The Journal of Animal & Plant Sciences, 27(3): 2017, Page: 961-970
ISSN: 1018-7081

ACCUMULATION OF MACRONUTRIENTS IN FORAGE GRASSES UNDER SALINE AND ALKALINE CONDITIONS

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ABSTRACT

This study was designed to determine P, K, Ca, Mg and Na mineral accumulations in *Agropyron elongatum, Chloris gayana*, *Cynodon dactylon* and *Festuca arundinacea* species grown on control (non-saline and non-alkaline), highly saline, highly alkaline and highly saline-alkaline soils, and to check whether the obtained fodders meet mineral requirements of animals. The research established in 2011 under a randomized complete blocks design, and continued for three years. Results revealed that macro nutrient contents (P, K, Ca, Mg and Na) accumulation differed significantly among species (except for K), locations (except for Ca) and years. No significant differences were observed among species in terms of potassium content. The highest phosphorus content was detected in *Agropyron elongatum,* while the highest Ca content observed in *A.elongatum* and *F.arundiancaea*. Moreover, the highest Mg content was observed in *F.arundiancae*and the highest Na content in *A.elongatum*and *F.arundiancaea*. The lowest P, K^+ and Na^+ accumulations were detected from highly saline-alkaline soils while Mg^{2+} content was observed in control, highly saline and highly alkaline soils. As for meeting mineral requirements by animals, Ca^{2+} content of the obtained fodder was found to be sufficient while K^+ accumulations were found to be lower and P and Na^+ contents, on the other hand, were found to be higher than the recommended levels. Thus, K^+ requirements by the animals should be met by additional feeding and because of rich sodium and phosphorus contents, fodder obtained from these species should be fed with caution.

Keywords: Salinity, alkalinity, forage grass, macronutrient.

INTRODUCTION

Plants are under the influence of, or in interaction with, many vegetative and environmental factors within the locations they grow. One of these environmental stress factors is soil salinity. Salinity, which is widespread in arid and sami-arid regions of the world, is an important environmental stress factor that has negative effects on the socioeconomic development of countries, germination-seedling development, plant diversity and yield (Ghassemi- Golezani *et al*., 2010; Kazemi and Eskandari, 2011; Temel *et al*., 2015). It is reported that over 6% of the world's land is affected by either salinity or sodicity (Munns, 2011). Accumulation of excess Na^+ and Cl^- ions in saline and alkaline areas has negative effects on the growth of many plants due to ion toxicity and osmotic effect (Parida and Das, 2005; Kacar *et al*., 2009; Ul-Hassan and Bano, 2015).On the other hand, salinity-resistant plants decrease their own osmotic potential by accumulating high amounts of inorganic minerals in their roots and these plants are affected relatively less from salinity by transcending to turgor state in saline areas (Greenway and Munns, 1980).

Plants that can be grown on saline soils may significantly meet nutritional and mineral requirements of animals (Temel *et al*., 2016). Plant species, fertilization, irrigation, precipitation of the cultivation area, root system of the plant, pH of the soil, cooperation and antagonism of the elements are important factors that affect mineral accumulation ability of the plants (Marschner, 1995; Bengtsson *et al*., 2003; Warman and Termeer, 2005). Acidity and alkalinity of the soil have significant effects on the usefulness of nutritional elements in soil and as a result of this effect the amount of mineral content that the plant can acquire may vary (Aydin *et al*., 2005).

The situation that salinity and alkalinity having effects on mineral content of the soils changes mineral compositions of the plants grown in these areas and, thus, the mineral demands of the animals (Khan *et al*., 2007). Lack of minerals may cause growth deficiencies and toxicities in both plants and animals (Ulrich and Hills, 1967). Daily nutritional, energy and mineral requirements of animals must be met in order for them to reproduce and grow healthily (Ganskopp and Bohnert, 2003). Otherwise excess or lack of mineral intake may have adverse effects on animal health and reproduction and nutritional disorders in animals (Goswami *et al*., 2005; Khan *et al*., 2007).There is a lack of Ca, P and Na content in forage grasses in general. These species may sometimes have a lack of Mgand K content (McDowell, 1996). In this study, P, K, Ca, Mg and Na macronutrient accumulations of 4 forage grasses (*Agropyron elongatum, Chloris gayana, Cynodon dactylon* and *Festuca arundinacea*) grown on saline and alkaline soils were determined and whether these accumulations are sufficient for the mineral requirements by animals were evaluated.

