Turk J
Field Crops
2015, 20(1), 24-30

EVALUATION OF THE QUALITY OF TWO DIFFERENT ARTIFICIAL PASTURES AND THEIR EFFECTS ON THE PERFORMANCE OF GRAZING BEEF ANIMALS

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Received: 02.04.2014

ABSTRACT

This research was conducted to determine the feeding quality of different artificial pastures and their effects on animal performance from the years 2010 to 2012. For this purpose, two different artificial pastures were established, each one covered 1.5 ha area during the first year of the research. The mixtures of the pastures used were as follows: Pasture 1 (P1): *Medicago sativa* L. (20%) + *Bromus inermis* L. (40%) + *Agropyron cristatum* L. (30%) + *Poteriumsanguisorba* (10%); Pasture 2 (P2): *Medicago sativa* L. (15%) + *Onobrychis sativa* Lam. (15%) + *Agropyron cristatum* L. (35%) + *Bromus inermis* L. (35%). The grazing was conducted in the second and the third years of the research. Twenty Holstein male calves with 6 months old were assigned to the experimental areas randomly, each pasture containing 10 animals. Forage samples were collected from grazing and non-grazing areas once every 15 days during the grazing seasons. Concurrently with forage sampling, liveweight gains of animals were also obtained. The dry matter (DM) yield, crude protein (CP), acid detergent fibre (ADF), neutral detergent fibre (NDF) contents, *in vitro* dry matter digestibility (IVDMD) were determined on the forage samples collected from grazing and non-grazing areas. The results showed that as grazing season advanced forage quality was declined in both pastures. The CP content and IVDMD were decreased with advancing growth stages in grazing and non-grazing areas of two pastures. The ADF and NDF contents were increased with advancing growth stages. There were no significant differences in the animal performances grazed on both pastures in terms of final weights, total weight gains and daily live weight gains.

Keywords: Animal performance; dry matter yield; forage quality; grazing; liveweight gain.

INTRODUCTION

The most important problems of raising livestock are not only the shortage of feed stuff but also the quality of forage that can be supplied in many countries with continental climate. Rangelands and harvest residue have a significant role in extensive animal husbandry in Turkey, due to the shortage of rangelands. Therefore, rangelands have substantial importance for animal production, especially during crop growing season because there are no artificial pastures or feed resources for extensive animal husbandry during this period.

In order to establish artificial pasture to produce sufficient and good quality feed in completely damaged vegetation is a suitable choice (Vallentine, 1989; Altin et al., 2005). In most situations, dryland pastures best comprised a simple mixture containing two and three species having similar palatability, season of growth, grazing tolerance, drought tolerance and rare cases of regrowth (Holzworth et al., 2003). Alfalfa (*Medicago sativa* L.), sainfoin (*Onobrychis sativa* Lam.), or other legumes planted in mixtures with grasses, provide nitrogen to increase yield and nutritive values of the entire mixture. However, it is sometimes difficult to keep legumes in the mixture because of their high palatability (Holzworth and Weisher, 2010). Alfalfa, crested wheatgrass and smooth brome cultivar would be suited for use in binary grass-alfalfa mixtures for dryland hay production (Berdahl et al., 2001).

Forage quality can be defined as the relative performance of animals (Buxton et al., 1996). In general, higher levels of cell-soluble, crude protein and minerals are considered as criteria for higher nutritive quality. These components of forage decline substantially with the advanced plant growth and reach the lowest level when plants become dormant (Koc and Gokkus, 1994) in all steppe vegetation. The changing trend of nutritive component of forage shows great differences among range types because the timing and length of growing season differ among them due to climate (Holechek et al., 2004). Most plants show a similarity in declining nutrient composition with advancing development towards maturation (Rao et al., 1973; Stubbendieck and Foster, 1978; Rebole et al., 2004; Turk et al., 2014).

Bozkurt (2012) reported about the superior performance of Holstein cattle compared to other some local and European breed cattle and concluded that under the Mediterranean conditions Holstein cattle were better suited to the feedlot beef systems than other local and some European type cattle. The live weight gain of grazing animals decreases parallel to the declining forage quality. Therefore, it is essential to give supplemental feed to grazing animals in order to maintain live weight gain after plants begin drying due to summer dormancy (Koc et al., 2014).

The objective of this research was to determine the feeding quality of different artificial pastures and monitor their effects on animal performance in the Mediterranean climatic conditions.

