Turk J
Field Crops
2015, 20(2), 131-141
DOI: 10.17557/tjfc.82860

PERFORMANCE OF SOME FORAGE GRASS SPECIES IN HALOMORPHIC SOIL

*Suleyman TEMEL[1], Bilal KESKIN[*1], Ugur SIMSEK[2] , Ibrahim H. YILMAZ[1]*

[1] Igdir University, Faculty of Agriculture, Department of Agronomy, IGDIR
[2] Igdir University, Faculty of Agriculture, Department of Soil Science and Plant Nutrition, IGDIR
Corresponding author: bilalkeskin66@yahoo.com

Received: 09.04.2015

ABSTRACT

In this study, performance and yield and quality parameters according to standard soil conditions of four forage grass species (*Cynodon dactylon, Chloris gayana, Agropyron elongatum* and *Festuca arundinacea*) which have different tolerance levels for salinity and alkalinity were compared. In this respect, research was carried out in four locations (control, highly saline, highly alkali, highly saline-alkali) which have the same climatic conditions but different soil characteristics for three years between 2011 and 2013. The trial was set up according to a randomized complete block design split-split plot with 3 replications. The research was established in Saraçli and Aşagi Camurlu with an altitude of 820 m in East Igdir Plain. *Agropyron elongatum* demonstrated growth in all locations while *Cynodon dactylon* demonstrated growth in all locations except highly saline-alkali. On the other hand, *Festuca arundinacea* and *Chloris gayana* showed growth only in control and highly saline locations. According to the results of research, saline and alkali soils caused a decrease in dry matter yields, plant heights and leaf area index in *Agropyron elongatum* and *Festuca arundinacea* species. According to non-saline soil, salinity and alkalinity were resulted in an increase in crude protein ratio of *Agropyron elongatum* while it's were recorded in a decrease in crude protein ratio of *Cynodon dactylon, Chloris gayana* and *Festuca arundinacea*. On the other hand, while neutral detergent fiber of *Cynodon dactylon* increased, neutral detergent fiber of *Chloris gayana, Agropyron elongatum* and *Festuca arundinacea* in salinity and alkalinity soils.

Keywords: Salinity, alkalinity, salt tolerance, forage grass, yield.

INTRODUCTION

Salinity is a soil degradation process that significantly reduces plant diversity and agricultural yield, land productivity and value in arid and semi-arid climate regions. High ground water, wrong irrigation practices, low irrigation water quality and topographic of the land are particularly important among the factors that cause salinization of soils (Ergene, 1982;Bressler et al., 1982;Anonymous, 1999). These areas inhibit plant's sufficient intake of water and nutritional elements from the soil due to intense sodium percentage and/or soluble salt concentrations. On the other hand, limited agricultural lands on earth and incremental increase of food demand, more productive use of existing land areas becomes a necessity. Therefore improvement of saline soils and their economic use are extremely important (Woods 1996).

Improvement of degraded soil can be achieved either by using different chemicals, by using appropriate drainage systems or by growing salinity-alkalinity resistant plants (Yadav 1980; Chaturvediet al., 1987; Singh 1989; Garg 1998). First two methods are the most commonly used soil improvement methods in the World, however, due to high costs associated with these methods as well as to some difficulties, such as need of excessive fresh water for washing and drainage water that cannot be evacuated, success rate of these methods have remained very low and their effectiveness was limited to small areas (Siyalet al., 2002; Hanayet al., 2004).Moreover, applicability of these methods in large land areas is limited since chemical inputs and production costs. Because of these reasons, several studies had been conducted on bio-improvement of degraded soil, which is relatively easily applicable in large land areas and more economic that obtained important results. For example, it was reported that plants used for bio-improvement purposes increase organic matter content and permeability of soil via their strong root systems. Thus, these plants reduced salinity and alkalinity rates of soils through decreasing electrical conductivity, pH and sodium adsorption rate of soils (More and Malewar, 1988; Rauf el al., 1989; Patrick and Lauchii, 1990; Perfect et al., 1990; Helaliaet al., 1992; Haynes and Francis, 1993; Chang et al., 1994; Kushievet al., 2005)

Forage crops particularly prevent development of salinity through such superior characteristics as forming a mulch layer on surface of soil and blocking off upward movement of water by using the water within the lower layers of soil by means of their strong root systems (Koç and Tan, 1999). For example, species like *Agroppyron elongatum* and *Agropyron cristatum* can grow in soil with 7.5 dS/m electrical conductivity without any yield losses (Moseret al., 1996). Since production of many cultivars in such arid areas is restricted, salt-tolerant forage crops, in particular, should be introduced. Thus, there are intensified efforts on improving such land areas through salt-tolerant plants in recent years (Qadir and Oster, 2002; Akhter et al., 2004; Akil 2008). It is important to determine species which can have a chance in salt-affected lands. Because of these reasons, use of salt-tolerant plants offers a useful approach for increasing yield (Sandhu and Qureshi, 1986; Qureshi and Barrett-Lennard, 1998, Hameed and Ashraf 2008). Therefore, use of salt-tolerant plants seems essential in improving saline and alkali soils. In addition, animal husbandry is an important source of livelihood of rural people living in arid and semi-arid climate zones. Lack of forage grass in these areas where climatic and soil conditions are extreme is an important problem in supplying roughage needed by animals.

