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FERAT UZUN

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Research Article

Changes in hay yield and quality of bulbous barley at different phenological stages

Ferat UZUN*

Ondokuz Mayıs University, Faculty of Agriculture, Department of Agronomy, 55139 Kurupelit, Samsun - TURKEY

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Abstract: The objective of this study was to determine the changes in hay yield and quality components at different phenological stages of a bulbous barley (*Hordeum bulbosum* L.) population handpicked from natural flora during 2003-2007 in Samsun, Turkey. The phenological stages of bulbous barley during spring-summer (grazing maturity, early heading, heading, and milk-dough) and autumn (early growing) were investigated. Significant differences were observed in hay yield, relative feed value (RFV), crude protein (CP), acid and neutral detergent fiber (ADF and NDF), Ca, Mg, K, P, Mn, Fe, and Zn concentrations, and $K(Ca + Mg)^{-1}$ and $Ca\ P^{-1}$ ratios of DM, depending on development stages. Hay yield, ADF, NDF concentrations, and the $Ca\ P^{-1}$ ratio increased, whereas RFV, CP, Ca, Mg, K, P, Mn, Fe, and Zn concentrations, and the $K\ (Ca + Mg)^{-1}$ ratio in DM decreased as plant development progressed. The Cu concentration was inconsistent at all phenological stages. The results of this research indicate that harvesting or grazing should not be delayed in order to obtain the maximum benefit of bulbous barley hay. Additionally, while some minerals were inadequate, others were in excess, in terms of healthy feeding, at all development stages. Therefore, additional supplementation with some minerals is needed for bulbous barley-based ration or bulbous barley should be grown in mixtures with legumes for feeding productive livestock.

Key words: Bulbous barley, phenological stage, hay yield, mineral content, livestock

Farklı gelişme dönemlerindeki yumrulu arpanın kuru ot verimi ve kalitesindeki değişiklikler

Özet: Bu çalışmanın amacı, Samsun ekolojik şartlarında 2003-2007 yılları arasında doğal floradan toplanan yumrulu arpa popülasyonunun farklı fenolojik dönemlerindeki kuru ot verimi ve kalite öğelerinin değişimini belirlemektir. Yumrulu arpanın ilkbahar-yaz (otlatma olgunluğu, erken başaklanma, başaklanma ve süt-hamur olum dönemi) ve sonbahar periyodundaki (erken gelişme) fenolojik dönemleri araştırılmıştır. Gelişme dönemlerine bağlı olarak; kuru ot verimi, nispi yem değeri, ham protein, asit ve nötral çözeltide çözünen lif, Ca, Mg, K, P, Mn, Fe ve Zn içerikleri, $K(Ca + Mg)^{-1}$ ve $Ca\ P^{-1}$ oranları arasında önemli farklılıklar belirlenmiştir. Bitki gelişiminin ilerlemesiyle; kuru ot verimi, asidik ve bazik ortamda çözünen lif oranı ve $Ca\ P^{-1}$ oranı artarken, nispi yem değeri, CP, Ca, Mg, K, P, Mn, Fe ve Zn içerikleri ve $K(Ca + Mg)^{-1}$ oranı azalmıştır. Cu içeriği ise bütün fenolojik dönemlerde değişken bir tavır göstermiştir. Araştırma sonuçları, yumrulu arpa kuru otundan en yüksek faydayı temin etmek için hasat veya otlatmanın geciktirilmemesi gerektiğini göstermiştir. Ayrıca, bütün gelişme dönemlerinde yumrulu arpa kuru otunda bazı minerallerin sağlıklı bir beslenme açısından yetersiz miktarda olduğu, diğer bazılarının ise ihtiyacın üzerinde olduğu bulunmuştur. Bundan dolayı verimli bir hayvan besleme için yumrulu arpanın ağırlıkta olduğu rasyonlara bazı minerallerin takviye edilmesi ya da yumrulu arpa ile baklagil yem bitkilerinin karışımlar halinde yetiştirilmesi gerekmektedir.

Anahtar sözcükler: Yumrulu arpa, fenolojik dönem, kuru ot, mineral içerik, çiftlik hayvanı

* E-mail: fuzun@omu.edu.tr

Introduction

Bulbous barley (*Hordeum bulbosum* L.) is one of the most common perennial cool-season grass species in many eastern Mediterranean types of grassland that are under heavy and very heavy grazing pressure. It is highly palatable and is widely distributed in both the Mediterranean and Irano-Turanian phytogeographical regions (Zohary 1989; Sternberg et al. 2000; Okumus and Uzun 2007). Although it is a perennial species that regenerates annually and reproduces asexually via corms, it also produces many seeds. Its resistance to grazing is also associated with the development of physical defense factors, such as spikes with rigid awns. It is quite competitive with weeds in the establishing year due to its rapid development at the seedling stage and hay yield is satisfactory during the autumn and winter (Weintraub 1953).

