Araştırma Makalesi
(Research Article)

Ahmet GÖKKUŞ[1]
Altıngül ÖZASLAN PARLAK[1]
Mehmet PARLAK[2]

[1] Çanakkale Onsekiz Mart Üniversitesi Ziraat Fakültesi Tarla Bitkileri Bölümü Çanakkale
[2] Çanakkale Onsekiz Mart Üniversitesi Lapseki Meslek Yüksekokulu Çanakkale
e-posta: mehmetparlak06@hotmail.com

Ege Üniv. Ziraat Fak. Derg., 2013, 50 (1): 409-418
ISSN 1018 – 8851

Change of Mineral Element Content in the Common Shrubs of Mediterranean Zone. II. Micronutrients

Akdeniz İklim Kuşağının Yaygın Çalılarında Mineral Element İçeriklerinin Değişimi II. Mikro elementler

Alınış (Received): 18.09.2013 Kabul tarihi (Accepted): 31.01.2013

Key Words:

Micronutrients , shrubby rangeland

Anahtar Sözcükler:

Mikro elementler, çalılı mera

ÖZET

Akdeniz vejetasyonunda çalılar yaygındır ve bu alanları en iyi keçiler değerlendirmektedir. Hayvanlar ihtiyaç duydukları besin elementlerini genellikle otladıkları bitkilerden karşıladıkları için bu makalede çalıların mikro besin elementlerinin yıl boyu değişimi incelenmiştir. Araştırma Çanakkale'nin maki vejetasyonuna sahip korunan ve otlanan meralarında Ekim 2006 – Kasım 2007 arasında yürütülmüştür. Denemede kermes meşesi, akçakesme, katran ardıcı, mazı meşesi, karaçalı, yapraklı laden, kekik ve abdestbozan çalılarında aylık olarak Fe, Mn, Cu, B, Na ve Zn miktarlarının değişimi incelenmiştir. Bu besin elementlerinin çalılardaki aylık değişimleri önemli olurken, sadece mazı meşesinde Zn, yapraklı laden ve kekikte Na'daki değişim önemli bulunmamıştır. Genellikle mikro elementlerinin değişimi bitkilere göre farklı seyir izlemiş, sadece Cu bütün çalı türlerinde ilkbahar başında yüksek olurken, olgunlaşmanın ilerlemesi ile azalmıştır. Bu alanlarda otlayan keçiler için çalıların Fe, Cu ve Na miktarları her dönemde yeterli, Zn yetersiz bulunmuştur. Bu sonuçlara göre, denemede ele alınan çalıların büyüme dönemleri içerisinde gerek duydukları mikro besin elementi yönünden herhangi bir açık görülmemektedir. Buna karşılık otlayan keçilerin en azından yaşama payı ihtiyaçlarını karşılayabilmeleri için Zn miktarlarında ortaya çıkan açığın mineral katkısı ile karşılanması gerekmektedir.

ABSTRACT

Shrubs are common vegetation over the Mediterranean zone and goats graze the most over these areas. Since animals meet their nutritional needs from the plants they grazed, variation in micro-nutrient contents of shrubs throughout the year was investigated in this study. The research was carried out over ungrazed and grazed maquis rangelands of Çanakkale (Turkey) between the dates October 2006 and November 2007. Monthly variations in Fe, Mn, Cu, B, Na and Zn contents of kermes oak, mock privet, prickly juniper, gall oak, Christ's-thorn, pink rockrose, thyme and prickly burnet shrubs were investigated in experiments. Except for variations of Zn in gall oak, Na in pink rockrose and thyme, monthly variations of the other nutrients in shrubs were found to be significant. In general, variation of micro nutrients had different trends in different shrubs, but only Cu had the same trend in all shrubs (high at the beginning of spring and decreased with maturation). Fe, Cu and Na contents of shrubs were found to be sufficient for all periods for goats grazing over these areas and Zn was found to be insufficient Results revealed that shrubs considered in this study did not have deficiencies for micro-nutrients during the growing season. However, deficiency of Zn should be eliminated by additional mineral supplement just to meet at least the maintenance requirements of the goats.

INTRODUCTION

Mediterranean climate zone covers about 100 million ha land area worldwide and Mediterranean coastal countries has about 30 million ha of this zone. Dominant ecological factors over these lands caused the widespread of shrubs (maquis). In Turkey, maquis lands cover about 7.5 million hectare land area and densely populated in Mediterranean, Aegean and Marmara Regions (Anonymous, 1978). Officially, significant amount of these shrublands is put under forest classification; they are mostly used for grazing of goats in practice. That is because the shrubs are considered as a significant forage source for animals. Evergreen shrubs are considered as significant nutrient source especially during the winter, end of spring and summer with dried herbaceous plants over these lands (Perevolotsky et al., 1998; Dupraz, 1999; Rogosic, 2000; Papachristou et al., 2003; Tolunay et al., 2009; Özaslan Parlak et al., 2011). Value of shrubs comes from their micro-nutrient contents.

Micro-nutrients have essential physiological effects for both plants and animals. They have prominent impacts on reproduction. Copper (Cu) like elements provides resistance against infections in animals (Whitehead, 2000). Most of micro-nutrients (like Mn, Cu, Zn) involve in metabolism activities as enzyme component and activator (Kirchgessner, 1985). Some micro-nutrients have also great significance for skeleton and conditions of the animals, Cu is significant for wool quality of sheep and Fe for blood functions (Kirchgessner, 1985; Freer et al., 2007). Deficiencies of these nutrients may cause several diseases up to deaths.

Trace elements undertake several important physiological tasks. Their functions in plants are generally related to capacity to change the oxidation status and ability to form complexes with organic molecules (Whitehead, 2000). For instance, Fe and Mn plays a role in redox processes by changing oxidation status; Cu, Zn, Mn are enzyme activators; B is important for tissue development (Aydemir and İnce, 1988; Whitehead, 2000). However, these elements are not at constant rates in plants. Significant variations are observed in plant nutrient contents with plant development. Therefore, trace element deficiencies may sometimes be observed in grazing animals. In this study, variations in trace element contents of common shrubs of Mediterranean zone with the growth season were investigated and their sufficiency to meet the grazing animals was evaluated.

MATERIALS AND METHODS

The initial part of this research concerning about macro-nutrients were previously published (Gökkuş et al., 2011). Therefore, this section of the paper was presented briefly.

The research was carried out between the dates October 2006 and November 2007 over the shrubby rangelands of Çıplak village located 30 km from Çanakkale Centrum and within campus area of Biga Faculty of Economics and Administrative Sciences located in Ağaköy village of Biga 85 km from the Centrum.

