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Change of mineral element content in the common shrubs of Mediterranean zone. I. Macronutrients

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Abstract

Shrubs are characteristic of Mediterranean zone and are a significant feed source for goats. However, nutrient contents of shrubs vary significantly with climate, soil and especially with plant growth. There are a few studies on annual variations in mineral contents of shrubs in Marmara Region. Therefore, in this study, seasonal variation of macronutrients (N, P, K, Ca, Mg, S) of kermes oak (*Quercus coccifera* L.), mock privet (*Phillyrea latifolia* L.), prickly juniper (*Juniperus oxycedrus* L.), gall oak (*Quercus infectoria* Oliv.), Christ's-thorn (*Paliurus spina-christi* Miller), pink rockrose (*Cistus creticus* L.), thyme (*Thymus longicaulis* C. Presl.) and prickly burnet (*Sarcopoterium spinosum* (L.) Spach) were investigated for 14 months (October 2006–November 2007). Variation of macronutrients throughout the year was found to be significant for all shrubs. The concentrations of N, P, K, and S in the shrubs reached the highest levels during the April–May months. However, Ca significantly decreased in April. Variation in Mg varied with shrub species. While the amount of N was able to meet the demands of goats during spring for all shrubs except for *Paliurus spina-christi* and *Quercus infectoria*, they were not able to meet the demands in other seasons. While *Paliurus spina-christi* had sufficient N every season, *Quercus infectoria* had also sufficient N during each season except for winter. P, K, and Ca were mostly observed at sufficient amounts for goats. While *Juniperus oxycedrus* had insufficient Mg in every season and mock privet in summer and autumn, Mg deficiency was not observed in other shrubs. Amounts of S were generally insufficient for the needs of goats.

Key words: macronutrients, shrubby rangeland.

Introduction

Shrubs are resistant to drought and salinity and play an important role in Mediterranean ecosystems. Maquis lands are considered as natural feed source for goats during the entire year. Therefore, goat production activities are widespread over these lands (Papachristou et al., 1999; 2003; Rogosic, 2000). Grazing studies carried out over Mediterranean shrublands revealed that more than 60% of goat feed comes from shrubs (Perevolotsky et al., 1998; Papachristou et al., 2005). The ration of shrubs in goat feed reaches up to 80% in December and January months (Papachristou, Nastis, 1993).

Nutrients generally form the constituents of important compounds in plants and play a role in enzyme activity (Kacar et al., 2006). They are basic constituents of body tissues in animals, provide the regulation of osmotic pressure and pH and take part in structure of enzymes (Whitehead, 2000). Concentrations of N, P, K, Ca, Mg and S in plant structure vary with plant growth, soil and climate conditions and several other factors. Young tissues have higher nutrient concentrations than older ones. For instance, N, P, S present distinctive decrease with maturation. As leaves senesce, some losses are observed in nutrients through remobilization and leaching with precipitation (Whitehead, 2000). Nutrient deficiencies can be seen in animals due to changes in nutrient contents of plants. Making this situation clear will prevent the nutritional disorders in animals.

Based on the year 2009 statistics, goats constitute 13.4% (5.1 million) of 38.1 million livestock assets of Turkey (Crop production statistics, 2010). Mediterranean maquis are indispensible part of goat production in Turkey. However, sufficient researches were not able to be performed over these maquis lands since these lands were involved in forest lines and were prohibited from grazing. Therefore, to investigate macronutrient (N, P, K, Ca, Mg, S) concentrations of eight shrubs of kermes oak, mock privet, prickly juniper, gall oak, Christ's-thorn, pink rockrose, thyme and prickly burnet, common in Mediterranean zone, and to emphasize both the significance of these shrubs for animal feeding and to evaluate possible nutrient deficiencies throughout the year were purposed in this study.

Materials and methods

The research was carried out in two different sites (Ağaköy and Çiplak) of Çanakkale, in north-western Anatolia, Turkey, between October 2006–November 2007. Ağaköy is in the Campus of Biga Faculty of Economics and Administrative Sciences which is located 85 km away from the centre of Çanakkale, while Çiplak is located 30 km away from the centre of Çanakkale (Fig. 1).

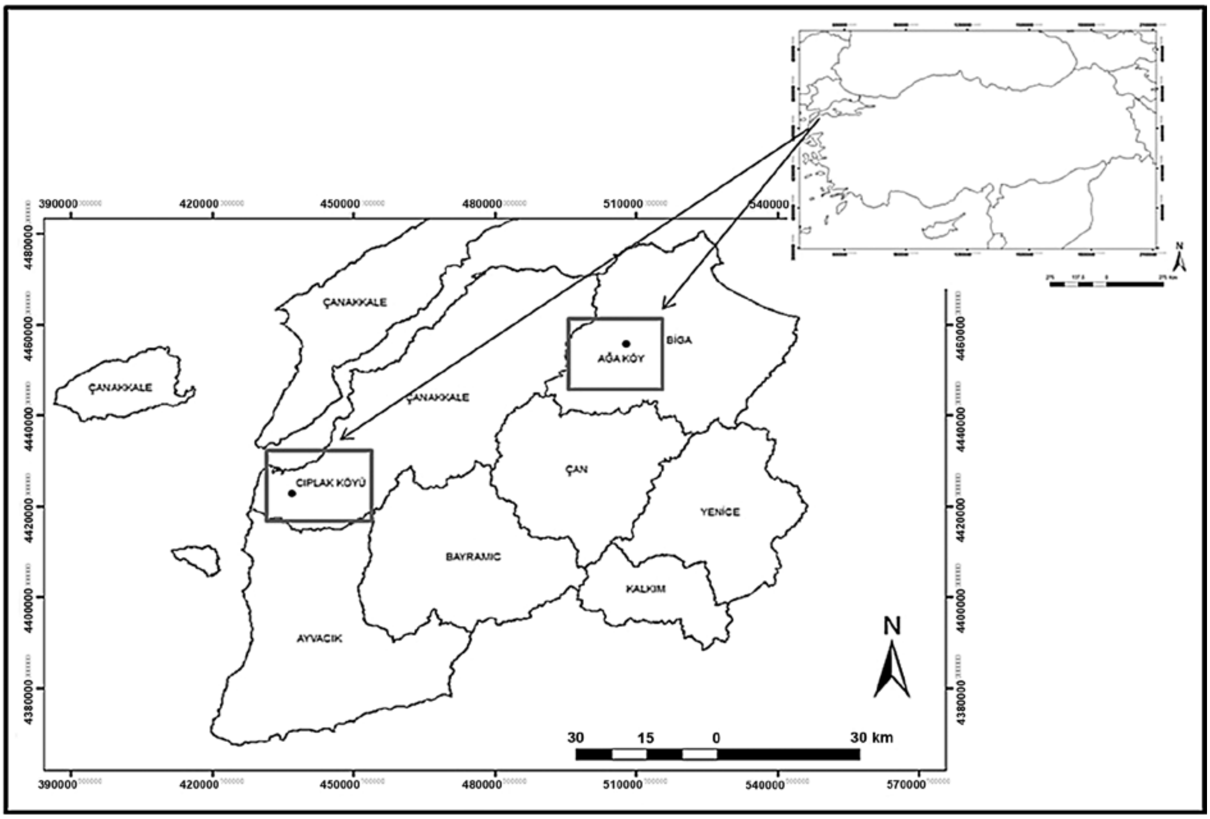

Figure 1. Location of the study area

Monthly average temperatures in both research sites during the research period were higher than the long-term averages. While there was severe precipitation (147.1 mm) in Ağaköy site during the first month of the research, winter, spring and summer precipitation was lower than long-term averages. October and November 2007 precipitation was higher than long-term averages. In Çiplak site, total precipitation during the months of March, May, October and November 2007 was higher than the long-term averages and lower in other months of the research (Fig. 2).

