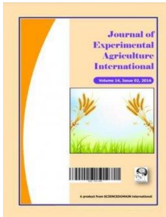

Journal of Experimental Agriculture International

22(5): 1-10, 2018; Article no.JEAI.41143
ISSN: 2457-0591
(Past name: American Journal of Experimental Agriculture, Past ISSN: 2231-0606)

Nutritional Status of Isabel and Niagara Rosada Vines with Integrated Diagnosis and Recommendation System (DRIS) and Ranges of Sufficiency

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Authors' contributions

This work was carried out in collaboration with all authors. Authors CMM and JSSL prepared the study, conducted the experiment in the field and handled the writing of the manuscript. Authors LAMM and EFO performed the evaluations of the parameters analyzed in the study. Author SAS performed the statistical analysis. Author JMC managed the bibliographical researches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JEAI/2018/41143
Editor(s):
(1) Anita Biesiada, Professor, Department of Horticulture, Wroclaw University of Environmental and Life Sciences, Poland.
Reviewers:
(1) Alexis Valerio, Valery Ramirez, Universidad Nacional Experimental del Táchira (UNET), Táchira, Venezuela.
(2) Müzeyyen Berkel Kaşikci, Manisa Celal Bayar University, Turkey.
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(4) Hakan Kurt, Necmettin Erbakan Üniversitesi Ahmet Keleşoğlu Eğitim Fakültesi, Turkiye.
Complete Peer review History: http://www.sciencedomain.org/review-history/24337

Short Research Article

Received 15th February 2018
Accepted 25th April 2018
Published 27th April 2018

ABSTRACT

Nutritional diagnosis is an efficient tool to detect a dietary imbalance of plants. This work aimed to evaluate the nutritional status of grapevines of the cultivars Niagara Rosada and Isabel by the methods Sufficiency Bands (SB) and DRIS in three environments in the municipal district of Santa

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Teresa-ES. Six vineyards had selected at three different high (250, 500 and 650 meters high) of the Niagara Rosada and Isabel cultivars. To perform the leaf diagnosis, complete and healthy leaves had collected at the time of full bloom, and the first fresh leaf opposite the first bunch had gathered. Plant tissues had collected and analysed for N, P, K, Ca, Mg, S, B, Cu, Fe, Mn and Zn contents. The results had submitted to statistical analysis and interpretation of the results of the foliar study of each vineyard had performed by the method of the Sufficiency Ranges, as proposed by Terra (2003) and by the DRIS method. The nutrients Zn, S, Cu and Mg were the most limiting for deficiency, and Fe, B, Ca and Fe were the most limiting by excess. There was a divergence between the DRIS and RS methods in nutritional diagnosis for vines in the three environments. The DRIS method, considering the interaction between nutrients, determines with better accuracy when nutrients are limiting.

Keywords: Viticulture; Vitis labrusca L.; foliar analysis; method.

1. INTRODUCTION

Balanced nutrition and fertilisation are essential components of growing technology in vines regarding achieving the required yields and quality of grapes [1]. Propagation is one of the cultivation techniques that the grower modifies the nutritional state of the plant in search of the correct balance between the yield and the quality of the crop [2]. Due to vines are often cultivated in a place for a long time, fertilisation requires careful attention to fertilisation of the vines before planting, as well as maintenance fertilisation of grape plantations [3]. A small application of fertilizers may unbalance the availability of nutrients, adversely affecting the nutritional status of plants, the final quality of the crop and even the environment [2].

The nutritional diagnosis is an efficient instrument to detect imbalances and help in the process of recommending fertilizers for vines and usually in vines, these are made from the chemical analysis of the foliar tissue and posterior comparison with optimal leaf contents, using such as critical levels (CL) or ranges of sufficiency (RS) [4]. However, the use of these methods is strongly influenced by some non-nutritional factors, related to environments and cultivars, requiring care when used.