In most parts of the world animal production is dependent on the pasture and rangeland areas, and the subsequent forage availability throughout the year (Ocak et al. 2006). Indeed, a great majority of feed for livestock is provided by rangelands in many countries of the Mediterranean region. Several problems, such as heavy grazing and grazing out of season, limited grassland, and local climatic conditions, that cause insufficient quantity and quality of forage are prevalent in many countries. Moreover, some rangeland areas are deprived of plant flora to prevent soil erosion. In such areas it is very important to increase hay production and quality for ruminant forage requirements by improving rangelands; bulbous barley has the potential to improve such areas.

Additional information on bulbous barley is currently needed to benefit grassland breeding and forage production. Understanding the relationship between hay production and the nutritive value of bulbous barley during the phenological stages is an important issue for grazing and hay management policies; however, little research has been conducted on local bulbous barley populations in field-based studies in Turkey and the Mediterranean region. Therefore, the objective of the present study was to determine the variation in hay production, quality, and mineral composition of a native bulbous barley population during the developmental stages under sub-humid Mediterranean conditions. Such data could be useful in selecting the appropriate harvesting or grazing time for attaining the highest yield or quality forage in bulbous barley.

Materials and methods

The experimental area

This study was conducted at the Ondokuz Mayıs University Research Station, Samsun, Turkey (41°21′N, 36°15′E, elevation 140 m) between 2003 and 2007. Some climatic values and soil characteristics of the experimental area are given in Tables 1 and 2. The growing season of the herbaceous vegetation is between the end of February and the beginning of June in Samsun.

Experimental design and treatments

Bulbous barley seeds were collected from natural flora at the campus of Ondokuz Mayıs University in June 2002. The collected seeds were sown at the rate of 25 kg ha^{-1} on 19 October 2002. Harvesting stages (grazing maturity, early heading, heading, and milk-dough) were randomly assigned to 4 plots within each of 3 blocks. Treatments were repeated in the same plots for 5 consecutive years. Each plot consisted of 5 rows that were 6 m long; row spacing was 20 cm. Soil samples were analyzed at the beginning of the study. As a result of the analyses, 30 kg ha^{-1} N and 80 kg ha^{-1} P_2O_5 were applied each autumn during the experimental period. At the beginning of the bulbous barley rapid growth period 60 kg ha^{-1} N was broadcasted by hand each spring.

Three rows in each plot were harvested at the grazing maturity, early heading, heading, and milk-dough stages from the beginning of May to the end of June, after recording the side effects. The plots that were previously harvested at the grazing maturity stage were re-grown and re-harvested in the middle of June. No harvesting was performed during the dormant stage in July, August, and September. Re-grown bulbous barley plots with autumn rainfall in October were harvested again in the middle of November during the early growing stage when were 16-20 cm tall.

Table 1. Some climatic values of the study area.

Precipitation (L m^{-2})													
Years	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
2003	28.1	77.8	73.5	45.0	54.7	3.30	37.2	3.4	94.0	194.7	64.0	104.0	779.7
2004	84.2	43.9	66.2	101.0	56.2	77.6	37.8	45.1	36.6	59.5	174.2	84.4	866.7
2005	62.8	43.1	141.6	87.8	34.7	51.1	5.9	114.2	69.4	62.9	74.2	40.4	788.1
2006	121.3	98.7	94.6	33.7	69.0	36.3	9.0	0.0	66.2	48.7	65.8	71.4	714.7
2007	24.5	43.8	68.1	25.9	67.0	38.0	31.4	111.8	28.7	72.4	96.5	69.4	677.5
1974-2007	58.4	48.8	52.7	58.3	50.6	47.9	31.3	31.5	50.9	87.4	78.1	74.4	670.2
Temperature (°C)													
Years	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
2003	9.3	4.8	5.0	8.7	16.2	20.7	23.7	24.1	19.5	17.5	11.5	9.3	14.2
2004	8.1	7.5	8.5	11.4	15.0	20.0	22.6	24.1	20.1	16.9	12.2	8.9	14.6
2005	9.0	7.5	7.2	11.4	15.8	20.2	24.2	25.4	21.3	15.7	12.3	10.0	15.0
2006	4.7	6.0	9.7	11.0	14.6	21.3	23.0	26.5	20.9	17.2	11.5	7.2	14.5
2007	9.6	7.5	8.6	9.9	17.2	23.0	24.7	25.4	21.5	18.2	11.2	8.0	15.4
1974-2007	7.0	6.6	7.8	11.2	15.3	20.0	23.2	23.2	19.8	15.9	11.9	8.9	14.2

