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An Investigation on Nutritional Status of Tea (*Camellia sinensis* L.) Grown in Eastern Black Sea Region of Turkey

Aydın Adiloğlu and Sevinç Adiloğlu
Department of Soil Science, Faculty of Tekirdağ Agriculture,
University of Trakya, 59030, Tekirdağ, Turkey

Abstract: This investigation was carried out to determine the nutritional status of tea (*Camellia sinensis* L.) in the Eastern Black Sea Region of Turkey. For this purpose 35 soil samples were taken from 0-40 cm depth different area and 35 tea leaf samples were collected from different plantation. pH, organic matter, texture, N, P, K, Ca, Mg, Fe, Cu, Zn and Mn contents were determined on these soil samples. N, P, K, Ca, Mg, Fe, Cu, Zn and Mn contents were determined in leaf samples. According to the results, soils were Clay (C) and Clay Loam (CL) texture, generally; strong and medium acid reactions and high organic matter content; N, P, K, Ca, Mg, Fe, Cu, Zn and Mn contents of soils were determined as 0.12-0.37%; 3.80-20.26 mg kg^{-1}; 87-325 mg kg^{-1}; 980-3460 mg kg^{-1}; 80-390 mg kg^{-1}; 10. 42-44.79 mg kg^{-1}; 0.73-16.76 mg kg^{-1}; 0.69-18.72 mg kg^{-1} and 14.80-82.42 mg kg^{-1}, respectively. N, P, K, Ca, Mg, Fe, Cu, Zn and Mn contents of leaf samples were determined as 3.80-9.87%; 0.06-0.40%; 1.46-2.68%; 0.33-0.86%; 0.15-0.38%; 540-1070 mg kg^{-1}; 10-26 mg kg^{-1}; 30-56 mg kg^{-1} and 111-465 mg kg^{-1}, respectively.

Key words: Tea, acid soil, plant nutrients, nutritional status

INTRODUCTION

Tea plant is the part of human life and a cheap drink. Therefore, tea is the most preferred drink after water and has been increasing all over the world, because of this property of tea. The basic reason for this situation is because tea is a healthy drink.

Turkey is a leading tea (*Camella sinensis* L.) producer in the world. According to produce area, Turkey is 6th and the product of tea amount is 5th in the world. Tea plantation in Turkey, has been growing in Eastern Black Sea Region with 76654 ha area (Anonymous, 2002).

Tea plant is economical value for this region. But, the desired yield has not been realised from tea plant in recent years. The main reason for this situation is that the excess $(NH_4)_2SO_4$ fertilizer has been applied to tea plant and soil acidity has been increased this application (Eyüpoğlu, 1999). On the other hand, the nutrient balance in this region's soil may be destroyed by this fertilizer program. As a result, some nutrient elements are toxic levels and some nutrient elements are deficient levels for tea plantation.

Tea plant is generally give the highest yield in acid soils. Optimum pH value is between 5.0 and 5.5 for tea plant. But, the pH values of the soil in this region are below these values. Tea production decreased with excess and missing fertilizing program in this region (Anonymous, 2000).

The fertilizer program should carefully be chosen to increase tea production. The choice of fertilizer program should not only be based soil analysis but also leaf samples analysis. Therefore, soil and leaf samples analysis results has been evaluated together to solve nutrition problems for many plants in the world (Kowalenko, 1984; Guneo *et al*., 2003; Tarakcilu *et al*., 2003; Zengin *et al*., 2003).

In this research nutritional status of tea which was grown in Vakfıkebir and Beşikdüzü Region in Trabzon province, Turkey was aimed to determine through soil and plant analysis.

MATERIALS AND METHODS

This research was conducted in Trabzon province of Turkey during June 2004. Soil and tea leaf samples were taken from thirty five different tea plantation. Soil samples were collected 0- 40 cm depth and prepared for necessary analysis in laboratory (Jackson, 1962). Leaf samples were taken in June month from the same areas brought to laboratory (Mills *et al*., 1996), washed with distilled water, dried at 65°C temperature and ground.

