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QUALITY CHARACTERISTICS OF THE MIXTURES OF SOME WARM SEASON PERENNIAL GRASSES WITH ALFALFA (*Medicago sativa* L.) UNDER IRRIGATED CONDITIONS OF CUKUROVA

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ABSTRACT

This research was conducted to determine forage quality characteristics of duo (alfalfa + one grass) and trio (alfalfa + two grasses) mixtures of some warm season perennial grass species such as dallis grass (*Paspalum dilatatum* Poir.), Rhodes grass (*Chloris gayana* L.) and Bermuda grass (*Cynodon dactylon* (L.) Pers.) with alfalfa as well as their pure sowings under irrigated conditions of Cukurova during the years of 2009-2011. In the study, crude protein contents, crude protein yields, acid detergent fiber contents (ADF), neutral detergent fiber contents (NDF) and relative feed values (RFV) of the mixtures and pure sowings were determined. The experimental design was completely randomized block design with three replications. The results of the study showed that there were significant differences among mixtures and pure sowings in the forage quality characteristics. The highest crude protein yield (2.32 t ha^{-1}) was obtained from the mixture of dallis grass + alfalfa. The highest crude protein ratio (20.6 %) and RFV (164.8) was obtained from the pure alfalfa. The highest ADF (40.2 %) and NDF (70.9 %) was obtained from the pure dallis grass. The result of the study indicated that duo mixture of alfalfa with dallis grass may be used to establish artificial pastures under irrigated conditions of Cukurova or of similar ecologies owing to its high forage quality and high crude protein yield.

Key words: Warm season perennial grasses, alfalfa, mixture, quality

INTRODUCTION

Grass-legume mixtures are preferred over pure-grass forage stands throughout the world because they often increase the total yields of herbage and protein and offer balanced nutrition (Albayrak and Ekiz, 2005). Some other advantages of mixtures include the control of erosion, weed control and prolonged stand longevity (Casler, 1988). Alfalfa is one of the most commonly used legumes for both hay and pasture in Turkey because of its high yield, high nutritional quality, ability to fix nitrogen and vigorous fall regrowth (Acikgoz, 2001).

Grass-legume mixtures tend to provide a superior nutrient balance and produce higher forage yields. The benefit of including legumes in mixture with grasses has long been recognized. Introducing legumes in pastures and hay fields improves forage quality and lowers the cost of production (Brown and Munsell, 1943). Legumes provide proteins that grasses lack and increase dry matter yield by fixing atmospheric nitrogen and converting it into a soluble inorganic form that can be absorbed into plant tissues.

In contrast to the above mentioned benefits of the grass-legume mixtures, they are more difficult to manage than monoculture pastures because of competition among the mixture components for light, water, and nutrients (Charles and Lehmann, 1989; Serin et al., 1998; Berdahl et al., 2001; Albayrak and Ekiz, 2005).

The advantages of cool season legumes in cool season pastures and hay lands have been well documented, but there is little information on mixing legumes with warm season grasses. Some researchers reported that warm-season forage crops could be succesfully grown in mixtures with legumes (Aganoglu 1985; Blanchet et al., 1995; Larbi et al., 1995; Gettle et al., 1996; Tessema and Baars 2006).

Mediterranean region of the Turkey experiences long periods of drought, especially in mid-summer. High temperatures and low precipitation are detrimental to production of cool season forages. Lack of productivity of cool season pastures during the summer months often results in overgrazing. Perennial warm season grasses produce their yields in midsummer, which could provide forage production during that period (Jung et al., 1978).

Rhodes grass is one of the main sub-tropical grasses and is widely grown in Africa, Australia, Japan, South America as well as in the Middle East under irrigation for both forage and soil conservation purposes (Tansi, 2009). Rhodes grass is a morphologically variable out-crossing species, which is native to east, central and southern Africa where it occurs in open grasslands.