MATERIALS AND METHODS

Experimental location

This study was carried out at Suleyman Demirel University Research Farm in Isparta Province (37°45′N, 30°33′E, elevation 1035 m) located in the Mediterranean region of Turkey on three consecutive years of 2010 and 2012. The total precipitation and average temperature data for the experimental area are given in Figures 1 and 2. The major soil characteristics of the research area, determined based on the method described by Rowell (1994), were as follows: The soil texture was clay loam, the organic matter was 1.3% as determined using the Walkley–Black method, the lime was 7.1% as determined using a Scheibler calcimeter, the total salt was 0.29%, the exchangeable K was 122 mg kg^{-1} by 1 N NH_4OAc, the extractable P was 3.3 mg kg^{-1} by 0.4 N $NaHCO_3$ extraction, and the pH of a soil-saturated extract was 7.7. The soil type was calcareous fluvisol (Akgul and Basayigit, 2005).

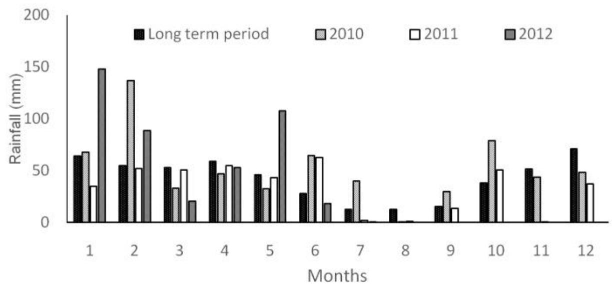

Figure 1. Rainfall values for individual experimental years and over the long term.

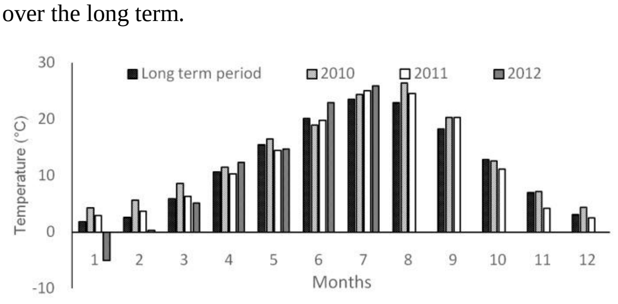

Figure 2. Temperature values for individual experimental years and over the long term.

Animal Management

In order to monitor animal performance, a total of 20 Holstein male calves with an average 6 months old were included and allocated evenly to two artificially established pastures in the experiment which lasted for 90 days in 2011 and 2012. The same breed and the same number of animals were used in both years. Animals were initially weighed at the beginning of the experiments and were randomly divided according to their weights into two grazing groups. Each group was weighed and monitored on a fortnightly basis, using electronic weighing scale (True-Test 2000 SmartUnit). The animals were turned out to pasture for grazing on the 1st of May and the grazing was terminated on the 1st of August each year. The free access of the animals to water and salt was available throughout the experimental period.

Pasture Management

For the establishment of artificial grazing land, 3 ha pasture land was chosen adjacent to the university farm and cultivated in March 2010 with two different botanical compositions. Pasture 1 (P1) was composed of *Medicago sativa* L. (20%) + *Bromus inermis* L. (40%) + *Agropyron cristatum* L. (30%) + *Poterium sanguisorba* (10%); and Pasture 2 (P2) had mixtures of *Medicago sativa* L. (15%) + *Onobrychis sativa* Lam. (15%) + *Agropyron cristatum* L. (35%) + *Bromus inermis* L. (35%), respectively. In first year, cutting and maintenance applications were made. Pastures were harvested twice during the end of June and beginning of October in 2010. Animal grazing applications were performed in the second and the third year of the study since the first year covered only the establishment of the artificial pastures.

In order to monitor chemical composition changes in pastures, 4 non-grazed areas within each pasture were established and fenced with wires by 4×3m size and grass samples were collected by using 0.5m^2 (0.5x1 m) quadrats fortnightly from May to August each year. The dry matter (DM) yield, crude protein (CP), acid detergent fibre (ADF), neutral detergent fibre (NDF) contents, *in vitro* dry matter digestibility (IVDMD) were determined as well.

After the harvest, samples were dried at 70 °C for 48 h, and weighed. The dried samples were reassembled and ground to pass through a 1-mm screen. The crude protein (CP) content was calculated by multiplying the Kjeldahl nitrogen concentration by 6.25 (Kacar and Inal, 2008). The acid detergent fiber (ADF) and neutral detergent fiber (NDF) concentrations were measured according to methods from Ankom Technology. Tilley and Terry's (1963) methods were used to determine *in vitro* dry matter digestibility (IVDMD) of samples.

