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Nutritional Status in Some Kiwifruit (*Actinidia deliciosa*) Orchards: A Case Survey from Karadeniz Region in Turkey

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Abstract: A survey study was initiated to determine the nutritional status of kiwifruit grown in the Ordu province in eastern part of the Karadeniz Region in Turkey. For this purpose soil and leaf samples were taken from 50 different kiwifruit orchards. Not only some soil chemical and physical properties and but also plant nutrient levels were determined and observed values were compared with their critical values and the degree of sufficiency was evaluated. According to the results, soils have medium-coarse in texture, slightyly and moderately in acid reactions, low in lime content, good in organic matter content. In general, available phosphorus, exchangable potassium, calcium and magnesium, available iron, copper, zinc and manganase contents of soil samples were sufficient. Soil has boron and nitrogen deficiency following order 26 and 22%. Kiwifruit leafs have sufficient and excess levels for boron, iron, copper, zinc and manganase, while nitrogen, phosphorus, potassium, calcium and sodium and chlorine were deficient levels following order 64, 24, 26, 100 and 84%.

Key words: Kiwifruit, plant nutrients, nutritional status, Ordu

INTRODUCTION

Actually Ordu province, near the Black Sea and part of the eastern Turkey, is the center of hazelnut production. But, kiwifruit cultivation has been developing a lot in our country since 1988. Ordu province has the second arranged according to growing area and has the third arranged to amount of kiwifruit production (Karadeniz *et al*., 2003). The Karadeniz (entitled as Blacksea) and the Marmara Regions have pioneered during the last twenty years to kiwifruit production of Turkey (Özcan and Zenginbal, 2003). Since this cultivation is rather recent, the practices of growing are stil not good enough for the best production results. Fertilization experiment of kiwifruit has begun since spring 1999 (Cangi *et al*., 2003).

In such favoured localities, symptoms of nutrient deficiencies are not often seen in kiwifruit vines. However, keeping the vines are highly fertile they must be adequately and regularly supplied with nutrutients. Annual uptakes by mature kiwifruit plants are greatest for nitrogen, potassium and calcium (between 125 and 180 kg ha^{-1}) while smaller quantities of chlorine (60 kg ha^{-1}), phosphorus, magnesium and sulphur (<25 kg ha^{-1}) are taken up. The quantity of nutrient recovered from fertilizer by mature kiwifruit vines are usually less than 50% for most elements (Smith *et al*., 1997).

In spite of the importance acquired by kiwifruit culture in the Eastern Karadeniz region, some orchards have problems related to growth and yield. Among of these problems, the nutritional status

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and pruning, may play an important role. To researchers, the type and amount of fertilizer and application times are different from region to region. Therefore, soil and leaf samples analysis has been evaluated together solving nutritional problems for kiwifruit and other plants (Battelli and Renzi, 1990; Tarakçıoğlu *et al*., 2003; Adiloğlu and Adiloğlu, 2005; Aydın *et al*., 2006). As no adequate research study concerning leaf diagnostic and soil fertility status in Turkey had been made we felt it necessary to carry out this type of analysis. It was reported that nutritional disorders of kiwifruit are common among vines grown in New Zealand (Smith *et al*., 1987a). While potassium deficiency is by far the most wide-spread of these disorder (Smith *et al*., 1987b) extensive surveys of the major growing regions of New Zealand and Greece have shown an unexpectedly large number of vines affected by excess boron (Smith *et al*., 1987b; Sotiropoulos *et al*., 1999, 2004).

Relevant data of the Ordu province in the Eastern Karadeniz Region in Turkey are missing. Therefore, the objective of the present study was to evaluate nutritional status in some kiwifruit orchards.

MATERIALS AND METHODS

Study Site and Design

A survey study was carried out on Hayward kiwi (*Actinidia deliciosa*) cultuvar vines in Ordu province of Turkey during 2001-2002 growing season. Ordu district is located in the Black Sea region of te northern Turkey (40°18'N, 38°40'E) and has semi-humid climate with temperatures ranging from -7.2°C in January to 33°C in June. The hottest months are June and August near the Black Sea. The annual mean temperature is 13.9°C and the annual mean precipitation is 1103 mm based on a 25-year period (Anonymous, 2004).

