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ORIGINAL ARTICLE

Potential of Organic Fertilizers: Enhancing *Pistacia Vera* Cultivar 'Kirmizi' Through Soil and Leaf Analysis

Bekir Erol Ak, Ezgi Morkoc Surucu, Birgul Dikmetas Dogan*, Ibrahim Halil Hatipoglu

Horticulture Department, Harran University, Sanliurfa, Turkiye

K E Y W O R D S

Micro and macro nutrients;
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A B S T R A C T

In this study, the impact of different organic fertilizers on the *Pistacia vera* L. cv. 'Kirmizi' cultivar was revealed through analyses conducted on both the soil and leaves. The trees in the garden are approximately 30 years old, and their growth and yield conditions are similar. The soil samples were found to be near neutral in terms of pH and slightly alkaline, with no salinity issues detected. However, the soil at a depth of 40-60 cm showed the highest salt content, reaching 1.38% with leonardite application. The highest lime content was recorded at 40-60 cm depth, with a value of 35.05% observed in the worm and chemical fertilizer application. All applications were deemed inadequate in terms of the required organic matter content. The soil at 40-60 cm depth showed the highest phosphorus levels, reaching 8.30 ppm with farm manure application, and the highest potassium levels, reaching 258.48 ppm, were also observed with farm manure application. Furthermore, the highest calcium content, 8535.73 ppm, was found at 40-60 cm depth, and the highest magnesium content, 288.41 ppm, was detected in the leonardite application. Iron levels were found to be sufficient across all applications, with the highest iron concentration, 6.66 ppm, observed in the leonardite application at 40-60 cm depth. An assessment of the applications overall revealed deficiencies in zinc, copper, and manganese levels. The highest concentrations of zinc (1.83 ppm), manganese (16.53 ppm), and copper (1.49 ppm) were all identified in the leonardite application at 40-60 cm depth.

Introduction

Pistacia vera L. is a dioecious tree and perennial fruit species in the Anacardiaceae family (Hosseini *et al*., 2022; Nazoori *et al*., 2022; Sharifkhah *et al*., 2020; Norozi *et al*., 2019). In the excavations carried out in 7000 BC, it was found that pistachio was being consumed. There are two homelands of this fruit in the world (Kaska 1990; Ak 1992; Ak *et al*. 1999; Ak, 2019).

It is a plant that is not very selective in terms of soil demand, but can grow in almost any soil except heavy clay soils. Considering the content of the soils of the region, they are high in lime and poor in plant nutrients. It is known that the presence of one of the nutrients in the soil more or less than the other, the intake of the nutrients by the plants in terms of the plants grown or preventing their functions in the plants have negative effects in terms of yield and quality (Behzadi Rad *et al*., 2021). For this reason, it is necessary to determine the chemical and physical conditions of the soil and to learn the connection

***Corresponding author**: Email address: dikmetasbirgul@gmail.com
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between the nutrients in the soil and the soil quality (Cimrin and Boysan, 2006; Ak *et al*., 2018).

While chemical fertilizers have a one-way effect, farm manure provides many nutrients necessary for the plant. In addition, it also shows a regulating effect on the soil. Farm manures also positively affect the water permeability of the soil. While it binds the particles together in granular soils such as sandy soil, it also loosens heavy clay soils and contributes to the aeration of the soil. It was observed that the color darkened in the soils where farm manure was applied. This situation increases the soil temperature and positively affects the development of the plant. In addition, these fertilizers have a positive effect on the amount and activities of soil microorganisms. This makes the soil reaction, humidity and temperatures suitable (Soyergin, 2003).

Yalcin and Cimrin (2019) stated that soils should be fertilized in terms of N, P from macro elements and Zn from micro elements. It was stated that there was no deficiency in terms of other macro and micro elements examined. In another study, it was determined that phosphorus and potassium elements were generally deficient in pistachios, while nitrogen and copper were below 50%. It has been revealed that the manganese content in the leaves is generally sufficient, while the iron and boron are partially sufficient (Bozgeyik and Cimrin, 2020).

As a result, iron deficiency can occur because pistachios are normally grown in alkaline conditions. The application of some organic stimulants such as humic substances can reduce or partially prevent some harmful effects of alkalinity and thereby improve plant growth. The results of the present researches also showed that these organic substances can stimulate Fe uptake by the plant and thus increase the vegetative growth of pistachio seedlings. For this reason, humic substances can be used instead of chemicals in the future, to prevent the soil from being polluted with chemicals, environmentally friendly, and the cost can be lower than chemicals (Pakdaman *et al*., 2020).

In this study, different organic (leonardite, vermicompost, farmyard manure) fertilizers and a chemical (15,15,15 NPK) fertilizer were applied to *P. vera* cv 'Kirmizi' plants from the soil. In this direction, it is aimed to determine the benefit of trees from these fertilizers. For this reason, the physical and chemical properties of the soil and the content of macro and micro nutrients in the soil samples taken from the cultivation area were examined. In order to better determine the utilization of these fertilizers, leaf samples were also taken from the trees from which soil samples were taken, and the micro and macro nutrient content was examined.

Materials and Methods

Material

In this study, ‘Kirmizi’ variety and some organic (Farm manure, Leonardite, Worm Manure) and chemical (N:P:K: 15:15:15) fertilizers were used in Kırkpınar neighborhood in Karakopru district of Sanliurfa province in Turkiye. The trees used in the research are 30 years old and the planting spacing is 7x7 meters. In terms of proper cultivation in the garden, irrigation and so on. cultural activities are carried out regularly (Fig.1).

Fig. 1. A view from pistachio orchard.

When we look at the general characteristics of 'Kirmizi' variety, it is observed that the general appearance is semi-erect, the color of the one-year shoot is brown, the shoot length is short and the density is strong. This variety has a high tendency to periodicity. Flowering time coincides with the middle and late spring. While the clusters are generally dense, when looking at the cross-section of the fruit bud, it is seen that it is cylindrical-conical. The cracking rate of the fruits is around 67%. Leaf shedding time is in the early autumn period (Aktug Tahtaci *et al*., 2007).

