10.31195/ejejfs.535803

Eurasian Journal of Forest Science

2019 7(2): 121-132

http://dergipark.gov.tr/ejejfs

The macro and micro nutrition status of Anatolian chestnut in Inegol (Bursa-Turkey)

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Abstract

Chestnut is a plant that is grown in limited areas in the world and is profitable for its producer. In spite of this, the determination of nutrient elements and fertilization studies in chestnut orchards are insufficient. This study was carried out to determine the mineral nutritional status of Anatolian chestnuts cultivated in Inegol (Bursa) by soil and leaf analysis. In this research, the soil samples were taken from 25 different chestnut orchards (5 locations) in Inegol district only in April 2012. The chestnut leaves were sampled both in August 2012 and 2013. During both years, chemical and organic fertilization have not been done in the chestnut orchards. In soil samples, texture, pH, total salt, lime ($CaCO_3$), organic matter, total nitrogen, available phosphorus, potassium, calcium, magnesium, iron, zinc, manganese, and copper; In the leaf samples, macro and micro plant nutrient elements were analyzed except boron. The results of the analysis of the leaves and soil samples were compared with the limit values and the nutrient status and nutritional problems of the studied orchards were determined.

According to the results, it was determined that the analyzed soils were the mostly coarse-textured, less salty, slightly acidic reaction and inadequate to organic matter and lime. In addition, N, Ca and Mg contents of the soil is very low, the P content is at the limit values and K, Fe, Zn, Mn, and Cu contents were found to be within the limit values. Also, leaf analysis results show that the plant's nutrients (N, P, K, Ca, Mg) are inadequate or below the limit values. However, the contents of micronutrients (Fe, Zn, Mn, Cu) remained within their limits.

As a result, chestnut trees must be fertilized with macro nutrients for efficient and profitable production.

Keywords: Chestnut (*Castanea sativa* Mill.), productivity, nutrition

INTRODUCTION

Turkey has one of the most important and largest productions of chestnut in the Europa. The naturally spreading chestnut species in Turkey is the European chestnut (*Castanea sativa* Mill.), and chestnut production utilizes native cultivars. It was known thirteen chestnut species in the world and these species have located in northern hemisphere. One of the chestnut species is a *Castanea sativa* Mill. (European chestnut) which is native to Asia Minor (Soylu and Erturk, 1999).

However, studies on production, marketing, and characteristics of chestnut growers are very limited in the literatüre (Serdar et al. 2018). Chestnut can be consume fresh by roasting and boiling in Turkey, is used in making cakes and is widely used in the candy industry (Uylaser et al. 2014). Chestnuts have played an important role in human nutrition since ancient times. The term “bread tree” has been used in some places for chestnuts (Bounous et al. 2000).

According to the FAO (2019), worldwide chestnut production is 2.236.223 tons. Chestnut is highly regarded and widely consumed throughout Europe, America, and Asia. In addition, chestnuts are one of the most popular nuts in the oriental world. Chestnuts are mainly cultivated in China (1.939.719 t), Turkey (62.904 t), Republic of Korea (52.764 t), Italy (52.356 t) and Greece (36.000 t)

Since nutrient management is a critical aspect of crop production, nutrient recommendations have been developed for several fruit and nut species. Sufficiency or survey ranges for individual nutrients are routinely used by soil and plant testing facilities as a basis for providing fertilizer recommendations. The sufficiency range, used for foliar testing, indicates the values at which the tissue is at the optimal nutritional status, as determined by field testing (Bryson et al. 2014).

However, there is limited scientific data on chestnut management, in particular in the field of mineral nutrition and crop fertilization (Portela et al. 2007). On the other hand, studies done with young potted plants have shown that the crop responds to the application of mineral nutrients (El Kohen et al. 1992; Laroche et al. 1997), and therefore it is expected that a positive response to fertilization may also occur in the field. Pérez-Cruzado et al. (2011), used wood-bark ash, a product rich in Ca, K, Mg, and to a lesser extent P, as a fertilizer in a young chestnut orchard. They recorded an increase in the diameter and height of the trees and also an improvement in the nutritional status of the plants in terms of K, Ca, and Mg.