This study, therefore, was carried out to compare yield and nutritional characteristics and to determine performances of some forage grasses cultivated under halomorphic soil conditions.

MATERIALS AND METHODS

This study was conducted between 2011-2013 for 3 (three) years in four locations (control (ECe= 0.4 dS/m, ESP= 8.9%), highly saline (ECe= 9.8 dS/m, ESP= 11.9%), highly alkali (ECe= 0.89 dS/m, ESP= 60.5%) and highly saline-alkali (ECe= 9.08 dS/m, ESP = 49.7%). which have same climatic characteristics, but different soil characteristics.

Four grasses with different salt tolerance levels (*Chloris gayana* Kunth var. Katambora, *Cynodon dactylon* L. var. Sem-Caska, *Agropyron elongatum* L. local ecotype and *Festuca arundinacea* L. var. Asterix) were used as materials. Sowing was done on trial plots prepared in 3x4 m dimensions on 20-21 April 2011. The trial was set up according to a randomized complete block design split-split plot with 3 replications.

The research was established in Saracli [control ($39^{o}54^{'}56.34^{''}$ K, $44^{o}28^{'}26.25^{''}$ D), highly alkali ($39^{o}54^{l}00.09^{ll}$ K, $44^{o}29^{l}25.23^{ll}$ D) and highly saline-alkali ($39^{o}54^{l}20.16^{ll}$ K, $44^{o}29^{l}29.44^{ll}$ D)] and Aşagi Camurlu [highly saline ($39^{o}55^{l}31.45^{ll}$ K, $44^{o}27^{l}05.49^{ll}$ D)] with an altitude of 820 m in East Igdir Plain.

Soil characteristics of trial areas are given in Table 1. As it can be seen from Table 1, all locations have clayey-loam soil, except highly saline soil which has sandy-loam.

Table 1. Soil properties at four locations

	LOCATIONS			
Properties	**Non-saline**	**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 (Exchangeable Sodium Percentage) (%)	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

Total annual precipitation of the region as to long-term average is 264.04 mm while relative humidity of the region is51.19% and average temperature is 12.48 ºC. Throughout the research years of 2011, 2012 and 2013, total annual precipitation amounts were calculated as 340.0, 237.2 and 226.9, respectively. Lowest temperatures during winters of 2011, 2012 and 2013 were recorded as -9.0 ºC, -2.9 ºC and -4.0 ºC, respectively. In trial construction year (year 2011) average annual total precipitation amount and relative humidity were calculated to be relatively higher than those in 2012 and 2013 while annual average temperature was lower in 2011 when compared to 2012 and 2013. Moreover, long-term average annual precipitation, average temperature and relative humidity are higher when compared to three-year average climate data of trial years (Anonymous, 2011-2013).

Seeds were sown in seedbeds prepared in spring. Seedbeds were prepared by opening furrows with a marker with a row spacing of 30 cm and a seeding depth of 2.0 cm. Sowings were made by broadcasting to seeding depth. Sowing rates for plants were determined by considering cultivation under ideal conditions for each plant. In this respect, 30, 6, 20 and 15 kg of seeds per hectare were used for *Cynodon dactylon, Chloris gayana, Agropyron elongatum* and *Festuca arundinacea* species, respectively. 60 kg/ha N (ammonium sulfate) and 100 kg/ha P_2O_5 (250 kg/ha TSP) were applied to forage grasses in sowing time. Moreover, 60 kg/ha N was applied row spacing after the first harvest and irrigation. Irrigation periods for each plant were determined using a "Soil Water Potential Measurement Device", taking soil texture classes into account. Irrigation was started when usable moisture level dropped to 50%. 75 mm of water was given in every irrigation period by means of surface irrigation method which is widely and practically used in the region.

Cynodon dactylon was cut out in full bloom stage (Belesky and Wilkinson, 1983; Burton, 1983 Serin and Tan; 1998), while*Festuca arundinacea* was cut out in booting stage (Serin and Tan, 1998), *Agropyron* elongatum was cut out before blooming (Serin and Tan, 1998) and *Chloris* gayana was cut out at the beginning of emergence of panicles (Skerman and Riveros, 1990).

Plant Height (cm)

Heights of randomly selected 10 plants from each trial spot were measured 1-2 days before harvest and averages of these 10 measurements were taken.

Leaf Area Index

Plants at the 30-cm-parts of border rows were cut out from ground level in blooming stage and immediately delivered to the laboratory. However, since *Chloris gayana* and *Cynodon dactylon* have stolon growth habitus, main plants on the rows demonstrated an average 50 cm of dispersion to every direction from their own root areas. Thus, specimen for leaf area index measurement for these species were cut-out from only above-ground biomass of plants grown on a 30x30 cm area. Leaf blades were separated from their combined with leaf sheaths and leaf areas were measured with the help of a leaf area measurement device (CI-202 Portable Area Meter Model).Then, measured leaf areas were transformed to unit areas (Yunusa and Sedgley, 1992).