Monthly average temperatures during the research period were higher than the long-term averages. Winter, spring and summer precipitations in Ağaköy were lower than long-term averages and October-November 2007 precipitations were higher than long-term averages. In Çıplak village, total precipitations during the months of March, May, October and November 2007 were higher than long-term averages and precipitations in other months were lower than averages. Soils of both research sites are sandy-loamy, neutral, nonsaline with high, organic material content, sufficient available P and insufficient K content. Calcium (Ca), Mg, K and Na contents were 13.42, 2.64, 0.17 and 0.07 meq 100 g^{-1}, respectively in Ağaköy soils and 13.13, 2.38, 0.17 and 0.07 meq 100 g^{-1}, respectively in Çıplak soils.

In this research, common evergreen shrubs of kermes oak (*Quercuscoccifera* L.), mock privet (*Phillyrealatifolia* L.), prickly juniper (*Juniperusoxycedrus* L.), pink rockrose (*Cistuscreticus* L.), thyme (*Thymus longicaulis* C. Presl.) and prickly burnet (*Sarcopoteriumspinosum* (L.) Spach) and deciduous shrubs of gall oak (*Quercusinfectoria* Oliv.) and Christ's-thorn (*Paliurusspina-christi* Miller) were used as the plant material.

Ağaköy rangeland is ungrazed and Çıplak rangeland is continuously and heavily grazed. Two plots of 20 × 50 m size were surrounded in grazed rangeland to prevent the grazing and to observe the normal growth of plants.

During the research, plant samples were taken in the middle of each month from the twigs (leafy young shoots), grazable by animals. Ten plants were randomly selected from each shrub type. Samplings were performed from the same shrub throughout the research program. For deciduous shrubs, samples were not taken during the period from defoliation in fall to leaf formation in spring. Samples were placed into cloth bags, they were dried, weighed, grinded and made ready for analysis.

As micro-nutrients, Fe, Mn, Cu, B, Na and Zn contents of samples were determined by using ICP-OES (Inductively Coupled Plasma-Optical Emission Spectrometer) device.

Calculations and statistical analyses: Experiments were designed in repeatable measurement method (Winer et al., 1991) and data was statistically analyzed by SPSS statistical software. Duncan test was used to compare the means.

In general, variations in micro-nutrient contents of shrubs considered in this study were found to be significant. Only the variations in Zn content of gall oak and Na content of pink rockrose and thyme were found to be insignificant.

For kermes oak, while the highest Fe content (237 mg kg^{-1}) was seen in December 2006, the value was lower in the other months and the lowest levels were observed especially during spring, summer and fall seasons. Manganese(Mn) content was the highest in March (315 mg kg^{-1}) and August 2007 (371 mg kg^{-1}) and decreased significantly especially in winter. Copper (Cu) (15.37 mg kg^{-1}) and Zn rates (33.93 mg kg^{-1}) increased in April. B content increased in fall and winter and decreased significantly especially in spring and summer months. While the high Na levels were observed from the initiation of samplings to April, the levels decreased until the end of sampling period (Table 1; Fig. 1).

Table 1. Contents (mean ±SE) of micro nutrients of kermes oak (mg kg^{-1} DM) (n = 10)*

Months	Fe	Mn	Cu	B	Na	Zn
Oct. 06	127.5±7.3 cd	71.2±8.8 e	7.24±0.22 cd	46.12±3.97 c	847.5±46.6 ab	17.31±1.53 c
Nov. 06	154.7±26.9 bc	72.7±13.4 e	6.88±0.40 de	56.40±3.82 ab	807.2±89.4 ab	21.70±0.97 bc
Dec. 06	236.7±17. 6 a	95.6±11.1 e	6.13±0.21 def	51.92±3.85 abc	872.7±44.8 a	20.40±1.07 bc
Jan. 07	183.4±18.0 b	112.0±17.5 de	6.52±0.14 de	61.51±3.24 a	741.3±41.1 bc	20.36±1.55 bc
Feb. 07	127.1±9.4 cd	204.7±14.7 c	6.25±0.42 def	50.07±3.16 bc	733.8±44.1 bc	20.14±0.71 bc
Mar. 07	152.7±9.9 bc	314.6±36.5 ab	6.67±0.13 de	50.75±0.78 bc	775.3±26.5 ab	24.10±2.11 b
Apr. 07	82.2±3.7 ef	264.5±37.9 bc	15.37±0.81 a	27.70±2.36 d	585.9±21.6 d	33.93±1.63 a
May 07	75.1±2.8 f	191.5±8.6 cd	8.41±0.31 bc	22.83±0.78 d	620.6±23.2 cd	20.67±1.97 bc
Jun. 07	84.3±2.6 ef	192.0±16.8 cd	6.79±0.41 de	30.30±1.45 d	573.2±29.2 d	21.41±1.22 bc
July 07	76.9±2.8 f	188.9±22.6 cd	9.61±0.74 b	28.59±0.79 d	620.7±27.9 cd	19.42±1.64 bc
Aug. 07	115.3±6.6 de	370.9±62.4 a	6.82±0.64 de	44.62±3.67 c	644.2±21.7 cd	20.37±2.01 bc
Sep. 07	79.2±7.3 ef	261.2±33.0 bc	5.29±0.52 ef	61.55±3.26 a	621.7±10.4 cd	23.84±0.76 b
Oct. 07	91.2±10.0 def	213.6±39.4 c	4.75±0.38 f	61.31±5.50 a	624.2±13.5 cd	18.49±0.95 c
Nov. 07	99.6±11.7 def	234.9±32.0 bc	5.46±0.79 ef	45.38±3.10 c	742.7±28.9 bc	18.73±1.00 c
Mean	120.4	199.2	7.30	45.65	700.8	21.49
Sign. (p)	0.000	0.000	0.000	0.000	0.000	0.001

* within the same column, the values with different letters are significantly different at $p < 0.01$

For mock privet, Fe decreased especially in summer months and was at high levels in other months. While high levels of Mn were observed during fall of the year 2007, a decrease was seen in other seasons. The highest values were seen in April (9.28 mg kg^{-1}) and May (9.62 mg kg^{-1}) for Cu and in July (20.20 mg kg^{-1}) for B. Except October-December of the year 2006, Na levels in mock privet were at high levels and varied between 546 -640 mg kg^{-1}. Variation in Zn was found to be significant but it was irregular (Table 2; Fig. 1).

