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Research Paper

Effects of Location x Cultivars Interaction on Crude Protein and Mineral Contents in Sainfoin

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Abstract: The relatively little information is available in the literature on their mineral concentrations and especially on micro elements of sainfoin hay in Central Anatolia, as in the rest of the world. Therefore, the aim of the study was to determine protein, macro and micro element contents in herbage of some sainfoin cultivars (Peschanyj, local population and Ozerbey-2003) grown in Central Anatolia. This study was carried out in Ankara and Konya provinces, during 2006 and 2007 years. The experiment was designed according to randomized complete block design with four replications. It was found significant differences for location × cultivar interaction with regard to many investigated traits. Crude protein ratio, micro and macro elements such as K, P, Mg, Ca, Na, Mn, Fe, Zn, Cu, Mo, Cu, Cr, Al, Pb and Ni contents were analysed in sainfoin dry weight. The research result showed that protein content of sainfoin hays ranged 10.88 to 12.69 %. Its macro element contents ranged 1.23 to 2.29 g kg^{-1} for P, 24.00 to 31.12 g kg^{-1} for K, 3.70 to 6.61 g kg^{-1} for Mg, 4.08 to 11.89 g kg^{-1} for Ca, whereas micro element contents ranged 15.10 to 38.25 mg kg^{-1} for Mn, 41.28 to 116.52 mg kg^{-1} for Fe, 19.50 to 40.97 mg kg^{-1} Zn, 3.48 to 6.65 mg kg^{-1} for Cu, 0.55 to 1.47 mg kg^{-1} for Cr, 25.75 to 41.52 mg kg^{-1} for Al, 0.32 to 0.80 mg kg^{-1} for Pb, 0.40 to 1.17 mg kg^{-1} for Ni. In conclusion, due to the fact that location × cultivar interaction was found significant, we suggest that the appropriate cultivars should be determined to each region.

Keywords: *forage crops, macro, micro element, nutritive value, Onobrychis sativa*

Introduction

Today, current meadow and pasture fields cannot satisfy the growing need for feeding of animal alone (Ozkose, 2013). Therefore, harvested area, yield and quality of forage crops are required to be increased. The presence of a wide area from Portugal and Spain in Europe to Siberia and Central Asia is known the existence of sainfoin species, especially focused on the Asian-Caucasus-Iran triangle and diversified (Aktoklu, 1995). Sainfoin (*Onobrychis sativa* L.) is a native, widely grown perennial legume well adapted to the highland farming system under the dry land conditions of Central and Eastern Anatolia in Turkey (Turk *et al*., 2011). Sainfoin hay has a high ratio of protein, macro and micro elements. Sainfoin is an important forage crop for soil improvement, rotation crop in barren soil, high adaptation capability under warm and cold climate, increasing of soil fertility, a source of nectar and pollen for honey bees, and provides the hay before the other forage plants in early periods of the spring (Avci *et al*., 2013).

All plants depend upon the soil for their supply of mineral nutrients, and grazing ruminant animals obtain the majority of their mineral nutrients from plants grown on these soils (Khan *et al*., 2006). Minerals make up a small portion of an animal's diet; however, they play an important role in health, growth, and reproduction (Lemus, 2013). Mineral concentrations in forages vary much more than do protein and energy concentration (Lemus 2013). Although crop yield is still the primary economic factor determining forage crop value per unit of land area, forage quality has become a close second (Putnam *et al*., 2007). Quality of sainfoin hay is closely related to protein and mineral contents (Tongel & Ayan, 2010). Hay quality and concentrations of mineral elements in forage crops could be influenced by factors such as harvesting at specific physiological stages, climatic factors, soil conditions, leaf losses during hay making, storage and feeding practice, diseases and insects, weeds, cultivar, moisture content during storage, water supply and fertilizer application (Khan *et al*., 2006; Putnam *et al*., 2007; Scholtz *et al*., 2009; Kahraman, 2017).

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An accurate estimate of ingredient nutritional value is necessary for precise formulations of feed rations in all groups of farm animals, and useful in evaluating forages (Jančík *et al.*, 2017). The relatively little information is available on their mineral concentrations and especially on micro elements of sainfoin hay in Central Anatolia in the literature, as in the rest of the world. Therefore, the aim of the study was to determine protein, macro and micro element contents in herbage of some sainfoin cultivars grown in Central Anatolia.

