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THE CHANGE IN THE FORAGE QUALITY OF CRESTED WHEATGRASS (*Agropyron cristatum* L.) IN GRAZING AND NON-GRAZING ARTIFICIALLY ESTABLISHED PASTURES

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Abstract

This research was conducted to determine the chemical composition of crested wheatgrass in artificial pasture from the years 2010 to 2012. The mixture of the pasture used were alfalfa (Medicago sativa L.) + sainfoin (Onobrychis sativa Lam.) + crested wheatgrass (Agropyron cristatum L.) + smooth bromegrass (Bromus inermis L.). Forage samples were collected from grazing and non-grazing areas once every 15 days during the grazing seasons. The crude protein (CP), acid detergent fibre (ADF), neutral detergent fibre (NDF) contents, in vitro dry matter digestibility (IVDMD), phosphorus (P), potassium (K), calcium (Ca) and magnesium (Mg), ratios were determined on the crested wheatgrass forage samples. According to results, CP, IVDMD and K contents decreased throughout the grazing season, while ADF and NDF contents increased in grazing areas. In non-grazing areas, the CP content, IVDMD, Mg, P and K contents decreased throughout the grazing season, while ADF, NDF and Ca contents increased. The ADF, NDF, Ca contents of crested wheatgrass in non-grazed areas were higher than the grazed areas, while CP, IVDMD, P, Mg and K contents of grazed areas were higher than non-grazed areas. It can be concluded that the harvesting at the late stages caused a reduction in forage quality of crested wheatgrass in grazing and non-grazing areas.

Key words: *Agropyron cristatum, artificial pasture, ADF, CP, forage quality.*

INTRODUCTION

A successful grazing management plan should consider seasonal quality of forage resources, adapt them to animal requirements and maximize animal production without adversely affecting longterm forage production. Van Poollen and Lacey (1979) reviewed specialized grazing systems on western ranges and concluded that they increased mean annual forage production by 13% compared to continuous or season-long grazing. Reducing stocking levels had an even greater effect. Additionally, Allison and Kothmann (1979) found that with lower stocking levels animals selected higher quality diets.

Crested wheatgrass has a growing season of April, May, and June. Forage is of high nutritive value early in the season but decreases rapidly in digestible protein and energy with increasing maturity. Young rapidly growing animals can efficiently utilize early season high quality forage and yearling steers can maintain daily gains above 0.8 kg through mid-June (Raleigh 1970). After this time, gains decrease with decreasing forage quality. Crested wheatgrass develops stiff unpalatable culms and a high stem to leaf ratio with increasing maturity. However, Hyder and Sneva (1963) have shown that adjusting stocking levels to achieve close grazing in late May, while plants are in the boot stage, will reduce formation of reproductive shoots and stimulate vegetative growth.

The relative performance of animals is generally associated with the forage quality. Higher nutritive quality of feeds are dependent on higher levels of cell-soluble, crude protein and mineral contents. These components of forage decline substantially with the advanced plant growth and reach the lowest level when plants become quality (Koc and Gokkus, 1994) as 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 (Rebole et al., 2004).

Therefore, in this research it was aimed to determine chemical composition of the crested wheatgrass during the grazing season in artificial pastures established in the Mediterranean Region of Turkey.

MATERIALS AND METHODS

This research was conducted 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 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.

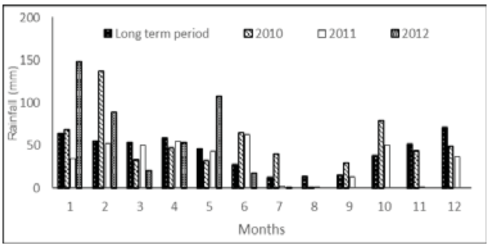

Figure 1. Rainfall values for individual experimental years and over the long term

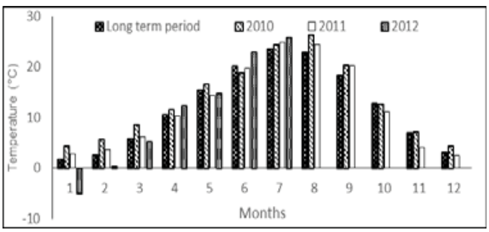

Figure 2. Temperature values for individual experimental years and over the long term

