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Full Length Research Paper

Comparison of several plant nutrient elements in conventionally and organically grown citrus orchards

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Organic citrus production has been increasing recently in Turkey. In this study, we compared several nutri-elements concentrations of organically (ORG) and conventionally (CON) grown citrus orchards in the Mediterranean region of Turkey. The samples included Satsuma mandarins (*Citrus unshiu* L.) and Washington navel and Valencia oranges (*Citrus sinensis* (L.) Osbeck), which were grafted on sour orange (*Citrus aurantium* L.). In 1996, 58 citrus orchards were sampled and 48 of them used for analyses. Three years after the first sampling, some orchards switched from CON to ORG production. Sampling was repeated in 2007 and included 31 samples from CON and 30 samples from orchards that switched to ORG after the 1996 samples were taken. Concentrations of N, P, K, Ca, Mg, Na, B, Cu, Fe, Mn and Zn were determined using the samples from 1996; with the exception of B, no significant differences were observed. Analysis of the samples from 2007 indicated statistically significant differences between the two groups for concentrations of N, K, Mg, B and Mn. The means of both samples were subjected to principle component analysis (PCA); the results indicated that, after several years of ORG culture, the two groups were clearly separated. The variables highly correlated with PC1 were Na, Fe and Ca, while P, K, Mn and Mg were correlated by PC2. B, Fe and Zn correlated by PC3. Several trace elements (Pb, Cu, Fe, Mn, Ni and Zn) from five randomly chosen soil samples from both CON and ORG growing groups were determined, and the results indicated that the mean concentrations for the two groups were similar for most of the elements (Pb, Cu, Fe and Ni). Our results shed light on the optimization of plant nutrient programs in organic citrus production.

Key words: Citrus, conventional, mandarin, Mediterranean, nutri-elements, orange, organic.

INTRODUCTION

Turkey's citrus production has increased about 177% over the last 10 years and has reached 3,220,450 tones (FAO, 1996, 2006). In Turkey, citrus fruits are grown mainly in the Mediterranean and Aegean regions and, to a lesser extent, the Eastern Black Sea region. The Mediterranean region has a typical Mediterranean climate suitable for producing high quality citrus fruits for fresh consumption (Özsan, 1979; Kaplankıran et al., 2001). In this region, Çukurova (Adana, Mersin, Hatay) had a very important role, constituting 72% of Turkey's citrus production (Anonymous, 2005). The increase in citrus production has resulted in some potential marketing problems, especially for commonly grown cultivars like Washington navel oranges, Satsuma mandarins, and Kütdiken lemons. Thus, a significant number of citrus growers have considered alternatives for production. Among these alternatives, organically (ORG) citrus production is a plausible option because of its increasing popularity and high profits.

ORG agriculture has experienced rapid growth in recent years. Although it remains small as a proportion of total agricultural production, it is a growing phenomenon that provides potential alternatives for many growers. In Europe, citrus fruit represents the largest category of ORG fruit sales, and both Europe and Japan import ORG

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citrus fruit and juice from the United States (Liu, 2003). In Çukurova, certified ORG citrus-growing land increased from 1,820 acres in 1996 to 6,056 acres in 2007. In Turkey as a whole, certified ORG citrus-growing land grew from 5,760 to 7,270 acres (Demirkeser, 2008). Çukurova's ORG citrus acreage is intended for the fresh market and is widely exported, particularly to Europe (France, Belgium, Holland, Germany) and Russia. Satsuma mandarins and Valencia oranges are the varieties with the largest ORG production volumes in Hatay. Washington navel oranges and Interdonato lemon varieties have the largest ORG production volumes in Adana and Mersin (Demirkeser, 2008).

Despite the rapid growth of ORG agriculture, information on ORG, in general, and ORG citrus, in particular, is scarce. A major complaint within the ORG community is the lack of university research on ORG agriculture (Athearn, 2004). Determination of plant nutrient status and development of optimum fertilization programs are among the areas where critical research is needed. Optimum fertilization of citrus orchards is important for plant growth and development as well as productivity and quality. Fertilization of mature, fruit-bearing citrus trees is necessary for replenishing nutrients lost during harvest and leaching or volatilization; fertilization also helps trees maintain their vigor and obtain optimum yields (Smith, 1966). Nitrogen has the largest effect on tree growth and yield (Davis and Albrigo, 1994). Citrus trees require relatively low levels of P and K. Fertilization is very important in many citrus-growing regions, particularly in fresh-fruit-producing areas where fruit size is an important concern (Embleton et al., 1978; Davis and Albrigo, 1994). Thus, variation in fertilization rates and the ratio of elements is used commercially to change fruit quality depending on market demands. For satisfactory growth and fruiting, micronutrient elements must sometimes be applied to citrus trees; they may be present in some soils in sufficient and available supply or present in ORG matter added to soil (Jackson, 1991).

