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DIAGNOSING THE NUTRITIONAL STATUS OF APPLE ORCHARDS AT SOUTH OF JORDAN

[29]

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ABSTRACT

A test survey was conducted to determine the nutritional status of apple trees grown at four highly productive orchards in south of Jordan. Leaf and soil samples were taken from each orchard, and analyzed for the concentrations of macro- and micronutrients. Soils of Al-Shoubak tend to have high pH, low organic matter and high $CaCO_3$ contents. The results showed that soil concentrations of N, K, Fe, Mn, Zn and Cu varied widely among the orchards. No deficiency or hunger signs of N, P, K, Mn and Zn nutrients were observed at any of the localities since concentrations of leaf nutrients were generally within the sufficient range, indicating adequate levels of fertilization applied to the trees. The leaf analysis has shown that Cu deficiency is found in some apple orchards. Soils and leaf nutrient levels were generally not well correlated with one another. The only highly significant correlation was between soil P and leaf N. However, positive relations were observed among leaf P and Mn, Fe and Mn, Fe and Zn, and Mn and Zn contents.

Key words: Al-Shoubak, Correlation coefficient, Fertilizer, Leaf analysis, Macro- and micronutrients, Sufficient range

INTRODUCTION

Apple (*Malus domestica*) is considered one of the most widely distributed fruit trees in Jordan. The area planted to this crop increased rapidly during the last two decades and reached about 3.9 thousand ha in 2003. This represents 4.5% of the total area planted with fruit trees. The majority of the Jordanian apple area is located in Al-Shoubak. Despite the significance of the local apple industry to the economy of the Governorate and the country, very little work had been conducted to evaluate nutritional status of apple trees in Jordan.

The nutritional status can be determined by observation of tree performance, leaf analysis and soil analysis. Soil analysis is of a value in determining the level of immediately available nutrients in the soil. Interpretation of soil analysis allows for assessing fertilizer needs, but it is poorly correlated with tree nutrient uptake to ensure optimal growth and productivity of the plants. So, in

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many cases, soil analysis is not a satisfactory guide for making fertilizers recommendations. Leaf analysis, on the other hand, is based on the comparison of the nutrient concentration with critical reference values. The potential role of leaf analysis in fertilizer use includes evaluation of the rates of nutrient inputs needed; checking on nutrient deficiencies, interaction or antagonisms; and determination of whether the fertilizers applied are being utilized by the plants. The nutrient concentration at which the maximum relative yield, is the critical nutrient concentration (CNC). There is a transition zone in which the concentration changes from deficient to sufficient. Much research has been done to establish the CNC and transition zones for many crops **(Rana *et al* 1984, Haynes 1990)**. The advantage of plant parts analysis is that it indicates how much nutrients the crop was getting from the fertilizers applied at the time the sample was taken; while soil analysis can only show what the plant might get. The interpretation of leaf analysis results for the different samples should take into account: varietal **(Tagliavini *et al* 1992)** as well as rootstock differences **(Ershadi and Talaie 2001, Slowinski and Sadowski 2001, Wojcik 2002)** and fertilization **(Neilsen *et al* 2001, Raese 1996, Zydlik and Pacholak 2001).** Seasonal trends in plant analysis results have been reported **(Drossopoulos *et al* 1996)**. The seasonal trend has been the most consistent for N, P, K, Ca, Mg, Mn and B **(Tagliavini *et al* 1992)**.

In addition to leaf analysis, flower analysis was also, used as an early method of diagnosis the nutritional status of pear and peach **(Sanz and Montanes 1995)**, and orange **(Pestana *et al* 2001)** trees, in order to give the growers the chance to correct nutrient deficiencies and prevent yield impairment in the same year.

Recently, much interest has been developed in ideal utilization of the fertilizers with an optimum rate. Accordingly, the objective of this survey was to determine the current status of leaf analysis and soil testing in various apple orchards located at Al-Shoubak area in south of Jordan and to investigate the relationships among some nutrients in order to develop a guideline for the use of leaf and soil analysis as basis for fertilizer recommendation and optimization of apple growth and production of high quality fruits.