Soils of both research sites are sandy-loamy, neutral, non-saline with high organic matter content, sufficient available P and sparse K content. Ca, Mg, K, Na and CEC were 13.42, 2.64, 0.17, 0.07 and 16.42 cmol kg^{-1}, respectively in Ağaköy soils and 13.13, 2.38, 0.17, 0.07 and 15.82 cmol kg^{-1}, respectively in Çiplak soils.

In this research, evergreen shrubs of kermes oak (*Quercus coccifera* L.), mock privet (*Phillyrea latifolia* L.), prickly juniper (*Juniperus oxycedrus* L.), pink rockrose (*Cistus creticus* L.), thyme (*Thymus longicaulis* C. Presl.) and prickly burnet (*Sarcopoterium spinosum* (L.) Spach) and deciduous shrubs of gall oak (*Quercus infectoria* Oliv.) and Christ's-thorn (*Paliurus spina-christi* Miller) were used as the plant material.

Ağaköy pasture is surrounded and protected by a wire fence and Çiplak pasture is continuously and heavily grazed. Two areas of 20 × 50 m (1000 m^2) were fenced in Çiplak pasture to prevent grazing and observe the normal growth of plants.

During the research (October 2006–November 2007), plant samples were taken from the shrubs in the middle of each month. Leafy young (annual) twigs, grazable by animals, were cut and collected. Ten samples were taken from each species in each sampling. For deciduous shrubs, samples were taken only in the period of active vegetation (except winter time). Samples were placed into fabric bags, dried at 60°C to a constant weight (Cook, Stubbendieck, 1986), weighed and ground. Since the shrub samples in October 2006 were not sufficient for analysis, N analysis was not performed on them.

Macronutrients of ground plant samples were determined. Total nitrogen was determined by Kjeldahl method on acid burned samples with silicylic-sulphuric acid mixture (Bremner, 1960). Other plant nutrients (P, K, Ca, Mg, S) were determined by using an inductively coupled plasma atomic emission spectrometer ICP-AES ("Varian Vista", USA) device.

Calculations and statistical analyses. The content of macronutrients was calculated as follows: the concentration of the element in g kg^{-1} was multiplied by the mass in kg of the plant biomass compartment (twigs together with leaves). Research was established using the repeated measurement design (Winer et al., 1991) and data was statistically analyzed by *SPSS* statistical software. LSD Multiple Comparing Test was used to compare the averages.

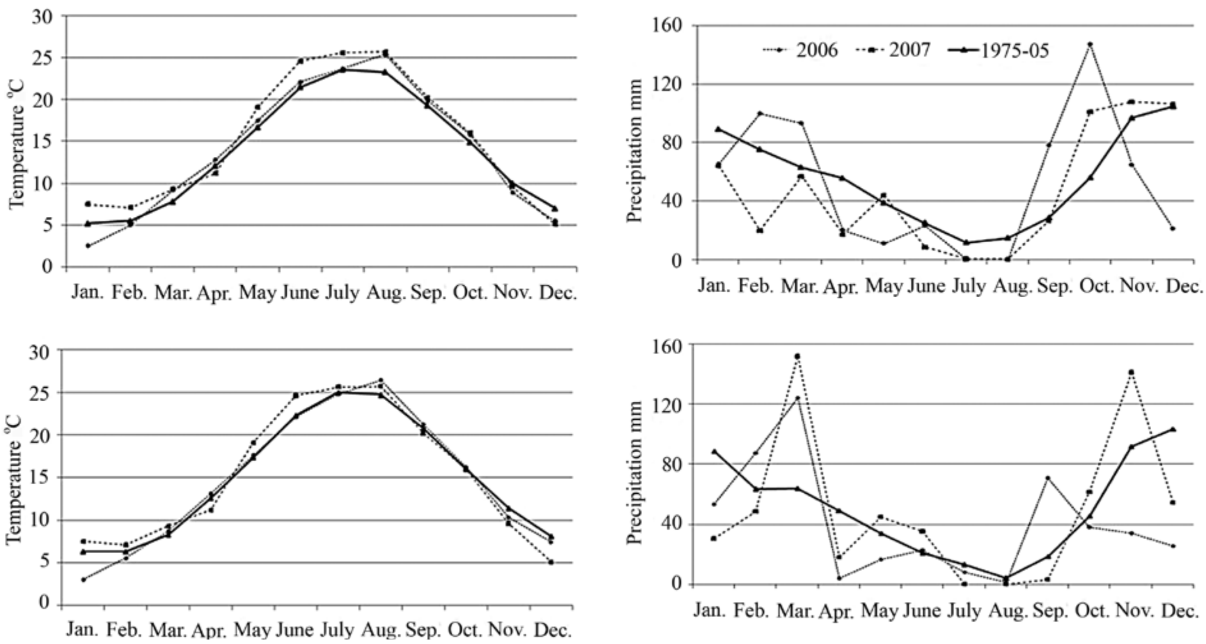

Figure 2. Temperature and precipitation values of the study locations (above Ağaköy, below Çiplak)

Results

Variation of macronutrients in grazable parts of kermes oak were found to be significant for all elements ($p < 0.001$) except for Mg ($p = 0.57$). N, P, K and S concentrations of plant samples reached the highest levels at the initial shoot development period (April) following the winter dormancy and decreased gradually during the following months. On the contrary, Ca reached the lowest levels in April and May (Figs 3–4).

Magnesium content of kermes oak varied between 2.38–2.85 g kg^{-1}. As the average of entire sampling periods for kermes oak, N (12.32 g kg^{-1}) and Ca (9.66 g kg^{-1}) were observed as the highest ones (Table 1).

Table 1. Amounts (mean ±SE) of macronutrients of kermes oak (g kg^{-1} DM) (n = 10)*, **

Months	N	P	K	Ca	Mg	S
Oct. 06	–	1.53 ± 0.04 *c*	5.93 ± 0.24 *ef*	10.4 ± 0.9 *bcd*	2.85 ± 0.09	0.65 ± 0.02 *cd*
Nov. 06	12.8 ± 2.5 *bcd*	1.49 ± 0.03 *c*	5.18 ± 0.22 *fg*	12.7 ± 0.6 *a*	2.72 ± 0.10	0.73 ± 0.02 *bcd*
Dec. 06	12.1 ± 2.1 *b-e*	1.46 ± 0.05 *c*	4.79 ± 0.30 *g*	11.0 ± 0.4 *abc*	2.62 ± 0.10	0.69 ± 0.01 *bcd*
Jan. 07	11.0 ± 0.5 *c-f*	1.55 ± 0.02 *c*	4.22 ± 0.16 *g*	11.9 ± 0.4 *ab*	2.74 ± 0.17	0.71 ± 0.03 *bcd*
Feb. 07	12.5 ± 1.0 *b-e*	1.52 ± 0.04 *c*	4.53 ± 0.20 *g*	11.4 ± 0.7 *abc*	2.60 ± 0.27	0.77 ± 0.02 *bc*
Mar. 07	14.1 ± 2.5 *b*	1.44 ± 0.03 *c*	4.44 ± 0.09 *g*	11.2 ± 0.3 *abc*	2.38 ± 0.05	0.75 ± 0.03 *bc*
Apr. 07	21.8 ± 0.9 *a*	3.74 ± 0.21 *a*	14.02 ± 0.79 *a*	6.7 ± 0.6 *e*	2.54 ± 0.10	1.57 ± 0.09 *a*
May 07	13.3 ± 0.8 *bc*	1.89 ± 0.05 *b*	8.88 ± 0.26 *b*	5.9 ± 0.5 *e*	2.53 ± 0.15	0.80 ± 0.03 *b*
Jun. 07	11.6 ± 0.9 *b-f*	1.57 ± 0.06 *c*	8.07 ± 0.09 *bc*	9.6 ± 0.7 *cd*	2.41 ± 0.19	0.69 ± 0.02 *bcd*
July 07	9.0 ± 0.1 *f*	1.56 ± 0.08 *c*	9.11 ± 0.19 *b*	6.3 ± 0.4 *e*	2.39 ± 0.08	0.62 ± 0.02 *d*
Aug. 07	10.4 ± 1.1 *def*	1.38 ± 0.02 *c*	7.49 ± 0.30 *cd*	8.9 ± 0.4 *d*	2.55 ± 0.12	0.77 ± 0.04 *bc*
Sep. 07	10.1 ± 0.1 *def*	1.38 ± 0.03 *c*	7.34 ± 0.40 *cd*	9.7 ± 0.5 *cd*	2.60 ± 0.18	0.72 ± 0.02 *bcd*
Oct. 07	9.8 ± 1.8 *ef*	1.40 ± 0.13 *c*	6.77 ± 0.60 *de*	10.1 ± 0.7 *cd*	2.52 ± 0.19	0.75 ± 0.08 *bcd*
Nov. 07	11.6 ± 0.6 *b-f*	1.55 ± 0.05 *c*	5.09 ± 0.39 *fg*	9.6 ± 0.6 *cd*	2.43 ± 0.12	0.81 ± 0.02 *b*
Mean	12.3	1.68	6.85	9.7	2.56	0.79
Sign. (p)	0.000	0.000	0.000	0.000	0.570	0.000

