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Full Length Research Paper

Effects of different organic materials and chemical fertilizers on nutrition of pistachio (*Pistacia vera* L.) in organic arboriculture

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This study was conducted under greenhouse conditions to investigate the effects of applied nutrients such as six organic materials (gyttja, alsil, humic acid, sea moss, straw and peat) and two chemical fertilizers (15-15-15, and 20-20-0) with different dosages on nutrient uptaking ability of one-year old and 7 cm long pistachio (*Pistacia vera* L.) trees by analyzing nutrient (mineral) contents of pistachio (*P. vera* L.) leaves. The experiment was designed as randomized block design with four replicates. Even though organic and inorganic materials had different effects on element contents of pistachio (*P. vera* L.) leaves, overall, these materials had statistically significant effects on P, Mg, Na, Mn, and Cu contents of pistachio leaves. The effect of organic and inorganic materials on K, Ca, Zn, and Fe contents of pistachio (*P. vera* L.) leaves was statistically not significant. Besides, inorganic fertilizers increased P content of pistachio (*P. vera* L.) leaves, but this increase caused the decrease of Cu content. High level of P content may be the reason of low uptake of some micro elements such as Cu. Although application of organic and inorganic materials generally increase P uptake, organic materials especially peat, gyttja and sea moss increased nutrient contents of pistachio (*P. vera* L.) leaves. This result is a significant knowledge in pistachio areas because they have low nutrients in there .

Key words: Organic material, chemical fertilizer, *Pistacia vera* L., soil conditioner, arboriculture.

INTRODUCTION

The success in organic production depends upon the systematic approach of soil and plant. Therefore, soil and plant should be planned together and a closed system should be formed by selecting resistant and demand varieties with agro ecosystem. In organic farming, solutions are based on rational, experiential and experimental ecological knowledge (Lammerts et al., 2004).

Anatolia is an important gene source for horticultural crops with varieties which have multiplied numerously during the centuries (Simsek, 2009a; Simsek 2009b). Pistachio (*Pistacia vera* L.) is known as the green almond and is the fifth most important commercial nut crop in the world. The species has been cultivated in Iran (Parsa and Wallace, 1980; Barone, 1997; Mozaffari et al., 2009; Fekri and Gharanjig, 2009; Malakouti and Mozaffari, 2009; Hosseinifard et al., 2010), Turkey (Aydeniz, 1990; Tekin and Güzel, 1992; Kaska, 1995; Tekin et al., 1995; Arpacı et al., 1997; Ak and Fidan, 2009), Tunisia (Ben Mimoun et al., 2005) and Italy (Crescimanno et al., 1987; Barone, 1997; Barone et al., 1998; Caruso et al., 2005) for centuries but more recently, it is being cultivated extensively in USA and Australia (Pillai, 1995; Allemann, 2006).

Ideally, soils should be deep, friable and well-drained, but moisture-retaining (Labavitch et al., 1982). Pistachios can survive on poor, stony, calcareous, highly alkaline or slightly acidy, or even saline soils, and are more tolerant of these conditions than most other nut trees. The tree can survive a wide acidic range, a soil pH between 7.1

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and 7.8 is optimal (Pillai, 1995).

