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Assessment of Almond (*Pronus sp*) Orchards Nutritional Balance utilizing Deviation from Optimum Percentage (DOP) Method on Chaharmahal va Bakhtiari Province

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ABSTRACT

BACKGROUND: Deviation from Optimum Percentage (DOP) Method is one of the most prominent procedures in order to evaluation of almond nutritional balance.

OBJECTIVES: The aims of current research were to determine the nutritional requirement of almond orchards on saman area of Chaharmahal va Bakhtiari Province.

METHODS: In order to evaluation nutritional balance of almond trees, an experiment was designed utilizing the Deviation from Optimum Percentage (DOP) technique. This was conducted in the orchards of Zayandehroud River with a length of 60 km, and an information database was accommodated. In current research, 36 gardens were selected and the leaf samples were prepared. The selected leaf samples were deterged and squelched for proving ground analysis. The high yield orchards were selected to provide reference data at the end of growth period and on this subject, 30% of high yield gardens were chosen.

RESULT: The DOP indicators were evaluated and the nutritional requirements arrangement was assigned. The findings revealed that the trees nutritional requirements were in the following order: Cu>S>Zn>Mn>P>Ca>Mg>B>N>K>Fe>Mo.

CONCLUSION: The final repercussions exhibited that among the considered nutrients, the highest and least nutrient shortage was dedicated to copper and molybdenum, respectively.

KEYWORDS: *DOP, Almond Gardens, Nutrition, Chaharmahal va Bakhtiari Province, DRIS method.*

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1. BACKGROUND

The exports of each kilogram of almonds resulting the earning of 15$ by the country, indicating its importance to the economy. Investment, planning for the development of the area under cultivation and increasing its production are necessary. Although, Chaharmahal va Bakhtiari province is one of the country's top provinces for almond cultivation from the view point of land under cultivation and almond production, it is one of the provinces most prominent for its less development, and optimal productivity of this situation requires planning and organizing more purposeful from planting to harvesting. Chaharmahal va Bakhtiari province has been placed as one of the most promising areas for cultivation and production of almonds. Due to its privileged location, suitable weather conditions, water resources, the existence of susceptible land for gardening and rural population as manpower in high-altitude areas, the province is considered as having the potential capacity to produce almonds. In this area, soil texture is generally lightweight and there is a rapid discharge of nutrients from these soils. Natural complications, steepness and low soil depths, autumn and winter rainfall, calcareous soil and nutritional problems caused by high pH affect the usability of some elements, especially low-energy elements and diseases caused by nutritional problems and soil fertility are justified by a comprehensive study that determined the nutritional priorities of the almond trees in this area (Schumann, 2009). The most commonly used methods to examine the plant and soil nutritional status are the visual symptoms of deficiency of the elements on the plant, plant analysis, biological tests, the use of plants or some microorganisms, and soil tests (soil chemical analysis) (Jone, 1998). One of the problems that exist in the interpretation of the results of plant analysis is the balance between nutritional elements. In some cases, the proportion of elements in plant tissue is used to study the nutritional balance. The ratio of some of the nutritional elements that the anti-interactions are more known between them includes N/S, K/Mg, Ca+Mg/K and N/P clarify. Moreover, given the little knowledge on these interactions, the relationship between these ratios and the plant's function has not been very helpful. The major methods for the interpretation of the obtained results of plant analysis include critical concentration sufficiency range, the diagnosis and recommendation integrated system (DRIS) method, and deviations from optimal percentages (DOPs) (Walworth and Sumner, 1987). In the methods of critical concentration and adequacy range (sufficiency range), the deficiency or surplus content of an element is determined by taking into account the standard concentrations. If the element concentration is lower than the standard values, the plant is deficient and it is expected to have a reduced yield (Havlin *et al*., 1999). In the DRIS method, the interpretation of leaf results does not depend on the age of physiology and on the site of sampling. It hence differs from the methods of critical concentration and adequacy.