The first objective of this study was to determine the important plant nutrient elements in the citrus orchards of the eastern Mediterranean region. The second objective was to compare the plant nutrient status of conventionally (CON) and ORG grown citrus orchards in 1996, when ORG production was initiated in some orchards, and in 2007, after many years of ORG production in those orchards.

MATERIALS AND METHODS

Study area

This study was carried out using plant and soil samples from Samandağ, Hatay, Turkey. Samandağ is located in the Mediterranean coastal area (around 36° 01' N latitude and 36° 01 N' longitude) and has suitable climatic conditions for citrus culture. For example, it has warm winter temperatures (averages temperatures in November, December, January and February are 16, 11, 9 and 11°C, respectively). Citrus culture is one of the most common agricultural practices.

Sampling

The samples included Satsuma mandarins (*C. unshiu* Marc.), Washington navel and Valencia oranges [*C. sinensis* (L.) Osbeck], which were grafted on sour orange (*C. aurantium* L.). Sampling was conducted in 1996 and 2007. In 1996, a total of 58 citrus orchards were sampled and 48 of which used for analyses. All orchards were at least 10 years old and ranged from 5 - 20 da. In Samandağ, a significant proportion of citrus producer switched to ORG culture in the late 1990s; therefore, within three years of the first sampling in 1996, some orchards switched from CON to ORG production. Sampling was repeated in 2007. Thirty-one samples were taken from CON orchards (in both 1996 and 2007). Thirty additional samples were from orchards that switched to ORG after 1996.

The ORG and CON sampling sites were similar in terms of cultural conditions and site characteristics. CON growers followed the regulations of the Department of Agriculture Extension Services for citrus production as well as Integrated Pest Management (IPM). ORG growers, on the other hand, followed their cooperative regulations under the supervision of consultants. They typically used poultry manure (in various degrees of compost) as a nutrient source. ORG bulk blend fertilizers such as potash, beet syrup (potash-rich), dolomite, cow manure, and colloidal phosphate were also used. A majority of growers used a seaweed/humic acid emulsion as a foliar spray for tree nutrition as well as pest control purposes. Additional sources of micronutrients often took the form of liquid foliar sprays. For pest management control, beneficial insect releases, copper, sulfur, vegetable oil, vegetable extract (hot red pepper, thyme) ORG miticide, and sulfur were used.

Soil and plant samples were collected three replicates. Several plants from each species, taken from all directions (east, south, west, and north), were sampled as suggested. In total, 80 - 100 leaves from 4 - 7-month-old non-fruiting spring flush leaves were sampled.

Analysis

All plant samples were placed in polyethylene bags at the sampling site and transferred to the laboratory within 3 h. They were washed immediately upon arrival at the laboratory. Leaves were first washed in tap water with 1% detergent, then rinsed with tap water, and subsequently washed three times with deionised water. The washed leaves were dried at 65 - 70°C for 72 h to a constant weight, then ground on a mill. Plant tissue (0.25 g) was mixed with 2 mL of H_2O, 2 mL H_2O_2 (30%) and 4 mL HNO_3 and heated in a closed-system microwave. The samples were brought up to 25 mL and filtered through blue filter paper. The filtrate was analyzed for micro nutrients and heavy metals by leveled ICP-OES (Perkin Elmer, Optima 2000 DV, Waltham, Massachusetts 02451, USA) and P by the Barton reagent at UV/Vis spectrometer (Shimadzu, 1208). Total N was determined by Kjeldahl procedure.