MATERIALS AND METHODS

Trial was conducted in Iğdır where continental climate is dominant. The research was carried out for 3 years between 2011 and 2013 at4 different locations of Iğdır plain where 39.9578 latitude, 44.3018 longitude and 800-900 m altitude. Mean annual temperature is 12.5 ºC, average relative humidity is 51.2% and annual amount of precipitation is 264.0 mm. Mean temperatures in 2011, 2012 and 2013 were recorded as 12.6 ºC, 13.5 ºC and 14.1 ºC, respectively, while relative humidity was recorded as 56.5%, 53.6% and 51.4% respectively and annual amounts of precipitation were 340.0 mm, 237.2 mm and 226.9 mm for the trial years (Table 1).

Table 1. Some climate features of Iğdır province in 2011, 2012 and 2013years(Anonymous, 2014).

Months	Monthly Total Precipitation (mm)			Temperature (ºC)			Monthly Avg. Relative Humidity (%)		
				2011	2012	2013			
	2011	2012	2013	Avg.	Avg	Avg.	2011	2012	2013
January	6,0	0,0	19,6	-0,6	0,3	-2,2	74,0	59,5	71,9
February	22,6	12,5	15,2	0,7	-3,1	4,3	66,1	63,1	64,3
March	17,2	13,5	14,8	7,8	3,6	9,3	48,5	47,1	44,3
April	73,9	16,2	34,6	13,5	16,1	15,4	57,7	43,4	46,1
May	76,9	57,4	58,9	17,5	19,7	18,9	59,8	51,3	52,6
June	40,4	26,7	38,3	23,5	25	23,3	47,0	37,6	43,7
July	24,0	23,0	10,6	28,0	26,1	26,5	40,5	43,8	39,7
August	24,3	0,6	8,3	25,9	27,6	35,4	43,2	38,0	41,7
September	10,6	29,3	9,9	21,4	21,5	21,4	45,8	47,7	43,2
October	25,8	11,5	15,4	12,6	15,4	12,3	60,0	62,5	53,8
November	9,2	20,7	1,3	3,0	8,4	2,4	63,7	75,0	57,3
December	9,1	25,8	7,6	-1,6	1,4	-8,7	71,6	74,5	80,88
Total/Avg.	**340,0**	**237,2**	**226,9**	**12,64**	**13,5**	**14,06**	**56,49**	**53,62**	**51,39**
3 years Avg.		**268,03**			**13,4**			**53,83**	

Chemical and physical characteristics of soil samples (0-30 cm depth) taken from in the trial area are shown in table 2. Textural analyses were carried out using Bouyoucus Hydrometer (Gee and Hortage, 1986); organic matter counts were made according to Walkey-Black method (Nelson and Sommers, 1982); soil pH was measured with a Glass-Electrode pH-meter (McLean, 1982); exchangeable Na, K, Ca and Mg contents were measured by reading in Atomic Absorption after extracting by shaking with ammonium acetate (1 N, pH=7.0) (Rhoades, 1982); phosphorus content was measured by spectrofotometer in subtles extracted by sodium bicarbonate (Olsen and Sommers, 1982); electrical conductivity (EC),was measured by EC tool in extraction solution (Demiralay, 1993) and boron analysis was carried out by reading color solutions prepared according to azometin-h method in spectrofotometer whose light absorption set at 420 nm wave length (John *et al*., 1975).