Experimental site

Field trials were carried out in the pistachio garden located in Kirkpinar Neighborhood of Karakopru district, which is 24.8 km from Sanliurfa. The research area shows the same climatic characteristics as the city center. The temperature data of Sanliurfa province are presented in Table 1. In Sanliurfa, where typical indicators of the continental climate are found, according to the data of the past years, it is seen that the summers are very hot and dry, while the winters are cold and rainy (Table 1.)

Table 1. Temperature data of Sanliurfa province (1981 and 2020) (Turkish State Meteorological Service, 2021).

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
Max.Temp.	21.6	25.5	29.5	36.4	40.3	44.1	46.8	46.2	42.1	37.8	30.8	26.0
Min.Temp.	-10.6	-12.4	-7.3	-3.2	2.5	8.3	15.0	16.0	10.0	1.9	-6.0	-6.4
Average Temp.	5.9	6.9	11.1	16.4	22.5	28.5	32.2	31.4	26.9	20.4	12.6	7.5
Average Max. Temp.	10.3	11.8	16.7	22.6	29.0	35.1	39.0	38.5	34.1	27.0	18.2	12.1
Average Min. Temp.	2.5	3.0	6.4	10.9	16.0	21.3	24.9	24.4	20.4	15.1	8.4	4.3

Fertilizers used in the research

The fertilizers used in the research were applied to the crown projection of the trees in the experiment in mid-February. The application was made by opening tapes to a depth of 20 cm. The bands that were opened after the application were closed with soil. 60 kg of manure per tree was given from composed farm manure. It was opened at a depth of 20 cm to the projection of the crown of the trees, and after the application was made to the opened band, it was covered.Vermicompost application was given as 20 kg per tree in solid form. The crown projection of the trees was opened at a depth of 20 cm. After applying fertilizer to the opened section, it was covered. 20 kg of leonardite (SLOWMIX©) was given per tree. The crown projection of the trees was opened at a depth of 20 cm, and after the fertilizer application was applied to the opened band, it was covered. 2.5 kg of compound fertilizer (TOROS©) was given per tree. The crown projection of the trees was opened at a depth of 20 cm, and after the fertilizer application was applied to the opened band, it was covered.

Farm manure

% Dry matter: 20-25; % N: 30-60; % P_2O_5:20-35; % K_2O: 15-70.

Leonardite (SLOWMIX©) % (w/w)

Total organic matter: 25; Total N: 8; NH_4-N:8; Total P_2O_5: 20; Water-soluble P_2O_5:18,5; Total (Humic+Fulvic) acid: 5; Maximum humidity: 4,9; pH: 5-7.

Vermicompost

Organic matter: %3.0; Total N: %0.5 Total (Humic+Fulvic) acid: %2.20; Organic carbon: %1; pH: 7-9.

Chemical fertilizer (TOROS©)

Total N:% 15; NH_4-N: % 13; Urea N: %2; Water-soluble P_2O_5:%14; Neutral ammonium citrate and Water-soluble P_2O_5:%15; Total SO_3: %20; Total Zn: %1.

Methods

Pistachio trees, which are close to each other, were selected from the fruit-bearing trees in the garden. 3 different organic fertilizers (leonardite, farm manure, vermicompost), 1 chemical fertilizer, control 1 and control 2 (sample taken from the betwen of two trees) groups (no application was made) were applied to the pistachio trees. There are 5 groups in total and the application amount of fertilizers is given in proportion to the crown projections of the trees. In the experiment, the Random Blocks Trial Design was used. In this way, the trial area was grouped with 3 replicates and 3 trees in each replica.

Organic fertilizers applied to pistachio were applied in winter (February) when the trees started to awaken. The fertilizers applied to the soil were applied by measuring the crown projections of the trees. The application was completed in a single day by digging the soil between 15-25 cm from the tree roots. Leaf samples were taken from each of the marked trees between 16-31 July (July 16) for macro and micro nutrient analysis. It was collected from all over the tree, preferably from the non-fruiting branch, from the middle of the shoot, and approximately 20 leaves per replication. Soil samples were obtained from three different depths of 0-20 cm, 20-40 cm and 40-60 cm in order to analyze macro and micro plant nutrients in the soil.

Soil sampling and analysis methods

Soil samples of 0-20 cm, 20-40 cm, 40-60 cm were taken from the trees marked in the garden where the application was made, from three different depths by auger. The samples taken were put into bags and labeled. It was then dried in a laboratory environment and sent for analysis.

The samples are then physical and chemical (pH, Organic Matter, Salt (EC), Lime, Copper (Cu), Phosphorus (P), Manganese (Mn), Potassium (K), Iron (Fe), Sodium (Na), Zinc) (Zn), Magnesium (Mg), Boron (B) and Calcium (Ca)) were analyzed and compared with reference (Peker, 2018) values.

Physical analysis

It is done to determine the size of the particles in the soil and how they are distributed. In other words, it is the classification of soil according to the diameter of the particles. After 100 g of air-dry soil is weighed in plastic saturation cups, a paste is formed by adding distilled water slowly with the help of a burette. This process determines how much water is consumed. The determination of the soil texture is decided according to the amount of pure water trapped in the soil sample. If the created paste is separated with the help of a spatula, it recombines and creates a shiny surface at the same time, it means that the amount of water it takes is sufficient.

pH analysis

In order to determine the pH in the soil, the method recommended by the International Soil Science Association was used. According to this method, a 1:2.5 soil-pure water mixture was obtained to saturate the soil with water, and it was kept for 1 hour and the pH of the soil samples was determined with a pH-meter (glass electrode). was measured (Kacar, 1972). The obtained pH values were evaluated according to Table 2 prepared for the classification of soils in terms of reaction (Fig. 2).

Table 2. The extent of the physical properties of the soil at different soil depths.