Dallis grass is a summer-active perennial grass native to the humid sub-tropics of southern Brazil, Argentina and Uruguay (Jones, 1985). It is now widespread in many areas of the world, and is capable of very high production under suitable conditions.

Bermuda grass is native to southern Africa and southeast Asia. It has been widely used in tropical and warm temperate regions as a pasture grass and is one of the major turf grasses in the world. Bermuda grass is widely sown in the south-eastern United States, where its hybrid cultivars with improved productivity and forage quality have been developed (Skerman and Riveros, 1990).

This paper was prepaired from a part of data obtained from the research conducted to determine the forage yields and qualities of duo (one grass + alfalfa) and trio (two grass + alfalfa) mixtures of some perennial warm season grass species such as dallis grass (*Paspalum dilatatum* Poir.), Rhodes grass (*Chloris gayana* L.), Bermuda grass (*Cynodon dactylon* (L.) Pers.) with alfalfa (*Medicago sativa* L.) as well as their pure growings under irrigated conditions of Mediterranean. A paper from data related to the yields and some other characteristics of the mentioned mixtures as well as pure growings had been published (Cinar and Hatipoglu, 2014).

MATERIALS AND METHODS

Plot establishment

The research was carried out during 2009-2011 growing seasons in Adana province (36°51'N, 35°20'E, elevation 12 m), located in the Mediterranean region of Turkey. The experimental area has typically natural Mediterranean climate with hot and dry summer and heavy precipitation during winter. According to the average of long years, the coolest month is January with a monthly mean temperature of 9.9 ºC and the hottest month is August with 28.8 ºC. The total precipitation was lower in 2010 (500.6 mm) and 2011 (462.3 mm), and higher in 2009 (671.6 mm) when compared with the long-term precipitation mean (647.1 mm). The means of the temperature and relative humidity during the experimental period were close to the long-term means (Anonymous, 2012a). The research area has a flat land; its soil texture is classified as silty clay with slightly alkaline, which contained medium organic matter, poor phosphorus (P), zinc (Zn) and calcium (Ca) contents (Anonymous, 2007).

Dallis grass (*Paspalum dilatatum* Poir.), Rhodes grass (*Chloris gayana* L.), Bermuda grass (*Cynodon dactylon* (L.) Pers.) and alfalfa (*Medicago sativa* L.) as welll as their duo (one grass + alfalfa) and trio (two grass + alfalfa) mixtures were used as experimental material.

The experiment was conducted according to the randomized complete block design with three replications. There were 10 treatment plots in each block. Each plot consisted of 6 rows each 5 m in length. The row spacing was 25 cm. The seeding rates for dallis grass, Rhodes grass, Bermuda grass and alfalfa were 11 kg ha^{-1}, 4 kg ha^{-1}, 10 kg ha^{-1} and 10 kg ha^{-1} respectively. Seed mixtures consisted of 30 % alfalfa and 70 % grasses. Seed ratio of each grass species in trio mixtures was 35 %. The seeds of alfalfa and grass species were sown in the same rows. Sowing was done by hand on April 28th 2009. Plots were fertilized with 100 kg ha^{-1} N and 100 kg ha^{-1} P at sowing (Avci, 2000). The plots were irrigated once after each harvest.

Methods

The harvest time was based on the 10% flowering stage of alfalfa (Serin et al., 1998). The plots were harvested at 5 cm cutting height. The plots were harvested 4, 6 and 5 times during the growing seasons of 2009, 2010 and 2011, respectively. The forage samples for the quality analyses were taken from the 3 randomly located quadrates each having 0.5 m^2 area in each plot.

All samples were dried at 70 ^oC for 48 h and weighed. The samples from the mixture plots were hand-separated to the mixture components before the drying. Dry matter content was determined from ground samples dried at 105 ^oC for 24 h.