Trial was established in 2011 and carried out for 3 (three) years (2011, 2012 and 2013) ina randomized complete blocks design with three replications. (Four locations were selected in trial; control (non-alkaline and non-saline) (DSY 8.9%, EC 0.43 dS/m), highly saline (DSY 11.9%, EC 9.80 dS/m), highly alkaline (DSY 60.5%, EC 0.89 dS/m), and highly saline-alkaline (DSY 49.7%, EC 9.08 dS/m), 4 (four) forage grasses (*Cynodon dactylon* L. var. Sem-Caska., *Chloris gayana* Kunth var. Katambora, *Festuca arundinacea* L. var. Asterix and *Agropyron elongatum* L) were selected as materials for determination of resilience under saline and alkaline conditions. Sowings were carried out on April 20, 2011 and 30 kg, 6 kg, 20 kg and 15 kg/ha^{-1} seeds were used, respectively, of *Chloris gayana*, *Cynodon dactylon*, *Festuca arundinacea* and *Agropyron elongatum* species. 60 kg ha^{-1} N (300 kg ha^{-1} ammonium sulphate) and 100 kg ha^{-1} P_2O_5 (250 kg ha^{-1} TSP) were applied as fertilizer during the sowings. After every harvest period in each year (2011, 2012 and 2013) an additional amount of 60 kg ha^{-1} N (300 kg ha^{-1} ammonium sulphate) fertilizer was applied. Moisture content of the soil was determined with ''Soil Water Potential Measurement Device'' and irrigation was made when the amount of useful water dropped under 50%.Irrigation was carried out 7 times in the first year, 8 times in the second year and 8 times in the third year according to the border irrigation method.

Cynodon dactylon was harvested at full bloom stage while *Festuca arundinacea* at boot stage, *Agropyron elongatum* at pre-anthesis (Serin and Tan, 1998) and *Chloris gayana* at the beginning of panicle generation stage (Skerman and Riveros, 1990). Harvested plants were first washed with purified water. After that, plants were first left in the open air and dried for 2-3 then dried in a drying oven set at 70 ºC for 48 hours. After drying, samples were ground in a Wiley grinder in order to enable them pass through 1 mm of sieve opening and ground plant material were taken to wet decomposition in solutions prepared with nitric acid mixture. Mineral matter contents were then determined using ICP-OES device after wet decomposition process (Kacar and Inal, 2008).

The data were exposed to General Linear Models with SPSS on the basis of main effects. Mean was performed using Duncan test.

Table 2. Chemical and physical characteristics of the experimental soils.

	EXPERİMENTAL LOCATIONS			
Soil Properties	**Control**	**High saline**	**High alkali**	**High saline-alkali**
Texture	Clay loam	Loamy sand	Clay loam	Clay loam
EC (dS/m)	0.43	9.80	0.89	9.08
pH (1:2,5)	8.2	8.5	10.3	9.4
Organic matter (%)	4.4	2.1	1.7	2.3
ESP (%)	8.9	11.9	60.5	49.7
N (%)	0.21	0.11	0.11	0.08
P (mg kg^{-1})	27.9	33.8	40.8	36.5
B (mg kg^{-1})	4.3	12.4	5.9	11.4
Ca (mg kg^{-1})	3640	3680	3180	3400
Mg (mg kg^{-1})	528	540	444	552
K (mg kg^{-1})	1248	1326	1638	1248
Na (mg kg^{-1})	552	759	3749	2737

ESP: exchangeable sodium percentage

RESULTS AND DISCUSSION

It was observed that all seedlings that have germinated and surfaced under highly saline-alkaline soil conditions in the year of establishment were dried and consequently could not manage to develop in a full plant. Upon this development, species were re-sown in the second year at locations where they did not grow and only *Agropyron elongatum* was able to be planted. This situation showed that *Agropyron elongatum* species is more resilient to highly saline-alkaline soils when compared to other studied species. It was reported that soil salinity and alkalinity affect germination and seedling development of the plants and the extent of this effect may vary according to species(Gu *et al*., 2012; Temel *et al*., 2015). *Chloris gayana* and *Cynodon dactylon* species showed a significant growth in the year of establishment, however, they could not continue this growth within the next your probably because of low winter temperatures. Tansi (2009) reported that *Cynodon dactylon* dies at -3 ºCwhile, *Chloris gayana* dies at -8 ºC which are in parallel with the findings of this study. Because of such reasons, plant samples could not be taken in some years and from some locations.

PHOSPHORUS: Phosphorus (P) accumulations of studied forage grasses grown atlocations with different chemical characteristics differed significantly between years, locations and species. As for the years, phosphorus content of the obtained fodder varied between 0.91% and 1.53% and higher phosphorus contents were recorded in the first and second years (2011 and 2012) when compared to 2013. In general, temperature, light, ventilation, soil pH and mutual interactions of ions are the basic factors that have an influence on intake of nutritional elements by plants (Kacar and Katkat, 2015). Therefore, one or a few of these factors may have an effect on the varying mineral contents among the plants. Looking at the locations, the highest phosphorus contents were observed in control, highly saline and highly alkaline soil conditions while the lowest value was recorded in highly saline-alkaline location (Table 3).

