS}	IBN	Deficient	Excessive
37	1.4	-1.7	2.1	1.5	-1.0	2.7	-3.3	2.9	-3.2	-1.8	0.3	0.0	22.1	B	Cu
38	2.6	-0.3	8.4	0.3	2.1	7.1	-0.3	0.7	-16.1	-1.6	-3.9	0.6	44.0	Fe	S
39	1.5	0.3	3.5	0.4	2.9	1.5	-5.1	0.3	-2.1	0.7	-3.8	-0.1	22.3	B	K
40	2.3	-1.9	5.3	-3.2	-2.2	7.2	-0.8	-0.4	-4.7	-3.4	0.0	1.3	32.6	Fe	K
41	0.9	5.2	2.6	0.8	-0.7	2.2	-5.0	-0.3	-0.6	-1.3	-4.5	0.7	24.8	B	P
42	-0.3	4.6	1.5	0.6	-1.9	1.6	3.9	0.0	-1.9	-1.5	-4.7	-2.0	24.6	P	Zn
43	-0.3	3.9	4.9	1.8	0.5	4.0	5.9	-0.5	-11.9	-2.1	-4.7	-1.7	42.1	Fe	B
44	0.2	1.9	4.6	-3.3	-2.6	8.8	5.6	0.4	-4.1	-3.9	-6.2	-2.0	43.6	Zn	S
45	0.3	5.7	3.1	0.1	0.0	1.5	4.0	-0.7	-5.9	-2.5	-3.8	-2.0	29.4	Fe	P
46	-0.7	4.7	3.8	0.9	1.2	1.6	5.2	-0.4	-2.4	-2.1	-9.3	-2.7	35.1	Zn	B
47	-0.6	5.5	2.4	1.5	-0.2	-0.2	4.2	-0.5	-2.3	-2.0	-5.1	-2.8	27.2	Zn	P
48	-1.1	7.1	3.6	1.4	0.1	-0.2	5.1	-0.3	-4.8	-1.3	-7.2	-2.5	34.8	Zn	P
49	0.0	6.2	2.8	-0.1	-0.9	0.5	3.4	-0.5	-5.3	-1.8	-2.7	-1.7	25.8	Fe	P
50	-0.7	6.1	3.6	0.0	-1.3	1.3	4.7	0.1	-3.7	-1.9	-5.6	-3.1	32.0	Zn	P
51	1.2	-0.9	4.4	-5.1	-1.0	1.7	-6.9	1.2	-1.7	4.3	4.1	-1.6	34.2	B	K
52	1.6	-0.1	3.8	-5.9	-1.3	1.0	-5.6	1.6	-2.0	6.9	0.3	-0.9	31.0	Ca	Mn
53	3.0	1.0	5.1	-7.4	-1.0	4.6	-8.8	2.7	-1.9	3.9	-0.2	-1.5	41.1	B	K
54	1.3	-0.4	6.2	-4.9	-0.8	2.6	-7.0	2.5	-1.8	4.1	-0.7	-1.6	34.0	B	K
55	1.6	-0.4	2.2	-2.5	-0.4	2.2	-5.6	1.7	0.2	2.0	-0.5	-0.7	19.9	B	K e S
56	1.4	0.6	4.1	-3.2	-0.7	2.5	-6.3	2.9	0.2	0.1	-1.8	-0.2	24.0	B	K
57	2.0	0.4	5.5	-3.8	-1.0	3.2	-7.1	2.5	-0.5	1.8	-2.5	-1.1	31.3	B	K
58	0.0	-0.2	5.6	-7.5	-1.7	3.4	-7.2	3.6	0.6	-0.9	5.7	-2.1	38.6	Ca	Zn
59	1.8	0.0	5.3	-8.3	-3.3	5.9	-6.5	3.5	-1.0	2.6	0.7	-1.5	40.5	Ca	S
60	0.5	0.5	6.7	-5.8	-1.0	2.2	-6.9	2.3	-0.2	1.4	1.4	-1.8	30.7	B	K
61	4.8	3.3	7.7	-6.0	1.4	4.2	-15.4	4.5	-3.8	-6.1	4.1	0.6	61.8	B	K
62	2.5	1.9	2.8	-2.6	1.5	4.0	-5.8	2.9	-0.1	-7.1	-0.4	0.1	31.6	Mn	B
63	7.0	3.7	10.3	-7.7	1.9	6.9	-18.3	2.7	-3.3	-7.7	3.5	0.1	73.1	B	K
64	3.8	3.1	5.8	-7.9	1.2	5.6	-8.7	3.7	-3.3	-4.3	-0.9	0.9	49.3	B	K
65	4.0	2.1	5.9	-10.7	0.3	3.4	-10.6	1.1	-2.8	-3.6	9.9	0.0	54.3	Ca	Zn
66	6.9	2.7	5.5	-5.5	1.3	3.0	-8.6	3.0	-4.8	-6.6	1.9	0.5	50.2	B	N
67	3.8	2.4	4.6	-2.9	0.5	1.6	-9.4	4.4	-2.8	-3.3	0.8	-0.2	36.7	B	K
68	5.0	2.4	6.2	-7.5	0.1	5.9	-10.0	3.4	-1.6	-5.6	0.9	-0.3	49.0	B	K
69	6.4	2.1	11.5	-8.2	1.8	4.3	-18.8	7.0	-4.5	-8.1	5.1	0.2	78.2	B	K
70	4.0	2.9	7.1	-8.5	0.8	4.7	-10.9	2.2	-1.9	-4.5	3.6	-0.4	51.4	B	K
71	1.0	0.5	0.2	-0.6	1.1	-0.4	-1.4	-0.9	0.3	0.7	-1.0	0.4	8.5	B	Mg
72	-0.4	0.7	1.1	-2.0	0.1	0.0	-1.4	0.0	1.2	1.4	0.4	-1.2	9.9	Ca	Mn
73	-0.5	0.8	-1.1	-2.7	0.2	0.6	-0.7	-0.3	1.5	-1.6	5.1	-1.3	16.2	Ca	Zn
74	-0.6	0.0	-0.2	-0.9	0.2	1.1	-0.2	-0.3	0.5	-0.3	2.6	-2.0	9.0	Ca	Zn
75	-0.4	1.3	-0.5	-1.6	0.2	-0.7	-0.8	0.3	0.4	-0.4	2.9	-0.7	-0.4	B	Zn
76	2.7	0.8	-1.4	-3.8	-0.2	0.4	-1.9	0.4	1.4	0.9	3.2	-2.5	2.7	Ca	Zn
77	0.5	-0.3	-0.8	-0.1	0.6	0.0	0.1	0.6	-0.7	0.5	-0.6	0.2	0.5	K	Mg e Cu
78	0.3	-0.8	0.1	-1.3	0.2	0.4	-0.5	-0.1	0.9	1.5	-0.9	0.3	0.3	Ca	Mn
79	-0.7	-0.1	0.0	0.2	-0.1	0.6	-0.1	-0.9	0.3	0.6	0.7	-0.4	-0.7	Cu	Zn
80	-0.5	0.6	0.0	0.4	0.7	0.2	-0.8	-0.7	0.0	-0.3	0.8	-0.3	-0.5	B	Zn
81	-0.9	0.3	-0.7	-0.1	1.0	-0.4	-1.2	-0.2	1.0	-0.5	2.6	-0.9	-0.9	B	Zn
82	0.7	-0.1	0.8	-0.5	-1.1	-0.8	0.8	1.0	0.4	-0.9	-0.9	0.5	0.7	Mg	Cu
83	0.0	0.5	-0.1	-3.0	0.3	1.5	-1.1	-0.6	1.5	-2.3	4.2	-0.9	0.0	Ca	Zn