An alternative approach, possibly more efficient to reveal nutritional imbalances and more robust about variations in sampling, is the Integrated Diagnosis and Recommendation System (DRIS) [4]. DRIS showed to be an accurate method in the analysis of nutrient requirements for several crops and proved to be advantageous in the interpretation of leaf analysis results [5]. For [6], the DRIS method is an alternative to the traditional techniques of nutritional diagnosis, since it allows the evaluation of the nutritional balance of the plant, classifying nutrient levels in a relative way. The system computes an index for each nutrient, based on the interrelationships between nutrients and compares them with a reference high-income population [7].

This study aimed to evaluate the nutritional status of grapevines of the cultivars Niagara Rosada and Isabel by the methods ranges sufficiency (RS) and DRIS in three different environments.

2. MATERIALS AND METHODS

The research was conducted in the municipal district of Santa Teresa, northwest region of Espirito Santo State (19º 56 '08 "South and 40º 36' 01" West), Brazil. The climate of the region, according to the classification of Köppen, is the Cwb type (temperate sea/tropical climate), with an average annual temperature of 24,6ºC and precipitation varying between 700 and 1,200 mm.

For the study, vineyards of the cultivars Niagara Rosada and Isabel had used. Six vineyards had selected at three different altitudes (250, 500 and 650 meters altitude). Each altitude had represented by two vineyards, one vineyard of the cultivar Niagara Rosada and the other of the cultivar Isabel. In this approach, the altitudes of 250, 500 and 650 m were denominated environments A1, A2 and A3 respectively.

The physical, chemical and physicochemical characterization of the soil of the vines in the three environments is shown on Table 1.

Plant tissue had collected during the vegetative cycle of 2016. For foliage diagnosis (macronutrients and micronutrients), leaves were collected at the time of full bloom (when most of the vines are in stage I - open and ready flowers to be fertilized). Only full and healthy leaves had analyzed, and the first fresh leaf opposite the first cluster had collected. The collected plant tissues were packed in paper bags, properly identified and dried in an oven with forced air ventilation at 65ºC until reaching constant weight. The tissues were ground in a Willey mill with a mesh of 20 mesh and sent to the laboratory for chemical analysis of the contents of N, P, K, Ca, Mg, S, B, Cu, Fe, Mn and Zn.

The results were submitted to descriptive statistical analysis (mean, median, maximum value, minimum value, standard deviation, ks: asymmetry coefficient, kc: kurtosis coefficient and VC: variation coefficient). The interpretation of the results of the foliar analysis of each vineyard had performed by the Sufficiency Band method and by DRIS method.

The ranges of sufficiency used were those proposed by [8], according to Table 2.

The used DRIS standards were those proposed by [9], where the reference crop had characterised by a high yield. For the calculations of reduced normal function, the mean ratio between the two nutrients (a / b) and the mean standard deviation of the quotients of the coefficients (a / b) according to values referenced by [8] were used (Table 2).

The common functions for the generation of the DRIS indexes had calculated by the formula proposed by Jones (1981), according to Equation 1:

$$f(A/B) = (X/Y - a/b).\ K/s \qquad (1)$$

where: f (A / B) = function of the relationship between the contents of two nutrients of the sample to be diagnosed; A / B = value of the relation between the contents of two nutrients of the sample to be diagnosed; a / b = optimal value (norm) for the relationship between nutrients;

Table 1. Physical, chemical and physicochemical characterization of the soil of the vineyards in the three environments