Materials and Methods

In the study, three different sainfoin (*O. sativa* L.) cultivars (CV) were used as materials; namely Peschanyj (CV1), local population (CV2) and Ozerbey-2003 (CV3). This research was conducted in two locations, Konya and Ankara provinces, Central Anatolia Region, in Turkey, during the October 2005 to September 2007. The research fields in Konya and Ankara are located at 38^{o}02'01.4"N 32^{o}30'56.4"E and 39^{o}50'15.1"N 32^{o}25'13.9"E and at altitude of 1130 m and 760 m above mean sea level, respectively. Soil samples were taken before sowing and analysed for some chemical and physical parameters (Table 1). The soil of the experimental area had clay loam texture, slightly alkaline and low organic matter in Konya and sandy clay texture, slightly alkaline and low organic matter in Ankara.

Table 1. Soil characteristics of the experimental area in Konya and Ankara

Parameters	Values	
	Konya	Ankara
Clay (%)	27.6	35.8
Silt (%)	31.4	18.6
Sand (%)	41.0	45.6
Textural class	Clay loam	Sandy clay
pH	7.8	7.6
Organic matter (%)	1.3	1.5
EC (μS/cm^{-1})	181	285
P_2O_5 (mg kg^{-1})	10.74	28.66
K_2O (mg kg^{-1})	227.4	286.92
Zn (mg kg^{-1})	6.05	1.526
Fe (mg kg^{-1})	2.76	6.378
Cu (mg kg^{-1})	0.87	1.59
Mn (mg kg^{-1})	3.71	15.83
Ca (mg kg^{-1})	6134	2765

The climate of Konya and Ankara provinces of Turkey are characterized as semi-arid. This location's long term averages of temperature are 11.4-11.7°C, annual rainfall levels are 323.6-389.1 mm, and relative humidity are 58.0-60.5% respectively. Yearly averages of temperature are 12.2-12.7°C, rainfall 278.4-321.2 mm and 58.1-57.5% for during the trial, respectively.

The experiment was designed according to randomized complete block design with four replications. The sowings were made with rows of 5 m length and 0.5 m intra row spaces, including six rows per plot. Plot size was 5 m x 3 m (15 m^2). It was sown as field trial on September for Konya and Ankara in 2005. Plots were watered after sowing in order to provide emergence. Fertilizers were applied by calculating 27 kg ha^{-1} nitrogen (N) and 69 kg ha^{-1} phosphorus (P_2O_5) before sowing.

The dates of cuttings at 10% flowering stage were 15th May 2006, 10th May 2007 in Ankara, and 20th May 2006, 15th May 2007 in Konya. After harvest, sainfoin cultivars samples were prepared for each plot. The sainfoin samples were dried in a forced oven at 70^{o}C to constant dry weight to identify moisture content (Aydin & Tosun 1991). Protein content of the samples was determined by the Kjeldahl method, by using a Kjeldahl device (ACCC 1990). Crude protein (CP) ratio was calculated by multiplied the nitrogen concentration by 6.25 (Kacar, 1972). About 0.5 g dried and ground samples were put into a burning cup, and 2 ml of 35% H_2O_2 and 5 ml of 65% HNO_3 were added. The samples were incinerated in a MARS 5 Microwave Oven at 180^{o}C temperatures and a solution diluted to certain volume with distilled water (Ozcan, 2004; Acar *et al.*, 2012). Mineral concentrations of these samples were determined by ICP-OES (Perkin-Elmer, 2000), as per instructions of the manufacturer. These values were expressed as %, g kg^{-1} or mg kg^{-1} in dry matter.

The data obtained from the research were analysed according to the randomized complete block model of ANOVA. Significance levels ranged from P<0.05 or P<0.01 for statistical analyses. Differences between means were assessed with the Least Significant Difference (LSD) test at P<0.05 or P<0.01 levels of significance. Statistical analyses were performed using the MSTAT-C statistical software (MSTAT-C, Version 3, Michigan State University, USA. package).

Results and Discussion

In this research, three sainfoin (*O. sativa* L.) cultivars were studied in two different locations for two years. The results of variance analysis are summarized in Table 2. The results showed that protein and mineral concentrations of sainfoin cultivars ranged widely for the lots of parameters. Results of the study are summarized below.

