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RELATIONSHIPS BETWEEN PHYSICAL AND CHEMICAL PROPERTIES OF SOILS AND PLANT NUTRIENT CONTENT OF LEAVES IN THE APPLE ORCHARDS

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Abstract
This study was carried out in 42 orchards located in the lowland of Develi, where the apple cultivation is intense in Kayseri province. The analyses were made to determine pH, $CaCO_3$, EC, organic matter, available phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), iron (Fe), zinc (Zn), manganese (Mn) and copper (Cu) in soil samples and nitrogen (N), P, K, Ca, Mg, Fe, Zn, Mn, Cu, and boron (B) in leaf samples. In the study, the relationships between some physical and chemical properties of the soils and the plant nutrient content of the leaves were evaluated by correlation analysis. In the study, between some physical and chemical properties of soils and the nutritional elements of soils and leaves were found important statistical relations. These relationships were mostly between soil samples rather than leaves. On the other hand, the pH and EC values of the soils showed less significant relationships with the nutrient contents of the samples according to the organic matter and $CaCO_3$ contents of soils. It was determined that the organic matter content of the soils had a positive relationship with all the investigated elements except phosphorus. It has been determined that the relationship between the $CaCO_3$ content and nutritional elements in the soils is statistically significant, it has a positive correlation with potassium and calcium and a negative correlation with other investigated elements. No significant relationships were found between the nutrient contents of the soils and the macro element contents of the leaves. While some important statistical relationships were determined between nutrient contents of the soils and micro element contents of the leaves, the highest correlation was determined between copper and boron contents. It was determined that the copper content of the leaves was positively related to the phosphorus, potassium and magnesium content of the soils and negatively related to the manganese content of the soils.

Keywords: apple, correlation, macro and micro element, plant nutrient element.

1. INTRODUCTION

Improving and reaching the desired level in yield and quality in fruit cultivation is possible with technical and cultural practices such as irrigation, fight against diseases and pests, and especially regular fertilization (Yaman et al., 2021). The first step of the fertilization program is carried out by revealing the nutritional status of the fruit trees (Alva et al., 2006). In addition, determining the plant nutrient content of the orchard soil and some physical and chemical properties interactions of soils is of great importance in terms of conscious fertilization. Nutritional problems have an important place among the factors affecting yield and quality in fruit trees (Milošević and Milošević, 2020). Nutritional disorders that occur in fruit trees retard plant growth, decrease fruit yield and quality, and in some cases may even cause the plant to die by completely pausing the

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development. For this reason, taking measures to prevent malnutrition in plants and eliminating this situation in a short time are of vital importance in terms of yield. Nutritional disorders not only reduce yield and quality, but also cause a decrease in the plant's resistance to stress conditions such as disease, extreme cold and heat, and drought (Lucena, 1996).

The interactions between factors such as lime ($CaCO_3$), organic matter and nutrient contents, reaction and texture of soils influence the amount of nutrients available to the plants. It is necessary to determine these soil properties, which are indicated in a healthy plant growth, and to create an appropriate feeding program by predicting their possible effects. Plants react to the deficiency or excess of one of the nutrients. As a matter of fact, insufficient intake of any nutritional element or the lack of an appropriate ratio between each other causes very important physiological disorders. This causes a decrease in productivity in agricultural production (Kacar and Katkat, 2007).

The most important purpose in plant production is to increase yield and quality, and the factors affecting them vary. It has been known for many years that there are close relationships between many physiological events related to fruit productivity and nutritional physiology (Mills and Jones, 1996), and this subject research are continuing (Şeker et al., 2009; Sürmeli, 2015; Abacı-Bayar and Boyacı, 2021). Achieving high quality and yield in plant production is achieved by the linear development of the bilateral relationship in the soil-plant system. From this perspective, interpretation of soil and plant analysis results together will provide important information in terms of effective fertilizer use. Soil and plant analysis is an indispensable method for estimating the fertilizer requirement of plants as accurately as possible. Many researchers are trying to find solutions to problems by evaluating soil and plant analyzes together to increase productivity and quality (Ceylan et al., 2004; Zengin et al., 2007; Bice and Karaman, 2009).