Fertilizer management in pistachio orchards have largely ignored the possibility that mineral demands and tree capacity for nutrients uptake (Weinbaum et al., 1994; Brown, 1995). In the different studies about pistachio, different methods of K applications was tested. The results revealed that K content in the control plots were between 0.98 and 2.06% (Malakouti and Mozaffari, 2009). In Iran, findings suggest the need to apply K fertilizers to old pistachio orchards where exchangeable K might be lower than 200 mg kg^{-1} (Hosseinifard et al., 2010). Recent studies indicated that K fertilization was found to be effective in increasing leaf K status (Zeng et al., 1998). A field experiment was conducted to examine the effects of K fertilization (0, 110, 220, and 330 kg-ha^{-1}) and K sources (K_2SO_4, KCl, and KNO_3) on pistachio. Leaf K concentration was low (<10 g-kg^{-1}) during spring flush. Leaf K concentration increased following K fertilization. There were no significant differences among the K sources in their effects on leaf K concentration. The critical leaf K value for optimal pistachio production was obtained to be 16.9 g-kg^{-1} (Qiupeng et al., 1998). A work was studied to evaluate the effects of potassium fertilization on the leaf mineral content of pistachio tree (*P. vera* L.). Both potassium nitrate and potassium sulfate were used. Concerning the foliar diagnostic, K fertilization increased leaf potassium concentration (0.40 - 0.82%) with no effect observed on N (0.56 -1.34%), P (0.06 - 0.10%) and Mg (0.65 - 0.81%) leaf contents (Mimoun et al., 2005). An experiment included treatments of K. The analysis of leaf samples demonstrated that treatments was increased to K leaf. The high concen-trations of zinc and copper were observed at 13 and 7 mg/kg, respectively. The rate of Na were observed between 0.83 and 0.04%. The effects of treatments on rate of P were not significant (Mozaffari et al., 2009). Other research was conducted to evaluate the effects of some pistachio rootstocks on mineral content of leaves. Mineral contents of cultivars leaves were deter-mined in different levels according to the cultivars (Tavallali and Rahemi, 2007). In the other experiment, results showed that there were no particular significant differences in the foliar concentrations of N, P, Fe, Mn and Zn, whereas, there were significant differences among rootstocks for Mg and K (Barone, 1997). In a different study, mineral contents were recorded in the Sicilian pistachio cultivar. The trees were grown using standard cultural practices in a fine sandy soil and analyzed for the main plant mineral elements. There were no particular significant differences in the foliar concen-trations of N, P, Fe, Mn and Zn, whereas, there were significant differences among the rootstocks for Mg and K. An antagonistic effect was detected between these last two elements, with a highly significant negative correlation between K and Mg (Barone et al., 1998). Zinc deficiency of pistachio trees was characterized visually as 'little leaf', analytically by low levels of zinc, and internally by increases in N, P and total soluble N (Durzan, 1995).

To study the effects of phosphorus levels (0, 50 and 100 P mg kg^{-1}) and salinity levels (0, 1000 and 2000 mg NaCl kg^{-1}) on the chemical composition of pistachio seeding, an experiment was conducted. According to results of this study, adding of P significantly decreased Na concentration in the all of pistachio organs, and increased P, K, Ca and Mg concentrations in leaf and root. Adding of P decreased Fe, Mn and Cu concentrations in leaf, stem and root. Increasing salinity decreased K concentration and increased Ca concentration in stem and root. Application of pistachio waste increased P, K, Ca, Fe, Zn, Mn and Cu concentrations in leaf, stem and root and this increase was different in several organs (Fekri and Gharanjig, 2009). To find the most appropriate nutrient solution for the growth of different pistachio, seedlings were grown in a glasshouse. Treatments included 0, 1/8, 1/4, 1/2, 1, 2, 4, 8, and 10 strength Hoagland solution. Highest growth of aerial and root portions were associated with dilute as 1 strength nutrient solution or lower (Parsa and Wallace, 1980). The ability of the rootstocks to take up nutrients from the soil differed significantly (Crescimanno et al., 1987).

In Turkey, pistachios are grown usually on produced field condition seedlings rootstocks. This seedlings grow very slowly on dry conditions; making seedlings to be grafted 5 - 7 years after transplanting. Potted seedlings have strong root system that grow quickly and adapt easily to orchard soil. After planting, budding is applied in autumn years or the next spring and fruit production begins after 4 - 5 years (Arpacı et al., 1997).

In the Southeastern part of Turkey, pistachios are grown in reddish-brown soil. Approximately, one third of the soil is shallow. Most of the soils are loamy texture, of low salinity and have a pH medium status to extreme alkalinity (8.1 - 8.7). Lime content varies from high to very high. The organic matter and available phosphorus contents of these soils are low and potassium and magnesium content generally sufficient. It was seen that there was deficiency in phosphorus and zinc. However, according to the limit values given for pistachio, there are no major problem with zinc. The iron value was at the lowest limit. There was no problem with copper, calcium and boron (Tekin et al., 1995). In the southeast Anatolia region, it was reported that while pistachio trees were lacking especially nitrogen and phosphorus, the other macro-nutrients such as calcium, magnesium, and potassium were in sufficient amounts, but micronutrient levels might be a problem in the future. Soil organic matter was less than 2 in 66% of pistachio orchards, P was insuf-ficient, 55.2% of the orchards. While all of the top soils had sufficient K, 18% of subsoils had deficiency of it. The 53.3% of pistachio orchards was never fertilized in the region (Tekin and Güzel, 1992).