Soil Depth	Physical Properties of Soil					
	Applications	**pH**	**Salinity** (%)	**Calcification** (%)	**Organic Matters** (%)	**Saturation** (%)
0-20 cm	**Control 1**	7.43 bc±0.005	0.77 f±0.000	33.53 d±0.490	1.07 e±0.000	52.60 c±0.200
	Farm Manure	7.37 d±0.005	0.86 e±0.005	32.04 e±0.030	1.18 a±0.005	53.80 b±0.090
	Leonardite	7.26 f±0.005	1.34 a±0.000	34.04 c±0.020	1.15 b±0.005	51.35 d±0.350
	Vermicompost	7.29 e±0.000	0.94 c±0.005	35.04 a±0.010	0.95 f±0.005	50.45 f±0.150
	Chemical Fertilizer	7.54 a±0.005	0.95 b±0.005	34.03 c±0.009	1.09 d±0.005	50.80 ef±0.200
	Control 2	7.42 c±0.005	0.88 d±0.005	34.07 bc±0.009	1.14 c±0.000	59.50 a±0.100
	Average	7.39	0.96	33.79	1.10	53.08
	LSD (%5)	0.015	0.008	0.361	0.008	0.36
20-40 cm	**Control 1**	7.49 c±1.080	0.95 b±0.005	34.54 b±0.520	1.20 a±0.005	53.95 cd±0.050
	Farm Manure	7.43 d±0.000	0.95 b±0.005	31.05 e±0.020	0.87 e±0.005	57.10 a±0.100
	Leonardite	7.34 f±0.000	1.35 a±2.710	33.05 c±0.020	1.01 d±0.005	56.25 ab±0.150
	Vermicompost	7.35 e±0.005	0.95 b±1.350	32.05 b±0.010	1.11 c±0.005	51.85 e±0.150
	Chemical Fertilizer	7.60 a±1.080	0.88 c±0.005	31.06 e±0.010	1.12 b±0.000	53.94 d±0.050
	Control 2	7.51 b±1.080	0.77 d±0.000	35.05 a±0.025	0.50 f±0.005	55.20 bc±0.200
	Average	7.45	0.98	32.80	0.97	54.72
	LSD (%5)	0.004	0.007	0.38	0.009	1.362
40-60 cm	**Control 1**	7.39 e±0.005	0.87 d±0.000	34.06 c±0.020	1.10 a±0.000	56.05 d±0.050
	Farm Manure	7.43 c±0.000	1.01 b±0.005	35.05 a±0.020	0.88 c±0.000	57.30bc±0.090
	Leonardite	7.28 f±0.005	1.38 a±0.005	35.03 a±0.005	0.59 f±0.005	57.10 c±0.100
	Vermicompost	7.51 b±0.005	0.76 e±0.005	34.54 b±0.480	0.76 d±0.005	55.10 e±1.810
	Chemical Fertilizer	7.40 d±0.005	0.95 c±0.005	35.05 a±0.025	1.05 b±0.005	59.60 a±0.200
	Control 2	7.74 a±0.005	0.64 f±0.005	35.04 a±0.020	0.70 e±0.005	57.10 c±0.100
	Average	7.46	0.94	34.80	0.85	57.04
	LSD (%5)	0.009	0.009	0.354	0.008	0.209
Reference (Tekin *et al*., 1986)		8.2 - 8.5	0.12 - 0.28	20 - 76	1.2 - 2.5	50 -70

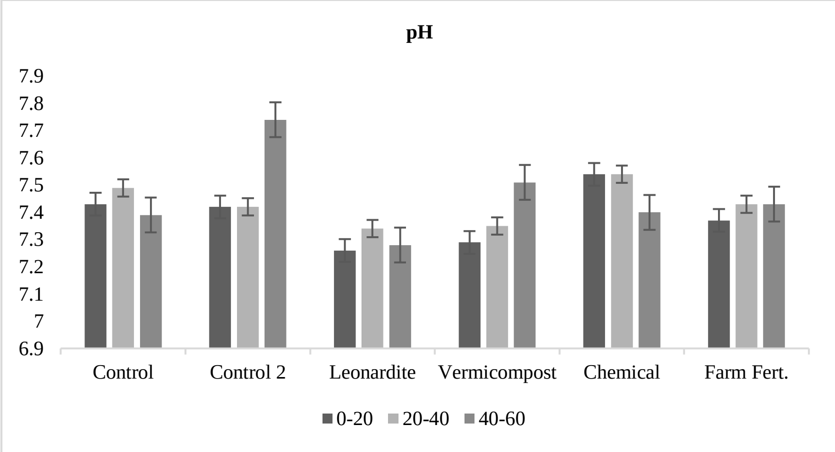

Fig. 2. Effect of fertilization and soil depth on pH

Determination of salinity

To measure the electrical conductivity of the soil, the salt content of the soil samples is checked. Certain techniques are used to determine the salt content. Soil samples are mixed with water to determine the salt content with the Conductivity Bridge instrument. The resistance to electrical conductivity of the soil sample saturated in terms of water content is measured so that the salt content of the soil is determined (Richards, 1954). (Fig.3).

