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An Investigation on Nutritional Problems of Hazelnut (*Corylus avellana*) Grown in Acid Soils of Turkey

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Abstract: This study aimed the determination of nutritional problems of hazelnut (*Corylus avellana*) grown acid soils in this research. For this purpose, soil and leaf samples were taken from 30 different hazelnut grown area from Trabzon Region. Some physical and chemical properties and some nutrient element contents of soil and leaf samples were determined. This determined values were compered with critical values and the degree of sufficiency were evaluated. According to the results, organic matter, total N, available P, exchangeable K and Mg contents of soil samples were determined sufficient and high, generally. Ca deficiency was obtained in the 93.4% of the soil, because of acid property of the soils. Available Fe, Cu and Mn contents of the soils were determined sufficient. In the 70 % of the soils; Zn deficiency was found. N, P, K, Ca, Mg and Zn deficiency of leaf samples were determined 20.0, 26.7, 6.7, 73.4, 50.0 and 66.7%, respectively. Fe, Cu and Mn contents of leaf samples were determined sufficient.

Key words: Hazelnut, acid soil, soil properties, plant nutrients, nutritional status

INTRODUCTION

Turkey is a leading hazelnut (*Corylus avellana*) producer in the world with 78% of total production and it is followed by Italy, Spain and USA with 12%, 6.5% and 2.5%, respectively. Although Turkey is the highest production ratio, average yield is 750 kg ha^{-1} in Turkey. This value is 1250 kg ha^{-1} for Italy and 1680 kg ha^{-1} for USA[1].

Hazelnut plant is generally give the highest yield in neutral soil conditions. The main region for hazelnut in Turkey is the Eastern Black Sea Region. Sixty nine percent of total hazelnut production in Turkey is from this region[1]. But the significant part of the hazelnut grown soils in this region is acid conditions[1,2].

Hazelnut plant should be fertilized according to the soil and leaf analysis results. The application of fertilizer schedule is crucial for more production. The choice of fertilizer schedule should not only be made based soil analysis but also leaf samples analysis. Therefore, soil and leaf samples results has been together evaluated to solve nutrient problems in the world, nowadays[3-5].

The nutrient problems of hazelnut was determined for different regions in some investigation. According to the results of the investigations, the kind, amount and application times of the necessary fertilizers are different from region to region[6-8].

In this research nutritional problems of hazelnut which was grown in acid soil in Turkey was aimed to determination through soil and plant analysis.

MATERIALS AND METHODS

Soil and hazelnut leaf samples were taken from Trabzon province. Because acid soils prevailing in this region and hazelnut have been intensively grown in this city. Thirty soil and leaf of hazelnut samples were used in this research. Soil samples were collected 0- 40 cm depth and prepared for necessary analysis in laboratory[9]. Leaf samples were taken in July and brought to laboratory[10]. Leaf samples were washed with distilled water, dried at 65°C temperature and ground.

Soil pH[11], organic matter[12], total nitrogen[13], available phosphorus[14], exchangeable potassium[15], exchangeable calcium and magnesium[16], available trace elements (Fe, Cu, Zn, Mn)[17] and texture[18], were determined for each sample.

Total nitrogen, phosphorus, potassium, calcium, magnesium, trace elements (Fe, Cu, Zn, Mn) were analysed for each plant leaf sample[19]. Nutrient element

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contents of plants were evaluated according to critical values[10].

RESULTS AND DISCUSSION

Some physical and chemical properties of acid soils: The pH values of soil samples ranged from 4.31 to 6.20. When the soil samples were evaluated according to pH values; 6.7% strong acid, 66.7% medium acid and 26.6% slightly acid[20] (Table 1).

Soil textures were determined clay loam (CL), generally. The distribution of the textures were 60.0% clay loam (CL) texture, 16.7% clay (C), 13.3% sandy clay loam (SCL) and 10.0% loam (L).

Organic matter amounts of soil samples ranged from 1.62 to 7.16% (Table 1). When soil samples were evaluated according to organic matter amounts, 6.7% poor, 13.3% medium, 23.3% sufficient and 56.7% high[20].

Total nitrogen contents of soil samples were determined between 0.06 and 0.34% (Table 2). 6.7% insufficient, 36.7% sufficient, 53.3% high and 3.3% excess of total nitrogen contents of soil samples were determined[20].

Available phosphorus contents of soil samples ranged from 1.26 to 49.48 mg kg^{-1} (Table 2). The ratio of very low, low, sufficient and high phosphorus contents were 6.7, 13.3, 63.3 and 16.7%, respectively[20].