Table 2. Analysis of variance with main effect and interaction effect of different factors (three sainfoin cultivars; two locations) on protein and mineral concentrations

Source	CP	P	K	Mg	Ca	Na	Mn	Fe	Zn	Cu	Cr	Al	Pb	Ni
Location (L)	ns	ns	ns	**	**	ns	*	*	ns	ns	ns	ns	ns	ns
Cultivar (C)	ns	ns	*	ns	**	**	**	*	*	**	**	**	**	ns
L x C	ns	**	**	**	*	**	**	*	*	ns	**	**	**	**

*F-test significance: *: P <0.05; **: P <0.01; ns: not significant*

The results of variance analysis showed that the CP ratio in sainfoin hay was not affected by the location, cultivar and location × cultivar interaction, statistically (Table 2). CP ratio was greater (12.28 %) in Ankara than (11.52%) in Konya. CP ratios of sainfoin cultivars were found to vary between 11.31% for CV1 and 12.57% for CV2 (Table 3). For the location × cultivar interaction, the highest CP ratio (12.69%) was obtained for CV2 in Ankara, while the lowest value (10.88%) was found for CV1 in Konya. CP ratio of sainfoin varied by depending on agricultural practices such as harvesting stage, fertilization, temperature, and also sainfoin cultivars. Okcu and Sengul (2014) mentioned that CP ratio of sainfoin species ranged 10.61 to 15.79 with an average of 13.45%, and CP difference between the species was found to be statistically significant. Parlak and Parlak (2008) stated that increase in salt and alkalinity of soil induced a reduction in CP ratio, and CP ratio ranged from 12.53 to 15.91%. The findings of this study are lower than results of the above researchers.

Table 3. Results of variance analysis of protein, P, K, Mg, Ca, Na and Mn contents of some sainfoin cultivars in different locations

Location	Cultivar	CP %	P g kg^{-1}	K g kg^{-1}	Mg g kg^{-1}	Ca g kg^{-1}	Na g kg^{-1}	Mn mg kg^{-1}
Konya	Peschanyj 1251	10.88	1.86 AB	31.07 A	6.61 A	8.81 bc	0.18 D	17.57 C
	Population	12.45	2.29 A	30.60 A	6.30 A	8.54 c	0.20 C	16.80 C
	Özerbey-2003	11.23	1.23 B	24.00 B	4.97 BC	11.89 a	0.27 A	38.25 A
	Mean of Konya	**11.52**	**1.79**	**28.56**	**5.96 A**	**9.75 A**	**0.22**	**24.21 a**
Ankara	Peschanyj 1251	11.77	1.51 B	27.57 AB	3.708 C	4.08 d	0.17 D	20.28 C
	Population	12.69	1.43 B	31.12 A	3.73 C	5.38 d	0.25 B	15.10 C
	Özerbey-2003	12.41	1.64 AB	30.81 A	5.54 AB	10.23 b	0.24 B	30.87 B
	Mean of Ankara	**12.28**	**1.52**	**29.83**	**4.32 B**	**6.56 B**	**0.22**	**22.08 a**
Peschanyj 1251		11.31	1.68	29.33 ab	5.15	6.44 B	0.17 C	18.93 b
Population		12.57	1.86	30.86 a	5.01	6.96 B	0.22 B	15.95 b
Özerbey-2003		11.82	1.43	27.41 b	5.25	11.05 A	0.26 A	34.56 a
General Mean		**11.90**	**1.66**	**29.19**	**5.14**	**8.15**	**0.22**	**23.15**

a, b, – means with different letters are significantly different (P≤0.05).
A, B, – means with different letters are significantly different (P≤0.01).

In this study, location × cultivar interaction has statistically highly significant on the Phosphorus (P) content of sainfoin hay (Table 2). Namely, P content of sainfoin cultivars was varied according to locations. The P content ranged from 1.23 g kg^{-1} at CV3 in Konya to 2.29 g kg^{-1} at CV2 in Konya (Table 3). P content of sainfoin hay was not affected by the locations and cultivars (Table 2). The P of sainfoin can be affected by many factors. Tufenkci *et al*., (2006) found that N, P and inoculation with rhizobium application had significant effect on the P content of sainfoin hay and it ranged from 0.231 to 0.396 g kg^{-1}. Turk *et al*., (2011) reported that P treatments significantly increased P content of sainfoin and also it was affected by the harvesting stages. Phosphorus is an essential bone component and is present in several organic compounds which participate in metabolic pathways (Kidambi *et al*., 1990) and also animals need P for energy metabolism (Lemus, 2013). Sainfoin hay is an important source of phosphorus for livestock.