In March 2010, two artificial grazing lands, covering 1.5 ha pasture each land were established at university farm. Pasture was composed of alfalfa (*Medicago sativa* L., 15%) + sainfoin (*Onobrychis sativa* Lam., 15%) + crested wheatgrass (*Agropyron cristatum* L., 35%) + smooth bromegrass (*Bromus inermis* L., 35%). Cutting and maintenance applications were made in the first year. 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. The animals were turned out to pasture for grazing on the 1^{st} of May and the grazing was terminated on the 1^{st} of August each year. 10 Holstein male calves with an average 6 months old were included and allocated evenly to artificially established pasture in the experiment which lasted for 90 days in 2011 and 2012. The animals had a free access to the water during all experimental periods.

Four non-grazed areas within pasture were established in order to determine chemical composition changes of crested wheatgrass and fenced with wires by 4×3m size and grass samples were collected by using $0.5m^2$ (0.5×1 m) quadrats fortnightly from May to August each year. The crude protein (CP), acid detergent fibre (ADF), neutral detergent fibre (NDF) contents, *in vitro* dry matter digestibility (IVDMD), phosphorus (P), potassium (K), calcium (Ca) and magnesium (Mg), ratios were determined as well.

The collected samples after the harvest were weighed and dried at 70°C for 48 h. 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); K, Ca and Mg contents of samples was determined using an atomic spectrophotometer after digesting the samples with $HClO_4$:HNO_3 (1:4); P content was determined by vanadomolybdophosphoric yellow colour method (Kacar and Kovancı 1982). 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.
The data were subjected the analysis of variance using GLM procedure (MINITAB 2010). The means were compared by pairwise comparison test by Duncan at the 5% level of significance

RESULTS AND DISCUSSIONS

The effects of the grazing and sampling times on all investigated traits were significant as shown in Table 1. The effects of the grazing and sampling times on CP contents were significant. The CP contents were decreased linearly throughout the grazing season in grazed and non-grazed areas (Figure 3). 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 3). 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).

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

Sources of variations	df	CP	NDF	ADF	IVDMD	P	K	Ca	Mg
Block (year)	6	0.01 ns	1.13*	1.42**	0.77 ns	0.001 ns	0.003*	0.001 ns	0.001 ns
Year	1	69.21**	311.3**	572.2**	102.1**	0.002 ns	0.411**	0.614**	0.046*
Grazing (G)	1	3.61**	22.27**	2.95**	213.12**	0.009**	0.472**	0.171**	0.179**
Sampling Times (ST)	6	178.11**	1312.22**	781.33**	1341.1**	0.051**	1.891**	4.511**	0.136**
G x ST intr	6	0.39 ns	5.66 ns	2.41 ns	8.13 ns	0.002 *	0.018 *	0.007 *	0.011 *
G x Year	1	1.28 ns	12.77 ns	0.09 ns	1.41 ns	0.0001 ns	0.007 ns	0.023 ns	0.001 ns
ST x Year	6	0.44 ns	0.22 ns	0.22 ns	0.09 ns	0.0001 ns	0.001 ns	0.005 ns	0.0003 ns
G x ST x Year intr.	6	0.027 ns	0.45 ns	0.11 ns	0.04 ns	0.0001 ns	0.003 ns	0.001 ns	0.0001 ns
Error	78	0.02	0.67	0.32	0.71	0.0001	0.001	0.001	0.0002

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

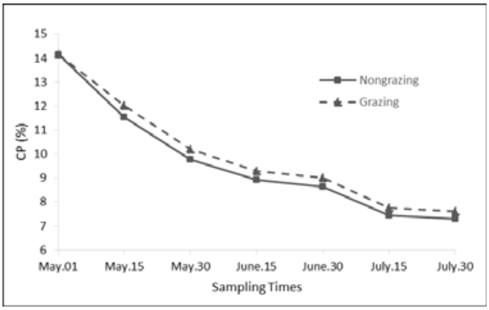

Figure 3. Seasonal variation of CP content of crested wheatgrass in artificial pastures

As shown in Table 1, ADF and NDF contents of crested wheatgrass were significantly affected by both grazing and sampling times. Acid detergent fiber and NDF contents were increased during the grazing season in grazed and non-grazed areas (Figures 4 and 5). 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 are higher than the leaves. Similar results were reported by Karslı et al. (2003), Kaya et al. (2004), Erkovan et al. (2009), Turk et al. (2014), 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 has 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.