For prickly juniper, Fe content reached to the highest level (418.02 mg kg^{-1}) in January and then decreased to minimum levels in October and November 2007 (124.8 and 125.3 mg kg^{-1}, respectively). While Mn rates were significantly higher in October and December 2006, the difference among Mn rates of the other months were not significant. Copper (Cu) rates increased from the beginning of spring to beginning of summer and then started to decrease. Boron (B) contents increased in spring and summer months. Variation in Na was found to be significant but irregular. Zinc (Zn) content of prickly juniper was at the lowest level especially in October and November 2007 (8.96 and 9.25 mg kg^{-1}, respectively) and the values were high and closer to each other in other months (between 10.57-13.45 mg kg^{-1}) (Table 3; Fig. 1).

For gall oak, variations in micro-nutrients during the research period were found to be significant for all except Zn. Iron (Fe), Mn, B and Na contents significantly decreased especially during the initial growth in spring, then increased in following months. A reverse trend was observed for Cu (Table 4; Fig. 1).

Table 2. Contents (mean ±SE) of micro nutrients of mock privet (mg kg^{-1} DM) (n = 10)*

Months	Fe	Mn	Cu	B	Na	Zn
Oct. 06	114.1±6.8 bc	35.7±1.1 c	5.36±0.59 e	11.14±0.36 fg	510.0±23.8 de	17.91±1.10 cde
Nov. 06	122.4±5.7 ab	31.9±2.3 cd	5.37±0.14 e	10.51±0.37 g	475.2±2.7 e	18.89±1.19 a-e
Dec. 06	150.6±19.0 a	31.8±2.5 cd	6.19±0.72 de	11.60±0.47 fg	482.1±8.9 e	16.49±1.41 de
Jan. 07	116.6±4.2 bc	37.6±2.1 bc	8.03±0.60 bc	12.11±0.44 efg	552.4±21.6 bcd	20.43±0.57 abc
Feb. 07	126.6±3.2 ab	33.2±1.1 cd	5.69±0.17 e	10.61±0.26 g	551.5±16.7 bcd	18.59±0.42 b-e
Mar. 07	139.2±11.7 ab	38.6±2.4 bc	6.80±0.63 cde	11.44±0.33 fg	612.0±23.6 ab	20.94±0.19 ab
Apr. 07	136.1±6.5 ab	32.2±1.4 cd	9.28±0.56 ab	14.19±0.60 cde	592.8±26.3 ab	20.08±0.92 abc
May 07	90.4±8.9 cd	25.3±1.7 d	9.62±0.30 a	14.86±0.88 bcd	596.9±29.7 ab	21.76±0.92 a
Jun. 07	71.3±2.4 d	31.9±2.2 cd	7.58±0.47 cd	13.38±0.46 def	546.4±6.9 bcd	16.19±0.60 e
July 07	61.7±2.1 d	34.1±1.7 c	7.53±0.36 cd	20.20±1.96 a	614.4±24.6 ab	17.82±1.09 cde
Aug. 07	80.6±5.8 d	44.7±2.5 ab	5.65±0.35 e	16.68±0.44 b	591.5±16.0 ab	18.26±1.08 b-e
Sep. 07	141.1±7.9 ab	50.0±4.7 a	5.47±0.21 e	16.06±0.39 bc	566.3±13.4 bcd	19.37±1.20 a-d
Oct. 07	128.9±9.9 ab	47.1±2.0 a	5.64±0.29 e	16.58±0.34 bc	584.2±17.1 abc	17.89±0.80 cde
Nov. 07	144.6±16.6 ab	48.1±3.7 a	7.11±0.28 cd	15.80±1.02 b	640.4±40.0 a	19.97±0.86 abc
Mean	116.0	34.5	6.81	13.94	565.4	18.90
Sign. (p)	0.000	0.000	0.000	0.000	0.000	0.001

* within the same column, the values with different letters are significantly different at p< 0.01

Table 3. Contents (mean ±SE) of micro nutrients of prickly juniper (mg kg^{-1} DM) (n = 10)*

Months	Fe	Mn	Cu	B	Na	Zn
Oct. 06	207.0±17.1 cde	84.7±9.7 a	3.46±0.17 bcd	13.32±0.58 abc	553.3±21.5 b	12.79±1.36 ab
Nov. 06	188.3±6.5 def	52.1±4.0 c	3.01±0.15 d	12.08±0.51 bcd	527.3±13.6 bc	12.08±0.67 ab
Dec. 06	261.1±36.2 bc	71.7±7.5 ab	3.57±0.30 bcd	12.18±0.80 d	465.9±13.1 de	11.42±0.72 ab
Jan. 07	418.2±11.0 a	62.5±2.0 bc	3.43±0.13 bcd	10.12±0.38 cd	460.6±16.4 e	10.92±0.66 bcd
Feb. 07	296.1±22.7 b	61.1±1.0 bc	4.33±0.53 ab	11.15±0.25 cd	508.5±8.6 b-e	13.45±0.38 a
Mar. 07	223.3±24.4 cd	54.3±4.4 c	3.75±0.24 bcd	11.33±0.50 cd	520.2±19.3 bcd	12.25±0.43 ab
Apr. 07	131.5±10.7 fg	61.0±4.7 bc	4.01±0.29 abc	12.77±0.93 a-d	480.8±14.3 cde	11.74±0.94 ab
May 07	187.2±13.1 def	62.2±6.5 bc	4.79±0.41 a	13.18±1.10 abc	515.1±9.2 b-e	11.76±0.34 ab
Jun. 07	152.7±18.4 efg	56.2±4.8 bc	4.16±0.14 ab	13.32±0.52 abc	521.1±34.7 bcd	10.59±0.56 bcd
July 07	194.9±11.3 de	48.1±2.8 c	3.48±0.21 bcd	14.15±1.90 abc	552.8±22.4 b	11.16±0.56 bc
Aug. 07	133.5±9.9 fg	52.6±3.5 c	3.20±0.09 cd	13.96±0.06 abc	529.3±17.8 bc	10.57±0.46 bcd
Sep. 07	190.8±23.2 de	60.7±2.3 bc	3.40±0.41 bcd	14.88±1.36 ab	627.1±18.2 a	12.36±0.52 ab
Oct. 07	124.8±11.2 g	53.2±5.4 c	3.19±0.43 cd	15.33±1.10 a	527.4±15.7 bc	8.96±0.42 d
Nov. 07	125.3±15.5 g	51.8±3.9 c	3.16±0.13 cd	9.94±0.33 d	512.7±11.9 b-e	9.25±0.46 cd
Mean	202.5	59.4	3.64	12.69	521.6	11.38
Sign. (p)	0.000	0.001	0.002	0.001	0.000	0.001