Corresponding Author: Aydın Adiloğlu, Department of Soil Science, Faculty of Tekirdağ Agriculture, University of Trakya, 59030, Tekirdağ, Turkey
Tel: 90 282 2931442 Fax: 90 282 2931454

Table 1: Some physical and chemical properties of the soil samples

Soil No.	Locations	pH	Organic matter (%)	Clay (%)	Silt (%)	Sand (%)	Texture class*
1	Beşikdüzü-Adacık	4.42	7.74	48.92	22.33	28.75	C
2	Beşikdüzü-Adacık	3.22	7.88	45.34	25.67	28.99	C
3	Beşikdüzü-Denizli	4.31	6.73	46.72	26.54	26.74	C
4	Beşikdüzü-Denizli	3.80	7.50	54.60	32.51	12.89	C
5	Beşikdüzü-Sayvancık	5.63	3.76	37.88	39.12	23.00	CL
6	Beşikdüzü-Çeşmeönü	4.66	6.18	25.76	41.49	32.75	L
7	Beşikdüzü-Çeşmeönü	4.61	5.06	32.40	24.85	42.75	CL
8	Beşikdüzü-Kalegüney	4.54	4.53	32.62	29.80	37.58	CL
9	Beşikdüzü-Anbarlı	5.01	5.06	46.05	32.15	21.80	C
10	Beşikdüzü-Anbarlı	4.90	5.90	43.47	44.30	12.23	SiC
11	Beşikdüzü-Kaleköy	3.90	4.97	42.22	36.58	21.20	C
12	Beşikdüzü-Çamlık	4.28	6.41	43.87	31.17	24.96	C
13	Beşikdüzü-Akkese	4.54	4.19	45.56	32.24	22.20	C
14	Beşikdüzü-Çorapçılar	3.56	4.75	31.71	26.42	41.87	CL
15	Beşikdüzü-Resullü	4.26	5.01	35.88	30.12	34.00	CL
16	Beşikdüzü-Resullü	4.97	4.27	25.11	32.78	42.11	L
17	Beşikdüzü-Hünerli	4.69	4.13	45.40	27.80	26.80	C
18	Beşikdüzü-Kutluca	3.85	5.18	42.50	28.30	29.20	C
19	Beşikdüzü-Aksaklı	4.88	5.92	21.50	42.20	36.30	L
20	Beşikdüzü-Türkelli	3.96	3.98	38.80	37.80	23.40	CL
21	Vakfikebir-Sinanlı	4.15	4.74	37.50	33.80	28.70	CL
22	Vakfikebir-Kirazlık	4.52	4.20	35.80	38.59	25.61	CL
23	Vakfikebir-Kirazlık	4.63	3.48	43.33	32.18	24.49	C
24	Vakfikebir-Yıldız	5.12	3.87	23.12	35.12	41.76	L
25	Vakfikebir-Yıldız	5.24	6.74	36.63	35.10	28.27	CL
26	Vakfikebir-Yalıköy	4.52	7.02	45.94	33.59	20.47	L
27	Vakfikebir-Akköy	4.45	4.95	43.10	37.19	19.71	C
28	Vakfikebir-Akköy	4.16	5.92	33.59	41.47	24.94	CL
29	Vakfikebir-Caferli	3.80	7.14	42.95	29.43	27.62	C
30	Vakfikebir-Güneyce	5.03	4.13	40.34	25.67	33.99	C
31	Vakfikebir-Yemişli	5.37	5.80	48.70	31.80	19.50	C
32	Vakfikebir-Yemişli	4.26	5.95	45.56	32.24	22.20	C
33	Vakfikebir-Yeşilköy	4.52	3.69	58.24	29.98	11.78	C
34	Vakfikebir-Ormanlı	4.66	6.49	36.63	28.27	35.10	CL
35	Vakfikebir-Hacıköy	4.24	5.49	32.40	24.85	42.75	CL

*: C: Clay, CL: Clay Loam, SiC: Silt Clay, L: Loam,

Soil pH (Thomas, 1996), organic matter (Nelson and Sommers, 1996), total nitrogen (Bremner, 1996), available phosphorus (Kuo, 1996), exchangeable potassium (Helmke and Sparks, 1996), exchangeable calcium and magnesium (Suarez, 1996), available trace elements (Fe, Cu, Zn, Mn) (Lindsay and Norvell, 1978) and texture (Gee and Bauder, 1986) were determined on each sample.

Total nitrogen, phosphorus, potassium, calcium, magnesium and trace elements (Fe, Cu, Zn, Mn) were analysed for each tea leaf sample (Kacar, 1972). Nutrient element contents of tea plants were evaluated according to critical values (Southern and Dick, 1969; Mills *et al.*, 1996).

RESULTS AND DISCUSSION

Some physical and chemical properties of the soil samples: The pH values of soil samples ranged from 3.22 to 5.37 (Table 1). When the soil samples were evaluated according to pH values; 46% were found to be strongly acidic while the rest were moderately acidic (Eyüpoğlu, 1999).

Organic matter amounts of soil samples ranged from 3.48 to 7.88%. When soil samples as for to organic matter amounts, 11% were sufficient and 89% high (Eyüpoğlu, 1999). Organic matter amounts of the soil does not make any problem.