Statistical analysis

A randomized complete block experimental design was used in this study. General Linear Model (GLM) procedure was applied for the statistical analysis of the data by using Minitab16 statistical software programme and for the data obtained from animal experiment, initial weight and age were taken as covariates to eliminate the weight and age differences at the start of the experiment (Minitab,2010).In statistical analysis, the average of two-year data was taken into account since the data related to animal and pastures were collected after the establishment of the artificial pastures.

RESULTS AND DISCUSSION

Dry Matter Yield and Forage Quality

The results of the variance analysis showed that the effects of the years, pasture types, grazing and sampling times on all investigated traits were significant (Table 1). The highest DM yields of non-grazed areas were determined in May 30 and June 15 in P1 and P2, respectively (Figure 3). The DM yields of grazed areas in both pastures decreased linearly during the grazing season. There was a quadratic relationship between DM yield and sampling times in non-grazed areas as opposed to expectation that the concentration of DM linearly increases with advancing stages of maturity (McDonald et al., 1995; Sankhyan et al., 1999). The DM yield increased until the end of May and reached the highest value (11.78 t ha^{-1}) in May 30 in non-grazed area of P 1 (Figure 3). This may be due to the continued growth of the plant as expected. The DM yield started to decrease in June 15 due to drying plants. In the non-grazed area of P 2, increase in DM yield lasted until June 15, after June 30 it began to decrease due to drying plants. However, DM yield was decreased linearly throughout the grazing season in the grazed areas of P 1 and P 2 due to the consumptions by animals. Those variations caused significant interaction between pasture types × grazing × sampling times for DM yield. Decreases in DM yields due to grazing have been reported in numerous studies (Karslı et al., 2003; Gokkus et al., 2005). DM yields of non-grazed areas were higher than those of grazed areas in the present study as expected. The DM yield of P2 was higher than that of P1. The reason for this difference is *Onobrychis sativa* in mixture of P2. Alfalfa, crested wheatgrass and smooth brome which types of both pastures are already suitable for arid rangelands (Altin et al., 2005). However, although sainfoin is not very suitable for long-term artificial pastures, it showed better performance than burnet.

Table 1. Results of analysis of variance and mean squares of the traits determined

Sources of variations	df	Dry Matter (DM) Yield	Crude Protein (CP)	NDF	ADF	IVDMD
Block (year)	6	11231**	0.015^{ns}	3.16**	1.798**	0.82^{ns}
Year	1	258766**	88.812**	280.59**	56.754**	102.09**
Pasture type (P)	1	2897919**	1.051**	103.44**	328.509**	409.54**
Grazing (G)	1	14069012**	3.745**	23.21**	2.870**	198.76**
Sampling Times (ST)	6	1294804**	291.814**	1278.55**	780.733**	1424.31**
P x G intr.	1	185985**	0.047^{ns}	24.21**	7.959**	3.72^{ns}
P x ST intr.	6	106535**	0.227**	0.97^{ns}	0.559^{ns}	1.06^{ns}
G x ST intr	6	675914**	0.464**	5.81**	2.759**	8.57**
P x Year	1	76671**	3.874**	16.50**	0.081^{ns}	1.53^{ns}
G x Year	1	23961**	1.335**	13.85**	0.101^{ns}	1.57^{ns}
ST x Year	6	15638**	0.545**	0.22^{ns}	0.255^{ns}	0.13^{ns}
P x G x ST intr.	6	28726**	0.031^{ns}	1.99^{ns}	0.866^{ns}	1.18^{ns}
P x G x Year intr.	1	63^{ns}	0.007^{ns}	1.97^{ns}	0.039^{ns}	0.05^{ns}
P x ST x Year intr.	6	10636**	0.042^{ns}	0.06^{ns}	0.156^{ns}	0.00^{ns}
G x ST x Year intr.	6	18267**	0.046^{ns}	0.51^{ns}	0.150^{ns}	0.05^{ns}
P x G x ST x Year int.	6	1376^{ns}	0.001^{ns}	0.10^{ns}	0.160^{ns}	0.00^{ns}
Error	162	1144	0.027	0.75	0.346	0.77^{ns}

df: degrees of freedom, ns: not significant, *P<0.05 and **P<0.01.