Chestnuts can grow and bear profitable crops of nuts without ever being fertilized, but to get the very highest yields a program of regular fertilization will be necessary. The higher cost can be easily offset by the high value of the crop. If chemical fertilizers are used then regular soil tests should determine the quantity and type. Regardless of what kind of fertilizer is used, it should be applied in spring and never any later than early June. Fertilizer applied later will result in tender late-season growth which will be subject to winter damage (Wahl 2002).

The aim of this study is to determine the productivity status of the orchards of the Anatolian chestnut which is an important source of income for the farmer in Inegol district of Bursa province in the Southeast Marmara Region.

MATERIAL AND METHODS

Site Properties

The region is located in the Marmara and the Aegean climate transition zone. In the 2012 and 2013 chestnut vegetation period (from March to October), the total amount of rainfall was 333.8 years in the first year and 396.3 mm in the second year. The average temperature in the period of the research is consistent with the average temperature long term years, and the total rainfall is consistent with the total rainfall long term years. Climate data for the research areas and periods are shown in Figure 1.

The study was carried out in 25 orchards in 5 location where intensive chestnut cultivation was made in İnegol district. Soil samples were taken only in April 2012 and leaf samples in August 2012 and 2013. Some location information about the sampling locations are shown in Table 1.

Soil Analysis

The pH of the soil samples in a mixture of 1 / 2.5 of soil pure water with pH meter; CaCO3 with calcimetric method; salt, conductometric method in saturation sludge; organic matter, according to the Walkley and Black titrimetric method; changeable K, Ca, Mg, Na photometric according to 1 N ammonium acetate method; availeble P, colorimetric according to Olsen method with 1.5 M sodium bicarbonate; Fe, Mn, Zn, Cu were spectrophotometrically analyzed by DTPA (Kacar 1995). The classification and interpretation of soil analyzes were done according to Kellog (1952), Forth and Jacobs

(1964), Soil Staff (1954), Evliya (1960), Schlincting and Blume, (1966), Kovancı (1969), Pizer (1967), Loue (1968), Viets and Lindsay (1973).

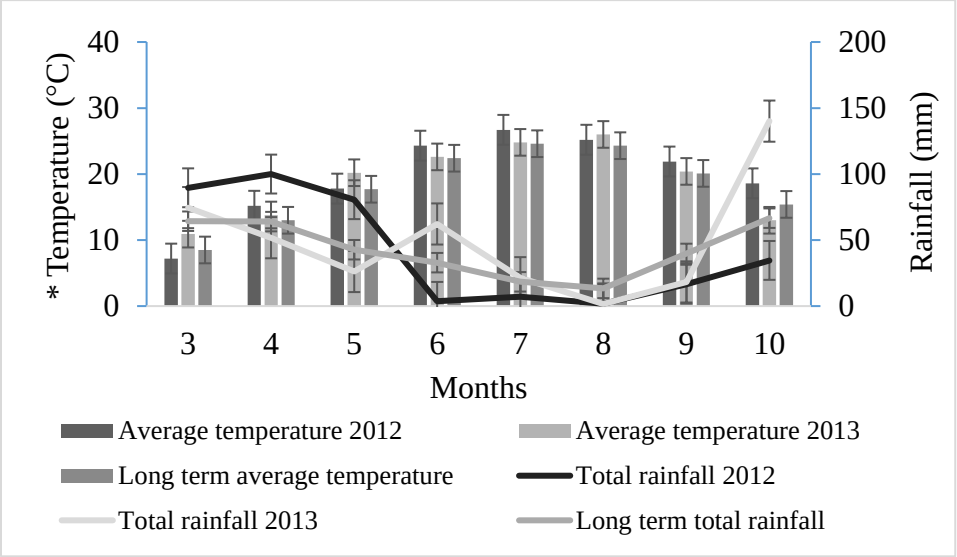

Figure 1. Climate data at the research area over two years (2012 and 2013). The values are shown (bars or symbols) means ± standard deviation (SD). The bars are shown the average temperature and the lines are shown total rainfall.

