Science Arena Publications
Specialty Journal of Biological Sciences
ISSN: 2412-7396
Available online at www.sciarena.com
2018, Vol, 4 (1): 1-7

Nutrient Status and Establishment of Adequate Ranges for Different Nutrients for Grape (VitisviniferaL., var. superior) through DRIS Method under Different K-fertilizers Combination Ratios

Abd El-RheemKh. M.[1*], Sahar M. Zaghoul[2], A. A. Yassen[2]

[1] Soils and Water Use Dept., National Research Centre, Dokki, Giza, Egypt
[2] Plant nutrition Dept., National Research Centre, Dokki, Giza, Egypt

***Corresponding Author:** khaled_abdelrheem@yahoo.com

Abstract : *A field experiment was organized on sandy soil (TypicTorriorthent) at a private vine yard (Agrofarms) at South El-Tahrer Province, El-Behiera Governorate, Egypt during 2015/2016, to establish the adequate ranges for some nutrients (N, P, K, Ca, Mg and Cl) through DRIS method under different K-fertilizers combination ratios. Fertigation was applied at the following twelve mixing ratios of potassium chloride (60 % K2O) K-KCl, potassium nitrate (46 % K2O) K-KNO3 and potassium sulfate (50 % K2O) K-K2SO4: (100 / 0 / 0), (75 / 25 / 0), (50 / 50 / 0), (25 / 75 / 0), (0 / 100 / 0), (0 / 75 / 25), (0 / 50 / 50), (0 / 25 / 75), (0 / 0 / 100), (25 / 0 / 75), (50 / 0 / 50) and (75 / 0 / 25) relative to 100 that equal to the total K requirement during growth stage (160 unit).*

The results showed that the lowest Nutrient Balance Index (NBI) was listed from blending treatments 0 % KCl + 50 % KNO3 + 50 % K2SO4, 25 % KCl + 75 % KNO3 + 0 % K2SO4, 0 % KCl + 25 % KNO3 + 75 % K2SO4 and 50 % KCl + 50 % KNO3 + 0 % K2SO4 were attained 25.90, 30.23, 30.56 and 33.13, respectively; these treatments achieved high quantity of grape yield which were 12.5, 11.0, 9.66 and 9.54 ton fed-1, respectively. The sufficient ranges for N, P, K, Ca, Mg and Cl were 0.97 to 0.86, 0.27 to 0.20, 2.81 to 2.11, 2.81 to 2.11, 1.05 to 0.77, 0.69 to 0.53 and 0.66 to 0.34 %, respectively. Whereas the deficient values of N, P, K, Ca, Mg and Cl when the concentration of these nutrients are less than 0.80, 0.16, 1.75, 0.64, 0.45 and 0.19 %, respectively.

Keywords: *Grape (Vitisvinifera L., var. superior), DRIS methods, K-fertilizers, Adequate ranges*

INTRODUCTION

Grapes are very important fruit crop in Egypt, and it is widely grown in the Middle East and other countries. Grapes are usually increased in light soils such as sandy and sandy loam and new system irrigated. The fertilization of the grapevine is a significant viticultural procedure that affects theproduction in terms of both quality and quantity. The fertilization programs design to conquer with the deficiency of certain nutrients that may appearon vines, in order to ensure a balance between growth and fruit set, the normal course ofmaturation of the grapes for the production of high quality wine and the timely and full differentiation of shoots.

It is known that K is among those nutrients (N, P, Ca) that continue to accumulate throughout berry growth (Rogiers et al., 2006; Petek et al., 2008) and it is also known that thegrapevine is one of the most K friendly plants and has a better ability to utilize soil Kthan most of the other plants. Potassium (K) constitutes up to 3% of the dry weight of a grapevine. In red varieties, potassium is important for berry colordevelopment. Like P, high levels of K do not directly affect the vine or fruit but may limit Ca and Mg uptake and increase grape juice pH levels (Bell & Henschke, 2005). The potassium nutrition status was not effected on grapevine growth and development but also played an important role in plant resistance to diseases (Sharma et al., 2005; Dordas, 2008) The impact of K fertilizer on the level ofavailable soil K and uptake is influenced by various factors, such as the amount of fertilizer applied, the timing and frequency of application, soil characteristics (Conradie & Saayman, 1989), the amount and frequency of irrigation (Mpelasoka et al., 2003), plant root activity (Mengel & Kirkby, 1982) and rootstock-scion combination (Wolpert et al., 2005).