Soil and Leaf Sampling and Preparation for Analysis

Soil samples of 500 g field-moist weight were collected from the 0-20 cm (D_1) and 20-40 cm (D_2) in depths at 50 sampling points using a soil sampler. Plant residues and roots were removed by hand and soils were sieved through a 2 mm grid and transferred to laboratory cool boxes. Samples were kept at room temperature and then analyzed. All data reported are means of three replicates and are expressed on a moisture-free basis. Moisture content was determined by drying the soil samples at 105°C for 24 h (Soil Survey Staff, 1993).

Leaf samples were taken from the second leaf, consist of the youngest fully expanded leaves, past the final fruit cluster on a fruiting at fruit set in mid June (Smith *et al*., 1987a; Sale and Lyford, 1990). Samples were washed with distilled water and then dried at 65°C temperature. The dried and finely ground plant tissue was ashed at 500°C by a muffle furnace for 5 h, dissolved in 5 mL of 2M HNO_3 and finally diluted to 25 mL with reverse osmosis water (Kacar, 1972).

Soil Physicochemical Analysis

Soil organic matter content was measured following a modified Walkley-Black method (Nelson and Sommers, 1982). The soil particle size distribution was determined by the hydrometer method (Gee and Bauder, 1979). Lime content was measured using a Scheibler calcimeter (Soil Survey Staff, 1993) and soil pH was measured based on a 1:2.5 (w/v) soil-water ratio using a pH meter with a glass electrode (Peech, 1965). Cation exchange capacity (CEC) and exchangable K, Na, Ca were determined by neutral ammonium acetate extraction using flamephotometer (Chapman and Pratt, 1961). Total nitrogen was established by Kjeldahl method (Bremner, 1965). Soil trace elements (Fe, Cu, Zn and Mn), after extracting with DTPA solution, were determined by atomic absorption spectrophotometer (Lindsay and Norvell, 1978). Water soluable boron was determined according to azomethine colorimetric method by NaOAc extraction (Wolf, 1971). Water extractable chlorine was determined by potentiometric titration with $AgNO_3$ (Johnson and Ulrich, 1959). Available phosphorus, according to their soil reaction, was established by 0.025 N HCl-0.03 N NH_4F extraction (Bray and Kurtz, 1945) and by $NaHCO_3$ extraction procedure (Olsen *et al*., 1954).

Leaf Analysis

Leaf samples were analyzed for total nitrogen, phosphorus, potassium, calcium, sodium, iron, copper, zinc, manganase according to Kacar (1972) and water extractable Cl also determined by Johnson and Ulrich (1959). Boron was determined using the azomethine-H reagent method, spectrophotometrically (John *et al*., 1975). Plant nutrient levels were evaluated according to their critical values (Testolin and Crivello, 1987).

RESULTS AND DISCUSSION

Soil Properties

Descriptive statistics on some soil properties are presented in Table 1. Soil texture was not similar for all samples, determining seven textural class (C, L, CL, SL, SCL, SC, LS) also clay, silt and sand contents of the 50 samples were between 6-53, 13-46 and 23-77% at D_1 in depth and 11-59, 6-38 and 17-76% at D_2 in, respectively. Also soil pH ranged from 4.60 to 8.37 (at D_1) and 4.71 to 8.38 (at D_2). Soil samples were moderately acidic (26%), slightly acidic (32%) and neutral (26%) in reaction at D_1 in depth and were of 18, 36 and 30% of soil samples at D_2 in depth, respectively. Soils were nearly low in lime content (average of 2.07% at D_1 and 2.24% at D_2). Kiwifruit grows the best on soils between 5.5 and 6.5 pH so liming is necessary to kiwifruit growing in acid soils (Smith *et al*., 1987a). Soils have high and moderate in organic matter content at D_1 and D_2 in depth (average of 3.52% and 2.54%, respectively). Organic matter contents were poor (10%), insufficient (18%), good (40%) and high (32%) in levels at D_1 and were poor (22%), insufficient (32%), good (28%) and high (18%) at D_2 in depths, respectively (Anonymous, 1991).