Determinations	Environments 1		Environments 2		Environments 3	
	Niagara Rosada	Isabel	Niagara Rosada	Isabel	Niagara Rosada	Isabel
O.M. (dag dm^{-3})	2,0	2,8	3,4	1,9	2,6	3,5
pH in water	6,5	6,4	6,2	6,4	6,3	6,0
P (mg dm^{-3})	247,0	227,2	290,2	135,8	231,6	202,5
K (mg dm^{-3})	334	306	312	324	150	157
Ca (cmolc dm^{-3})	5,7	5,6	5,9	4,3	5,8	4,4
Mg (cmolc dm^{-3})	1,4	1,4	1,5	1,3	1,6	1,0
Al (cmolc dm^{-3})	0,00	0,00	0,00	0,00	0,00	0,00
H + Al (cmolc dm^{-3})	1,60	1,60	2,50	1,50	1,60	4,10
S.B. (cmolc dm^{-3})	7,95	7,78	8,20	6,43	7,78	5,80
C.E.C. (cmolc dm^{-3})	9,55	9,38	10,70	7,93	9,38	9,90
V (%)	83	83	77	81	83	59
K na C.E.C. (%)	9	8	7	10	4	4
Ca na C.E.C. (%)	60	60	55	54	62	44
Mg na C.E.C. (%)	15	15	14	16	17	10
Al na C.E.C. (%)	0,0	0,0	0,0	0,0	0,0	0,0
H+Al na C.E.C. (%)	17	17	23	19	17	41
P-rem. (mg L^{-1})	29,1	29,3	33,0	22,2	25,2	28,0
S(mg dm^{-3})	32	43	32	53	26	27
B (mg dm^{-3})	0,79	0,52	0,90	0,62	0,94	0,74
Zn (mg dm^{-3})	2,1	2,0	1,7	2,9	2,7	3,0
Mn (mg dm^{-3})	135,0	124,5	87,9	88,6	44,8	62,1
Cu (mg dm^{-3})	3,7	5,6	3,3	5,9	1,6	3,0
Fe (mg dm^{-3})	30	32	28	51	75	87
Total Sand (%)	51,5	55,9	56,0	49,1	49,1	49,6
Silt (%)	11,3	8,1	13,0	10,4	11,2	12,2
Clay (%)	37,2	36,0	31,0	40,5	39,8	38,2

C.R.C.: cation exchange capacity; S.B.: sum of bases; O.M.: organic matter

Table 2. Criteria for interpretation of macronutrient (g kg^{-1}) and micronutrients (mg kg^{-1}) in leaf analysis for grapevine

Macronutrients	Lack	Fast lack	Optimum	Slight exceeding	Excess
	(g kg^{-1})				
N	<26	26-29	30-35	36-40	>40
P	<1,3	1,3-2,3	2,4-2,9	3,0-3,9	>3,9
K	<7	7,0-14	15-20	21-29	>29
Ca	<8	8-12	13-18	19-32	>32
Mg	<3,0	3,0-4,7	4,8-5,3	5,4-10	>10,0
S	<2,0	2,0-3,2	3,3-3,8	3,9-6,0	>6,0
Micronutrients	**Lack**	**Fast lack**	**Optimum**	**Slight exceeding**	**Excess**
	(mg kg^{-1})				
B	<20	20-44	45-53	54-100	>100
Cu	<5	5-17	18-22	23-40	>40
Fe	<50	50-96	97-105	106-200	>200
Mn	<20	20-66	67-73	74-300	>300
Zn	<15	15-29	30-35	36-200	>200

Source: Terra, (2003).

K = 1 (sensitivity constant), and s = standard deviation of the relation x / y (norm) in the reference population.

After the calculations of the reduced normal functions, the DRIS indices had calculated the following the recommendations of [10], according to Equation 2:

Index A= {[f(A/B) +...+ f(A/Z)] - [f(B/A) +...+f(Z/A)]} / (n+m) (2)

Where: f (A / B) ... f (A / Z) = reduced normal function of the direct relationship between the contents of two nutrients A and B; A and Z; f (B / A) ... f (Z / A) = reduced normal function of the inverse relationship between the contents of two nutrients A and B; Z and A, respectively, n = number of functions where the nutrient A in analysis appears in the numerator (direct relations); m = number of functions where the nutrient A under analysis appears in the denominator (inverse ratios).

For the interpretation of the rates, the standard procedure proposed by [11] had used. Negative values mean a deficiency of the element about the others; positive values indicate an excess, and the closer to zero these indexes are, the closer the nutritional balance will be.

The nutritional balance index (NBI) had calculated by the sum of the DRIS indices for each variable of leaf analysis in each plot of conventional soybean and transgenic soybean, according to Equation 3:

NBI= | Index A| + | Index B| +...+ | Index Z| (3)

where: Index A, index B and index Z = DRIS indices of nutrients A, B and Z.

3. RESULTS AND DISCUSSION

The results of the leaf tissues analysis of the Niagara Rosada and Isabel cultivars cultivated in the municipal district of Santa Teresa - ES are showed in Tables 3 and 4, respectively.