Table 2. Physical and chemical characteristic of the soil at the experimental site (0-20 cm depth).*

Soil parameter	Value	Comment
Soil texture	-	Clay
pH (1:1, w v^{-1})	6.25	Slightly acid
EC (1:1, w v^{-1})	0.23 dS m^{-1}	Low (<0.98 dS m^{-1})
Organic matter	2.30%	Moderate (1.70%-3.00%)
[1] Available P	1.22 mg kg^{-1}	Low (< 8.00 mg kg^{-1})
[2] Exchangeable K	0.28 cmol (+) kg^{-1}	Low (0.25-0.38 cmol (+) kg^{-1})
[2] Exchangeable Ca	38.00 cmol (+) kg^{-1}	High (>14.30 cmol (+) kg^{-1})
[2] Exchangeable Mg	21.30 cmol (+) kg^{-1}	High (>0.95 cmol (+) kg^{-1})
[2] Exchangeable Na	0.11 cmol (+) kg^{-1}	Low (0.10-0.30 cmol (+) kg^{-1}
[3] Available Mn	38.17 mg kg^{-1}	High (>2.00 mg kg^{-1})
[3] Available Fe	31.37 mg kg^{-1}	High (>4.50 mg kg^{-1})
[3] Available Cu	2.46 mg kg^{-1}	High (>0.20 mg kg^{-1})
[3] Available Zn	0.61 mg kg^{-1}	Low (<1.00 mg kg^{-1})

*Soil characteristics were determined by the methods of Rowell (1996) and Jones (2001)
[1] 0.03 N NH_4F + 0.025 NHCl extractable phosphorus
[2] 1 N NH_4OAc extractable cations
[3] DTPA-extractable micronutrients

The harvested area for each cutting was 5 m long × 0.6 m wide (total: 3.0 m^2) during spring-summer and autumn. Plants were clipped 5 cm above the ground in 5 consecutive years (2003-2007). After clipping, whole plant samples at each growth stage were placed in a paper bag, oven-dried at 60 °C for 48 h, and the hay ratio of the samples was calculated. Hay yield of each plot was calculated based on green forage yield and hay-weight percentage. Plant samples were homogenized by particle size reduction (<0.5 mm). Powdered samples were stored at room temperature until analyzed.

Samples were scanned using a near-infrared scanning monochromator (NIR Systems, Perstorp Analytical Co., Silver Spring, MD, USA). Using near infrared reflectance spectroscopy (NIRS), prediction equations were developed for crude protein (CP), acid detergent fiber (ADF), and neutral detergent fiber (NDF) for all samples. Software options CENTER and SELECT (Win ISI II v.1.5, Foss NIR Systems, Silver Springs, MD, USA) were used for calibration equation development. The relative feed value (RFV) was calculated as digestible dry matter multiplied by dry matter intake divided by 1.29 (Undersander and Moore 2008). Samples were digested with the 3:1 (v:v) HNO_3:$HClO_4$ wet digestion method (Ryan et al. 2001). Ca, Mg, K, Na, Mn, Fe, Cu, and Zn concentrations were determined by atomic absorption spectrophotometer (Perkin Elmer, Model 1300) using the emission (flame) mode, according to Johnson and Ulrich (1959). P content of the plant materials was determined by the vanadomolybdophosphoric yellow color method, according to Ryan et al. (2001). The rate of K $(Ca + Mg)^{-1}$ and Ca P^{-1} were calculated on a milliequivalent basis. The results of chemical analysis were expressed as dry matter (AOAC 1980).

Except for mineral element contents, all data for 2003-2007 were combined because of homoscedasticity. Mineral element concentrations for 2006 and 2007 were combined. The data were analyzed by 1-factor randomized complete block design for all years combined and differences between treatments were tested by Duncan's multiple comparison test (Little and Hills 1978) (**$P < 0.01$). Furthermore, CP, ADF, NDF, and mineral concentrations were explained by means of descriptive statistics (mean ± SD). Computations were performed using Excel and MSTAT-C.