MATERIAL AND METHODS

Field site

This study was conducted on mature ‘Golden Delecious’,‘Granny Smith’ and ‘Royal Gala’ apple trees grafted on M9 rootstock, without symptoms of nutrient deficiency, and spaced 3 x 1.5m, in four highly productive orchards; namely: Hashlamoun (100ha), Tarawneh (50ha),, Zanouneh (3.5ha), and Abualhaj (2500ha), located at Al-Shoubak area during the 2001 growing season. Al-Shoubak is one of the most important locations of growing apples in the Mediterranean region. It is located 250 Km to the south of the capital Amman, in which adverse climatic conditions such as cold winter, late spring frost and very low mean annual rainfall (average less than 250 mm) are dominated. Approximate mean daily maximum and minimum temperatures are 5 and 12°C in winter, and 18 and 32°C in summer, respectively. The main chemical properties of the soils of the four experimental orchards are shown in Table (1).

Table 1. Selected chemical properties of the soils of the four experimental orchards

Analysis	Orchard name			
	Hashlamoun (H)	Tarawneh (T)	Zanouneh (Z)	Abualhaj (A)
PH (in water, 1:2.5)	7.93 b	7.99 ab	8.09 ab	8.14 a
Total $CaCO_3$	24.1 a	23.65 a	25.85 a	24.90 a
Organic matter(%)	1.75 ab	2.15 a	1.97 ab	1.56 b
E.C. (dS/m)	0.96 a	0.78 a	0.97 a	0.63 a
Total N (ppm)	957.4 b	1198.7 a	912.5 b	634.2 c
Available P (ppm)	582.0 a	545.9 a	582.0 a	509.4 a
Available K(ppm)	92.5 b	129.37 a	118.45 a	57.25 c
Extraxtable Fe (ppm)	16.82 b	27.67 a	11.07 bc	7.15 c
Extraxtable Mn (ppm)	98.38 b	130.4 a	76.5 b	76.9 b
Extraxtable Zn (ppm)	1.91 b	2.97 a	2.84 a	0.57 c
Extraxtable Cu (ppm)	4.89 a	3.34 b	4.63 a	2.71 b

Means within rows followed by the same letter are not significantly different at P=0.05 (DMRT).

Experimental procedure and measurements

Because the bulk of the M9 root systems is spread in the soil surface layer, ninety-six surface soil samples (0 to 30 cm) were collected from those orchards (24 sample from each orchard) in June 2001. Each sample was collected from three trees. The samples were kept in polyethylene bags and brought to the laboratory for chemical analysis. Therefore, they were air-dried and then passed through a 2mm sieve. The soil texture was determined using the Bouyoucus hydrometer method based on the particle settling in a dispersed solution were determined according to the standard procedures of the United States Salinity Laboratory Staff **(USSL, 1954)**. Organic matter content of the different soil samples was measured using H_2O_2 as an oxidizing agent. Calcium carbonate ($CaCO_3$%) content was measured by Calcimeter method **(USSL, 1954)**. The pH and electrical conductivity were also measured. Soil nitrogen (N), phosphorus (P), potassium (K), iron (Fe), manganese (Mn), zinc (Zn) and cupper (Cu) were determined by flame photometer as described by **Tandon (1995).**

In order to determine the leaf mineral composition, representative 96 samples of two leaves usually 4th-5th mature leaves from randomly distributed shoots that were collected randomly around the selected trees 4 weeks after full bloom in July 2001 from the four selected orchards. Twenty four samples were collected from each orchard and each is a composite of the four mentioned cultivars. They were washed with distilled water and oven dried at 70°C till constant weight was obtained. The samples were ground and digested with nitric acid **(El-Hassan *et al* 2002)**. From these solutions, the subsequent analyses were performed. Nitrogen (N) was determined by a semi-micro-Kjeldahl method **(Bermner and Mulvaney, 1982).** Phosphorus (P) was measured by atomic emission spectrophotometer **(Tandon, 1995).** Potassium (K) was determined by flame photometer as described by **Tandon, (1995).** Copper (Cu), iron (Fe), manganese (Mn) and zinc (Zn) were determined by an atomic absorption spectrophotometer.

Statistical design and analysis

The experimental design was completely randomized design. The data were subjected to analysis according to **Snedecor and Cochran (1980)**. The analysis of variance (ANOVA) was used to determine significant differences. Means were compared by using the method of Duncan's Multiple Range Test (DMRT) at 5% level. In addition, the correlation coefficients among the different leaf nutrient concentrations and the relationship between leaf and soil mineral contents have been investigated.