In fact, in the DRIS method, instead of the absolute composition of the elements, the ratio between them is used for the determination of the nutritional status of the plant at each stage of growth and fertilizer application is recommended (Beaufils, 1973). One of the advantages of using the ratio of the elements is that it does not depend on the age of the plant, and the ratio of the elements remains constant when the absolute concentration of the elements in the organs of the plant changes during growth. Another advantage of this method is that the effect of dilution does not affect the results. In DRIS method, in addition to the determination of the deficiency or excesses, the relative balance between nutritional elements and the order of the nutritional needs of the plant is expressed quantitatively. Generally, in the DRIS method, there is a possibility of detecting the nutritional status at each stage of plant growth (Mourao Filho, 2004). One of the problems with this method is the determination of the reference values.Another issue is that in DRIS method, the indices and the calculated numbers based on available norms do not specify deficiency or surplus of a particular element, but only indicate that the relevant element is lower or higher insufficiency range than other elements (Bhargava and Chadha, 1988). In contrast, the simple method of DOP was developed which, like the DRIS method, is used to calculate an index for each nutrient element and to identify them as positive, negative or zero numbers and to determine the deficiency or surplus or proper concentration of the nutrient element in the plant, respectively. In this method, the most negative index is the limiting factor in plant nutrition, and the order of the need will be from the negative to positive index. In addition, by calculating the total absolute value of DOP indicators in this method, the severity of exiting balance can be seen. In this case, the zero number represents the state of balance and the larger the number becomes, the greater the distortion from balance state (MouraoFilho, 2004). Many researchers have identified DOP indices for different crop and garden plants, for example reference can be made to the DOP indices in Cherry (Jimens *et al*., 2007) in determination of the DOP indices in white seedless grapes. According to the results, DOP in all low yielding vineyards were much larger than zero, which is not a sign of the balance of absorbed nutrients in vineyards (Davee *et al*., 1986). The DOP for low yielding gardens in grapes was calculated. The results showed that all the gardens with relatively low yields had a non-balance nutrient status and deficiency of iron in 91%, manganese and copper in 82%, potassium in 67%, zinc in 59% and boron in 54.5% of these gardens which are predictable (Hartz *et al*., 1998).In a study comparing DRIS method and DOP on vineyards in West Azerbaijan, the results showed that the nutrient balance indicators of DRIS and DOP in all low-yield vineyards were significantly greater than zero, which indicated a lack of balance of absorbed nutrients in vineyards. The comparison of DIRS and DOP indices (norms) for elements with low and deficient elements showed that in both, magnesium and zinc elements were the most negative indicators which suggested a high similarity between the two methods in interpretation of the results of plant analysis (Davee *et al*., 1986). In a study on Golestan province's Peach gardens, the results showed that the method of DOP is new and the most recent model in comparison with the comprehensive diagnosis and recommendation of fertilization method in the interpretation of leaf analysis and its index for each nutrient element is simply calculated. In this research, DOP for low-yield gardens were calculated. The results showed that the average nutritional requirements of peaches in these gardens are P>Ca>Mn> K> Fe> Cu> Zn> Mg> N (Sharma *et al*., 2012). In another study on the DOP method in the Sisakht area of Kohgiluyeh and Boyer-Ahmad Province, the results showed that, except in few cases, the elements are either in deficiency or excess condition. The results also showed that there are vast areas of nutrient deficiency in some gardens and excess in others. For example, copper concentrations range from 3.29 to 26, manganese concentrations range from 26 to 173, and boron concentrations range from 18.3 to 67.4 $mg.kg^{-1}$ in dry leaves of different gardens. This has led to deficiency of an element in one garden, while the excess of that element in the other garden is problematic. On the other hand, it was shown through calculations, that there was no nutritional balance in any of the poor yield in gardens and this nutritional imbalance was the most important factor in reduction of the gardens' yield (Sumner, 1986). The purpose of this study is to study the nutritional status of almond trees in Chaharmahal va Bakhtiari province using the DOP, and determination of the order of nutritional needs and diagnosis of the limiting factor with the help of these indices.

2. OBJECTIVES

The aims of current research were to determine the nutritional requirement of almond orchards on saman area of Chaharmahal va Bakhtiari Province.

3. MATERIALS AND METHODS

In order to determine the balance of nutrients in almond trees using deviations from optimum percentage, a 2-year experiment was carried out in almond gardens in the banks of Zayandeh-Rood River and in a 60-kmlong path in Chaharmahal va Bakhtiari province. A database of the results of soil and plant analysis using this method was randomly obtained from the gardens in this region. In this study, 36 gardens of banks of Zayandeh-Rood River were selected and the samples were collected in July. The longitude and latitude of the selected gardens are shown in Table 4. In each sampling unit, the age, stipe (bases) and the variety of trees were the same, and the leaves were prepared from the non-fructification twig of the same year with the petiole of the leaf.The plant samples were prepared after washing and drying and they were grinned and prepared for laboratory analysis. The total nitrogen was measured using Kjeldahl method. Spectrophotometer, photoelectric flame photometer and atomic absorption were used for the extraction of phosphorus, potassium, calcium and magnesium concentrations. For determination of the concentration of zinc, manganese, iron and copper after extraction, the atomic absorption (spectroscopy) apparatus was used (Beyton *et al*., 1990). All the samples were divided into two groups of high and low yields based on the apparent growth status of the plant and its yield (Brack *et al*., 2002; Montas *et al*., 1993). The selection of high yielding gardens is based on maximum yields from gardens sampled at the end of the growing season and the consideration of 30% of the gardens sampled as high-yielding gardens. The deviation index of the optimum percentage for different elements and for the low-yielding gardens were calculated and these indices were indicated as positive, negative or zero numbers, which is a process of deficiency, excess and balance of the ele- to specify the deviation index of the optimum percentage of each element for low yield gardens, the following relationships were used (Equ.1):