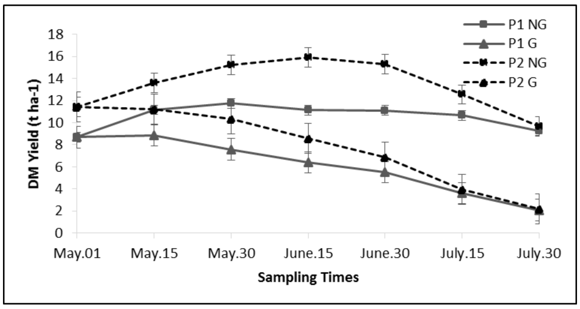

Figure 3. Seasonal variation of DM yields of two different artificial pastures (P1:Pasture 1, P2:Pasture 2, NG: Non grazing, G:Grazing).

The effects of the years, pasture types, grazing and sampling times on CP contents were significant (Table 1). The CP contents decreased linearly in grazed and non-grazed areas in both pastures. The highest CP contents were obtained from beginning of the grazing season while the lowest CP contents were determined at end of the grazing season (Figure 4). Statistically significant interactions between pasture types × sampling times and grazing × sampling times were found for CP ratios (Table 1). These interactions indicated that harvesting stage affected CP ratios differently according to the different pastures and grazing. The CP contents were decreased linearly throughout the grazing season in grazed and non-grazed areas of P1 and P2 (Figure 4). Maturity stage at harvest is the most important factor determining forage quality. Besides N, and hence protein, most minerals, decline with advancing plant development. Other reports also support that the CP contents decreases by advancing stage of maturity (Koc et al., 2000; Rebole et al., 2004), suggesting that animals should be supplemented with protein sources, especially towards the end of the grazing season. As a result of this process, forage quality lessens substantially towards the end of growing season. The CP ratios of the grazed areas were higher than that of non-grazed areas in the present study. This could be associated with the continued re-growth of the plants in grazed areas because young plant tissues are more nutritious than dead or mature plant (Lyons et al., 1996). The CP ratio of P2 was higher than that of P1. The reason for this was that legume rates of pastures were different. Legumes are rich in terms of protein concentration (Altin et al., 2011). Pasture 1 have 20% legume ratio while Pasture 2 have 30% legume ratio in the present study.

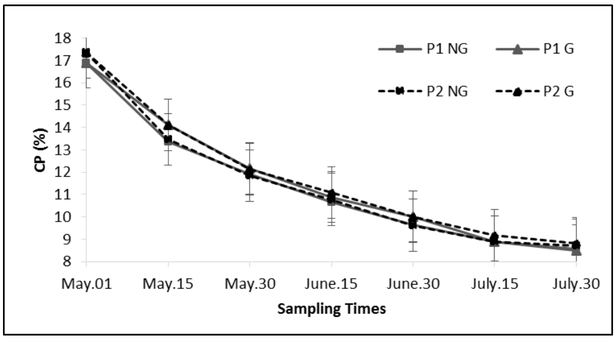

Figure 4. Seasonal variation of CP ratios yield of two different artificial pastures (P1:Pasture 1, P2:Pasture 2, NG: Non grazing, G:Grazing).

The effects of the years, pasture types, grazing and sampling times on ADF and NDF contents were significant (Table 1). The NDF and ADF contents increased linearly in grazed and non-grazed areas in both pastures. The lowest NDF and ADF contents were obtained from beginning of the grazing season while the highest NDF and ADF contents were determined at end of the grazing season (Figures 5 and 6). The effects of pasture types × grazing and grazing × sampling times interactions on ADF and NDF contents were found statistically significant ($P< 0.05$). The reason for this, differences are the changes in the ADF and NDF rates. Acid detergent fiber and NDF contents were increased linearly during the grazing season (Figures 5 and 6). This could be explained by the decrease in proportion of leaves and the increase of the stems proportion with advanced maturity. Because, ADF and NDF contents of stems is higher than the leaves. Similar results were reported by Karslı et al. (2003), Kaya et al. (2004), Erkovan et al. (2009), Turk et al. (2007), Albayrak et al. (2009). The trends in ADF and NDF contents with increasing maturity are normally the reverse of protein (Rebole et al., 2004). Young plant cells have the primary cell wall, but also the secondary cell wall occurs with maturing. This causes being the more fibrous of mature plants (Arzani et al., 2004). ADF and NDF contents of non-grazed areas were higher than those of grazed areas in the present study. This could be explained by the continued re-growth of the plants in the grazed areas. The ADF and NDF contents of P2 were higher than those of P1. Plants with mature structural carbohydrates (cellulose, hemicellulose, lignin) increases (Arzani et al., 2001). As a result, decrease in proportion of leaves and the increase of the stems proportion with advanced maturity causes a decrease in feed quality (Lacefield et al., 1999; Linn and Martin, 1999).