Besides, nutrient contents of the trees or leaves in the Southeastern part of Turkey region were: N (< 2%), P (0.32 - 1.54%), Fe (90 - 170 ppm), Mn (20 - 115 ppm), Cu (> 10 ppm), and Zn (25 ppm) (Aydeniz, 1990). A study was conducted to search plant nutrition content of different parts of pistachio cultivars. As the results of the analysis of leaf samples showed, nitrogen, phosphorus and calcium contents were not sufficient, while potassium, magnesium, iron and copper contents of the samples were sufficient. Also it was determined that zinc level is good enough in fruitful pistachio trees, but insufficient in unfruitful trees. Plants could not utilize the elements in the soil because of high level of Ca, low water content and high temperature (Ak and Fidan, 2009).

Various organic based fertilizers were extensively used in agriculture to compensate nutrient deficiency in soil. Recently, the variety of fertilizers used in organic farming has increased and in addition to organic materials such as compost, humic and fulvic acids and leonardite, the production of fertilizers which contain different micro-organisms, enzymes and moss extracts have been started commercially. In studies using such fertilizers, it was reported that soil microbial activity was affected in different ways by seaweed extracts (Blunden, 1991), and leonardite (Tamer and Karaca, 2004; Karaca et al, 2006; Demirkıran et al., 2008). It was clearly carried out that addition to organic matter application, N, P, K fertilization was very important for pistachio (Weinbaum and Muraoka, 1989). However, studies on feeding of small pistachio trees (one-year-old) with organic and inorganic fertilizers are very limited in the scientific world (Aaliabadi, 2006). In a study, the effect of peat on the growth and nutrition of *Pistacia lentiscus* L. was tested. For growing media each compost was added at a rate of 40%, fresh pine bark at 20or 40% and peat at 20, 40 or 60%. In relation to plants growing in peat-based substrate (control), nutrition and P uptake was notably enhanced (Ostos et al., 2008). A greenhouse experiment was conducted to determine the effect of peat moss-shrimp wastes compost on barley (*Hordeum vulgare L.*) grown on a limed loamy sand soil. Results from this study indicate that peat moss-shrimp wastes compost could represent a potential means of renovating low fertility sand soils (Parent and Isfan, 1995).

In existing studies, some organic or inorganic materials were used separately as nutrition in the experiments, but they were not applied to small pistachio trees and seedlings simultaneously. Most of these studies conducted generally include pistachio trees. However, a suitable first growing stage and available nutrients are very important for a systematic plant growth. In this respect, the effects of different organic and inorganic materials on small pistachio trees was studied together and in utilizing, it is occasionally used to investigate their nutritional effects.

Therefore, the objective of this study is to investigate the effects of different organic and inorganic materials as nutrients on nutrient up taking ability of one-year old and 7 cm long pistachio (*P. vera* L.) seedlings by analyzing nutrient (mineral) contents of pistachio leaves. The experiment was conducted in a greenhouse by using six organic materials (gyttja, alsil, humic acid, sea moss, straw, and peat) and two chemical fertilizers (15-15-15, and 20-20-0) with different dosages.

MATERIALS AND METHODS

Materıals

General properties of organic materials

Alsil: It is obtained as a result of sieving and transformation prosesses of magma formed through transformations in billions of years in deep layers of earth. Alsil used in the treatment was supplied by Sinor Agricultural Company®, Istanbul (www.sinor.com.tr).

Sea moss: Submerged and decomposed formations of moss and other swamp plants. Moss is acidic (pH is 3.5 - 4.5), loose, very permeable, poor in terms of nutrients, and has very high water holding capacity. Plants and plant roots grow very well under these conditions (Parent and Isfan, 1995). Nutrient needs of mosses are fulfilled by absorption of airborne particles from wet and dry deposition. These ectohydric organisms have primitive tissues without cuticle or waxy layers, enabling water and elements to reach cell wall and membranes, or the cytoplasm by passive or active processes (Brown and Bates, 1990). The moss material used in the treatment was provided by Izotar Anonymous Company®, Istanbul.