The concentrations of macro and micronutrients in the analysed leaves of the cultivars Niagara Rosada and Isabel (Tables 3 and 4) present medium and near average, indicating, therefore, normal distribution, which was proved by the Kolmogorov-Smirnov test ($p<0.05$) (KS). Regarding the distribution asymmetry, 51.5% of the data are positive (right) and 48.9% as negative (left) for Niagara Rosada. For Isabel, 57.6% were positive and 42.3% negative. In the decisive balance, the mean is higher than the median of the data, showing a concentration of values below the way.

Regarding kurtosis for Niagara Rosada cultivar, 63.6% of the data present positive kc, indicating the leptokurtic distribution and the other (negative) flattening with flattening and for these attributes distancing from the central value. Regarding the Isabel cultivar, 39.4% and 40.6% for negative kurtosis (leptokurtic) were present, with a higher dispersion of the data when compared to the Niagara Rosada cultivar. Considering the interval $-0.50 < kc < 0.50$ we have 21.2% and 24.2% of the data as mercuric distribution for the varieties Niagara Rosada and Isabel, respectively.

Table 3. Descriptive analysis of leaf chemical attributes of the Rosa Niagara grape in the three environments

Attribute	A	Md	Mín	Max	S	as	kc	CV	RS
				$g\ kg^{-1}$					
N_1	41,16	40,25	37,10	44,80	2,46	0,07	-0,94	6,0	Excess
N_2	38,92	39,20	32,20	42,00	2,78	-1,60	3,64	7,2	Slight exceeding
N_3	31,22	31,15	27,30	35,00	2,38	-0,23	-0,35	7,6	Optimum
P_1	3,74	3,80	2,80	4,50	0,46	-0,57	1,37	12,2	Slight exceeding
P_2	3,64	3,65	3,10	4,40	0,37	0,61	0,93	10,3	Slight exceeding
P_3	3,29	3,05	2,90	4,20	0,47	1,15	-0,14	14,2	Slight exceeding
K_1	20,08	20,00	18,00	24,80	1,89	1,79	4,68	9,4	Optimum
K_2	17,95	17,50	16,00	22,20	1,89	1,45	2,02	10,5	Optimum
K_3	10,76	10,35	9,80	14,80	1,47	2,77	8,16	13,7	Fast lack
Ca_1	15,06	15,40	12,80	16,60	1,32	-0,92	-0,30	8,8	Optimum
Ca_2	16,41	16,60	14,50	17,80	1,03	-0,94	0,50	6,3	Optimum
Ca_3	11,65	12,30	8,30	13,30	1,78	-1,26	0,40	15,3	Fast lack
Mg_1	4,24	4,25	3,80	4,50	0,21	-0,75	0,87	5,0	Fast lack
Mg_2	3,42	3,45	2,80	4,10	0,46	-0,05	-1,45	13,6	Fast lack
Mg_3	2,71	2,65	2,30	3,70	0,42	1,50	2,89	15,5	Lack
S_1	2,85	2,90	2,40	3,20	0,24	-0,15	0,31	8,5	Fast lack
S_2	2,69	2,70	2,50	3,10	0,17	1,48	3,27	6,4	Fast lack
S_3	2,25	2,25	1,90	2,60	0,26	0,00	-1,92	11,7	Fast lack
				$mg\ kg^{-1}$					
B_1	96,00	101,27	48,93	127,16	22,56	-0,94	1,00	23,5	Slight exceeding
B_2	45,44	45,99	33,07	54,17	6,24	-0,62	0,39	13,7	Optimum
B_3	43,27	44,44	33,91	49,60	5,43	-0,65	-0,70	12,5	Fast lack
Zn_1	29,07	29,15	18,55	36,60	5,49	-0,46	0,13	18,9	Fast lack
Zn_2	33,74	31,58	24,40	50,55	7,60	1,18	1,67	22,5	Optimum
Zn_3	35,94	31,88	23,10	73,30	14,07	2,41	6,74	39,2	Optimum
Mn_1	157,00	155,00	125,00	175,00	18,14	-0,49	-0,89	11,6	Slight exceeding
Mn_2	142,50	145,00	95,00	175,00	27,11	-0,37	-0,93	19,0	Slight exceeding
Mn_3	128,50	107,50	70,00	400,00	97,33	2,93	8,95	75,7	Slight exceeding
Fe_1	202,50	195,00	160,00	275,00	32,85	1,22	1,78	16,2	Excess
Fe_2	170,50	170,00	155,00	195,00	12,57	0,75	0,02	7,4	Slight exceeding
Fe_3	228,88	229,98	182,25	254,40	21,36	-1,02	1,50	9,3	Excess
Cu_1	10,81	10,23	7,40	14,60	2,46	0,23	-1,27	22,8	Fast lack
Cu_2	9,62	9,63	7,75	12,60	1,29	1,19	3,08	13,4	Fast lack
Cu_3	8,89	8,80	7,70	10,75	0,81	1,15	2,81	9,1	Fast lack