* – within the same column, the values with different letters are significantly different at $p < 0.01$, ** – there is not for the lettering in the same column of values are not statistically significant

Variations of macronutrients in mock privet were found to be significant throughout the year ($p < 0.001$). N, P and S increased significantly in spring (April or May). N and S levels were at low levels during the summer, autumn and winter months. Phosphorus was relatively high during the summer and autumn months of the year 2007. However, it significantly decreased between October 2006–March 2007. Although K concentration of mock privet was at low levels during autumn, winter and spring months, it increased significantly during July and August. Ca and Mg contents started to increase in August and reached the highest levels between September–November 2007. While S was increasing during the shooting period of spring, during the months of April and May, it was low in the rest of the months and there were no significant differences among them (Figs 3–4). As the average of entire sampling periods for mock privet, N (10.48 g kg^{-1}), Ca (9.16 g kg^{-1}) and K (8.64 g kg^{-1}) were observed as the highest ones (Table 2).

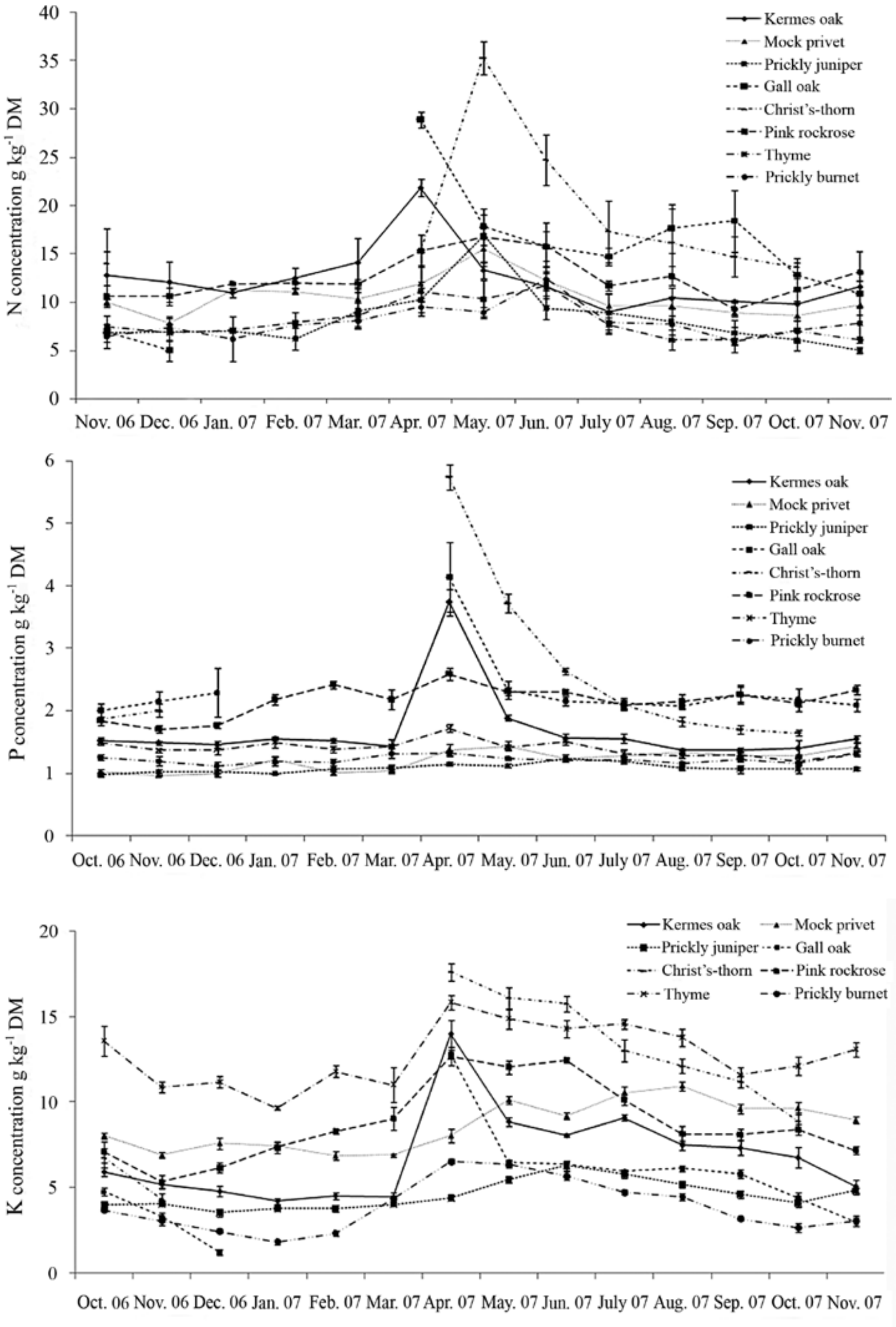

Figure 3. Change of N, P and K concentrations of the shrub species

Variation of macronutrients in prickly juniper samples were found to be significant during the research period of 14 months ($p < 0.001 - p < 0.01$). N concentration in May, P and K at the beginning of summer (June) reached the highest level and they decreased to the lowest levels especially during autumn and summer months. Increasing Ca and Mg in plant samples of winter and spring decreased in summer months. S ratio of juniper did not yield a regular change throughout the year. While S was observed at the highest levels in January, February and June, the lowest levels were observed in September, October and November 2007 (Figs 3–4). The amounts of all macronutrients, Ca (11.58 g kg^{-1}) and N (8.24 g kg^{-1}) were observed as the highest ones (Table 3).

Statistical analysis revealed significant variations in macronutrient contents of gall oak throughout the year ($p < 0.001 - p < 0.01$). Gall oak is a deciduous shrub. Initial growth and leaf appearance started in April. In this month, N, P, K, and S levels were found to be the highest and significant decreases were observed during the following months. Mg also started to increase in April but this increase continued to the end of the year. Unlike Mg, Ca showed reverse tendency. While it was at the lowest levels during the initial growth in spring, it reached the highest levels in September and October 2007 (Figs 3–4). Gall oak had high Ca (12.34 g kg^{-1}) and N (11.97 g kg^{-1}) contents (Table 4).