Materials and Methods

A field experiment was conducted on sandy soil (TypicTorriorthent) at a private vine yard (Agrofarms) at South El-Tahrer Province, El-Behiera Governorate, Egypt during the productionseason of 2015/2016. To identify the initial characteristicsof the experimental soil, a surface soil sample (0-30cm depth) was collected before the beginning of the experiment and subjected to some physical andchemical analyses according to Jackson (1973), Page et al. (1982) and Gee and Bauder (1986) as well some soil essential nutrients status (Follett and Lindsay, 1971; Soltanpour & Schwab, 1977; Lindsay & Norvell, 1978). The obtainedresults were presented in (Table 1).

Table 1. Some characteristics of grape experimental site

Physical properties	Value		
Texture Sandy soil	Sand % 93	Silt % 4	Clay % 3
Saturation Percentage	24.2		
Infiltration rate (mm/hr)	70.2		
Chemical properties	Value		
pH	7.24		
EC dS/m	0.31		
Ca CO_3(%)	1.72		
Organic matter (%)	0.23		
Water Soluble Cations(meqL^{-1})			
Ca^{++}	1.52		
Mg^{++}	0.74		
Na^{+}	0.38		
K^{+}	0.36		
Water Soluble Anions (meqL^{-1})			
CO_3^{--}	Not detected		
HCO_3^{-}	0.09		
SO_4^{--}	1.12		
Cl^{-}	1.78		
Available Nutrients (ppm)			
N	52.4		
P	8.40		
K	253		
Ca	1852		
Mg	457		
Fe	8.98		
Cu	1.84		
Zn	8.66		
Mn	0.75		

To evaluate the response of the grape plants to K-fertilization throughout fertigation system, by using different potassium fertilizer forms, i.e., KCl, KNO_3 and K_2SO_4, applied as solely or together. The experiment area was about half feddan, divided into twelve treatments. The factorial experiment was designed as a split plot each treatment consisted of 3 replicates, one vine constituted the experiment unit. The chosen vines were nearly similar in growth and vigor planted in sandy soil at 1.5 x 4 meters. Each treatment separated using a fertigation unit. Fertigation was applied at the following twelve combination ratios of potassium chloride (60 % K_2O) K-KCl, potassium nitrate (46 % K_2O) K-KNO_3 and potassium sulfate (50 % K_2O) K-K_2SO_4: (100 / 0 / 0), (75 / 25 / 0), (50 / 50 / 0), (25 / 75 / 0), (0 / 100 / 0), (0 / 75 / 25), (0 / 50 / 50), (0 / 25 / 75), (0 / 0 / 100), (25 / 0 / 75), (50 / 0 / 50) and (75 / 0 / 25) relative to 100 that equal to the total K requirement during growth stage (160 unit). The maximum Cl concentration in the treatment of 100 / 0 / 0 (K-KCl / K-KNO_3 / K-K_2SO_4) was about 9.5 meq/ l or 337.25 mg / l (114 mg/l supplied with KCl + 222 mg/l supplied with irrigation water). The application of organic fertilizers (60 m^3 cattle manure) and inorganic fertilizers as kg / fed (300 super-phosphate 15 % P_2O_5, 100 ammonium sulfate 20.6 % N).
The samples of grape were dried at $65C^0$ for 48 hrs, ground and wet digested using H_2SO_4:H_2O_2 method (Cotteine, 1980). The digests sampleswere then subjected to measurement of N and NO_3using Micro-Kjeldahle method; P was assayed usingmolybdenum blue method and determined byspectrophotometer (Chapman & Pratt, 1961); Kwas determined by Flame Photometer, while Fe, Zn and Mn were determined using atomic absorptionspectrophotometer.
In order to establish the DRIS norms, it is necessary to use a representative value of leaf nutrient concentrations and respective yields to obtain accurate estimates of means and variances of certain nutrient ratios that discriminate between high- and low yielding groups. Pair of nutrient ratios is calculated from the data bank of nutrient concentrations and then, the mean, the variance and the coefficient of variation of each ratio are calculated. There are two forms of expression for a pair of nutrients, although in DRIS calculations only one form is used. The way to select the form of ratio for a pair of nutrients to be used in DRIS calculation is described by Walworth and Sumner (1987) and Hartz et al., 1998.
Calculation of DRIS indices: The DRIS indices were calculated by using the following index equations by Bailey et al., (1997): -