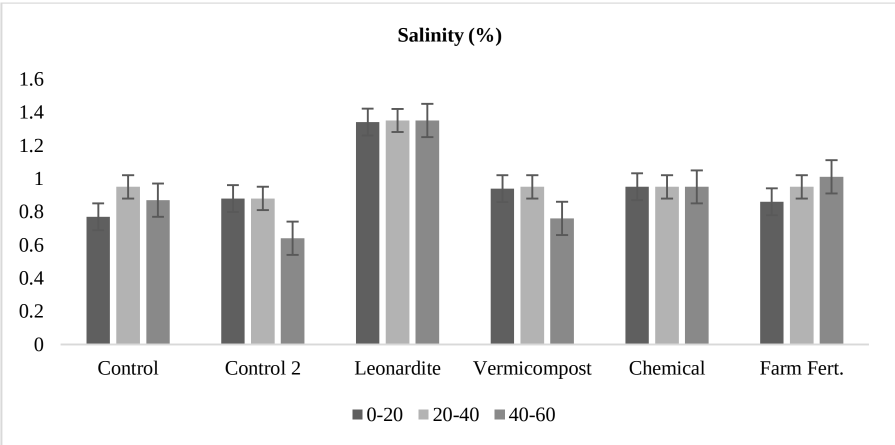

Fig.3. Effect of fertilization and soil depth on salinity

Determination of organic matter content

In order to determine the organic matter content in the soil, 0.5 g of the soil sample was taken into a plastic container, wetted with distilled water, then mixed with 20 ml of sulfuric acid and kept. Then, 170 ml of distilled water and 10 ml of 85% phosphoric acid were mixed and titrated with the ferrosulphate method. and the amount of organic matter was determined (Kacar, 1972).

Determination of the lime content of the soil

In order to determine the lime ratio in the soil, 1 g is taken from the soil sample and mixed with 3 ml of hydrochloric acid, and a calcimeter device is set up and a volumetric analysis is performed with the help of this setup (Kacar, 1972). (Fig.4).

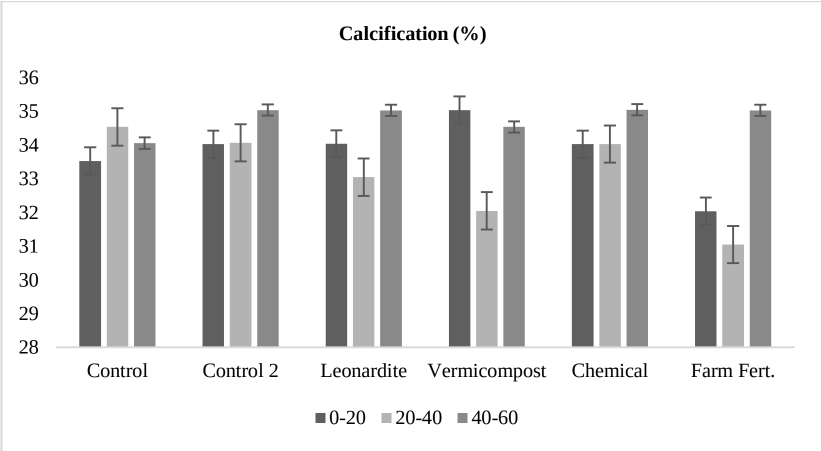

Fig. 4. Effect of fertilization and soil depth on calcification.

Determination of phosphorus content of soil

The available phosphorus content of soil samples is determined by the sodium bicarbonate soluble phosphorus method. According to this method, 1 g of the soil sample was mixed with 1 spatula of activated charcoal and 20 ml of $NaOHCO_3$ with a molarity of 0.5, and the phosphorus content was analyzed by measuring in the spectrophotometer using the molybdophosphoric blue color method (Kacar, 1972).

Taking leaf samples and analysis methods

In total, 15 bags of leaf samples were taken from the application area. The samples were then labeled and placed in bags. After being transferred to the laboratory, it was washed first with tap water and then with distilled water and then dried. It was kept in the oven at 65°C for 72 hours until it reached a constant weight. The leaf samples dried in the oven were ground in porcelain crucibles with the help of a pestle and placed in plastic bags. Dried and ground leaf samples are placed in porcelain crucibles by weighing 1 g. 1 ml of 20 ml solution consisting of a mixture of 1 ml of H_2SO_4 and 19 ml of C_2H_5OH is poured into each container and the leaves are wetted. Then, the incineration process is started gradually in the muffle furnace. It is burned in a muffle furnace at 250 °C for 2 hours in the first stage and for 4 hours at 650 °C in the second stage. The crucibles are cooled in the oven. To prevent them from flying away, some distilled water is poured over them and another 5 ml of hydrochloric acid is added. The samples are filtered using a funnel and filter paper. After pouring distilled water into the crucibles and soaking, filtration through filter paper is applied three or four times. Then, distilled water is added to the solution obtained to make up to 100 ml. It is read in atomic absorption spectrophotometer (AAS) and the Fe, Zn, Cu and Mn contents in the samples are obtained as ppm, while Mg is calculated as % (Kacar, 1972).

The nitrogen content of the leaves used in this study was determined by the Kjeldahl method. According to this method, 0.25 g of leaf sample is weighed and put into each tube. Afterwards, tablets that act as catalysts are placed in tubes containing leaf samples. 5 ml of Merck Sulfuric acid and hydrogen peroxide (2 ml of 35%) are poured over the materials in the tubes. In this way, the burning process starts and as a result, the foaming process accompanies the burning process. This burning process continues until the color becomes clear. Afterwards, the tubes are kept for a certain period of time and allowed to come to room temperature. In the next step, 20 ml of distilled water is added to the tubes and the sulfate is precipitated and the distillation process is started. With the help of 25 ml of 4% boric acid with an indicator, the Erlenmeyer device and sodium hydroxide, N2 is obtained in gaseous form. Thus, N2 gas is attached to boric acid. N2 gas attached to boric acid is found by titration. For titration, hydrochloric acid with a normality of 0.1 is used. The titration process is thus completed when the green color turns pink (Kacar, 1972).

In the study, the determination of the amount of potassium and calcium was determined by reading the filtrate obtained from the dry burned plant extract in the Flamephotometer device (Kacar, 1972).

The dry burning method was preferred because it is easier for the Mg analysis in the content of the leaf samples and it minimizes the loss. According to this method, the burned plant pulp is diluted and the Mg content is determined in the form of reading in the AAS device (Kacar, 1972).

Micro element analyzes such as copper, zinc, manganese and iron of the filtrate obtained as a result of the combustion processes are performed with the help of the ICP-OES device (Tekin *et al*., 1986).

