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Leaf Nutrient Concentrations of Apple Orchards in Isparta Province*

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Abstract: This study was conducted in Isparta province to investigate the mineral nutritional status of apple orchards by means of leaf analysis. For this purpose, seven districts were chosen and ten orchards from each district were selected. Leaf samples were taken during two years from the chosen trees. Leaf analyses results indicated that there was no Mg deficiency in trees. Similarly 97% of orchards did not show N deficiency. The most important nutritional problem was Zn nutrition, and 80% of the orchards showed Zn deficiency. On the other hand, 69, 64, 24 and 11% of the orchards showed P, Ca, K and Mn deficiencies, respectively. Finally, it was concluded that soils were fertilized sufficiently with N, but some important nutritional problems continued. Therefore; special fertilization programs should be applied for other nutrients specially for Zn, P and Ca as well.

Key Words: Plant nutrients, nutrient concentrations, leaf analysis

Isparta Yöresi Elma Bahçelerinin Yaprak Besin Elementi Konsantrasyonları

Öz: Bu çalışma, Isparta yöresinde bulunan elma bahçelerinin verimlilik durumlarının yaprak analizleriyle belirlenmesi için yürütülmüştür. Bu nedenle yedi ilçe belirlenmiş ve her ilçeden on bahçe seçilerek iki yıl süreyle aynı ağaçlardan olmak üzere yaprak örnekleri alınmıştır. Yaprak analiz sonuçlarına göre Mg eksikliği görülmemiştir. Benzer şekilde ağaçların büyük oranda (%97) N bakımından da yeterli düzeyde beslendiği belirlenmiştir. Ağaçlarda en fazla Zn eksikliği belirlenmiş olup, bu oran % 80 olarak gerçekleşmiştir. Ayrıca bahçelerin P, Ca, K ve Mn açısından da sırasıyla % 69, 64, 24 ve 11 oranlarında yetersiz olduğu saptanmıştır. Sonuç olarak, toprakların N ile yeterince gübrelendiği fakat Zn, P ve Ca gibi diğer besin elementleri açısından sorunların olduğu görülmektedir. Bu nedenle özellikle Zn, P ve Ca gübrelemesine özel önem verilmelidir.

Anahtar Kelimeler: Bitki besin elementleri, besin elementi içerikleri, yaprak analizleri

Introduction

In plant production, productivity and quality are closely related to nutrient concentrations of plant. To get optimum plant production, nutrient concentrations should be at sufficient level in plants. Nutrient availability to plants is controlled by numerous factors. Factors such as soil, environment and plant affect the mineral nutrition and nutritional status of plants (Marschner 1995).

Soil and leaf analysis methods are often applied to determine plant nutritional status. Leaf analyses methods are often used to determine total amount of nutrients and used for evaluating soil fertility status. With these methods, determined nutrient concentrations are compared to sufficiency level and evaluated. Because nutrient requirement changes among plant species and genotypes, critic levels indicating healthy plant growth may differ. Therefore, some standard values are used to interpret plant nutritional status. However; for evaluating nutritional status of apple trees some different values were reported by authors (Bould 1966; Jones et al. 1991; Bergmann 1992; Wichmann 1992). Because knowing nutritional status of a plant is important for healthy growth. So, nutritional programs depending on analyses results, should be applied. Therefore, leaf analyses have important place on the works trying to overcome plants nutritional problems (Katkat et al. 1994; Güleryüz et al. 1996; Başar et al. 1997; Sönmez et al. 1999; Feramuz et al. 1999; Topçuoğlu 2003). Alpaslan et al. (2001) collected leaf samples to determine the nutritional status of cucumber, tomato, eggplant and pepper grown under green house conditions and compared leaf nutrient concentrations to threshold nutrient levels to explain nutritional status of plants. Mordoğan and Ergun (2001) examined leaf and fruit nutrient concentrations, and they found significant correlation between fruit organic acid contents and nutrient concentrations.

Turkey having 2.300.000 tons apple production is ranked as 4 th in the world. Isparta province meets the 20% of this total production (FAO 2004). Despite the region has an important role in apple production, quality and yield are not satisfactory. One of the most important reason of this is insufficient and unbalanced nutrition of apple trees.