RESULTS

The results of selected chemical analysis of the soil samples collected from Hashlamoun (H), Tarawneh (T), Zanouneh (Z) and Abualhaj (A) orchards are given in Table (1). Soil analyses carried out in the studied orchards have shown that there were no considerable variations in E.C and $CaCO_3$ values. It is clear that soils of tested orchards tend to have high pH, and low organic matter content. The pH of the soils varied between 7.93 and 8.14. The highest value of pH was found at (A), while the lowest one was found at (H). Soil analysis data show that organic matter content of (T) orchard was significantly higher than that of (A). Total soil N concentration at (T) was higher than in either of the other orchard sites. Similar differences were found among the orchards for soil Fe content. The lowest soil N and Fe were found at (A) orchard. There were few and inconsiderable variations in available soil P concentration among the studied apple orchards. Soil of (T) orchard had lower P than (H) and (Z) orchards and higher than (A) orchard. The levels of available soil K showed significant variation, with concentrations of 129.37, 118.45, 92.50 and 57.25 ppm at (T), (Z), (H) and (A) orchards, respectively. Concerning Mn content, soil of (T) had higher concentration than the other orchards. Soils of (Z) and (A) had the lowest values (76.5, 76.9 ppm, respectively). There was a wide range of values for extractable soil Zn content. The mean concentration was found to be in the order (T) and (Z) > (H) > (A). A significant difference in soil Cu content was found at the studied orchards. Soils of (H) and (Z) orchards had higher concentrations than those of (T) and (A) orchards.

With regard to apple leaf composition, the reference values used for interpreting the results of apple leaf analysis, which were established by Ohio Plant Analysis Laboratory, Ohio, USA, as recommended by **Rana *et al* (1984)** are listed in Table (2). The mean values with standard deviations, minimum and maximum values for leaf nutrient concentration are presented in Table (3). The N content in leaf samples of the four studied orchards varied from 0.91 to 2.75 % with a mean of 2.05%. The survey results indicate that N concentrations at all orchards were within the optimum range. Furthermore, there were no significant differences in leaf N content among apple trees of the studied orchards (Table, 4). In addition, Leaf P, K, Mn, Fe and Zn nutrient concentrations (Tables 3 and 4) were above the deficient levels (Table, 2). Except for (Z) orchard, the leaf samples of (H), (T) and (A) orchards demonstrated Cu deficiency (Table 3 and 4). These results indicate that all trees are capable of absorbing the elements in sufficient quantities to sustain adequate growth and production. However, growers of the studied orchards should constantly monitor their trees for Cu content in order to correct the deficiency with foliar or soil applications or combination of the two. The only possible incipient luxury identified was the high leaf Zn concentration (62.25 ppm) found in (Z) orchard (Table 4). The leaf Fe, Mn, Zn and Cu contents at (Z) orchard were considerably higher than those of the other orchards (Table 4). The leaf concentration of Fe at (Z) orchard was two times higher than at (H) and (A) orchards. On the contrary, the lowest leaf Fe, Mn and Cu contents were found at (H) orchard, and the lowest content of leaf Zn was found at (T) orchard.

Table (5) shows the correlation coefficients between soil and leaf nutrient contents. For most nutrients, no significant correlations were found among soil and leaf nutrient contents. The only highly significant correlation (0.355) was found between soil P and leaf N levels. The correlation coefficients among leaf nutrient concentrations are shown in Table (6). The linear analysis indicated that there was no interrelations among most of leaf nutrients. The correlations were recorded only between P and Mn (0.213), Fe and Mn (0.323), Fe and Zn (0.572) and Mn and Zn (0.227).

DISCUSSION

The soil analysis of the studied orchards at Al-Shoubak area indicated that these soils are calcareous with extremely low organic matter and high pH value content. There were considerable variations among the orchards in pH value and organic matter content. In the case of soil P concentration, no clear variation was found in the orchards. However, significant differences were observed in soil N, K, Fe, Mn, Cu and Zn contents among the orchards. The soil of (T) orchard had higher soil N, K, Fe, Mn and Zn contents than the others. On the other hand, the lowest values of the previous nutrients, except Mn, were found at (A) orchard. These results may be attributed to the differences in organic matter content, soil texture, cultural practices and fertilizer management methods followed by the different growers. The mineral contents of soils of the current study are considered very high if compared with soils of Jordan Valley and other regions of the country **(Hattar and Khattari, 1995)** and most of them are above the critical level growth of most plants.

