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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, 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 increases P uptake, organic materials especially peat, gyttja and sea moss increased nutrient contents of pistachio (*P. vera* L.) leaves. The results of this study can be utilized by pistachio growers in especially areas having low nutrients.

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 (Van Bueren and Struik, 2004).

In pistachio production, 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 acid, or even saline soils and are more tolerant of these conditions than most other nut trees. The tree can survive in a wide acidic range; a soil pH between 7.1 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 (*P. vera* L.), different methods of K applications were 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 that K fertilizers application to old pistachio orchards, where exchangeable K might be lower than 200 mg kg^{-1}, is needed (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

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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 study was conducted 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). Durzan (1995) reported that 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. 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 by Fekri and Gharanjig (2009). According to their results, 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.

To find the most appropriate nutrient solution for the growth of different pistachio seedlings, pistachios 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 was shown that differed significantly (Crescimanno et al., 1987).

Anatolia is an important gene source for horticultural crops with varieties which have multiplied numerously during the centuries (Simsek, 2009). In Turkey pistachios are grown usually on produced field condition seedlings rootstocks. These seedlings grow very slowly on dry conditions. The seedlings are grafted 5 - 7 years after transplanting. Potted seedlings have strong root system that grows quickly and adapt easily to orchard soil. After planting, budding is applied in autumn of the same year or the next spring and fruit production begins after 4 - 5 years (Arpaci et al., 1997).

In the Southeastern part of Turkey, pistachios are grown in reddish-brown soil. Approximately the 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 is 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 hungry to especially nitrogen and phosphorus, the other macronutrients such as calcium, magnesium and potassium were in sufficient amounts, but micronutrient levels might be problem in the future. Soil organic matter was less than 2% in 66% of pistachio orchards, P was insufficient 55.2% of the orchards. While all of the top soils had sufficient K, 18% of sub soils had deficiency of it. The 53.3% of pistachio orchards was never fertilized in the region (Tekin, 1992).

Besides, nutrient contents of the trees or leaves in the Southeastern part of Turkey 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, 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).

Organic fertilizers are 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 fertilizers which contain different microorganisms, enzymes and moss extracts have been commercially started to be produced. 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; Demirkiran 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).

Even though several studies (Parsa and Wallace, 1980; Aydeniz, 1990; Tekin et al., 1995; Arpaci et al., 1997; Mimoun et al., 2005; Allemann, 2006; Malakouti and Mozaffari, 2009; Ak and Fidan, 2009; Hosseinifard et al., 2010) have been conducted to investigate the effects of organic and inorganic fertilizers on pistachio trees, studies on feeding of small pistachio trees (one-year-old) are very limited in scientific world. In addition, in existing studies, either some organic or inorganic materials have been used separately instead of simultaneous application of them as nutrition in the experiments. A suitable first growing stage and available nutrients are very important for a systematic plant growth.

Therefore, the objective of this study was to investigate the effects of different organic and inorganic materials as nutrients on nutrient uptaking 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

General properties of organic materials

Alsil

It is obtained as a result of sieving and transformation processes 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.

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 not used for fuel due to low calorie (Demirkiran 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, 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 Kahramanmaraş 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. The most important reasons of using humic acids is to increase 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 downfall of water level in lake beds and then death of plants when rise of water level in winter time and through repetition of this natural event, transformaions 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 lead to many individual countries to limit the extent of peat mining and prices are 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 and 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. Inceptisol soil developed on alluvial sediments in the Aksu River region of Kahramanmaraş was used in the experiment. Twenty-kilogram portions of the soils were treated and thoroughly mixed with following organic matters and inorganic fertilizers. Each treatment was replicated four times. The treatments including control, organic materials and inorganic fertilizers with different dosages are given as follows in the following. After the application of organic and inorganic materials, the plants were irrigated regularly.

Control: 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

- 15-15-15 of 0.15, 0.3, 0.45, and 0.6 g in 20 kg soil, - 20-20-0 of

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

Table 2. According to some researchers, the optimum values of nutrients in leaves for pistachio grown in arid conditions.

Optimum values	P	K	Ca	Mg	Fe	Zn	Mn	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						

0.75, 1.5, 2.25, and 3 g in 20 kg soil.

The application of nutrients was stopped when the small trees reached to 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 nutrient contents.

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 under 60℃ and then grinded. The 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® (Chapman and Pratt, 1961), P was determined by spectrophotometer by 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 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, countings and analysis results based on the randomized block design (SAS, 1989).

RESULTS AND DISCUSSION

Soil properties and optimum values of nutrients in leaves

Some physical and chemical properties of soils used in the experiment are 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 are tabulated in Table 2.