Results

Hay production

The effects of year (Figure 1) and phenological stage (Figure 2) on hay production were significant (F values were 35.42** and 6254.61,** respectively). Total hay production in 2005 (5930.6 kg ha^{-1}) and 2007 (6116.3 kg ha^{-1}) was higher than in 2003 (4161.8 kg ha^{-1}), 2004 (4588.2 kg ha^{-1}), and 2006 (4619.3 kg ha^{-1}); however, hay production during the spring-summer period in 2003 (2597.4 kg ha^{-1}) was lower than that in the other years (4588.2, 4662.3, 4619.3, and 4801.7 kg ha^{-1} for 2004, 2005, 2006, and 2007, respectively) (Figure 1).

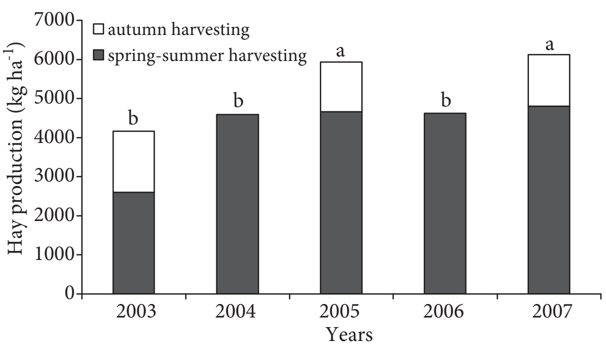

Figure 1. Hay production during the spring-summer and autumn in each year.

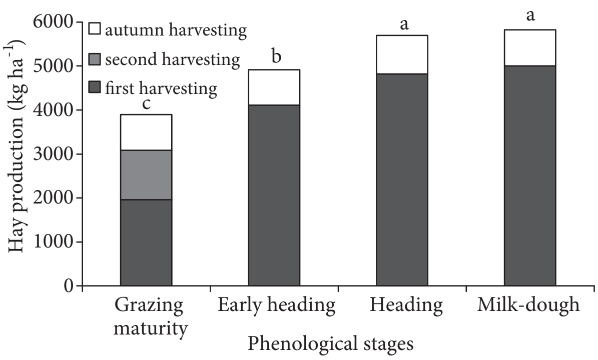

Figure 2. Hay production at the different phenological stages.

Bulbous barley did not produce hay during autumn in 2004 and 2006, but did in 2003, 2005, and 2007, totaling 1564.4, 1268.3, and 1314.6 kg ha^{-1}, respectively (Figure 1).

Hay production of the heading (5694.2 kg ha^{-1}) and milk-dough stages (5823.2 kg ha^{-1}) was higher than that of grazing maturity (3897.3 kg ha^{-1}) and early heading (4918.4 kg ha^{-1}). The early heading stage also produced more hay than the grazing maturity stage (Figure 2).

As shown in Figure 2, hay production at first harvesting in spring-summer was higher at the heading (4819.3 kg ha^{-1}) and milk dough stages (5001.9 kg ha^{-1}) than that at the grazing maturity (1966.6 kg ha^{-1}) and early heading (4110.4 kg ha^{-1}) stages. Hay production at second harvesting (1116.9 kg ha^{-1}) in spring-summer, which was previously harvested at the grazing maturity stage, was higher than that of autumn cutting (813.8 kg ha^{-1}). No significant differences were observed in hay production in autumn (813.8, 808.0, 874.9, and 821.3 kg ha^{-1} for grazing maturity, early heading, heading, and milk-dough stages, respectively).

A dramatic increase was observed in hay production from grazing maturity to heading, except for the milk-dough stage. It was not significantly different between the heading and milk-dough stages.

Crude protein concentration

The crude protein (CP) concentration declined as bulbous barley gradually grew from the grazing maturity (144.8 g kg^{-1}) to heading (55.7 g kg^{-1}) stage; however, CP concentration began to increase gradually from the heading to milk-dough stage. The CP concentration was 66.9 g kg^{-1} in the milk-dough stage. Mean CP concentration of bulbous barley in autumn for all phenological stages was 184.0 g kg^{-1} (Figure 3).