The aims of this study were to determine the nutritional status of apple trees using leaf analyses and to assist proper nutritional programs for the future activities.

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Material and Methods

Selection of orchards and sampling: The study was conducted in Isparta province including 7 districts (Eğirdir, Gelendost, Yalvaç, Senirkent, Uluborlu, Keçiborlu and Atabey) in consecutive years (2002-2003). For this purpose, 10 orchards provided by commercial farm planted with Starking and Golden Delicious were chosen. Trees (5 trees for each da.) from different points of the orchards were selected. Leaf samples were collected from current year's terminals in July representing whole tree from four sides for 2 years from the same tree.

Soil characteristics of research areas: Some characteristics of the soils taken from the research areas were given in Table 1. When the soil properties were evaluated by Ülgen and Yurtsever (1995) and Viets and Lindsay (1973), it was seen that 6% of the soils was neutral, 94% of was slightly alkaline and lime content of about 70% of the soils was higher than 15%. About 70%, 40% and 60% of the soils were insufficient in terms of organic matter, P and Zn, respectively. Potassium, Mg and Mn concentrations of the soils were sufficient.

Plant analysis: Leaf samples were washed thoroughly with fountain water, dilute acid (0.2 N HCl) and re-distilled water to remove surface residues then dried at 65 C^0 and grounded for nutrient analysis. Nitrogen concentration in samples was determined according to modified Kjeldahl method. In order to determine P, K, Ca, Mg, Zn and Mn concentrations, 1 g of leaf sample was dry ashed at 500 ± 50 ^{0}C for 8 h, and the ash was dissolved in 4 ml of 3N HCl and filled up with re-distilled water. Phosphorus concentrations of leaf samples were measured by vanadate-molybdate colorimetric method. The other nutrients were determined by an atomic absorption spectrophotometer (Kacar 1972).

Evaluation of analysis results: Plant nutrient concentrations were evaluated with adequate ranges for apple trees. Adequate ranges of leaf mineral nutrient contents in apple trees were indicated as 1.90-2.60%, 0.14-0.40%,1.50-2.00%,1.20-1.60%, 0.25-0.40%, 20-100 mg kg^{-1} and 25-200 mg kg^{-1} for N, P, K, Ca, Mg, Zn and Mn, respectively by Jones et al. (1991).

Results and Discussion

Nitrogen concentrations of trees grown in different districts were given in Table 2. Leaf N concentrations ranged between 2.27 to 2.82% for Atabey, 2.40 to 2.70% for Uluborlu, 1.86 to 2.64 for Keçiborlu, 2.39 to 2.80 for Senirkent, 2.38 to 2.80 for Eğirdir, 2.15 to 2.78 for Yalvaç and 1.89 to 2.82% for Gelendost. Average N concentration of trees in Isparta province representing whole orchards was found to be 2.48%. Leaf N concentrations were sufficient (>1.90%) according to Jones et al. (1991) in most orchards, and only one orchard from Keçiborlu and Gelendost had insufficient N levels (Table 6). Average P concentrations of leaf samples ranged from 0.08 to 0.21%. General mean representing whole samples was determined as 0.13%. As detailed in Table 2, mean P concentrations for each districts were 0.11, 0.14, 0.11, 0.12, 0.16, 0.12 and 0.13% for Atabey, Uluborlu, Keçiborlu, Senirkent, Eğirdir, Yalvaç and Gelendost, respectively. Because P concentrations were lower than 0.14%, all of the orchards in Atabey were considered P-deficient (Jones et al. 1991). 90% of the orchards in Keçiborlu and Yalvaç provinces had also P deficiency. While orchards in Gelendost, Senirkent and Uluborlu had P deficiency at high rates, only 20% o f the orchards in