Leaf analysis

The samples were taken from the shoots on four sides of the tree and from the leaves in the middle size. Leaf samples taken from the chestnut orchards were brought to the laboratory in paper bags, washed with sterile distilled water and dried at 65 °C for 24 hours in the oven. The dried samples were grounded in the steel mill and had been made ready for the analysis (Kacar and İnal 2008). Total N analysis was performed according to Kjeldahl distillation method by using grounded leaf samples. Phosphorus, potassium, calcium, magnesium, iron, copper, zinc and manganese were determined from the samples obtained by wet burning method using ICP-OES (Inductively Coupled Plasma) device (Kacar and İnal 2008). Results were given as % dry matter for P, K, Ca, Mg and mg kg^{-1} in dry matter for Fe, Cu, Zn, Mn.

RESULTS AND DISCUSSIONS

Some physical and chemical status of orchard soils

According to the results of soil samples analysis, 48% of the soils were loamy, 24% were sandy loam and 28% were clay loam. All of the orchards in the A location have loamy soil structure. Other locations have sandy loam and clay loam soil structure characteristics (Table 2).

As it is known, chestnut is better grown in deep profile loamy soil structure (Soylu, 2004). According to the results of soil pH, all of the chestnut orchards are slightly acidic soils. Soil pH ranges between 5.57 and 6.86. The lowest pH values were recorded as average 6.09 and 6.10 at C and B locations, respectively. The chestnut tree is mostly grown in slightly acidic pH (Soylu 2004; Toprak and Seferoğlu 2013). The content of organic matter was determined below the value of the standard (2-3%) in all orchards. Organic matter content is important in terms of nutrient richness and organism activities of soils. The lowest organic matter content was found in location A (Average 1.47%), and the highest organic matter content was determined in location D (Average 1.79%). In the soil analyzes, the lime

content of the soils is very low. Calcium is leached with precipitation in deep profile and loamy soils and its amount has decreased in the soil.

Table 1. Some location information about sampling locations.

Sampling no	Location No	Location name	Coordinates		Altitude (m)
			N	E	
1			39.932463	29.633146	824
2			39.935017	29.635486	851
3	A	Tahtaköprü	39.929757	29.640401	848
4			39.933225	29.634879	784
5			39.931875	29.640887	824
1			39.929199	29.630084	839
2			39.927594	29.628688	835
3	B	Bahçekaya	39.924987	29.627231	824
4			39.922474	29.625198	817
5			39.919262	29.624167	807
1			39.919914	29.606384	849
2			39.918098	29.606354	836
3	C	Mesruriye	39.916818	29.604594	827
4			39.914770	29.604169	862
5			39.916120	29.611118	843
1			39.946680	29.589177	861
2			39.947552	29.587482	847
3	D	Hilmiye	39.948967	29.585143	859
4			39.944259	29.589757	848
5			39.944509	29.585594	862
1			39.925914	29.568821	876
2			39.924696	29.566584	863
3	E	Saadet	39.922648	29.564271	817
4			39.921154	29.565609	849
5			39.920683	29.565393	867

However, the $CaCO_3$ content of the soil ranges between 0.22 and 0.55%. The highest $CaCO_3$ content was found at location D (Average 0.41%), while the lowest $CaCO_3$ content was recorded at location B (Average 0.34%). These values show that the soil is in the less calcareous soil class (0-1%). Soils are classified as low salty (<0.15%) according to salinity class. The highest salt content was found at location E (Average 0.100%) and the lowest salt content at location A (Average 0.078%).

The macronutrient status of soils

Macronutrient contents of chestnut orchards soils of the sampling locations are shown in Table 3. The total N% content of the sampled orchards soils were determined below the limit values (<0.090%).

Table 2. Some chemical and physical properties of soil in sampling orchards.