Chemical fertilizers

Fertilizer 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 application increased P content of pistachio leaves in significant level, its application decreased Na and Cu

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

15-15-15 g	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, *significant at p = 0.05 level, **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 g	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, *significant at p = 0.05 level (LSD test).

contents of the leaves in significant level. The results are compatible with that reported by Durzan (1995).

Fertilizer 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 in significant level. Cu content decreased with applying of 20-20-0 fertilizer. Durzan (1995) also reported that zinc deficiency of pistachio trees was characterized by low levels of zinc, and internally by increases in N, P.

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 in significant level. Durzan (1995) also reported that decreasing of the zinc by increases in N and P. Furthermore, alsil materials which have been included magmatic characteristic as mentioned where in materials section were increased calcium content of pistachio leaves. This property is important for trees which have calcium deficiencies.

Sea moss

The effect of sea moss application on leaf nutrient 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 were enhanced phosphorus content of pistachio leaves due to sea materials have been significantly included phosphorus element. Through this organic material was treated to the plants, phosphorus contents of pistachio leaves were raised to the mentioned in this text by Ben Mimoun et al. (2005) and Tekin et al. (1986). Phosphorus content of leaves was 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 in significant level, its application first increased and then decreased Mn content of the leaves in 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.

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

Alsil/soil as volume	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
1/5	251.57	10.42	1052.68	266.50	650.90	4.51	31.02	4.00b	12.10
2/5	48.30	12.26	967.78	267.50	585.08	5.51	24.94	2.40b	21.50
3/5	124.78	12.26	1039.35	253.86	643.59	5.51	28.59	2.40b	24.75

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

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 in 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; Demirkiran et. al., 2008), K, Ca, Mg, Zn (Durzan, 1995) and Fe contents of pistachio leaves decreased. Due to phosphorus content of gyttja are high, P contents of pistachio leaves increased. As in the higher sea moss application, 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 in significant level, its application decreased K, Ca, Mg, Na, Zn (Durzan, 1995) and Cu, especially Na and Cu contents of the leaves in significant level. Humic acid had the same effect on nutrient contents of pistachio leaves as the 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 in 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

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

Humic acid (ml)	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
1	464.90a	9.19	297.87	118.96	299.85b	4.17	14.96	4.20b	28.25
2	452.15a	11.28	734.82	215.82	504.63b	6.77	27.49	7.20b	21.27
5	360.25ab	8.58	725.84	193.65	511.94b	6.03	19.83	6.00b	27.78
10	251.57bc	8.09	496.06	149.95	358.36b	5.50	14.60	5.00b	29.48

^{ns} not significant, *significant at p = 0.05 level, **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 (g)	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, **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/Soil as volume	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
1/5	392.45a	10.42	911.86	251.59	570.45	21.77	101.33	293.32	23.91
2/5	348.84a	11.89	444.19	182.72	497.32	27.70	197.92	478.07	30.44
3/5	392.45a	12.63	711.93	216.93	519.26	27.23	232.59	160.76	37.19

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

pistachio is tabulated in Table 9. Straw application had no statistically significant effect on nutrient contents of pistachio leaves except P content in which P content increased in 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 in which P content increased in significant level. Many researchers (Parent and Isfan, 1995; Chong, 2005) reported that peat facilitated and increased the uptake of nutrients by many plants.

As reported by several researchers (Tekin et al., 1995; Tekin, 1992), soils of pistachio trees were significantly lack of 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; Zeng et al., 1998; Mimoun et al., 2005; Malakouti and Mozaffari, 2009; Hosseinifard et al., 2010) and organic materials with soil improves soil structure, have supplied plant nutrients (Weinbaum and Muraoka, 1989; Blunden, 1991; Parent and Isfan, 1995; Tamer and Karaca, 2004; Karaca et al., 2006; Demirkiran et al., 2008).

This study showed that chemical fertilizers (15-15-15 and 20-20-0) negatively effected to micro nutrients especially Zn content and statistically Cu content of plant leaves. This situation can be assumed for these fertilizers that have macro nutrients, especially phosphorus which known interaction relationship between phosphorus and zinc nutrient (Durzan, 1995). These fertilizers was increased phosphorus contents of pistachio leaves have low levels in that were given in Table 3 (Ashworth et al. 1985, Tekin et al. 1995; Brown, 1995; Caruso et al., 2005) 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 were decreased zinc and cupper content of pistachio leaves and alsil and humic acid were 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 of 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 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 increases P uptake, organic materials especially peat, gyttja and sea moss increased nutrient contents of pistachio leaves. This is an important applied knowledge in pistachio growth where they are lack of nutrients with.

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