Gyttja: Gyttja is a semi-formed lignite coal cover layer and is not used for fuel due to low calorie (Demirkıran et al., 2008). Gyttja is normally greenish in color, but may be brown or red. It bleaches on drying, usually to a grey color. In the wet state, gyttja has an elastic, rubbery consistency. It has a brittle rupture. It shrinks strongly on drying to form hard lumps with low density (Hartlén and Wolski, 1996). The pH of gyttja was 7.75, electrical conductivity (EC) was 0.68 dS m^{-1}, total organic C content was 25.5%, and $CaCO_3$ content was 32.5%. Total P content of gyttja was 17 mg kg^{-1}, and total N, 0.84%. The contents of humic and fulvic acids were 40.78 and 27.49%, respectively (Tamer and Karaca, 2004; Karaca et al., 2006). Gyttja samples used in the treatment were provided by Afşin-Elbistan Coal Mining Company® enterprise of Kahra-manmaraş province.

Humic acid: They are black or dark brown materials which are partially or fully decomposed plant or animal wastes. Main composition of soil organic materials is humus, which is the most important reasons of using humic acids in increasing soil fertility. The most important property of humic acids is their ability to combine insoluble metal ions, oxides, and hydroxides, and afterwards to release them to crops slowly and continuously when needed. The benefits of humic acids can be grouped as physical, chemical, and biological (Singh and Amberger, 1997; Çelik, 2003). Liquid humic acid used in the treatment was obtained from Izotar Anonymous Company®, Istanbul.

Straw: The residues of wheat used in the treatment grown in Kahramanmaraş region were grounded in a porcelain container and then used as straw.

Peat: Peat is an organic soil formed by plant growth when there is downfall of water level in lake beds and then death of plants when there is rise of water level in winter time, and through repetition of this natural event, transformations and accumulations of plant roots and stems take place for thousands of years. Most nurseries in the world have based, for many years, their growing media on peat. Peat is obtained from wetlands, which are being rapidly depleted, causing environmental concerns that have led to many individual countries to limit the extent of peat mining, and prices are

Table 1. Some physical and chemical properties of the study soil.

Soil property	Value
Texture	**Clay loam**
Saturation (%)	55
pH	7.6
Lime ($CaCO_3$,%)	5.6
Organic matter (%)	1.46
Total salt (%)	0.06
P_2O_5 (kg/ha)	4.6
K_2O (kg/ha)	655

increasing as a result. Research on peat alternatives is of great interest in the future (Ingelmo et al., 1998; Guerrero et al., 2002; Chong, 2005; Wilson et al., 2006). The combination of peat and compost in growing media is synergistic; peat often enhances aeration, water retention and compost or other additives improves the fertilizing capacity of a substrate. In addition, organic by-products and composts tend to have porosity and aeration properties comparable to those of bark or peat and, as such are ideal substitutes in propagating media (Chong, 2005). The peat used in the treatment was obtained from Malatya province of Turkey.

Methods

This study was conducted in a greenhouse using one-year old and about 7 cm length *P. vera* L. seedlings planted into 20 kg pots. Dosages of organic and inorganic materials were applied to these small trees and then the plants were irrigated regularly.

The experiment was conducted with an Inceptisol soil developed on alluvial sediments in the Aksu region of Kahramanmaraş. Twenty-kilogram portions of the soils, treated and thoroughly mixed with organic matter and inorganic fertilizers. Each treatments was replicated four times. The treatments which contained control, organic materials and inorganic fertilizers are given in the following:

Control

The control was carried out in 20 kg soil.

Organic material

Alsil of 1/5, 2/5, and 3/5 as volume in 20 kg soil; sea moss of 1, 2, 4, and 8 g in 20 kg soil; gyttja of 10, 20, 40, and 80 g in 20 kg soil; humic acid of 1, 2, 5, and 10 ml in 20 kg soil; straw of 10, 20, 40, and 80 g in 20 kg soil; peat of 1/5, 2/5, and 3/5 as volume in 20 kg soil.

Chemical fertilizer

Chemical fertilizers used were 15-15-15 of 0.15, 0.3, 0.45, and 0.6 g in 20 kg soil as well as 20-20-0 of 0.75, 1.5, 2.25, and 3 g in 20 kg soil.

The application of nutrients was stopped when the small trees reached grafting thickness. After the application of different dosages of organic and inorganic nutrients, the nutrient contents of leaves for each treatment were determined. After one month of the experiment, the leaf samples were collected and analyzed for nutrients.