Locations	Texture Class	pH (1:2.5)	Organic matter (%)	Lime ($CaCO_3$ %)	Salt (%)
A 1	Loamy	6.36	1.32	0.38	0.083
A 2	Loamy	6.23	1.25	0.41	0.094
A 3	Loamy	6.20	1.41	0.24	0.084
A 4	Loamy	6.39	1.74	0.32	0.067
A 5	Loamy	6.58	1.34	0.43	0.061
Average		6.35	1.41	0.36	0.078
B 1	Sandy Loam	5.99	1.94	0.28	0.093
B 2	Loamy	6.26	1.32	0.35	0.101
B 3	Loamy	6.46	1.64	0.41	0.094
B 4	Sandy Loam	5.99	1.55	0.35	0.097
B 5	Sandy Loam	5.80	1.87	0.29	0.095
Average		6.10	1.66	0.34	0.096
C 1	Sandy Loam	5.68	1.52	0.22	0.083
C 2	Loamy	6.24	1.64	0.34	0.091
C 3	Loamy	6.28	1.88	0.43	0.068
C 4	Clay Loam	6.58	1.54	0.55	0.076
C 5	Sandy Loam	5.89	1.64	0.23	0.095
Average		6.09	1.64	0.35	0.083
D 1	Clay Loam	6.28	2.11	0.51	0.087
D 2	Clay Loam	6.57	2.04	0.47	0.076
D 3	Clay Loam	6.87	1.78	0.44	0.092
D 4	Loamy	6.24	1.64	0.34	0.082
D 5	Sandy Loam	5.57	1.36	0.28	0.090
Average		6.31	1.79	0.41	0.085
E 1	Clay Loam	6.27	1.22	0.31	0.101
E 2	Clay Loam	6.36	1.47	0.46	0.093
E 3	Clay Loam	6.86	1.66	0.39	0.103
E 4	Loamy	6.05	1.58	0.31	0.098
E 5	Loamy	6.39	1.44	0.27	0.103
Average		6.39	1.47	0.35	0.100

According to this, the highest total N content was determined at D location (Average 0.084%) and the lowest total N content at A location (Average 0.066%). Inadequate nitrogen levels in the soil cause weakness of the chestnut and decrease in flowering (Rutter et al. 1990). The available P contents were obtained range from 8.7 to 12.4 mg kg^{-1} in orchard soils. According to the available P contents, 44% of the orchards soils were determined at the limit value and above the limit value (10.5 mg kg^{-1}). The highest P content was recorded as average 10.9 and 10.8 mg kg^{-1} at C and D locations, respectively. The lowest available P content was recorded at the location A (Average 9.8 mg kg^{-1}). It is reported that low phosphorus levels caused a decrease in the number of female flowers (Rutter et al. 1990). According to this, the highest K content was found in the C location (Average 148 mg kg^{-1}) and the lowest in B (Average 124 mg kg^{-1}). In all sampling locations, K contents were recorded above the limit value (100

Table 3. Macronutrient concentrations of soil in sampling orchards

Locations	N (%)	P (mg kg^{-1})	K (mg kg^{-1})	Ca (mg kg^{-1})	Mg (mg kg^{-1})
A 1	0.062	10.7	138.0	211.8	35.1
A 2	0.058	8.7	114.5	223.5	34.3
A 3	0.065	8.8	115.2	131.5	31.9
A 4	0.079	9.4	122.4	156.6	26.5
A 5	0.064	8.3	164.4	235.3	39.1
Average	0.066	9.8	130.9	191.7	33.4
B 1	0.089	10.2	127.3	164.5	27.5
B 2	0.065	8.9	117.7	183.2	29.5
B 3	0.077	10.4	124.6	216.3	35.1
B 4	0.075	10.7	131.2	193.4	32.1
B 5	0.081	10.0	119.3	158.1	27.1
Average	0.077	10.0	124.0	183.1	30.2
C 1	0.069	11.4	138.4	131.4	21.9
C 2	0.074	10.2	132.5	177.6	29.6
C 3	0.082	10.6	166.4	227.4	37.8
C 4	0.073	9.8	147.4	297.6	39.6
C 5	0.075	12.3	155.3	127.9	31.3
Average	0.075	10.9	148.0	192.4	32.1
D 1	0.092	11.4	136.5	281.1	45.8
D 2	0.095	10.5	126.4	261.4	43.2
D 3	0.078	12.4	151.4	252.9	42.0
D 4	0.085	9.2	112.6	198.9	33.2
D 5	0.072	10.4	125.5	164.6	28.2
Average	0.084	10.8	130.4	231.8	38.5
E 1	0.065	9.8	137.4	181.1	30.2
E 2	0.064	12.4	148.5	235.9	38.5
E 3	0.074	8.9	116.9	210.3	34.7
E 4	0.078	9.8	127.4	181.1	30.3
E 5	0.075	10.8	131.4	151.0	27.5
Average	0.071	10.3	132.3	191.9	32.3