Table 1. Some characteristics of the soils taken from the research areas

Characteristics		Depth (cm)	Districts						
			Atabey	Uluborlu	Keçiborlu	Senirkent	Eğirdir	Yalvaç	Gelendost
pH (1/2.5)		0-20	7.3-8.0	7.3-7.9	7.8-8.0	7.7-8.4	7.6-7.9	7.6-7.9	7.8-8.0
		20-40	7.3-7.9	7.3-7.9	7.7-8.0	7.7-8.5	7.5-7.9	7.6-8.0	7.8-8.0
$CaCO_3$ (%)		0-20	11-23	2-29	39-47	24-36	2-28	25-39	8-43
		20-40	11-23	2-33	39-48	25-38	2-29	26-37	10-40
OM (%)		0-20	1.2-2.8	1.6-3.6	1.0-2.1	1.3-2.7	1.1-2.2	1.4-2.8	0.9-2.4
		20-40	0.9-2.8	1.2-2.8	0.6-1.3	0.9-2.4	0.9-1.6	1.0-1.8	0.8-2.7
Extractable nutrients	P (Kg $P_2O_5da^{-1}$)	0-20	2.6-41.8	4.3-57.7	2.0-28.0	5.0-30.0	4.4-37.3	3.0-21.4	6.3-32.0
		20-40	2.0-42.0	1.9-58.2	2.0-9.0	3.0-20.0	3.8-19.2	2.5-14.8	1.9-16.0
	K (me $100g^{-1}$)	0-20	0.7-3.0	0.5-1.9	0.7-3.0	0.5-1.7	0.7-2.5	0.7-2.4	1.1-25.0
		20-40	0.5-5.0	0.4-2.0	0.5-2.0	0.4-1.5	0.6-1.9	0.5-3.3	1.2-23.0
	Mg (me $100g^{-1}$)	0-20	3.3-12.2	2.0-5.1	4.6-9.1	2.1-8.4	4.9-9.4	2.9-12.6	2.9-12.0
		20-40	2.5-11.0	1.6-5.9	4.6-9.9	0.5-8.3	4.7-10.5	2.7-14.9	3.1-8.4
	Zn (mg kg^{-1})	0-20	0.17-1.84	1.0-5.9	0.23-0.87	0.23-1.80	0.30-2.35	0.09-0.50	0.12-0.93
		20-40	0.16-1.31	0.5-4.6	0.06-0.30	0.21-0.70	0.22-0.60	0.08-0.40	0.08-0.40
	Mn (mg kg^{-1})	0-20	5.1-12.0	12.0-20.7	2.2-37.0	3.2-7.1	9.7-22.0	2.3-6.6	1.80-9.56
		20-40	5.2-9.5	11.1-20.7	2.2-25.2	3.5-6.8	4.2-21.4	1.8-5.9	1.34-8.48

Table 2. Leaf N, P and K concentrations of apple trees grown in Isparta province.

Orchards	Districts						
	Atabey	Uluborlu	Keçiborlu	Senirkent	Eğirdir	Yalvaç	Gelendost
	N (%)						
1	2.27	2.50	2.64	2.80	2.45	2.39	2.48
2	2.82	2.40	2.46	2.57	2.65	2.72	2.43
3	2.40	2.60	2.46	2.39	2.70	2.38	1.89
4	2.69	2.70	2.54	2.50	2.50	2.15	2.25
5	2.44	2.40	2.27	2.41	2.80	2.41	2.16
6	2.48	2.60	2.32	2.46	2.48	2.40	2.22
7	2.69	2.50	2.12	2.47	2.38	2.60	2.30
8	2.66	2.40	1.86	2.63	2.59	2.78	2.55
9	2.30	2.70	2.54	2.57	2.39	2.27	2.78
10	2.51	2.60	2.33	2.48	2.53	2.64	2.82
Mean	2.53±0.28	2.50±0.12	2.37±0.23	2.53±0.12	2.55±0.14	2.47±0.20	2.41±0.29
	P (%)						
1	0.13	0.15	0.11	0.13	0.16	0.12	0.13
2	0.10	0.15	0.08	0.08	0.16	0.11	0.17
3	0.11	0.17	0.08	0.15	0.17	0.11	0.17
4	0.10	0.13	0.10	0.10	0.13	0.16	0.12
5	0.12	0.10	0.08	0.15	0.14	0.12	0.13
6	0.10	0.15	0.10	0.17	0.18	0.11	0.10
7	0.10	0.12	0.11	0.10	0.16	0.12	0.11
8	0.12	0.13	0.17	0.14	0.21	0.11	0.12
9	0.12	0.11	0.13	0.10	0.16	0.11	0.14
10	0.12	0.18	0.09	0.11	0.16	0.08	0.11
Mean	0.11±0.01	0.14±0.03	0.11±0.03	0.12±0.030	0.16±0.02	0.12±0.02	0.13±0.02
	K (%)						
1	1.83	2.06	2.48	1.47	2.46	1.71	1.47
2	1.32	1.87	1.72	1.65	3.01	1.72	1.98
3	1.28	1.82	1.86	2.53	2.14	1.27	1.63
4	1.46	1.77	2.23	1.77	2.59	1.88	1.26
5	1.12	1.87	1.64	2.63	2.26	1.81	1.10
6	1.22	2.28	2.42	2.21	2.73	1.43	1.16
7	1.51	1.97	2.01	1.70	2.37	1.83	1.01
8	2.03	2.48	2.06	2.82	1.99	1.97	1.18
9	1.49	1.77	1.67	1.87	1.77	1.33	2.30
10	1.32	2.21	1.97	1.86	1.72	1.93	1.28
Mean	1.46±0.28	2.01±0.24	2.01±0.30	2.05±0.46	2.30±0.41	1.69±0.25	1.44±0.42