1-environment with 250 m high; 2- environment with 500 m high; 3- environment with 600 m high, A: average; Md: medium; Min: minimum value; Max: maximum value; S: standard deviation; as: assimetry coefficient; kc: kurtosis coefficient and VC: variation coefficient

Variation coefficient (VC) indicates the variability of data in a less dimension scale, thus comparing this variation between different attributes and according to [12] is classified as low (VC<10%) for 36.4% of the data for the Niagara Rosada cultivar; as mean (10% <VC<20%) for 48.5% of the data; high (20% <VC<30%) to 9.0% of data and very high (VC> 30%) to 6.0% of data. In the environment 3 (650 m high) all attributes present, as compared to the other two, the highest VCs, except for B, Fe and Cu. Mn and Zn in environment 3 have VC values higher than 30%. This fact may be indicative of the nutritional imbalance at the highest altitude for the cultivar Niagara Rosada.

About Isabel cultivar, VC classification for the data had given below (VC<10%) to 30.3%; mean (10% <VC<20%) to 48.5%; high (20% <VC<30%) to 18.2% and very high (VC> 30%) to 3.3% of the data. In the high VC gap, the percentage for Isabel grape is the same as for the Niagara Rosada grape. Considering VC, we have in the environment three the occurrence of lower VCs for K, Mg, B, Mn and Cu. However, Zn also showed the highest VC, as well as for Niagara Rosada. In the environment two smaller VC had observed for N, P, Ca, S, Zn and Fe about environment 1 and 2. This observation indicates that in environment 1, data present bigger variability.

The DRIS indices for each nutrient that had calculated based on nutrient leaf content by the methodology of [13] for the complete leaf of the cultivars Niagara Rosada and Isabel in the three environments follow on Table 5. The estimation of optimal leaf contents for the vine, from the results of the DRIS, had obtained assuming that plants with DRIS indexes tending to zero are well nourished [4].

Table 4. Descriptive analysis of the leaf chemical attributes of the Isabel grape in the three environments