The soil samples were analyzed using the DTPA (diethylenetriaminepentaacetic acid) method of Lindsay and Norvell (1978). With this method, the experimental material was passed through a 2 mm stainless steel screen from which a 10 g-subsample was processed in 20 ml 0.05 M DTPA (pH 7.3) for 2 h. After shaking, the solution was filtered through blue filter paper (Schleicher and Schuell, Dassel, Germany), and the filtrate was analyzed directly by Inductively Coupled Plasma-Optical Emission Spectrometry (ICP-OES) (Perkin Elmer, Optima 2000 DV, Waltham, Massachusetts 02451). Soil pH was measured using a digital pH-meter (Model 691, Metrohm AG Herisau Switzerland).

Statistical analysis

The data were analyzed using SAS (SAS, 2005). CON and ORG samples were compares using a t-test at 5%, assuming equal variance for the two sets of samples. To evaluate the overall diversity pattern between plant samples, the two groups' data on 11 elements (N, P, K, Ca, Mg, Na, B, Cu, Fe, Mn and Zn) were analyzed with PCA.

RESULTS AND DISCUSSION

We tested the concentrations of several nutrient elements (N, P, K, Ca, Mg, Na, B, Cu, Fe, Mn and Zn) in plant samples in 1996. The results indicated that the means of the CON samples were similar to those of the samples that later shifted to ORG. For example, the means for N, P, K and Na were 2.43 vs. 2.51%; 0.11 vs. 0.12%; 0.66 vs. 0.70%; and 0.05 vs. 0.05% for CON and ORG, respectively (Table 1). The differences between the two sets were not significant for any of the elements except B. The CON group had higher concentrations of B as compared to the ORG samples (114 vs. 53 mg kg^{-1}); this finding is thought to be attributable to sampling error. Overall, the results presented in Table 1 indicate that the plant nutrient status for both groups was similar at the beginning of the experiments.

When the tabulated means were compared to the optimum values for citrus production (Marchal, 1987), some deviations were observed (Table 2). For example, mean levels of K for both CON and ORG grown orchards were below the suggested range. Similar results were found for Mn concentrations. For mean levels of Fe, only CON cultured Washington navel oranges were within the optimum range. Some samples showed above-optimum levels of Ca and Mg.

The mean concentrations of the same plant nutrient elements in 2007 are presented in Table 2. The results revealed that the means of several plant nutrient concentrations in ORG orchards were similar to those in CON orchards. For example, the mean levels of P, Na, Cu and Zn for CON and ORG groups were 0.12 vs. 0.14; 0.09 vs. 0.10; 11 vs. 11; and 13 vs. 13 mg kg^{-1}, respectively. T-tests revealed, however, that there were statistically significant differences in levels of N, K, Mg, B and Mn. Similar to the 1996 results, there were significantly higher levels of B in the CON samples than in the ORG samples (81 vs. 55 mg kg^{-1}). The CON group also had higher means for N and Mg concentrations (2.63 vs. 2.50% and 0.51 vs. 0.34 mg kg^{-1}) as compared to the ORG group. Conversely, the means of K and Mn for ORG orchards were higher than those of CON orchards (1.03 vs. 1.20% and 11 vs. 14 mg kg^{-1}).

When the means from 2007 were compared with the optimum ranges (Marchal, 1997), it was concluded that concentrations of P, Na, B, Cu and Fe were all within the range. For N, only CON grown Washington navel oranges had concentrations above the optimum range (Table 2). Ca concentrations of Washington navel oranges were found to be above the optimum range for both ORG and CON groups. While the mean of three cultivars for ORG culture was within the range, the mean K concentrations of Satsuma mandarins and Washington navel oranges were below the optimum range. CON-grown Washington navel oranges had concentrations of Mg outside the optimum range, while their ORG counterparts were all within range. All cultivars, regardless of growing conditions, had lower means for Mn and Zn concentrations than the optimum ranges.

The results of PCA indicated that, after 11 years of ORG culture in 30 sample orchards, the overall diversity patterns made it possible to group the two sets. The three-dimensional figure of the PCA results separated the two groups (Figure 1). In this analysis, the first three PCs explained 22, 21 and 13% of total variation. The variables highly correlated with PC1 were Ca, Fe and Na; P, K, Mg and Mn were correlated by PC2, and B, Fe and Zn were correlated by PC3 (Table 3).