Soil textures were classified as Clay (C), generally. The distribution of the textures were 52, 34, 12 and 2%, respectively for Clay (C), Clay Loam (CL), Loam (L) and Silt Clay (SC).

Total nitrogen contents of soil samples were determined between 0.12 and 0.37% (Table 2). Forty three percent is considered sufficient while 57% were found to be high and excess (Sillanpaa, 1990). According to the results, farmers have consumed high amount of nitrogen fertilizers in this region. The same fact, excess nitrogen fertilizers consumption in this region was also determined by Eyüpoğlu (2002).

Available phosphorus contents of soil samples ranged from 3.80 to 20.26 mg kg^{-1}(Table 2). The ratio of low, sufficient and high phosphorus contents were 9, 71 and 3%, respectively (Sillanpaa, 1990). According to the results, farmers use the phosphorus fertilizers regularly in this region.

Table 2: Nutrient element contents of the soil samples

		(mg kg^{-1})							
Soil No.	N (%)	P	K	Ca	Mg	Fe	Cu	Zn	Mn
1	0.37	5.40	150	1100	120	13.40	8.42	4.33	40.80
2	0.32	5.16	180	1120	140	24.76	11.48	1.52	45.38
3	0.22	7.80	210	1400	200	13.80	10.60	0.85	32.80
4	0.24	13.40	120	2300	160	25.40	9.56	0.69	52.16
5	0.24	14.16	87	980	80	17.90	6.68	1.65	39.90
6	0.27	10.12	126	2100	250	16.30	3.57	0.80	71.36
7	0.14	17.80	134	3200	340	20.80	4.63	0.82	30.40
8	0.16	5.47	124	1130	100	18.50	1.61	2.40	42.60
9	0.30	9.32	197	1050	120	16.70	9.15	3.28	54.70
10	0.13	4.17	214	1090	280	20.16	2.27	1.98	76.80
11	0.24	6.10	325	1000	280	19.40	3.38	2.07	26.62
12	0.27	5.90	97	3400	350	24.80	4.63	6.30	24.50
13	0.14	8.09	112	2900	400	23.70	0.73	5.18	22.73
14	0.16	6.14	127	2570	280	21.14	0.86	9.21	14.80
15	0.20	11.90	134	3460	340	29.76	2.15	2.31	32.46
16	0.19	15.17	131	1090	180	11.68	4.82	3.93	57.53
17	0.14	16.26	126	1120	210	16.87	11.68	6.18	81.50
18	0.16	9.64	145	1040	140	28.96	9.74	2.40	29.76
19	0.12	10.33	217	1060	140	34.40	16.76	4.80	62.84
20	0.14	16.26	263	1190	130	29.74	10.90	9.72	45.38
21	0.16	14.54	310	2450	160	19.37	9.67	8.50	37.04
22	0.17	20.26	285	1850	190	20.17	14.27	11.40	40.16
23	0.12	13.50	129	1340	250	28.50	5.17	18.72	25.56
24	0.17	16.34	118	1110	210	34.40	6.26	13.42	82.42
25	0.19	12.97	300	990	80	44.79	1.72	13.04	64.17
26	0.26	18.78	105	1010	90	21.17	1.41	5.96	20.44
27	0.29	7.94	129	1130	150	10.42	1.48	14.71	29.32
28	0.27	5.34	137	1120	180	30.16	10.27	1.10	72.40
29	0.30	3.80	148	1450	210	29.45	12.64	0.85	18.76
30	0.16	15.17	155	2380	220	17.92	8.97	1.37	42.50
31	0.24	14.76	186	2800	380	13.67	0.88	11.17	32.90
32	0.20	9.80	117	3400	390	24.71	0.56	15.36	16.74
33	0.16	16.34	129	1040	210	32.54	0.91	16.68	43.17
34	0.26	10.82	280	1130	140	26.84	5.40	5.40	37.04
35	0.24	9.34	214	1120	110	24.18	5.42	12.20	26.12
Max.	0.37	20.26	325	3460	390	44.79	16.76	18.72	82.42
Min.	0.12	3.80	87	980	80	10.42	0.73	0.69	14.80

Exchangeable potassium contents of soil samples were determined between 87 and 325 mg kg^{-1}. According to these results, potassium contents of soil samples, 37% was insufficient and 63% sufficient (Sillanpaa 1990). Potassium content of this region soils were generally sufficient (Eyüpoğlu, 1999). But, potassium deficient ratio was determined 37%. The reason of this situation, with the excess nitrogen fertilizers application to tea plantation, tea plant vegetation and potassium uptake from soil increases, as a result potassium deficiency occurs (Kacar, 1984; Ranganathan and Natesan, 1987).