Table 1: Descriptive statistics on selected physical and chemical properties of soil samples (n = 50)

		Soil depth (cm)							
		0-20 (D_1)				20-40 (D_2)			
Properties		Min	Max	Mean	SD	Min	Max	Mean	SD
Clay		6.00	53.00	24.30	10.16	11.00	59.00	29.20	10.56
Silt		13.00	46.00	28.90	6.54	6.00	38.00	25.00	7.19
Sand	(%)	23.00	77.00	46.80	13.86	17.00	76.00	45.80	14.46
LC		trace	49.70	2.07	8.43	trace	53.80	2.24	9.21
OMC		0.14	10.18	3.52	2.30	0.14	9.22	2.54	2.05
N		0.004	0.433	0.161	0.099	0.004	0.348	0.111	0.080
pH	1:2.5 (w/v)	4.60	8.37	6.34	1.08	4.71	8.38	6.45	1.07
P, (mg kg^{-1})	Olsen	10.50	154.90	59.53	42.99	15.50	146.40	55.41	36.04
	Bray	1.60	233.30	79.66	56.50	trace	262.50	44.08	64.23
CEC		18.50	70.30	34.34	10.52	17.10	67.40	32.64	10.39
K		0.21	6.52	1.28	1.10	0.15	6.08	0.94	1.05
Ca	(cmol kg^{-1})	1.81	32.60	16.52	8.03	0.64	28.60	13.71	8.03
Mg		0.74	28.80	6.40	5.41	0.68	34.84	7.38	6.21
Na		0.16	2.24	0.58	0.35	0.11	0.90	0.39	0.17
Cl		25.00	200.00	122.00	40.97	50.00	150.00	102.00	26.90
Fe		7.20	226.40	53.50	47.10	5.70	208.20	38.20	39.60
Cu	(mg kg^{-1})	0.22	24.28	3.12	3.65	0.12	25.58	2.52	3.78
Zn		0.17	58.01	5.50	9.53	0.04	36.89	2.50	5.87
Mn		3.90	226.10	50.30	47.40	3.00	172.2.0	30.20	33.10
B		0.53	2.85	1.31	0.52	0.27	2.47	0.90	0.50

LC, Lime Content; OMC, Organic Matter Content; N, Nitrogen; CEC, Cation Excheange Capacity; SD, Standard Deviation