Exchangeable potassium contents of soil samples were determined between 114.9 and 263.0 mg kg^{-1} (Table 2). According to these results, potassium contents of soil samples were 6.6 insufficient and 94.4% sufficient[20].

Exchangeable calcium contents of soil samples were determined between 2.25 and 9.02 me 100 g^{-1} (Table 2). Twenty percent of soil samples was very low, 73.4% was low and 6.6% was medium calcium content[21].

As for exchangeable magnesium content, ranging from 0.30 to 2.07 me 100 g^{-1}, 10.0% of the soil sample was insufficient, 40.0% was medium and 50.0% was sufficient[21].

When the available trace element contents of soil samples were investigated. It was seen that Fe, Cu, Zn and Mn contents were 10.35-85.17, 0.62-9.36, 0.18-1.09 and 14.18-81.50 mg kg^{-1}, respectively. According to FAO[22], Fe, Cu and Mn contents of the soil samples were considered to be sufficient and high for all soils. Seventy percent was low and 30.0% was sufficient in Zn contents of soil samples.

Nutrient element contents of hazelnut leaf samples: Nutrient element status of hazelnut leaf samples were compared with the critical percentage values which were given by Jones *et al.*[10].

Total N contents of leaf samples were between 2.05 and 2.96% (Table 3). According to these results, 20.0% of leaf samples were deficient, 56.7% of leaf samples were sufficient and 23.3% of leaf samples were excess.

P contents of leaf samples ranged from 0.09 to 0.59% (Tabe 3). 26.7% was deficient, 63.3% was sufficient and 10.0% was excess.

K contents of leaf samples ranged from 0.50 to 2.14% (Tabe 3) and 6.7% of these values were deficient while 93.3% of these values were sufficient.

Ca contents of leaf samples were between 0.56 and 1.75% (Table 3). 73.4% of these values were deficient and 26.6% of these values were sufficient. On the other hand, in Mg contents of these samples, ranging from 0.16 to 0.50% (Table 3), 50.0% was found to be deficient while the rest was sufficient.

Fe, Cu and Mn contents of leaf samples were 107-544, 13.2-80.5 and 209-994 mg kg^{-1} respectively (Table 3). According to these results, Fe, Cu and Mn contents of samples were determined sufficient and excess. Zn contents of leaf samples were between 12.1 and 37.6 mg kg^{-1}, 66.7% of these values were deficient and 33.3% of these values were sufficient.

According to the results of the investigation, organic matter amount and total N content of the soil samples are generally sufficient and high. Same way, this result reflected to leaf samples and total N contents of leaf samples were generally sufficient and high level. This implies that N nutrition does not limit the hazelnut growing in acid conditions. But, in the fertilizer application to these soils, leaching should carefully be considered. Because N deficiency ratio of 20.0% were determined for leaf samples.

P content of soil samples were generally sufficient. But 26.7% of plants were determined deficient, which shows that there is a problem in the phosphorus uptake of the plants. This should be considered in the P fertilizer application to these soils.

K contents of soil samples were sufficient. Same results were determined for leaf samples. Therefore, K nutrition of hazelnut grown acid soils have not nutrient problems.

Ca deficiency was determined high ratio in soil and leaf samples. Therefore, when hazelnut is grown in acid soils lime must be applied.

Mg contents of soil samples were generally sufficient. But, Mg deficient ratio of leaf samples higher than soil samples. This is because some physical and chemical properties of soil samples and Mg uptake and transporting hindered by Ca and Al ions in soil[23].

When Table 2 and 3 is critically evaluated in respect to the available Fe, Cu and Mn contents of soil

