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RESEARCH ARTICLE

Determination of Nutrition Status of Apple Orchards in Doğanşehir, Malatya

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ABSTRACT

In order to determine nutrition status of the apple orchards in Doğanşehir region of Malatya Province, chemical and physical properties of soil samples, and macro and micro nutrient contents of soil and leaf samples taken from the selected orchards from different parts of the region were determined in 2017. Soil samples were collected from two depths of 0-30 cm and 30-60 cm, 1 kg from each depth, in September. Leaf samples, 100 leaves taken from head level of trees representing the related orchard, were collected 11 weeks after full blossom. Results indicated that soil texture, pH and salinity level was appropriate for apple growing, but loam content was generally high and organic matter was poor. Except Mn and Zn, macro and micro nutrients were found adequate in soil samples of most of the orchards. Sampling depth did not affected soil properties in most of the orchards. Almost all of the leaf samples were found adequate in N, P, Fe, and Cu contents, whereas they were found inadequate in terms of K, Ca, and Zn contents. N content varied between 0.068% and 0.106% in soil samples, and between 1.78% and 2.68% in leaf samples.

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Introduction

Malus genus belongs to Rosaceae family and comprises more than 40 species, that apple (*Malus domestica* Borkh.) is included with its thousands of cultivars (Qian et al., 2010). Apple is one of the most important fruit species with its production quantity, wide range of uses and nutritional benefits. As the fruit is subjected to fresh consumption, it is processed especially for juice and vinegar, but also patisserie, cosmetics, pharmaceuticals etc. Nutritional value of apple is a result of its ingredients that 100 grams of apple includes 84% water, 59 kcal energy, 15.2 g carbohydrate, 2.68 g total fiber, 7.2 mg Calcium (Ca), 0.15 mg Iron (Fe), 115.2 mg Potassium (K), 52.9 IU vitamin A, 0.015 mg thiamine, 0.015 mg riboflavin, 0.07 mg of niacin and 5.8 mg of ascorbic acid (Gebhardt et al., 2002).

Apple is produced throughout the world thanks to its high adaptation skills, hence apple was the most produced fruit species in 2016 with its 89.329.179 tons of world total production quantity. Producing 2.925.828 tons of this production, Turkey was the fourth biggest apple producer in the same year (FAO, 2018). Malatya Province produced 35.823 tons of apple production of Turkey and was the 12th apple producer province in 2016, and apple is the second most produced fruit after apricot in Malatya. Having more than 20 thousand tons of annual apple production, Doğanşehir is the leading apple growing region of Malatya Province (TÜİK, 2018).

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Availability of soil nutrients are related to soil texture, organic matter content, salinity, lime and pH level (Özbek, 1981). When an apple orchard is established, properly ventilated with high water holding capacity and drainage should be selected. An apple tree prefers loamy or silty, moderately calcareous and deep soils with 2% and higher organic matter content (Çolakoğlu, 1979). On the other hand, the tree is sensitive to salinity that does not affect significantly until 1 mmhos cm^{-1} but from this level cause significant yield losses (Havlin et al., 2005). The level of pH plays key role on nutrient availability in soil, and almost all nutrients are sufficiently available at the pH level of 6-7 (Anonymous, 2006; Stiles, 2004).

In terms of fertilization, together with the above soil factors, tree age, cultivar, growth and yield situation are important factors when deciding the amount and the type of fertilizers to be applied (Özkan et al., 2009). Soil analysis is the most common method to determine the fertilizer need of the crops because a positive correlation is expected between soil nutrition contents and plant nutrition contents. However, in many cases this may not be true as a result of various factors such as soil biological, chemical and physical characteristics, balance between available nutrient amounts, developmental situation of plant roots and vegetative parts, cultivars, tree age and climatic conditions, since nutrient uptake is related to those factors. For those reasons, determination of nutritional status of especially perennial plants should be supported by leaf analysis (Uçgun, 2012).

