Asian Journal of Chemistry Vol. 21, No. 7 (2009), 5517-5522

Effects of Different Soil Textures on The Yield and Chemical Composition of Alfalfa (*Medicago sativa* L.) Cultivars Under Mediterranean Climate Conditions

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The effects of two soil textures (heavy and light) and five cultivars (Alpha, Barlydia, Verdor, Pioneer-5683, Elci) on the yield and chemical compositions of alfalfa were evaluated under Mediterranean climatic conditions in Izmir, Turkey in 2005 and 2006. The experimental design was a randomized complete blocks design with four replications. Results indicated that, effect of soil texture and cultivar interactions on fresh biomass yields and dry matter and crude cellulose content were found to be significant. Verdor and P-5683 cultivar. had better performances than other cultivars with regard to fresh biomass yield, contents of dry matter, crude protein and crude ash. The alfalfa yields on light soil texture were significantly higher than heavy textured soil.

Key Words: Alfalfa, Soil texture, Cultivars, Fresh biomass yield, Chemical composition.

INTRODUCTION

Alfalfa is a very important forage crop throughout the world. It has superior forage qualities and high yields that can be consumed by livestock readily. It has high protein content and it is also rich in minerals and vitamins[1]. Alfalfa leaves serve as a factory for raw, biodegradable plastic beads, other industrial products or better livestock feed, while the stem goes to ethanol production last decade in the world[2]. Despite all these advantages, the alfalfa planting area in Turkey is limited and far from to meet the need for quality roughage[3]. Alfalfa is grown only on 450,000 ha land area with a production of 3 million tons of hay in Turkey[4]. Asia minor, Iran and Turkmenistan are known as the gene centres for alfalfa which can be grown successfully in all regions of Turkey[5]. Alfalfa production tends to increase in all areas from the Aegean, Mediterranean and Black sea coasts to the high plateaus of eastern Turkey[6]. In the coastal regions, non-dormant alfalfa cultivars suitable for warm, humid climates are common[2,3,5-11]. However, in the cool and high plateaus of eastern Turkey dormant and cold tolerant cultivars can be grown successfully[12]. Therefore, to increase alfalfa planting areas in the country, it is important to introduce new alfalfa varieties suitable for different ecological regions. The aim of this study was to evaluate the biomass yield and chemical composition of alfalfa cultivars on different soil textures under Mediterranean climatic condition of Aegean region.

EXPERIMENTAL

The studies were carried out in Bornova experimental field (38°27.236 N, 27°13.576 E, 28 m a s.l.) of Faculty of Agriculture, Department of Field Crops and experimental field of Odemis (38º13.234 N, 27º57.880 E, 115 m a.s.l) Vocational Training School of Ege University, during 2 years in 2005 and 2006. Meteorological data and soil properties of locations are presented in Tables 1 and 2, respectively. As can be seen in Table-2, heavy soil texture is represented by Bornova whereas light soil by Odemis location.

TABLE-1
MONTHLY PRECIPITATION AND AVERAGE TEMPERATURES RECORDED AT BORNOVA AND ODEMIS LOCATIONS DURING THE 2005 AND 2006 GROWING SEASONS

	Temperature (ºC)						Precipitation (mm)					
	Bornova			Odemis			Bornova			Odemis		
	2005	2006	LY	2005	2006	LY	2005	2006	LY	2005	2006	LY
Jan.	9.4	6.9	8.1	8.8	5.6	7.1	111.4	77.5	109.7	53.0	73.2	103.7
Feb	7.8	9.6	8.6	7.7	8.2	8.1	191.8	93.4	89.8	116.0	114.8	86.3
Mar.	11.6	12.1	10.8	11.1	11.0	10.5	71.5	180.9	72.3	95.0	89.8	70.5
April	15.9	17.4	15.0	15.0	16.2	14.7	13.8	29.4	48.9	23.5	14.1	50.9
May	21.1	21.1	20.2	20.6	20.5	19.9	71.7	0.2	32.2	22.0	21.4	33.2
June	24.9	25.7	25.0	25.0	25.4	24.7	40.0	10.0	8.2	10.2	6.2	14.9
July	29.1	28.1	27.6	28.8	27.9	27.5	0.3	-	3.6	5.0	22.0	6.0
Aug	28.5	29.2	27.0	27.8	28.4	26.8	0.5	-	2.1	1.5	-	2.9
Sept.	23.5	23.8	22.2	22.5	22.8	22.5	5.5	167.2	17.0	5.8	66.9	16.2
Oct.	17.1	19.2	18.0	15.8	17.9	16.8	9.2	114.5	46.8	24.0	77.0	36.2
Nov.	12.3	12.4	13.2	11.0	12.5	12.0	129.8	63.1	80.3	160.0	55.8	76.6
Dec.	11.1	9.7	9.9	10.4	10.6	8.8	54.3	9.1	122.3	31.0	12.7	126.4

LY = Long year average.