mg kg^{-1}). The fertilization program should be started in spring when the development period begins. For a mature chestnut orchard, 112 kg N ha^{-1} is sufficient. Besides, it is recommended to apply 560 kg $K2SO_4$ ha^{-1} potassium fertilizer application to hectare to meet the K needs of plants (Vossen 2000). In soil analysis, Ca values of soils were determined below the limit value (<1150 mg kg^{-1}) parallel to the lime content. The highest Ca content was recorded at the location D (Average 231.8 mg kg^{-1}) and the lowest Ca content at A location (Average 191.7 mg kg^{-1}). Mg contents of soils were determined below the limit value (<50 mg kg^{-1}). The highest Mg content was recorded at D (Average 38.5 mg kg^{-1}) and the lowest Mg content was recorded at B location (Average 30.2 mg kg^{-1}). In rainy regions, calcium and

magnesium minerals in the main rock insufficient and coarse-textured soils have low Ca and Mg contents (Kacar and Katkat 1998).

Table 4. Micronutrient concentrations of soil in sampling orchards

Locations	Fe (mg kg^{-1})	Zn (mg kg^{-1})	Mn (mg kg^{-1})	Cu (mg kg^{-1})
A 1	5.41	0.61	62.8	0.87
A 2	4.23	0.53	72.4	1.10
A 3	5.75	0.74	63.4	0.87
A 4	5.06	1.08	58.3	0.75
A 5	5.22	0.89	61.9	0.94
Average	5.13	0.77	63.7	0.91
B 1	5.24	0.71	61.2	1.08
B 2	4.33	0.84	51.2	0.84
B 3	4.51	1.05	54.3	0.76
B 4	3.57	0.98	68.2	1.03
B 5	3.72	1.08	76.4	1.15
Average	4.27	0.93	62.2	0.97
C 1	3.73	0.91	75.5	1.06
C 2	4.61	0.85	53.6	0.82
C 3	4.24	0.73	53.2	0.76
C 4	5.46	0.87	61.5	0.93
C 5	5.08	0.68	85.4	1.03
Average	4.62	0.81	65.8	0.92
D 1	5.44	1.03	61.3	0.94
D 2	4.47	1.12	52.6	0.87
D 3	5.04	1.28	59.6	0.93
D 4	5.23	0.87	58.1	0.91
D 5	4.51	0.92	53.3	1.06
Average	4.95	1.04	57.0	0.94
E 1	4.61	1.12	54.3	0.98
E 2	5.25	1.06	62.4	1.13
E 3	3.18	0.97	61.9	0.85
E 4	4.91	1.06	57.7	1.19
E 5	3.52	1.13	75.1	1.05
Average	4.29	1.04	62.3	1.04

The micronutrient status of soils

According to soil analysis, micronutrient contents are presented in Table 4. The Fe content of 54% of the soils was above the sufficient limit (> 4.5 mg kg^{-1}) and 46% was found at the medium limit (0.2-4.45 mg kg^{-1}). The highest Fe content of the soils was recorded at location A (Average 5.1 mg kg^{-1}) and the lowest at location B (Average 4.2 mg kg^{-1}).

Table 5. Macronutrient concentrations of leaf in sampling orchards (Average of 2012 and 2013)