Anatolia is the gene center of the apple and its ecological conditions are suitable. Therefore, it has been cultivated in almost every part of Türkiye since ancient times. Apple is one of the most important and popular fruits both in terms of trade and cultivation in the world. In recent years, researchs on many subjects related to apple have made it one of the fruits that give privilege in the economy. As in all cultivated plants, it is very important to determine the nutrition contents of the soils and plants to increase the amount and quality of the product in solving the nutritional problems in apples. In this study, it was aimed to determine the relationship between the physical and chemical properties of the soil and nutrient levels soil and leaf in the apple orchards in Kayseri province of Türkiye, where intensive fruit cultivation is carried out.

2. MATERIALS AND METHODS

The study was carried out in 42 apple orchards in the Develi, Yeşilhisar and Yahyalı districts on located the Develi Plain of Kayseri. The Develi Plain has an area of approximately 1000 km². It was formed by the volcanic movements of Mount Erciyes. Soil samples were taken between mid-June and early July. The soil samples were taken to describe the characteristics of soils from 0–30 cm depth from the tree canopy projectional areas from 5-6 different points in apple orchards. The soil samples were mixed in a plastic container and turned into a single representative sample. Air dried soil samples were gently crushed and passed through a 2 mm sieve. Soil chemical properties were determined following Standard procedures, pH and soluble salts in 1:2.5 soil:water suspension, organic matter by potassium dichromate ($K_2Cr_2O_7$) oxidation (Jackson, 1959), calcium carbonate ($CaCO_3$) equivalent by a manometric method (Caglar, 1949), available phosphorus (P) by extraction with 0.5 M sodium bicarbonate ($NaHCO_3$) at pH 8.5 (1 g soil:20 mL solution) (Olsen et al., 1954), exchangeable potassium (K), magnesium (Mg) and calcium (Ca) by replacing with 1 M ammonium

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acetate (NH_4CH_3COO) at pH 7.0 (Carson, 1980). In the extracts iron (Fe), manganese (Mn), zinc (Zn), copper (Cu) and boron were determined by extraction with DTPA (Lindsay and Norvell, 1978) by Inductively Coupled Plasma - Atomic Emission Spectrometer (ICP-AES, Varian Liberty Series II; Varian Inc., Palo Alto, CA, USA).

The leaves were sampled at the end of July from non-fruiting shoots on 10-15 trees for each apple orchard. For a sampling, 40-50 leaves were collected from healthy leaves from each side of the tree for each orchard. Sampled leaves were quickly placed in an ice-box and immediately transferred to the laboratory to remove the contaminants by washing with 0.1% surface reactive detergent and rinsed with de-ionized water. Then, samples were dried at 65-70 ºC till constant weight and homogenized by particle size reduction to <0.5 mm. Nitrogen (N) content of samples was determined by Kjeldahl digestion and steam distillation (Lees, 1971). For determination of other nutrient elements were digested in nitric acid (HNO_3) and perchloric acid ($HClO_4$) (V/V:4/1) mixture (Kacar, 1972). The concentrations of P, K, Mg, Ca, Fe, Mn, Zn, Cu and B in digest were determined by means of Inductively Coupled Plasma Atomic Emission Spectrometer (ICP-AES, Varian, Liberty Series II; Varian Inc., Palo Alto, CA, USA) (Kacar and Inal, 2008).

In the study, the relations between some physical and chemical properties of the soil and the leaf nutrient contents were evaluated by correlation analysis. Correlation analysis was performed in the statistical package program JMP Pro 14 (SAS Institute, Cary, NC).

3. RESULTS AND DISCUSSIONS

In the study, information on the relationship between some physical and chemical properties of soil and the nutrient contents of soil and leaf in the apple orchards is given in Table 1. Significant statistical relationships were found between these parameters.