Total nitrogen contents of 26% of soil samples was poor and low in levels, 74% was sufficient and high in levels at D_1 in depth while were 48% poor and low, 52% sufficient and high in levels at D_2 in depth (Anonymous, 1991). Up to 50% reduction in photosynthesis rate has been measured on kiwifruit leafs assigned to be nitrogen deficient (Smith *et al*., 1997). Regarding the available phosphorus, 96% and 78% of the soil samples at D_1 and D_2 in depth showed sufficient and high in levels, respectively (Anonymous, 1990). It has been determined cation exchange capacity values of soils (CEC) ranged from 18.5 to 70.3 and 17.1 to 67.4 cmol kg^{-1} at D_1 and D_2 in depth. According to Dawson, CEC values were found to be adequate and high in nutrient holding capacity at every soil depth (Dawson, 2001). While percentage of soil samples assigned to be sufficient and high their potassium content was 80% at D_1 in depth, this ratio was 52% at D_2 in depth (Pizer, 1967). Potassium is an important element for kiwifruit nutrition. Potassium deficiency severely reduces fruit yield, both fruit numbers and fruit size being affected (Smith and Clark, 1984; Smith *et al*., 1985). The potassium adsorption ratio ranged from 31.3 to 81.8% in the some kiwifruit growing soils in Ordu province (Aşkın *et al*., 2003). Also, the highest yields were obtained when 800 g of K_2SO_4 per vine applied for the kiwifruit grown in sandy loam soils (Cangi *et al*., 2003). With respect to exchangable calcium, it was determined to be very low in levels of 4% of soils, low of 8%, medium of 28% and adequate of 60% at D_1 in depth while at D_2 in depth it was found to be 8, 18, 26 and 48% and exchangable magnesium contents were usually sufficient in levels (Loue, 1968). Exchangable sodium ranged from 0.16 to 2.24 cmol kg^{-1} at D_1 and 0.11-0.90 cmol kg^{-1} at D_2 in depths. The chloride contents of soils varied from 25 to 200 mg kg^{-1} and 50 to 150 mg kg^{-1} at D_1 and D_2 in depths, respectively. However, unlike other plant species, which require large concentration of chloride ions for growth and can tolerate sodium ions, kiwifruit is extremely sensitive to comparatively low concentrations of sodium ions in their root zone (Smith and Clark, 1986; Smith *et al*., 1987a,c, 1988). The accumulation of sodium in the roots is typical for a natrophobic species (Smith *et al*., 1978) and may be a mechanism for preventing possible adverse effects of this elements on the aerial tissues (Marschner, 1971). In addition to, sodium and chloride were effective ions on plant growth and mineral contents in kiwifruit plants were reported by Cangi and Tarakçioğlu (2006).

It has been determined the DTPA-extractable micro elements of soils were 7.2-226.4 mg kg^{-1} Fe, 0.22-24.28 mg kg^{-1} Cu, 0.17-58.01 mg kg^{-1} Zn and 3.9-226.1 mg kg^{-1} Mn at D_1 in depth. According to FAO Fe, Cu and Zn contents of the soils were usually considered to be sufficient and high in levels for all soil depths, whereas 24 and 40% were found low in Mn content at every soil depth (Anonymous, 1990). Available boron contents of soils were found to below 22 and 68% in all of soil depths (Wolf, 1971).

Leaf Nutrient Concentrations

Descriptive statistics on the leaf nutrient concentrations (maximum, minimum, mean and standard deviation) are given in Table 2. The contents of leaf nutrient are compared with the recommended

Table 2: Concentration of leaf nutrients of kiwifruit (n = 50)

Nutrient		Min	Max	Mean	SD
N		1.30	2.92	2.12	0.34
P		0.12	0.63	0.25	0.10
K	(%)	1.00	4.02	1.96	0.56
Ca		1.29	2.49	1.92	0.30
Cl		0.10	1.10	0.42	0.23
Na		144.00	349.00	231.30	46.04
Fe		105.90	355.70	171.70	48.78
Cu	(mg kg^{-1})	5.60	22.80	15.40	3.83
Zn		18.60	94.40	52.10	18.65
Mn		53.20	664.00	269.40	175.10
B		34.00	79.50	63.40	10.32

SD; Standard Deviation

sufficient values given by Testolin and Crivello (1987). The N concentration ranged from 1.30 to 2.92% (average of 2.12%) assigned 64% of the leaf samples showed an inadequate N supply and fertilization techniques. The P contents of leaves ranged from 0.12 to 0.63% (average of 0.25%). The P levels were found to be low with the 24%, sufficient with the 46% and high with the 30% according to the leaf critical contents of P by Testolin and Crivello (0.18 to 0.25%). Given by Testolin and Crivello (1987) regarding the critical K content of kiwifruit leaves range between 1.6 and 2.0%. Twenty six percent of the leaf K contents, ranged from 1.00 to 4.02% and average of 1.96%, were lower than that of the critic level, however 32% were sufficient in levels and 42% were high in levels (Table 2). It was reported the high incidence of bacterial blossom root caused by *Pseudomonas viridiflava* observed on potassium deficient vines may have contributed to the much lower numbers of fruit per vine and hence total yield, since infected flowers usually fail to set fruit (Smith *et al.*, 1985, 1987b).