$$\text{N- Index} = \frac{f(N/P) + f(N/K) + f(N/Ca) + f(N/Mg) + f(N/Cl)}{n}$$

$$\text{P-Index} = \frac{-f(N/P) - f(K/P) - f(Ca/P) + f(P/Mg) + f(P/Cl)}{n}$$

$$\text{K- Index} = \frac{-f(N/K) + f(K/P) - f(Ca/K) + f(K/Mg) + f(K/Cl)}{n}$$

$$\text{Ca-Index} = \frac{-f(/N/Ca) + f(Ca/P) + f(Ca/K) + f(Ca/Mg) + f(Ca/Cl)}{n}$$

$$\text{Mg-Index} = \frac{-f(N/Mg) - f(P/Mg) - f(K/Mg) - f(Ca/Mg) + f(Mg/Cl)}{n}$$

$$\text{Cl- Index} = \frac{- f(N/Cl) - f(P/Cl) - f(K/Cl) - f(Ca/Cl) - f(Mg /Cl)}{n}$$

where:

$f(A/B) = 1000\ [(A/B)/(a/b)-1]/CV$ when $A/B > a/b$

or

$f(A/B) = 1000\ [(1- (a/b)/(A/B)]/CV$ when $a/b > A/B$

in which A/B is the value of the ratio of the two nutrients (N, P, K, Ca, Mg and Cl) in the leaves of grape, and a/b is the value of corresponding norm, n is the number of function, and CV is the coefficient of variation associated with each nutrient ratio norm.
The Nutritional Balance Index (NBI) was calculated by summing the value in module of the index generated in sample. This NBI may be useful to indicate the nutritional status of the plant. The higher NBI is the greater the nutritional imbalance (Beaufils, 1973).
The sufficiency range for leaf tissues of grape crop was determined by the DRIS technique. The range of sufficiency are the values derived from the mean ± 4/3 SD and mean ± 8/3 SD (standard deviation), respectively (Beaufils & Sumner, 1976; Bhargava, 2002). The value of nutrients< (mean-8/3 SD) are considered deficient, whereas their low range included all values between> (mean-8/3 SD) and < (mean - 4/3

SD). Values between> (mean - 4/3SD) and < (mean + 4/3 SD) are taken as sufficient, whereas the range between > (mean + 4/3 SD and < (mean + 8/3 SD) are expressed as high. The nutrient concentrations > mean + 8/3 SD are expressed as excessive or toxic.

Discussion and Conclusion:

The mean, coefficient ofvariation (CV), variance (S^2) of all nutrient ratios of the high-(S^2_h) and low-yielding population (S^2_l) and thevariance ratio between the low- and high- yielding population (S^2_l/S^2_h) ratio are shown in (Table, 2). The selection of a nutrient ratio as DRIS norms (i.e.: N/Kor K/N) is indicated by the S^2_l/S^2_h ratio (Hartz et al., 1998). The higher S^2_l/S^2_h ratio, the more specific the nutrient ratio must be in order to obtain a high yield (Payne et al., 1990). The selected DRIS norms were N/P: 3.988, N/K: 0.375, N/Ca: 1.012, N/Mg: 1.506, N/Cl: 1.925, K/P:10.74, Ca/P: 3.961, P/Mg: 0.382, P/Cl: 0.490, Ca/K: 0.374, K/Mg: 4.062, K/Cl: 5.112, Ca/Mg: 1.505, Ca/Cl: 1.924 and Mg/Cl: 1.285. Under the same condition, Carneiro et al., (2015) established preliminary DRIS norms for grape crop in Portugal, some norms were N/P: 2.670, N/K: 0.540, N/Ca: 0.594, N/Mg: 1.349, K/P: 0.281, Ca/P: 0.297, Mg/P: 0.678, K/Ca: 1.322, K/Mg: 3.209 and Ca/Mg: 2.483.

Data in (Table, 3) showed that the comparison between mean, coefficient ofvariation (CV), variance (S^2) of yield, N, P, K, Ca, Mg and Clunder high and low yielding populations. It stands to reason, the values of yield and other nutrients were under high yielding population higher than under low yielding population.