Analyses of macro and micro nutrients in the leaves

After taking 2 or 3 mature leaves from the small tree in each pot, the leaves were dried in oven at 60°C and then grinded. A sample of 0.5 g grinded leaf was exposed to burning by using the mixing of nitric and perchloric acid. After the completion of burning, the sample was diluted and then the instrumental analysis was conducted. While the elements of Ca, Mg, K, Na, Fe, Cu, Zn, and Mn were determined by atomic absorption spectrophotometer, AAS 3110 Perkin Elmer®, P was determined by spectrophotometer using the method of coloring with Barton solution (Jackson, 1973).

Analyses of soil

The soil sample was air-dried and passed through a 2-mm sieve before analysis. The soil pH was determined by glass electrode on saturated soil samples. Electrical conductivity of the soil was measured in saturation paste extract (Rhodes, 1996). Lime content of the soil was measured by the Scheibler calcimeter. Organic matter content of the soil was determined by the modified Walkley-Black wet oxidation procedure described by Nelson and Sommers (1996). The soil potassium content including exchangeable potassium was determined using the methods described in Knudsen et al. (1982). The soil texture was determined by the hydrometer method (Bouyoucous, 1951). The phosphorus content of the samples was determined by spectrophotometer, Jenway 6100, using the sodium bicarbonate method (Olsen and Sommers, 1982).

Statistical Analyses

Data tests were performed for evaluation of all experimental data such as measurements, counting's, and analysis results based on the randomized block design (SAS, 1989).

RESULTS

Soil properties and optimum values of nutrients in leaves

Some physical and chemical properties of soils used in the experiment is presented in Table 1. As shown in Table 1, experimental soil was slightly alkali in pH, clay loam in texture, mid level in lime content, low in organic matter, mid level in salinity, low in phosphorus content, and sufficient in potassium. The optimum values of nutrients in leaves for pistachio is tabulated in Table 2 according to Ashworth et al. (1985), Tekin et al. (1995) and Brown, (1995).

Effects of chemical fertilizers

Composed fertilizer as 15-15-15

The effect of fertilizer 15-15-15 on leaf nutrient contents of pistachio is tabulated in Table 3. The effect of fertilizer 15-15-15 on P, Na, and Cu contents of pistachio leaves was statistically significant, whereas, its effect on K, Ca, Mg, Zn, Mn, and Fe contents of pistachio leaves was statistically not significant. While fertilizer 15-15-15

Table 2. The optimum values of nutrients in leaves for pistachio grown in arid conditions according to some researchers.

Optimum values	P (%)	K (%)	Ca (%)	Mg (%)	Fe (ppm)	Zn (ppm)	Mn (ppm)	Cu (ppm)
Tekin et al. (1986)	0.06 - 0.1	0.8 - 1.2	2.2 - 3.7	0.5 - 0.9	108	17.5	35	48
Caruso et al. (2005)	0.35 - 0.4	0.8 - 1.9	0.2-0.6	0.7 - 4.7	33 - 130	17.2 - 37.3	13.3 - 28.6	7.3 - 31.1
Brown (1995)	0.14	1.00		0.60				
Ashworth et al. (1985)	0.24	0.7 - 0.9						

Table 3. The effect of fertilizer 15-15-15 on leaf nutrient contents of the pistachio seedlings leaves.

15-15-15 application	P**	K^{ns}	Ca^{ns}	Mg^{ns}	Na*	Zn^{ns}	Mn^{ns}	Cu*	Fe^{ns}
	ppm								
0.00	135.51b	12.75	604.14	245.74	12557.26a	16.29	24.82	21.79a	19.34
0.15	374.33a	16.30	686.43	187.65	658.21b	6.11	15.33	6.00b	31.35
0.30	423.98a	15.20	644.13	199.07	511.94b	4.25	13.87	8.20b	6.40
0.45	423.98a	14.10	1028.34	253.23	628.96b	4.90	30.78	3.20b	13.37
0.60	413.24a	12.75	671.07	217.16	504.63b	3.48	24.57	5.80b	23.69

^{ns}Not significant (LSD test), *significant at p = 0.05 level (LSD test), **significant at p = 0.01 level (LSD test).

Table 4. The effect of fertilizer 20-20-0 on leaf nutrient contents of the pistachio seedlings leaves.

