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Research Article

DETERMINATION OF NUTRITIONAL STATUS OF APPLE (*Malus communis* L.) ORCHARDS IN KAYSERI (TURKEY) WITH SOIL AND LEAF ANALYSIS

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ABSTRACT. This study was carried out in 2020 to determine the mineral nutrition status of some apple orchards in Develi, Yeşilhisar and Yahyalı districts of Kayseri province with soil and leaf analysis. Soil samples were analyzed for texture, pH, electrical conductivity (EC), lime ($CaCO_3$), organic matter, available phosphorus, potassium, calcium, magnesium, iron, zinc, manganese, and copper. On the other hand, in leaf samples, nitrogen and boron analyzes were also carried out in addition to the processes performed in soil samples. By comparing the analysis results of the leaf and soil samples with the limit values of the apple species, the nutrient status and nutritional problems of the examined orchards were tried to be determined. According to the results of the study, the soil texture in the orchards is generally loamy (38.1%) and clay-loam (30.9%). While there was not salinity problem in the orchards, lime problem was determined in 81% of the orchards. In terms of organic matter, the orchards were predominantly (75.2%) in the "low" and "very low" categories. According to the results obtained from the leaf samples, no serious deficiency was detected in the orchards in terms of nutrient elements. The highest deficiency was determined as phosphorus (P) with 40.5% and copper (Cu) with 21.4% of the orchards. Iron and manganese elements were found sufficient in all of the orchards.

Keywords: *apple, soil and leaf analysis, mineral nutrition, Kayseri*

INTRODUCTION

Due to its ecological differences, Turkey is among the rare countries that allow most fruit species to be grown throughout the country [1]. Apple (*Malus communis* L), which is among these fruit types, is one of the fruits that can adapt in the country. For this reason, according to 2019 FAO data, Turkey ranks third in the world with 3.618.752 tons of world production, which is approximately 87 million tons [2].

There are various factors affecting yield and quality in apple production [3]. Among these, the most widely known are the genetic texture of the variety, climatic conditions, and cultural practices. One of the prominent parameters among the cultural practices is the fertilization situation. Successful plant nutrition: knowing the nutrient content of the soil and the nutrient demand of the plant requires optimum management of environmental conditions and other agricultural inputs. For this reason, excess or scarcity of one of the plant nutrients causes disruptions in plant development. Nutritional disorders in plants not only affect the yield, but also affect the plant's resistance to diseases and pests, cold and drought. At more advanced levels, it has effects that reach plant deaths. [4].

A correct and balanced plant nutrition program can be made by knowing both the current nutritional status of the plant and the useful amounts of nutrients in the soil. In this way, the condition of the nutrients that are present in the soil and cannot be taken up by the plant are determined and necessary interventions are made. In this regard, both in our country and abroad, studies are carried out and continue to be done to determine the areas where nutrient deficiency is observed or can be seen in fruit trees and to determine an accurate plant nutrition plan [5].

In this study, it was aimed to determine the fertility status of soil, and nutrient levels in plants in apple orchards in Develi, Yeşilhisar and Yahyalı districts of Kayseri province. Preliminary information has been obtained for plant nutrition and soil fertility studies to be carried out in the study area in the future. It is envisaged that the results of the research will contribute to increasing the quality and productivity in the agricultural field in the region and will shed light on possible future studies on this subject.

MATERIAL AND METHOD

Material

The study was carried out in Develi, Yeşilhisar and Yahyalı districts of Kayseri province in 2020. In the study, soil and leaf samples were taken in mid-June and early July from 42 modern apple orchards, which differ in land sizes (at least 10 decares), where trellis systems are used.

Different criteria were used for leaf sampling. These are the samples taken from the leaves that have completed their development on the fruitless annual shoots from 5-6 different points and 10-15 trees depending on the size of the land and the age of the tree. [6]. While sampling, healthy leaves from each side of the tree from the varieties in the orchard were used. Soil sampling was carried out from 0-30 cm depth from the canopy of the trees where the leaf sampling was made and from 3-4 different points according to the orchard size. The samples were mixed homogeneously and turned into a single representative sample.

Method

After the soil samples were air-dried, they were passed through a 2 mm sieve. Particle size distribution was determined by the hydrometer method [7], the pH and salt contents were determined in a 1:2.5 soil-water mixture, and the organic matter content was determined by the Walkley-Black wet combustion method [8]. The lime content in the soil was determined by the Scheibler calcimeter and the manometric method [9]. The amount of phosphorus available to the plant in the samples [10], the amounts of potassium, magnesium, and calcium extractable with molar ammonium acetate according to the ammonium acetate method [11], the concentrations of useful micro elements (zinc, iron, manganese, copper) was detected by extraction with DTPA in the ICP-OES instrument [12].