The chemical analysis of plant leaves for diagnostic purposes is based on the casual relationship exist between plant growth and their mineral content **(Kenworthy, 1973 and Marschner, 1995).** As already noted, concentrations of leaf N, P, K, Mn and Zn were generally within the

Table 2. Standard values and ranges used for diagnostic purposes on apple trees*

Nutrient	Deficient	Low	Optimum	High
N, (%)	< 1.5	1.5-1.8	1.9-2.4	> 2.5
P, (%)	< 0.14	0.14-0.18	0.19-0.28	> 0.30
K, (%)	< 1.0	1.0-1.2	1.3-1.8	> 1.9
Ca, (%)	< 1.0	1.0-1.2	1.3-1.7	> 1.8
Mg, (%)	< 0.2	0.20-0.24	0.25-0.36	> 0.37
Fe, ppm	< 30	30-35	36-150	> 150
Mn, ppm	< 25	25-30	31-150	> 150
Zn, ppm	< 15	15-20	21-50	> 50
Cu, ppm	< 5	5-10	11-20	> 20

***Rana R.S.; R.B. Sharma and K.C. Azad (1984)**. Nutritional status of apple orchards in Hinachal Pradesh. **Indian J. Hort. 41: 244-250.**

Table 3. Mean and standard deviation, minimum and maximum leaf nutrient concentrations of apple trees at the four orchard sites.

Nutrient	Mean ± SD	Minimum	Maximum
N, (%)	2.05 ± 0.42	0.91	2.75
P, (%)	0.19 ± 0.09	0.030	0.45
K, (%)	1.41 ± 0.58	0.66	5.80
Fe, ppm	233.75 ± 107.87	95.50	588.00
Mn, ppm	113.60 ± 42.15	41.00	238.00
Zn, ppm	38.01 ± 27.40	11.00	189.00
Cu, ppm	11.10 ± 9.17	3.00	65.00

Table 4. Average leaf N, P, K, Fe, Mn, Zn and Cu contents for apple trees grown at four orchards at south of Jordan

Analysis	Orchard Name			
	Hashlamoun (H)	Tarawneh (T)	Zanouneh (Z)	Abualhaj (A)
N (%)	2.17 a	2.07 a	1.97 a	2.07 a
P (%)	0.20 a	0.21 a	0.22 a	0.17 a
K (%)	1.28 a	1.29 a	1.41 a	1.39 a
Fe (ppm)	170.20 bc	206.75 b	364.08 a	182.75 b
Mn (ppm)	82.65 c	126.13 ab	137.13 a	112.65 b
Zn (ppm)	28.93 b	26.83 b	62.25 a	33.30 b
Cu (ppm)	8.87 b	8.95 b	16.33 a	9.53 b

Means within rows followed by the same letter are not significantly different at P=0.05 (DMRT).

Table 5. Correlation coefficients between soil and leaf nutrient concentrations collected from the four-apple orchards at Al-Shoubak area

Soil content	Leaf content						
	N	P	K	Fe	Mn	Zn	Cu
N	0.068	- 0.060	- 0.022	- 0.110	0.021	- 0.111	- 0.004
P	0.355**	0.078	- 0.157	0.057	- 0.027	0.065	- 0.10
K	0.177	- 0.003	-0.098	- 0.012	- 0.034	- 0.065	- 0.001
Fe	0.180	0.156	- 0.021	- 0.005	- 0.030	0.049	0.009
Mn	0.139	0.144	0.021	0.109	- 0.044	-0.008	0.027
Zn	0.191	- 0.007	- 0.206	- 0.206	- 0.043	- 0.053	- 0.012
Cu	0.074	- 0.136	- 0.049	- 0.056	- 0.132	- 0.100	0.094

**Significant at level of 1% probability.

Table 6. Correlation coefficients between macro- and micronutrients concentrations in apple tree leaves collected from the four-apple orchards at Al-Shoubak area.