TABLE-2
SOIL CHARACTERISTICS OF LOCATIONS (0-20 cm depth)

Characteristic	Bornova	Odemis	Characteristic	Bornova	Odemis
Sand (%)	24.720	68.72	OM (%)	1.13	1.58
Silt (%)	42.720	24.00	$CaCO_3$ (%)	21.52	1.44
Clay (%)	32.560	7.28	N (%)	0.11	0.16
pH	7.800	6.40	P (ppm)	40.52	20.50
Salt (%)	0.095	0.03	K (ppm)	400.00	110.00

OM = Organic matter.

In this study, five alfalfa cultivars (Alpha, Barlydia, Verdor, Pioneer-5683, Elci) were used as research material. The experimental design was a randomized complete block with four replications. Each plot consisted of 8 rows with 20 cm apart and 5 m length. Seeding rate was 20 kg ha^{-1} for all cultivars[1]. Seeds were sown by hand on 25th April, 2005 in Bornova, 26th April, 2005 in Odemis. 25 kg ha^{-1} N fertilizer as starting rate and 80 kg ha^{-1} P and 80 kg ha^{-1} K were applied before sowing process. All plots were irrigated through the growing season using 80 mm water for each application. Weeds were removed by hoeing as needed. The plots were cut at the 10-25 % flowering stage with 5 cm stubble height[13] at 4.8 m^{-2} net areas during the season. There were 5 cuts in 2005 and 8 cuts in 2006 shown at Table-3. Plant heights were measured before the harvests. Fresh biomass yield was determined and samples were dried in oven at 105 ºC to a constant weight for dry matter content[8]. Dried samples were ground and the amount of N was determined using the Kjehldal method. The amount of N from each sample was multiplied by 6.25 and crude protein content was calculated. Crude ash was determined at 550 ºC. Total yield values and average plant height of each year were statistically analyzed using analysis of variance (ANOVA) with the statistical analysis system[10]. Probabilities equal to or less than 0.05 were considered significant. If ANOVA indicated differences between treatment means a LSD test was performed to separate them.

TABLE-3
CUTTING DATES OF ALFALFA AT DIFFERENT LOCATIONS

Cutting No.	Bornova		Odemis	
	1st year	2nd year	1st year	2nd year
1st	13 Jun. 2005	6 Mar. 2006	29 Jun. 2005	3 Mar. 2006
2nd	13 Jul. 2005	14 Apr. 2006	28 Jul. 2005	10 Apr. 2006
3rd	9 Aug. 2005	22 May 2006	24. Aug. 2005	18 May 2006
4th	19 Sep. 2005	20 Jun. 2006	30. Sep. 2005	20 Jun. 2006
5th	7 Nov. 2005	17 Jul. 2006	7 Nov. 2005	13 Jul. 2006
6th	-	9 Aug. 2006	-	9 Aug. 2006
7th	-	25. Sep. 2006	-	27 Sep. 2006
8th	-	2 Nov. 2006	-	6 Nov. 2006

RESULTS AND DISCUSSION

The results are summarized in Table-4 and were discussed based on 2 year averages.

Plant height: Soil texture x cultivar interaction was not significant in 2006 but in 2005. Average plant height of P-5683 on light texture soil (79.9 cm) was highest in 2005 whereas Verdor cultivar on heavy soil (90.2 cm) was highest in 2006. However, the interaction in two year averages was not found to be significant indicating that the cultivars did no responded differentially to the soil types. The average plant height of Verdor cultivar (84.1 cm) and P-5683 cultivar (83.6 cm) were higher than other cultivars in two year average. Elci cultivar (76.2 cm) was found to be the shortest one. Average plant heights were higher in 2006 than 2005. It can be concluded that cultivars being perennial legumes, performed better in the second year. These results were in agreement with those of researchers[2,3,5,6,8] who claimed the effects of legume age on the agronomical properties.