Acid detergent fiber and neutral detergent fiber ratio

Acid detergent fiber (ADF) and neutral detergent fiber (NDF) ratios of the samples harvested at different developmental stages were almost parallel. Irrespective of early growing stage in autumn, both the ADF and NDF ratios of samples obtained from the grazing maturity stage in spring-summer were the lowest. While ADF and NDF increased from grazing maturity (333.9 and 577.4 g kg^{-1}, respectively) to heading (483.3 and 758.6 g kg^{-1}, respectively), they decreased slightly from heading to milk-dough (475.7 and 735.2 g kg^{-1}, respectively). Moreover, ADF and NDF ratios were 318.1 and 537.4 g kg^{-1}, respectively, in autumn (Figure 4).

Relative feed value

Relative feed value (RFV) was significantly affected by the stage of maturity; as the plant matured RFV decreased. According to phenological stage RFV of bulbous barley was as follows: 101.30 (grazing maturity), 81.5 (early heading), 62.8 (heading), and 65.5 (milk-dough). RFV was 110 in autumn.

Mineral concentration

Ca, Mg, K, P, Mn, Fe, and Zn concentrations in bulbous barley DM decreased with maturity up to the milk-dough stage (Table 3). The highest concentrations were obtained in autumn (early

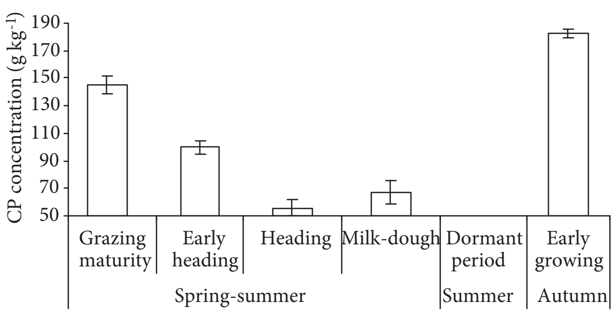

Figure 3. Crude protein concentration at different phenological stages.

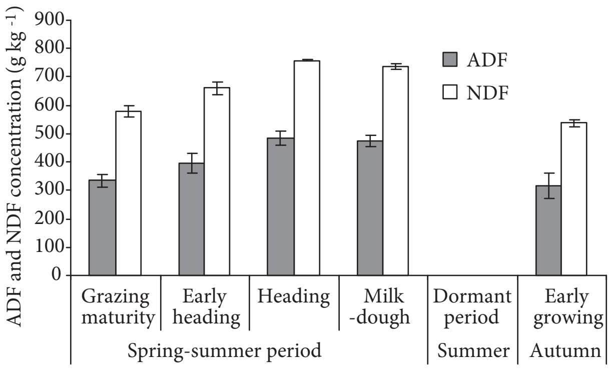

Figure 4. ADF and NDF concentration at the different phenological stages.

Table 3. Mineral concentration of bulbous barley dry matter (mean ± SD) (n = 6).

Phenological stage	Macro elements					
	Ca ($g\ kg^{-1}$)	Mg ($g\ kg^{-1}$)	K ($g\ kg^{-1}$)	P ($g\ kg^{-1}$)	$K\ (Ca + Mg)^{-1}$	$Ca\ P^{-1}$
Grazing maturity	2.14 ± 0.17	0.92 ± 0.12	21.62 ± 0.79	3.64 ± 0.08	7.06 ± 0.36	0.59 ± 0.05
Early heading	1.95 ± 0.07	0.76 ± 0.02	19.81 ± 1.80	2.75 ± 0.33	7.30 ± 1.16	0.71 ± 0.09
Heading	1.85 ± 0.09	0.68 ± 0.01	13.23 ± 0.65	1.88 ± 0.14	5.23 ± 0.18	1.00 ± 0.12
Milk-dough	2.17 ± 0.05	0.85 ± 0.05	13.58 ± 1.04	2.51 ± 0.23	4.50 ± 0.26	0.86 ± 0.08
Early growing (Autumn)	3.46 ± 0.18	1.46 ± 0.07	23.04 ± 1.40	4.84 ± 0.42	4.68 ± 0.46	0.71 ± 0.11
Phenological stage	Micro elements					
	Na ($g\ kg^{-1}$)	Mn ($mg\ kg^{-1}$)	Fe ($mg\ kg^{-1}$)	Cu ($mg\ kg^{-1}$)	Zn ($mg\ kg^{-1}$)	
Grazing maturity	1.04 ±0.07	34.03 ±1.57	251.1 ±8.20	9.83 ±2.55	29.53 ±2.05	
Early heading	1.22 ±0.04	25.88 ±1.26	254.0 ±12.2	11.72 ±2.81	27.33 ±5.69	
Heading	1.37 ±0.04	23.22 ±3.77	212.5 ±10.6	6.95 ±0.63	21.14 ±2.94	
Milk-dough	0.92 ±0.04	26.32 ±1.64	142.7 ±14.32	8.33 ±1.82	33.17 ±4.09	
Early growing (Autumn)	1.17 ±0.16	72.93 ±3.71	618.9 ±15.87	13.96 ±1.53	37.07 ±2.69	