Soil fertility situation, convenience of soil type for fruit growing and nutritional status of fruit orchards in a certain area is possible to be detected by survey studies. According to this method, orchards in adequate amount and distribution to represent a certain area are selected and soil and leaf analyses are performed. Obtained results are used to examine plant nutrition problems and fertilizer applications in the surveyed area (Özkan et al., 2009).

According to their study conducted to determine the fertility of apple orchards located in Erzincan Plain, Güleryüz et al. (1999) reported that soil texture was fine but organic matter, P and Mn contents were poor in the sampled orchards. Topcuoğlu (2003) found soils of apple orchards in Korkuteli area as clay loam and loam textured, slightly alkaline, highly calcareous, salt-free, poor in organic matter content, adequate in terms of macro and micro contents except Zinc (Zn) content. Şeker et al. (2009) examined nutritional status of dwarf apple orchards at different locations of Çanakkale Province by analyzing soil and leaf samples, and significant differences were found between locations, cultivars and orchard management.

Plant growth, yield and fruit quality are significantly affected by growing conditions. Soil fertility and fertilization are some of those conditions which can highly vary between different orchards even in a certain growing area. Doğanşehir is such an area that apple orchards are planted on varying soil properties and under different cultivation practices applied by more than thousand of growers in the region. For those reasons, yield and quality in apple production stimulates significant fluctuations. In order to contribute in improving this situation, this study was conducted to determine nutrition status of the apple orchards selected from different parts of the region.

Materials and Methods

The study was conducted on 20 selected apple orchards in 2017. The orchards were selected from different parts of Doğanşehir region in Malatya Province, Turkey. Orchards were mixed in terms of planted cultivars which were all grafted on MM106 (Malling-Merton 106) rootstock.

Soil and leaf samples (1 sample from each) were collected in required amounts for analyses from different parts of the orchards in order to represent the average. Soil samples were collected from two depths of 0-30 cm and 30-60 cm in September. Soil samples were collected according to Soil Survey Staff (Anonymous, 1993). Leaf samples were collected 11 weeks after full blossom from the third and fourth leaves of current-year shoots when counted from shoot tips to main stem or trunk (Jones et al., 1991; Rosen, 2005; Walker et al., 1993).

In soil samples; texture was detected by hydrometrical method described by Bouyoucos (1952), pH and EC were measured in 1:2.5 soil-water mixture (Jackson, 1962), lime content (%) were detected with Scheibler calcimeter (Çağlar, 1949), and organic matter content was determined according to Walkley Black method (Jackson, 1962). Total N (%) was determined by Kjeldahl method (Chapman and Pratt, 1961). Available P content (kg P_2O_5 da^{-1}) was determined by Olsen method (Olsen, 1982). Exchangeable K (kg K_2O da^{-1}), Ca (kg CaO da^{-1}) and Magnesium (kg MgO da^{-1}) were determined by ammonium acetate-ICP method (Kacar, 1995). Available Fe, Mn, Zn and Cu contents were detected by DTPA-ICP method (Lindsay and Norwell, 1978).

In leaf samples N (%) content was measured according to Kjeldahl method (Chapman and Pratt, 1961). P (%), K (%), Ca (%), Mg (%), Fe (ppm), Mn (ppm), Zn (ppm), and Cu (ppm) were detected by dry combustion-ICP method (Plank, 1992; Kacar and İnal, 2008).

Results and Discussion

Maximum, minimum and average values obtained from physical and chemical analyses performed as part of the study on soil samples collected from apple orchards located in different parts of Doğanşehir were given in Table 1. According to the results, soil types and characteristics significantly varied between the orchards examined.

In terms of pH, maximum, minimum and average values of soil samples were 7.9, 7.3, and 7.58 for 0-30 cm depth and 7.8, 6.1, and 7.4 for 30-60 cm depth (Table 1). While all of the soil samples taken from 0-30 cm depth were in slightly alkaline group, there were one orchard in neutral and two orchards in slightly acid group of which soil samples taken from 30-60 cm depth (Table 1) (Kellog, 1952).