Dry Matter Yield (t/ha)

Grass from trial plots were harvested when plants reached the planned harvesting phase. Harvested fresh grass was weighed and 500 g sample were taken. Samples were put into paper bags and first dried in open air for 2-3 days and then for 48 hours in a drying oven set at 70 ^oC. Dry matter yields were calculated in metric tons ha^{-1} by comparing dried grass with fresh grass yield.

Crude Protein Ratio (%)

Nitrogen content of 0.3-0.5 g samples taken from dried and grinded plants in each cutting stages were determined according to Micro Kjeldahl method. Determined nitrogen ratios were multiplied with coefficient 6.25 to calculate crude protein ratios (Kacar 1972, Akyildiz 1984).Average Crude Protein Ratio was determined by dividing sum of all Crude Protein Ratios obtained after each harvest to the total number of harvests.

Neutral Detergent Fiber (NDF) Ratio (%)

Samples of 0.950-1.050 g (including Filter bag weight) were taken from dried and grinded plants and analyzed in an ANKOM fiber device. Samples were taken out and washed with acetone. After this samples were dried at 105^{o}C for 12 hours, cooled in a desiccator and then weighed. NDF ratios were determined by the method developed by Van Soest et al., (1991).

The data were exposed to GLM (General Linear Models) with SPSS (version 20) on the basis of main effects. Mean separation were performed using Duncan test.

RESULTS

Dry matter yields, plant heights, leaf area index, crude protein ratios and neutral detergent fiber ratios of *Cynodon dactylon, Chloris gayana, Agropyron elongatum* and *Festuca arundinacea* plants, cultivated in control, highly saline, highly alkali and highly saline-alkali soils, for years 2011, 2012 and 2013 were measured in the study (Tables2, 3, 4, 5 and 6).

Looking at Tables2, 3, 4, 5 and 6, yield was taken from *Cynodon dactylon* and *Chloris gayana* only in establishment year (2011) and no yield was taken in other years since these plants were negatively affected from winter conditions of the region. *Cynodon dactylon* showed no growth in highly saline-alkali soil and *Chloris gayana* showed no growth in highly alkali and highly saline-alkali soils in the sowing year. *Agropyron elongatum* showed insufficient growth in highly saline-alkali soil in 2011. However, since *Agropyron elongatum* showed growth in both highly saline and highly alkali soils, it was decided to re-cultivate this plant in highly saline-alkali soil in 2012 and yield was obtained in the last two years of research. Only *Agropyron elongatum* showed growth in all locations. *Festuca arundinacea* showed growth only in control and highly saline soil.

It can be seen from Table 2 that 4.66, 5.49 and 6.29 t/ha of dry matter yields were obtained in 2011, 2012 and 2013, respectively. Highest dry matter yield was obtained in 2013 (6.29 t/ha), while the lowest yield (4.66 t/ha) was taken in 2011, the cultivation year of plant. Dry matter yields were increased over the years. Dry matter yields for control, highly saline, highly alkali and highly saline-alkali soils were recorded as 6.10, 5.82, 4.03 and 2.92 t/ha, respectively. Salinity and alkalinity caused decreases in dry matter yield. However, in 2011 (establishment year), dry matter yields of *Cynodon dactylon*, *Chloris gayana* and *Agropyron elongatum* cultivated in highly saline soil was much higher than dry matter yields of those in control soil. The lowest dry matter yield was recorded in highly saline-alkali soil (2.92t/ha). When compared to control, dry matter yields were decreased by 4.75, 33.93 and52.13% in highly saline, highly alkali and highly saline-alkali soils, respectively. Dry matter yields for *Agropyron elongatum*, *Chrolis gayana* and *Festuca arundinacea* was recorded as 5.73, 5.36 and 5.27 t/ha, respectively and no significant differences between these plants were observed. The lowest dry matter yield was taken from *Cynodon dactylon* (3.95 t/ha).

Table 2. Dry Matter yields of some forage grasses grown on halomorphic soil ((MT) metric tons ha^{-1})

Years	Plants	Non-Saline	High Saline	High Alkali	High Saline-Alkali	Years x Plants Average	Average of Years
2011	*Cynodon dactylon*	5.01	6.43	0.43	X	3.95	**4.66 c****
	Chlorisgayana	4.87	5.86	X	X	5.36	
	Agropyron elongatum	4.57	6.41	3.14	X	4.71	
	Festuca arundinacea	5.70	4.15	X	X	4.93	
	Years x Loc. average	5.04	5.71	1.79	--		
2012	*Cynodon dactylon*	X	X	X	X	--	**5.49 b**
	Chlorisgayana	X	X	X	X	--	
	Agropyron elongatum	8.09	6.75	5.23	2.52	5.65	
	Festuca arundinacea	5.85	4.50	X	X	5.18	
	Years x Loc. average	6.97	5.62	5.23	2.52		
2013	*Cynodon dactylon*	X	X	X	X	--	**6.29 a**
	Chlorisgayana	X	X	X	X	--	
	Agropyron elongatum	8.44	7.29	7.32	3.31	6.59	
	Festuca arundinacea	6.27	5.13	X	X	5.70	
	Years x Loc. average	7.36	6.21	7.32	3.31		
	Average of Location	**6.10 a**	**5.82 a**	**4.03 b**	**2.92 c**		
	changecomparedtothenon-saline (%)	0.0	-4.75	-33.93	-52.13		**Average of plants**
Plants x Loc. aver.	***Cynodon dactylon***	5.01	6.43	0.43	--		**3.95 b**
	Chlorisgayana	4.87	5.86	--	--		**5.36 a**
	Agropyron elongatum	7.04	6.82	5.23	2.92		**5.73 a**
	Festuca arundinacea	5.94	4.59	--	--		**5.27 a**