$$DOP = \left[\frac{(C*100)}{C_{ref}}\right] - 100 \quad (1)$$

Where, C: the concentration of the nutrient element in the sample being examined, C_{ref}: optimum concentration of the nutrient element. In this study, mean values for element concentration data in high yielding samples were used as reference values to calculate the DOP indices. Using the calculated indices, the order of the nutritional needs of the gardens was determined by the different nutrient elements and the limiting nutrient elements (the most negative index) ments in the plant, and using variance ratio of the two groups of determined norms, the coefficient of variation of the group with high yield and the chemical composition of the leaves of these gardens was obtained. After determination of the deviation index from the optimum percentage, the order of the nutritional elements and the nutritional balance indices for the selected gardens of the low yield group were calculated based on the index of the deviation from the optimum percentage, regardless of their sign (Biofiles, 1973; Mong and Colleagues, 1995). The balance of nutrients showed a balance or lack of nutritional balance in the garden. When this index is zero, the feeding of the garden is balanced, and when it rises from zero, the plant also fails to have the nutritional balance, and this imbalance reduces the performance. of yield were specified (Beyton *et al*., 1999).

In addition, using the following equations, the balance index was calculated for each element and the results were also compared in each method (Eq2.). Where, B is the balance index, X: the concentration of the element in the sample, S: the standard concentration or the mean of concentration of the nutrient element in the samples with high yield and V: the coefficient of variation.

$$B = \frac{100X}{S} + V\left(1 - \frac{X}{S}\right) \quad (2)$$

4. RESULT AND DISCUSSION

The mean, coefficient of variation and standard deviation of nutrient concentrations in high yield leaves are shown in Table 1.

The mean concentration of nutrients in these gardens was used as standard values to calculate the deviations from the optimum percentage (Montanes *et al*., 1993). Table 2 shows the deviation of the percentage of optimum percentage indices and the order of nutritional needs of almond trees. As shown, the indices are positive, negative or zero numbers. The zero number represents the optimum concentration state. Positive and negative numbers represent respectively, excess and deficiency of the element. As shown in the results presented in Table 2, the average DOP index for nitrogen was obtained as 3.43, phosphorus as 2.22, potassium as6, calcium as 1.68, magnesium as 2.11, sulfur as 8.89, copper as 15.42, zinc as 7.94, iron as 6.1, manganese as 5.73, molybdenum as18.06 and boron as2.94. Based on the results of this study, the elements range in the order: Cu>S>Zn>Mn>P>Ca>Mg>B>N>K>Fe>M

Table 1. Mean coefficient of variation and standard deviation of nutrient concentration in leaves of almond trees with high yield

Element	Unit	Mean	coefficient of variation	standard deviation
N%	%	2.11	28.96	0.611
P%	%	0.27	14.79	0.04
K%	%	1.85	18.21	0.336
Ca%	%	2.04	13.62	0.278
Mg%	%	0.71	18.77	0.132
S	%	0.27	29.19	0.078
Cu	mg/kg	15.84	21.2	3.359
Zn	mg/kg	24.94	25.13	6.268
Fe	mg/kg	89.89	12.22	10.986
Mn	mg/kg	67.25	30.43	20.468
Mo	mg/kg	0.36	31.95	0.114
B	mg/kg	27.29	42.37	11.563

Table 2. Mean concentration of nutrients and DOP index in almond leave

Mean Dris Value	Mean Concentration Value	Unit	Element
-15.42	13.4	(mg.kg-1)	Cu
-8.89	0.25	(%)	S
-7.94	22.96	(mg.kg-1)	Zn
-5.73	63.04	(mg.kg-1)	Mn
-2.22	0.26	(%)	P
-1.68	2.01	(%)	Ca
2.11	0.73	(%)	Mg
2.94	28.09	(mg.kg-1)	B
3.43	2.18	(%)	N
6	1.96	(%)	K
6.10	95.37	(mg.kg-1)	Fe
18.06	0.43	(mg.kg-1)	Mo

Copper, sulfur, zinc, manganese, phosphorus, calcium and magnesium had the highest to the least deficiencies, and boron, nitrogen, potassium, iron and molybdenum had the least to the highest excesses in the gardens of the area under study. Table 3 shows the concentration of different nutrients in low yielding leaves of the trees.