Eğirdir was P-deficient (Table 6). Potassium concentration of orchards in Isparta province ranged from 1.01 to 3.01% with a means of 1.85%. Mean K concentrations in districts were found to be 1.46, 2.01, 2.01, 2.05, 2.30, 1.69 and 1.44% for Atabey, Uluborlu, Keçiborlu, Senirkent, Eğirdir, Yalvaç and Gelendost, respectively (Table 2). Because leaf K concentrations were higher than 1.50%, there was not a nutritional problem in Uluborlu, Keçiborlu and Eğirdir (Jones et al. 1991). Senirkent and Yalvaç orchards had also sufficient K levels at rates of 90% and 70%, respectively. But Atabey and Gelendost orchards were found to be K-deficient, generally (Table 5). Different Ca concentrations were recorded in leaves taken from the orchards. Average Ca concentrations were 1.18, 1.40, 0.84, 1.38, 0.98, 1.33 and 0.80% for Atabey, Uluborlu, Keçiborlu, Senirkent, Eğirdir, Yalvaç and Gelendost districts, respectively (Table 3). According to results, all orchards in Keçiborlu, Eğirdir and Gelendost were Ca-deficient (< 1.20 %), and orchards in Atabey, Uluborlu, Senirkent and Yalvaç had Ca deficiency at the rates of 60,

40, 20 and 30%, respectively (Table 5). It was observed that leaf Mg concentrations were higher than (Table 3) critical level given by Jones et al. (1991), thus all orchards were evaluated as Mg-sufficient (Table 5). Mean Mg concentrations were found to be 0.37, 0.35, 0.38, 0.50, 0.37, 0.44 and 0. 41% in Atabey, Uluborlu, Keçiborlu Senirkent, Eğirdir, Yalvaç, respectively, and general mean was recorded as 0.40% for Isparta province. Leaf Zn concentrations of apple trees in Atabey and Yalvaç were lower than 20 mg kg^{-1} (Table 4). Thus these areas were considered as Zn-deficient (Jones et al. 1991). Similarly, 80, 90, 90 and 70% of the orchards in Uluborlu, Keçiborlu, Senirkent and Gelendost had insufficient Zn concentrations. On the other hand in Eğirdir district, most of the orchards had sufficient Zn concentration (Table 5). Average Zn concentrations were 8.8, 16.2, 14.6, 16.9, 24.7, 14.2 and 15.1 mg kg^{-1} for Atabey, Uluborlu, Keçiborlu, Senirkent, Eğirdir, Yalvaç and Gelendost, respectively. Manganese concentration as general mean for the region was found to be 43.9 mg kg^{-1} (Table 4). According to the results obtained, whole orchards in Atabey, Senirkent and Eğirdir were sufficient in Mn based on critical levels given by Jones et al. (1991). Similarly, most of the of orchards in Uluborlu, Keçiborlu, Yalvaç and Gelendost districts were found to be Mn-sufficient. When the region was examined generally, it was seen that 89% of the samples were Mn-sufficient and 11% was Mn-deficient (Table 5).