*: Plants didn't grow at application shown with X.
**: Values indicated with different letters are significantly different at P<0,05

Effects of non-saline (control), highly saline, highly alkali and highly saline-alkali soil conditions on dry matter yields of *Chloris gayana, Festuca arundinacea, Cynodon dactylon* and *Agropyron elongatum* cultivated in 2011, 2012 and 2013 are shown in Table 2.

It can be seen from Table 2 that dry matter yields of *Cynodon dactylon*, *Chloris gayana* and *Agropyron elongatum* were relatively higher in highly saline soil in 2011. Only dry matter content of *Festuca arundinacea* was declined in highly saline soil in comparison with the control. Only *Cynodon dactylon* and *Agropyron elongatum* gave dry matter yield in highly alkali soil. *Agropyron elongatum* showed the highest growth and gave the highest dry matter yield.

Looking at Table 2, dry matter yields of *Agropyron elongatum* and *Festuca arundinacea* in saline and alkali soils were declined in 2012 and 2013. Dry matter yield was taken from *Agropyron elongatum* in all locations. Dry matter yield was taken from *Festuca arundinacea* in saline soils while it did not grow on alkali soils.

In Table 3, it can be seen that the highest plant height was observed in 2013 while the lowest plant height was observed in 2011. Plant heights were increased as the growth years increased. Plant heights were decreased as soil salinity and alkalinity increased. In comparison with the control, decreases in plant heights in saline and alkali soils were much lower when compared to the decreases in dry matter yields. When compared to control, plant heights were decreased by 6.78, 15.13 and 2.40% in highly saline, highly alkali and highly saline-alkali soils, respectively. Highest plant height was observed in *Chloris gayana*, followed by *Agropyron elongatum, Festuca arundinacea* and *Cynodon dactylon*, respectively.

Looking at Table 4, highest leaf area index was observed in 2013 (1.831) and the lowest leaf area index was observed in 2011 (1.608). Leaf area index were increased over the years. Leaf area index was affected by salinity and alkalinity. Highest leaf area index was observed in the control soil while the lowest was observed in highly saline-alkali soil. When compared to control, leaf area index were decreased by 16.07, 65.36 and 67.67% in highly saline, highly alkali and highly saline-alkali soils, respectively. The highest leaf area index was observed in *Chloris gayana* followed by *Festuca arundinacea*, *Agropyron elongatum* and *Cynodon dactylon*, respectively.

Table 3. Plant height of some forage grasses grown on halomorphic soil (cm)

Years	Plants	Non-saline	High saline	High alkali	High saline-alkali	Years x Plants average	Average of years
	Cynodon dactylon	37.76	37.93	25.30	X	33.66	**63.00 c****
	Chloris gayana	100.53	102.25	X	X	102.39	
	Agropyron elongatum	80.23	78.20	69.00	X	75.81	
2011	*Festuca arundinacea*	54.56	44.23	X	X	49.40	
	Years x Loc. average	68.27	65.65	47.15	--		
	Cynodon dactylon	X	X	X	X	--	**77.20 b**
	Chloris gayana	X	X	X	X	--	
	Agropyron elongatum	106.13	96.65	76.88	73.26	88.23	
2012	*Festuca arundinacea*	56.88	53.41	X	X	55.15	
	Years x Loc. average	81.50	75.03	76.88	73.26		
	Cynodon dactylon	X	X	X	X	--	**84.40 a**
	Chloris gayana	X	X	X	X	--	
	Agropyron elongatum	121.63	109.66	89.85	76.82	99.49	
2013	*Festuca arundinacea*	57.43	51.03	X	X	54.23	
	Years x Loc. average	89.53	80.35	89.85	76.82		
	Average of location	**76.89 a**	**71.67 b**	**65.25 c**	**75.04 a**		
	Change compared to the non-saline (%)	0.0	-6.78	-15.13	-2.40		**Average of plants**
	Cynodon dactylon	37.76	37.93	25.30	--		**33.66 d**
Plants x	***Chloris gayana***	100.53	102.25	--	--		**101.39 a**
Loc.	***Agropyron elongatum***	102.66	94.83	78.57	75.04		**88.94 b**
aver.	***Festuca arundinacea***	56.29	49.56	--	--		**52.92 c**

*: Plants didn't grow at application shown with X.
**: Values indicated with different letters are significantly different at $P<0.05$.