Macronutrients in defoliating Christ's-thorn were found to be significant ($p < 0.001$). P, K, and S were at the highest levels during the leaf appearance (April). N increased through May and June. These minerals decreased

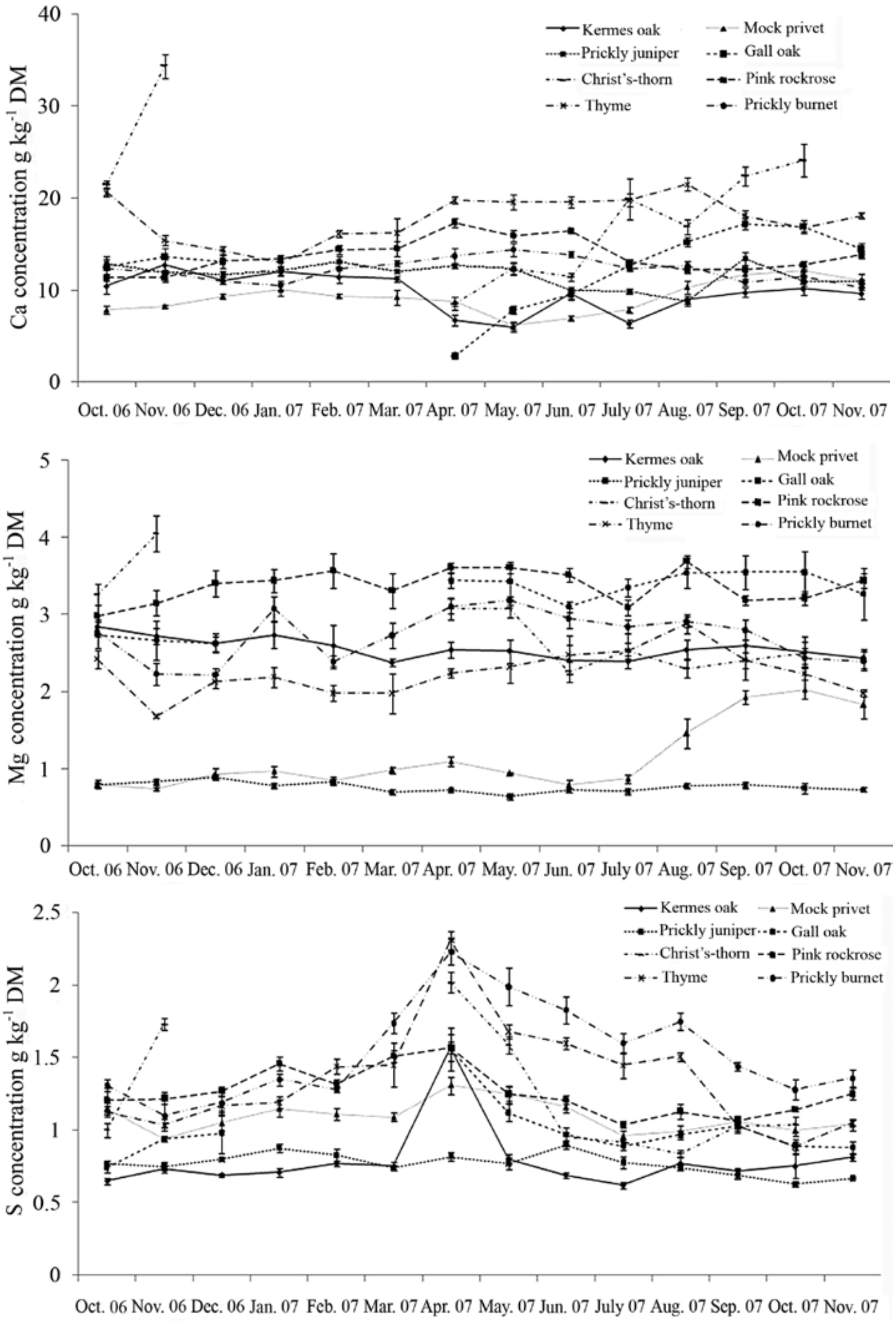

Figure 4. Change of Ca, Mg and S concentrations of the shrub species

significantly especially during the summer and autumn months (Figs 3–4). Ca presented a reverse trend with the other minerals. The highest level Ca (34.40 g kg^{-1}) was observed just before the defoliation (November 2006). Mg was at the highest levels both during October and November of 2006 and April and May of 2007, and lower values were observed in other months. Ca (19.1 g kg^{-1}) and N (18.9 g kg^{-1}) were found to be the highest in terms of average value of entire sampling periods for Christ's-thorn (Table 5).

Variations of macronutrients in plant samples of pink rockrose were found to be significant for all elements ($p < 0.001 – p < 0.01$) during the entire research period. N, K and Ca ratios started to increase in April, P ratios in February and S in January. These elements were observed at low levels during the summer, autumn and winter months. Mg exhibited more irregular variation than the other nutrients (Figs 3–4). The lowest levels of Mg were observed in October and November 2006. Based on 14-months ave-rages, Ca (13.67 g kg^{-1}) and N (12.51 g kg^{-1}) were the highest in pink rockrose (Table 6).

Variations of macronutrients in thyme samples were found to be significant for all nutrients throughout the research period ($p < 0.001$). As it was in most of the other shrubs, N, P, K and S levels started to increase in April and decreased to the lowest levels especially in autumn and winter months. Ca and Mg started to increase in April but reached the highest levels in summer (Figs 3–4). Considering the averages of entire sampling periods, Ca and K were observed as the highest ones respectively with 17.56 and 12.75 g kg^{-1}) (Table 7).

Table 2. Amounts (mean ±SE) of macronutrients of mock privet (g kg^{-1} DM) (n = 10)*

Months	N	P	K	Ca	Mg	S
Oct. 06	–	1.03 ± 0.04 *c*	8.06 ± 0.16 *e*	7.8 ± 0.4 *ef*	0.80 ± 0.05 *d*	1.15 ± 0.04 *bc*
Nov. 06	10.0 ± 0.3 *cde*	0.97 ± 0.01 *c*	6.92 ± 0.16 *f*	8.2 ± 0.2 *ef*	0.74 ± 0.02 *d*	0.94 ± 0.02 *f*
Dec. 06	7.8 ± 0.7 *f*	1.00 ± 0.05 *c*	7.60 ± 0.36 *ef*	9.3 ± 0.3 *de*	0.93 ± 0.07 *cd*	1.05 ± 0.05 *c-f*
Jan. 07	11.2 ± 0.2 *bcd*	1.22 ± 0.05 *b*	7.42 ± 0.22 *ef*	10.0 ± 0.7 *cd*	0.97 ± 0.07 *cd*	1.15 ± 0.06 *bc*
Feb. 07	11.1 ± 0.3 *bcd*	1.01 ± 0.03 *c*	6.87 ± 0.25 *f*	9.3 ± 0.2 *de*	0.85 ± 0.05 *cd*	1.11 ± 0.04 *cd*
Mar. 07	10.3 ± 1.3 *b-e*	1.04 ± 0.03 *c*	6.91 ± 0.09 *f*	9.2 ± 0.8 *de*	0.98 ± 0.04 *cd*	1.09 ± 0.03 *cde*
Apr. 07	11.9 ± 1.9 *bc*	1.37 ± 0.10 *ab*	8.04 ± 0.39 *e*	8.7 ± 0.5 *de*	1.10 ± 0.06 *c*	1.31 ± 0.06 *a*
May 07	15.5 ± 1.3 *a*	1.44 ± 0.07 *a*	10.14 ± 0.23 *bc*	6.1 ± 0.4 *g*	0.94 ± 0.01 *cd*	1.25 ± 0.06 *ab*
Jun. 07	12.2 ± 0.8 *b*	1.24 ± 0.01 *b*	9.19 ± 0.19 *d*	6.9 ± 0.3 *fg*	0.80 ± 0.05 *d*	1.16 ± 0.04 *bc*
July 07	9.6 ± 1.2 *def*	1.28 ± 0.10 *b*	10.56 ± 0.34 *ab*	7.8 ± 0.3 *ef*	0.87 ± 0.05 *cd*	0.96 ± 0.04 *ef*
Aug. 07	9.6 ± 1.0 *def*	1.35 ± 0.04 *ab*	10.95 ± 0.28 *a*	10.3 ± 0.7 *bcd*	1.46 ± 0.19 *b*	0.99 ± 0.04 *def*
Sep. 07	8.9 ± 0.4 *ef*	1.28 ± 0.03 *b*	9.62 ± 0.26 *cd*	11.7 ± 0.7 *ab*	1.93 ± 0.09 *a*	1.06 ± 0.04 *c-f*
Oct. 07	8.6 ± 1.3 *ef*	1.29 ± 0.01 *ab*	9.66 ± 0.36 *cd*	12.1 ± 0.5 *abc*	2.03 ± 0.12 *a*	1.00 ± 0.04 *def*
Nov. 07	9.7 ± 1.0 *def*	1.44 ± 0.04 *a*	8.96 ± 0.19 *d*	11.0 ± 0.7 *a*	1.83 ± 0.18 *a*	1.04 ± 0.04 *c-f*
Mean	10.5	1.21	8.64	9.2	1.16	1.09
Sign. (p)	0.000	0.000	0.000	0.000	0.000	0.000