Locations	N (%)	P (%)	K (%)	Ca (%)	Mg (%)
A1	2.04	0.26	1.29	0.52	0.38
A2	2.12	0.18	1.18	0.46	0.31
A3	1.82	0.21	1.31	0.41	0.37
A4	2.21	0.31	1.27	0.61	0.45
A5	2.09	0.18	1.16	0.55	0.34
Average	2.06	0.23	1.24	0.51	0.37
B1	2.09	0.35	1.64	0.63	0.31
B2	1.82	0.19	1.16	0.78	0.49
B3	2.16	0.22	1.23	0.67	0.43
B4	2.10	0.28	1.21	0.71	0.37
B5	2.27	0.18	1.34	0.67	0.55
Average	2.09	0.24	1.32	0.69	0.43
C1	1.93	0.37	1.12	0.61	0.52
C2	2.07	0.16	1.21	0.58	0.49
C3	2.12	0.19	1.41	0.71	0.37
C4	2.03	0.21	1.38	0.53	0.47
C5	2.11	0.18	1.52	0.49	0.36
Average	2.05	0.22	1.33	0.58	0.44
D1	2.28	0.16	1.37	0.58	0.37
D2	2.06	0.29	1.68	0.51	0.31
D3	2.11	0.33	1.74	0.48	0.29
D4	2.31	0.30	1.36	0.67	0.31
D5	2.02	0.19	1.55	0.84	0.48
Average	2.16	0.25	1.54	0.62	0.35
E1	1.92	0.28	1.60	0.67	0.64
E2	2.09	0.17	1.38	0.58	0.31
E3	2.07	0.15	1.19	0.53	0.42
E4	2.18	0.31	1.21	0.48	0.34
E5	2.10	0.23	1.32	0.51	0.41
Average	2.07	0.23	1.34	0.55	0.42

The Zn content of the orchards soils remained within the limit values (0.5-2.4 mg kg^{-1}). The highest Zn content was found in the D location (Average 1.07 mg kg^{-1}) and the lowest Zn content was recorded in the location A (Average 0.77 mg kg^{-1}). The contents of Cu were found to be sufficient (> 0.2 mg kg^{-1}) in orchards soils, while the contents of Mn were determined above the limit value (14-50 mg kg^{-1}). The highest Cu and Mn contents were recorded at E and C locations (Average 1.04 and 65.8 mg kg^{-1}), respectively. Toprak and Seferoglu (2013) determined the Fe, Zn, Mn, and Cu contents of soils the ranged 3.74-5.72, 0.48-1.62, 0.60-1.43 and 1.49-2.85 mg kg^{-1}, respectively in chestnut orchards in Kosk district of Aydın province.

Table 6. Micronutrient concentrations of leaf in sampling orchards (Average of 2012 and 2013)

Locations	Fe (mg kg^{-1})	Zn (mg kg^{-1})	Mn (mg kg^{-1})	Cu (mg kg^{-1})
A1	112.8	30.5	652.2	5.16
A2	108.4	26.2	832.4	6.18
A3	121.8	37.0	748.5	5.21
A4	104.6	54.1	820.3	5.83
A5	118.4	44.6	656.7	5.37
Average	113.2	38.5	742.0	5.55
B1	118.4	35.6	626.6	5.21
B2	119.5	42.2	642.7	4.87
B3	103.7	52.5	764.1	5.37
B4	93.8	49.3	706.2	4.92
B5	107.1	54.6	782.0	5.61
Average	108.5	46.8	704.3	5.20
C1	106.8	45.6	672.1	6.12
C2	105.6	42.8	630.5	5.72
C3	118.2	36.5	620.2	4.87
C4	121.2	43.3	646.0	5.31
C5	105.0	34.2	564.8	4.92
Average	111.4	40.5	626.7	5.39
D1	123.0	51.5	762.1	5.48
D2	103.1	56.0	824.0	5.10
D3	114.4	64.1	746.5	4.89
D4	108.5	44.6	642.8	5.19
D5	104.7	46.0	682.6	5.16
Average	110.7	52.4	731.6	5.16
E1	97.4	56.1	826.5	4.86
E2	108.4	46.8	670.0	5.58
E3	125.3	48.5	736.6	5.13
E4	102.7	54.0	782.2	5.84
E5	114.6	58.2	834.3	6.05
Average	109.7	52.7	769.9	5.49

The macronutrient status of plant

The macronutrient concentrations of leaves are shown in Table 5. According to the results of the analysis, the foliar N concentrations were determined between 1.82 and 2.82%. The highest leaf N concentration was recorded at D location (Average 2.16%) and the lowest at B location (Average 2.05%). The chestnut foliar N concentrations were found between 1.5 and 3.0% in various studies (Arrobas et al. 2017; Toprak and Seferoglu 2013). Chestnut trees averaged 2.38% and 2.41% foliar N when an annual application of 140 or 168 kg ha^{-1} to soil-applied N was applied and a nut yield response was recorded (Warmund 2018).