Statistical analyzes

This research was planned with three replications and one tree in each iteration. The values obtained for the applications were compared by applying the LSD test at the $P<0.05$ significance level according to the Random Blocks Trial Design. To identify the most important influencing traits in the grouping of fertilizer, principal component analysis (PCA) was applied using PAST package programme (Hammer *et al*., 2001).

Results

Physical Properties of Soil and Contents of Plant Nutrient Elements

The average organic matter ratio was found to be less with 1.10%. The soil texture, on the other hand, was evaluated as clayey-loamy with 53.08%. Also, in the statistical evaluation, it was determined that the difference between the averages was significant.

When evaluated according to the data obtained, the high content of lime in the soil prevents the root region of the plant from benefiting from the nutrients (Ergene 1972). At the same time, phosphorus and iron intake becomes difficult in soils with high lime content. In addition, the high amount of calcium in the soil and the high pH cause the calcium phosphates to remain in the form of insoluble compounds in water, causing a negative situation for the plants (Aydemir, 1992; Aktas, 2005; Mohit Rabari *et al.*, 2023).

The highest pH value of 7.60 was found in the soil sample where chemical fertilizer was applied, in the findings at a soil depth of 20-40 cm. It is neutral with a value of 7.45 as the mean of all samples in the chart. In the salt content, the highest value with 1.35% was obtained in the soil sample where leonardite was applied. The average salt value was found to be 0.98% salt-free. The highest value in the lime content of the soil was found between rows with 35.05%. It was determined to be very calcareous with an average lime content of 32.80%. As organic matter, the highest value of 1.20% was obtained from the soil sample containing the control 1 group. It has been determined that the average organic matter content is very low as 0.96%. The soil texture is generally found to be clayey - loamy.

The highest pH value at 40-60 soil depths was obtained between rows with 7.74. The mean pH value was 7.46. It has been determined that it has a neutral value as in other soil depths. The salt content, on the other hand, was obtained from the soil sample with the highest leonardite application, with 1.38%, as in other soil depths. The average salt content was found to be unsalted with a value of 0.94%. The highest lime content was obtained from the soil sample where chemical fertilizer was applied with 35.05%, and the average lime content was found to be very calcareous with 34.80%. Organic matter content was 1.10% in the control 1 group at 40-60 cm soil depth. with the highest. The average organic matter content was determined to be very low with a value of 0.85%. It has been determined that the soil has a clayey - loamy structure with an average of 57.04%. In the study, when the physical properties of the soil are examined in general, according to the findings obtained, pH of all 3 soil depths (0-20cm, 20-40cm, 40-60cm) shows a neutral and slightly alkaline reaction, the salinity of the soil is low, the lime content is very high, It has been determined that the organic matter content is insufficient and the soil texture is clayey-loamy.

As a result of all fertilizer applications, the average phosphorus content was determined as 3.50 ppm. Potassium was obtained from the soil sample where farm manure was applied with the highest 258.48 ppm. The average potassium content was found to be 247.91 ppm.

The highest value in calcium was obtained from the soil sample applied to leonardite with 8381.04 ppm. The average calcium content was found to be 8106.707 ppm (Table 3). Magnesium content at 0-20 cm soil depth, on the other hand, was obtained from the soil sample applied with leonardite, with the highest value of 249.55 ppm. The average magnesium value was determined as 231.89 ppm (Table 3).