When an evaluation was made based on adequate ranges of mineral nutrition of apple trees indicated by Jones et al. (1991) for two years results, it could be said that there were no any Mg deficiency in trees. This results show well correspondence with previous study conducted on soils (Erdal et al. 2004). Similarly 97% of N When an evaluation was made based on adequate ranges of mineral nutrition of apple trees indicated by Jones et al. (1991) for two years results, it could be said that there were no any Mg deficiency in trees. This results show well correspondence with previous study conducted on soils

Table 3. Leaf Ca and Mg concentrations of apple trees grown in Isparta province.

Orchards	Districts						
	Atabey	Uluborlu	Keçiborlu	Senirkent	Eğirdir	Yalvaç	Gelendost
	Ca (%)						
1	1.47	0.69	0.74	1.67	0.82	1.20	0.82
2	1.51	1.01	0.58	1.32	1.15	1.11	0.63
3	0.91	1.90	0.63	1.40	1.12	1.17	0.58
4	1.02	1.76	1.15	1.61	1.03	1.04	0.85
5	0.76	1.33	1.15	1.66	0.81	1.54	1.07
6	1.36	1.19	1.17	1.44	0.96	2.02	0.77
7	0.99	1.92	1.04	1.17	0.98	1.48	0.58
8	0.74	1.65	0.68	1.20	1.02	1.31	0.93
9	1.16	1.31	0.62	1.00	0.76	1.33	0.67
10	1.89	1.19	0.61	1.34	1.19	1.14	1.10
Mean	1.18±0.37	1.40±0.40	0.84±0.26	1.38±0.22	0.98±0.15	1.33±0.30	0.80±0.19
	Mg (%)						
1	0.37	0.36	0.37	0.53	0.34	0.44	0.39
2	0.44	0.29	0.36	0.53	0.44	0.45	0.42
3	0.36	0.36	0.35	0.43	0.37	0.42	0.37
4	0.27	0.36	0.37	0.56	0.38	0.41	0.43
5	0.33	0.36	0.38	0.47	0.37	0.40	0.43
6	0.36	0.37	0.38	0.54	0.40	0.42	0.46
7	0.40	0.40	0.42	0.59	0.33	0.42	0.41
8	0.40	0.36	0.36	0.49	0.37	0.51	0.38
9	0.35	0.32	0.43	0.50	0.34	0.46	0.41
10	0.40	0.27	0.42	0.37	0.36	0.42	0.42
Mean	0.37±0.05	0.35±0.04	0.38±0.03	0.50±0.06	0.37±0.03	0.44±0.03	0.41±0.03

(Erdal et al. 2004). Similarly 97% of N concentrations of orchards were found to be sufficient. This results did not show well correspondence with the soil analyses results (Erdal et al. 2004). Because, soil analysis results showed that organic matter content in experimental area was generally deficient. This results indicated that plants are sufficiently fertilized by N. In another study conducted by Demircan and Yılmaz (2005), it was reported that N containing fertilizer application was quite high in the region. The biggest nutritional problem observed was in Zn nutrition, and 80% of the orchards had Zn deficiency. And orchards having P, Ca, K and Mn deficiency were at 69, 64, 24 and 11%, respectively. Despite, nearly 70% of the region soils have high amount of $CaCO_3$ (> 15%), occurring Ca deficiency in a large area seems to be surprising. This findings indicates that there are some factors preventing Ca uptake by plant. In the literature, it is mentioned that there are several factors affecting Ca uptake. For instance, in-balanced watering, low transpireation rates and high soil pH negatively affect plants Ca uptake (Mix and Marschner 1976). Higher rate of Mg and sometimes K in the external solution might be another factor. Because Mg and K are easily carried in plant tissues, higher amount of these nutrients prevents plants from uptaking sufficient Ca. The other important factor leading to Ca deficiency in plants might be higher concentration of N, K and Mg in irrigation water (Güneş et al. 2000). In a study conducted in the region, over fertilization was determined for N and K (Demircan and Yılmaz 2005).