Table 3. Indicators of the DOP and their absolute value in the studied gardens with low yield

Gardens	Yield kg	Dop-Mo	Dop-B	Dop-Fe	Dop-Mn	Dop-Cu	Dop-Zn	Dop-S	Dop-Mg	Dop-Ca	Dop-K	Dop-P	Dop-N
1	2000	-25.00	2.46	47.00	25.74	-33.90	-20.37	-29.63	-8.45	8.33	32.97	-11.11	59.24
2	3500	72.22	9.12	-5.93	-18.38	-35.98	-33.64	-37.04	19.72	18.14	36.76	-14.81	41.71
3	2050	100.00	73.65	-11.10	-18.54	-29.04	18.81	-33.33	0.00	-2.94	35.68	-25.93	40.76
4	2150	2.78	44.92	56.99	4.92	12.88	64.88	-22.22	9.86	22.06	16.76	-3.70	59.24
5	870	155.56	-34.55	57.04	12.71	-10.92	59.22	-44.44	-16.90	23.04	50.27	-18.52	52.13
6	3700	36.11	-24.29	81.50	39.06	-4.42	-19.33	-7.41	-30.99	-12.75	37.84	0.00	41.23
7	3700	58.33	2.16	-23.33	-22.62	-47.92	19.81	-33.33	-12.68	8.33	24.86	-14.81	64.93
8	1600	8.33	47.49	37.01	37.62	12.63	-28.31	-33.33	-56.34	-7.84	8.65	-14.81	42.65
9	1150	138.89	-10.63	57.04	50.86	4.48	-25.98	-29.63	-11.27	-9.80	55.68	-3.70	40.76
10	2440	75.00	27.34	-2.70	11.35	-53.03	-23.50	-37.04	-14.08	12.25	5.95	-29.63	0.00
11	800	255.56	92.23	72.50	35.52	-51.64	-17.60	-7.41	-50.70	14.71	48.11	-29.63	10.90
12	3750	22.22	41.15	17.24	19.73	-34.72	-28.47	-48.15	-30.99	-7.35	31.89	3.70	42.65
14	2100	-8.33	-32.03	29.66	13.59	-56.63	-3.65	-29.63	-28.17	10.29	-3.24	18.52	4.74
15	3200	36.11	-27.19	-10.61	-10.20	-31.12	-23.74	-22.22	-42.25	3.43	-1.08	33.33	14.22
16	3800	30.56	48.99	34.76	-16.57	6.94	-33.72	-29.63	249.30	8.33	60.00	-22.22	36.02
18	2560	-47.22	-31.26	-10.96	0.94	13.13	16.32	11.11	-7.04	-13.73	-7.03	7.41	-17.54
19	3150	-16.67	-4.40	23.04	-10.29	9.91	14.72	25.93	-11.27	-5.39	-14.59	22.22	-19.91
21	3850	-33.33	3.11	6.44	-18.26	21.91	9.98	29.63	-2.82	-12.25	-10.27	14.81	-10.43
22	3750	-38.89	14	0.52	-6.11	28.47	28.9	33.33	11.27	-13.37	-10.81	22.22	-15.17
23	3600	41.67	-13.59	7.4	-13.99	21.97	-87.61	-3.70	11.27	-6.86	-3.78	22.22	-2.84
24	3650	-19.44	-7.22	-9.68	4.12	2.75	8.42	11.11	16.90	-11/27	-9.19	14.81	-26.54
25	3800	-30.56	-30.52	22.75	-12.39	16.35	18.16	0.00	1.41	-17.65	-7.03	14.81	-16.59
29	1490	-30.56	18.18	-56.70	-13.20	-42.68	-15.12	7.41	26.76	-3.43	-13.51	0.00	-41.23
30	950	-47.22	-18.40	-65.39	-71.72	-49.31	-0.84	11.11	-14.08	-10.29	-27.03	-22.22	-45.50
31	930	-30.56	-25.39	-60.27	-64.30	-34.41	-33.76	25.93	21.13	-9.31	-32.43	11.11	-46.92
32	3100	-5.56	-9.27	-43.28	-16.85	-21.28	2.69	11.11	-2.82	-6.86	-20.54	-11.11	-36.97
33	1100	-36.11	-15.68	-38.58	-67.75	-41.60	-30.11	0.00	15.49	-5.88	-29.19	-37.04	-38.86
34	1440	-25.00	-34.48	0.95	-53.84	11.30	6.42	3.70	9.86	-8.82	-35.68	3.70	-45.50
35	2340	-47.22	-6.08	-32.86	2.62	-34.72	-22.53	7.41	14.08	-4.41	-14.59	11.11	-50.24
36	1740	-50.00	-11.58	2.50	4.27	-22.10	-58.14	3.70	-2.82	-8.82	-25.41	-7.41	-34.12