20-20-0 application	P^{ns}	K^{ns}	Ca^{ns}	Mg^{ns}	Na*	Zn^{ns}	Mn^{ns}	Cu*	Fe^{ns}
	ppm								
0.00	135.51	12.75	604.14	245.74	12557.26a	16.29	24.82	21.79a	19.34
0.75	414.59	13.73	571.98	190.28	387.62b	6.01	20.19	6.40b	28.11
1.50	300.54	16.55	471.72	228.50	380.30b	4.08	7.77	4.80b	21.90
2.25	222.72	16.18	482.73	221.72	475.38b	4.46	21.65	4.20b	25.18
3.00	328.05	14.71	522.72	202.51	497.32b	3.73	17.27	3.20b	15.35

^{ns} Not significant (LSD test), *significant at p = 0.05 level (LSD test).

application increased P content of pistachio leaves to a significant level, its application decreased Na and Cu contents of the leaves at significant level. Durzan (1995) reported that zinc deficiency of pistachio trees was characterized visually as 'little leaf', analytically by low levels of zinc, and internally by increase in N, P and total soluble N.

Composed fertilizer as 20-20-0

The effect of fertilizer 20-20-0 on leaf nutrient contents of pistachio is tabulated in Table 4. The effect of fertilizer 20-20-0 on Na and Cu contents of pistachio leaves was statistically significant, whereas, its effect on P, K, Ca, Mg, Zn, Mn, and Fe contents of pistachio leaves was statistically not significant. The fertilizer 20-20-0 application decreased both Na and Cu contents of pistachio leaves to a significant level. Cu content decreased with the application of 20-20-0 fertilizer. Durzan (1995) also reported that zinc deficiency of pistachio trees was characterized analytically by low levels of zinc, and internally by increases in N, P and total soluble N.

Effect of organic materials

Alsil

The effect of alsil application on leaf nutrient contents of pistachio is tabulated in Table 5. Alsil application had no statistically significant effect on nutrient contents of pistachio leaves except Cu content in which Cu content decreased at significant level. Durzan (1995) also reported that decrease of zinc content of pistachio trees was characterized analytically by low levels of zinc, and internally by increases in N and P. Furthermore, alsil materials which have been included in magmatic characteristic as mentioned above increased calcium content of pistachio leaves. These properties are important for trees which have calcium deficiencies.

Sea moss

The effect of sea moss application on leaf nutrient

Table 5. The effect of alsil on leaf nutrient contents of the pistachio seedlings leaves.

Alsil application	P^{ns}	K^{ns}	Ca^{ns}	Mg^{ns}	Na^{ns}	Zn^{ns}	Mn^{ns}	Cu*	Fe^{ns}
	ppm								
0	135.51	12.75	604.14	245.74	12557.26	16.29	24.82	21.79a	19.34
1	251.57	10.42	1052.68	266.50	650.90	4.51	31.02	4.00b	12.10
2	48.30	12.26	967.78	267.50	585.08	5.51	24.94	2.40b	21.50
3	124.78	12.26	1039.35	253.86	643.59	5.51	28.59	2.40b	24.75

^{ns}Not significant (LSD test), *significant at p = 0.05 level (LSD test).

Table 6. The effect of sea moss application on leaf nutrient contents of the pistachio seedlings leaves.

Sea moss application	P^{ns}	K^{ns}	Ca^{ns}	Mg*	Na^{ns}	Zn^{ns}	Mn*	Cu^{ns}	Fe^{ns}
	ppm								
0	135.51	12.75	604.14	245.74a	12557.26	16.29	24.82b	21.79	19.34
1	714.46	13.48	658.03	113.21ab	1016.58	2.68	223.71a	281.92	37.66
2	1233.69	14.22	673.97	46.19b	1908.82	11.65	182.71ab	235.74	20.13
4	1007.62	10.79	884.91	44.78b	2881.52	13.83	13.14b	254.33	16.62
8	72.45	10.91	361.04	73.51b	7284.24	23.89	21.53b	366.30	23.75

^{ns}Not significant (LSD test), *significant at p = 0.05 level (LSD test).

Table 7. The effect of gyttja application on leaf nutrient contents of the pistachio seedlings leaves.