Table 1: Some physical and chemical properties of the acid soils

Locations	pH	Organic matter (%)	Particle size distribution (%)			Texture
			Clay	Silt	Sand	
Beşikdüzü-Denizli	5.42	4.83	22.90	23.00	55.10	SCL
Beşikdüzü-Adacık	5.10	5.11	38.40	22.00	39.60	CL
Beşikdüzü-Çeşmeönü	6.19	3.04	38.97	29.02	32.01	CL
Beşikdüzü-Anbarlı	4.83	3.76	35.15	23.20	41.65	CL
Beşikdüzü-Anbarlı	4.83	6.02	30.79	29.51	39.70	CL
Beşikdüzü-Aksaklı	4.69	6.01	25.76	41.49	32.75	L
Vakfikebir-Çamlık	4.31	5.06	34.99	19.69	45.32	SCL
Vakfikebir-Çamlık	4.47	4.97	45.70	26.30	28.00	C
Vakfikebir-Çamlık	4.71	2.95	21.70	26.00	52.30	SCL
Vakfikebir-Çamlık	4.93	3.03	32.12	25.03	42.85	CL
Vakfikebir-Çamlık	5.74	3.72	31.54	10.69	57.77	SCL
Çarşıbaşı-Kaleköy	5.25	1.96	35.74	38.33	25.93	CL
Çarşıbaşı-Kadıköy	5.29	2.28	24.82	32.74	42.43	L
Çarşıbaşı-Kadıköy	6.10	3.80	32.18	24.49	43.33	CL
Çarşıbaşı-Gülbahçe	5.78	4.13	43.10	37.19	19.71	C
Çarşıbaşı-Veliköy	5.91	2.73	37.88	23.00	39.12	CL
Akçaabat-Mersin	5.65	1.62	35.94	30.47	33.59	CL
Akçaabat-Taşlıca	5.03	3.76	47.11	20.11	32.78	C
Akçaabat-Akçakale	5.82	2.84	36.63	28.27	35.10	CL
Akçaabat-Yıldızlı	5.35	3.12	42.95	29.43	27.62	C
Merkez-Çilekli	4.96	4.53	32.40	24.85	42.75	CL
Merkez-Çilekli	5.45	5.06	36.58	37.04	26.38	CL
Merkez-Konaklar	6.20	4.19	39.48	30.17	30.35	CL
Merkez-Çimenli	4.55	4.75	35.58	33.22	31.20	CL
Merkez-Akyazı	4.50	5.01	40.34	25.67	33.99	C
Yorma-Kaşüstü	4.70	6.73	25.11	32.78	42.11	L
Yorma-Yokuşlu	4.62	6.88	32.49	30.20	37.31	CL
Yorma-Yokuşlu	4.90	7.16	37.22	36.58	26.20	CL
Arsin-Gölcük	5.10	6.75	30.05	32.15	37.80	CL
Arsin-Yeşilyalı	4.83	6.11	35.88	30.12	34.00	CL

Table 2: Nutrient element contents of the acid soils

Soil No.	N (%)	P mg kg^{-1}	K mg kg^{-1}	Ca me 100 g^{-1}	Mg me 100 g^{-1}	Fe mg kg^{-1}	Cu mg kg^{-1}	Zn mg kg^{-1}	Mn mg kg^{-1}
1	0.22	4.60	240.0	3.60	1.16	13.45	0.83	0.28	23.16
2	0.23	16.03	187.0	3.36	0.95	19.26	0.73	0.26	18.79
3	0.15	13.80	143.0	5.24	2.07	29.85	1.92	0.58	29.76
4	0.16	27.27	142.5	3.03	0.31	32.60	2.26	0.61	42.76
5	0.29	10.97	190.0	3.10	0.83	50.87	3.45	0.33	43.35
6	0.28	8.86	162.1	4.25	0.80	23.27	0.86	0.77	40.80
7	0.24	5.90	114.9	4.00	1.03	85.17	4.37	0.42	26.64
8	0.23	8.44	175.7	2.25	0.30	40.07	2.67	0.42	81.50
9	0.11	1.26	154.0	3.18	0.96	62.15	4.08	0.45	39.90
10	0.13	14.77	263.0	4.02	1.06	77.72	3.38	0.31	52.16
11	0.16	23.21	187.0	6.09	1.17	80.92	9.36	0.36	33.46
12	0.08	26.17	163.5	6.03	0.85	55.16	7.34	0.63	72.46
13	0.10	13.54	135.0	5.52	1.26	18.15	0.62	0.60	57.53
14	0.17	17.77	150.7	9.02	1.05	57.76	2.27	0.70	71.36
15	0.18	22.79	219.0	6.15	2.03	38.53	3.79	0.49	69.30
16	0.11	9.70	224.3	5.94	0.90	52.76	7.05	0.21	46.26
17	0.06	1.26	145.0	5.67	0.67	43.04	8.87	0.36	16.80
18	0.16	20.26	218.5	4.90	1.15	32.87	2.28	0.67	14.58
19	0.12	24.05	260.0	6.17	1.08	61.40	3.79	0.96	26.40
20	0.13	42.63	217.5	4.37	0.82	75.69	2.92	0.18	16.24
21	0.22	49.48	165.0	3.18	0.43	68.14	1.03	0.90	14.18
22	0.21	16.58	229.0	4.26	0.96	59.16	1.86	1.09	26.43
23	0.18	46.43	210.6	8.19	1.19	64.21	4.32	0.76	32.86
24	0.20	14.77	217.6	5.03	0.90	16.87	1.33	0.53	52.40
25	0.22	5.48	157.5	4.17	1.11	10.35	2.32	0.42	42.27
26	0.30	7.17	162.0	4.85	0.92	18.26	2.46	0.60	32.90
27	0.32	9.64	175.0	5.16	0.83	15.96	0.96	0.85	53.43
28	0.34	15.19	173.5	5.32	0.90	56.17	5.14	0.67	25.64
29	0.30	20.27	143.7	6.15	1.20	75.63	2.45	1.02	37.32
30	0.27	6.55	156.7	5.20	0.76	70.57	3.57	1.06	62.20
Max	0.34	49.48	263.0	9.02	2.07	85.17	9.36	1.09	81.50
Min	0.06	1.26	114.9	2.25	0.30	10.35	0.62	0.18	14.18