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

Table 3. Amounts (mean ±SE) of macronutrients of prickly juniper (g kg^{-1} DM) (n = 10)*

Months	N	P	K	Ca	Mg	S
Oct. 06	–	0.98 ± 0.03 *d*	4.00 ± 0.19 *gh*	12.9 ± 0.8 *ab*	0.79 ± 0.03 *abc*	0.77 ± 0.02 *cde*
Nov. 06	6.8 ± 0.3 *efg*	1.03 ± 0.03 *cd*	4.06 ± 0.04 *fgh*	11.9 ± 0.2 *abc*	0.83 ± 0.04 *ab*	0.75 ± 0.03 *c-f*
Dec. 06	6.9 ± 0.9 *d-g*	1.03 ± 0.03 *cd*	3.54 ± 0.21 *h*	11.7 ± 0.3 *bc*	0.89 ± 0.03 *a*	0.80 ± 0.01 *bcd*
Jan. 07	7.0 ± 0.1 *c-g*	1.00 ± 0.01 *d*	3.79 ± 0.06 *gh*	12.1 ± 0.5 *abc*	0.78 ± 0.03 *abc*	0.88 ±0.03 *ab*
Feb. 07	6.2 ± 1.1 *fg*	1.07 ± 0.01 *bcd*	3.79 ± 0.19 *gh*	13.1 ± 0.6 *ab*	0.83 ± 0.04 *ab*	0.83 ±0.04 *abc*
Mar. 07	9.1 ± 1.9 *bcd*	1.09 ± 0.05 *bcd*	4.02 ± 0.11 *gh*	12.0 ± 0.2 *abc*	0.70 ± 0.04 *cd*	0.74 ± 0.02 *def*
Apr. 07	10.2 ± 1.3 *b*	1.15 ± 0.03 *abc*	4.39 ± 0.14 *efg*	12.6 ± 0.2 *ab*	0.72 ± 0.02 *bcd*	0.82 ± 0.03 *bcd*
May 07	16.9 ± 1.0 *a*	1.12 ± 0.03 *bcd*	5.44 ± 0.15 *bc*	12.3 ± 0.7 *abc*	0.64 ± 0.04 *d*	0.77 ± 0.04 *cd*
Jun. 07	9.3 ± 1.1 *bc*	1.24 ± 0.06 *a*	6.31 ± 0.28 *a*	9.9 ± 0.2 *de*	0.72 ± 0.03 *bcd*	0.90 ± 0.03 *a*
July 07	8.9 ± 2.0 *b-e*	1.19 ± 0.03 *ab*	5.80 ± 0.23 *ab*	9.8 ± 0.3 *de*	0.71 ± 0.04 *bcd*	0.78 ± 0.04 *cd*
Aug. 07	8.0 ± 1.4 *b-f*	1.09 ± 0.04 *bcd*	5.16 ± 0.14 *cd*	8.7 ± 0.4 *e*	0.78 ± 0.03 *abc*	0.74 ± 0.02 *def*
Sep. 07	6.8 ± 1.3 *efg*	1.07 ± 0.06 *bcd*	4.62 ± 0.23 *def*	13.4 ± 0.7 *a*	0.79 ± 0.04 *abc*	0.69 ± 0.03 *efg*
Oct. 07	6.1 ± 1.1 *fg*	1.07 ± 0.06 *bcd*	4.12 ± 0.23 *fgh*	10.9 ± 0.5 *cd*	0.75 ± 0.07 *bcd*	0.63 ± 0.02 *g*
Nov. 07	5.0 ± 0.3 *g*	1.07 ± 0.02 *bcd*	4.82 ± 0.19 *de*	10.9 ± 0.2 *cd*	0.73 ± 0.03 *bcd*	0.67 ± 0.01 *fg*
Mean	8.2	1.085	4.56	11.6	0.76	0.77
Sign. (p)	0.000	0.002	0.000	0.000	0.004	0.000

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

Table 4. Amounts (mean ±SE) of macronutrients of gall oak (g kg^{-1} DM) (n = 10)*

Months	N	P	K	Ca	Mg	S
Oct. 06	–	2.01 ± 0.10 *b*	4.78 ± 0.22 *d*	12.5 ± 0.8 *e*	2.74 ± 0.17 *bcd*	0.74 ± 0.03 *d*
Nov. 06	6.9 ± 1.7 *f*	2.15 ± 0.16 *b*	3.30 ± 0.26 *e*	13.6 ± 0.9 *cde*	2.67 ± 0.25 *cd*	0.94 ± 0.02 *bcd*
Dec. 06	5.0 ± 1.1 *f*	2.29 ± 0.39 *b*	1.23 ± 0.15 *f*	13.1 ± 0.7 *de*	2.63 ± 0.12 *d*	0.98 ± 0.14 *bc*
Apr. 07	28.9 ± 0.8 *a*	4.14 ± 0.56 *a*	12.81 ± 0.24 *a*	2.8 ± 0.2 *g*	3.44 ± 0.10 *a*	1.56 ± 0.15 *a*
May 07	17.8 ± 1.2 *bc*	2.33 ± 0.14 *b*	6.48 ± 0.18 *b*	7.8 ± 0.4 *f*	3.43 ± 0.23 *a*	1.12 ± 0.06 *b*
Jun. 07	15.7 ± 2.5 *bcd*	2.16 ± 0.08 *b*	6.36 ± 0.21 *bc*	9.5 ± 0.5 *f*	3.10 ± 0.07 *a-d*	0.97 ± 0.01 *bc*
July 07	14.7 ± 0.9 *cd*	2.12 ± 0.08 *b*	5.95 ± 0.10 *bc*	12.7 ± 0.6 *de*	3.35 ± 0.11 *ab*	0.89 ± 0.03 *cd*
Aug. 07	17.6 ± 2.5 *bc*	2.08 ± 0.06 *b*	6.13 ± 0.19 *bc*	15.2 ± 0.5 *bc*	3.54 ± 0.20 *a*	0.97 ± 0.03 *bc*
Sep. 07	18.4 ± 3.2 *b*	2.26 ± 0.15 *b*	5.81 ± 0.24 *c*	17.2 ± 0.6 *a*	3.55 ± 0.22 *a*	1.03 ± 0.02 *bc*
Oct. 07	12.8 ± 1.7 *de*	2.18 ± 0.18 *b*	4.41 ± 0.31 *d*	16.9 ± 0.7 *ab*	3.55 ± 0.27 *a*	0.89 ± 0.03 *cd*
Nov. 07	10.9 ± 1.3 *e*	2.09 ± 0.10 *b*	2.98 ± 0.25 *e*	14.5 ± 0.6 *cd*	3.27 ± 0.34 *abc*	0.88 ± 0.04 *cd*
Mean	12.0	2.35	5.48	12.3	3.21	1.00
Sign. (p)	0.000	0.000	0.000	0.000	0.004	0.000