Soil samples of 0-30 cm depth varied between 1.60 and 16.00 % in $CaCO_3$ content and average value was 4.21 %, whereas these values varied between 1.30 and 15.30 %, and 4.73 % was the average value in the soil samples of 30-60 cm depth (Table 1). In the samples of 0-30 depth, 12 orchards lowly, 3 orchards moderately, 3 orchards highly and 2 orchards were very highly calcareous, whereas soils of 10, 4, 3 and 3 orchards were lowly, moderately, highly and very highly calcareous in the 30-60 cm sampling depth (Evliya, 1964).

Regarding salinity level, all soil samples were classified as non-saline (Dellavalle, 1992). Maximum, minimum and average values were 0.064, 0.011 and 0.025 µmhos cm^{-1} in 0-30 cm samples, and 0.062, 0.011 and 0.02 µmhos cm^{-1} for 30-60 cm samples (Table 1).

Soil organic matter content varied between 0.14 and 2.72 % in 0-30 cm soil samples and the average was 1.61 %. In 30-60 cm soil samples these values varied between 0.17 and 1.79 %, and 0.97 % was the average (Table 1). While 14 samples were poor and 6 samples were slightly humus in 0-30 cm depth, all soil samples taken from 30-60 cm depth were poor (Thun et al., 1955).

Total N contents varied between 0.106 % and 0.068 % in 0-30 cm depth, 0.102 and 0.072 % in 30-60 cm depth (Table 1). Except three orchards, total N content was same in two depths, and while total N level was adequate in 15 samples of 0-30 cm depth, it was 12 in 30-60 cm depth (Anonymous, 1990).

Available P level of soil samples taken from 0-30 cm and 30-60 cm depths varied between 0.70-39.47 kg P_2O_5 da^{-1}, and 0.70-30.03 kg P_2O_5 da^{-1}, respectively (Table 1). Half of the 0-30 cm soil samples contained very high available P level, while this level was 35% in 30-60 cm depth (Lindsay and Norvell, 1978).

Minimum and maximum exchangeable K contents were 11.70 and 100.80 kg K_2O da^{-1}, 5.40 and 94.20 kg K_2O da^{-1} in 0-30 cm and 30-60 cm soil depths, respectively (Table 1). In 0-30 cm soil samples, 65% contained moderate and high, and 35% were inadequate in exchangeable K contents, while these rates were 55% and 45% in 30-60 cm depth (Lindsay and Norvell, 1978).

Soil exchangeable Ca contents varied between 978.60 and 2365.30 kg CaO da^{-1} in 0-30 cm, 858.20 and 2328.90 kg CaO da^{-1} in 30-60 cm soil depth (Table 1). While eight orchards were poor and 12 orchards were moderate in exchangeable Ca contents of 0-30 cm depth, the numbers were nine for poor and 11 for moderate in 30-60 cm depth (Loue, 1968).

Exchangeable Mg contents changed between 54.40 and 176.40 kg MgO da^{-1} in 0-30 cm, and 49.35 and 171.80 kg MgO da^{-1} in 30-60 cm depth (Table 1). All of the orchards were found adequate in terms of exchangeable Mg contents in 0-30 cm depth, whereas 2 of them contained poor exchangeable Mg in 30-60 cm (Loue, 1968).

All soil samples were found with adequate available Fe level (Lindsay and Norvell, 1978). According to Table 1, minimum available Fe contents were 2.75 ppm for 0-30 cm and 4.48 ppm for 30-60 cm samples, whereas maximum available Fe contents were 13.09 ppm for 0-30 cm and 107.30 ppm for 30-60 cm, and the average values were 7.49 and 12.79, respectively (Table 1).