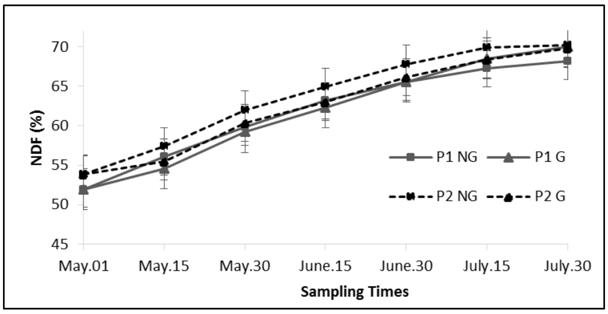

Figure 5. Seasonal variation of NDF contents of two different artificial pastures (P1:Pasture 1, P2:Pasture 2, NG: Non grazing, G:Grazing).

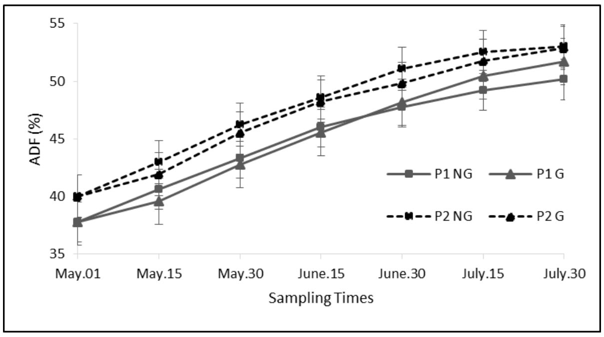

Figure 6. Seasonal variation of ADF contents of two different artificial pastures (P1:Pasture 1, P2:Pasture 2, NG: Non grazing, G:Grazing).

The effects of the years, pasture types, grazing and sampling times on IVDMD were significant (Table 1). The IVDMD was decreased throughout the grazing season in grazed and non-grazed areas of P 1 and P 2 (Figure 7). Similar results were reported by Horney et al. (1996), Hitz and Russell (1998), Karsli et al., (1999). The reason for this decrease in digestibility of plants is the increase in the lignin content (Jung and Vogel, 1992; Van Soest, 1982). The decrease in IVDMD resulted from the increase structural tissues in stems (Arzani et al., 2004). Pinkerton (1996) stated that there is a close relationship between digestibility and cell wall structure. Fiber content is increased as the plants grow, the digestibility decreases (Erfanzadeh, 2001). Overall, IVDMD varies depending on crude cellulose levels in its structure. Digestibility of plenty of leafy green forage is very high, whereas the increase of the stems proportion with advanced maturity causes a decrease digestibility (Aksoy and Yilmaz, 2003).

The IVDMD of legumes are higher than others. Therefore, IVDMD content of P2 was higher than that of P1.

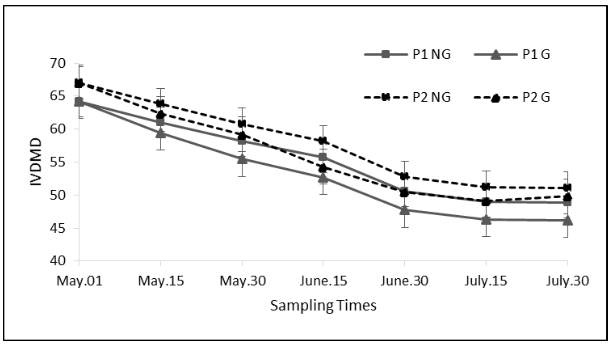

Figure 7. Seasonal variation of IVDMD of two different artificial pastures (P1:Pasture 1, P2:Pasture 2, NG: Non grazing, G:Grazing).

Animal Performance

Animal live weights were increased during the grazing season in both pastures and years (Figure 8). It was observed that these increases were greater until July 15, then these increases slowed down in both years.

