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Macro- and microelement concentrations in different parts of “on”- and “off”-year ‘Siirt’ Pistachio trees

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Abstract. This study was conducted to determine the mineral element concentrations in different parts of ‘Siirt’ pistachio trees. This research was carried on 35-year old, fruitful or unfruitful (showing alternate bearing) trees that were grafted on *Pistacia vera* rootstock at the Ceylanpinar State Farm near Sanliurfa, Turkey. The results of the analysis of leaf samples taken from fruitful or unfruitful trees as follow; nitrogen (N), phosphor (P), potassium (K), magnesium (Mg), calcium (Ca) contents were not sufficient; iron (Fe), copper (Cu) and manganese (Mn) contents of the samples were sufficient. Also it was determined that zinc (Zn) level is insufficient in both kind of trees (fruitful and unfruitful trees). In this conditions the pistachio trees could not utilize the elements in the soil because of high level of Ca, low soil moisture content and high air temperature.

Keywords: *Pistacia* – Mineral nutrition – Fertilization – Alternate bearing – Tree nut.

Concentrations en macro- et microéléments dans différentes parties en année productive et non productive pour les pistachiers ‘Siirt’

Résumé. *Cette étude a été menée pour déterminer les concentrations en éléments minéraux dans différentes parties des pistachiers ‘Siirt’. Cette recherche a été menée sur des arbres de 35 ans d’âge, fructifères ou non fructifères (montrant une alternance de production) qui avaient été greffés sur porte-greffe* Pistacia vera *à la Ferme d’État de Ceylanpinar près de Sanliurfa, Turquie. Les résultats de l’analyse d’échantillons de feuilles prélevées sur des arbres fructifères ou non fructifères sont comme suit; les teneurs en azote (N), phosphore (P), potassium (K), magnésium (Mg), calcium (Ca) n’étaient pas suffisantes; les teneurs en fer (Fe), cuivre (Cu) et manganèse (Mn) étaient suffisantes. Il a aussi été déterminé que le niveau de zinc (Zn) était insuffisant dans les deux types d’arbres (fructifères et non fructifères). Dans ces conditions les pistachiers ne pouvaient pas utiliser les éléments du sol à cause du haut niveau de Ca, de la faible teneur en humidité du sol et de la haute température de l’air.*

Mots-clés. Pistacia *– Nutrition minérale – Fertilisation – Alternance de production – Fruit sec.*

I – Introduction

Pistachio is grown most intensively in Iran, Syria, Turkey, and USA. The other pistachio-producing countries are in the Near East, North Africa and Southern Europe. Based on nut production data for 2009-2012, Iran is responsible for over 459,000 tons, about half (53.2%) of world production. The second highest-yielding country, USA, produces 207,000 tons, about 22.3% of world production, while Turkey is third with a yield of 117,000 tons and 12.7% of total world production.

Pistachio trees can be grown under very poor soil conditions. *Pistacia* spp. tolerate very high lime contents in soil and can be grown on calcareous soils that would limit production of other fruit crops. Fertilization is a very important factor to ensure high nut quality and yield. Pistachio trees do suffer from excessive alkalinity. Nutrient availability and soil fertilization strategies depend on irrigation practices and soil pH. Some soil nutrients are poorly available because of high pH and competitive uptake caused by soil nutrient imbalances (Ak, 1992; Ak, *et al*., 2002; Gursoz, *et al*., 2010).

In Turkey, pistachios are grown on soils that typically contain inadequate supplies of N, P, K, and organic matter. In a survey conducted in 30 pistachio orchards in southeast Anatolia, Tekin *et al*. (1985) found that the trees in many orchards were markedly deficient in P and Zn and slightly deficient in N, Fe and Mn. The level of K was found adequate in many orchards though there were some districts where the trees showed slight deficiencies. Soil pH in the pistachio-growing region of Turkey varied between 7.5 and 9.3 while the organic matter content was very low. Zinc deficiency appears to substantially limit fruit set.