Several trace elements (Pb, Cu, Fe, Mn, Ni and Zn) in five randomly chosen soil samples from both CON and ORG growing groups were determined (Table 4). The results indicated that the mean concentrations for most of the elements were similar between the two groups (Pb, Cu, Fe and Ni). However, t-tests indicated that there were significant differences between the means of the two groups for Cd, Co, Mn and Zn. For all elements, ORG-grown samples had higher means than CON-grown samples.

pH and salt concentrations of the five randomly chosen samples from CON and ORG growing groups were determined at two depths, 0 - 30 and 30 - 60 cm. T-test results revealed no significant differences between the two depths for any of the elements tested (results not presented). Moreover, pair-wise comparisons between CON and ORG yielded no significant differences at two depths for both pH and salt concentration means (Table 5).

The popularity of ORG production is increasing for many crop species, including citrus. One of the main reasons for this is that ORG produce is thought to be better tasting and more nutritious than CON produce. Recent studies have provided support for this claim. For example, Laster et al. (2007) compared the juice properties of Rio Red grapefruits grown under either ORG or CON conditions and found that the ORG samples had thinner peels and juices higher in ascorbic acid and sugars and lower in nitrates and furanocoumarins. Turra et al. (2006) also found significant differences for several plant-nutri elements (Br, Co, Cs, La and Rb) in the juices of ORG and CON grown Valencia oranges and Rangpur limes.

In our study, we compared the plant nutrient status of CON and ORG grown citrus orchards from Samandağ, located in the Mediterranean coastal area. The comparisons were made using 11 nutri-elements (N, P, K, Ca, Mg, Na, B, Cu, Fe, Mn and Zn). Our results indicated

Table 1. Several plant nutrient element contents for Satsuma, Washington navel and Valencia citrus cultivars sampled in 1996. Within the next four years, organic culture was initiated at 15 of the sample orchards. Values represent means of three replications. Conventional and organic cultures were compared by t-tests at 5%.

Source	Sample number	N	P	K	Ca	Mg	Na	B	Cu	Fe	Mn	Zn
		(%)							(mg kg^{-1})			
Conventional (CON)												
Satsuma	14	2.49	0.12	0.56	5.76	0.60	0.04	117	13	50	10	50
Washington navel	9	2.44	0.12	0.72	8.15	0.50	0.07	135	14	65	16	54
Valencia	8	2.31	0.10	0.77	5.94	0.51	0.07	83	13	48	10	35
Mean/Total	31	2.43	0.11	0.66	6.53	0.55	0.05	114	13	54	12	48
Organic (ORG)												
Satsuma	5	2.53	0.11	0.62	6.04	0.55	0.04	64	15	58	15	51
Washington navel	5	2.53	0.12	0.85	5.42	0.50	0.05	50	11	49	13	34
Valencia	5	2.45	0.11	0.83	5.70	0.42	0.06	44	9	58	13	34
Mean/Total	15	2.51	0.12	0.77	5.72	0.49	0.05	53	12	55	14	40
Significance P-value												
CON vs. ORG		0.338	0.884	0.068	0.286	0.252	0.442	0.008	0.679	0.777	0.339	0.438
Optimum range*		2.20-2.70	0.12-0.18	1.00-1.70	3.00-6.00	0.30-0.50	0.01-0.15	36-100	5-15	60-150	25-100	25-100

*According to Marchal (1987).

Table 2. Several plant nutrient element contents for Satsuma, Washington navel and Valencia citrus cultivars sampled in 2007 after many years of organic culture at 27 the sample orchards. Thirty-one samples represent conventional orchards. Values represent means of three replications. Conventional and organic cultures were compared by t-tests at 5%.

Source	Sample number	N	P	K	Ca	Mg	Na	B	Cu	Fe	Mn	Zn
		(%)							(mg kg^{-1})			
Conventional (CON)												
Satsuma	14	2.62	0.12	0.93	4.23	0.50	0.07	73	12	134	10	14
Washington navel	8	2.54	0.12	0.99	7.02	0.57	0.12	97	8	140	10	11
Valencia	9	2.72	0.14	1.23	5.98	0.49	0.10	79	12	142	11	13
Mean/Total	31	2.63	0.12	1.03	5.46	0.51	0.09	81	11	138	11	13
Organic (ORG)												
Satsuma	10	2.51	0.13	1.16	4.48	0.34	0.06	53	9	129	14	13
Washington navel	9	2.43	0.13	1.05	7.35	0.36	0.13	55	12	142	15	12
Valencia	8	2.57	0.16	1.41	5.75	0.33	0.12	59	11	120	15	12
Mean/Total	27	2.50	0.14	1.20	5.81	0.34	0.10	55	11	130	14	13

Table 2. Cond.