Table 4. Leaf area index of some forage grasses grown on halomorphic soil (cm)

Years	Plants	Non-saline	High saline	High alkali	High saline-alkali	Years x Plants average	Average of years
	Cynodon dactylon	1.195	0.586	0.432	X	0.737	**1.608 b****
	Chloris gayana	4.041	2.989	X	X	3.515	
	Agropyron elongatum	1.352	1.416	0.700	X	1.156	
2011	*Festuca arundinacea*	1.769	1.608	X	X	1.689	
	Years x Loc. average	2.089	1.650	0.566	--		
	Cynodon dactylon	X	X	X	X	--	**1.790 a**
	Chloris gayana	X	X	X	X	--	
	Agropyron elongatum	2.450	2.073	0.777	0.677	1.494	
2012	*Festuca arundinacea*	2.553	2.210	X	X	2.382	
	Years x Loc. average	2.502	2.142	0.777	0.677		
	Cynodon dactylon	X	X	X	X	--	**1.831 a**
	Chloris gayana	X	X	X	X	--	
	Agropyron elongatum	2.170	2.037	1.220	0.783	1.553	
2013	*Festuca arundinacea*	2.533	2.247	X	X	2.390	
	Years x Loc. average	2.352	2.142	1.220	0.783		
	Average of location	**2.258 a**	**1.895 b**	**0.782 c**	**0.730 c**		
	Change compared to the non-saline (%)	**0.0**	**-16.07**	**-65.36**	**-67.67**		**Average of plants**
	Cynodon dactylon	1.195	0.586	0.432	--		**0.737 d**
Plants x	***Chloris gayana***	4.041	2.989	--	--		**3.515 a**
Loc.	***Agropyron elongatum***	1.991	1.842	0.899	0.730		**1.423 c**
aver.	***Festuca arundinacea***	2.285	2.022	--	--		**2.153 b**

*: Plants didn't grow at application shown with X.
**: Values indicated with different letters are significantly different at $P<0,05$.

Effects of non-saline (control), highly saline, highly alkali and highly saline-alkali soils on leaf area index of forage grasses are shown in Table 4.

Table 4 shows that leaf area index of *Cynodon dactylon* was declined in highly saline and highly alkali soils in 2011. Alkali soils had the highest effect on leaf area index of *Cynodon dactylon*. In comparison with control, leaf area index of *Agropyron elongatum* showed a slight increase in highly saline soil while it was relatively lower for *Chloris gayana* and *Festuca arundinacea* in saline soils.

In table 4 (year 2012) and C (year 2013), it can be seen that salinity and alkalinity decreased leaf area index of *Agropyron elongatum*. *Festuca arundinacea* did not perform well in alkali soils; it only grew in saline soils. When compared to control, saline soils decreased leaf area index of *Festuca arundinacea*.

As it can be seen from Table 5, crude protein ratios (9.04, 9.73 and 8.24%) were obtained in 2011, 2012 and 2013, respectively. The highest crude protein ratio was obtained in 2012 while the lowest was obtained in 2013. Crude protein ratios (9.66, 8.91, 8.17 and 8.44%) were obtained in non-saline (control), highly saline, highly alkali and highly saline-alkali soils, respectively. Salinity and alkalinity caused a decrease in crude protein ratios. Crude protein ratios for *Cynodon dactylon, Chloris gayana*, *Agropyron elongatum* and *Festuca arundinacea* were obtained as 7.04, 8.86, 8.34 and 11.27%, respectively. *Festuca arundinacea* had the highest crude protein ratio among investigated plants while *Cynodon dactylon* had the lowest.

Table 5. Crude protein of some forage grasses grown on halomorphic soil (%)

Years	Plants	Non-saline	High saline	High alkali	High saline-alkali	Years x Plants average	Average of years
	Cynodon dactylon	7.97	7.08	6.08	X	7.04	**9.04 b****
	Chloris gayana	9.55	8.18	X	X	8.86	
	Agropyron elongatum	8.42	9.27	10.47	X	9.39	
2011	*Festuca arundinacea*	11.69	11.69	X	X	11.69	
	Years x Loc. average	9.41	9.05	8.27	--		
	Cynodon dactylon	X	X	X	X	--	**9.73 a**
	Chloris gayana	X	X	X	X	--	
	Agropyron elongatum	8.03	8.77	8.47	9.04	8.58	
2012	*Festuca arundinacea*	12.84	11.22	X	X	12.03	
	Years x Loc. average	10.43	10.00	8.47	9.04		
	Cynodon dactylon	X	X	X	X	--	**8.24 c**
	Chloris gayana	X	X	X	X	--	
	Agropyron elongatum	7.76	5.96	7.68	7.84	7.31	
2013	*Festuca arundinacea*	11.05	9.15	X	X	10.10	
	Years x Loc. average	9.40	7.55	7.68	7.84		
	Average of location	**9.66 a**	**8.91 b**	**8.17 c**	**8.44 c**		
	Change compared to the non-saline (%)	0.0	-7.76	-15.42	-12.62		**Average of plants**
	Cynodon dactylon	7.97	7.08	6.08	--		**7.04 d**
Plants x	***Chloris gayana***	9.55	8.18	--	--		**8.86 b**
Loc.	***Agropyron elongatum***	8.07	8.00	8.87	8.44		**8.34 c**
aver.	***Festuca arundinacea***	11.86	10.68	--	--		**11.27 a**

*: Plants didn't grow at application shown with X.
**: Values indicated with different letters are significantly different at P<0,05.