* within the same column, the values with different letters are significantly different at p< 0.01

Table 4. Contents (mean ±SE) of micro nutrients of gall oak (mg kg^{-1} DM) (n = 10)*

Months	Fe	Mn	Cu	B	Na	Zn
Oct. 06	179.1±10.8 bcd	1049.1±174.4 b	6.38±0.25 bc	38.40±6.86 de	792.6±19.7 def	22.44±1.19
Nov. 06	192.0±33.9 bc	1436.1±236.4 ab	5.93±0.28 c	36.08±7.27 def	1011.3±67.9 bc	24.19±2.43
Dec. 06	217.5±22.5 b	1252.1±53.7 ab	6.54±0.31 bc	30.11±1.41 efg	919.4±39.2 cde	23.17±0.62
Apr. 07	138.5±16.9 cd	552.5±55.5 c	113.78±0.93 a	23.92±1.58 fg	680.4±58.1 f	30.47±2.93
May 07	122.3±11.2 d	627.4±108.9 c	6.69±0.47 bc	21.09±0.92 g	780.9±46.4 def	24.96±3.89
Jun. 07	306.9±19.8 a	1339.0±155.4 ab	7.50±0.39 b	35.73±2.77 def	769.7±19.9 ef	24.00±1.76
July 07	202.6±10.2 bc	1176.0±123.5 ab	6.76±0.28 bc	53.43±1.93 bc	762.0±31.4 ef	23.97±2.36
Aug. 07	321.6±26.4 a	1189.4±58.7 ab	7.03±0.43 bc	49.25±4.84 cd	788.1±39.5 def	26.96±1.37
Sep. 07	300.2±14.8 a	1240.1±61.2 ab	7.17±0.44 bc	64.78±5.92 ab	974.5±79.3 cd	28.72±1.70
Oct. 07	346.2±46.4 a	1219.1±66.4 ab	6.72±0.36 bc	69.24±4.67 a	1440.8±126.9 a	24.99±1.30
Nov. 07	281.9±13.7 a	1569.3±81.2 a	6.78±0.57 bc	52.02±5.65 bc	1190.5±76.6 b	26.13±1.70
Mean	237.2	1150.0	7.39	43.10	919.1	25.45
Sign. (p)	0.000	0.000	0.000	0.000	0.000	0.248

* within the same column, the values with different letters are significantly different at p< 0.01

Table 5. Contents (mean ±SE) of micro nutrients of Christ's-thorn (mg kg^{-1} DM) (n = 10)*

Months	Fe	Mn	Cu	B	Na	Zn
Oct. 06	161.1±16.8 ab	1111.9±82.8 b	5.55±0.20 c	23.04±1.15 e	1059.1±57.6 b	27.69±3.25 bc
Nov. 06	186.2±15.0 a	1577.8±177.3 a	6.21±0.34 bc	107.60±8.33 a	1508.4±182.4 a	29.39±2.01 b
Apr. 07	159.2±8.2 ab	538.2±29.2 de	8.92±0.35 a	70.49±2.51 b	711.9±27.0 c	51.18±2.15 a
May 07	108.4±4.2 cde	716.4±73.3 cde	6.29±0.31 bc	60.73±1.62 c	608.5±22.6 c	29.57±1.46 b
Jun. 07	75.7±6.9 f	429.2±29.5 e	7.34±0.73 b	54.97±2.08 cd	605.0±19.3 c	27.07±1.10 bc
July 07	85.3±12.3 ef	789.4±226.4 cd	6.55±0.85 bc	50.13±1.45 d	639.5±42.0 c	24.79±1.98 bc
Aug. 07	100.1±8.9 def	557.5±52.4 de	6.23±1.03 bc	48.97±0.73 d	747.0±43.7 c	22.39±1.58 c
Sep. 07	128.9±12.2 cd	924.1±64.8 bc	6.38±0.67 bc	51.31±0.98 cd	778.0±39.7 c	23.18±1.46 bc
Oct. 07	132.9± 9.3 bc	997.8±85.9 bc	6.37±0.82 bc	51.53±1.74 cd	848.0±52.1 bc	24.15±1.18 bc
Mean	126.4	893.6	6.65	57.64	867.3	28.82
Sign. (p)	0.000	0.000	0.007	0.000	0.000	0.000

* within the same column, the values with different letters are significantly different at p< 0.01

Table 6. Contents (mean ±SE) of micro nutrients of pink rockrose (mg kg^{-1} DM) (n = 10)*

Months	Fe	Mn	Cu	B	Na	Zn
Oct. 06	303.9±29.2 bc	50.4±9.3 ab	4.71±0.34 de	14.61±0.91 h	667.3±10.4	28.5±1.5 ef
Nov. 06	226.6±26.4 d-g	41.9±3.6 a-e	4.41±0.36 e	14.93±0.93 h	620.1±21.9	26.8±0.6 f
Dec. 06	424.5±27.6 a	46.8±2.2 abc	5.00±0.28 de	21.39±0.67 d-g	674.2±38.3	39.9±1.6 d
Jan. 07	276.6±34.5 cd	40.0±1.8 b-e	5.77±0.21 cd	19.11±0.40 fg	736.4±56.8	46.6±5.2 cd
Feb. 07	155.8±6.8 fgh	41.8±1.7 a-e	8.36±0.39 b	22.14±1.27 def	742.5±31.5	57.4±2.4 b
Mar. 07	219.4±19.0 d-h	46.8±5.3 abc	9.52±0.44 b	25.88±0.89 bc	757.3±48.1	82.3±4.7 a
Apr. 07	353.5±43.9 b	50.7±1.6 ab	12.29±0.69 a	30.05±1.05 a	703.8±17.0	83.9±7.6 a
May 07	242.0±21.9 cde	43.7±1.8 a-d	8.84±0.55 b	23.84±0.93 cd	737.8±30.4	50.3±2.5 bc
Jun. 07	167.1±11.9 e-h	35.7±2.7 cde	9.06±0.23 b	27.24±1.71 ab	650.3±19.4	50.5±1.6 bc
July 07	152.4±7.2 gh	31.7±1.0 e	6.39±0.17 c	22.13±1.35 def	664.1±25.7	37.1±2.0 def
Aug. 07	145.2±10.3 h	31.5±2.0 e	6.19±0.16 c	20.03±1.05 efg	710.1±47.8	29.1±1.9 ef
Sep. 07	182.2±6.3 e-h	33.6±1.9 de	6.78±0.29 c	21.21±0.66 d-g	771.1±47.7	36.4±2.3 def
Oct. 07	229.9±17.6 c-f	36.2±1.9 cde	6.38±0.34 c	22.95±0.42 cde	725.6±25.9	37.0±1.2 def
Nov. 07	258.1±25.1 cd	51.9±2.9 a	6.77±0.32 c	18.36±1.22 g	718.3±15.7	37.9±2.7 ef
Mean	238.4	41.6	7.18	21.71	705.6	46.0
Sign. (p)	0.000	0.000	0.000	0.000	0.051	0.000