Attribute	A	Md	Mín	Max	S	as	kc	CV	RS
				g kg^{-1}					
N_1	39,69	40,25	31,50	44,80	4,06	-0,79	0,46	10,2	Slight exceeding
N_2	35,91	36,05	32,90	39,20	2,29	-0,07	-1,39	6,4	Optimum
N_3	31,22	31,15	27,30	35,00	2,38	-0,23	-0,35	7,6	Optimum
P_1	3,41	3,40	2,70	4,20	0,43	0,19	0,26	12,6	Slight exceeding
P_2	3,64	3,65	3,10	4,40	0,19	1,10	1,68	6,9	Slight exceeding
P_3	3,63	3,55	2,90	4,50	0,43	0,46	1,16	11,9	Slight exceeding
K_1	16,89	17,00	14,00	20,20	1,94	0,26	-0,72	11,5	Optimum
K_2	17,36	17,50	12,80	19,80	2,13	-0,94	1,22	12,3	Optimum
K_3	13,42	13,80	12,00	14,20	0,80	-0,95	-0,43	5,9	Fast lack
Ca_1	16,30	16,40	14,60	17,70	0,96	-0,32	-0,69	5,9	Optimum
Ca_2	16,71	16,70	15,40	18,00	0,81	-0,21	-0,47	4,9	Optimum
Ca_3	11,01	10,90	9,90	12,50	0,77	0,52	0,43	6,9	Fast lack
Mg_1	4,01	4,05	3,20	4,50	0,45	-0,58	-0,72	11,1	Fast lack
Mg_2	2,94	2,85	2,10	4,10	0,75	0,41	-1,23	25,5	Lack
Mg_3	2,34	2,40	2,00	2,50	0,16	-0,99	0,45	7,0	Lack
S_1	2,64	2,60	2,30	3,30	0,30	1,33	1,57	11,5	Fast lack
S_2	2,89	2,85	2,50	3,20	0,22	0,01	-0,39	7,7	Fast lack
S_3	2,20	2,25	1,90	2,50	0,24	-0,32	-1,69	10,7	Fast lack
				mg kg^{-1}					
B_1	83,46	80,49	50,12	108,58	19,24	-0,10	-0,73	23,0	Slight exceeding
B_2	53,12	55,24	37,18	68,07	9,95	-0,10	-0,80	18,7	Optimum
B_3	41,68	39,90	35,55	51,29	5,14	0,83	-0,26	12,3	Fast lack
Zn_1	26,57	26,95	16,50	39,75	7,66	0,17	-0,74	28,8	Fast lack
Zn_2	43,84	44,83	28,25	52,60	7,82	-0,98	0,31	17,8	Slight exceeding
Zn_3	30,54	26,78	22,50	59,00	10,86	2,33	6,13	35,6	Optimum
Mn_1	176,50	162,50	125,00	265,00	47,50	1,37	0,78	26,9	Slight exceeding
Mn_2	238,50	262,50	140,00	335,00	61,83	-0,20	-1,05	25,9	Slight exceeding
Mn_3	96,00	95,00	80,00	120,00	14,87	0,36	-1,27	15,5	Slight exceeding
Fe_1	239,50	220,00	185,00	410,00	65,85	2,30	5,69	27,5	Excess
Fe_2	204,50	202,50	180,00	235,00	18,63	0,68	-0,20	9,1	Excess
Fe_3	228,07	219,80	208,75	307,50	29,89	2,51	6,68	13,1	Excess
Cu_1	9,14	9,00	6,15	12,60	1,92	0,30	-0,19	21,0	Fast lack
Cu_2	6,61	6,50	5,25	9,05	1,09	1,12	2,20	16,5	Fast lack
Cu_3	9,02	8,88	7,85	10,30	0,97	0,25	-1,68	10,7	Fast lack

1-environment with 250 m high; 2- environment with 500 m high; 3- environment with 600 m high, A: average; Md: medium; Min: minimum value; Max: maximum value; S: standard deviation; as: assimetry coefficient; kc: kurtosis coefficient and VC: variation coefficient

Table 5. DRIS values, Nutritional Balance Index (NBI) and nutritional excess deficiency sequence for Niagara Rosada and Isabel cultivars in three environments in the municipal district of Santa Teresa-ES

	NrE1	NrE2	NrE3	IsE1	IsE2	IsE3
N	2,1031	5,9248	-0,4884	2,1011	0,819	1,5159
P	-9,7033	-4,4978	-1,2172	-10,7725	-18,4291	3,7289
K	9,4363	9,9931	-6,688	4,0797	10,2438	3,5838
Ca	5,1238	16,8693	5,3494	11,6417	19,4563	3,9695
Mg	31,1598	19,892	-24,8271	9,8679	-15,9798	-39,6089
S	-37,3322	-25,9793	-57,0023	-54,4489	-28,3859	-58,4307
B	30,2403	2,3406	6,2085	25,994	9,6962	5,3737
Cu	-20,2877	-19,1509	-17,2853	-26,3293	-36,9122	-16,1736
Fe	38,0906	30,4092	125,0418	86,302	77,4689	135,3033
Mg	-8,0904	-7,7483	-7,5324	-4,8603	1,8644	-13,0073
Zn	-40,7402	-28,0527	-21,5591	-43,5755	-19,8417	-26,2545
NBI	23,231	17,086	27,32	27,997	23,91	30,695
	Sequence deficiency to excess					
NrE1	Zn<S<Cu<P<Mn<N<Ca<K<B<Mg<Fe					
NrE2	Zn<S<Cu<Mn<P<B<N<K<Ca<Mg<Fe					
NrE3	S<Mg<Zn<Cu<Mn<K<P<N<Ca<B<Fe					
IsE1	S<Zn<Cu<P<Mn<N<K<Mg<Ca<B<Fe					
IsE2	Cu<S<Zn<P<Mg<N<Mn<B<K<Ca<Fe					
IsE3	S<Mg<Zn<Cu<Mn<N<K<P<Ca<B<Fe					