According to the results of Malakouti (1991) researches, concentration of N, P, K, Ca and mg of high consumption elements were all in the normal range, while sulfur was deficient. The concentrations of low-intake elements in this study were not within the Malakouti's standard range. Therefore, these elements had the highest nutritional needs among other studied elements. Among the high-intake elements, phosphorus was more needed than others since its highest absorption is in acidity, 6 to 6.5 soil pH, which can be due to the calcareous nature of the soil. Due to the fact that the soil of the investigated areas is calcareous and has a pH of 7.5, the low-intake elements in the trees of the garden under study are expected to be deficient.

According to the results obtained in this study, low-intake elements such as copper, zinc, manganese and boron have different degrees of deficiency. As for the calcareousness of the soils of the studied regions, this result is confirmed because the highest absorption of these elements is in lower amount of pH. The most severe deficiency among the low-intake elements is related to the copper element, followed by sulfur, zinc, manganese, phosphorus, calcium, magnesium, boron, iron, potassium and molybdenum, and the results obtained from calculating the deviation index from the optimum percentage and the balance index clearly confirmed this. Among the nutrients, molybdenum has the lowest amount in low-yielding gardens, and this is evident, because the deficiency of these elements unlike other micro elements occurs at high pH and the pH of the soils under the study are in alkaline range. Another reason for the shortage of micro nutrients in almond trees under the study can be sandy soils. The gardens have sandy soil which is light-textured and the effect of severe leaching of these soils by rainfall has led to lack of micro nutrients. Among other causes, micro-nutritional needs in comparison with macro in almond trees of this region can be explained by the slope of the area under study and the higher runoff rate and the loss of micronutrients in the surface soil layers (Table 4). On the other hand, according to the field research that was conducted in this area, it was determined that gardener in these areas use more macro fertilizers than micro fertilizers, which are also affected by the calcareous, sloping and sandy soil texture of these gardens. These will have a significant effect on reduction of concentration of low-intake nutrient elements and more nutritional requirements of trees. By using deviation from optimum percentage method, arrangement of nutritional needs for almond trees in low-yielding gardens was copper, sulfur, zinc, manganese, phosphorus, calcium, magnesium, boron, nitrogen, potassium, iron and molybdenum (Table 3). The results obtained from calculation of balance index also confirm same arrangement, as shown in Table 5. The calculated mean values of the balance of copper, sulfur, zinc, manganese, phosphorus, calcium, magnesium, boron, nitrogen, potassium, iron and molybdenum were 84.61, 91.14, 92.06, 94.29, 97.78, 98.32, 102.11, 10.93, 4.103, 105.99, 106.09 and 118, respectively, indicating the order of nutritional requirements among studied elements would be from most necessary to least necessary element:

Cu>S>Zn>Mn>P>Ca>Mg>B>N>K>Fe>Mo

The results obtained of this method are in agreement with those obtained from deviation of optimum percentage (Tables 2 and 3). The relationship between total absolute values deviations of optimum percentage and yield of almond trees in gardens being studied are shown in Fig. 1. As the results of the chart show, the total absolute values of indices of deviation from optimum percentage of product performance decreased such that correlative coefficient between total absolute values of indices of deviation from optimum percentage of product performance clearly suggests same result.

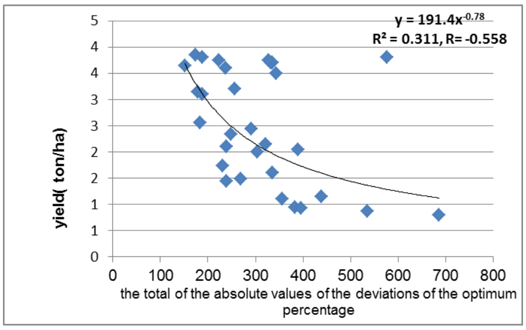

Fig. 1. Relationship between the total of the absolute values of the DOP indices and the performance of the almond trees in the garden under the study.