* within the same column, the values with different letters are significantly different at p< 0.01

Table 7. Contents (mean ±SE) of micro nutrients of thyme (mg kg^{-1} DM) (n = 10)*

Months	Fe	Mn	Cu	B	Na	Zn
Oct. 06	214.6±12.3 cd	43.0±3.5 bc	6.61±0.02 de	32.61±1.80 b	1424.1±82.7	22.34±0.39 cde
Nov. 06	252.1±32.1 cd	32.7±2.2 d	6.31±0.15 e	25.50±1.01 de	1497.1±181.8	19.57±0.95 e
Dec. 06	210.2±31.3 cd	35.8±2.1 cd	6.60±0.36 de	24.29±0.65 e	1145.5±70.9	20.30±1.13 e
Jan. 07	293.3±22.1 c	43.3±2.3 bc	6.73±0.20 de	24.90±1.16 de	1235.5±33.9	26.85±1.79 bc
Feb. 07	227.7±21.8 cd	44.6±3.3 bc	6.94±0.37 cde	29.23±1.09 bc	1251.1±46.3	28.79±2.16 ab
Mar. 07	230.8±53.8 cd	35.3±3.4 cd	7.48±0.73 b-e	27.94±1.65 cd	1454.9±192.8	26.68±2.44 bc
Apr. 07	434.7±42.8 a	58.8±2.9 a	9.71±0.36 a	26.89±1.25 cde	1333.1±131.2	32.44±2.07 a
May 07	241.0±28.3 cd	46.8±3.2 b	8.37±1.21 abc	26.54±1.28 cde	1122.3±38.7	23.28±1.90 cde
Jun. 07	207.9±26.6 cd	35.9±1.8 cd	8.92±0.44 ab	26.80±1.25 cde	1421.0±171.9	25.35±1.34 bcd
July 07	175.4±16.1 d	35.7±1.8 cd	8.05±0.45 bcd	31.61±0.84 b	1027.4±83.5	25.82±0.88 bcd
Aug. 07	163.3±16.5 d	39.0±2.2 bcd	7.52±0.23 b-e	36.16±0.83 a	1057.8±37.5	25.31±1.14 bcd
Sep. 07	205.6±21.9 cd	36.1±2.2 cd	6.78±0.19 cde	31.56±0.94 b	1311.9±106.3	19.04±1.03 e
Oct. 07	303.4±37.9 bc	46.4±5.8 b	6.46±0.28 de	24.05±1.01 e	1197.1±59.6	21.80±1.01 de
Nov. 07	384.6±28.6 ab	41.0±2.2 bcd	7.24±0.31 cde	23.78±0.99 e	1242.9±64.9	21.58±0.55 de
Mean	253.2	41.0	7.41	27.99	1265.8	24.23
Sign. (p)	0.000	0.000	0.000	0.000	0.067	0.000

* within the same column, the values with different letters are significantly different at p< 0.01

Table 8. Contents (mean ±SE) of micro nutrients of prickly burnet (mg kg^{-1} DM) (n = 10)*

Months	Fe	Mn	Cu	B	Na	Zn
Oct. 06	279.3±17.6 ab	44.4±3.3 abc	4.81±0.27 a-d	30.12±1.65 bc	946.2±51.9 a	20.32±0.92 bcd
Nov. 06	275.3±47.5 ab	38.4±1.5 c	4.96±0.48 a-d	26.95±1.83 cde	708.0±42.9 bcd	22.76±1.54 a-d
Dec. 06	226.3±22.2 bcd	43.6±3.1 bc	4.14±0.28 d	24.13±0.96 de	598.1±32.7 e	20.60±1.09 a-d
Jan. 07	326.4±62.2 a	44.0±3.8 bc	4.91±0.38 a-d	24.37±1.11 de	670.1±14.9 cde	21.41±1.05 a-d
Feb. 07	261.6±7.1 abc	44.6±3.9 abc	4.34±0.04 cd	27.05±1.90 cde	729.9±18.3 bcd	19.95±0.98 cd
Mar. 07	156.6±6.9 d	43.7±2.7 bc	4.54±0.22 bcd	36.44±0.88 a	783.7±31.1 b	24.11±2.99 abc
Apr. 07	255.5±23.3 abc	45.6±5.6 abc	5.38±0.19 ab	30.68±1.37 bc	768.2±38.7 b	24.86±2.51 ab
May 07	251.0±17.6 abc	54.1±2.5 a	5.45±0.19 a	32.96±0.77 ab	726.3±13.4 bcd	25.15±0.90 a
Jun. 07	236.2±11.7 bcd	52.2±2.0 ab	5.29±0.13 ab	30.83±2.19 bc	639.7±17.3 de	24.32±0.70 abc
July 07	215.7±9.3 bcd	46.3±1.4 abc	4.83±0.14 a-d	28.37±1.42 cd	713.5±16.2 bcd	19.84±1.10 cd
Aug. 07	179.0±15.1 cd	45.2±2.0 abc	4.69±0.09 a-d	30.59±1.16 bc	733.1±18.3 bcd	25.24±1.66 a
Sep. 07	178.8±7.0 cd	39.4±3.2 c	4.88±0.23 a-d	30.46±1.54 bc	673.8±29.7 cde	18.07±0.95 d
Oct. 07	224.0±19.3 bcd	44.2±4.0 abc	5.14±0.24 abc	30.37±0.62 bc	649.2±10.6 de	22.25±1.32 a-d
Nov. 07	200.0±27.3 bcd	38.8±1.0 c	4.70±0.23 a-d	23.51±1.08 e	748.9±21.2 bc	20.12±1.07 bcd
Mean	233.3	44.6	4.86	29.06	720.6	22.07
Sign. (p)	0.002	0.027	0.020	0.000	0.000	0.006

* within the same column, the values with different letters are significantly different at $p< 0.01$

For Christ's-thorn, while Fe ratios were at high levels in October and November 2006 and April 2007 (161, 186 and 159 mg kg^{-1}, respectively); it decreased in other months and in especially in summer. Beside this, Mn, B and Na levels were high at the end of growing season (October and November 2006) and low in other periods. Copper (Cu) and Zn contents increased in initial growth period in spring and decreased afterwards (Table 5; Fig. 1).