Leaf samples were washed with water and distilled water as a preliminary step. It was then dried at 65-70 °C until the weight stabilized. The samples were ground to be less than 0.5 mm in size. The total nitrogen content of leaf samples burned by the Kjeldahl method was determined by steam distillation [13]. To determine the amount of other nutrients, the samples were thawed by dry combustion method [14] and then the phosphorus, potassium, calcium, magnesium, iron, zinc, manganese, copper, and boron concentrations of the samples were read in the ICP-OES instrument [15].

RESULTS AND DISCUSSION

Soil textures obtained from soil samples taken from apple orchards and the percentage classification of orchards are given in Table 1. According to this information, the most common soil texture in orchards is loamy soil with 38.1%. After that, clayey-loam soil texture with 30.9% and sandy-loam soil texture with 23.8% were followed. The texture determined with the lowest ratio was silty loam with 2.4% (Table 1). It is the soil texture that significantly determines the movement and retention of water in the soil, the aeration, heating, and nutrient content of the soil [16]. Considering that apple trees show good growth in loamy and sandy loam soils [17], it is seen that the study area is suitable for soil texture.

Table 1. *Percentage classification of apple orchards according to soil texture*

Texture	**%**
Loamy	38.1
Clay-Loamy	30.9
Sandy-Loamy	23.8
Clayey	4.8
Silty-Loamy	2.4

The lowest value in the EC values determined in the soil in apple orchards is 0.13 dS/m, and the highest EC value is 0.80 dS/m (Table 2). When the EC values of the soils in the study area are compared with the classification values, they are in the "Not salinity" class (Table 3). The pH values of the orchards ranged between 7.5 and 8.5, with an average pH value of 8.1 (Table 2). When 97.6% of the orchards examined within the scope of the study were classified in terms of soil pH, they were in the slightly alkaline class (Table 3). Our study results showed similar results with other studies conducted in apple orchards in different area in Turkey [18, 19, 20, 21]. Soil pH has a significant effect on factors such as beneficial soil bacteria that are effective in plant growth, availability of nutrients and toxicity of nutrients [22]. The optimum pH value for apple varies between 5.6-7.5 [23]. The soils of the region in the study have a slightly high pH value in terms of apple growing. For this reason, importance should be given to the use of acidic fertilizers to bring the soil pH value to the optimum limits so that the apple trees in the region can develop optimally.

Table 2. *Some physical and chemical properties of soils belonging to apple orchards*

Level	**EC (dS/m)**	**pH**	**lime (%)**	**Organic matter (%)**
Minimum	0.13	7.5	1.63	0.64
Maximum	0.80	8.5	50.57	2.54
Mean	**0.41**	**8.1**	**26.12**	**1.53**

Table 3. *Situation of apple orchards in terms of nutrients, pH, organic matter in terms of soil samples [26]*

Property	Percantages of orchards(%)				
	Very Low	**Low**	**Sufficient**	**High**	**Very High**
P (mg/kg)	7.1	28.6	35.7	28.6	0.0
K (mg/kg)	2.4	7.1	42.9	47.6	0.0
Ca (mg/kg)	0.0	7.1	26.2	66.7	0.0
Mg (mg/kg)	0.0	11.9	88.1	0.0	0.0
Mn (mg/kg)	45.2	23.8	31.0	0.0	0.0
Zn (mg/kg)	28.6	35.7	14.3	21.4	0.0
Fe (mg/kg)	**Low**		**Sufficient**		**High**
	66.7		9.5		23.8
Cu (mg/kg)	**Insufficient**				**Sufficient**
	28.6				71.4
Lime (%)	**Very Low Lime**	**Low Lime**	**Medium Lime**	**High Lime**	**Very High Lime**
	0.0	19.0	16.7	0.0	64.3
EC (dS/m)	**Not Salinity**		**Low Salinity**	**Medium Salinity**	**High Salinity**
	100.0		0.0	0.0	0.0
Organic Matter (%)	**Very low**	**Low**	**Medium**	**High**	**Very High**
	19.0	57.2	23.8	0.0	0.0
pH	**Strong Acid**	**Medium Acid**	**Slightly Acid**	**Neutral**	**Slightly Alkaline**	**Strong Alkaline**
	0.0	0.0	0.0	2.4	97.6	0.0

A very wide range has emerged in terms of % lime content in the orchards. The lime content of the orchards was the lowest 1.63%, while the highest was 50.57% (Table 2). 64.3% of the orchards are in the "very high lime" class (Table 3). The high lime content in orchard soils poses a potential danger especially in terms of the availability of phosphorus and micro (iron, zinc, copper, manganese, etc.) elements [24]. The organic matter content of the examined soils is in the range of 0.64-2.54%, with an average value of 1.53% (Table 2). 76.2% of the orchard soils had "very low" or "low" organic matter content (Table 3). These results are like the results of other researchers [19, 21, 25]. As a result of the climatic effect and long years of agricultural use in our country, most of the soils are insufficient in terms of organic matter [26]. For a continuous production, it is recommended that the soil organic matter content be 3% and above [27]. Because organic materials are important in improving the physical, chemical, and micro-biological properties of the soil, increasing the cation exchange capacity of the soil, organic carbon, microbial biomass, and biological activity. [28, 29].