5. CONCLUSION

According to the results obtained from the method of deviation from the optimum percentage, the balance index of the almond gardens being studied in this research were not balanced in terms of nutritional status. Due to less use of micro-fertilizers and factors such as slope of the soil, lightweight soil texture and their calcareous content, among the nutritional elements, micro-nutrients were insufficient and the nutritional need of the trees for them become more. Finally, the deviation of the optimum percentage as an efficient way to determine the nutritional needs of almond gardens can be used in these areas.

Table 4. The nutritional requirement trends of almond trees in the studied gardens with low yield

Garden	Longitude	Latitude	Yield	nutrition requirement
1	50°57'56.8″	32°29'38.5″	2000	Cu> S> Mo>Zn>P>Mg>B>Ca>Mn>K>Fe>N
2	50°58'57.6″	32°32'52.6″	3500	S>Cu>Zn>Mn>P>Fe> B>Ca>Mg>K>N>Mo
3	50°59'28.2″	32°27'51.4″	2050	S>Cu>P>Mn>Fe>Ca>Mg > Zn>K> N>B>Mo
4	50°54'1.1″	32°30'30.4″	2150	S > P>Mo>Mn>Mg>Cu>K>Ca>B> Fe>N>Zn
5	50°53'41.5″	32°30'14.6″	870	S>B>P>Mg>Cul>Mn>Ca> K>N>Fe>Zn>Mo
6	50°52'52.3″	32°30'57.9″	3700	Mg>B>Zn>Ca> S>Cu>P>Mo>K>Mn>N>Fe
7	50°52'39.2″	32°31'19.2″	3700	Cu>S>Fe>Mn>P>Mg > B>Ca>Zn>K> Mo>N
8	50°52'24.4″	32°31'24.1″	1600	Mg >S>Zn>P>Ca>Mo>K>Cu>Fe>Mn>N>B
9	50°52'08.7″	32°31'48.1″	1150	S>Zn >Mg>B>Ca>P>Cu>N>Mn>K>Fe>Mo
10	50°51'52.7″	32°35'35.1″	2440	Cu>S>P>Zn>Mg>Fe>N>K>Mn>Ca>Bl>Mo
11	50°50'55.5″	32°37'09.9″	800	Cu>Mg>P>Zn>S>N>Ca>Mn>K>Fe>B>Mo
12	50°51'10.4″	32°31'16.5″	3750	S>Cu>Mg>Zn>Ca>P>Fe>Mn>Mo>K>B>N
14	50°50'58.1″	32°31'45.6″	2100	Cu>B >S>Mg>Mo>Zn>K>N>Ca>Mn>P>Fe
15	50°48'00.3″	32°42'26.5″	3200	Mg>Cu>B>Zn>S>Fe>Mn>K>Ca>N>P>Mo
16	49°26'07.0″	32°40'05.7″	3800	Zn>S>P>Mn>Cu>Ca>Mo>Fe>N>B>K>Mg
18	50°52'47.5″	32°30'47.8″	2560	Mo>B >N>Ca>Fe>Mg>K>Mn>P>S>Cu>Zn
19	50°52'47.4″	32°30'47.7″	3150	N>Mo> K>Mg>Mn>Ca>B>Cu>Zn>P>Fe>S
21	50°52'12.6″	32°31'20.2″	3850	Mo>Mn>Ca>N>K>Mg>B>Fe>Zn>P>Cu>S
22	50°49'41.5″	32°39'48.0″	3750	MO>N >Ca>K>Mn>Fe>Mg>B>P>Cu>Zn>S
23	50°49'41.4″	32°39'48.1″	3600	Zn>Mn>Ca>B>K>S>N>Fe>Mg>Cu>P>Mo
24	50°48'19″	32°42'34.4″	3650	N>Mo>Ca>Fe >K>B>Mn>Zn>S>Cu>P>Mg
25	50°51'34.3″	32°3037.4″	3800	Mo>B>Ca>N>Mn>K>S>Mg>P>Cu>S>Fe
29	50°55'46.2″	32°28'04.1″	1490	Fe>Cu>N>Mo>Zn>K>Mn>Ca>P>S>B >Mg
30	50°55'52.8″	32°28'07.7″	950	Mn>Fe>Cu>Mo>N>K>P>B >Mg>Ca>Zn>S
31	50°56'40.7″	32°28'08.8″	930	Mn>Fe>N>Cu>Zn>K>Mo >B>Ca>P>Mg>S
32	50°56'40.8″	32°28'08.7″	3100	Fe>N >Cu>K>Mn>P>B>Ca>Mo>Mg>Zn>S
33	50°56'57.1″	32°28'08.7″	1100	Mn>Cu>N>Fe>P>Mo>Zn>K>B>Ca>S >Mg
34	50°57'42.7″	32°30'29.3″	1440	Mn>N>K>B>Mo >Ca>Fe>S~P>Zn>Mg>Cu
35	50°57'52.4″	32°30'56.2″	2340	N>Mo>Cu>Fe>Zn>K>B>Ca>Mn>S>P>Ca
36	50°57'48.9″	32°30'05.0″	1740	Zn>Mo>N >K>Cu>B>Ca>P>Mg>Fe>S>Mn