It may be said that the reason for the decrease in phosphorus contents of fodder obtained under highly saline-alkaline conditions is the negative effect of sodium, which is abundant in such soils, on phosphorus intake.It has been reported that increase of soil salinity, especially of Na^{+}amount in soils, results in a decrease of phosphorus intake, in other words, in a decrease of P amount in plant tissues (Unlukara *et al*., 2008). Phosphorus content varied between 1.25% and 1.59% among species. It can be seen in table 3 that *C.dactylon*, *C.gayana* and *F.arundianacea* species fell within the same statistical group in terms of phosphorus content and these species have accumulated higher amounts of phosphorus within their structures than *A.elongatum*. Cacan*et al*. (2015) reports that mineral compositions of 12 forage grasses collected from natural areas with neutral pH and non-saline soil characteristics have varied, and *F.arundinacea* species have the highest phosphorus content among all investigated species. Other researches have also reported variations in phosphorus contents of fodder crops as to species and varieties (Abdullah *et al*., 2013; Bayraktar, 2005).

Table 3. Phosphorus contents (%) of forage grasses cultivated underdifferent soil conditions.

Years	Plant	Control	High Saline	High Alkali	High Saline-alkali	Average of Years
2011	*Cynodon dactylon*	1.58	1.59	1.59	x	**1.53 a**
	Chloris gayana	1.60	1.59	x	x	
	Agropyron elongatum	1.01	1.59	1.60	x	
	Festuca arundinacea	1.60	1.58	x	x	
2012	*Cynodon dactylon*	X	X	x	x	**1.58 a**
	Chloris gayana	X	X	x	x	
	Agropyron elongatum	1.59	1.43	1.61	1.44	
	Festuca arundinacea	1.65	1.75	x	x	
2013	*Cynodon dactylon*	X	X	x	x	**0.91 b**
	Chloris gayana	X	X	x	x	
	Agropyron elongatum	1.02	0.91	0.89	0.69	
	Festuca arundinacea	1.10	0.87	x	x	
	Average of location	**1.39 a**	**1.41 a**	**1.42 a**	**1.07 b**	
Average of plants	***Cynodon dactylon***	**1.59 a**				
	Chloris gayana	**1.59 a**				
	Agropyron elongatum	**1.25 b**				
	Festuca arundinacea	**1.42 a**				

*: Plants didnot growth at applications shown with X.
**: Values showed with different letters are significantly different

POTASSIUM: Location and years have significantly affected K^+ content (Table 4). Maximum K^+ content was recorded in 2012 (0.44%) and K^+ content in the year of establishment (0.30%) was observed to be higher than that of 2013(0.19%) (Table 4).This may be a result of lower temperatures during 2011 in comparison with 2012. Hence, it has been reported that increasing temperatures during the growth periods of many fodder crops caused an increase of K^+ accumulation in plants (Reid and Horvath, 1980). Potassium content of the fodder varied between 0.21% and 0.34% among locations. The highest potassium level was observed in highly saline conditions followed by control and these two locations were in the same statistical group in terms of K^+ content. The lowest value was determined in highly saline alkaline soil conditions followed by highly alkaline (Table 4).Thus, K^+ content of the obtained fodder showed a significant decrease under highly alkaline and highly saline conditions. This situation is thought to be stenmming from the antagonistic effect of Na^+ ions which are abundantly available both in the soil and in plant structure. Hence, Gunes *et al*. (2005) and Kacar and Katkat (2015) have expressed that excess amounts of Na^+ and other ions in soil decrease K^+ intake by plants. A study by Mezni *et al*. (2010) reported the negative effect of increasing amounts of Na^+ on K^+ content of alfalfa as well. Results of other research also showed that K^+ intake was inhibited in plants under salt stress and in high doses of NaCl applications (Haro *et al*., 2010; Samad and Karmoker, 2013; Turan *et al*., 2010).