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

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

Months	N	P	K	Ca	Mg	S
Oct. 06	–	1.87 ± 0.03 *def*	6.77 ± 0.56 *f*	21.5 ± 0.4 *bc*	3.26 ± 0.14 *b*	1.00 ± 0.05 *c*
Nov. 06	14.0 ± 3.6 *c*	2.01 ± 0.10d *e*	4.35 ± 0.29 *g*	34.4 ± 1.3 *a*	4.05 ± 0.23 *a*	1.73 ± 0.04 *b*
Apr. 07	15.3 ± 1.7 *c*	5.74 ± 0.20 *a*	17.63 ± 0.53 *a*	8.5 ± 0.7 *f*	3.08 ± 0.14 *b*	2.02 ± 0.07 *a*
May 07	35.3 ± 1.7 *a*	3.72 ± 0.15 *b*	16.10 ± 0.65 *b*	12.3 ± 0.6 *e*	3.08 ± 0.12 *b*	1.59 ± 0.06 *b*
Jun. 07	24.7 ± 2.6 *b*	2.63 ± 0.05 *c*	15.79 ± 0.45 *b*	11.4 ± 0.4 *ef*	2.26 ± 0.13 *c*	0.96 ± 0.06 *cd*
July 07	17.3 ± 3.2 *c*	2.09 ± 0.06 *d*	13.04 ± 0.65 *c*	19.9 ± 2.2 *c*	2.53 ± 0.22 *c*	0.92 ± 0.02 *cd*
Aug. 07	16.1 ± 3.6 *c*	1.83 ± 0.07 *def*	12.13 ± 0.44 *cd*	16.9 ± 0.8 *d*	2.30 ± 0.12 *c*	0.84 ± 0.02 *d*
Sep. 07	14.7 ± 2.1 *c*	1.70 ± 0.07 *ef*	11.20 ± 0.36 *de*	22.4 ± 1.0 *bc*	2.41 ± 0.26 *c*	1.03 ± 0.05 *c*
Oct. 07	13.6 ± 0.5 *c*	1.65 ± 0.05 *f*	8.89 ± 0.52 *e*	24.1 ± 1.8 *b*	2.50 ± 0.14 *c*	1.04 ± 0.05 *c*
Mean	18.9	2.85	11.77	19.1	2.83	1.24
Sign. (p)	0.000	0.000	0.000	0.000	0.000	0.000

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

Table 6. Amounts (mean ±SE) of macronutrients of pink rockrose (g kg^{-1} DM) (n = 10)*

Months	N	P	K	Ca	Mg	S
Oct. 06	–	1.84 ± 0.07 *d*	7.10 ± 0.63 *ef*	11.3 ± 0.3 *f*	2.98 ± 0.14 *e*	1.21 ± 0.08 *bc*
Nov. 06	10.6 ± 1.1 *cd*	1.71 ± 0.06 *d*	5.36 ± 0.35 *g*	11.3 ± 0.4 *f*	3.15 ± 0.16 *cde*	1.22 ± 0.04 bc
Dec. 06	10.6 ± 0.9 *cd*	1.77 ± 0.05 *d*	6.17 ± 0.28 *fg*	13.2 ± 0.2 *de*	3.41 ± 0.17 *a-e*	1.27 ± 0.03 *bc*
Jan. 07	11.9 ± 0.1 *c*	2.18 ± 0.08 *bc*	7.37 ± 0.34 *def*	13.4 ± 0.4 *cde*	3.44 ± 0.15 *a-d*	1.46 ± 0.05 *a*
Feb. 07	12.0 ± 0.1 *c*	2.42 ± 0.06 *ab*	8.30 ± 0.15 *cde*	14.4 ± 0.5 *c*	3.57 ± 0.22 *abc*	1.32 ± 0.03 *b*
Mar. 07	11.9 ± 0.5 *c*	2.18 ± 0.16 *bc*	9.06 ± 0.67 *bc*	14.5 ± 0.8 *c*	3.31 ± 0.22 *a-e*	1.51 ± 0.04 *a*
Apr. 07	15.3 ± 0.1 *ab*	2.59 ± 0.10 *a*	12.71 ± 0.53 *a*	17.3 ± 0.5 *a*	3.61 ± 0.06 *ab*	1.57 ± 0.04 *a*
May 07	16.7 ± 3.0 *a*	2.31 ± 0.06 *bc*	12.07 ± 0.40 *a*	15.9 ± 0.6 *b*	3.61 ± 0.08 *ab*	1.25 ± 0.05 *bc*
Jun. 07	15.8 ± 1.5 *a*	2.30 ± 0.04 *bc*	12.47 ± 0.15 *a*	16.4 ± 0.2 *ab*	3.52 ± 0.09 *a-d*	1.21 ± 0.03 *bc*
July 07	11.7 ± 0.5 *cd*	2.09 ± 0.08 *c*	10.16 ± 0.29 *b*	13.0 ± 0.2 *de*	3.09 ± 0.10 *de*	1.04 ± 0.02 *d*
Aug. 07	12.7 ± 1.0 *c*	2.15 ± 0.11 *c*	8.15 ± 0.48 *cde*	12.2 ± 0.4 *ef*	3.69 ± 0.08 *a*	1.13 ± 0.05 *cd*
Sep. 07	9.3 ± 0.6 *d*	2.26 ± 0.12 *bc*	8.12 ± 0.30 *cde*	12.2 ± 0.2 *ef*	3.19 ± 0.06 *b-e*	1.07 ± 0.02 *d*
Oct. 07	11.3 ± 1.2 *cd*	2.12 ± 0.05 *c*	8.41 ± 0.31 *cd*	12.7 ± 0.4 *de*	3.21 ± 0.09 *b-e*	1.14 ± 0.01 *cd*
Nov. 07	13.1 ± 2.2 *bc*	2.34 ± 0.07 *bc*	7.19 ± 0.21 *def*	13.8 ± 0.4 *cd*	3.44 ± 0.09 *a-d*	1.25 ± 0.04 *bc*
Mean	12.5	2.16	8.76	13.7	3.37	1.26
Sign. (p)	0.000	0.000	0.000	0.000	0.004	0.000

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

Table 7. Amounts (mean ±SE) of macronutrients of thyme (g kg^{-1} DM) (n = 10)*

Months	N	P	K	Ca	Mg	S
Oct. 06	–	1.50 ± 0.05 *b*	13.60 ± 0.86 *bcd*	20.6 ± 0.4 *ab*	2.42 ± 0.12 *bc*	1.13 ± 0.04 *d*
Nov. 06	7.5 ± 0.2 *cd*	1.37 ± 0.03 *bcd*	10.91 ± 0.30 *fg*	15.4 ± 0.5 *ef*	1.68 ± 0.02 *d*	1.04 ± 0.04 *de*
Dec. 06	6.8 ± 1.5 *cd*	1.38 ± 0.07 *bcd*	11.20 ± 0.32 *fg*	14.3 ± 0.4 *fg*	2.13 ± 0.09 *bc*	1.17 ± 0.06 *d*
Jan. 07	7.1 ± 0.2 *cd*	1.50 ± 0.09 *b*	9.67 ± 0.10 *g*	13.0 ± 0.5 *g*	2.19 ± 0.13 *bc*	1.19 ± 0.04 *d*
Feb. 07	7.9 ± 0.1 *cd*	1.39 ± 0.05 *bc*	11.80 ± 0.34 *ef*	16.1 ± 0.4 *de*	1.98 ± 0.10 *cd*	1.44 ± 0.05 *c*
Mar. 07	8.6 ± 1.3 *bc*	1.44 ± 0.11 *bc*	11.04 ± 1.06 *fg*	16.2 ± 1.6 *de*	1.98 ± 0.26 *cd*	1.45 ± 0.15 *c*
Apr. 07	11.1 ± 1.0 *a*	1.72 ± 0.06 *a*	15.85 ± 0.42 *a*	19.8 ± 0.4 *abc*	2.24 ± 0.06 *bc*	2.31 ± 0.06 *a*
May 07	10.3 ± 2.0 *ab*	1.42 ± 0.04 *bc*	14.91 ± 0.59 *ab*	19.6 ± 0.8 *bc*	2.32 ± 0.20 *bc*	1.68 ± 0.05 *b*
Jun. 07	11.7 ± 2.0 *a*	1.51 ± 0.05 *b*	14.31 ± 0.52 *abc*	19.6 ± 0.6 *bc*	2.48 ± 0.25 *ab*	1.60 ± 0.04 *bc*
July 07	7.6 ± 0.5 *cd*	1.32 ± 0.06 *bcd*	14.59 ± 0.27 *abc*	19.8 ± 0.7 *abc*	2.53 ± 0.10 *ab*	1.45 ± 0.09 *c*
Aug. 07	6.1 ± 1.0 *d*	1.29 ± 0.04 *cd*	13.81 ± 0.50 *bc*	21.5 ± 0.7 *a*	2.88 ± 0.12 *a*	1.51 ± 0.03 *bc*
Sep. 07	6.1 ± 1.3 *d*	1.30 ± 0.03 *cd*	11.61 ± 0.43 *ef*	18.1 ± 0.6 *cd*	2.41 ± 0.10 *bc*	1.03 ± 0.03 *de*
Oct. 07	7.1 ± 1.3 *cd*	1.20 ± 0.04 *d*	12.12 ± 0.55 *def*	16.8 ± 0.4 *de*	2.23 ± 0.07 *bc*	0.89 ± 0.05 *e*
Nov. 07	7.8 ± 1.6 *cd*	1.33 ± 0.02 *bcd*	13.10 ± 0.44 *cde*	18.1 ± 0.3 *cd*	1.98 ± 0.05 *cd*	1.05 ± 0.02 *de*
Mean	7.5	1.41	12.75	17.6	2.25	1.35
Sign. (p)	0.000	0.000	0.000	0.000	0.000	0.000