Table 5. The values of the calculated balance index in different gardens.

gardens	Yield (kg)	B_{Mo}	B_B	B_{Fe}	B_{Mn}	B_{Cu}	B_{Zn}	B_S	B_{Mg}	B_{Ca}	B_K	B_P	B_N
1	2000	75.08	102.44	146.94	125.66	66.17	79.68	70.46	91.56	108.32	132.91	88.91	159.07
2	3500	172.00	109.09	94.08	81.68	64.09	66.44	63.07	119.68	118.11	136.69	85.21	141.59
3	2050	199.69	173.34	88.91	81.51	71.02	118.76	66.77	100.00	97.06	135.61	74.11	140.64
4	2150	102.77	144.73	156.92	104.91	112.85	164.71	77.84	109.84	122.03	116.73	96.30	159.07
5	870	255.08	65.59	156.97	112.68	89.10	159.07	55.69	83.13	123.01	150.18	81.51	151.98
6	3700	136.00	75.81	181.40	138.94	95.59	80.72	92.61	69.07	87.27	137.77	100.00	141.11
7	3700	158.16	102.15	76.70	77.45	52.18	119.76	66.77	87.35	108.32	124.82	85.21	164.74
8	1600	108.31	147.29	136.97	137.51	112.60	71.76	66.77	43.77	92.17	108.63	85.21	142.53
9	1150	238.46	89.42	156.97	150.70	104.47	74.08	70.46	88.75	90.21	155.57	96.30	140.64
10	2440	174.77	127.22	97.30	111.31	47.08	76.56	63.07	85.94	112.24	105.94	70.41	100.00
11	800	354.77	191.84	172.41	135.42	48.47	82.44	92.61	49.39	114.69	148.02	70.41	110.87
12	3750	122.15	140.98	117.22	119.67	65.35	71.60	51.99	69.07	92.66	131.83	103.70	142.53
14	2100	91.69	68.11	129.62	113.55	43.49	96.36	70.46	71.88	110.28	96.76	118.49	104.73
15	3200	136.00	72.93	89.40	89.83	68.94	76.32	77.84	57.82	103.43	98.92	133.28	114.18
16	3800	130.46	148.79	134.72	83.49	106.93	66.36	70.46	348.84	108.32	159.89	77.81	135.91
18	2560	52.92	68.88	89.06	100.93	113.10	116.28	111.08	92.97	86.29	92.99	107.40	82.52
19	3150	83.38	95.62	123.01	89.74	109.89	114.68	125.85	88.75	94.62	85.43	122.19	80.15
21	3850	66.77	103.10	106.43	81.80	121.86	109.96	129.54	97.19	87.76	89.75	114.79	89.60
22	3750	61.23	113.94	100.52	93.91	128.41	128.84	133.24	111.25	86.29	89.21	114.79	84.88
23	3600	141.54	86.46	107.39	86.05	121.92	12.61	96.31	111.25	93.15	96.22	122.19	97.16
24	3650	80.61	92.8	90.33	104.11	112.73	108.40	111.08	116.87	88.74	90.83	114.79	73.54
25	3800	69.54	69.61	122.72	87.65	116.32	118.12	100.00	101.41	82.38	92.99	114.79	83.46
29	1490	69.54	118.10	43.37	86.84	57.41	84.92	107.39	126.71	96.57	86.51	100.00	58.89
30	950	52.92	81.68	34.69	28.50	50.80	99.16	111.08	85.94	89.72	73.02	77.81	54.63
31	930	69.54	74.71	39.80	35.90	65.67	66.32	125.85	121.09	90.70	67.63	111.09	53.22
32	3100	94.46	90.77	56.78	83.20	78.77	102.68	111.08	97.19	93.15	79.50	88.91	63.14
33	1100	64.00	84.38	61.47	32.46	58.48	69.96	100.00	115.46	94.13	70.86	63.02	61.25
34	1440	75.08	65.66	100.94	46.32	111.28	106.40	103.69	109.84	91.19	64.39	103.70	54.63
35	2340	52.92	93.94	67.18	102.61	65.35	77.52	107.39	114.06	95.59	85.43	111.09	49.91
36	1740	50.15	88.47	102.50	104.25	77.95	42.01	103.69	97.19	91.19	74.64	92.60	65.98
Mean		120.00	103.51	106.83	94.24	80.56	93.06	88.65	100.89	99.31	107.53	95.34	105.44