CALCIUM: Locationshas no significant effect on Ca^{2+} content, species and years were found to have a significant effect on Ca^{2+} content (Table 5). Maximum Ca^{2+} accumulation in the study were measured in 2012. Minimum values were observed in 2011 and 2013 and these two study years were observed to be in the same statistical group (Table 5). This may be caused by abundance of relatively more Na^+ ions in soil during 2011 due to no prior soil processing and cultural activities when compared to 2012 (Table 2). Grattan and Grieve (1999) reported that existence of high amounts of Na^+ concentration in root environment has a negative effect on Ca^{2+} intake by the plants. Highest Ca^{2+} accumulation was determined in *F.arundinacea* while the lowest value was found in *C.dactylon*. This may be a result of higher proportions of Na^+ ions found within the structure of *C.dactylon* in comparison with *F.arundinacea* (Table 7). Excess amounts of Na ions in plant structure decrease Ca^{2+} intake by the plant due to antagonism of ions (Grattan and Grieve, 1990).

MAGNESIUM: Mg^{2+} contents of the obtained fodder showed significant differences for years, locations and species. According to table 6, significant increases were recorded in Mg^{2+} contents of the fodder in years following the year of establishment and the highest values were observed during 2013 (0.33%). This may be a result of low amount of precipitation and higher temperatures during 2013 when compared to other trial years, since increasing evaporation ratios due to increasing temperatures causes transfer of salts that are more soluble in soil to the upper layers of soil through capillarity (Ashraf *et al*., 2005). As a consequence plants tend to intake more mineral ions within their structure (Aydemir and Sunger, 2012). As for the locations, a higher Mg^{2+} accumulation was observed in highly saline-alkaline soil conditions in comparison with the other locations (Table 6). It is thought that this is a result of antagonistic effects of Na^{+} ions found abundantly in soils. Thus, Suyama *et al*. (2007) have reported that Mg^{2+} content of clover increased in paralel to increasing $NaCl_2$ salinity. Yet, Semiz *et al*. (2012) have reported that Mg^{2+} content of fennel leaves subjected to increasing amounts of salt ($NaCl_2$ and $CaCl_2$) decresed due to increasing salt concentration. On the other hand, the lowest Mg^{2+} content was observed in highly alkaline soils while control and highly saline soils fell within the same statistical group (Table 6). A similar result was also obtained by Gonzales and Hailman (1977) who reported that there wasno difference in Mg^{2+} contents of *Chloris gayana* and *Cynodon dactylon* species grown under saline and non-saline soil conditions. The highest Mg^{2+} content was obtained in *F.arundinacea* with 0.31%, while *C.dactylon* and *C.gayana* species had the lowest Mg^{2+} content (Table 6). In another study conducted by Kilic *et al*. (2015) under non-saline, lightly saline, fairly (medium) saline and highly saline soil conditions, it is reported that *F.arundiacea* species has the highest Mg^{2+} content among all fodder crops species (except *Lolium perenne)* included in the study. Moreover, results of other studies conducted in different ecologies have shown that Mg^{2+} contents accumulated within the structure of fodder-crop species grown on same soil type vary (0.03%-0.38%) (Cacan *et al.*, 2015; Elmali and Kaya, 2012).

SODIUM: Sodium content has changed significantly according to years, locations and species. As shown in table 7, the highest Na^{+} ratio was measured during 2011 and significant decreases in Na+ content were observed in years following the year of establishment. This may be stemming from the improvement of soil conditions due to carrying-out of more intensive cultural activities (fertilizing, hoeing and irrigation) on soils, which have not been subjected to any previous soil processing, in years following the year of establishment and, as a result of this situation, lower concentrations of Na^{+} in soils (particularly in the root area). Hence, prior research also reports that Na^{+} content in both roots and offshoots of many plant species increases in relation to increasing soil salinity (Majid *et al*., 2012; Wang *et al*., 2012). Na^{+} content has varied between 0.73% and 0.32% among locations and the highest Na^{+} content was determined in highly alkaline (0.73%) soil conditions (Table 7). This may be resulting from the existence of relatively higher amount of Na^{+} ions in highly alkaline soil conditions (3749 mg kg^{-1}) and relatively higher amounts of Ca^{2+} ions in control conditions (Table 2), when compared to other locations, since Na^{+} intake by the plants may decrease depending on soil Ca^{2+} concentration in soil solution (Cramer, 1997). The lowest Na^{+} value, on the other hand, was detected in highly saline alkaline conditions (Table 7). However, in another similar study, the highest Na^{+} ion concentration in plants was shown to be obtained under saline-alkaline soil conditions (Aydemir and Sunger, 2012). This result is not in agreement with our findings. Other species except *A.elongatum* could not manage to establish under highly saline-alkaline conditions due to climatic conditions or due to reasons stemming from the soil itself and therefore did not contribute statistically to the means and it is thought that this was the reason for the disagreement with findings of previously-conducted research. In the study, *C.dactylon* and *C.gayana*, *A. elongatum* and *F. arundiancea* fell into same statistical groups in terms of Na^{+} accumulation and warm season forage grasses *C. dactylon* (1.10%) and *C.gayana* (1.13%) observed to have higher Na+ content than cool season forage grasses *A. elongatum* (0.47%) and *F.arundiancea* (0.51%). In a study by Sima *et al*. (2013) conducted to determine the effects of different salt types (sodium chlorure, sodium sulphate, potassium chlorure and potassium sulphate) on growth and development of different forage grass species, it is reported that, *A.elongatum*, a species which has one the highest salinity-resistance levels among fodder crops, has a lower Na^{+} concentration in comparison with other species which are more sensible to salinity. On the other hand, Deifel *et al*. (2006) have reported that *C.gayana*, which is known as the most salinity-tolerant species, can accumulate higher proportions of Na^{+} ions within its structure through osmotic modification even under low salinity conditions and this result are in support of our findings.