Contents of crude protein, acid detergent fiber (ADF) and neutral detergent fiber (NDF) of samples were determined using Infrared Reflectance Spectroscopy (NIRS) (Hoy et al., 2002; Aydin et al., 2010). NIRS was calibrated using software program coded IC-0904 FE hay and fresh forage.

Crude protein yield (CPY), digestible dry matter yield (DDMY), dry matter intake (DMI), digestible dry matter (DDM) and relative feed value (RFV) were estimated according to the following equations adapted from Sheaffer et al. (1995):

CPY = Crude protein content (CP%) x dry matter yield (DMY)

DMI = 120/ (NDF%) dry matter basis

DDM = 88.9 - (0.779 x ADF% dry matter basis)

RFV = (DDM% x DMI)/1.29

Experimental design and statistical analyses

The experimental design was completely randomized block design with 3 replications. Data were analyzed by using MSTATC software program (V.1.2, Michigan State University, USA). The differences between means were separated by Duncan multiple range test ($P \leq 0.05$), however means of year were compared according to least significant difference (LSD) test ($P \leq 0.05$) (Steel and Torrie, 1960).

RESULTS AND DISCUSSION

Crude Protein Ratio and Crude Protein Yield

The results of the variance analysis showed that the crude protein ratio was influenced by pure sowings and mixtures as well as years. Year x treatment (pure sowings and mixtures) interaction was also statistically significant. Averaged crude protein ratios in the second and third years were significantly higher than that in the first year (Table 1). The alfalfa sown in April, normally sown in November under Mediterranean conditions, produced lower hay yield than that sown in November in the first year. Therefore contribution of the alfalfa on the yield of the mixtures in the first year was significantly lower than those in the second and third years. Lower alfalfa ratio in the hay yields of mixtures in the first year resulted in the lower averaged crude protein ratio than those in the second and third years.

Table 1. Crude protein ratios (%) of dry matters from pure sowings and alfalfa-grass mixtures

Pure Sown and mixtures	Years			Average
	2009	2010	2011	
Alfalfa (A)	20.2 a*	21.0 a	20.5 a	20.6 a
Dallis grass (DG)	11.4 ef.	8.4 e	9.9 d	9.9 f
Bermuda grass (BG)	13.9 cd	9.3 e	10.8 d	11.4 e
Rhodes grass (RG)	10.0 f	9.6 e	10.5 d	10.0 f
A+DG	14.2 b	16.6 cd	17.4 b	16.0 c
A+BG	16.5 b	18.5 b	18.2 b	17.7 b
A+RG	11.9 c-f	15.6 d	14.4 c	14.0 d
A+DG+RG	11.6 d-f	16.3 cd	13.2 c	13.7 d
A+BG+DG	13.2 c-e	17.3 bc	17.1 b	15.9 c
A+BG+RG	11.9 c-f	16.1 cd	13.0 c	13.7 d
Average	13.5 b+	14.9 a	14.5 a	14.3

*Values within a column with different letters are significantly different from each other according to the Duncan Test at $P \leq 0.05$
+) Values within the row with different letters are significantly different from each other according to the LSD Test at $P \leq 0.05$

In the first year, crude protein content of alfalfa dry matter was statistically significant higher than those of the other pure sowings and all of the mixtures (Table 1). Rhodes grass gave the dry matter with statistically significant lower crude protein ratio than pure growings of alfalfa and Bermuda grass as well as than the mixtures of alfalfa+dallis grass and alfalfa+Bermuda grass.

In the second year, alfalfa produced the dry matter with statistically significant higher crude protein content than all of the other pure sowings and mixtures. All of the pure sowings of the grasses gave the dry matter with statistically significant lower crude protein content than the pure sowing of alfalfa and all of the mixtures.

In the third year, the highest crude protein content (20.5%) was obtained from pure sown alfalfa as in the first and second years. All of the pure sowings of the grasses gave the dry matter with statistically significant lower crude protein content than the pure sowing of alfalfa and all of the mixtures as in the second year.