Nr-Niagara Rosada; Is-Isabel; A1- environment 1; A2- environment 2; A3- environments 3; NBI-Nutritional balance index

For the nutritional evaluation done by the DRIS method for the cultivar Niagara Rosada in environment 1 and 2 (Table 5), Zn, S and Cu were the nutrients that showed the biggest limitation due to deficiency, since they presented in the first orders of lack. Regarding the environment 3, the boundaries were referring to nutrients S, Mg Zn. According to the Range of sufficiency method (RS) (Table 3), Zn is considered the level of rapid grace for environment 1 and optimal for situation 2 and 3. Regarding S and Cu, the leaf values for the cultivar Niagara Rosada in the three settings are in the range of rapid shortage established by [8]. As for the nutrient Mg, it had observed that the environment 1 and 2 are with the foliar Mg values in the fast-deficiency range and the environment 3 in the deficiency range.

It is interesting noting that there was a divergence between the two methods regarding the classification for Zn in environments 2 and 3, whereby the DRIS method, values are classified as deficient, whereas by the RS method they appear as values within the optimal range. Another observed divergence for the nutrient Mg in environment 1 and 2 for the cultivar Niagara Rosada. By the DRIS method, costs are classified as a nutritional disorder linked to the excess, and by the RS method, the values are in the fast-deficiency range. Probably this difference in the interpretation of the results is due to the methodology used in each process. [14] suggests that RS had recommended, with restrictions, exclusively for soil-climatic and cultural management conditions similar to those used in the development of nutritional standards. Therefore, [15] reported that normal range of estimated nutrients through DRIS, usually, show lower amplitude contrasting to ranges of sufficiency given by calibration essays, efficiently contributing to the increase in discrepancy among different evaluated methods of standard foliage mean, to range sufficiency method. Smaller methods of amplitude emphasise with more evidence the differences which can be influenced by various edaphoclimatic condition and, or, social management [16], with the occurrence of dilution and concentration effects [17], showing the necessity of local nutritional standard, when RS method is used [18].

In Table 5, it had observed that the nutritional disorders related to excess for Niagara Rosada cultivar were given for nutrients B, Mg and Fe in room 1 and for Ca, Mg and Fe in room 2. Nutritional disorders related to excess had linked to nutrients Ca, B and Fe. By the RS method, the nutrients considered in the environment 2 are N, B, Mg, Mn and Fe and in room 3 are the P, Mn and Fe. Differences were observed between N, P, B, Mg, Fe and Mn. The two methods, especially for N and P, which in the DRIS method are not limiting for excess and in the RS method are in light excess or excess. In general, it had observed that in the RS method there was interference in the distribution of the diagnoses about the DRIS method, contributing to a more significant amount of nutrients considered in excess limitation. Corroborating with the results of this work, [14] evaluating the nutritional status of common bean irrigated by the CND, DRIS and sufficiency ranges, observed that RS tends to present a higher frequency of nutrients considered in excess dietary, compared to other diagnostic methods.

In order to cultivate Isabel, nutritional evaluation using the DRIS method (Table 5), S, Zn and Cu and Mg were the nutrients that showed the greatest limitation due to deficiency, except for Mg, which appears only in environment 3. (Table 4) showed that the nutrients with the highest frequency of deficiency are: Mg, S, Cu and Zn for the environment 1; Mg, S, B and Cu for environment 2 and K, Mg and S, for the environment 3. By comparing these two methods, nutrients said to be limiting by deficiency were similar in these two methods except in some cases, such as Mg, which the DRIS method does not appear in the order of limiting in environment 1 and 2. OB and K also, by the DRIS method, do not appear in the limiting order in environment 1 and two respectively.