Table 2. Continued...

Lots	I_N	I_P	I_K	I_{Ca}	I_{Mg}	I_S	I_B	I_{Cu}	I_{Fe}	I_{Mn}	I_{Zn}	I_{MS}	IBN	Deficient	Excessive
84	-0.7	0.0	-0.6	0.5	1.1	-0.8	-0.2	-0.5	1.3	0.4	0.0	-0.5	-0.7	S	Fe
85	-0.4	-0.8	-0.8	-0.4	0.4	-1.1	-0.5	0.2	1.6	-0.3	2.2	-0.1	-0.4	S	Zn
86	-0.2	0.1	-0.6	-1.6	0.3	1.3	-1.3	0.0	0.8	-2.5	4.5	-0.9	-0.2	Mn	Zn
87	-0.1	0.6	0.1	-1.0	-0.7	1.8	-0.4	0.3	1.4	-2.5	1.2	-0.7	-0.1	Mn	S
88	-0.2	0.3	-0.2	0.0	0.1	1.0	-0.5	-0.4	0.6	-3.1	3.6	-1.0	-0.2	Mn	Zn
89	-0.7	-0.5	0.2	-1.1	0.5	0.2	-0.3	-0.3	1.4	-0.5	1.2	-0.2	-0.7	Ca	Fe
90	-0.7	0.0	-0.1	-0.5	0.6	0.1	-0.9	-0.1	2.2	0.3	0.3	-1.2	-0.7	B	Fe
91	1.3	0.7	3.6	-0.9	0.1	3.4	-4.2	-0.1	-0.3	-1.5	-2.6	0.4	1.3	B	K
92	2.7	1.3	3.7	-3.0	1.6	1.7	-6.3	-0.4	0.1	-2.6	-1.4	2.0	2.7	B	K
93	0.6	2.9	2.7	0.0	0.8	1.7	-6.9	-0.2	-0.5	-1.9	-1.1	1.9	0.6	B	P
94	3.5	1.5	1.9	-1.5	1.8	1.3	-5.2	-0.5	-0.7	-1.9	-1.7	1.5	3.5	B	N
95	0.2	1.2	4.5	-0.8	-0.3	2.3	-4.5	0.7	-2.6	-0.9	-0.6	0.5	0.2	B	K
96	0.7	0.4	4.1	0.5	0.4	1.1	-7.8	0.4	-0.1	-0.6	-0.4	1.1	0.7	B	K
97	1.2	1.4	4.2	-0.3	0.6	3.4	-9.4	-0.1	-0.2	-0.5	-1.1	0.7	1.2	B	K
98	1.0	2.2	4.8	-1.3	-0.2	2.0	-9.4	0.8	0.4	-0.6	-0.8	0.7	1.0	B	K
99	0.9	0.7	5.3	-0.1	-0.9	0.9	-10.0	0.4	-0.1	-0.8	2.1	1.4	0.9	B	K
100	0.8	0.2	4.1	0.3	-0.5	2.8	-7.7	1.2	-0.3	-0.7	-0.7	0.4	0.8	B	K