There were wide differences in the nutrient contents of the soil samples examined in the orchards (Table 4). Phosphorus values ranged from 1.31 mg/kg to 51.19 mg/kg, potassium was between 39.33 mg/kg and 484.07 mg/kg, and calcium range was determined between 944.53 mg/kg and 6857.60 mg/kg. The average values of magnesium, manganese, zinc, iron and copper values of orchards are 268.90 mg/kg, 13.31 mg/kg, 1.33 mg/kg, 2.67 mg/kg and 2.72 mg/kg, respectively. In general, 92.9% of the orchards are in the sufficient and rich class in terms of calcium, 90.5% potassium and 88.1% magnesium. On the other hand, the manganese (69.0%), zinc (64.3%) and phosphorus (35.7%) contents of orchard soils were deficient (Table 3).

Table 4. *Some nutrient contents of soils belonging to apple orchards (mg/kg)*

Level	P	K	Ca	Mg	Mn	Zn	Fe	Cu
Minimum	1.31	39.33	944.53	103.04	1.16	0.01	0.01	0.01
Maximum	51.19	484.07	6857.60	471.98	45.89	7.44	21.59	17.56
Mean	**17.50**	**321.97**	**3777.66**	**268.90**	**13.31**	**1.33**	**2.67**	**2.72**

Table 5 also presents the results of leaf nutrient content in apple orchards cultivated in Kayseri province. N contents of apple leaves were found between 1.74% and 2.67%. Phosphorus values ranged from 0.09% to 0.19% and potassium range was determined between 1.44% and 1.95%. In the study, it was determined that Ca and Mg contents of the leaves were 1.07 and 0.70%, and 0.19 and 0.41%, respectively. The Mn, Zn, Fe, Cu and B contents of leaves from apple orchards ranged between 29.94-117.53 mg kg^{-1}, 19.71-96.71 mg kg^{-1}, 56.81-146.98 mg kg^{-1}, 4.62-14.51 mg kg^{-1} and 21.80-68.45 mg kg^{-1}, respectively.

Table 5. *Some plant nutrient contents of apple leaves*

Level	N	P	K	Ca	Mg	Mn	Zn	Fe	Cu	B
	%					mg/kg				
Minimum	1.74	0.09	1.44	1.07	0.19	29.94	19.71	56.81	4.62	21.80
Maximum	2.67	0.19	1.95	1.70	0.41	117.53	96.71	146.98	14.51	68.45
Mean	2.10	0.14	1.65	1.36	0.31	61.69	42.72	91.74	7.91	42.11

The leaf nutrient content results were evaluated through the optimum range suggested by Jones et al. [30]. According to the results obtained from the leaf samples (Table 6), the most deficiency in the nutrient deficiency point of the orchards is phosphorus with 40.5%. Phosphorus was followed by copper with 21.4%. In general, all nutrients were found to be sufficient in orchards based on leaf analysis. There is a positive relationship between phosphorus deficiency in the percentages of orchards classified at the point of sufficiency of nutrients according to soil results, and phosphorus results obtained by leaf analysis. The elements found in excess in orchards are boron with 19%, calcium and nitrogen with 4.8%, and magnesium with 2.4%, respectively. Although the soil contents in the orchards were in the insufficient class in terms of microelements, microelement deficiency was not observed in the leaves. The reason for this can be explained by the producers' application of these elements with foliar fertilization. Phosphorus deficiency in leaves can be attributed to the effects of calcium present in the soil on the inhibition of phosphorus and potassium by plants [31]. In studies examining the nutritional status of apple orchards in terms of macro and micro elements, nitrogen, calcium, potassium, zinc, and copper deficiencies were found in Tokat province [18] and potassium, iron, zinc, and boron deficiencies in Çanakkale province [20].

Table 6. *Nutrient adequacy status in terms of leaf analysis in apple orchards [30]*

Elements	Insufficient (%)	Sufficient (%)	Rich (%)
N	14.3	81.0	4.8
P	40.5	59.5	0.0
K	7.1	92.9	0.0
Mg	9.5	88.1	2.4
Ca	7.1	88.1	4.8
Fe	0.0	100.0	0.0
Mn	0.0	100.0	0.0
Zn	4.8	95.2	0.0
Cu	21.4	78.6	0.0
B	2.4	78.6	19.0

As a result, the nutritional status of the orchards was evaluated in accordance with the soil properties and leaf analysis in apple orchards in Develi, Yeşilhisar and Yahyalı districts of Kayseri province. In addition to the high lime content in the soils of orchard, deficiencies in terms of organic matter were also detected, and both issues should be emphasized at the point of cultivation. Since the soil reaction is slightly alkaline, acidic fertilizers should be preferred for fertilization. Green manure should be given importance to increase the amount of organic matter in the region. Legumes should be preferred as a sub-plant in the orchards and these plants should be mixed with the soil during the flowering period. These suggestions can be a guide to the producers to eliminate the nutritional problems in the region.

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