The results of statistical analysis showed significant differences (P<0.05) with regard to the Potassium (K) contents among the cultivars (Table 2) and K contents of CV2 and CV1 (30.86 g kg^{-1} and 29.33 g kg^{-1}, respectively) were higher than CV3 (27.41 g kg^{-1}; Table 3). The effect of locations on K content was no significant. But location × cultivar interaction was significant. According to location × year interactions, the highest K content (31.12 g kg^{-1}) was found in CV2 at Ankara whereas CV3 had the lowest K content (24.00 g kg^{-1}) at Konya. Tufenkci *et al*. (2006) stated that phosphorus and nitrogen applications and rhizobium inoculation had significant effects on the K contents of sainfoin. Kidambi *et al.* (1990) stated that significant (P≤ 0.01) effects due to harvest dates and harvest date × irrigation interaction was observed for the K contents in sainfoin and K content ranged from 10.8 to 30.5 g kg^{-1}. Turk *et al.* (2011) reported that K content in sainfoin significantly decreased with advancing stages and phosphorus treatments and also varied from 15.8 to 24.7 g kg^{-1}. When compared with other published data concerning K content of sainfoin hay, result of the present study were generally similar. The differences could be partly explained by genotypic differences, vegetative parts, stage of maturity, levels of available K in the soil and soil pH (Khan *et al.*, 2006). Animals need K for milk production, maintenance of body fluids, nerve impulse transmission, muscle contraction, and the maintenance of enzyme systems (Lemus, 2013). For a dairy Holstein cow with milk production of 35 kg day^{-1} needs 10.5 g kg^{-1} in dry-matter herbage (NRC 2001). In present investigation, the level of K in sainfoin was higher than the recommended standard values for ruminants.

Locations had highly significant effects (P<0.01) on Magnesium (Mg) content of sainfoin hay (Table 2). Mg content with 5.96 g kg^{-1} in Konya is higher than in Ankara (4.32 g kg^{-1}) (Table 3). For Mg contents, differences between cultivars were not statistically significant as given in Table 2. Location × cultivar interaction was highly significant (P<0.01). The highest Mg content in location × cultivar interaction was found to be 6.61 g kg^{-1} (for CV1 in Konya), while the lowest were found to be 3.70 g kg^{-1} (for CV1 in Ankara). The Mg content of sainfoin depends on many factors. The Mg content of sainfoin decreased with advancing stages while phosphorus applications increased Mg contents (Turk *et al*., 2011). While these results were in agreement with earlier reports presented by Tongel and Ayan (2010), lower than those of Jenkins and Bottomley (1984). Differences in the content of Mg in this study with those in the literature could partly be explained by differences between forage species, level of Mg in the soil, influences of locality and climate, growth stage, proportion of leaf and stem fractions collected for mineral analysis, and season when forage sampling was taken (Jenkin and Bottomley 1984; Khan *et al*., 2006). Animals need Mg for skeletal growth, milk production, nerve impulse transmission, muscular control, and the maintenance of enzyme systems (Lemus 2013). The mineral analysis showed that the sainfoin hay provided herbage of high nutritive value in terms of the concentrations of Mg levels in present investigation (3.70 - 6.61 g kg^{-1}), as these were generally above the Mg requirement values (1.9 g kg^{-1}) of a Holstein dairy cow producing 35 kg of milk per day (NRC 2001).

Locations and cultivars had highly significant effect (P<0.01), on Calcium (Ca) content and Location × cultivar interaction had significant effect (P<0.05) on Ca content (Table 2). Ca content of sainfoin hay was 9.75 g kg^{-1} in Konya and 6.56 g kg^{-1} in Ankara (Table 3). In Location × cultivar interaction, the highest Ca content (11.89 g kg^{-1}) was obtained from the CV3 in Konya while the lowest Ca content (4.08 g kg^{-1}) was obtained from CV1 in Ankara. According to results reported by *Kidambi et al.* (1989), Ca contents of sainfoin hay ranged from 4.0 to 8.0 g kg^{-1} in dry matter. Kidambi *et al.* (1990), in his study to determine the effects of soil moisture level on mineral concentrations, reported that the Ca concentration of sainfoin varied from 3.2 to 12.5 g kg^{-1}. Ca content of sainfoin increased as phosphorus fertilization increased (Turk *et al*., 2011) and with advancing harvest stages (Tufenkci *et al*., 2006; Turk *et al*., 2011). Animals need Ca for skeletal growth, milk production, nerve impulse transmission, and the maintenance of enzyme systems (Lemus 2013). Forage Ca requirements of grazing ruminants is a subject of considerable debate as the requirement is influenced by animal type and level of production, age and weight (Khan *et al*., 2006).