The foliar P concentrations ranged from 0.15 to 0.37%. The highest and lowest foliar P concentrations were determined at D and B locations (Average 0.25 and 0.22%), respectively. In their study, some

researchers (Arrobas et al. 2017) were determined the foliar P concentrations between 0.10 and 0.25%, while some researchers (Toprak and Seferoglu 2013) were found between 0.14 and 0.19%.
The highest foliar K content was recorded at D location (Average 1.54%) and the lowest at A location (Average 1.24%). These values were above the limit value (11 g kg-1 or/ 1.1%) for the chestnut foliar K concentration indicated by Arrobas et al. (2017). Although the foliar K concentration in European chestnut and other nut trees is 2.1-2.2% (Toprak and Seferoglu 2013), it has low K concentrations (0.5-0.6%) due to the lack of application of fertilization in trees grown in Missouri (Warmund 2018). The foliar Ca concentrations directly was affected by the low Ca content of the soil. The Ca concentrations ranged from 0.41 to 0.84%. The limit values of leaf Ca concentration were determined as 1.0% and 1.0-2.5% in some hard-shell nuts such as walnuts and hazelnuts, respectively (Kacar and Katkat 1998). The foliar Ca content was recorded at the highest location C (Average 0.69%) and lowest at location A (Average 0.51%).

The micronutrient status of plant

Micronutrient levels in leaves were also investigated in the chestnut orchards for two years. The amounts of micronutrient in chestnut leaves are presented in Table 6. The foliar Fe concentrations ranged from 93.8 to 125.3 mg kg^{-1}. The highest Fe content was recorded at the location A (Average 113.2 mg kg^{-1}) and at the lowest location C (Average 108.5 mg kg^{-1}). The limit values of foliar Fe concentration were determined as 50-350 mg kg^{-1} in some hard-shell nuts such as hazelnuts (Kacar and Katkat 1998). Toprak and Seferoglu (2013), in their study on chestnut nutrition, found that foliar Fe concentrations were between 197-271 mg kg^{-1}.

The highest Zn concentration was recorded as 52.4 and 52.7 mg kg^{-1} in D and E locations, respectively. The lowest leaf Zn content was determined at the location A (Average 0.77 mg kg^{-1}). In their study, some researchers (Arrobas et al. 2017) were determined the foliar Zn concentrations between 20 and 50 mg kg^{-1}, while some researchers (Toprak and Seferoglu 2013) were found between 34 and 60 mg kg^{-1}. The limit values of foliar Zn concentration were determined as 22-25 mg kg^{-1} and 15-80 mg kg^{-1} in some hard-shell nuts such as walnuts and hazelnuts, respectively (Kacar and Katkat 1998).
In all locations, leaf Mn concentrations were determined above the limit values determined by the researchers (Arrobas et al. 2017). The foliar Mn content ranged from 564.8 to 834.3 mg kg^{-1} in chestnut orchards. In other hard-shelled nuts, leaf Mn contents are for example 30-300 mg kg^{-1} for walnuts and 25-500 mg kg^{-1} for nuts (Kacar and Katkat 1998). The Cu concentrations in the plant were determined between 4.86 and 6.18 mg kg^{-1} in this study. In different studies, these values were determined as 4-50 mg kg^{-1} for hazelnuts and 4-20 mg kg^{-1} for walnuts (Kacar and Katkat 1998). In another study, the Cu contents of chestnut plants were determined between 16 and 24 mg kg^{-1} (Toprak and Seferoglu 2013).

Conclusions

The soil of chestnut orchards examined within the scope of the research is either insufficient or limited by macro nutrients. All the orchards are inadequate for total N, organic matter, lime and therefore Ca and Mg. Although the existing P and K contents seem to be sufficient, fertilization should be done in terms of flowering and fruit quality. Micro nutrients are sufficient in orchards. This situation continued in the same way in plant analysis. As in all cultivated plants, a fertilization program is necessary for the chestnut. However, important decisions should be taken to increase the amount of organic matter in the soil. In addition, Ca content fertilizers should be added to the fertilization program for the plant to be resistant to diseases.

Acknowledgment

This research was financially supported by the Ministry of Agriculture and Forestry, General Directorate of Agricultural Research and Policies under project number TAGEM- BB-100205E6.

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Submitted: 05.03.2019 Accepted: 21-07-2019