TABLE-4
YIELD AND CHEMICAL COMPOSITION OF ALFALFA CULTIVARS
GROWN ON DIFFERENT SOIL TEXTURED

Cultivars (C)	2005			2006			2005-2006		
	Soil texture (ST)			Soil texture (ST)			Soil texture (ST)		
	Heavy	Light	Mean	Heavy	Light	Mean	Heavy	Light	Mean
				Plant height (cm)					
Alpha	74.6	73.8	74.2	80.7	82.6	81.6	77.7	78.2	77.9
Barlydia	77.0	74.6	75.8	82.6	83.6	83.1	79.8	79.1	79.5
Verdor	78.5	78.9	78.7	90.2	88.6	89.4	84.4	83.8	84.1
P-5683	77.9	79.9	78.9	88.3	88.2	88.2	83.1	84.0	83.6
Elçi	74.2	75.0	74.6	76.9	78.7	77.8	75.6	76.9	76.2
Mean	**76.5**	**76.4**	**76.4**	**83.7**	**84.3**	**84.0**	**80.1**	**80.4**	**80.2**
LSD (0.05)	ST: ns C: 1.4 ST × C: 2.0 CV: 1.82 %			ST: ns C: 1.5 ST × C: ns CV: 1.69 %			ST: ns C: 1.1 ST × C: ns CV: 1.27 %		
				Fresh biomass yield (kg ha^{-1})					
Alpha	82100	86710	84400	114510	142430	128470	98300	114570	106440
Barlydia	85160	89150	87150	117440	135390	126410	101300	112270	106780
Verdor	93290	95100	94190	128970	148240	138610	111130	121670	116400
P-5683	94200	94480	94340	129200	142010	135610	111700	118240	114970
Elçi	82660	87960	85310	107220	119490	113350	94940	103730	99330
Mean	**87480**	**90680**	**89080**	**119470**	**137510**	**128490**	**103470**	**114090**	**108780**
LSD (0.05)	ST: 1290 C: 2040 ST × C: ns CV: 2.23 %			ST: 1290 C: 2030 ST × C: 2880 CV: 1.54 %			ST: 1050 C: 1660 ST × C: 2350 CV: 1.49 %		
				Dry matter content (%)					
Alpha	23.0	23.9	23.5	23.2	24.5	23.8	23.1	24.2	23.6
Barlydia	22.5	24.4	23.4	23.2	25.4	24.3	22.8	24.9	23.9
Verdor	23.0	24.6	23.8	23.6	24.9	24.3	23.3	24.7	24.0
P-5683	22.3	25.1	23.7	23.5	24.9	24.2	22.9	25.0	24.0
Elçi	21.9	24.0	23.0	23.5	24.3	23.9	22.7	24.1	23.4
Mean	**22.6**	**24.4**	**23.5**	**23.4**	**24.8**	**24.1**	**23.0**	**24.6**	**23.8**
LSD (0.05)	ST: 0.3 C: 0.5 ST × C: 0.7 CV: 1.92 %			ST: 0.3 C: ns ST × C: 0.6 CV: 1.74 %			ST: 0.2 C: 0.3 ST × C: 0.4 CV: 1.15 %		
				Crude protein content (%)					
Alpha	20.0	19.0	19.5	19.7	18.7	19.2	19.9	18.9	19.4
Barlydia	19.0	19.5	19.3	18.7	19.2	19.0	18.9	19.4	19.1
Verdor	19.5	19.5	19.5	19.4	19.4	19.4	19.5	19.4	19.4
P-5683	19.0	20.0	19.5	18.8	19.8	19.3	18.9	19.9	19.4
Elçi	18.5	19.5	19.0	18.3	19.1	18.7	18.4	19.3	18.8
Mean	**19.2**	**19.5**	**19.4**	**19.0**	**19.2**	**19.1**	**19.1**	**19.4**	**19.2**
LSD (0.05)	ST: ns C: ns ST × C: ns CV: 5.60 %			ST: ns C: ns ST × C: ns CV: 5.68 %			ST: ns C: ns ST × C: ns CV: 5.64 %		
				Crude ash content (%)					
Alpha	9.4	9.3	9.4	9.6	9.6	9.6	9.5	9.5	9.5
Barlydia	9.0	9.1	9.1	9.2	9.4	9.3	9.1	9.3	9.2
Verdor	9.6	9.2	9.4	9.7	9.5	9.6	9.7	9.4	9.5
P-5683	9.4	9.3	9.4	9.6	9.2	9.4	9.5	9.2	9.4
Elçi	9.4	9.6	9.5	9.7	9.9	9.8	9.6	9.8	9.7
Mean	**9.4**	**9.3**	**9.3**	**9.5**	**9.5**	**9.5**	**9.5**	**9.4**	**9.4**
LSD (0.05)	ST: ns C: ns ST × C: ns CV: 7.55 %			ST: ns C: ns ST × C: ns CV: 7.29 %			ST: ns C: ns ST × C: ns CV: 7.42 %		