Conclusion: It could be concluded that plants are sufficiently fertilized by N. Soil characteristics showed that pH was slightly alkaline and lime content was high. Because these factors affect mineral availability, especially Zn and P nutritional deficiency is inevitable. Therefore, specific attentions should be given to P and Zn fertilization. This problem may be dissolved by choosing proper fertilizer, fertilization type and fertilization time. Avoiding from applying nutrients which are sufficient in soil and plant prevents ion antagonism. Calcium is another nutritional problem in a wide area. Because Ca is one of the most important nutrient for plant growth and fruit quality especially under storage conditions, plant Ca concentration must be increased by any ways. Under unfavorable soil condition for nutrient availability, foliar applications or usage of chelated forms may overcome nutritional deficiencies. In same cases, dipping or spraying methods may be applied to increase fruit Ca concentrations before storage.

Table 4. Leaf Zn and Mn concentrations of apple trees grown in Isparta province.

Orchards	Districts						
	Atabey	Uluborlu	Keçiborlu	Senirkent	Eğirdir	Yalvaç	Gelendost
	Zn (mg kg^{-1})						
1	9.5	10.0	10.0	13.5	21.5	19.5	23.0
2	9.0	11.5	15.0	17.0	28.0	14.0	11.0
3	9.5	20.0	9.5	9.5	27.5	9.50	31.0
4	7.0	16.0	18.5	41.5	23.5	14.0	14.5
5	13.5	32.5	18.5	15.5	22.5	15.5	12.5
6	6.0	9.5	21.5	19.0	28.5	12.0	12.5
7	9.5	17.5	19.5	15.0	19.0	14.0	10.0
8	8.0	15.0	12.0	11.0	15.5	13.5	12.0
9	8.0	13.5	13.0	12.5	26.0	15.0	12.0
10	7.5	16.5	8.5	14.0	35.0	15.0	12.5
Mean	8.8±2.0	16.2±6.6	14.6±4.7	16.9±9.0	24.7±5.5	14.2±2.6	15.1±6.6
	Mn (mg kg^{-1})						
1	40.0	21.0	35.5	67.5	41.0	53.0	19.5
2	46.0	29.0	34.0	40.0	67.0	26.5	19.5
3	34.5	57.0	28.5	49.5	98.0	21.0	26.0
4	31.5	36.0	22.5	47.5	39.0	15.0	29.5
5	35.0	39.0	44.0	73.0	51.0	69.0	23.5
6	52.5	31.5	37.0	101.5	47.5	59.5	27.5
7	37.0	32.0	35.0	95.5	89.0	56.5	24.5
8	30.5	41.5	31.5	59.5	82.5	52.5	35.0
9	35.5	30.0	30.5	77.5	34.5	51.5	28.5
10	53.5	25.0	25.5	71.5	42.0	40.5	56.5
Mean	39.6±8.3	34.2±10.0	32.4±6.1	68.3±20.0	59.2±23.2	44.5±18.0	29.0±10.7

Table 5. Sufficiency levels of nutrients in leaf of apple trees grown in Isparta province.

Nutrients	Atabey		Uluborlu		Keçiborlu		Senirkent		Eğirdir		Yalvaç		Gelendost		Means	
	Sufficiency rates (%)															
	Sufficient	Deficient	Sufficient	Deficient	Sufficient	Deficient	Sufficient	Deficient	Sufficient	Deficient	Sufficient	Deficient	Sufficient	Deficient	Sufficient	Deficient
N	100	0	100	0	90	10	100	0	100	0	100	0	90	10	97	3
P	0	100	50	50	10	90	40	60	80	20	10	90	30	70	31	69
K	30	70	100	0	100	0	90	10	100	0	70	30	40	60	76	24
Ca	40	60	60	40	0	100	80	20	0	100	70	30	0	100	36	64
Mg	100	0	100	0	100	0	100	0	100	0	100	0	100	0	100	0
Zn	0	100	20	80	10	90	10	90	70	30	0	100	30	70	20	80
Mn	100	0	90	10	90	10	100	0	100	0	70	30	70	30	89	11

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