Forage for ruminants should contain at least 0.3% Ca content (Bickoff *et al*., 1972; NRC 2001). Thus the sainfoin Ca values found in the study were considered adequate for the optimum performance of ruminants and sufficiently higher than the requirements of ruminants. Similar statements were also expressed by other researchers such as Khan *et al.* (2006), Tongel and Ayan (2010).

Sodium (Na) content in sainfoin was affected ($P < 0.05$) by cultivars and location × cultivar interaction (Table 2). Na contents of sainfoin cultivars were found ranging from 0.17 g kg^{-1} in CV1 to 0.26 g kg^{-1} in CV3. In location × cultivar interactions, the highest Na content (0.27 g kg^{-1}) was found in CV3 at Konya whereas CV1 had the lowest K content (0.17 g kg^{-1}) at Ankara (Table 3). For Na, similar result was obtained by Foos (1979) who reported that Na contents in sainfoin ranged from 0.11 to 0.81 g kg^{-1}. Bickoff *et al.* (1972) stated that Na concentrations of herbage varied more than a thousand folds from 0.002 to 2.12%, and any values between 0.05 and 1% would not be considered unusually. Animals need Na for glucose and amino acid transport, maintaining body fluids, and acid-base balance (Lemus 2013). Khan *et al.* (2009) stated that, quoted from other researchers, the Na requirement for a ruminants was debatable yet its adequate range from 1 to 4 g kg^{-1} was been recommended. For a dairy Holstein cow with milk production of 35 kg day^{-1} needs 2.3 g kg^{-1} Na in dry-matter herbage (NRC 2001). Na content in the present study was below the levels recommended for optimal animal production.

The variance analysis showed the statistically significant effects of locations on Manganese (Mn) and Fe contents in sainfoin hay (Table 2). Effects of cultivars were highly significant on Mn, Copper (Cu), Chromium (Cr), Aluminium (Al) and Lead (Pb) contents in sainfoin hay. Locations were also statistically significant in terms of Iron (Fe) and Zinc (Zn) contents. However, locations had no effect on Ni contents. Lastly, location × cultivar interaction had highly significant effect on Mn, Cr, Al, Pb and Nickel (Ni) contents, and significant effect on Fe and Zn contents, but, no effect on Cu content of sainfoin hay.

Mn content of sainfoin hay ranged from 15.10 to 38.25 mg kg^{-1}, with an average 23.15 mg kg^{-1} (Table 3). Manganese deficiency can cause impaired growth, skeletal abnormalities (shortened and deformed), disturbed or depressed reproduction, and for a dairy Holstein cow with a milk production of 35 mg kg^{-1} needs 15.0 mg kg^{-1} dry-matter herbage (NRC 2001). According to this situation, Mn concentrations of sainfoin in this study were equal or above the Mn requirement values of a Holstein dairy cow producing 35 kg of milk per day.

Fe contents of sainfoin hay ranged from 41.28 to 116.52 mg kg^{-1}, with an average 68.18 mg kg^{-1} (Table 4). According to Scholtz *et al.* (2009), soil pH is the most important factor governing Fe uptake. Also, deficiency of Fe due to the low availability of insoluble oxides and phosphates and therefore is most likely to occur on calcareous soils. Another researcher stated that differences in the Fe contents could be partly explained by depending on agricultural practices such as harvesting stage, fertilization, and stage of growth, variations in the content of Fe in the soil, and climatic conditions between localities (Jenkin and Bottomley 1984; Khan *et al*., 2006), and also sainfoin cultivars. As a matter of fact, in this study, Fe content of sainfoin was changed according to location, cultivar and location × cultivar interaction. The mineral analysis of the sainfoin hay showed that the sainfoin provided herbage of high nutritive value in terms of the concentrations of Fe levels, as these were generally above the nutrient requirement values (15 mg kg^{-1} dry-matter herbage) of a Holstein dairy cow producing 35 kg of milk per day (NRC 2001).

Zn contents of sainfoin hay ranged from 19.50 to 40.97 mg kg^{-1}, with an average 26.20 mg kg^{-1}. These findings have similar to 12.7-28.3 mg kg^{-1} range in the results reported by Kidambi *et al.* (1990) for sainfoin. The sainfoin hay had Zn contents below the recommended daily requirement of 48 mg kg^{-1} by the NRC (2001).