growing). The $K(Ca + Mg)^{-1}$ ratio of DM decreased during plant development in the spring-summer period (from 7.06 mg kg^{-1} for grazing maturity to 4.50 mg kg^{-1} for milk-dough) versus 4.68 mg kg^{-1} in autumn (early growing). While Ca P^{-1} ratio was 0.59 at grazing maturity, it reached the maximum 1.00 at the heading stage with the advancement of plant development, followed by a decrease during the next stage. Na concentrations increased from grazing maturity to heading stage (from 1.04 to 1.37 g kg^{-1}), decreased at milk-dough (0.92 g kg^{-1}), and then increased again at the early growing stage in autumn (1.17 g kg^{-1}). Nonlinear variation was observed for Cu content, ranging between 6.95 and 13.96 mg kg^{-1} (heading and early growing stage, respectively).

Discussion

Results of the present study indicate that bulbous barley had similar hay production during the spring-summer period over the course of 4 years, except for in the first year. This lower hay production in the first year could be attributed to the fact that climatic conditions in that year were less suitable for plant development in the spring-summer period, as well as the expected difficulties experienced with seedlings in the establishment year (Table 1).

Hay production was not steady in autumn, unlike the spring-summer period, as a result of climatic conditions (mostly precipitation and temperature). As a matter of fact, plant growth was not sufficient for cutting or grazing in 2004 and 2006. The most impressive factor for Mediterranean hay production in autumn is rainfall during late summer and early autumn. Table 1 shows that hay production was associated with total rainfall in August, September, and October. The reason why the highest hay yield was observed in autumn in 2003 could be the higher precipitation (292.1 L m^{-2}) in the months of 2003 mentioned above. In contrast, lower hay production in autumn was obtained in 2005 and 2007 than in 2003 due to less precipitation in 2005 and 2007 (246.5 L m^{-2} and 212.9 L m^{-2}, respectively). Finally, harvesting was not performed in 2004 or 2006 due to low rainfall in the months mentioned above (140 and 115 L m^{-2}, respectively).

The plots harvested at the grazing maturity stage were re-grown rapidly because plants were harvested at the early growing stage under favorable rainfall and temperature conditions; thus, sufficient plant re-growth allowed a second harvesting to be performed in the middle of June. There was no re-growing in the plots harvested at the other phenological stages due to the fact that the plants began to reproduce and climatic conditions were not suitable.

As reported previously by Seligman (1996), humid and warm weather conditions in the experimental area from early April to mid-June were adequate for plant growth (Table 1). The combination of moisture and temperature seems to have a critical importance for plant growth during the period. Variation in growth of bulbous barley was significant during the mentioned period, as reported by Anderson and Holte (1981), who concluded that growth and development were strong indicators of growing conditions. While the warm-humid period during early April to mid-June was optimum for plant growth and dry matter accumulation, the dry and hot conditions accelerated plant maturity at the end of the period (El-Shatnawi et al. 2004).

Crude protein is one of the most limiting factors for livestock productivity. Ewes require a diet containing 70-90 g CP kg^{-1} day^{-1} for maintenance of live weight and 100-120 g CP kg^{-1} day^{-1} for lactation. Green herbage of grasses usually has a higher concentration of CP than mature or dry forage (Holechek et al. 1998); therefore, the CP rate required by ruminant animals could be supplied by bulbous barley, until the early heading stage.

White (1983) and Arzani et al. (2004) reported seasonal changes in CP during different phenological stages. Our results were similar to theirs; as plants matured CP declined. The CP of bulbous barley was highest in autumn because the plots were harvested at the earliest phenological stage in that period.

According to Van Soest et al. (1991), acid detergent fiber is an indicator of forage digestibility in ruminants and neutral detergent fiber is the best single plant predictor for potential forage intake. Ghadaki et al. (1974), McDonald et al. (1995), and Gustavsson and Martinsson (2004) reported that ADF and NDF fractions represent more indigestible parts of the plant and digestibility decreases with maturity; however, concentrations of ADF and NDF increase. According to the results of this study on ADF and NDF, digestible DM and DM intake of bulbous barley were the highest at the early growing stage in autumn and at the grazing maturity stage in spring-summer. Digestibility and intake of the plants decreased from the grazing maturity to heading stage, and increased slightly to the milk-dough stage. It can be concluded that bulbous barley has higher nutritive value when grazed or cut at an early phenological stage for hay.