Crane and Maranto (1988) concluded that pistachio is not a luxury N consumer when N is abundantly available in the soil. The chemical form of nitrogenous fertilizer should be chosen depending on soil pH. For instance, in the GAP (Southeast Anatolia Region) area, only ammonium sulfate is recommended as a source of N because of the alkaline soils. Nitrogenous fertilizers should be applied at the end of February or the beginning of March at rates of 1.5 to 4 kg per tree (Kaska, 1995).

The current experiment was conducted to determine (1) the macro– and microelemental status of pistachios grown at Ceylanpinar State Farm in Sanliurfa, Turkey; (2) whether pistachio trees are getting enough nutrients from the soil; and (3) the distribution of nutrients among the various components of the pistachio fruits.

II – Materials and methods

This research was carried on 35-year-old fruitful or unfruitful 'Siirt' pistachio trees grafted on *P. vera* rootstock at the Ceylanpınar State Farm in Sanliurfa. This cultivar is very prone to alternate bearing. The trees were grown under non-irrigated conditions. Rainfall and relative humidity are very low at this farm while temperature is very high (Table 1).

The six trees are selected for testing. Three of the trees were bearing, or "on"-year trees. The remaining three were non-bearing, or "off"-year, trees. Any flower clusters developing on the non-bearing trees were removed manually so that no flower clusters were present at all. The leaves were sampled in late July from middle portion of the current year's shoots (Tekin *et al*., 1990). The fruits were sampled when they have reached harvesting maturity. Hull, endocarp, and kernel portions of the fruit, and the remaining stem portion of the clusters, were separated and dried. Soil samples were collected and analyzed (Tables 2 and 3). Analyses were conducted following procedures in Kacar (1972). All analyses were done at the Laboratory of the Gaziantep Pistachio Research Institute.

Table 1. Climatical data at the Ceylanpınar State Farm

Months	Minimum Temp. (°C)	Maximum Temp. (°C)	Average Temp. (°C)	Relative Humidity	(%) Rainfall (mm)
January	-3.4	17.0	7.1	73.3	52.8
February	-2.6	16.4	6.3	73.0	88.2
March	-3.0	21.6	9.6	63.4	52.0
April	1.6	28.0	15.9	60.5	27.6
May	7.0	37.0	23.8	36.9	16.4
June	14.2	41.0	29.2	27.6	1.0
July	16.8	46.0	31.8	32.4	–
August	14.9	45.4	32.0	33.1	–
September	8.3	42.2	24.8	34.0	–
October	0.4	37.0	20.3	43.2	20.1
November	-1.7	27.3	11.3	64.4	45.8
December	-4.2	16.8	6.6	74.1	35.8

Source: State Farm Records.

Table 2. Soil physical traits and organic matter content of the experimental orchard

Soil depth (cm)	Soil attribute				
	pH (Soluble in Water)	Salt (%)	Lime (%)	Texture (%)	Organic matter (%)
0-20	8.07†	0.03	50.14	loam	1.54
20-40	8.20	0.04	51.37	loam	0.80
40-60	8.00	0.04	46.90	loam	1.07
Average	8.09	0.03	49.47	loam	1.14

† Each number is average of three different part of orchard of soil samples.

Table 3. Macro- and microelemental content of the soil in the experimental orchard

Soil depth	Nutritional content of the soil							
	P (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)	Fe (ppm)	Cu (ppm)	Zn (ppm)	Mn (ppm)
0-20	5.27	303.40	15455.50	414.37	4.17	5.60	0.02	20.30
20-40	1.97	152.84	15324.80	534.60	4.27	5.80	0.07	15.53
40-60	3.20	150.24	17215.20	550.34	5.34	5.07	0.10	19.23
Average	3.48	202.16	15998.5	499.77	4.59	5.49	0.06	18.35

III – Results and discussion

1. Macro- and micronutrient concentrations in leaves

The results of the leaf analyses appear in Table 4, along with the critical levels published by Brown (1995) and Tekin (2002). There are some differences in nutrient status between “on”-year and “off”-year pistachio leaves. Some elements were higher in “off-year” than in “on-year” trees. With the exception of N, K, Fe and Cu, leaf nutrient concentrations were low compared to the recommended critical ranges, suggesting that tree nutrient status is generally inadequate. Because the soil contains adequate amounts of nutrients, the poor nutrient phytoavailability may be due to indequate soil moisture, high soil pH, or competitive nutrient uptake. The orchard was established under rainfall conditions. That means the trees are not irrigating during summer.