Table 2. Mean, coefficient of variation (CV) and variance (S2) of nutrient ratios of the low- and high-yielding populations, the variance ratio (S^2_l / S^2_h) and the selected ratios for grape DRIS norms

Nutrients ratio	High yielding population			Low yielding population			S_l/S_h	Selected ratios
	Mean	CV	S^2_h	Mean	CV	S^2_l		
N/P	3.988	11.03	0.194	4.403	12.01	0.280	1.445	√
P/N	0.254	11.02	0.00078	0.229	11.35	0.0007	0.862	
N/K	0.375	9.60	0.0013	0.428	20.79	0.008	6.112	√
K/N	2.689	9.85	0.070	2.413	18.65	0.2025	2.884	
N/Ca	1.012	10.38	0.011	1.067	3.374	0.0013	0.118	√
Ca/N	0.996	9.54	0.009	0.938	3.412	0.0010	0.113	
N/Mg	1.506	9.56	0.021	1.691	29.15	0.2430	11.72	√
Mg/N	0.669	8.97	0.0036	0.629	26.07	0.027	7.471	
N/Cl	1.925	25.45	0.240	2.411	46.37	1.250	5.206	√
Cl/N	0.551	26.13	0.021	0.469	31.98	0.023	1.085	
P/K	0.095	15.79	0.00023	0.097	14.43	0.0002	0.871	
K/P	10.74	16.45	3.122	10.52	16.54	3.028	0.970	√
P/Ca	0.256	12.11	0.00096	0.245	9.796	0.0006	0.599	
Ca/P	3.961	11.89	0.222	4.123	10.50	0.187	0.845	√
P/Mg	0.382	14.40	0.003	0.379	18.73	0.005	1.666	√
Mg/P	2.669	14.99	0.16	2.71	18.04	0.239	1.495	
P/Cl	0.490	31.43	0.024	0.534	33.33	0.032	1.336	√
Cl/P	2.202	28.29	0.388	2.014	27.06	0.297	0.765	
K/Ca	2.722	13.67	0.138	2.578	19.94	0.264	1.909	
Ca/K	0.374	14.97	0.003	0.401	20.70	0.007	2.197	√
K/Mg	4.062	16.20	0.433	4.018	30.36	1.488	3.438	√
Mg/K	0.251	15.14	0.001	0.264	23.86	0.0040	2.749	
K/Cl	5.112	21.65	1.225	5.456	24.23	1.748	1.426	√
Cl/K	0.204	22.55	0.002	0.191	21.47	0.0017	0.794	
Ca/Mg	1.505	15.28	0.053	1.58	27.47	0.188	3.561	√
Mg/Ca	0.68	17.65	0.014	0.67	25.22	0.029	1.983	
Ca/Cl	1.924	28.43	0.299	2.258	45.31	1.047	3.498	√
Cl/Ca	0.56	29.64	0.028	0.501	32.93	0.027	0.988	
Mg/Cl	1.285	26.77	0.118	1.416	25.64	0.132	1.114	√
Cl/Mg	0.828	26.93	0.050	0.752	30.45	0.052	1.055	

Table 3. Mean, coefficient of variation (CV), variance and variance ratio between the low- and high yielding populations (S^2_l/S^2_h) of both yield and nutrient contents in the leaf dry matter of grape at high- and low-yielding populations

	High yielding population			Low yielding population		
	Mean	S	CV	Mean	S	CV
Yield	10.01	1.654	12.85	8.232	0.140	4.543
N	0.980	0.026	16.33	0.914	0.002	4.705
P	0.231	0.0007	11.26	0.222	0.0002	5.856
K	2.457	0.070	10.74	2.320	0.077	11.94
Ca	0.918	0.020	15.36	0.911	0.011	11.31
Mg	0.611	0.004	9.984	0.600	0.010	16.67
Cl	0.500	0.014	23.40	0.442	0.010	22.85

The combination effect between different potassium fertilizers combination ratios on nutrient indices and Nutrient Balance Index (NBI) in leaves of grape plants are presented in Table (4). Data revealed that the lowest NutrientBalance Index (NBI) was recorded from combination treatments 0 % KCl + 50 % KNO_3 + 50 % K_2SO_4, 25 %KCl + 75 % KNO_3 + 0 % K_2SO_4, 0 % KCl + 25 %KNO_3 + 75 % K_2SO_4 and 50 % KCl + 50 % KNO_3 + 0% K_2SO_4 were attained 25.90, 30.23, 30.56 and 33.13, respectively; these treatments achieved high quantity of grape yield which were 12.5, 11.0, 9.66 and 9.54 ton fed^{-1}, respectively.