Exchangeable calcium contents of soil samples were determined between 980 and 3460 mg kg^{-1} (Table 2). 51% of soil samples was low and 49% was medium calcium content (Sillanpaa, 1990). Soil pH was determined strong and medium acid in this region, generally. Therefore, it should be lime applied to tea grown soils until pH 5.8 value (Kacar, 1984). Because ammonium sulphate (21% N) fertilizer is used excessively. As a result, acidity degree and calcium deficiency increase with time in this region.

Exchangeable magnesium content of soil samples ranged from 80 to 390 mg kg^{-1} (Table 2). According to Sillanpaa (1990), 43% of the soil sample was low and 57% was sufficient. It can be magnesium deficiency hindered with the necessary lime application to this region's soils.

Available Fe contents of soil samples were 10.42-44.79 mg kg^{-1}; available Cu contents were 0.73-16.76 mg kg^{-1}; available Zn contents were 0.69-18.72 mg kg^{-1} and available Mn contents were 14.80 - 82. 42 mg kg^{-1} (Table 2). According to Lindsay and Norvell (1978), available Fe, Cu, Zn and Mn contents of the soil samples were determined sufficient and excess for all soil samples. Same way, according to Kacar (1984), available Fe, Cu, Zn and Mn contents of tea grown acid soils were generally high in Eastern Black Sea Region, Turkey.

Table 3: Nutrient element contents of the tea leaf samples

	(%)					(mg kg^{-1})			
Sample No.	N	P	K	Ca	Mg	Fe	Cu	Zn	Mn
1	4.94	0.19	1.98	0.33	0.24	820	13	46	176
2	4.88	0.24	2.00	0.47	0.23	813	10	30	381
3	4.72	0.25	1.96	0.496	0.23	740	16	39	299
4	3.80	0.20	1.56	0.80	0.38	945	12	41	117
5	5.10	0.10	1.46	0.35	0.24	655	12	38	158
6	4.42	0.12	1.74	0.41	0.25	545	21	56	371
7	4.18	0.14	1.80	0.46	0.18	660	15	42	280
8	5.16	0.26	1.74	0.27	0.20	840	16	43	130
9	6.20	0.29	1.94	0.35	0.34	580	19	32	326
10	5.24	0.18	2.04	0.43	0.19	575	22	40	193
11	4.31	0.21	2.68	0.41	0.16	650	18	33	258
12	3.96	0.16	1.66	0.86	0.15	602	16	30	142
13	4.46	0.24	1.70	0.46	0.24	704	10	41	185
14	4.78	0.40	1.78	0.57	0.26	947	15	52	354
15	6.44	0.29	1.60	0.52	0.27	1005	18	50	120
16	6.76	0.36	1.60	0.50	0.19	800	23	37	372
17	5.94	0.18	1.69	0.38	0.24	785	17	44	310
18	9.87	0.16	1.82	0.35	0.26	940	17	39	360
19	7.14	0.10	2.01	0.41	0.19	780	19	39	281
20	3.94	0.09	2.18	0.43	0.15	590	18	44	408
21	4.96	0.06	2.10	0.62	0.17	710	25	53	365
22	5.46	0.17	2.08	0.52	0.26	840	16	44	230
23	8.10	0.14	1.70	0.54	0.18	965	19	42	395
24	6.60	0.10	1.56	0.38	0.30	540	18	39	252
25	5.71	0.20	1.80	0.40	0.37	905	18	40	384
26	4.75	0.18	2.15	0.54	0.23	1020	26	43	111
27	5.36	0.16	2.03	0.57	0.23	1070	23	47	193
28	6.17	0.40	1.90	0.40	0.26	615	17	35	336
29	4.90	0.16	1.92	0.35	0.38	770	19	32	418
30	7.14	0.13	1.84	0.46	0.25	980	13	51	233
31	6.98	0.12	1.96	0.59	0.15	595	17	44	421
32	5.74	0.16	1.61	0.65	0.28	865	15	40	382
33	5.20	0.16	1.76	0.70	0.16	890	20	46	225
34	8.45	0.18	2.15	0.55	0.19	820	24	33	465
35	9.17	0.11	1.97	0.43	0.21	580	21	42	386
Max.	9.87	0.40	2.68	0.86	0.38	1070	26	56	465
Min.	3.80	0.06	1.46	0.33	0.15	540	10	30	111

Nutrient element contents of tea leaf samples: Some nutrient element contents of tea leaf samples are given in Table 3. Total N contents of leaf samples were between 3.80 and 9.87%. According to these results, 29% of leaf samples were sufficient and 71% of leaf samples were excess (Mills *et al*., 1996). Excess nitrogen fertilizer consumption in this egion reflected to plant analysis results and n deficiency was not obtained in leaf samples. Same results were determined in tea plantation of Eastern Black Sea Region by Kacar *et al*. (1979).