Significance P-value												
CON vs. ORG		0.018	0.114	0.036	0.464	0.000	0.476	0.001	0.974	0.358	0.000	0.873
Optimum range*		2.20-2.70	0.12-0.18	1.00-1.70	3.00-6.00	0.30-0.50	0.01-0.15	36-100	5-15	60-150	25-100	25-100

*According to Marchal (1987).

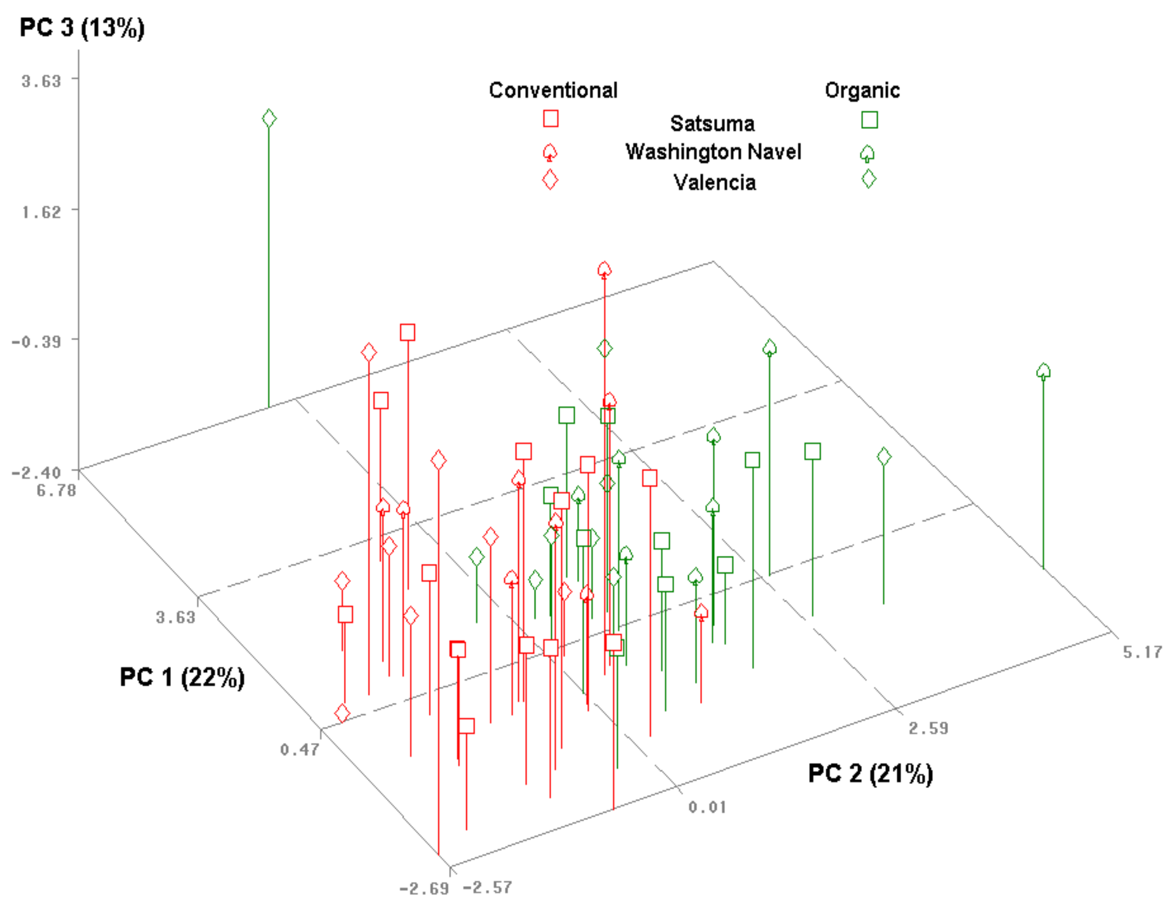

Figure 1. Principle component (PC) analysis plot of the first three PCs depicting relationships among the Satsuma, Washington Navel and Valencia cultivars. Samples included conventionally cultured and organically cultured citrus orchards. Analysis was conducted using the 11 plant nutrient elements presented in Table 2.