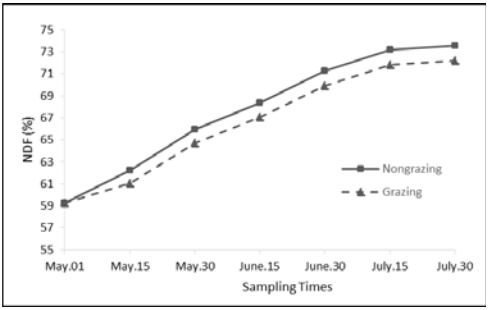

Figure 4. Seasonal variation of NDF content of crested wheatgrass in artificial pastures

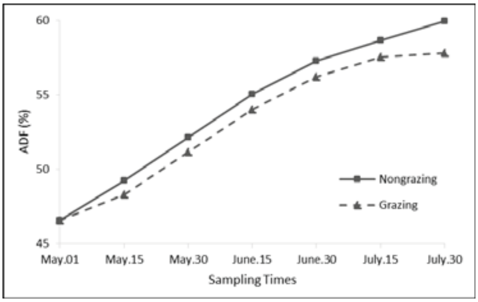

Figure 5. Seasonal variation of ADF content of crested wheatgrass in artificial pastures

The grazing and sampling times showed significant effects on IVDMD of crested wheatgrass (Table 1). The IVDMD was decreased throughout the grazing season in grazed and non-grazed areas (Figure 6). Similar results were reported by 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). 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. 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).

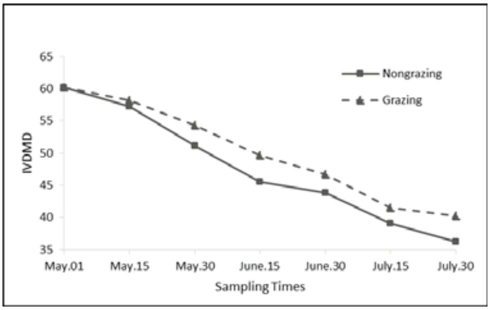

Figure 6. Seasonal variation of IVDMD of crested wheatgrass in artificial pastures.

Statistically significant interactions between grazing × sampling times were found for P, K, Ca and Mg ratios in crested wheatgrass (Table 1). These interactions indicated that harvesting stage affected P, K, Ca and Mg ratios differently according to the different grazing applications. The Mg and P contents of crested wheatgrass in non-grazing areas were decreased with advanced maturity, while those of grazing areas did not change statistically significant. The Ca content of crested wheatgrass in non-grazing areas was increased with advanced maturity, while that of grazing areas did not change statistically significant. The K content was decreased in grazing and non-grazing areas of artificial pasture during the grazing season. 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 (Rama et al., 1973).

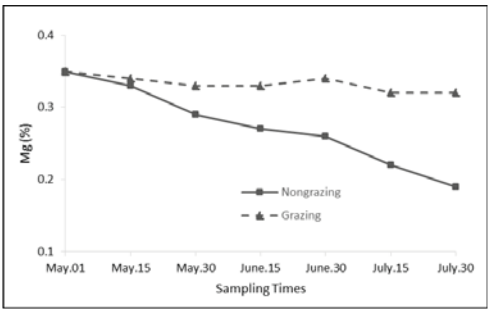

Figure 7. Seasonal variation of Mg content of crested wheatgrass in artificial pastures

Forage quality is determined by maturity stage at harvest as the most important factor. Because P, Ca, Mg and K contents of forage decreased with delayed cutting, forage quality declines with advancing maturity (Blaser et al., 1986; Tan and Serin, 1996; Turk et al., 2007). There is a rapid uptake of minerals during early growth and a gradual dilution as the plant matures (Lanyasunya et al., 2007).