In general, the most limiting nutrients for deficiency, both in Niagara Rosada and Isabel in the three environments and in the two methods of interpretation, were S, Zn and Cu.

It is believed that the low leaf values of Zn and Cu found are due to soil pH, which is equal to or greater than 6 in all evaluated vineyards (Table 1). According to [19] the ability of the soil to provide the micronutrients Zn, B, Cu, Fe, and Mn to plants depends mainly on their pH, which has higher acid solubility. According to the author, deficiency symptoms of Zn, B and Cu in plants are observed in the soil where the pH was raised to above 6 by liming. According to [20], at pH values greater than 6.5 the cell membranes of the root apices lose their stability, negatively affecting the processes of selective ion absorption. Thus, it had assumed that higher pH values had negatively affected the absorption of these nutrients by plants.

About S, the lowest leaf values found had related to the use of formulations of concentrated fertilizers with low S content. There is no doubt about the efficiency of this nutrient, but the great difficulty of using S consists in its absence in NPK formulations [21] and formulations of low-element fertilizers [22]. Thus, the use of fertilizers containing a low concentration of S coupled to the export of the same by fruits had caused the lowest leaf values of S found.

According to Table 5, it had observed that nutritional disorders related to excess for the Isabel cultivar, were given for the nutrients Ca, B, Fe and K, being the limiting K only in the environment 2. By the RS, the nutrients framed in the binding ranges. Light excess or excess for environments 1, 2 and 3 was: N, P, B, Mn and Fe; P, Zn, Mn and Fe; P, Mn and Fe, respectively. The nutrients P and Mn that appear as excesses by RS in the DRIS method are not present in the first excess orders and thus are not considered super limited in this method. Possibly this divergence between the two methods is due to the methodology used to obtain the standard values. Nutritional diagnosis comparing nutrient contents with RS does not consider the interactions between nutrients or the conditions of plant growth, which is why it is necessary that all other situations, except the nutrient under analysis, be controlled and maintained concerning optimal availability [23]. Therefore, the growth conditions of the plants had evaluated should be similar to those used to obtain the calibration curve, used to obtain the standard values (SV or RS), with regard to edaphoclimatic conditions, age plant and tissue, type of genetic material, position of the tissue in the plant and availability of other nutrients [24]. In contrast, in the DRIS method, the relationship between foliar concentrations of nutrients had used to interpret the results of tissue analysis, which are less sensitive to factors such as age of plant, season, organs sampled in the plant, among others, which have a great effect on leaf contents [25], determining with better precision which nutrients are in excess or deficiency. Thus, a divergence between these methods had expected when the nutritional diagnosis is made.

Fe was the most limiting nutrient for excess, both by the RS method and by the DRIS in all environments and cultivars analyzed. This suggests to the grape growers of the studied region a bigger observation about this nutrient in the annual fertilization planning. The balance of Fe should be controlled, since both the deficiency and the toxicity affect the plant metabolism [26], and thus the development and growth of the plants [27]. In plants, damage caused by Fe toxicity can be direct, through absorption and excessive accumulation of the nutrient, or indirect, when high levels of Fe in the soil solution result in the precipitation on the roots, forming a ferric oxide crust, which alters the absorption of other nutrients such as P, K and Zn [28].

4. CONCLUSION

There is a divergence between the DRIS and RS methods in the nutritional diagnosis for vines in the three environments, where the sufficiency ranges tend to present a higher frequency of nutrients considered in nutritional excess, and the DRIS method has a greater accuracy when nutrients are in excess or deficiency.

The nutrients Zn, S, Cu and Mg were the most limiting by deficiency, and Fe, B, Ca and Fe were the most limiting in excess for vines in the unbalanced region.

Through the two methods of nutritional evaluation, the environments analyzed presented a high degree of nutritional imbalance for the nutrient Fe.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
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