Table 3. Coefficients and eigenvalues for the first three principle components (PC) of PCA analysis. The analysis was conducted using several plant nutrient element contents for Satsuma, Washington navel and Valencia citrus cultivars sampled in 2007 (after many years of organic culture for 30 of the sample orchards).

Variable	PC1	PC2	PC3
N	-0.30	-0.20	-0.07
P	-0.22	0.43	0.25
K	-0.29	0.42	0.33
Ca	0.43	-0.12	-0.17
Mg	-0.14	-0.55	0.03
Na	0.40	0.11	0.06
B	-0.15	-0.27	0.50
Cu	0.17	-0.03	-0.09
Fe	0.44	-0.16	0.43
Mn	0.30	0.40	-0.21
Zn	0.26	0.03	0.55
Eigenvalue	2.39	2.28	1.46
Proportion	0.22	0.21	0.13

Table 4. Several plant nutrient element contents of five randomly selected soil samples from conventionally and organically cultured citrus orchards. Values represent means of three replications expressed in mg kg-1. Conventional and organic cultures were compared by t-tests at 5%.

Source	K	P	Pb	Cu	Fe	Mn	Ni	Zn
Conventional (CON)								
43	37.1 ± 0.4	558 ± 8	0.3 ± 0.1	1.1 ± 0.1	7.1 ± 1.8	5.1 ± 0.6	2.6 ± 0.8	0.7 ± 0.4
48	18.2 ± 0.7	577 ± 18	0.6 ± 0.2	2.3 ± 0.6	12.8 ± 3.8	6.1 ± 1.6	4.3 ± 1.1	2.1 ± 1.5
52	34.9 ± 0.9	742 ± 7	0.4 ± 0.1	1.5 ± 0.1	8.7 ± 0.6	4.0 ± 0.9	3.0 ± 0.5	1.1 ± 0.6
57	24.2 ± 0.2	455 ± 17	0.5 ± 0.1	1.3 ± 0.0	4.5 ± 0.7	5.7 ± 1.0	3.6 ± 0.2	0.6 ± 0.5
82	17.2 ± 0.5	290 ± 13	0.9 ± 0.1	1.0 ± 0.1	5.0 ± 1.5	5.5 ± 1.1	3.9 ± 0.8	0.7 ± 0.3
Mean	26.3 ± 0.55	524 ± 13	0.5 ± 0.2	1.4 ± 0.5	7.6 ± 3.6	5.3 ± 1.2	3.5 ± 0.9	1.0 ± 0.9
Organic (ORG)								
16	35.9 ± 0.5	566 ± 5	0.5 ± 0.1	1.8 ± 0.2	7.6 ± 1.8	6.7 ± 1.4	2.8 ± 0.5	3.3 ± 2.0
22	34.6 ± 0.5	530 ± 0	0.8 ± 0.1	2.0 ± 0.4	10.4 ± 0.1	7.6 ± 0.8	3.4 ± 0.2	3.6 ± 1.1
23	28.9 ± 0.3	498 ± 9	0.5 ± 0.2	2.4 ± 1.5	5.4 ± 0.9	8.1 ± 2.7	2.6 ± 1.0	2.2 ± 1.8
25	5.9 ± 0.5	263 ± 9	0.5 ± 0.1	1.2 ± 0.0	6.1 ± 0.4	7.6 ± 0.2	2.7 ± 0.1	0.7 ± 0.1
27	34.3 ± 0.9	482 ± 7	0.6 ± 0.0	1.7 ± 0.1	7.4 ± 0.2	6.6 ± 1.3	3.4 ± 0.5	5.1 ± 1.6
Mean	27.9 ± 0.6	467 ± 6	0.6 ± 0.2	1.8 ± 0.8	7.4 ± 2.0	7.3 ± 1.5	3.0 ± 0.6	3.0 ± 2.0
Significance (*P* value)								
CON vs. ORG	0.827	0.355	0.316	0.085	0.817	0.000	0.057	0.000