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

Prickly burnet is a common shrub of disturbed pastures. Variations of macronutrients in this shrub were found to be significant throughout the research period ($p < 0.001 – p < 0.05$). The variation in P was irregular. N reached the highest level in June and lower and similar values were observed in other months. K, Mg and S increased during the initial plant growth in April and then decreased in later periods. Ca had high levels between March–May 2007 (Figs 3–4). Ca (12.18 g kg^{-1}) and N (7.76 g kg^{-1}) were observed as the highest ones in plant samples of prickly burnet (Table 8).

Table 8. Amounts (mean ±SE) of macronutrients of prickly burnet (g kg^{-1} DM) (n = 10)*

Months	N	P	K	Ca	Mg	S
Oct. 06	–	1.26 ± 0.05 *a-d*	3.70 ± 0.13 *d*	12.4 ± 0.3 *bcd*	2.78 ± 0.06 *bcd*	1.31 ± 0.04 *fg*
Nov. 06	6.4 ± 0.5 *d*	1.20 ± 0.07 *a-d*	3.06 ± 0.25 *ef*	11.9 ± 0.8 *cde*	2.23 ± 0.15 *f*	1.10 ± 0.08 *h*
Dec. 06	7.3 ± 0.4 *cd*	1.12 ± 0.06 *d*	2.46 ± 0.10 *fg*	11.0 ± 0.4 *de*	2.22 ± 0.08 *f*	1.19 ± 0.05 *gh*
Jan. 07	6.2 ± 2.3 *d*	1.19 ± 0.07 *a-d*	1.82 ± 0.13 *h*	10.5 ± 0.5 *e*	3.08 ± 0.16 *abc*	1.35 ± 0.04 *fg*
Feb. 07	7.6 ± 1.3 *bcd*	1.18 ± 0.05 *bcd*	2.34 ± 0.15 *gh*	12.3 ± 0.8 *bcd*	2.39 ± 0.08 *ef*	1.28 ± 0.02 *fgh*
Mar. 07	8.1 ± 0.6 *bcd*	1.32 ± 0.07 *abc*	4.36 ± 0.34 *c*	12.9 ± 0.3 *abc*	2.73 ± 0.16 *cde*	1.74 ± 0.07 *cd*
Apr. 07	9.5 ± 0.9 *b*	1.33 ± 0.04 *a*	6.56 ± 0.16 *a*	13.7 ± 0.8 *ab*	3.11 ± 0.10 *ab*	2.23 ± 0.09 *a*
May 07	9.0 ± 0.5 *bc*	1.24 ± 0.02 *a-d*	6.39 ± 0.20 *a*	14.4 ± 0.7 *a*	3.18 ± 0.06 *a*	1.99 ± 0.13 *b*
Jun. 07	12.4 ± 1.2 *a*	1.21 ± 0.02 *a-d*	5.71 ± 0.26 *b*	13.9 ± 0.3 *ab*	2.95 ± 0.13 *abc*	1.83 ± 0.09 *bc*
July 07	7.9 ± 1.2 *bcd*	1.23 ± 0.04 *a-d*	4.73 ± 0.15 *c*	12.4 ± 0.4 *bcd*	2.84 ± 0.09 *abc*	1.60 ± 0.07 *de*
Aug. 07	7.7 ± 1.7 *bcd*	1.17 ± 0.02 *cd*	4.47 ± 0.22 *c*	12.7 ± 0.4 *bc*	2.91 ± 0.07 *abc*	1.75 ± 0.06 *cd*
Sep. 07	5.9 ± 0.3 *d*	1.22 ± 0.03 *a-d*	3.18 ± 0.08 *de*	10.8 ± 0.4 *de*	2.80 ± 0.13 bc	1.44 ± 0.03 *ef*
Oct. 07	7.0 ± 1.1 *cd*	1.16 ± 0.03 *d*	2.66 ± 0.26 *efg*	11.5 ± 0.5 *cde*	2.44 ± 0.12 *def*	1.28 ± 0.07 *fgh*
Nov. 07	6.1 ± 0.3 *d*	1.32 ± 0.04 *ab*	3.06 ± 0.30 *ef*	10.3 ± 0.3 *e*	2.40 ± 0.12 *ef*	1.36 ± 0.06 *fg*
Mean	7.8	1.22	3.89	12.2	2.72	1.53
Sign. (p)	0.000	0.032	0.000	0.000	0.000	0.000

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

Discussion

Nitrogen (N) levels of shrubs reached the highest levels in April and May when the active vegetation of plants startes. N content of only prickly burnet had the peak value in June. There are close relationships between the amount of N and physiological activities of plants since all of the important biochemical reactions are realized under catalyst of nitrogenous compounds (Kacar et al., 2006). Therefore, N levels increased during the periods in which shrubs form their initial shoots. N concentrations decreased during summer, autumn and spring months, in which plant growth is slowed down and stopped. Some research on this issue deals with crude protein instead of N. Therefore, decrease in N or crude protein was observed with plant maturation in studies investigating the variations in N or crude protein ratios with plant growth (Del Valle, Rosell, 2000; Kamalak, 2006; Mountousis et al., 2008). Ataşoğlu et al. (2010) carried out research over the same area and observed the highest protein levels of kermes oak in May and significant decreases during the later months (summer and autumn). Since the leaves started to grow in spring, they presented higher rate of growth in June and later in prickly burnet, ratio of leaves and consequently the ratio of N increased.

Although there were some differences among the shrub species, phosphorus (P) ratio generally started to increase during the spring months for all shrubs and decreased through the summer. Only prickly burnet had a decrease in December, August and October and the variations in other months were not found to be significant. Increase in P especially in April was due to initiation of plant growth and corresponding high level of physiological activities in this month. Larger amount of P is located within protoplasm where intensive physiological activities take place (Spears, 1994) and P constitutes the basis of energy systems (ATP) and nucleic acids (DNA, RNA) in plants (Kacar et al., 2006). These compounds accelerate the physiological activities. Therefore, P contents increased during the initial growth period in which the highest cytokinesis and cell growth are observed. Decreasing physiological activities during the further stages of plant growth also decreased the P ratios. Similar variations were also pointed out by Cook (1972), Holechek et al. (1989) and El Aich (1991). A different variation in prickly burnet with regard to others was due to very small leaves of the plant and location of these leaves among the thorns. In each sampling, thorny shoots were taken beside the leaves. Location of P in cells mostly in protoplasm, and location of highest rate of protoplasm containing cells in leaves and increase in membrane ratios in shoots and thorns caused irregular variations in P contents of samples. As the average of sampling periods, P ratios of shrubs varied between 1.09 g kg^{-1} (prickly juniper) and 2.85 g kg^{-1} (Christ's-thorn). In a study carried out with five different shrubs, Ventura et al. (2004) reported P contents of shrubs as between 1.50–2.80 g kg^{-1}. El Aich (1991) reported average P contents of shrubs as 3.00 g kg^{-1} for the beginning of the season and as 2.00 g kg^{-1} for the end of the season.