According to the averaged values over three years, the highest crude protein ratio was obtained from pure sown alfalfa. Pure sowings of dallis grass and Rhodes grass produced the dry matter with statistically significant lower crude protein content than the other pure sowings and mixtures.

Previous studies have shown that alfalfa contains significantly more protein than grasses and that grass+legume mixtures contain more crude protein than the pure sowing grasses (Spandl and Hesterman, 1997; Avci, 2000; Albayrak and Ekiz, 2005).

Nutrient value of a forage relatively depends on the botanical composition and harvesting time. The results indicated that CP contents of dry matter of the mixtures were generally lower than 16-18% which requires supplementary feeding to obtain high performance from milk cows (Baytekin and Gul, 2009).

The crude protein yield (CPY) significantly varied depending on the years. The averaged crude protein yield in first year was significantly lower than those in the second and third years (Table 2). The variation in the crude protein yield of the pure sowings and mixtures depending on the years was due to the variation in dry matter yield and crude protein ratio.

Table 2. Crude protein yields (t ha^{-1}) of pure sowings and alfalfa-grass mixtures

Pure Sown and mixtures	Years 2009	2010	2011	Average
Alfalfa (A)	1.40	2.71 a*	2.31 bc	2.14 a
Dallis grass (DG)	1.24	0.59 b	0.60 e	0.81 c
Bermuda grass (BG)	1.33	0.68 b	0.60 e	0.87 c
Rhodes grass (RG)	1.46	0.93 b	1.18 d	1.19 c
A+DG	1.39	2.68 a	2.90 a	2.32 a
A+BG	1.62	2.50 a	2.61 ab	2.24 a
A+RG	1.72	2.34 a	2.07 bc	2.04 ab
A+DG+RG	1.55	2.32 a	2.08 bc	1.99 ab
A+BG+DG	1.08	2.12 a	1.78 c	1.66 b
A+BG+RG	1.51	2.69 a	2.16 bc	2.12 a
Average	1.43 b+	1.96 a	1.83 a	1.74

*Values within a column with different letters are significantly different from each other according to the Duncan Test at P≤0.05
+) Values within the row with different letters are significantly different from each other according to the LSD Test at P≤0.05

In the first year of the experiment, the CPY was not statistically significant changed among the pure sown plots and mixtures. In the second year, pure growing alfalfa and its mixtures with grasses gave statistically significant higher CPY than all of the other pure sown grasses. In the third year, the mixture of alfalfa + dallis grass gave statistically significant higher crude protein yield than the pure sowings and the other mixtures with the exception of the alfalfa + Bermuda grass mixture.

According to the averaged values over three years, the highest crude protein yield was obtained from the mixture of alfalfa + dallis grass. The crude protein yield of this mixture was not statistically significant different from that of pure sown alfalfa and all of the mixtures with the exception of the trio mixture of alfalfa+Bermuda grass+ dallis grass.

ADF and NDF ratios

The results of the variance analysis showed that ADF and NDF contents of the dry matter were statistically significant influenced by pure sowing and mixtures. as well as the years. Interaction of the years and treatments was also statistically significant. The averaged ADF content over the pure sowings and mixtures in the first year was significantly higher than those in the second and third years (Table 3) . In the first year, contribution of the warm season grasses on the hay yield of the mixtures was higher than those in the second and third years. The grasses contain generally higher ADF than alfalfa (Linn and Martin, 1999). Therefore averaged ADF content of the dry matter in the first year was significantly higher than those in the second and third years.