that, at the first sampling, when all sites were CON grown, both groups had comparable means for all elements (excluding B, where the difference may have been caused by sampling error). After many years of ORG growing, the two groups diverged based on their plant nutrient status, as shown by PCA results (Figure 1). PCA is a commonly used statistical analysis method for comparing CON and ORG groups when many nutri-elements are tested. For example, Gundersen et al. (2000) clearly separated CON and ORG grown onions and peas; they used samples from 21 sites and analyzed 63 elements. For our study, the important elements explaining overall patterns were P, K, Ca, Mg, Na, Fe, Mn and Zn. The most apparent differentiation of two groups was found with PC2. As expected, most of the significant elements for these two groups and elements highly correlated with PC2 overlapped.

Similar to our study, the nutrient status of citrus (Navalina and Tarocco oranges and Commune clementines) grown either CON or ORG in the Mediterranean basin was compared for plant nutrient elements as well as agronomic differences. The two groups did not differ on

Table 5. pH and salt contents of five randomly selected soil samples from conventionally (CON) and organically (ORG) cultured citrus orchards. Values represent means of three replications. Conventional and organic cultures were compared by t-tests at 5%.

	pH		Salt (mS)	
Sample	**CON**	**ORG**	**CON**	**ORG**
0-30 cm				
2	7.92 ± 0.02	8.01 ± 0.02	0.17 ± 0.01	0.12 ± 0.02
16	7.64 ± 0.03	7.85 ± 0.03	0.35 ± 0.01	0.14 ± 0.01
23	7.71 ± 0.01	7.93 ± 0.02	0.24 ± 0.02	0.11 ± 0.00
25	7.86 ± 0.03	7.96 ± 0.01	0.13 ± 0.01	0.11 ± 0.01
27	7.96 ± 0.01	7.84 ± 0.01	0.11 ± 0.01	0.14 ± 0.01
Mean	7.82 ± 0.02	7.92 ± 0.02	0.20 ± 0.01	0.12 ± 0.01
Significance (*P*) CON vs. ORG	0.188		0.125	
30-60 cm				
2	7.96 ± 0.01	8.05 ± 0.05	0.14 ± 0.01	0.09 ± 0.01
16	7.62 ± 0.01	7.93 ± 0.01	0.46 ± 0.01	0.15 ± 0.01
23	7.82 ± 0.02	7.97 ± 0.01	0.21 ± 0.01	0.10 ± 0.01
25	7.88 ± 0.02	7.96 ± 0.02	0.14 ± 0.02	0.10 ± 0.01
27	7.950.02	7.92 ± 0.02	0.11 ± 0.01	0.11 ± 0.01
Mean	7.84 ± 0.02	7.96 ± 0.02	0.21 ± 0.01	0.11 ± 0.01
Significance (*P*) CON vs. ORG	0.101		0.149	

agronomic parameters and, although some nutrient contents (especially N) were higher in ORG citrus, the overall patterns were similar (Canali et al., 2002). N usually differed among the fruits of CON and ORG grown citrus, such that markers were developed to detect differences in nitrogen content and nitrogen metabolism components as a tool for discriminating between the two groups (Rapisarda et al., 2005).

In our study, the plant nutrient status of the ORG and CON groups differed for N, K, Mg, B, and Mn. We recovered lower N concentrations in or ORG samples when compared to CONs. This is an expected results considering CON utilizes mineral fertilizers most of which having N in several forms. It is also known that N and mostly applied elements in CON fertilization and it may have negative effects on productivity, quality parameters and environment.

It was found that ORG cultivation increased concentrations of Mn, Zn, Co and Cd in soil as compared to CON. These differences were possibly caused by the activities of the materials added as fertilizer in ORG cultivation. The ORG citrus production system has higher microbial biomass carbon and a higher respiration and metabolic quotient (respiration/biomass) as compared to CON citrus orchards (Franca et al., 2007). This may be explained by the increase in the movement of Zn and other elements caused by organic matter. Organic matter may increase the element concentration moved to the root zone by chelating the plant nutria elements. Moreover, organic matter may cover the mineral fractions which absorb plant nutria elements therefore increase the availability of the nutri elements in soil.