Gyttja application	P^{ns}	K^{ns}	Ca^{ns}	Mg**	Na^{ns}	Zn^{ns}	Mn^{ns}	Cu^{ns}	Fe^{ns}
	ppm								
0	135.51	12.75	604.14	245.74a	12557.26	16.29	24.82	21.79	19.34
10	292.49	9.93	143.43	49.97b	314.48	5.95	48.66	255.93	7.68
20	268.34	8.95	339.59	46.63b	3583.61	7.98	39.29	205.34	17.89
40	216.69	7.97	390.59	58.24b	5046.31	5.66	50.00	214.14	13.56
80	275.72	8.46	364.51	50.30b	4073.61	5.20	44.16	38.99	15.54

^{ns} Not significant (LSD test), **significant at p = 0.01 level (LSD test).

contents of pistachio is tabulated in Table 6. The effect of sea moss application on Mg and Mn contents of pistachio leaves was statistically significant, but its effect on P, K, Ca, Na, Zn, Cu, and Fe contents of pistachio leaves was statistically not significant. Sea moss treatments enhanced phosphorus content of pistachio leaves due to sea materials having significant phosphorus element. Through this, organic material was treated to the plants and phosphorus contents of pistachio leaves were raised as mentioned by Ben Mimoun et al. (2005) and Tekin et al., (1986). Phosphorus content of leaves were not enhanced to the optimum level of phosphorus by other organic and inorganic nutrient treated. While sea moss application decreased Mg content of pistachio leaves to a significant level, its application first increased and then decreased Mn content of the leaves to a significant level. The application of sea moss which is rich in nutrients (Blunden, 1991), increased Cu content of leaves and also the applications up to certain level increased P and Mn contents. In the higher sea moss application, it should be carefully applied for potential salinity problem in soil.

Gyttja

The effect of gyttja application on leaf nutrient contents of pistachio is tabulated in Table 7. Gyttja application had no statistically significant effect on nutrient contents of pistachio leaves except Mg content in which Mg content decreased at significant level. Gyttja was obtained from the Afsin–Elbistan Lignite deposits (Kahramanmaraş, Eastern Turkey). Since EC and $CaCO_3$ of gyttja are high (Tamer and Karaca, 2004; Karaca et al., 2006; Demirkıran et al., 2008), K, Ca, Mg, Zn (Durzan, 1995), and Fe contents of pistachio leaves decreased. Due to high phosphorus content of gyttja, P contents of pistachio leaves increased. As in the higher sea moss application,

Table 8. The effect of humic acid application on leaf nutrient contents of the pistachio seedlings leaves.

Humic acid application	P***	K^{ns}	Ca^{ns}	Mg^{ns}	Na^{*}	Zn^{ns}	Mn^{ns}	Cu^{*}	Fe^{ns}
	ppm								
0	135.51c	12.75	604.14	245.74	12557.26a	16.29	24.82	21.79a	19.34
10	464.90a	9.19	297.87	118.96	299.85b	4.17	14.96	4.20b	28.25
20	452.15a	11.28	734.82	215.82	504.63b	6.77	27.49	7.20b	21.27
40	360.25ab	8.58	725.84	193.65	511.94b	6.03	19.83	6.00b	27.78
80	251.57bc	8.09	496.06	149.95	358.36b	5.50	14.60	5.00b	29.48

^{ns}Not significant (LSD test), *significant at p = 0.05 level (LSD test), **significant at p = 0.01 level (LSD test).

Table 9. The effect of straw application on leaf nutrient contents of the pistachio seedlings leaves.

Straw application	P**	K^{ns}	Ca^{ns}	Mg^{ns}	Na^{ns}	Zn^{ns}	Mn^{ns}	Cu^{ns}	Fe^{ns}
	ppm								
0	135.51b	12.75	604.14	245.74	12557.26	16.29	24.82	21.79	19.34
10	271.69a	9.07	278.46	134.90	277.91	5.12	15.81	4.40	14.98
20	303.90a	10.79	263.39	261.64	221.89	3.13	18.49	5.80	14.78
40	318.65a	11.03	1218.71	221.86	277.91	4.34	23.96	5.20	30.53
80	370.31a	10.30	285.12	178.68	263.29	2.96	14.60	7.20	45.20

^{ns}Not significant (LSD test), **significant at p = 0.01 level (LSD test).

Table 10. The effect of peat application on leaf nutrient contents of the pistachio seedlings leaves.