Table 3. ADF ratios of dry matters from pure sowings and alfalfa-grass mixtures (%)

Pure Sown and mixtures	Years 2009	2010	2011	Average
Alfalfa (A)	29.7 d*	24.2 e	26.2 d	26.7 e
Dallis grass (DG)	43.4 a	39.6 a	37.7 a	40.2 a
Bermuda grass (BG)	35.7 c	32.6 b	30.9 c	33.1 c
Rhodes grass (RG)	39.8 b	34.3 b	34.6 b	36.2 b
A+DG	38.8 b	30.3 c	30.6 c	33.2 c
A+BG	34.0 c	26.3 d	26.7 d	29.0 d
A+RG	39.4 b	29.0 c	29.9 c	32.7 c
A+DG+RG	40.0 b	29.4 c	32.1 bc	33.8 c
A+BG+DG	36.2 c	28.4 cd	26.9 d	30.5 d
A+BG+RG	40.1 b	28.1 cd	31.3 c	33.1 c
Average	37.7 a+	30.2 b	30.7 b	32.9

*Values within a column with different letters are significantly different from each other according to the Duncan Test at P≤0.05
+) Values within the row with different letters are significantly different from each other according to the LSD Test at P≤0.05

In all the experimental years and according to the averaged values over the three years, alfalfa gave the dry matter with statistically significant lower ADF content than the other pure sowings and all of the mixtures. In contrast to this, dallis grass produced the dry matter with statistically significant higher ADF content than the other pure sowings and all of the mixtures in all of the experimental years. The reasons of the higher ADF content of dallis grass could be development stage of the plant at the harvest (Anonymous, 2012b) as well as the lower leaf- stem ratio (Pinkerton and Cross, 1992).

The averaged NDF ratio of dry matter in the first year was statistically significant higher than those in the second and third year (Table 4). As mentioned above, higher

grass ratio in the hay yield of the mixtures in the first year than those in the second and third years resulted in the higher NDF content. As for ADF content, in all of the experimental years, alfalfa produced the dry matter with the statistically significant lower NDF content than the other pure sowings and all of the mixtures. On the other hand, pure sowings of the grasses gave the dry matter with higher NDF content.

Table 4. NDF ratios of dray matters from pure sowing and alfalfa grass-mixtures (%)

Pure Sown and mixtures	Years			Average
	2009	2010	2011	
Alfalfa (A)	39.4 d*	37.0 f	39.2 d	38.5 f
Dallis grass (DG)	75.4 a	69.7 a	67.5 a	70.9 a
Bermuda grass (BG)	75.8 a	64.5 b	64.4 a	68.2 b
Rhodes grass (RG)	73.9 a	66.6 b	66.5 a	69.1 ab
A+DG	67.1 bc	49.4 cd	47.7 c	54.7 d
A+BG	61.9 c	43.8 e	44.5 c	50.1 e
A+RG	72.3 ab	50.7 c	54.2 b	59.1 c
A+DG+RG	71.0 ab	49.4 cd	57.1 b	59.1 c
A+BG+DG	70.0 ab	47.0 d	47.8 c	54.9 d
A+BG+RG	72.1 ab	49.5 cd	53.7 b	58.4 c
Average	67.9 a+	52.8 c	54.3 b	58.3

*Values within a column with different letters are significantly different from each other according to the Duncan Test at P≤0.05
+) Values within the row with different letters are significantly different from each other according to the LSD Test at P≤0.05

The ADF concentration refers to the cell wall portion of the forage. The portion consist of cellulose and lignin. The ADF value is important because it describes the ability of an animal to digest the forage. As the ADF increases, the digestibility of the forage usually decreases. The NDF value refers to the total cell wall, composed of the ADF fraction plus hemicellulose. NDF value is important in ration formulation because it reflect the amount of forage that the animal can consume. As the NDF percentages increase, the dry matter intake will generally decrease (Joachim and Jung, 1997; Albayrak et al., 2011). Horner et al. (1985) determined ADF content of alfalfa as 35.3 - 41.1 % while Cassida et al. (2000) reported it as 29.7 - 33.5 %,. ADF content of the mixture of Rhodes grass + white sweet clover was reported by Corletto et al. (2009) as 37.0 % . Horner et al. (1985) determined NDF content of alfalfa as 46.0% while Cassida et al. (2000) reported it as 37.8 - 42.0%. Jeranyama and Garcia (2004) reported a NDF value of 54 % for the mixture of alfalfa + grasses of mixtures. Tessema and Baars (2006) determined NDF values for Rhodes grass and for the mixture of alfalfa + Rhodes grass as 55.7 % and 46.9 %, respectively. Lemus (2009) reported a NDF value of 67.2 - 67.6 % for dallis grass. Some of our findings are consistent with those above mentioned, some of them are incompatible. Differences between the findings may be due to differences in climatically conditions, under which researches were conducted, and management techniques applied in the researches (Linn and Martin, 1999; Belyea et al. 1999; Bani et al. 2007).