For pink rockrose, variations in micro-nutrient contents were found to be significant for all nutrients except for Na. While high Fe levels were observed in December and April, significant decreases were seen in other months, especially in summer months. Manganese (Mn) and Cu levels went down to the lowest levels of the year in fall months. Boron (B) content of pink rockrose started to increase from March, reached to the highest level in April (30.05 mg kg^{-1}) and decreased to minimum levels in winter months. Zinc (Zn) content increased in March (82.3 mg kg^{-1}) and April (83.9 mg kg^{-1}) and was generally closer to each other in other months (Table 6; Fig. 1).

For thyme, variations in trace element contents were found to be significant for all nutrients except for Na. Rates of entire micro-nutrients, except B, increased in April in which new shoots are developed and then decreased afterwards. Boron (B) has the highest value (36.16 mg kg^{-1}) in August. Copper (Cu) content of thyme was at maximum levels in April, May and June. Micro-nutrient contents generally decreased more in fall and winter months (Table 7; Fig. 1).

For prickly burnet, variations of micro-nutrient contents for all nutrients throughout the year were found to be significant, but the variations were irregular (Table 8; Fig. 1). In all shrub types, of which micro-nutrient contents were determined, Na was the one with highest amounts. Also, Mn was the highest trace element in defoliating shrubs like gall oak and Christ's-thorn.

DISCUSSION

Variations in micro-nutrient contents of eight shrub types considered in this study were generally found to be significant. Except for Cu, monthly variations in these nutrients exhibited different trends in each shrub. While high Cu levels were observed in all shrubs at the beginning of spring, decreasing values were seen with maturation. High levels were only sustained in prickly burnet also in summer and fall months. Decrease in Cu is mostly related to maturation, changes in climate and seasonal conditions (Spears, 1994). Cu exists in several enzymes in plants and provided support in preservation of chlorophyll structure and participates into protein synthesis (Sebanek, 1992). Therefore, Cu is generally intensified in physiologically active cells. That is why, high Cu levels are observed during the vegetative growing periods (spring) of plants (Ramirez et al., 2001). Average Cu values in this research were between 3.64 mg kg^{-1} (prickly juniper) and 7.41 mg kg^{-1} (thyme). In other researches, the ratios were reported as 4.8-5.8 mg kg^{-1} for shrubs (Ramirez-Orduna et al., 2005) and as 8.9 mg kg^{-1} for dry hay (Macpherson, 2000).

Iron (Fe) contents of mock privet and Christ's-thorn decreased in summer and increased in other months. An increase in Fe content was observed only in winter

for prickly juniper and kermes oak. Higher Fe ratios were observed in summer and fall samples of gall oak and prickly burnet. Generally an irregular variation was observed in pink rockrose. Iron contents of forage crops are mostly related to soil conditions and variations in climate and conditions during the growing season (Macpherson, 2000). Varying results observed in this study may be tied to these conditions. Iron is related to enzyme systems of plants and plays an activating role in biochemical processes like photosynthesis, respiration and N fixation (Hawkes et al., 1985). Similarly as it was in mock privet, Christ's-thorn and pink rockrose of this study, seasonal changes were observed in Fe contents of Mexican shrubs (Ramirez-Orduna et al., 2005).

Researchers indicated increasing variations in spring and decreasing variations in other months. Average Fe contents in present study varied between 116 mg kg^{-1} (mock privet) – 253 mg kg^{-1} (thyme). Closer to these values, Ramirez-Orduna et al. (2005) observed Fe ratios as between 227-312 mg kg^{-1} and Fe ratios of New Zealand rangelands were recorded as between 111-3850 mg Fe kg^{-1} DM (average 581 mg kg^{-1}) (Campbell et al., 1974).