Peat application	P**	K^{ns}	Ca^{ns}	Mg^{ns}	Na^{ns}	Zn^{ns}	Mn^{ns}	Cu^{ns}	Fe^{ns}
	ppm								
0	135.51b	12.75	604.14	245.74	12557.26	16.29	24.82	21.79	19.34
1	392.45a	10.42	911.86	251.59	570.45	21.77	101.33	293.32	23.91
2	348.84a	11.89	444.19	182.72	497.32	27.70	197.92	478.07	30.44
3	392.45a	12.63	711.93	216.93	519.26	27.23	232.59	160.76	37.19

^{ns}Not significant (LSD test), **significant at p = 0.01 level (LSD test).

gyttja should be carefully used as organic material due to salinity problem, potentially.

Humic acid

The effect of humic acid application on leaf nutrient contents of pistachio is tabulated in Table 8. The effect of humic acid application on P, Na, and Cu contents of pistachio leaves was statistically significant, whereas, its effect on K, Ca, Mg, Zn, Mn, and Fe contents of pistachio leaves was statistically not significant. While humic acid application increased P content of pistachio leaves at significant level, its application decreased K, Ca, Mg, Na, Zn (Durzan, 1995) and Cu, especially Na and Cu contents of the leaves at significant level. Humic acid had the same effect on nutrient contents of pistachio leaves as fertilizer 15-15-15. In recent studies, the solubility of phosphorus in soil increased due to humic and fulvic acids (Singh and Amberger, 1997). In this study, humic acid increased phosphorus content of pistachio leaves at significant level parallel to the fact that the solved phosphorus is better used by plants.

Straw

The effect of straw application on leaf nutrient contents of pistachio is tabulated in Table 9. Straw application had no statistically significant effect on nutrient contents of pistachio leaves except P content which increased at significant level. While straw application increased P content of pistachio leaves, its application decreased K, Ca, Na, Zn (Durzan, 1995) and Cu contents.

Peat

The effect of peat application on leaf nutrient contents of pistachio is tabulated in Table 10. Peat application had no statistically significant effect on nutrient contents of pistachio leaves except P content which increased at significant level. Many researchers (Ostos et al., 2008; Parent and Isfan, 1995; Chong, 2005) reported that peat facilitate and increase the uptake of nutrients by many plants.

DISCUSSION

As reported by several researchers (Tekin et al., 1995; Tekin and Güzel, 1992), soils of pistachio trees significantly lack many plant nutrients and had generally low level of organic matter content in Turkey. Using inorganic fertilizers for nutrient supplement of the pistachio trees (Weinbaum et al., 1994; Brown, 1995; Durzan, 1995; Barone, 1997; Barone et al., 1998; Qiupeng et al., 1998; Zeng et al., 1998; Mimoun et al., 2005; Tavallali and Rahemi, 2007; Malakouti and Mozaffari, 2009; Mozaffari et al., 2009; Hosseinifard et al., 2010) and organic materials with soil improves soil structure and supply plant with nutrients (Weinbaum and Muraoka, 1989; Blunden, 1991; Parent and Isfan, 1995; Tamer and Karaca, 2004; Karaca et al., 2006; Aaliabadi, 2006; Ostos et al., 2008; Demirkıran et al., 2008).

This study showed that chemical fertilizers (15-15-15 and 20-20-0) negatively affected micro nutrients especially Zn content and statistically, Cu content of plant leaves. This situation can be assumed for those fertilizers that have macro nutrients, especially phosphorus whose interaction relationship between phosphorus and zinc nutrient is known (Durzan, 1995). These fertilizers increased phosphorus contents of pistachio leaves with low levels. This is shown in Table 3 (Ashworth et al., 1985, Tekin et al., 1995; Brown, 1995) and were reported by Aydeniz (1990) and Ak and Fidan (2009).

In addition, it has been determined that alsil, humic acid and straw in these organic materials decreased zinc and cupper content of pistachio leaves, and alsil and humic acid decreased cupper content in the plant leaves, statistically. This result indicated that these organic materials have been naturally macro nutrients.

In this study, moss had positive effect on Mn uptake by pistachio trees, whereas peat, straw, and humic acid positively affected P uptake. The possible reasons for these positive effects may be direct and indirect effects of organic materials on soils. Besides, inorganic fertilizers increased P content of pistachio leaves, but this increase caused decrease of Cu content. High level of P content may be the reason for the low uptake of some micro elements such as Cu. Although application of organic and inorganic materials generally increases P uptake, organic materials especially peat, gyttja and sea moss increased nutrient contents of pistachio leaves. This important knowledge is applied in areas where pistachio lacks nutrients.

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