Cultivars (C)	2005			2006			2005-2006		
	Soil texture (ST)			Soil texture (ST)			Soil texture (ST)		
	Heavy	Light	Mean	Heavy	Light	Mean	Heavy	Light	Mean
	Crude cellulose content (%)								
Alpha	24.5	26.9	25.7	25.1	27.5	26.3	24.8	27.2	26.0
Barlydia	27.3	30.7	29.0	28.2	31.3	29.8	27.8	31.0	29.4
Verdor	25.7	30.0	27.9	26.0	30.4	28.2	25.9	30.2	28.0
P-5683	25.4	30.0	27.7	25.8	30.4	28.1	25.6	30.2	27.9
Elçi	24.2	27.6	25.9	25.3	28.7	27.0	24.8	28.2	26.5
Mean	**25.4**	**29.0**	**27.2**	**26.1**	**29.7**	**27.9**	**25.8**	**29.4**	**27.6**
LSD (0.05)	ST: 0.9 C: 1.3 ST × C: ns CV: 4.78 %			ST: 1.7 C: 1.3 ST × C: ns CV: 4.65 %			ST: 0.8 C: 1.3 ST × C: ns CV: 4.71 %		

Fresh biomass yield: Interaction was not significant on the fresh biomass yield in 2005 but in 2006. Average yields of Verdor cultivar on light soil in both years (95100 and 148240 kg ha^{-1}, respectively) were the highest. In two year average, interaction was significant on the biomass yield displaying that alfalfa cultivars responded differently to the soil texture and the highest biomass yield was produced by Verdor cultivar (121670 kg ha^{-1}) on light soil. However, Elci cultivar (94940 kg ha^{-1}) of alfalfa grown on heavy soil produced the lowest biomass yield. These could be due to the genotypic characteristics of the cultivars tested in the experiment. The biomass yields of all tested alfalfa cultivars increased in the second year and all alfalfa cultivars on light soil yielded better heavy soil. Some researchers[2,3,5,6,8,13], confirming present results, compared the yield of alfalfa on light and heavy soil under Mediterranean conditions over 3 years and emphasized that alfalfa produced significantly higher biomass yield in light soil. It appears that different cultivars should be recommended for different regions[3,4,6,7,12,13].

Dry matter content: Effect of soil texture x cultivar interaction on dry matter contents were also significant in both trial years and 2 year average. The highest dry matter contents were determined in P-5683 cultivar (25.1 %), Barlydia cultivar (25.4 %) and P-5683 cultivar (25.0 %) on light soils in 2005, 2006 and 2 year average, respectively. Average dry matter contents were lower than 2006 in 2005, most probably because of the dominating young alfalfa crops in the stands in the first year. Some researchers also pointed out that, dry matter content is closely related to the age of the perennial crop[3,6-8,13]. Dry matter contents of alfalfa cultivars grown on heavy soil were about 1-2 % less than light soil in 2 year average. These results were in agreement with Forbes and Watson[9] who stated that soil factors which influence root growth and development and thereby affect the yield of a crop can be classified as nutritional, biological or physical including soil temperature, aeration and resistance to penetration by roots.

Crude protein and crude ash content: The trends of alfalfa cultivars with regard to crude protein and crude ash contents were similar to each other. Neither cultivars and soil textures nor interactions had statistically different crude protein and crude ash contents in 2005, 2006 and 2 year average, respectively, which are significant for forage crop quality. Although those nutritional traits are highly significant, the crude protein and crude ash content of the cultivars ranged between 18.4-19.9 and 9.1-9.8 % in 2 year average, respectively. The reason for having no striking variation in terms of either crude protein or crude ash content could be that all tested alfalfa crops were cut in similar flowering stages during harvest procedures. Present results indicate that the crude protein and crude ash contents were in agreement with those of many researchers[2,3,5,8-11].

Crude cellulose content: There were significant differences among the crude cellulose contents of cultivars in different soil types in both years and 2 year average whereas interactions were not significant. Average crude cellulose contents of Barlydia cultivar in both years (29.0 and 29.8 %, respectively) were highest whereas Alpha cultivar had the lowest crude cellulose contents (25.7 and 26.3 %, respectively) in 2005 and 2006 experimental years. Average crude cellulose content of alfalfa cultivars grown on light soil (29.0 and 29.7 %, respectively) were high compared to heavy soil (25.4 and 26.1 %, respectively) displaying the unfavourable nutritive value of tested material[1,3,11]. Some researchers working on alfalfa forage quality indicated that protein and ash content are favourable properties to increase the nutritional value of material whereas cellulose and related derivatives are unfavourable contents[5,6,13]. Considering this approach, it can be concluded that tested cultivars are significantly different in term of cellulose content depending on their genetic properties and these nutritional characteristics can be considered as a selection criteria to choose proper cultivars for this type of ecologies and soil types.

In conclusion, alfalfa cultivation on light soil had many advantageous including biomass production and forage quality compared to practices on heavy soil under Mediterranean climatic conditions. Verdor and P-5683 cultivars of alfalfa are the most promising genotypes for this type of Mediterranean ecologies. Moreover, these cultivars should be considered for future breeding programmes in the area.

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(*Received*: 29 October 2008; *Accepted*: 30 April 2009) AJC-7501