Table 3. Macro and micro elements contents at different soil depth

Soil Depth	Applications	Macro/Micro Nutrients							
		P	K	Ca	Mg	Fe	Zn	Mn	Cu
0-20 cm	**Control 1**	2.95 cd ±0.150	251.27 ab ±11.170	7867.29 b ±113.350	233.81 cd ±0.360	5.79 a ±0.150	0.35 bc ±6.790	10.24 b ±0.060	1.57 a ±0.090
	Farm Manure	3.70 b ±5.430	258.48 a ±2.610	8146.38a ±47	228.52 de ±2.300	4.97 c ±0.070	0.28 d ±0.000	10.78 a ±0.050	1.34 c ±0.050
	Leonardite	5.05 a ±0.950	237.34 bc ±7.280	8381.04 a ±188.480	249.55 a ±5.550	5.26 b ±0.005	1.32 a ±0.045	7.99 d ±0.230	1.38 c ±0.020
	Vermicompost	4.55 a ±0.250	257.63 a ±8.710	7906.85 ab ±206.920	217.57 f ±2.320	5.36 b ±0.050	0.34 c ±0.010	9.59 c ±0.480	1.56 a ±0.025
	Chemical Fertilizer	2.50 d ±0.000	230.59 c ±9.260	8140.39 a ±263.600	223.94 ef ±5.670	4.89 c ±0.010	0.33 c ±0.010	8.23 d ±0.100	1.50 ab 0.030
	Control 2	2.30 d ±0.000	252.19 a ±6.630	8194.80 a ±207.420	237.99 bc ±9.020	4.52 d ±0.070	0.38 b ±6.790	5.87 e ±0.100	1.42 bc ±0.075
	Average	3.50	247.91	8106.20	231.89	5.13	0.50	8.78	1.46
	LSD (%5)	0.722	14.355	329.707	9.055	0.136	0.034	0.41	0.1
20-40 cm	**Control 1**	2.90bc ±0.100	223.42 b ±8.380	7802.26b ±65.190	243.79b ±2.100	6.41 a ±0.085	0.26 c ±0.005	8.39 d ±0.060	1.52 ab ±0.070
	Farm Manure	5.70a ±1.650	238.68 a ±12.160	8256.00 a ±91.860	231.42 b ±5.730	5.76 c ±0.040	0.26 c ±0.005	10.96 c ±0.035	1.36 c ±0.060
	Leonardite	5.25 a ±0.050	233.27 ab ±7.940	8379.15 a ±185.040	264.26 a ±5.940	5.70 c ±0.120	1.48 a ±0.025	12.12 b ±0.160	1.43 bc ±0.050
	Vermicompost	2.20 cd ±0.000	240.28 a ±7.610	7787.91 b ±197.740	217.07 cd ±2.780	6.04 b ±0.065	0.32 b ±0.010	14.60 a ±0.520	1.55 a ±0.010
	Chemical Fertilizer	2.65 c ±0.050	219.70 bc ±7.590	8153.70 ab ±243.050	240.23 b ±10.870	5.36 d ±0.040	0.26 c ±0.005	7.66 e ±0.145	1.43 bc ±0.065
	Control 2	1.60 d ±2.710	207.64 c ±7.260	8258.66 b ±570.530	214.51 d ±11.100	4.94 e ±0.035	0.31 b ±0.005	6.06 f ±0.020	1.35 c ±0.065
	Average	3.38	227.165	8106.28	235.21	5.70	0.48	9.97	1.44
	LSD (%5)	1.202	15.407	498.502	13.033	0.126	0.021	0.412	0.102
40-60 cm	**Control 1**	1.50 f ±0.000	218.50 d ±7.300	7516.66 c ±50.290	246.43 c ±1.170	6.47 a ±0.080	0.24 e ±0.005	16.18 a ±0.050	1.30 b ±0.045
	Farm Manure	8.30 a ±0.000	254.88 a ±6.680	7758.64 bc ±120.880	230.16 d ±5.830	6.09 b ±0.110	0.43 b ±0.005	11.09 b ±0.025	1.29 b ±0.060
	Leonardite	5.20 b ±0.000	241.06 b ±8.810	8535.73 a ±195.030	288.41 a 8.660	6.66 a ±0.009	1.83 a ±0.045	16.53 a ±0.320	1.49 a ±0.030
	Vermicompost	3.20 c ±0.100	185.11 e ±7.930	7070.20 d ±219.050	181.17 e ±4.010	5.68 d ±0.040	0.39 c ±0.010	8.38 d ±0.270	1.12 c ±0.015
	Chemical Fertilizer	2.50 d ±0.000	222.32 cd ±7.360	8064.86 ab ±235.660	263.72 b ±8.690	5.83 cd ±0.115	0.3 d ±0.005	10.09 c ±0.125	1.44 a ±0.055
	Control 2	2.30 e ±0.000	164.29 f ±1.880	6678.38 e ±290.470	145.93 f ±5.620	5.34 e ±0.265	0.23 e ±0.010	6.65 e ±0.460	1.12 c ±0.055
	Average	3.83	214.36	7604.07	225.97	6.01	0.57	11.49	1.29
	LSD (%5)	0.073	12.505	358.223	11.11	0.236	0.035	0.466	0.084
Reference (Sillanpää M., 1990; Lindsay and Norvel 1978; FAO 2020)		8-25	110-290	>1500	160-480	2.5 – 4.5	0.7 – 2.4	14 - 50	>2

Phosphorus in the soil is highly correlated with organic matter. In mineral soil groups, P is organically bound up to 80%. During the conversion of organic materials into mineral matter, P passes into the soil (Gunes *et al*., 2002). Phosphorus is not available in most of the soils. For this reason, in phosphorus fertilizer applications, it is necessary to apply the phosphorus element to the soil together with farm manure in order to make it useful. Thus, calcium, iron and aluminum elements, which prevent phosphorus from being useful with the dissolution of farm manure, come together with phosphorus and enable phosphorus to come to a useful form.

The presence of high calcium in the soil prevents the uptake of some micronutrients. These elements are Fe, P, Mn and B. This inhibition causes nutrient deficiency symptoms in the plant (Ergene, 1972). In addition, Aktas's study in 2005 reported that the K uptake of the plant decreased due to the antagonistic effect of the high amount of calcium in the soil.

Considering the macro element contents at 40-60 cm, the highest phosphorus content was obtained from the soil sample where farm manure was applied with 8.30 ppm. The average phosphorus content was found to be 3.83 ppm. Potassium was obtained from the soil sample where the highest farm manure was applied, and the average potassium content is 214.36 ppm. The highest calcium content of 8535.73 pmm was obtained from the soil sample where leonardite fertilizer was applied. The average calcium was found to be 7604.07 ppm. The highest value in magnesium was obtained from the soil sample where leonardite fertilizer was applied, and the average magnesium value was determined as 225.97 ppm. According to Aydeniz (1990), in the study examining the nutrient content of pistachio orchards in the Southeastern Anatolia Region, they stated that P deficiency was observed in both soil and leaves. The most important reasons for this situation are; They showed that the lime rate in the soil is high, the pH is greater than 7.5, and the phosphorus element is stable in the soil. They stated that if the phosphorus is less than 7 ppm in the soil at a depth of 30-60 cm, it should be applied. When the macro nutrients found in the soils where the ‘Kirmizi’ variety of Pistachio is cultivated are generally evaluated according to the limit values determined by Sillanpää (1990), it has been determined that the phosphorus content is generally low, potassium is sufficient, calcium is very high and magnesium is sufficient in all 3 soil depths.

According to the data obtained from the soil samples at a depth of 40-60 cm, it was observed that the iron element content, which is one of the micro element contents, was sufficient, and the zinc was insufficient in the soil samples where other fertilizer applications were made, except for leonardite. In addition, it was determined that the manganese and copper contents of the soil samples were insufficient.

When the micro element contents of the soil samples at a depth of 20-40 cm were examined, it was determined that the iron was sufficient, the zinc was sufficient only in the soil sample where Leonardite fertilizer was applied, it was insufficient in the soil samples where other fertilizer applications were applied, and the manganese and copper elements were insufficient.

When the macro element contents in the leaves of ‘Kirmizi’ variety were evaluated according to the lowest and upper highest values that should be found in the leaves of pistachio trees under dry conditions in Tekin's study in 1992; nitrogen and phosphorus content in the leaves was found to be insufficient in the samples except the samples taken from the leaves of the trees where leonardite and vermicompost were applied. Potassium, magnesium and calcium were found to be insufficient in leaf samples taken from all applications.