Relative feed value, combining such important nutritional factors as potential intake and digestibility, is a very important criterion that can be used to compare the hay quality of different forages at different phenological stages. The RFV of bulbous barley in the present study was recorded as good and fair hay quality until the beginning of early heading, but was poor for the following stages, according to Linn and Martin (1999). In the present study it was observed that the feed value of the hay was lower when the plants fully matured, as reported by Jafari (1993) and Arzani et al. (2004). RFV results and changes in the examined parameters in the present study during the stages of plant development indicate that plants at early stages of development are suitable for all kinds of usage.

The NRC (2001) recommends that Ca, Mg, and P rates should be at least 6.5 g kg^{-1}, 2.5 g kg^{-1}, and 4.0 g kg^{-1}, respectively, of the total ration DM for productive cows. Generally, in all phenological stages Ca, Mg, and P (except for the P content in autumn) concentrations of bulbous barley DM were lower compared to aforementioned values. Therefore, additional supplementation of Ca, Mg, and P are needed to ensure adequate daily intake with bulbous barley hay or mixed mostly bulbous barley-based feed. When the Ca P^{-1} ratio is over 2.00, milk fever may be observed in animals or growing performance and effectiveness of forage-animal product transformation may decrease (Jacobsen et al. 1972). Considering these determinations, bulbous barley hay did not exceed the Ca P^{-1} ratio mentioned above for all phenological stages. The K concentration of bulbous barley DM in all stages of plant development was significantly higher than that reported by the NRC (2001) for high producing cows (10 g kg^{-1} of the DM). Aydin and Uzun (2008) also reported similar findings for grasses. The K concentration was high compared to the values mentioned above and may cause problems related to mineral imbalances. For example, excess K in DM is thought to be related to grass tetany (Table 3). The risk of grass tetany dramatically increases for dams during early lactation when the K $(Ca + Mg)^{-1}$ ratio of forage exceeds 2.2 (Georgievskii 1982; Jefferson et al. 2001). Bulbous barley DM in all phenological stage was higher than the critical value and posed an evident risk of tetany. Na, Mn, and Zn (except for the Zn in autumn) content of bulbous barley DM was lower, generally, as compared to that reported by the NRC (2001).

In the present study seed production of bulbous barley was not observed during the experiment because of cutting; however, they managed to survive by producing new siblings and corms derived from thickened basal internodes. Bulbous barley produces new siblings each year; therefore, just like perennial forages the production of herbaceous vegetation was maintained during the 5-year study period. This feature of the plant should be considered a factor that increases the ability of bulbous barley to compete with weeds in the establishing year.

Bulbous barley developed rapidly and in a very productive and high quality manner in spring, but it lost its feed value because of the following prolific spring development. This phenomenon indicates that this plant should be grazed rather than used as forage. Moreover, the main factor restricting productivity is irregular precipitation throughout the year in the region. The annual-like life cycle of bulbous barley, in fact it is a perennial, produced a big advantage for this plant in utilizing the spring and autumn precipitation. Another advantage of bulbous barley is that it is less dependent on seed production to sustain its existence. Additionally, its establishment is quite easy and it grows fast after precipitation. It is also rather resistant to heavy grazing; therefore, bulbous barley can be used in degenerated rangeland for permanent pasture establishment. It is also an alternative forage crop species for improving marginal land, such as stony, hilly, and eroded areas.

In conclusion, bulbous barley had considerable yield and hay quality during the study. Additionally, it can adapt better to marginal lands than other perennials. Therefore, its potential to grow in the places where climax species have not successfully grown is high. It can be used in annual legume mixtures with the aim of putting these lands to good use. In addition, it can also be used for establishing short rotation pastures, and these pastures supply high quality feed for grazing livestock. Concerning all these aspects, bulbous barley is deserving of more research.

References

Anderson JE, Holte KE (1981) Vegetation development over 25 years without grazing on sagebrush-dominated rangeland in southeastern Idaho. J Range Manag 34: 25-29.

AOAC (1980) Official Methods of Analysis. 13th ed., Association of Official Analytical Chemists, Washington, DC.