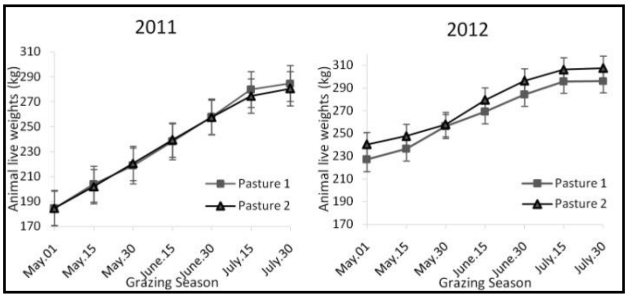

Figure 8. Animal live weights throughout the grazing season determined in 2011 and 2012 years.

There were no significant (P >0.05) differences between pasture types in final weight (FW), total weight gain (TWG) and daily live weight gain (DLWG) (Figure 8). In respect to performance of animals in pasture types, the final weights were 284.7 and 280.5 kg for P1 and P2 in 2011, 296.2 and 307.4 kg for P1 and P2 in 2012, respectively. The average total weight gains 100.1 and 95.9 kg for P1 and P2 in 2011, 69.1 and 68.1 kg for P1 and P2 in 2012 and finally daily live weight gains of 1.112 and 1.066 kg for P1 and P2 in 2011, 0.768 and 0.746 kg for P1 and P2 in 2012, respectively (Table 2).

Table 2. Overall performance comparisons of animals by years and pasture types

	2011			**2012**		
	Pasture 1	**Pasture 2**	**Mean**	**Pasture 1**	**Pasture 2**	**Mean**
IW	184.6	184.6	184.6	227.1	240.3	233.7
FW	284.7	280.5	282.6	296.2	307.4	301.8
TWG	100.1	95.9	98.0	69.1	67.1	68.1
DLWG	1.112	1.066	1.089	0.768	0.746	0.757

IW= Initial weight, FW= Final weight, TWG= Total weight gain, DLWG= Daily live weight gain.

There were significant (P <0.05) differences between years in Final weight (FW), Total weight gain (TWG) and DLWG. The animals in 2011 tended to perform better than the cattle in 2012 in all parameters observed. As it is presented in Table 2, final weights of the animals in the years 2011 and 2012 were 282.6 and 301.8 kg; the average total weight gains 98.0 and 68.1 kg and finally daily live weight gains of 1.089 and 0.757 kg respectively. The reason for the TWG and DLWG differences between years could be due to higher DM yield of pastures in 2011.

In literature, there are no many published studies on performance of different breeds and comparison on different beef production systems in the Mediterranean conditions. However, Bozkurt (2012) reported about the superior performance of Holstein cattle compared to other some local and European breed cattle and concluded that under the Mediterranean conditions Holstein cattle were better suited to the feedlot beef systems than other local and some European type cattle.

Keane et al. (1989) and Keane and More O'Ferrall (1992) reported some results on breed comparisons indicating that differences in factors such as production systems, slaughter weights and climate conditions are of great importance. Similarly, it was stated that breeds and crosses of beef cattle show distinctive differences in performance in different production systems (Bozkurt and ApDewi, 1996). Performance potential vary greatly between different breeds of cattle and different production systems. While there are certainly differences between performance of animals in growth rate, the live weight gain which can be achieved from a given area of grass or quantity of feed is similar for most breeds of animals, provided that animal is fed and managed according to its own particular requirements in its own environment (Wilkinson, 1985).

CONCLUSIONS

It can be concluded thatthe highest DM yields of non-grazed areas were determined in May 30 and June 15 in P1 and P2, respectively, while the DM yields of grazed areas in both pastures decreased linearly during the grazing season. The harvesting at the late stages caused a reduction in forage quality. The CP content and IVDMD decreased throughout the grazing season, while ADF and NDF contents increased in grazing and non-grazing areas in both pastures. The effects of pastures on animal performance were not significant. Animal performances were similar during both grazing seasons in both pastures and years.

At the end of a three-year research conducted in the Mediterranean type of climatic conditions, pasture 2 (*Medicago sativa* L. (15%) + *Onobrychis sativa* Lam. (15%) + *Agropyron cristatum* L. (35%) + *Bromus inermis* L. (35%)) can be recommended in respect for high yield and quality for the regions with similar type of climatic conditions and especially for the inner parts of the region with an altitude higher than a thousand meter.

ACKNOWLEDGMENTS

This work was financially supported by TUBITAK (Turkish Scientific and Technological Research Council, project no. 109O162).

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