Potassium (K) had the highest levels in almost all shrubs in April. It plays a role in regulation of osmotic potential in plants (Kacar et al., 2006). Osmotic potential regulates the water and other dissolved materials through the cells. That is closely related to physiological activities of the plants. There is a little amount of K at cell walls (Spears, 1994). Therefore, increase in the wall ratio with cell growth indicates the decrease of this mineral. Fleming (1973) reported that Ca did not change with increased plant maturation; however P and K decreased distinctively. Average K contents of shrubs were between 3.89 g kg^{-1} (prickly burnet) and 12.75 g kg^{-1} (thyme). These values were between 12.10–15.00 g kg^{-1} in Ventura et al. (2004) and between 21.00–31.00 g kg^{-1} in Ramirez-Orduna et al. (2005). The difference comes from the local soil and climate conditions of these studies. The species of those shrubs considered in these studies and the ones in current study are different.

Except for prickly burnet, pink rockrose and thyme, an inverse variation of calcium (Ca) with regard to variation of P and K were observed in grazable parts of the shrubs. While the Ca content was generally decreasing in April remarkably, it was higher in other months. Ca is mostly located in hard tissues of the plants (cell walls) (Spears, 1994). Higher cell protoplasm compounds and lower wall compounds at the beginning of growth yielded these results.

Contrary results for prickly burnet, pink rockrose and thyme come from hard and woody structure of prickly burnet and thyme in spring (especially in April) and softer structure of pink rockrose both in spring and in the other months. Average Ca contents of the investigated shrubs varied between 9.16 g kg^{-1} (mock privet) and 19.05 g kg^{-1} (Christ's-thorn). Lower Ca ratios (3.20–22.70 g kg^{-1}) were observed by Ventura et al. (2004) or higher values (21.40–28.00 g kg^{-1}) were observed by Ramirez-Orduna et al. (2005).

Variation in magnesium (Mg) content was found to be insignificant in kermes oak. It increased significantly in fall and winter for mock privet and prickly juniper, in spring and summer for gall oak, prickly burnet and pink rockrose, in summer for thyme and in fall for Christ's-thorn. Since gall oak and Christ's-thorn defoliate in winter, plant samples were not able to be taken in this season. Therefore, seasonal variation trend for Mg contents of shrubs was different from the other elements (Figs 3–4). As stated by Spears (1994), most of the Mg is located within protoplasm. That was observed in gall oak, pink rockrose and prickly burnet. Since thyme sprouts out in summer, increase in Mg content in summer for this shrub was an expected case. However, inverse cases were observed in prickly juniper, mock privet and Christ's-thorn and the results were not able to be interpreted. Results about variation in Mg contents of plants vary according to researchers. For instance, Ramirez-Orduna et al. (2005) performed a study in Mexico and indicated that variation in Mg contents of shrubs with regard to seasons was not significant; Greene et al. (1987) and Ramirez et al. (2001) indicated that variation in Mg content was significant. As the average of sampling periods, the lowest Mg content (0.76 g kg^{-1}) was observed in prickly juniper and the highest (3.37 g kg^{-1}) was observed in pink rockrose. Mg contents in other studies were between 2.90–4.80 g kg^{-1} and 1.20–8.20 g kg^{-1} (Ventura et al., 2004; Ramirez-Orduna et al., 2005).

Monthly variations in sulphur (S) ratios of plants were similar to variations in P and K. Again, most of this element is also located within protoplasm of cells (Spears, 1994). Significant increases were observed in spring, especially in April in all shrubs except for prickly juniper. Variation of S in prickly juniper did not follow an order with growing season. Average S contents of plant samples throughout the research period were between 0.77 g kg^{-1} (prickly juniper) and 1.53 g kg^{-1} (prickly burnet). As stated by Güneş et al. (2000) plants should have an S content equal to 0.5–1.0% of their dry weights. Based on these criteria, shrubs in this study had insufficient amounts of S in their structure. As a result of the observations, S deficiency symptoms in the shrubs were not able to be found.

Conclusions

The macronutrients considered in this research were interpreted by taking the maintenance for goats into consideration. An average goat with about 50 kg live-weight should consume at least 2.12 g Ca (Meschy, 2000), 1.28 g P (Pfeffer, 1989), 12.0 g N, 5.6 g K, 0.87 g Mg and 2.2 g S (National Research Council, 2007) daily. The following conclusions can be drawn considering 1 kg daily shrub consumption of a goat from the rangeland:

1. Amount of N in kg-dry matter of kermes oak was not sufficient in summer and autumn months. N deficiency was observed most of the time except in May and June for mock privet, in May for prickly juniper, in April, May and June for pink rockrose. N was sufficient in gall oak in all seasons except in winter. There was not N deficiency in Christ's-thorn. Thyme had N deficiency in all seasons.

2. P concentration was sufficient in kermes, gall oaks, Christ's-thorn, pink rockrose and thyme throughout the sampling periods. Mock privet had P deficiency in winter months. Prickly juniper had sufficient P levels only in June and prickly burnet had sufficient P generally in spring and autumn.

3. All the shrubs had sufficient K and Ca contents.

4. Kermes oak, gall oak, Christ's-thorn, pink rockrose, thyme and prickly burnet had sufficient Mg content. Mock privet had sufficient Mg levels throughout the sampling periods expect in October and November 2006 and June and July 2007. Mg deficiency for grazing goats can also be mentioned for prickly juniper during the research period.

5. An S deficiency was not observed in shrub samples except for the samples of thyme and prickly burnet taken in April.

Besides the above stated conclusions, the fact is that under normal conditions goats get about 50–60% of their daily dry matter consumption from the shrubs of pastures. As a result, if the goats are supplied with N both in the summer and winter and with S in every period, shrublands produce adequate amounts of forage requirements of goats.

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Mineralinių elementų kiekio pokyčiai Viduržemio jūros zonoje paplitusiuose krūmuose. I. Makroelementai

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Santrauka

Krūmai yra būdingi Viduržemio jūros zonos augalai ir svarbus ožkų maisto šaltinis. Tačiau mitybos elementų kiekis juose smarkiai įvairuoja, priklausomai nuo klimato, dirvožemio ir augalų augimo sąlygų. Atlikta keletas tyrimų apie metinį mineralinių medžiagų įvairavimą krūmuose Marmario regione. Šio tyrimo metu 14 mėnesių (nuo 2006 m. spalio iki 2007 m. lapkričio) tirtas sezoninis makroelementų (N, P, K, Ca, Mg ir S) varijavimas *Quercus coccifera*, *Phillyrea latifolia*, *Juniperus oxycedrus*, *Quercus infectoria*, *Paliurus spina-christi*, *Cistus creticus*, *Thymus longicaulis* ir *Sarcopoterium spinosum* augaluose. Makroelementų įvairavimas per metus buvo didelis visuose krūmuose. Krūmuose didžiausia N, P, K, ir S koncentracija buvo balandžio–gegužės mėnesiais, o Ca smarkiai sumažėjo balandžio mėnesį. Mg varijavo priklausomai nuo augalų rūšies. N kiekis visuose krūmuose, išskyrus *Paliurus spina-christi* ir *Quercus infectoria*, ožkų mitybos poreikius galėjo patenkinti tik pavasarį. *Paliurus spina-christi* pakankamą kiekį N turėjo visais metų laikais, taip pat ir *Quercus infectoria*, išskyrus žiemą. P, K, ir Ca kiekis daugeliu atvejų tenkino ožkų mitybos poreikius. Mg *Juniperus oxycedrus* turėjo pakankamai visais metų laikais, o *Phillyrea latifolia* L. – vasarą ir rudenį. Mg trūkumo kituose krūmuose nebuvo nustatyta. S kiekis buvo nepakankamas patenkinti ožkų mitybos poreikius.

Reikšminiai žodžiai: makroelementai, krūmais apaugusi vietovė.