Phosphorus contents of leaf samples ranged from 0.06 to 0.40% (Table 3). Sixty five percent was deficient, 20% was sufficient and 15% was excess (Mills *et al*., 1996). Phosphorus deficiency ratio of leaf samples was more than that of the soil samples. The reason for this result may be because of strong acidity of soil pH and the hindering of P uptake from soil (Willson, 1969). Same results were obtained earlier researchers in tea plantation of Eastern Black Sea Region (Özgümüş *et al*., 1982).

Potassium contents of leaf samples were between 1.46 and 2.68%. When evaluating these values according to Mills *et al*. (1996), 40% was deficient, 34% was sufficient and 26% was excess (Table 3). Potassium deficient ratio of leaf samples was similar for soil samples. K deficient were determined in tea leaf and soil samples by earlier researchers (Kanwar, 1974; Morchiladze, 1975; Kacar *et al*., 1978; Xun and Jianyun, 1994).

Calcium contents of tea leaf samples were determined between 0.33 and 0.86% (Table 3). 23% was deficient; 63% was sufficient and 14% was excess of these values (Mills *et al*., 1996). Calcium deficiency ratio of leaf samples was less than that of the soil samples. This result shows that Ca deficiency in soil does not reflect the leaf samples. On the other hand, Ca requirement of tea plant was less than many plants. Therefore, Ca deficiency of tea plant does not in great amount (Kacar, 1984). Similar result was also obtained in this research.

Magnesium contents of tea leaf samples ranged from 0.15 to 0.38% (Table 3). According to Mills *et al.* (1996), all of these values was sufficient and excess. According to some researchers, Mg deficient is not seen commonly. Exchangeable Mg amount in soil is sufficient for tea plant nutrition (Willson, 1975; Kacar *et al*., 1979). Similarly, Mg deficient was not determined in leaf samples.

It was seen that Table 3 that Fe, Cu, Zn and Mn contents of leaf samples were 540-1070; 10-26, 30-56 and 111-465 mg kg^{-1}, respectively. According to Southern and Dick (1969), Fe, Cu, Zn and Mn contents of tea leaf samples were determined sufficient and excess. Plant analysis results are similar with soil analysis results. According to many researchers, Fe, Cu, Zn and Mn deficient for tea plant is not seen commonly. Because, tea plant is grown in acid soils and Fe, Cu, Zn and Mn solubility are high in these soil conditions. Therefore, Fe, Cu, Zn and Mn deficient is not seen in tea plantation, generally (Lin, 1966; Willson, 1969; Southern and Dick, 1969; Kacar *et al*., 1979; Kacar, 1984).

CONCLUSION

According to the results of the investigation, soil samples are generally Clay (C) and Clay Loam (CL) textures and pH values of soil samples are strong acid and medium acid reactions. Organic matter amount and total N content of the soil samples are generally sufficient and high. Similarly, these results reflected the leaf samples and there was not any nutrient problem for N nutrition of tea plant.

Phosphorus contents of soil samples were generally sufficient. But, according to the tea leaf analysis results, 65% of tea plants were determined deficient. According to Kacar *et al.* (1975), great deal of applied phosphorus to soils were fixed during the growing period of tea plantation. Therefore, sufficient level of soil phosphorus did not reflected the plant analysis results.

According to soil and leaf samples analysis results, K deficient were determined. Potassium fertilizers should be applied to tea plantation for the K deficient hindering. As a matter of fact, K fertilizers should be applied to tea plantation by Eyüpoğlu (2002).

Calcium deficient was determined both soil and leaf samples, because great amount of soil samples were strong acid reaction. For this purpose, lime should be applied to these soils, but the pH value of soils should not be excessively high.

Magnesium deficient was determined in soil samples, but this deficient did not reflect the plant samples, at the present. However, $(NH_4)_2SO_4$ fertilizer has been applied excessively to the soils (Anonymous, 2002). If this application is to continue for a long time, Mg deficiency will reflect the tea plant. Consequently, this fertilization program should be stopped.

Iron, Cu, Zn and Mn contents of soil and leaf samples were sufficient and high. Soil acidity was increasing in this region (Eyüpoğlu, 2002). Therefore, the levels of these nutrient elements may be toxic level in the near future. This situation should not be remembered for application of fertilizer program in this region.

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