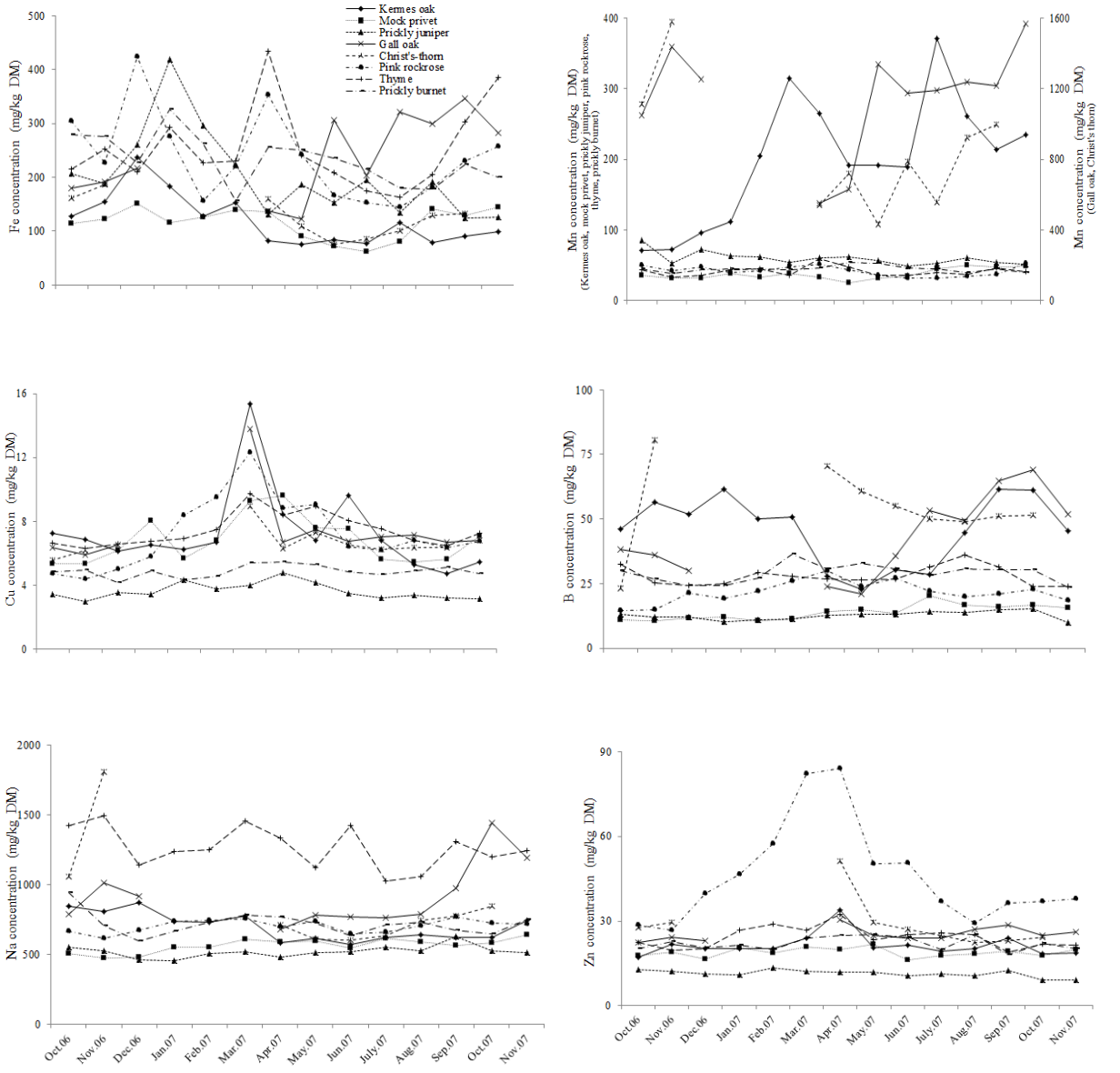

Figure 1. Change of Fe, Mn, Cu, B, Na, and Zn concentrations of the shrub species

Manganese (Mn) contents of shrubs increased at the end summer and fall for mock privet, in spring for kermes oak, prickly burnet, pink rockrose and thyme and decreased in spring for gall oak and Christ's-thorn. Most of Mn in plants presents in cell wall (Spears, 1994) therefore it is usual to expect an increase in especially summer, fall and winter months. However, Mn ratios of half of the investigated shrubs increased especially in spring. It was possible due to enzyme activating role of Mn and existence of certain rate of Mn in protoplasm because of functional role of Mn in chloroplast membranes (Salisbury and Ross, 1992). Significant seasonal variations in Mn contents (40.8-44.9 mg kg^{-1}) were also observed in Mexican shrubs (Ramirez-Orduna et al., 2005). Manganese (Mn) contents of plant samples varied more than that of shrubs in that study. Manganese levels in current study were observed as 34.5 mg kg^{-1} in mock privet and as 1150.0 mg kg^{-1} in gall oak. This kind of large difference in Mn contents of shrubs was also observed by Ramirez-Orduna et al., (2005).

Boron (B) ratios increased in spring for prickly juniper, prickly burnet and pink rockrose, in summer and fall for mock privet, in fall and winter for kermes oak, in fall for gall oak, in November 2007 for Christ's-thorn and at the end of summer-beginning of fall for thyme and decreased in other months. Results revealed significant differences in B contents with regard to shrub type. Boron play a role in sugar synthesis and transport (Sebanek, 1992), nucleic acid and hormone synthesis (Kabata-Pendias, 2000), cell growth and cell membrane processes (Güneş et al., 2000). These B activities in protoplasm structure can explain the increasing B contents during the early stages of plant growth. However, B is also fixed to cell wall with weaker ties than Ca (Güneş et al., 2000). Therefore, an increase in B contents can be mentioned in some shrubs during the maturation period. Average boron contents of shrubs in this study were between 12.69 mg kg^{-1} (prickly juniper) and 57.64 mg kg^{-1} (Christ's thorn). These values are closer to the values specified in text books giving the trace element content of various plants (Güneş et al., 2000; Kabata-Pendias, 2000; Suttle, 2010).

Sodium (Na) contents of shrubs generally increased in fall. However, this increase started from spring in mock privet, was irregular in prickly burnet and was not significant in pink rockrose and thyme. Sodium contents of plants vary based on plant type, growth season, soil and climate conditions. Sodium level increases especially in dry sites and dry seasons (Ramirez-Orduna et al., 2005). Lower precipitations in fall and winter of research period than long-term averages may explain the current results with regard to Na contents of shrubs. On the contrary to results of current study, Na contents of rangeland grass was found to be minimum (100-200 mg kg^{-1}) in September and maximum (500 mg kg^{-1}) in spring in a research carried out in California (Morris et al., 1980). Similarly, Ramirez-Orduna et al. (2005) indicated higher Na contents (1200 mg kg^{-1}) for shrubs in spring than the other seasons (700-900 mg kg^{-1}) and explained these findings with drought. Sodium (Na) contents of shrubs in current study were found to be between 522 mg kg^{-1} (prickly juniper) and 1266 mg kg^{-1} (thyme).

Zinc (Zn) contents of shrubs generally increased in spring and decreased in other months. The variation was not significant in gall oak and irregular in prickly burnet. Zn constitutes basic component of some enzyme systems for protein synthesis (Salisbury and Ross, 1992). Since plants have high protein rates at the beginning of growth (spring), increasing Zn contents were observed for shrubs in spring. In a study carried out with milk-vetch (Leano, 1986), Zn increased from the initiation of growth and decreased from the flowering until maturation. Ramirez-Orduna et al. (2005) in a research carried out on shrubs in Mexico indicated increasing Zn contents in winter and summer and decreasing values in other months and observed an average Zn content of 14.1-17.0 mg kg^{-1}. Beside this, Ramirez et al. (2005) observed Zn contents of various shrubs as between 17-50 mg kg^{-1}. Minson (1990) recorded average Zn content of 719 forage crops as 36 mg kg^{-1}. Zinc contents of shrubs considered in this study varied between 11.38 mg kg^{-1} (prickly juniper) and 46.0 mg kg^{-1} (pink rockrose).

Sufficiency of shrub micro-nutrients to meet the nutritional needs of goats were evaluated by taking surviving needs of goats. Daily needs of a goat with a live-weight of 50 kg is about 30-40 mg kg^{-1} for Fe , 60-120 mg kg^{-1} for Mn, 10-20 mg kg^{-1} for Cu, 50-80 mg kg^{-1} for Zn (Anonymous, 1998), and 400-900 mg kg^{-1} Na (Anonymous, 1998; National Research Council, 2007). Since B is a nutrient for plants but not considered as a nutrient for animals (National Research Council, 2007), evaluations were not performed with regard to B in this study. Considering the daily dry matter consumption of a 50 kg-goat as 1 kg:

a) Iron (Fe) ratios of all shrubs in growing seasons were found to be sufficient to meet the needs of goats.

b) While Mn was found to be sufficient for kermes oak, gall oak and Christ's-thorn year-around, it was not

sufficient for mock privet, pink rockrose, thyme and prickly burnet. Mn content of prickly juniper was at lower limits of the needs. Mn content of juniper left below the needs in some seasons (especially in summer and fall).

c) Copper (Cu) contents of shrubs can generally be said insufficient to meet the needs of goats. Cu deficiencies were observed in April for kermes oak, gall oak and pink rockrose.

d) Sodium (Na) contents of all shrubs in all growing periods were found to be sufficient to meet the needs of goats.

e) Except the Zn contents of pink rockrose in March and April, Zn ratios of shrubs were found to be below the needs of goats. Therefore, Zn deficiency can be mentioned for goats grazing over shrublands.