Cu contents of sainfoin hay ranged from 3.48 to 6.65 mg kg^{-1}, with an average 4.88 mg kg^{-1}. Kidambi *et al.* (1990) reported that the Cu concentration of sainfoin varied from 5.5 to 12.1 mg kg^{-1}. For a dairy Holstein cow with milk production of 35 kg day^{-1} needs 11 mg kg^{-1} Cu in dry-matter herbage (NRC 2001). According to the results of the present study, Cu concentration was below the levels recommended for optimal animal production.

Cr contents of sainfoin hay were found ranging from 0.55 to 1.47 mg kg^{-1}, with an average 1.00 mg kg^{-1}. Al contents of sainfoin hay ranged from 25.75 to 41.52 mg kg^{-1}, with an average 31.67 mg kg^{-1}. Pb contents of sainfoin hay ranged from 0.32 to 0.80 mg kg^{-1}, with an average 0.54 mg kg^{-1}. Ni contents of sainfoin hay ranged from 0.40 to 1.17 mg kg^{-1}, with an average 0.81 mg kg^{-1}.

Table 4. Results of variance analysis of Fe, Zn, Cu, Cr, Al, Pb and Ni contents of some sainfoin cultivars in different locations

Location	Cultivar	Fe mg kg^{-1}	Zn mg kg^{-1}	Cu mg kg^{-1}	Cr mg kg^{-1}	Al mg kg^{-1}	Pb mg kg^{-1}	Ni mg kg^{-1}
Konya	Peschanyj 1251	61.77 b	20.75 c	3.48	1.20 B	33.55 AB	0.45 BC	1.15 A
	Population	67.73 b	19.50 c	4.20	1.17 B	31.50 B	0.80 A	1.05 A
	Özerbey-2003	41.28 c	40.97 a	6.65	0.55 E	26.25 B	0.32 C	0.40 B
	Mean of Konya	**56.93 b**	**27.07**	**4.77**	**0.97**	**30.43**	**0.52**	**0.87**
Ankara	Peschanyj 1251	64.82 b	23.10 c	4.22	0.85 C	25.75 B	0.58 AB	0.50 B
	Population	116.52 a	23.65 c	4.50	1.47 A	41.52 A	0.57 AB	0.60 B
	Özerbey-2003	56.95 b	29.47 b	6.23	0.75 D	31.45 B	0.50 BC	1.17 A
	Mean of Konya	**79.43 a**	**25.41**	**4.98**	**1.02**	**32.91**	**0.55**	**0.76**
Peschanyj 1251		63.30 b	21.93 b	3.85 B	1.02 B	29.65 B	0.51 B	0.82
Population		92.12 a	21.57 b	4.35 B	1.32 A	36.51 A	0.69 A	0.83
Özerbey-2003		49.11 c	35.22 a	6.44 A	0.65 C	28.85 B	0.41 B	0.79
General Mean		**68.18**	**26.20**	**4.88**	**1.00**	**31.67**	**0.54**	**0.81**

a, b, – means with different letters are significantly different ($P \leq 0.05$).
A, B, – means with different letters are significantly different ($P \leq 0.01$).

Conclusions

This study was found significant differences among the sainfoin cultivars with regard to contents of several elements. As a result of our research, due to the fact that location × cultivar interaction was found significant, we suggest that the appropriate cultivars should be determined to each region. In conclusion, the mineral analysis showed that the sainfoin hay provided herbage of high nutritive value in terms of the concentrations of K, Mg, Ca, Mn, Fe and Cu levels, as these were generally above the nutrient requirement values of a Holstein dairy cow producing 35 kg of milk per day. However, P, Na and Zn concentrations were below the required values. The high protein and mineral content of the sainfoin hay is important for organic livestock production.

Sainfoin has adequate mineral content for ruminant animal requirements for production in the Mediterranean conditions of Turkey (Turk *et al*., 2011). Particularly, sainfoin hay including high protein and mineral contents can be sufficient without supplementary any feeds where sainfoin is under snow cover during winter in organic livestock husbandry enterprises. Due to the fact that crude protein and element contents differed among the cultivars, increasing of those should be one of main objects in future breeding programs. Therefore, improving of hay yield and as well as protein and mineral contents should be purposed in breeding of sainfoin.

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