Available Mn contents changed between 2.51 and 25.86 ppm in 0-30 cm samples, and 2.28 and 69.09 ppm in 30-60 cm samples (Table 1). In both of the sampling depth, most of the orchards contained inadequate level of Mn content, and based on the average values available Mn was higher in 30-60 cm (Table 1) (Lindsay and Norvell, 1978).

While 30% of 0-30 cm samples contained adequate level of available Zn contents, the rate was 15% for 30-60 cm depth (Lindsay and Norvell, 1978). Minimum and maximum levels were 0.09 and 2.64 ppm for 0-30 cm depth, and 0.06 and 1.68 ppm for 30-60 cm depth (Table 1).

Available Cu contents were adequate in all samples (Lindsay and Norvell, 1978). Based on the average values soil Cu contents were decreased with depth. Minimum and maximum Cu contents were (Table 1) 0.89 and 19.08 ppm for 0-30 cm and 0.73 and 24.74 ppm for 30-60 cm depth.

Table 1. Maximum, minimum and average values of soil samples

Soil Characteristics	**Minimum**		**Maximum**		**Average**	
	0-30 cm	*30-60 cm*	*0-30 cm*	*30-60 cm*	*0-30 cm*	*30-60 cm*
pH	7.30	6.10	7.90	7.80	7.58	7.40
$CaCO_3$ (%)	1.60	1.30	16.00	15.30	4.21	4.73
EC (µmhos cm^{-1})	0.011	0.011	0.064	0.06	0.025	0.02
Organic Matter (%)	0.14	0.17	2.72	1.79	1.61	0.97
N (%)	0.068	0.072	0.106	0.102	0.095	0.090
P (kg P_2O_5 da^{-1})	0.70	0.70	39.47	30.03	14.80	9.63
K (kg K_2O da^{-1})	11.70	5.40	100.80	94.20	44.74	36.05
Ca (kg CaO da^{-1})	978.60	858.20	2365.30	2328.90	1560.41	1626.62
Mg (kg MgO da^{-1})	54.40	49.35	176.40	171.80	100.54	94.50
Fe (ppm)	2.75	4.48	13.09	107.30	7.49	12.79
Mn (ppm)	2.51	2.28	25.86	69.09	12.93	15.13
Zn (ppm)	0.09	0.06	2.64	1.68	0.61	0.41
Cu (ppm)	0.89	0.73	19.08	24.74	4.06	2.97

Soil texture classes were similar between two sampling depths. Except four orchards, both soil samples were classed in the same texture class (Table 2). The texture class of soil samples taken from 0-30 cm and 30-60 cm depths in orchards number 1, 7, 10 and 20 were clay-clay loam, clay loam-clay, clay loam-loam, and loam-clay loam, respectively.

Table 2. Classification of soil samples according to texture

Classification	Number of Orchards	
	0-30 cm	*30-60 cm*
Sandy Loam	-	-
Loamy	5	5
Sandy Clay Loam	-	-
Silty Loam	-	-
Silty Clay Loam	-	-
Clay Loam	12	12
Silty Clay	-	-
Clay	3	3

Maximum, minimum and average values of macro and micro nutrient contents of leaf samples are given in Table 3. In terms of macro nutrients; N, P, K, Ca and Mg contents varied between 1.78 and 2.68 %, 0.14 and 0.32 %, 0.56 and 1.28 %, 0.58 and 1.38 %, and 0.18 and 0.29 %, and the average values were 2.33, 0.19, 0.87, 0.80, 0.22 ppm, respectively. The micro nutrients which were examined as part of the study changed between 66.20 and 194.60 ppm for Fe, 10.00 and 63.50 ppm for Mn, 6.75 and 45.40 ppm for Zn, 4.70 and 61.20 ppm for Cu. Average values for Fe, Mn, Zn, and Cu contents of leaf samples were 98.46, 32.09, 17.92, and 10.72 ppm, respectively.