Table 4. Effect of alternate bearing on leaf macro- and micronutrient concentrations of the experimental ‘Siirt’ pistachio trees, and comparison with suggested desirable ranges

Some elements	“On” year	“Off” year	Average	Critical levels† (Brown, 1995)	Critical levels†† (Tekin, 2002)
N (%)	1.00	1.03	1.02	2.50-2.90	1.80-2.40
P (%)	0.07	0.05	0.06	0.14-0.17	0.06-0.14
K (%)	0.51	0.52	0.52	1.00-2.00	0.80-1.20
Mg (%)	0.51	0.47	0.49	0.60-1.20	0.50-0.90
Ca (%)	0.91	1.21	1.06	1.30-4.00	2.30-3.00
Fe (ppm)	167.17	181.07	174.12		43-170
Cu (ppm)	12.20	17.87	15.04		6-90
Zn (ppm)	6.93	3.57	5.25		10-25
Mn (ppm)	51.30	49.07	50.19		25-50

† Suggested range under irrigated conditions for pistachio.
†† Suggested range under dryland conditions.

2. Some macro and micro nutrient contents in different fruit organs

Distribution of macro– and microelements in the various components of the pistachio fruit were given Table 5. There was differential preferential accumulation of elements in the different organs. Nitrogen and Mn concentrations were highest in the kernel. Manganese and Iron concentration also was high in the cluster stems. Phosphorus concentration was appreciably higher in the endocarp. The hull contains higher concentrations of K, Mg, and Zn. Calcium, Fe and Cu concentrations were highest in the hull and cluster stems.

Table 5. Nutrient concentrations in different organs of the 'Siirt' pistachio cultivar

Some Elements	Cluster	Hull (Red Skin)	Endocarp	Kernel	LSD (% 5)
N (%)	0.93 b	0.73 b	0.02 c	2.16 a	0.218
P (%)	0.05 b	0.03 b	34.30 a	0.26 b	6.319
K (%)	1.02 b	5.61 a	0.08 b	0.79 b	3.152
Mg (%)	0.06 c	0.15 a	0.01 d	0.10 b	0.021
Ca (%)	0.88 a	0.70 ab	0.19 b	0.22 b	0.510
Fe (ppm)	138.37 a	150.47 a	74.98 b	72.30 b	56.950
Cu (ppm)	11.32	18.36	19.93	21.21	Ö.D.
Zn (ppm)	3.30	22.73	0.00	2.20	52.360
Mn (ppm)	8.71 ab	2.21 b	5.83 b	16.06 a	8.440

IV – Conclusions

Turkey is the only country in the world that pistachio nuts are grown on such marginal lands with a dry climate and poor, rocky and calcareous soils. Alternate bearing is one of the important features of pistachio. Alternate bearing cultivars produce heavy crops in "on" years and little or no crop in the "off" years (Ak and Kaska, 1992). The tendency for alternate bearing varies among the different pistachio cultivars. This can be decreased by irrigation and fertilization. Research has shown that management practices can dramatically influence yield of pistachio trees, with irrigation enhancing yields by up to 70%, fertilization 50%, choice of cultivar 45%, and light pruning 17% (Ak and Agackesen, 2005). Resolution of such limitations would substantially enhance the importance of pistachio as a world food source.

Our study showed that the Turkish soil on which the experimental pistachio trees were grown contains a very high calcium content and high pH. These soil factors may interfere with nutrient supply, restricting uptake from the soil into the trees. This effect may be exacerbated by the low soil moisture status of the nonirrigated orchard soils, which reduces root activity as well as soil nutrient solubility and translocation.

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