In addition, whether fodder obtained from forage grasses grown under different soil conditions meets the mineral requirements by animals was also investigated in the study. As reported by NRC (1985), recommended ratios of P, K^{+}, Ca^{2+}, Mg^{2+}, Na^{+} for all ruminant classes are 1.25 to 1.59%, 0.5 to 1.0%, 0.19 to 0.82%, 0.12 to 0.20% and 0.06 to 0.18% , respectively. In our present study, average P, K, Ca, Mg and Na contents of the plants varied between 0.12% to 0.48%, 0.28% to 0.35%, 0.24% to 0.42%, 0.11% to 0.31% and 0.47% to 1.13%. According to these findings, Ca^{2+} content of the investigated fodder-crop species was found to be sufficient for mineral requirements of animals, while K^{+} accumulation was found to be lower and P and Na^{+} contents were found to be higher than recommended levels. On the other hand, Mg^{2+} contents of the species differed than those of recommended by NRC (1985) for all ruminants. Only *F.arundinacea* species found to have a high Mg^{2+}content. Therefore, keeping in mind that feeds with high mineral content can cause toxicity in animals, feeds must be given with caution (for example, by rationing with other feeds with low mineral content). In this case, it would be appropriate to supplement animal diets with additional minerals in order to meet with animal mineral requirements.

Table 4. Potassium contents (%) of forage grasses cultivated under different soil conditions.

Years	Plants	Control	High Saline	High Alkali	High Saline-alkali	Average of Years
2011	*Cynodon dactylon*	0.40	0.31	0.25	X	**0.30 b**
	Chloris gayana	0.29	0.27	x	X	
	Agropyron elongatum	0.15	0.38	0.25	x	
	Festuca arundinacea	0.30	0.34	x	x	
2012	*Cynodon dactylon*	X	X	x	x	**0.44 a**
	Chloris gayana	X	X	x	x	
	Agropyron elongatum	0.40	0.51	0.42	0.31	
	Festuca arundinacea	0.50	0.52	x	x	
2013	*Cynodon dactylon*	X	X	x	x	**0.19 c**
	Chloris gayana	X	X	x	x	
	Agropyron elongatum	0.21	0.20	0.21	0.12	
	Festuca arundinacea	0.21	0.18	x	x	
	Average of location	**0.31 ab**	**0.34 a**	**0.27 bc**	**0.21 c**	
Average of plants	***Cynodon dactylon***	**0.32**				
	Chloris gayana	**0.28**				
	Agropyron elongatum	**0.28**				
	Festuca arundinacea	**0.35**				

*: Plants did not growth at applications shown with X.

**: Values showed with different letters are significantly different

Table 6. Calcium contents (%) of forage grasses cultivated under different soil conditions.