In summary, our study demonstrated that ORG and CON citrus orchards grown under Mediterranean conditions can become differentiated after just a few years of ORG culture. We also showed that this differentiation can be modeled by multivariate analysis. We discovered lower N, P, Mg, B and Mn concentrations in ORG grown orchards and suggested better plant nutrient programs for these elements. This suggestion can be extended to other elements like Mn and Zn, of which ORG had higher concentrations.

REFERENCES

Anonymous (2005). Tarımsal Yapı ve Üretim. DİE Yayın No: 3070, Ankara.

Athearn K (2004). The Florida Organic Citrus Sector: Results of a (2003-2004) Study. Final Project Report, University of Florida, FL.

Canali S, Trincher A, Di Bartolomeo E, Benedetti E, Intrigliolo F, Calabretta ML, Giuffrida G, Lacertosa G (2002). Soil fertility status of conventional and organic managed citrus orchards in Mediterranean area. Options Méditerranéennes, Série A 50: 275-284.

Davis FS, Albrigo LH (1994). Citrus, CAB International, Wallingford, UK.

Demirkeser TH (2008). Citrus organic farming in Turkey. Çukurova's organic citrus sector analysis (unpublished).

Embleton TW, Jones WW, Pallares C, Platt RG (1998). Effects of fertilization of citrus on fruit quality and ground water nitrate-pollution potential. In: Proceedings of the International Society of Citriculture, Sydney, Australia, pp. 280-285.

FAO (1996). FAOSTAT: Statistical Database. http://faostat.fao.org.

FAO (2006). FAOSTAT: Statistical Database. http://faostat.fao.org.

Franca SC, Gornes-da-Costa SM, Silveira APD (2007). Microbial activity and arbuscular mycorrhizal fungal diversity in conventional and organic citrus orchards. Biol. Agric. Horticult. 25: 91-102.

Gundersen V, Bechmann IE, Behrens A, Sturup S (2000). Comparative investigation of concentrations of major and trace elements in organic and conventional Danish agricultural crops 1. Onions (*Allium cepa*

Hysam) and peas (*Pisum sativum* Ping Pong). J. Agric. Food Chem. 48: 6094-6102.
Jackson LK (1991). Citrus Growing in Florida. University of Florida Press, Gainesville.
Kaplankıran M, Demirkeser TH, Toplu C, Uysal M (2001). The structure of citrus production, the status of rootstocks and nursery tree production in Turkey. In: 6th International Congress of Citrus Nurserymen (Eds. Donadio LC, Moreira CS, Stuchi ES), Ribeirao Preto, Brazil, pp. 190-195.
Lester GE, Manthey JA, Buslig BS (2007). Organic vs. conventionally grown Rio red whole grapefruit and juice: Comparison of production inputs, market quality, consumer acceptance, and human health-bioactive compounds. J. Agric. Food Chem. 55: 4474-4480.
Lindsay WL, Norvel WA (1978). Development of a DTPA soil test for zinc, iron, manganese, and copper. Soil Sci. Soc. Am. J. 42: 421-428.
Liu P (2003). World markets for organic citrus and citrus juices. Food and Agriculture Organization of the United Nations (FAO), Rome.
Marchal J (1987). Citrus. In: Plant analysis (Eds. Prevel PM, Gagnard J, Gautier P) Lavoiser Publishing, NY., USA.
Özsan M (1979). Türkiye turunçgil yetiştiriciliğinin dünyadaki yeri ve önemi. In: Akdeniz bölgesi bahçe bitkileri yetiştiriciliğinde sorunlar ve çözüm yolları ve yapılması gereken araştırmalar simpozyumu, İncekum, Alanya Antalya, Turkey, pp. 40-46.
Rapisarda P, Calabretta ML, Romano G, Intrigliolo F (2005). Nitrogen metabolism components as a tool to discriminate between organic and conventional citrus fruits. J. Agric. Food Chem. 53: 2664-2669.
SAS Institute (2005). SAS Online Doc, Version 8. SAS Inst., Cary, NC.
Smith PF (1966). Citrus Nutrition. In: Fruit Nutrition (Ed. Childers NF). Horticult. Publications, New Jersey, pp. 174-207.
Turra C, Fernandes EAN, Bacchi MA, Tagliaferro FS (2006). Differences between elemental composition of orange juices and leaves from organic and conventional production systems. J. Radioanalytical Nucl. Chem. 270: 203-208.