FOOTNOTES

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REFERENCES

Beaton Jones, J. and V. W. Case. 1990. Sampling, handling and analyzing plant tissue samples. *In*: Westerman, R. L. 1990. Soil testing and plant analysis. 3rd Ed. Madison Wisconsin, USA: SSSA, Inc.

Beaufils, E. R. 1973. Diagnosis and recommendation integrated system (DRIS). Soil Science Bull. No. 1 University of Natal, Pieteariznurp, South Africa.

Bhargava, B. S. and K. L. Chadha. 1988. Developing leaf nutrient guide in fruit crops. Fertilizer News. 33: 21–29.

Brakke, F. H. and N. Salih. 2002. Reliability of foliar analysis of Norway spruce stands in a nordic gradient. Silva Fennica. 36: 489-504.

Daryashenas, A. and H. Rastagar. 2002. Determination of the nutrient norms for citrus in southern Iran with DRIS approach. Soil and Water Research Institute. Technical Publication. No. 1132. Tehran. Iran. 26p.

Davee, D. E, T. L Righetii, E. Fallahi. and S. Robbins. 1986. An evaluation of the DRIS approach for identifying mineral limitations on yield in 'Napolean' sweet cherry. J. Amer. Soc. Hort. Sci. 111: 988-993.

General, B. 2008. Statistical yearbook of Golestan province in 2007. 778p.

Hartz, T. K, E. M. Miyao. and J. G. Valencia. 1998. Evaluation of the nutritional status of processing tomato. HORTSC. 33: 830-832.

Havlin, J. L, J. D. Beaton, S. L. Tisdale. and W. L. Nelson. 1999. Soil fertility and fertilizers, an introduction to nutrient management. PrenticeHall, Inc.

Jimenez, S. J, Y. Pinochet, J. A. Gogorcena. and M. A. M. Betran. 2007. Influence of different vigour cherry rootstocks on leaves and shoots mineral composition. Sci. Hort. 112: 73-79.

Jones, B. J. R. 1998. Field sampling procedures for conducting plant analysis. In: Kalra YP, Editors.

Malakouti, M. J. 1991. Comprehencive method for diagnosing of plant and advising on fertilizers in Iranian. Tarbiatmodares University Technology.

Monge, E., L. Montañés, J. Val. and M. Sanz. 1995. A comparative study of the DOP and DRIS methods, for evaluating the nutritional status of peach trees. ISHS ActaHortic. 383: 191-199.

Montanes, L., L. Heras, J. Abadia. and M. Sanz. 1993. Plant analysisinterpretation based on a new index: deviation from optimum percentage (DOP). J. Plant Nutr. 16: 1289-1308.

MouraoFilho, F. A. A. 2004. DRIS: Concepts and applications on nutritional diagnosis infruit crops. Sci. Agri. 61: 550-560.

Schumann, A. 2009. Potential use of DRIS for leaf nutrient diagnosis in Florida citrus. Citrus Industry.

Sumner, M. E. 1986. Diagnosis and recommendation integrated system (DRIS) as a guide to orchard fertilization. International seminar on Leaf Diagnosis as a Guide to Orchard Fertilization. Food and Fertilizer Technology Center for Asia and Pacific Region Suweon, Korea. Bulletin No. 231. Taiwan. 21p.

Sharma, J., S. D. Shikhamany, R. K. Singh. and H. B. Raghupathi. 2005. Diagnosis of nutrient imbalance in Thompson seedless grape grafted on Dog Ridge rootstock by DRIS. Commun. Soil Sci. Plant Anal. 36: 2823-2838.

Walworth, J. L. and M. E. Sumner. 1987. The Diagnosis and Recommendation Integrated System (DRIS). *In*: BA, Stewart. 1987. Adv. in Soil Sci. p. 149-188.