Calcium concentrations of leafs ranged from 1.29 to 2.49% (average of 1.92%) were found to be severely deficient, according to their sufficiency by Testolin and Crivello (1987) for Ca is ranged from 2.5 to 3.0%, with the 100%. Chlorine concentrations of leafs, ranged from 0.10 to 1.10% and average of 0.42%, were found to be severely deficient, to their sufficiency for Cl is ranged from 0.60 to 1.50%, with the 84%. Also Na concentrations ranged from 144.0 to 349.0 mg kg^{-1} (average of 231.3 mg kg^{-1}) and were found to be severely deficient, deficiency level for Na is ranged from 400 to 1400 mg kg^{-1} by Testolin and Crivello (1987), with the all of them. Preliminary studies, however, have unexpectedly shown kiwifruit to have an abnormally large requirement for chlorine (Smith and Clark, 1986; Smith *et al.*, 1987c).

It has been determined the micro elements of leafs were 105.9-355.7 mg kg^{-1} Fe, 5.6-22.8 mg kg^{-1} Cu, 18.6-94.4 mg kg^{-1} Zn and 53.2-664.0 mg kg^{-1} Mn, respectively. Normally, Fe content of kiwifruit plant is <102 mg kg^{-1} as dry matter assumed to be sufficient level. Based on this criterion, the leafs of kiwifruit plants has no Fe deficiency. Also Fe, Cu, Zn and Mn contents were usually determined to be sufficient and excess levels. This results confirm the data of the soil analysis. Boron contents were between 34.0 and 79.5 mg kg^{-1} assigned as sufficient (2%) and excess (98%). Excess boron severely reduced fruit yield, not only fruit numbers and but also weight of individual fruit being reduced. The storage quality of the fruit is also affected, with the fruit ripening prematurely in cool storage (Smith *et al.*, 1987a; Smith and Clark, 1984, 1989).

CONCLUSIONS

As overall evaluation of results from our data, amount of organic matter and total nitrogen of the soils are generally sufficient, but, this is an opposite result to plant analysis and may because from inadequate nitrogen mineralization. In fertilizer application into these soils, leaching should be carefully considered because N deficiency ratio was of 64% in the study site. Soil phosphorus and potassium contents were generally sufficient and this situation confirms the data of the leaf analysis. Fertilizers with P and K should be considered into soils assigned as deficiency by P and K. A large number of the soil samples indicated an adequate Ca supply although the plant analysis showed the deficiency of Ca.

Fe, Cu, Zn, Mn and B contents of soil samples were determined sufficient and excess. These results are usually confirmed with the plant analysis. Therefore, these micro elements may be toxic for kiwifruit plants and alter the soil contamination status by heavy metals in the near future. So heavy metal concentrations of kiwifruit plants should be monitored by means of survey and laboratory studies.

Kiwifruit cultivation has started a couple of decades ago in our country. The cultivation has been increased year by year at various locations of the country. A literature search revealed limited published studies on nutritional status of kiwifruit plants in Turkey. The Karadeniz region has favourable ecological conditions for kiwifruit growing and many farmers interested in kiwifruit cultivation. Kiwifruit farming is generally considered to be second product with the hazelnut and tea growing. Although kiwifruit has not shown nutritional disorders, kiwifruit is require to fertilize for high in yields. Moreover, previous studies showed plant nutrient element is effective quantity of yield and storage quality after harvesting. Therefore, when the preparing fertilization programs to future for kiwifruit growing of this and the corresponding environments, the results of this investigation should be taken into consideration.

Present results with the help of the sufficiency ranges and critical limits cited in literature and to compare the results in order to make a contribution to the possibility of preparing more specific and appropriate fertilization programs for kiwifruit orchards in Ordu province in Turkey. These assessments are generalized and should only be used for regional planning purposes. A case survey study from Karadeniz Region in Turkey in kiwifruit orchards could be useful for assessing nutritional status, as well as developing appropriate sampling strategies.

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