from different levels of productivity, lower values of the magnitudes of the Diagnostic Indices and, consequently, lower values of IBN for norms originated of populations with yields above 30 t ha^{-1}.

Also, we observed in the data samples of Table 2 that the major deficiency was of nutrient B (55% of the plots) due to the high extraction by the crop in the phenological stages of the flowering and fruiting.

We verified excess of the nutrient k (34% of the plots) this can be attributed to frequent fertilizations using formulations containing high concentrations of K2O.

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REFERENCES

Bataglia OC & Santos WR (1990) Efeito do procedimento de cálculo e da população de referência nos índices do Sistema Integrado de Diagnose e Recomendação (DRIS). Revista Brasileira de Ciência do Solo 14: 339-344.

Beaufils ER (1973) Diagnosis and Recommendation Integrated System (DRIS): a general scheme for experimentation and calibration based on principles develop from research in plant nutrition. Soil Science Bulletin 1: 1-132.

Hallmark WB, Walworth JL, Sumner ME, Mooy CJ, Pesek J & Shao KP (1987) Separating limiting from non-limiting nutrients. Journal of Plant Nutrition 10: 1381-1390. http://dx.doi.org/10.1080/01904168709363670.

IAPAR – Instituto Agronômico do Paraná (2016) Cartas climáticas do Paraná: classificação climática. Londrina. Available from: <http://www.iapar.br/modules/conteudo/conteudo.php?conteudo=863> Accessed: 14 apr. 2016.

IBGE – Instituto Brasileiro de Geografia e Estatística (2014) Sistema IBGE de Recuperação Automática – SIDRA. Rio de Janeiro. Available from: <http://www.sidra.ibge.gov.br/bda/tabela/protabl.asp?c=1613&z=t&o=11&i=P> Accessed: 17 apr. 2016

IPARDES – Instituto Paranaense de Desenvolvimento Econômico e Social (2014) Anuário estatístico do Estado do Paraná: território. Curitiba. Available from: <http://www.ipardes.pr.gov.br/anuario_2014/index.html>. Accessed: 5 may 2016.

Jones CA (1981) C.A. Proposed modifications of the Diagnosis and Recomendation Integrated System (DRIS) for interpreting plant analysis. Communications in Soil Science and Plant Analysis 12(8): 785-794. http://dx.doi.org/10.1080/00103628109367194.

Nachtigall GR (2004) Sistema Integrado de Diagnose e Recomendação (DRIS) para avaliação do estado nutricional da macieira no Sul do Brasil. Tese de Doutorado, Escola Superior de Agricultura "Luiz de Queiroz", Universidade de São Paulo, Piracicaba.

Paraná. SEAB – Secretaria de Estado da Agricultura e do Abastecimento. DERAL – Departamento de Economia Rural (2015) Fruticultura. Curitiba. Available from: <http://www.agricultura.pr.gov.br/arquivos/File/deral/Prognosticos/fruticultura_2014_15.pdf>. Accessed: 18 apr. 2016.

Walworth JL & Sumner ME (1987) The Diagnosis and Recommendation Integrated System (DRIS). Advances in Soil Science 6: 149-188. http://dx.doi.org/10.1007/978-1-4612-4682-4_4.

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