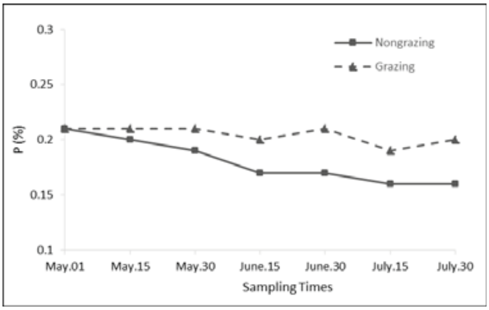

Figure 8. Seasonal variation of P content of crested wheatgrass in artificial pastures

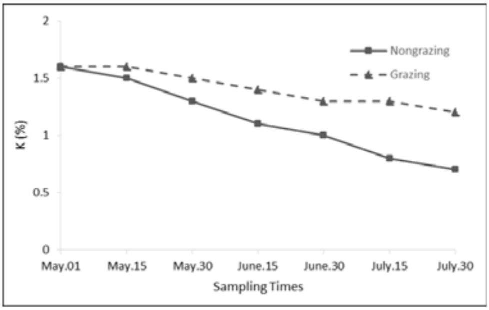

Figure 9. Seasonal variation of K content of crested wheatgrass in artificial pastures

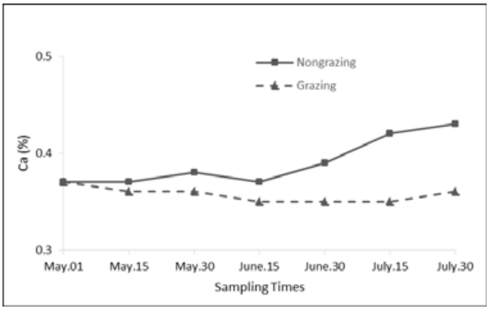

Figure 10. Seasonal variation of Ca content of crested wheatgrass in artificial pastures

The changes in element content with maturity are related to the increasing stem to leaf ratio. Leaves are richer in mineral nutrients than stems (Tan et al., 1997), and the proportion of leaves declines as plant growth advances because of senescence of the lower leaves or damage by diseases (Albrecht and Marvin, 1995). Changes in P content normally parallel those of protein in regard to seasonal changes. Phosphorus and Mg contents both decreased significantly with advancing season (Oelberg, 1956). In contrast, Ca content generally increases as the season advances (Savage and Heller, 1947). The increase with maturity was explained on the basis of the increased amount of cellular material which is composed principally of this element.

In the present study the Ca ratios of the non-grazed areas were higher than that of grazed areas The P, Mg and K ratios of the grazed areas were also higher than that of non-grazed areas. The American National Research Council (NRC 1996) recommends that forage crops should contain 3.1 g kg^{-1} Ca, 6.5 g kg^{-1} K concentration for beef cattle. Tajeda et al. (1985) reported that forage crops should contain at least 0.3% of Ca, 0.2% of Mg, 0.8% of K for ruminants. The chemical properties found in this research indicate that the nutritional quality values of artificial pastures were higher than all the recommended standard values for ruminants.

CONCLUSIONS

The results from the change in the forage quality of crested wheatgrass in grazing and non-grazing artificially established pastures in Mediterranean conditions of Turkey can be summarised as follows:

1. CP, IVDMD and K contents decreased throughout the grazing season, while ADF and NDF contents increased in grazing areas.
2. The CP content, IVDMD, Mg, P and K contents decreased throughout the grazing season, while ADF, NDF and Ca contents increased in non-grazing areas.
3. The ADF, NDF, Ca contents of crested wheatgrass in non-grazed areas were higher than the grazed areas.
4. The CP, IVDMD, P, Mg and K contents of grazed areas were higher than non-grazed areas.

5. It can be concluded that the harvesting at the late stages caused a reduction in forage quality of crested wheatgrass in grazing and non-grazing areas.

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