Arzani H, Zohdi M, Fish E, Zahedi Amiri GH, Nikkhah A, Wester D (2004) Phenological effects on forage quality of five grass species. J Range Manag 57: 624-629.

Aydin I, Uzun F (2008) Potential decrease of grass tetany risk in rangelands combining N and K fertilization with MgO treatments. Eur J of Agron 29: 33-37.

El-Shatnawi MKJ, Saoub HM, Haddad NI (2004) Growth and chemical composition of wild oat (*Avena fatua*) under Mediterranean conditions. Grass and Forage Science 59: 100-103.

Georgievskii VI (1982) The physiological role of macro elements. In: Mineral Nutrition of Animals (Eds. VI Georgievskii, BN Annenkov, VT Samokhin), London, Butterworth, pp. 257-271.

Ghadaki MB, Van Soest PJ, McDowell RC, Malekpour B (1974) Composition and in-vitro digestibility of some arid zone forage from Iran. In: 12th International Grassland Congress, Moscow, 3, pp. 542-549.

Gustavsson AM, Martinsson K (2004) Seasonal variation in biochemical composition of cell walls, digestibility, morphology, growth and phenology in timothy. Eur J of Agron 20: 293-312.

Holechek JL, Pıeper RD, Herbel CH (1998) Range Management: Principles and Practices. Prentice Hall, New York.

Jacobsen DR, Hemken RW, Buton RS, Hatton RH (1972) Mineral nutrition, Ca, P, Mg and K interrelationships. J Dairy Sci 55: 935-944.

Jafari M (1993) Determination of dry matter digestibility of some rangeland species by in vitro analysis. J of Pjeuhesh and Sazandegi 18: 66-68.

Jefferson PG, Mayland HF, Asay KH, Berdahl JD (2001) Variation in mineral concentration and grass tetany potential among Russian Wild rye accessions. Crop Sci 41: 543-548.

Johnson CM, Ulrich A (1959) Analytical Methods for Use in Plant Analysis. California Agricultural Experimental Station, Bulletin 766, California.

Jones Jr (2001) Laboratory Guide for Conducting Soil Tests and Plant Analysis. CRC Press, London.

Linn JG, Martin NP (1999) Forage quality tests and interpretations. Univ. of Minnesota Ext. Ser. Publ. FO-02637, Univ. of Minnesota, St. Paul.

Little TM, Hills EJ (1978) Agricultural Experiment (Design and Analysis) John Wiley & Sons, New York.

McDonald P, Edwards RA, Greenhalgh JFD, Morgan CA (1995) Animal Nutrition. Longman Scientific & Technical, Harlow.

NRC 2001. Nutrient Requirements of Dairy Cattle. National Research Council, National Academy Press, Washington.

Ocak N, Çam MA, Kuran M (2006) The influence of pre- and post-mating protein supplementation on reproductive performance in ewes maintained on rangeland. Small Ruminant Research 64: 16-21.

Okumus A, Uzun F (2007) Genetic and geographic variation of bulbous barley (*H. bulbosum* L.) assessed by RAPD markers. Russian J of Genetics 43: 294-298.

Rowell DR (1996) Soil Science: Methods and Applications. Longman, Harlow.

Ryan J, Estefan G, Rashid A (2001) Soil and Plant Analysis Laboratory Manual. ICARDA, Aleppo.

Seligman NG (1996) Management of Mediterranean grasslands. In: The Ecology and Management of Grazing Systems (Eds. J Hodgson, AW Illius), CAB International, Wallingford, pp. 355-392.

Sternberg M, Gutman M, Perevolotsky A, Ungar ED, Kigel J (2000) Vegetation response to grazing management in a Mediterranean herbaceous community: a functional group approach. J of Applied Ecology 37: 224-237.

Undersander D, Moore JE (2008) Relative Forage Quality. Focus on Forage. Extension Service of the University of Wisconsin, Vol: 4, No: 5.

Van Soest PJ, Robertson JB, Lewis BA (1991) Methods for dietary, neutral detergent fiber, and non starch polysaccharides in relation to animal nutrition. J of Dairy Sci 74: 3583-3597.

Weintraub FC (1953) Grasses Introduced in to the United States. Agriculture Handbook. U.S. Government Printing Office, Washington.

White LM (1983) Seasonal changes in yield, digestibility, and crude of vegetative and floral tillers of two grasses. J Range Manag 36: 402-405.

Zohary M (1989) A new analytical flora of Israel. Am Oved, Tel Aviv, Israel.