Years	Plant	Control	High Saline	High Alkali	High Saline-alkali	Average of Years
2011	*Cynodon dactylon*	0.13	0.27	0.31	x	**0.27 b**
	Chloris gayana	0.33	0.26	X	x	
	Agropyron elongatum	0.20	0.29	0.36	x	
	Festuca arundinacea	0.30	0.21	X	x	
2012	*Cynodon dactylon*	X	x	X	x	**0.54 a**
	Chloris gayana	X	x	X	x	
	Agropyron elongatum	0.52	0.49	0.55	0.44	
	Festuca arundinacea	0.83	0.45	X	x	
2013	*Cynodon dactylon*	X	x	X	x	**0.32 b**
	Chloris gayana	X	x	X	x	
	Agropyron elongatum	0.22	0.34	0.27	0.34	
	Festuca arundinacea	0.35	0.39	X	x	
	Average of location	**0.36**	**0.34**	**0.37**	**0.39**	
Average of plants	***Cynodon dactylon***	**0.24 c**				
	Chloris gayana	**0.29 bc**				
	Agropyron elongatum	**0.36 ab**				
	Festuca arundinacea	**0.42 a**				

*: Plants did not growth at applications shown with X.

**: Values showed with different letters are significantly different

Table 6. Magnesium contents (%) of forage grasses cultivated under different soil conditions.

Years	Plant	Control	High Saline	High Alkali	High Saline-alkali	Average of Years
2011	*Cynodon dactylon*	0.09	0.12	0.11	x	**0.11 c**
	Chloris gayana	0.14	0.12	x	x	
	Agropyron elongatum	0.08	0.11	0.14	x	
	Festuca arundinacea	0.13	0.08	x	x	
2012	*Cynodon dactylon*	X	X	x	x	**0.25 b**
	Chloris gayana	X	X	x	x	
	Agropyron elongatum	0.18	0.21	0.23	0.23	
	Festuca arundinacea	0.39	0.27	x	x	
2013	*Cynodon dactylon*	X	X	x	x	**0.33 a**
	Chloris gayana	X	X	x	x	
	Agropyron elongatum	0.15	0.24	0.18	0.37	
	Festuca arundinacea	0.46	0.55	x	x	
	Average of location	**0.20 b**	**0.21 b**	**0.16 c**	**0.30 a**	
Average of plants	***Cynodon dactylon***	**0.11 c**				
	Chloris gayana	**0.13 c**				
	Agropyron elongatum	**0.19 b**				
	Festuca arundinacea	**0.31 a**				

*: Plants did not growth at applications shown with X.
**: Values showed with different letters are significantly different

Table 7. Sodium contents (%) of forage grasses cultivated under different soil conditions.

Years	Plant	Control	High Saline	High Alkali	High Saline-alkali	Average of Years
2011	*Cynodon dactylon*	1.12	1.13	1.06	x	**1.08 a**
	Chloris gayana	1.15	1.11	x	x	
	Agropyron elongatum	0.73	1.11	1.15	x	
	Festuca arundinacea	1.05	1.14	x	x	
2012	*Cynodon dactylon*	X	X	x	x	**0.46 b**
	Chloris gayana	X	X	x	x	
	Agropyron elongatum	0.40	0.35	0.64	0.58	
	Festuca arundinacea	0.36	0.42	x	x	
2013	*Cynodon dactylon*	X	X	x	x	**0.048 c**
	Chloris gayana	X	X	x	x	
	Agropyron elongatum	0.033	0.045	0.07	0.06	
	Festuca arundinacea	0.036	0.041	x	x	
	Average of location	**0.61 c**	**0.67 b**	**0.73 a**	**0.32 d**	
Average of plants	***Cynodon dactylon***	**1.10 a**				
	Chloris gayana	**1.13 a**				
	Agropyron elongatum	**0.47 b**				
	Festuca arundinacea	**0.51 b**				

*: Plants did not growth at applications shown with X.
**: Values showed with different letters are significantly different

Conclusion: According to the findings of the study, salinity and alkalinity have significant effects on the mineral contents of the investigated plants. In general, cool season forage grasses had higher mineral contents than the warm season forage grasses. In terms of meeting the mineral requirements by animals, Ca^{2+} contents of the obtained fodder are found to be sufficient, while K^+ accumulations are found to be lower and P and Na^+contents were found to be higher than recommended levels. Therefore, it is recommended to meet K^+ requirements by animals through additional feeding and feeds should be given to animals with caution due to high sodium and phosphorus content.

Acknowledgements: This research is financed by TUBİTAK (The Scientific and Technological Research

Council of Turkey) with Project No. 110 O 259. We would like to thank the Council for their contribution to this research.

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