Effects of non-saline (control), highly saline, highly alkali and highly saline-alkali soils on crude protein ratios of *Chloris gayana, Festuca arundinacea, Cynodon dactylon* and *Agropyron elongatum* cultivated in 2011, 2012 and 2013 shown in Table 5.

It can be seen from Table 5that a higher crude protein ratio for *Cynodon dactylon* was obtained in control soil in 2011 while crude protein ratios were relatively lower in highly saline and highly alkali soils. The lowest crude protein ratio for *Cynodon dactylon* was obtained in highly alkali soil. According to non-saline, crude protein ratio of *Chloris gayana* declined in highly saline soils. Also, crude protein of *Festuca arundinacea* was similar in non-saline and highly saline. In contrast (other three plants), salinity and alkalinity were caused an increase of crude protein ratios of *Agropyron elongatum*.

Looking at Table 5, slight increases were observed in crude protein ratios of *Agropyron elongatum* cultivated in alkali and saline soils in 2012 and 2013 when compared to control soil, while there was a slight decrease in crude protein ratios of *Festuca arundinacea* cultivated in highly saline soils.

It can be seen from Table 6 that NDF ratios (64.24, 64.68 and 64.13%) were obtained in 2011, 2012 and 2013, respectively. Effect of years on NDF ratio was found to be insignificant. NDF ratios (65.20, 62.43, 65.05 and 67.05%) were obtained in control, highly saline, highly alkali and highly saline- alkali soils, respectively. When compared to control, NDF ratios were declined in highly saline soils, while it remained same in highly alkali soil and increased in highly saline-alkali soil. NDF ratios for *Cynodon dactylon*, *Chloris gayana*, *Agropyron elongatum* and *Festuca arundinacea* were found as 69.79, 71.44, 65.54 and 57.01%, respectively. The highest NDF ratio was obtained from *Chloris gayana* while the lowest was obtained from *Festuca arundinacea*.

Table 6. Neutral detergent fiber (NDF) of some forage grasses grown on halomorphic soil (%)

Years	Plants	Non-saline	High saline	High alkali	High saline-alkali	Years x Plants average	Average of years
2011	*Cynodon dactylon*	67.26	68.27	73.85	X	69.79	**64.24****
	Chloris gayana	72.98	69.89	X	X	71.44	
	Agropyron elongatum	63.61	61.25	58.36	X	61.07	
	Festuca arundinacea	55.64	51.35	X	X	53.50	
	Years x Loc. average	64.87	62.69	66.10	--		
2012	*Cynodon dactylon*	X	X	X	X	--	**64.68**
	Chloris gayana	X	X	X	X	--	
	Agropyron elongatum	70.76	67.85	65.76	66.72	67.77	
	Festuca arundinacea	60.35	56.66	X	X	58.50	
	Years x Loc. average	65.55	62.25	65.76	66.72		
2013	*Cynodon dactylon*	X	X	X	X	--	**64.13**
	Chloris gayana	X	X	X	X	--	
	Agropyron elongatum	71.06	66.02	62.23	67.38	66.67	
	Festuca arundinacea	59.92	58.15	X	X	59.03	
	Years x Loc.average	65.49	62.08	62.23	67.38		
	Average of location	**65.20 b**	**62.43 c**	**65.05 b**	**67.05 a**		
	Change compared to the non-saline (%)	0.0	-4.24	-0.23	+2.83		**Average of plants**
Plants x Loc.aver.	***Cynodon dactylon***	67.26	68.27	73.85	--		**69.79 b**
	Chloris gayana	72.98	69.89	--	--		**71.44 a**
	Agropyron elongatum	68.47	65.04	62.12	67.05		**65.54 c**
	Festuca arundinacea	58.63	55.38	--	--		**57.01 d**

*: Plants didn’t grow at application shown with X.
**: Values indicated with different letters are significantly different at P<0,05.

Effects of non-saline, highly saline, highly alkali and highly saline-alkali soils on NDF ratios of *Chloris gayana, Festuca arundinacea, Cynodon dactylon* and *Agropyron elongatum* cultivated in 2011, 2012 and 2013 shown in Table 6.

When Table 6 is analyzed, it can be seen that salinity and alkalinity resulted in a decrease in NDF ratios of plants in 2011, 2012 and 2013 in comparison with non-saline. Salinity and alkalinity were resulted in an increase in NDF ratios for *Cynodon dactylon* only in 2011.

According to the years, effect of locations (years x locations average) on dry matter yields, plant heights, leaf area index, crude protein ratios and neutral detergent fiber ratios are shown in table 2, 3, 4, 5 and 6.

According to non-saline soil in all years, salinity and alkalinity (years x locations average) were caused a decrease of dry matter yields (except high saline in 2011 year and high alkali in 2013 year), plant heights (except high alkali in 2013 year), leaf area index and crude protein ratios. On the other hand, while salinity was resulted in a decrease in neutral detergent fiber ratios, alkalinity was caused an increase in neutral detergent fiber.