The relationship between the soil properties was determined more than the relationship between the nutrient content of the leaves. The lime ($CaCO_3$) content in the soil showed a positive relationship with the potassium, calcium and organic matter content in soil, and manganese and zinc content in leaf. The existence of a positive relationship between the $CaCO_3$ and the organic matter contents in soil has been reported by various researchers (Yalcin and Cimrin, 2019; Abacı-Bayar and Boyacı, 2021). On the other hand, the $CaCO_3$ content in the soil showed a negative relationship with the phosphorus, magnesium, manganese, zinc, iron and copper content in the soil. Turan et al. (2013) and Deliboran et al. (2019) reported that there was a negative relationship between the $CaCO_3$ content in the soil and the iron and manganese content in the soil in olive orchards. Indeed, the availability of iron and manganese decrease in calcareous soils (Bloom and Inskeep, 1988; Eyupoglu et al., 1998). In this study, the organic matter content in the soil showed a positive relationship with macro and micro elements in the soil. The soil-organic matter content had highest correlation with between soil-calcium content (r= 0.694), and had lowest correlation with soil-magnesium content (r= 0.378). It has been reported that soil-organic matter content has a positive relationship with soil-iron content (Deliboran et al., 2019) and soil-zinc content (Turan et al., 2013). While the organic matter content provides ventilation of the soil, it increases the usefulness of iron (Guzel et al., 2002) and zinc elements (Eyupoglu et al., 1998).

A statistically significant relationship was not found between the soil nutrient contents and the leaf macroelement contents. However, significant statistical relationships were determined between the soil nutrient contents and the leaf micronutrient contents. While the macro and micro nutrients in the soil exhibited positive relationships among themselves, they showed a mutually negative relationship.

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Table 1. The correlation coefficients between features of soil and leaf-nutrient content

Variables	EC	pH	$CaCO_3$	O.M	S.P	S.K	S.Ca	S.Mg	S.Mn	S.Zn	S.Fe	S.Cu	L.N	L.P	L.K	L.Mg	L.Ca	L.Fe	L.Mn	L.Zn	L.Cu	L.B
EC	1.000	-0.021	0.065	0.053	**0.366**	-0.152	0.085	-0.094	0.091	0.193	0.058	0.181	-0.062	-0.115	-0.081	0.054	-0.004	-0.064	0.083	0.256	0.255	0.007
pH		1.000	0.029	-0.170	**-0.544**	0.011	0.005	-0.012	0.138	0.083	0.265	-0.174	-0.011	-0.204	0.093	0.286	0.055	-0.269	-0.022	-0.279	**-0.392**	0.294
$CaCO_3$			1.000	**0.742**	**-0.380**	**0.669**	**0.955**	**-0.467**	**-0.726**	**-0.614**	**-0.586**	**-0.467**	0.127	-0.085	0.074	0.196	0.031	0.018	**0.368**	**0.348**	0.258	-0.263
O.M.				1.000	0.196	**0.629**	**0.694**	**0.378**	**0.667**	**0.530**	**0.535**	**0.427**	0.147	-0.174	0.211	0.145	0.121	-0.044	0.062	0.195	0.239	-0.196
S.P					1.000	0.146	**0.360**	-0.011	-0.233	-0.180	-0.246	0.038	0.118	0.073	-0.067	0.019	0.052	**0.401**	**0.402**	**0.568**	**0.392**	-0.245
S.K						1.000	**0.628**	**0.381**	**-0.784**	**-0.661**	**-0.659**	**-0.675**	0.100	-0.064	-0.069	-0.067	0.049	0.098	0.004	0.209	**0.422**	-0.204
S.Ca							1.000	**0.515**	**-0.763**	**-0.625**	**-0.625**	**-0.456**	0.109	-0.090	0.032	0.166	0.092	0.036	**0.313**	0.296	0.285	**-0.305**
S.Mg								1.000	**-0.545**	**-0.546**	**-0.472**	**-0.384**	0.241	-0.040	0.167	-0.214	0.006	0.092	-0.062	0.018	**0.310**	-0.285
S.Mn									1.000	**0.827**	**0.893**	**0.733**	-0.028	0.154	-0.094	-0.050	-0.164	0.007	-0.001	-0.120	**-0.306**	**0.335**
S.Zn										1.000	**0.650**	**0.794**	-0.068	0.248	-0.176	-0.116	-0.156	-0.027	0.021	-0.064	-0.136	0.286
S.Fe											1.000	**0.552**	0.060	0.032	-0.027	0.087	-0.086	0.013	-0.074	-0.181	-0.259	**0.397**
S.Cu												1.000	-0.045	0.229	-0.158	-0.140	-0.115	-0.070	0.166	0.123	-0.056	0.139
L.N													1.000	0.010	0.179	-0.103	0.061	0.223	0.151	0.174	0.163	-0.006
L.P														1.000	**-0.342**	-0.032	0.035	0.189	**0.389**	0.022	0.190	**0.353**
L.K															1.000	0.085	0.089	-0.129	-0.086	-0.238	-0.245	0.022
L.Mg																1.000	0.304	**-0.418**	**0.312**	0.009	-0.250	0.267
L.Ca																	1.000	-0.298	0.042	-0.193	-0.120	-0.021
L.Fe																		1.000	0.152	0.233	0.280	0.163
L.Mn																			1.000	**0.509**	-0.030	**0.329**
L.Zn																				1.000	**0.550**	-0.088
L.Cu																					1.000	-0.126
L.B																						1.000