Table 4. Effect of between different potassium fertilizers combination ratios on nutrient indices, NBI and yieldof grape (var. superior) plants

Treatments	Nutrient indices						NBI	Yield ton fed^{-1}
$KCl/KNO_3/K_2SO_4$	N	P	K	Ca	Mg	Cl		
100/0/0	8.546	-4.640	14.928	-1.860	-22.88	5.906	58.76	8.01
75/25/0	40.43	-0.711	-13.80	21.303	-17.74	-29.47	123.5	7.63
50/50/0	5.965	-2.217	-6.734	2.276	8.324	-7.614	33.13	9.54
25/75/0	-1.326	1.957	-11.07	-2.721	11.19	1.968	30.23	11.0
0/100/0	-1.770	-5.790	-3.520	-9.184	14.03	6.237	40.53	8.24
0/75/25	-4.414	-9.678	11.85	0.084	-9.614	11.77	47.41	8.17
0/50/50	3.040	-11.51	2.726	-0.485	7.189	-0.953	25.90	12.5
0/25/75	5.016	4.476	3.098	2.692	-10.20	-5.077	30.56	9.66
0/0/100	2.725	0.619	-11.35	11.56	4.016	-7.561	37.81	8.30
25/0/75	-1.335	13.173	-0.938	-1.626	5.097	-14.37	36.54	8.33
50/0/50	0.599	-3.978	-2.501	-18.24	11.39	12.72	49.43	8.11
75/0/25	-8.071	4.486	-5.038	0.736	-5.948	13.84	38.12	8.26

Also, The DRIS method could be employed to compute deficient, low, sufficient, high and exceed rangesfor nutrients, following the procedure developed by Bhargava (2002). TheSufficiency ranges of N, P, K, Ca, Mg and Cl derived from a nutrient indexing survey of grape (var. superior) crop grown in sandy soil were shown in (Table, 5).

Table 5. Optimum ranges of nutrients derived DRIS method of grape (var. superior) crop grown in sandy soil

Nutrients (%)	Deficient	Low	Sufficient	High	Exceed
N	< 0.80	0.80-0.86	0.97-0.86	0.97-1.03	> 1.03
P	< 0.16	0.16-0.20	0.27-0.20	0.27-0.30	> 0.30
K	< 1.75	1.75-2.11	2.81-2.11	2.81-3.16	> 3.16
Ca	< 0.64	0.64-0.77	1.05-0.77	1.05-1.19	> 1.19
Mg	< 0.45	0.45-0.53	0.69-0.53	0.69-0.77	> 0.77
Cl	< 0.19	0.19-0.34	0.66-0.34	0.66-0.81	> 0.81

It was found that the sufficient ranges for N, P, K, Ca, Mg and Cl were 0.97 to 0.86, 0.27 to 0.20, 2.81 to 2.11, 2.81 to 2.11, 1.05 to 0.77, 0.69 to0.53 and 0.66 to 0.34 %, respectively. Whereas the deficient values of N, P, K, Ca, Mg and Cl when the concentration of these nutrients are less than 0.80, 0.16, 1.75, 0.64, 0.45 and 0.19 %, respectively. Cummings (1977) indicated that the sufficiency rate of N, P, K, Ca and Mg were 1.65-2.15, 0.12-0.18, 0.80-1.20, 0.70-1.10 and 0.15-0.25 %, respectively.