DISCUSSION

Cynodon dactylon and *Chloris gayana* were shown a significant growth in saline and non-saline in 2011. However, since these two grasses are warm climate grasses (C4 plants), they were not kept up with low winter temperatures of the region. These plants could not continue their growth in the second year and thus, dried and exited from the environment. Moore et al. (2006) and Tansi (2009) have similarly reported that *Chloris gayana* demonstrated maximum growth at 30 ºC, significant declines in the growth of *Chloris gayana* under 18 ºC, and that the plant stopped to grow completely at 8 ºC and ceased at -8 ºC. In another study, it is reported that *Cynodon dactylon* can keep up with minimum temperatures of -2 and -3 ºC and cannot live under temperatures lower than those (Burton and Hanna, 1995). However, it is known that, although *Cynodon dactylon* is a warm climate forage grass, it can also be found in cold climate ecologies (Avcioglu and Soya, 2009). Likewise, natural *Cynodon dactylon* species were also observed within the ecology in which the trial was conducted. On the other hand, *Cynodon dactylon* used in this study could not keep up with low winter temperatures of the region and dried. This may be a result of the difference of *Cynodon dactylon* type used in the study. *Cynodon dactylon* has many types belonging to same genus and species which differ in cold- and drought-resistance (Avcioglu and Soya, 2009).

Dry matter yields of *Cynodon dactylon* and *Chloris gayana* in saline soils was higher than those in control soil. In another study, dry matter yields for *Cynodon dactylon* cultivated in non-saline and saline soils have been found as 12.9 and 13.8 t/ha), respectively, while dry matter yields for *Chloris gayana* have been found as 16.3 and 13.5 t/ha in non-saline and saline soils, respectively (Gonzales and Heilman, 1977). It has also been reported that NaCl applied to *Cynodon dactylon* in increasing amounts resulted in a slight effect in dry matter yield (Hameed and Ashraf, 2008). These results showed in parallel with the results of our study. It was observed in our study that high amounts of dry matter yields can be obtained in these plants cultivated in saline soils without having any setbacks in growth. On the other hand, although *Cynodon dactylon* demonstrated growth to a certain extent in highly alkali soil as well, levels of obtained dry matter yield were very low. It has been observed that high amounts of dry matter yield of *Cynodon dactylon* and *Chloris gayana* can be produced (6.43 and 5.86 t/ha, respectively) for animals, in regions where spring and summer temperatures are sufficient, if these plants are cultivated annually. It has also been determined that *Chloris gayana* is the most salt-tolerant plant among 8 perennial forage grasses in an environment established by EC_S between 1.4 and 38 dS m^{-1} (Deifel et al., 2006).

Cynodon dactylon's plant height was affected by highly saline soils, but not affected by alkali soils.Leaf area index of *Cynodon dactylon* was declined in both saline and alkali soils. Plant height of *Chloris gayana* was not affected by saline soils; however, saline soils caused a significant decrease in leaf area indices for this plant.

Leaf area index of *Festuca arundinacea* and *Agropyron elongatum* were decreased as salinity of soil increased. Decreases in leaf area index also resulted in a decrease of dry matter yields of *Agropyron elongatum* and *Festuca arundinacea*. Several other researchers have also reported that a decrease in leaf area index leads to a decrease in the yield (Taleisnik et al., 2009; Hay and Porter, 2006; de Luca et al., 2001).

Dry matter yield, plant height and leaf area index of *Agropyron elongatum* were decreased as salinity and alkalinity of soils increased. Despite this decrease, significant dry matter yields were obtained in saline and alkali soils. It has been determined in another study that no significant decreases (only 15%) observed in the yield of *Agropyron elongatum* cultivated in highly saline soil (Suyama et al., 2007).Ozaslan Parlak et al. (2006) reported that increasing salt concentration decreased plant height.

In the present study, saline soils caused a decrease in dry matter yield, plant height and leaf area index of *Festuca arundinacea*.

In saline soils, plant spends more energy for taking water, therefore water intake from the soil decreases. This situation negatively affects yield and quality of the plant. Hence, it has also been determined in several other studies that grass yield in saline soils is declined (Greenway and Roger, 1963; Guggenheim and Waisel, 1977; Yurtseven and Bozkurt, 1997; Yurtseven 2000; Yurtseven et al., 2001; Robinson et al., 2004; Ozaslan Parlak et al., 2006; Masters et al., 2007; Qadir et al. 2008;Kopittke et al., 2009;Hussain et al. 2009; Kandil et al. 2012; Khosh Kholgh Sima et al., 2013).

Crude Protein (CP) and Neutral detergent fiber(NDF)contents were also investigated in the research. CP ratios demonstrated differences over the years while no differences were seen in NDF ratios as to years. The highest CP ratios were recorded in the second year of the study (2012) while the lowest CP ratios were recorded in the last year of the study.

According to the results of the study, the highest NDF ratios over three years were recorded under control soil conditions. Decreases in NDF contents were observed as degradation level of soil structure increased. The reason for this was determined as plants' not showing as sufficient growth under stress conditions caused by salinity and alkalinity as under normal conditions. Several other studies on the subject have also reported that forage quality changes depending on soil characteristics (Arzani et al., 2001; Panahi et al., 2012).