Values in bold are different from 0 with a significance level alpha=0.05
O.M: Organic matter, S: Soil L:Leaf

The soil-phosphorus content showed a positive relationship only with the calcium content in soil, but also with the manganese, iron, zinc and copper contents in the leaf. The soil-potassium and soil-calcium contents had significant relationship with the determined all element contents in soil, but soil-phosphorus content. This parameters showed the highest positive relationship with soil-calcium content (r= 0.628) and soil-potassium content (r= 0.628), respectively, and a negative relationship with soil-manganese content (r= -0.784 and r= -0.763, respectively). Also, this parameters showed significant relationship with only 1 element (with copper) and 2 elements (with manganese and boron) in the leaf, respectively. While the soil-magnesium content had negative correlation with microelement contents, it showed a significant relationship only with the copper content in the leaf (r= 0.310). The microelement contents in the soil showed a statistically significant relationship among themselves, and this relationship was positive. The strongest correlation between microelement contents in soil was determined between manganese content and iron (r= 0.893) and zinc contents (r= 0.827). The soil-manganese content had a statistically significant relationship with the copper (r= -0.306) and boron contents (r= 0.335) in the leaf. The soil-iron content showed a significant relationship only with the boron content in the leaf (r= 0.397). There was no statistically significant relationship between the nutrient contents of the leaf and the zinc and copper contents in the soil. Also, the nitrogen and calcium contents in leaf had not significant relationship both soil-nutrient and leaf-nutrient contents. The leaf-phosphorus content showed a positive relationship with the leaf-potassium content and negative with the leaf-manganese and leaf-boron contents. The leaf-

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magnesium content had a positive correlation with the leaf-iron content and negative with the leaf-manganese content. The positive relationship was determined between the leaf-manganese content and leaf-zinc and leaf-boron contents, and between leaf-zinc content and leaf-copper content. The nutrient contents of leaf and soil in olive (Turan et al., 2013; Deliboran et al., 2019; Pekcan et al., 2021), grape, walnut, apple, pear, peach, cherry, apricot, peach and plum orchards (Bozkurt et al., 2001; Abacı-Bayar and Boyacı, 2021) was determined. In addition, the relationship between nutrient contents was defined in these research. Similar results were obtained in this study as in different fruit species. However, the uptake level of nutrients in the soil by trees is affected at different levels by rootstocks, cultivars and even rootstock-scion interaction. In addition, it should not be forgotten that factors such as soil reaction and texture, content of $CaCO_3$ and organic matter in soil, and interactions between nutrients have an effect on the availability of nutrients in the soil to the plant.

4. CONCLUSIONS

In the study, the relationships between some physical and chemical properties of soil and the nutrient contents of soil and leaf in the apple orchards were investigated. A statistically positive and negative relationship was observed between many soil properties and nutritional elements. In fruit trees, rootstocks, cultivars and even rootstock-scion combinations differ in the uptake levels of nutrients in the soil. For this reason, the relationships between physical and chemical properties of soil and the nutrient contents of soil and leaf show us that leaf and soil analyzes should be evaluated together in the preparation of fertilization programs.

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