When the data obtained are compared with the limit values obtained by Tekin in 1992 for pistachio orchards grown without irrigation; It was observed that the iron element in the leaves was generally insufficient except for leonardite, whereas copper, zinc and manganese elements were within the limit values.

Cluster analysis results of soil depths and fertilizer applications

PCA has been previously used to investigate the phenotypic diversity of plant genotypes. In this study, it is aimed to classify the effects of different fertilizer applications and soil depths on some parameters. The scatter plot created using PC1/PC2 showed variations between fertilizer applications at different depths (Fig. 5).For example; starting from negative to positive values of PC1, genotypes, K, Mg uptakes Control 1 (0-20), Control 1 (40-60), Farm Manure. (40-0) showed gradual increases in applications.

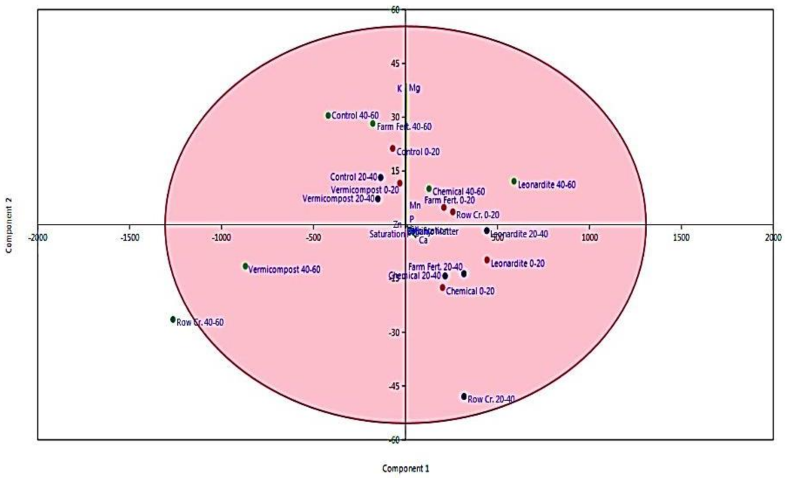

Fig.5. Scatter plot based on PC1/PC2 to determine the effect of fertilizer applications at different depths.

In order to understand the clear relationship of the classifications, a dendogram graph was created. In Fig. 6, applications that are close to each other are given.

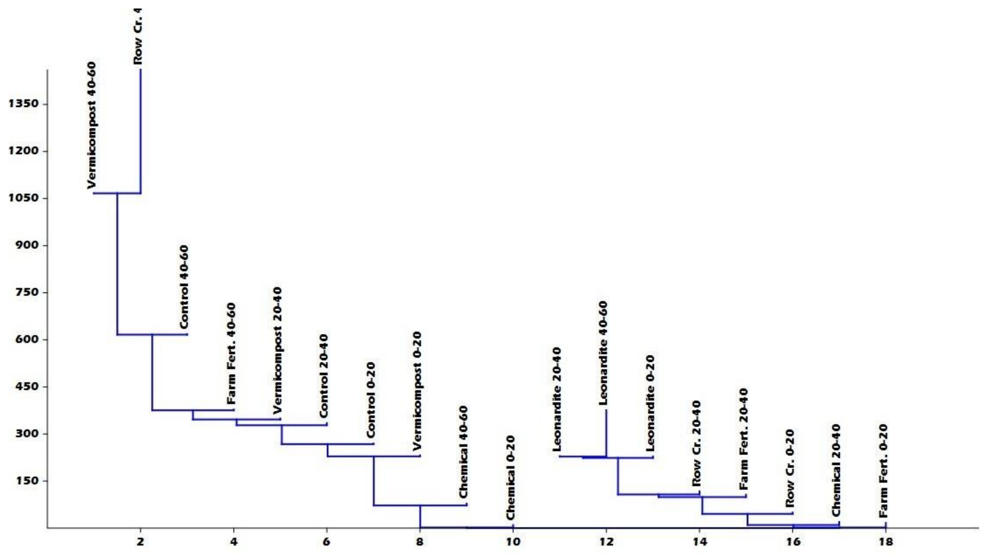

Fig. 6. Dendogram plot to determine the effect of fertilizer applications at different depths.

When fertilizer applications were evaluated according to the results of micro/macro nutrient analysis in the leaves, leonardite and vermicompost were found in the group in which N, P and Mg were effective (Fig. 7). These groupings support the results of the LSD analysis.

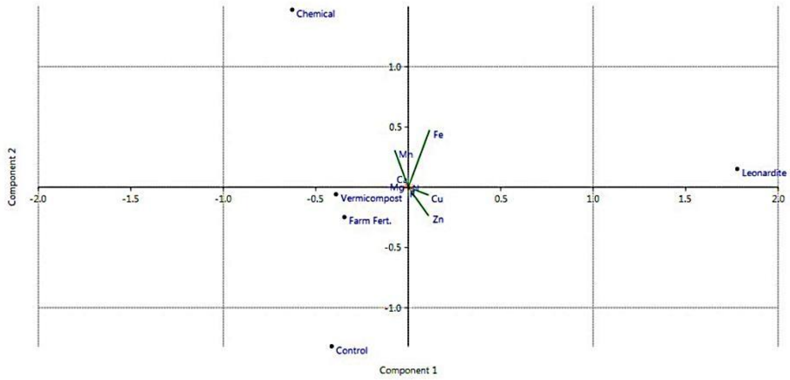

Fig. 7. Distribution plot of different fertilizer applications based on PC1/PC2 according to leaf nutrient content.

Discussion

In the garden where traditional pistachio cultivation is carried out, fed by rain water; The macro and micro nutrient contents of the soil samples discussed and the connection of these nutrients with certain properties of the soil, as well as the evaluation of the soil in terms of productivity were carried out. In addition, it was desired to determine which organic and inorganic fertilizers are more effective on the development of pistachio trees.