CP and NDF contents varied significantly depending on the species. The highest CP ratio was obtained in *Festuca arundinacea* while the highest NDF ratio was obtained in *Chloris gayana*. As shown by different studies, qualities characteristics of plants may differ among species and even among varieties belonging to the same species (Anonymous, 2001; Mlay et al., 2006; Tavirimirwa et al., 2012). This may be explained by genetic differences by which each plant demonstrates different characteristics in taking nutritional elements from soil and collecting these elements. This is an expected result. Because there are a number of factors, such as plant characteristics, environmental factors and cultural applications, that affects nutritional value of forage crops. Species and variety characteristics have an important effect on plant qualities (Arzani et al., 2001; Schut et al., 2010; Panahi et al., 2012). For example, in a study carried out by Mohajer et al. (2013), which has been conducted to determine plant quality content of plants belonging to different and same species, all quality parameters among species and varieties are found to be significant. In other research, Vendramini et al. (2010) have shown in a study conducted to determine yields and quality values of 9 warm-season forage grasses that qualitative and yield differences exist among species, and even among varieties belonging to the same species.

Difference among chemical compositions was found to be significant as well between cool season and warm season forage grass. In this study, the highest CP ratio (11.27%) and the lowest NDF ratio (57.01%) were seen in *Festuca arundinacea*, which is a cool season forage grass. On the other hand, the lowest CP ratio (7.04%) among warm season forage grasses was recorded in *Cynodon dactylon*while the highest NDF ratio (71.44%) was detected in *Chloris gayana*. These differences may be stemming from differences in species, genetics, climatic and cultivation conditions. In a study carried out by Tavirimirwa et al. (2012) for determining nutritional values of different forage grasses, it has been reported that CP contents of species differ and these differences may essentially be resulting from genotype effect and environmental conditions. Moreover, warm season forage grass utilizes sunlight more efficiently and their leaves accumulated high amounts of lignin. Mlay et al. (2006),found in a study conducted to determine nutritional contents of tropical forage species that CP and NDF contents of *Cynodon dactylon* in full maturation stage were8.9% and67.5%,CP and NDF contents of *Chloris gayana* were 5.5% and 78.4% in maturation stage, respectively. Mlay et al. (2006) also showed that nutritional differences among plants are resulting from differences in species, climatic and growth conditions. In this study, warm season forage grasses have higher NDF contents and lower CP contents than cool season forage grass due to reasons listed above.

Furthermore, photosynthetic way followed by plants may result in differences in forage quality characteristics among species. In the present study, forage qualities of *Chloris* gayanaand *Cynodon dactylon*, which are C4 plants, were found to be lower than those of *Agropyron elongatum* and *Festuca arundinacea*, which are C3 plants. Our results were in agreement with the results of another study conducted by Vona et al. (1984) who have concluded that C4 forage grass have more NDF ratios in comparison with C3 forage grass. Warm season forage grass, which generally called as C4, hasthicker cell wall parenchyma and lower proportions of thin cell wall mesophyll tissue than C3 grass (Wilson, 1993). These anatomic characteristics result in lower CP and soluble carbohydrates in C4 compared to C3; however, they also cause C4 to have more proportions of cell wall compounds such as cellulose and hemicelluloses.

In addition, quality differences may occur between species following the same photosynthetic way, as between *Chloris gayana* and *Cynodon dactylon* that follow C4 path, and between *Agropyron elongatum* and *Festuca arundinacea* that follow C3 path, which were investigated in the present study. It was found in the study that *Festuca arundinacea* have an average CP content of 11.27% in different soil types over three years. However, average CP content for *Agropyron* elongatum was determined as 8.34%. Differences in nutritional values of plants following the same photosynthetic path may be stemming from differences in anatomic and morphologic structures of the plants. In another study, Flores et al. (1993) compared anatomies of leaf tips of two species and reported that leaf tips of one of these species have thicker epidermis and lesser sclerenchyma ratios. In addition,Flores et al. (1993) also determined that *Agropyron elongatum*, which is a cool season forage grass, has strong leaf and stem structure and that this plant have been rapidly coarsening with ripening, therefore, quality characteristics for this plant may be much lower.

CONCLUSIONS

According to the results of the study, since *Agropyron elongatum* showed growth in both saline and alkali soils, it was important for expansion of agriculture, soil improvement and provision of needed forage in land areas which demonstrate saline and alkali soil characteristics. It was determined that if varieties of *Chloris gayana* and *Cynodon* dactylonthat could be adapted to the regionweredetermined, these two plants could be used as perennial plants, otherwise they can be used annually for improvement of salt-affected soils. Years variable affected dry matter yield, plant height and leaf area index, but it did not affect neutral detergent fiber. The highest dry matter yield, plant height and leaf area index of plants obtained in year 2013. On the other hand, the highest crude protein was obtained in year 2012 while the lowest was observed in year 2013.According to non-saline soil, salinity and alkalinity caused a decrease in dry matter yields, plant heights, leaf area index and crude protein ratios. Although salinity was resulted in a decrease in neutral detergent fiber ratios, alkalinity was caused an increase in neutral detergent fiber.

ACKNOWLEDGEMENTS

This study is financed by TUBİTAK, The Scientific and Technological Research Council of Turkey with Project No. 110O 259. We would like to thank the Council for their contribution to this study.

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