Relative Feed Value (RFV)

The results of the variance analysis showed that RFV was statistically significant influenced by pure sowings and mixtures as well as years. Year x mixture interaction was also statistically significant. The averaged RFV over the pure sowings and mixtures significantly changed depending on the years. The averaged RFV in the second year was statistically significant higher than those in first and third years while the averaged RFV in the third year was higher than that in the first year (Table 5). The higher alfalfa contribution to the hay yield of the mixtures in the second and third years as compared to the first year resulted in higher RFV in those years. RFV is inversely proportional to the ADF and NDF. Therefore higher averaged RFV's were obtained in the second and third years in which ratios of NDF and ADF were lower than those in the first year.

Table 5. RFV's of pure sowings and alfalfa- grass mixtures (%)

Pure Sown and mixtures	Years			Average
	2009	2010	2011	
Alfalfa (A)	155.4 a*	176.4 a	162.8 a	164.8 a
Dallis grass (DG)	68.0 d	77.4 f	82.1 f	75.8 f
Bermuda grass (BG)	75.0 cd	91.6 e	93.7 ef	86.8 e
Rhodes grass (RG)	72.8 cd	86.6 e	86.7 f	82.1 e
A+DG	94.3 b	145.2 b	142.4 b	127.3 b
A+BG	81.8 c	123.1 cd	127.0 c	110.6 c
A+RG	75.1 cd	121.7 d	112.8 d	103.2 d
A+DG+RG	80.7 c	132.4 c	132.5 bc	115.2 c
A+BG+DG	74.5 cd	126.6 cd	112.5 d	104.5 d
A+BG+RG	75.8 cd	124.5 cd	104.3 de	101.5 d
Average	85.3 c+	120.6 a	115.7 b	107.2

*Values within a column with different letters are significantly different from each other according to the Duncan Test at P≤0.05
+) Values within the row with different letters are significantly different from each other according to the LSD Test at P≤0.05

In all of the experimental years, pure sown alfalfa produced the dry matter with statistically significant higher RFV than the other pure sowings and all of the mixtures. According to the averaged values over the three years, the mixture of alfalfa + dallis grass produced the dry matter with statistically significant higher RFV than the other mixtures and all of the pure sown grasses.

Relative feed value (RFV) has been used for years to compare the quality of legume and legume/grass hays and silages. Having one index to price hay and predict animal performance has been very useful for livestock producers and hay farmers. Forages with an RFV value over 151, between 150-125, 124-103, 102-87, 86-75, and less than 75 are categorized as prime, premium, good, fair, poor and rejected respectively (Kiraz, 2011, Uzun, 2010; Albayrak, 2011). According to these index values, pure sowing alfalfa is classified as prime while mixture of alfalfa + dallis grass is classified as premium.

CONCLUSIONS

From the results of the study, it was concluded that the duo mixture of alfalfa and dallis grass could be recommended as the summer pasture mixture for irrigated conditions in the Mediterranean region due to its moderate crude protein ratio, high crude protein yield, moderate ADF and NDF content sa well as its premium RFV. It was reported that this mixture was also in the group with higher dry matter yield and the highest LER value as compaired with the pure sowings and the mixtures mentioned in this study (Cınar and Hatipoglu, 2014).

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