Nutrient	N	P	K	Fe	Mn	Zn
P	0.184					
K	- 0.178	0.031				
Fe	0.020	0.095	0.099			
Mn	0.033	0.213*	-.0051	0.323**		
Zn	0.130	0.157	0.076	0.572**	0.227*	
Cu	0.162	0.090	0.022	0.118	0.176	0.099

*, ** Significant at level of 5% and 1% probability, respectively

sufficiency range (Tables, 2 and 3), indicating adequate levels of fertilization applied to the trees. No deficiency or hunger signs of these nutrients were observed at any orchard. Thus, a continuing moderate supply of the previous elements is essential for sustained fruit production. The contents of leaf macronutriens (Tables, 3 and 4) in the study area were generally similar to those obtained by **Haynes, (1990),** while miconutrients levels, except Zn, were higher. However, the results have shown that Cu deficiency is found in most apple orchards. The deficiency of a micronutrient or more, in apple orchards, was reported by **Cline, (1990) and Slowinski & Sadowski (2001).** Furthermore, Fe in leaves of all orchards was generally in the higher limit range, indicating an oversupply of Fe fertilizers to the vast majority of the four orchards and that the fertilizer additions of these nutrients could be substantially reduced. In addition, the excessive use of the chemical fertilizers can dramatically influence the balance of nutritional elements in plants. The leaf Fe levels found in this study are very high in comparison with values observed in India **(Rana *et al* 1984)** and New Zealand **(Haynes, 1990). Awasthi and Kaith (1990)**, indicating that crop load largely determines the nutrient uptake of the trees and could be used as a guide for the fertilization of apple orchards. It is of prime importance to mention that flower buds and flowers were successfuly used to predict the nutritional status and fertilization requirement of apple trees **(Wojcik, 2002).**

In the current study, the complexity of the soil plant relationship in apple trees and influence of cultural practices and environmental conditions on nutrient uptake may explain the lack of close relationship among soil and leaf nutrient contents, except between soil P and leaf N (Table, 3) Thus, contents of soil nutrients are not often a good reflection of contents of leaf nutrients. However, the high concentrations of most nutrients in leaves reflect the high content of them in the soil. The absence of clear correlations among leaf and soil levels was reported by other workers **(Basso *et al* 1990, Haynes 1990)**. Concerning correlations among leaf nutrient levels, significant correlation coefficients were obtained between P and Mn, Fe and Mn, Fe and Zn, and Mn and Zn. Similarly, high significant correlations were found between Fe and Mn in coffee-tree leaves and flowers **(Martinez *et al* 2003)**. However, the values of coefficients were higher than those determined in the present study.

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تشخيص الحالة الغذائية لبساتين التفاح في جنوب الأردن

[29]

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تم إجراء هذا الفحص لتحديد الحالة الغذائية لأشجار التفاح المزروعة في أربعة بساتين عالية الإنتاج في منطقة الشوبك جنوب الأردن.تم جمع عينات أوراق و نبات من كل بستان، وتم تحليلها من حيث بعض العناصر الغذائية الكبرى و الصغرى.

تبين من النتائج أن ترب البساتين الأردنية عالية الحموضة وبها محتوى منخفض من المادة العضوية ومحتوى عال من الجير. كما أظهرت النتائج أن تراكيز N, K, Fe, Mn, Zn و Cu في التربة تتباين تباينا واضحا ما بين البساتين المختلفة.

ولم يلاحظ أية أعراض لنقص أو عوز العناصر N, P, K, Mn و Zn في أوراق الأشجار في البساتين المختلفة ذلك لأن تراكيز هذه العناصر كان، بشكل عام ، ضمن الحد الأمثل، مما يدل على أن الأشجار تتلقى مستويات كافية من الأسمدة.

تبين من نتائج تحليل الأوراق وجود أعراض نقص عنصر Cu في بعض البساتين ، ولم يكن هناك ارتباط واضح ما بين مستويات العناصر الغذائية في الأوراق والترب. وقد كان الارتباط المعنوى ما بين محتوى التربة من P ومحتوى الأوراق من N . وفي المقابل ، فقد لوحظ وجود علاقات إيجابية واضحة في محتوى الأوراق ما بين P وMn ، Fe وMn ، Fe و Zn ، وMn و Zn .

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