Soil samples taken from different depths (0-20 cm, 20-40 cm, 40-60 cm) within the scope of the research in the garden, as a result of the analysis, showed a neutral and slightly alkaline reaction, and all of the pellet samples were found in the group without salt problem, and this situation is a result of the salinity of the soils. Moreover, in all applications, it was determined that the lime content was very high, the organic matter content was low, average 1.10%, and the soil texture was clayey loam.

When the available phosphorus content in the soil samples of the application plot was analyzed, the highest values of 5.05ppm and 5.25ppm were obtained from leonardite fertilizer at 0-20 cm and 20-40 cm soil depths. It was obtained from the soil sample where farm manure was applied with 8.30 ppm at a depth of 40-60 cm. However, according to the limit values determined in the study by Sillanpää (1990), the phosphorus content was determined as insufficient in this study.

Conclusions

As a result of the analysis made on soil samples taken from certain depths in the application area, when the exchangeable potassium (K) contents were examined, the highest values were obtained from farm manure with 258.48 ppm and 254.88 ppm at 0-20 cm and 40-60 cm depths. At 20-40 cm depth, the highest value was reached with 240.28 ppm from the soil sample where vermicompost was applied. In this study, the potassium content was found to be sufficient in general.

As a result of the analysis made on soil samples taken from certain depths in the application area, the calcium (Ca) content is 8381.04 ppm, 8379.15 ppm, 8535.73 at all 3 soil depths of 0-20 cm, 20-40 cm, 40-60 cm, respectively. It was the highest in soil samples applied with ppm and Leonardite fertilizer. Calcium content was also found to be very high in this study. As a result of the analysis made on soil samples taken from certain depths in the application area, the magnesium (Mg) content was 249.55 ppm, 264.26 ppm, 288.41 in all 3 soil depths (0-20 cm, 20-40 cm, 40-60 cm), respectively. It was the highest in soil samples applied with ppm and Leonardite fertilizer. In this study, however, the magnesium content was found to be sufficient according to the limit values determined by Sillanpää (1990).

As a result of the analysis made on soil samples taken from certain depths in the application area, when the exchangeable potassium (K) contents were examined, the highest values were obtained from farm manure with 258.48 ppm and 254.88 ppm at 0-20 cm and 40-60 cm depths. At 20-40 cm depth, the highest value was reached with 240.28 ppm from the soil sample where vermicompost was applied. In this study, the potassium content was found to be sufficient in general.

As a result of the analysis made on soil samples taken from certain depths in the application area, when the zinc (Zn) content of all 3 soil depths (0-20 cm, 20-40 cm, 40-60 cm) is examined; According to the specified limit values (<0.7mg kg^{-1} low, 0.7-2.4mg kg^{-1}moderate, >8.0mg kg^{-1}very high), only leonardite at soil depths of 0-20cm, 20-40cm, 40-60cm Since 1.32 ppm, 1.48 ppm and 1.83 ppm were found in the soil sample where the fertilizer was applied, respectively, they were within the limit values and found sufficient. In other fertilizer applications, zinc content was found to be insufficient since it was outside the limit values in all 3 soil depths.

When the manganese (Mn) content is examined as a result of the analysis made on soil samples taken from certain depths in the application area, according to the limit values (<14mg kg^{-1} less, 14-50mg kg^{-1} enough, >170mg kg^{-1} too much), 0-20 cm soil depth Manganese was found to be insufficient in all applications. The manganese content was found to be sufficient in the soil samples where leonardite fertilizer was applied with 14.60 ppm at 20-40 cm soil depth and 16.53 ppm at 40-60 cm soil depth, as it was within the limit values. In other applications, manganese content at 20-40cm and 40-60cm soil depths was considered insufficient because it was outside the limit values.

When copper (Cu) content is examined as a result of the analysis made on soil samples taken from certain depths in the application area, the copper content according to the limit values determined by Follet (1969) (<0.2 mg kg^{-1} less, >0.2 mg kg^{-1} sufficient). found to be insufficient in all applications.

As a result of all these investigations; soil samples were found to be neutral and slightly alkaline in terms of pH, no salt problems, high lime content and insufficient organic matter. Considering the nutrient content in the soil; adequate levels of potassium, magnesium, iron; too much calcium, insufficient in terms of phosphorus, zinc, copper and manganese.

When a general examination is made in leaf samples in terms of macro and micro nutrients content; In Tekin's study in 1992, it was found that nitrogen (N) and phosphorus (P) were sufficient in soil samples where leonardite and vermicompost were applied, according to the lowest and highest limit values that should be found on the leaves in pistachio orchards without irrigation. Nitrogen and phosphorus were found to be insufficient in soil samples taken from other fertilizer applications. Again, potassium (K), magnesium (Mg) and calcium (Ca) other macronutrients were found to be insufficient in soil samples taken from all applications. According to the limit values determined by Tekin (1992), the iron (Fe) element, which is one of the micro-elements, was found to be sufficient only in the soil sample where Leonardite fertilizer was applied, and it was below the lowest limit value in other applications. Copper (Cu), zinc (Zn) and manganese were found to be within the average limit values and were found to be sufficient.

In the garden where the application is made, the pH of the soils is generally high, which is weak in terms of organic matter and high lime content makes it difficult to obtain microelements. The high amount of lime content and pH reaction in the soil content causes the Zn to be low. In this study, the Zn content in the soil was found to be low. For this reason, it will be beneficial to apply low pH character fertilizers such as sulfur and ammonium sulfate, which are among the measures that reduce the pH of the soil. In addition, although the nutrient content of organic fertilizers is limited, it is important to gain organic matter to the soil and eliminate its physical deficiencies. For this reason, regular applications every year to meet the organic matter need of the soil will be beneficial both in terms of increasing the availability of phosphorus and in terms of soil fertility. The presence of water in the soil is important for the intake of macro and micro elements. Since there is no irrigation in the sampled garden, it will be beneficial to make up for the deficiency, especially the microelements in the form of foliar fertilization.

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Conflict of interests

The authors declare no competing interests.

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