Table 3. Maximum, minimum and average values of leaf samples

Nutrients	Minimum	Maximum	Average
N (%)	1.78	2.68	2.33
P (%)	0.14	0.32	0.19
K (%)	0.56	1.28	0.87
Ca (%)	0.58	1.38	0.80
Mg (%)	0.18	0.29	0.22
Fe (ppm)	66.20	194.60	98.46
Mn (ppm)	10.00	63.50	32.09
Zn (ppm)	6.75	45.40	17.92
Cu (ppm)	4.70	61.20	10.72

The relations between soil and leaf mineral contents were examined by correlation analyses performed on the results obtained from soil and leaf samples. Accordingly, significant positive correlations were found between soil K content and leaf Mn content, soil Ca content and leaf Ca, Mn and Zn contents, and soil Mg content and leaf N, P and K contents (Table 4).

Table 4. The correlations between some nutrients composition of leaf and soil samples

Soil Nutrient Elements	Leaf Nutrient Elements								
	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu
N	-.141	.264	.187	.175	-.061	-.022	.258	.061	-.258
P	-.262	.404	.374	-.154	-.322	.193	.160	-.088	-.178
K	.040	.076	.118	.273	-.241	-.142	.572**	.233	-.189
Ca	.267	-.053	-.077	.595**	-.159	-.046	.790**	.538*	-.291
Mg	.455*	-.618**	-.402	-.029	.492*	-.242	-.284	-.111	.398
Fe	-.080	-.189	.062	.073	.265	.031	-.366	-.161	.003
Mn	-.186	-.041	.179	.030	.031	.166	-.298	-.120	-.148
Zn	-.102	-.162	.153	.232	.226	.050	.057	-.068	-.069
Cu	-.224	.064	.260	.090	.084	.034	.159	-.094	-.015

*Correlation is significant at the 0.05 level. **Correlation is significant at the 0.01 level.

Colak et al. (2010) examined physical and chemical properties of 1297 soil samples taken from apricot orchards in Malatya and its counties. Most of the soil samples were found clay loam or loamy, and 17 % of the orchards were slightly alkaline, 23.9 % were medium alkaline and 51.4 % were strongly alkaline. Lime contents were found high in 23.9 % and very high in 51.4 % of the orchards. Bozkurt et al. (2000) reported that N and Zn contents of apple leaves were inadequate while P, K, Fe, Mn and Cu contents were adequate according to their study conducted in Van Province. However, Güleryüz et al. (1999) reported that N contents of the leaves in 70 % of the apple orchards were inadequate in Erzincan Province. In another study conducted in apple orchards of Karaman province, researches detected that N levels were medium in 65 % orchards while the P levels were adequate in 88 % orchards (Oktay and Zengin, 2005).

Soil and leaf nutrient contents have important effects on productivity of fruit trees (Dejampour and Zeinalabedini, 2006), and it is emphasized that these contents are not only complementary in terms of productivity but also important for the developmental strength of the apple trees. For that reason, before an orchard is established, soil analyses need to be done in order to determine soil properties. As a matter of fact, it is known that in the years when sufficient fruits were obtained, nutrient element deficiencies cause yield loses in the apple trees the following year (Gerçekçioğlu et al, 2012).

Conclusion

Results of the soil analyses indicated that the soils of apple orchards in Doğanşehir are generally slightly alkaline, non-calcareous, non-saline and clay loam in texture, and poor in organic matter content, and those characteristics do not significantly depend on soil depth. In terms of macro and micro nutrient contents, most of the orchards were found adequate except Mn and Zn. According to the results, nutrient sufficiency classes were slightly changed with soil depth. When the results of two soil depth compared, Ca, Fe and Mn were found to higher in samples taken from 30-60 cm depth. Leaf sample results showed that even though K and Ca levels were adequate in most of the soil samples, these nutrients were not adequate in leaf samples, indicating a problem in uptake of these nutrients. As a result of the study, it was concluded that the measures would be taken to improve soil organic matter content and macro nutrient fertilization should be done more efficiently of apple orchards in Doğanşehir.

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