References

1. Bailey, J.S.; J. A. M. Beattie and D. J. Kilpatrick (1997). The diagnosis and recommendation integrated system (DRIS) for diagnosing the nutrient status of grassland swards: I. Model establishment. Plant and Soil, 197: 127-135.
2. Beaufils, E. R. (1973). Diagnosis and recommendation integrated system (DRIS). Soil Science Bulletin I. Pietermaritzburg, South Africa: University of Natal.
3. Beaufils, E.R. and M. E. Sumner (1976). Application of DRIS approach in calibrating soil, plant yield and quality factors of sugarcane. Proceedings of the South Africa Sugar Technology Association.1:123-127.
4. Bell, S.J. and P.A. Henschke (2005). Implications of nitrogen nutrition for grapes, fermentation andwine. Australian Journal of Grape and Wine Research, 11: 242-295.
5. Bhargava, B.S. (2002) Leaf analysis for nutrient diagnosis, recommendation and management in fruit crops. Journal of the Indian Society of Soil Science,54:353-373.
6. Chapman, H.D. and R. E. Pratt (1961). Methods of analysis for soil, Plants and Water.Dept. of Soil, Plant Nutrition, Univ. of California. U.S.A.
7. Cotteine, A. (1980). Soil Management for Conservation and Production. New York, pp. 245-250.
8. Carneiro; A., Ó. Pereira, M. Cunha and J. Queiroz (2015). The Diagnosis and Recommendation Intgrated System (DRIS) – first approach for the establishment of norms for vineyards in Portugal. CiênciaTéc. Vitiv. 30: 53-59.
9. Conradie, W.J. and Saayman, D. (1989). Effect of long term nitrogen, phosphorus and potassium fertilization on Chenin Blanc vines II. Leaf analyses and grape composition. Am. J. Enol. Vitic.40, 9198.
10. Cummings, G. A. (1977). Variation in the concentration of certain elements in muscadine grape leaves related to season, leaf portion and age. J. Am. Soc. Hort. Sci., 102:339–42.
11. Dordas, C. (2008). Role of nutrients in controlling plant diseases in sustainable agriculture. A review. Agronomy for sustainable development.28:1, 3346.
12. Follett, R.H. andW. L. Lindsay (1971). Changes in DTPA-extractable Zinc, Iron, Manganese and Copper in soils following fertilization. Soil Sci. Soc. Am. Proc., 35:600-602.
13. Gee, G.W. andJ. W. Bauder (1986). Particle-size analysis.p.383–411.In A. Klute (ed.) Methods of soil analysis. Part 1.2nd ed. Agron. Monogr. 9. ASA and SSSA, Madison, WI.
14. Hartz T. K; E. M. Miyao and J. G. Valencia (1998). DRIS evaluation of the nutritional status of processing tomato. Hort Science, 33: 830-832.
15. Jackson, M.I. (1973). Soil chemical analysis. Prentic Hall of Indian private limited, New Delhi, India.
16. Lindsay W. L. andW. A. Norvell (1978). Development of a DTPA soil test for zinc, iron, manganese, and copper. Soil Sci. Soc. Amer. J. 42:421-428.
17. Mengel, K. and E.A. Kirkby (1982). Principles of Plant Nutrition.I.P.I. Bern Switzerland.
18. Mpelasoka, B.; D. Schachtman, M. Treeby and M. Thomas (2003). A review of potassium nutrition in grapevines with special emphasis on berry accumulation.Aust. J. of Grape Wine Res. 9, 154168.
19. Page, A. L.; R. H. Miller and D. R. Keeney (1982). Methods of soil analysis. Part 2. Chemical and Microbiological properties 2nd ed. Amer. Soc. of Agron., pp. 411-414 and 421-422. Inc. Soil Sci. Society of America, Inc. Publ, Madis. Wisc., USA.
20. Petek, M. J.; S. Berend, N. Kopjar, D. Želježić, M. Mladinic, B. Radić, and A. L. Vrdojak, (2008). ActaBiochim. Polonica, 55: 97-105
21. Rogiers, S.; D. Greer, J. Hatfield, B. Orchard and M. Keller (2006). Solute transport into Shiraz berries during development and late-ripening shrinkage. Am. J. Enol. Vitic.57:1.

22. Sharma S.; E. Duveiller, R. Basnet, C. B. Karkiand R. C. Sharma (2005). Effect of potash fertilization on helminthosporium leaf blight severity in wheat, and associated increases in grain yield andkernel weight. Field Crop Res. 93:142–150.
23. Soltanpour P. N. andA. P. Schwab (1977). A new soil test for simultaneous extraction of macro- and micronutrients in alkaline soils. Comm. Soil Sci. Plant Anal. 8:195-207.
24. Wolpert, J.; D.R. Smart andM. Anderson (2005). Lower petiole potassium concentration at bloom in rootstocks with Vitisberlandieri genetic backgrounds. Am. J. Enol. Vitic.56:2, 163-169.
25. Walworth J. and M. Sumner (1987). The diagnosis and Recommendation Integrated System (DRIS). Adv. Soil Sci., 6, 149-188.
26. Payne, G. G., J. E. Rechcigl, and R. J. Stephenson. (1990). Development of diagnosis and recommendation integrated system norms for Bahia grass. Agronomy Journal 82: 930–934.