CONCLUSION

Any deficiency was not observed in micronutrient contents of shrubs during 14 months. Except for Zn deficiency with regard to needs of goats, deficiency was not observed in other investigated micronutrients.

ACKNOWLEDGEMENTS

This study was supported by The Scientific and Technological Research Council of Turkey (TUBITAK) (Project No: 106O458).

REFERENCES

Anonymous, 1978. Türkiye Arazi Varlığı. Köyişleri ve Kooperatifler Bakanlığı, Topraksu Genel Müdürlüğü. Toprak Etüdleri ve Haritalama Dairesi Başkanlığı, Ankara,55 sayfa.

Anonymous, 1998. The Nutrition of Goats. Agricultural and Food Research Council. Wallingford, UK. Pages 118

Aydemir, O. and F. İnce, 1988. Bitki Besleme [Plant Nutrition]. Diyarbakır, Turkey. Pages 653. (in Turkish).

Campbell, A. G., M. R. Coup, W. H. Bishop and D.E. Wright, 1974. Effect of elevated iron intake on the cupper status of grazing cattle. New Zealand Journal of Agricultural Research, 17: 393-399.

Dupraz, C, 1999. Fodder trees and shrubs in Mediterranean areas: Browsing for the future. Grassland and Science in Europe, 4: 145-158

Freer, M., H. Dove and J.V. Nolan, 2007. Nutrient requirements of domesticated ruminants. Collingwood, Australia. Pages 266.

Gökkuş, A., A. Özaslan Parlak and M. Parlak, 2011. Change of mineral element content in the common shrubs of Mediterranean zone. I. Macronutrients. Žemdirbyst=Agriculture, 98: 357-366.

Güneş, A., M. Alpaslan and A. İnal, 2000. Bitki Besleme ve Gübreleme [Plant Nutrition and Fertilization]. Ankara, Turkey. Pages 576. (in Turkish).

Hawkes, G.R., K.B. Campben and A.E. Ludwick, 1985. Western fertilizer handbook. In: California Plant Health Association (Ed.), Essential Plant Nutrients. The Interstate Printers & Publishers. Illinois, USA, pp. 61-81.

Kabata Pendias, A, 2000. Trace Elements in Soils and Plants. USA. Pages 432.

Kirchgessner, M, 1985. Hayvan besleme [Animal nutrition]. Translated: Kılıç A. TÜBİTAK, Ankara, Turkey, Pages 515 . (in Turkish).

Leano, P. A, 1986. Mineral elements concentration and carbohydrate trends in Woolly Loco *Astragalusmollissimus.* M.Sc. thesis (unpublished). Texas Technical University. Pages 67.

Macpherson, A, 2000. Forage evaluation in ruminant nutrition. In: Trace-Mineral Status of Forages. (Eds: D. I. Givens, E. J. Owens and H.M. Omed), CABI Publishing, USA, pp. 345-371.

Minson, D. J, 1990. Forage in Ruminant Nutrition. London. Pages 483.

Morris, J. G., R. E. Delmas and J. L. Hull, 1980. Salt supplementation of range beef cows in California. Journal of Animal Science, 51: 71-73.

National Research Council, 2007. Nutrient Requirements of Small Ruminants: Sheep, Goats, Cervids, and New World Camelids. National Research Council of the National Academies. Washington, D.C., USA. Pages 362 .

Özaslan Parlak, A., A. Gökkuş, B.H. Hakyemez and H. Baytekin, 2011. Shrub yield and forage quality in Mediterranean shrublands of West Turkey for a period of one year. African Journal of Agricultural Research, 6: 1726-1734.

Papachristou, T. G., A. S. Nastis, R. Mathur and M. R. Hutchings, 2003. Effect of physical and chemical plant defenses on herbivory: implications for Mediterranean shrubland management. Basic and Applied Ecology, 4: 395–403.

Perevolotsky, A., S. Landau, D. Kababya and E. D. Ungar, 1998. Diet selection in dairy goats grazing woody Mediterranean rangeland. Applied Animal Behaviour Science, 57: 117–131.

Ramirez, R. G., G. F. W. Haenlein and M. A. Nunez Gonzalez, 2001. Seasonal variation of macro and trace mineral contents in 14 browse species that grow in Northeastern Mexico. Small Ruminant Research, 39: 153-159.

Ramirez Orduna, R., R. G. Ramirez, H. Gonzalez Rodriquez, and G. F. W. Haenlein, 2005. Mineral content of browse species from Baja California Sur, Mexico. Small Ruminant Research, 57: 1–10.

Rogosic, J. 2000. Management of the Mediterranean Natural Resources. Mostar, Bosni Herzegovina. Pages 352.

Salisbury, F. B. and C. W. Ross, 1992. Plant Physiology. California, USA. Pages 682.

Sebanek, J. 1992. Plant Physiology. Amsterdam. Pages 454 .

Spears, J.W, 1994. Forage quality, evaluation, and utilization. In: Minerals in Forages. (Ed. G.C. Fahey), Wisconsin, USA, pp 281-317.

Suttle, N. F, 2010. The Mineral Nutrition of Livestock. 4th Ed. UK. Pages 608.

Tolunay, A., V. Ayhan and E. Adıyaman, 2009. Dry matter yield and grazing capacity of kermes oak (*Quercuscoccifera* L.) shrubland for pure hair goat (*Capra hircus* L.) breeding in Turkey's Western Mediterranean Region. Journal of Animal and Veterinary Advances, 8(2): 368-372.

Whitehead, D.C, 2000. Nutrient Elements in Grassland: Soil-Plant-Animal Relationships. Cambridge, UK. Pages 384.

Winer, B.J., D.R. Brown and K.M. Michels, 1991. Statistical Principles in Experimental Design. California, USA. Pages 928.