Table 3: Nutrient element contents of the leaf samples

Sample No.	N (%)	P mg kg^{-1}	K mg kg^{-1}	Ca me 100 g^{-1}	Mg me 100 g^{-1}	Fe mg kg^{-1}	Cu mg kg^{-1}	Zn mg kg^{-1}	Mn mg kg^{-1}
1	2.45	0.29	0.80	0.62	0.18	332	13.2	12.8	451
2	2.92	0.20	1.14	0.56	0.32	141	38.3	27.7	399
3	2.90	0.12	0.76	0.86	0.22	371	46.7	28.2	698
4	2.40	0.40	0.50	0.83	0.26	268	49.2	26.4	304
5	2.54	0.35	0.64	1.75	0.18	133	80.5	18.5	344
6	2.76	0.25	0.73	0.87	0.17	208	23.2	12.4	320
7	2.11	0.19	0.79	1.16	0.50	265	47.1	12.1	692
8	2.47	0.36	0.75	1.25	0.21	544	70.5	13.7	683
9	2.73	0.18	1.16	0.82	0.27	180	37.9	19.8	465
10	2.80	0.09	1.36	0.96	0.32	375	26.0	12.6	359
11	2.96	0.14	0.96	0.65	0.18	167	14.9	14.0	402
12	2.05	0.20	1.32	0.87	0.46	196	48.8	21.4	852
13	2.47	0.26	1.20	1.18	0.19	241	32.1	26.7	644
14	2.46	0.47	1.14	1.27	0.26	250	22.6	12.6	427
15	2.40	0.38	1.96	0.97	0.16	224	20.4	13.2	465
16	2.56	0.56	0.87	1.67	0.20	232	43.4	19.5	379
17	2.25	0.59	2.14	1.24	0.27	217	32.6	13.3	444
18	2.36	0.39	1.17	0.96	0.46	179	42.8	12.7	983
19	2.44	0.19	1.26	0.71	0.32	107	17.7	13.6	792
20	2.40	0.13	0.82	0.95	0.29	188	30.6	25.5	493
21	2.71	0.15	0.89	0.86	0.23	260	21.7	13.6	321
22	2.52	0.12	1.12	0.89	0.36	196	25.4	37.6	590
23	2.07	0.26	1.54	0.94	0.18	118	26.0	12.4	853
24	2.17	0.14	0.75	0.68	0.23	276	28.7	13.0	209
25	2.46	0.18	0.73	0.77	0.40	148	23.3	12.4	566
26	2.42	0.11	1.57	0.70	0.19	225	17.4	13.2	994
27	2.10	0.19	0.73	0.69	0.20	174	13.4	13.6	742
28	2.54	0.32	1.70	1.12	0.29	196	22.6	12.9	258
29	2.60	0.29	1.16	0.73	0.27	205	32.4	13.1	456
30	2.56	0.33	0.87	0.70	0.16	277	26.8	12.7	270
Max	2.96	0.59	2.14	1.75	0.50	544	80.5	37.6	994
Min	2.05	0.09	0.50	0.56	0.16	107	13.2	12.1	209

and leaf samples no deficiency is seen. The available Fe, Cu and Mn contents of acid soils are generally high, which is similar for the leaf samples. Zn deficiency was determined in the soil and leaf samples in high level. This is attributed to the low soluble organic matter and Zn complex compound in acid soil conditions[24].

Hazelnut is an important plant in Turkish agricultural production. To increase the yield not only a balanced fertilizer programme should be done but also lime and Zn in the required amount should be applied. Because, optimum yield is obtained under neutral pH conditions. Therefore, Ca deficiency should always be bared in mind for hazelnut grown.

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