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The Study of Forage Quality of *Haloxylon aphyllum* and *Eurotia ceratoides* in Different Phenological Stages

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Abstract: Information on nutritive values of each plant part in each phenological stage could help range managers choose suitable grazing times to achieve higher animal performance without detriment to vegetation. Thus, nutritive value of different plant parts of 2 species in 3 phenological stages (vegetative, flowering and seed production) from 2 sites was investigated. Species included: *Haloxylon aphyllum* and *Eurotia ceratoides*. Forage quality was evaluated based on Crude Protein (CP), Acid Detergent Fiber (ADF), Dry Matter Digestibility (DMD) and Metabolizable Energy (ME) contents. A completely randomized design with a factorial arrangement of species and phenological stage was analyzed with 5 replicates. The result of chemicals analysis indicates that there were significant differences among different phnological stages of various species in terms of their properties. As the plant ages were increased, CP, ME and DMD are decreased while ADF was increased. Significant differences were obtained between forage quality of divers species ($p<0.01$). There is not significant difference between flowering and growth stages in view point of their CP, ME, DMD and ADF, it seems that this stage could be considered as favorable time for *Haloxylon aphyllum* and *Eurotia ceratoides* utilization by livestock.

Key words: Phenological stages, forage quality, *Haloxylon aphyllum*, *Eurotia ceratoides*, performance, Iran

INTRODUCTION

Understanding the nutrient content of plant body will be a useful way for determining rangeland capacity, the most proper time of utilization of range plants, prediction of malnutrition and evaluation of nutrition requirements of plants. In order to optimum utilization of rangelands, it is necessary to consider temporal variation of forage quality. For determining forage quality, different variables are evaluated.

Information on the nutritive value of forage by phenological stage could help range managers choose suitable grazing times and stocking rates to achieve higher animal performance without damage to vegetation. Factors that affect forage quality include species, leaf to stem ratio, stage of growth, soil agents, climate, harvesting, diseases and pests (Harrocks and Valentine, 1999; Arzani *et al*., 2001). Mcdonald *et al.* (1995) reported that in early spring, digestibility of plants might reach 80% or higher and will decrease when plant growth is complete. Digestible energy, Metabolizable energy and digestibility of forage decrease whereas fiber and lignin increase with maturity of plants. Ghoorchi (1995) and Ghadaki *et al.* (1974) reported reduction of Crude Protein (CP) and digestibility of forage when plants matured; however, percentages of Acid Detergent Fiber (ADF) and Neutral Detergent Fiber (NDF) increased. Differences among ratios of plant parts in different phenological stages were reported by Jafari (1993).

Assessment of the nutritive value of pastures is mainly concerned with the supply of energy, protein and minerals. Among various common chemical determinations of plant materials, CP, DMD and ME are mainly considered for evaluation of forage quality (Cook and Stubbendieck, 1986; Minson, 1987; Rhodes and Sharrow, 1990; Arzani *et al*., 2004).

Walton (1983) stated that digestibility is frequently considered to be the most valuable estimate of forage quality, since it is closely associated with animal productivity.

Digestibility may be related to dry matter, energy or to any component of the nutrient material available in the feed (Van Soest, 1982). In this study, the forage quality of 2 woody plant in 3 phenological stages (vegetative, flowering and completed growth) was determined and compared.

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MATERIALS AND METHODS

The study was conducted at 2 study areas: The Sisab region is located in North East of Iran (North Khorasan province) 35 km east of Bojnourd city and other area is reforest region of Sabzevar suburbs city. Sabzevar region is situated between 57°40'30" East longitudes and 45°20'45" North latitude. The altitude of the area is 750 m. The mean annual rainfall is 209.6 mm and the median annual temperature is 17.5°C. The climate of this region with using of Demartonne method is arid. Sisab region is situated between 57°27'20" East longitudes and 37°28'15" North latitude. The altitude of the area is 1570 m. The mean annual rainfall is 250 mm and the median annual temperature is 12.2°C. The climate of this region with using of Demartonne method is semi-arid.

Samples were collected in 3 phenological stages: primary growth (rapid growth, vegetative), flowering and seed production (plant growth completed). At each site, 5 points were randomly selected for sample collections of each species. Plant parts were collected, oven dried at 70°C for 24 h and weighed. Finally, samples were ground by a mill and passed through a 0.5 mm sieve for chemical analysis. *Haloxylon aphyllum* and *Eurotia ceratoides* species were selected for study. These species are observed in most dry rangelands of Iran are relatively palatable to domestic grazing animals and are able to regrow after grazing or harvesting. They belong to the family of Chenopodiaceae.

CP was calculated on the basis of nitrogen percentage (N% 6.25) measured by the Kjeldahl technique (AOAC, 1980). It was multiplied by a factor of 10 to convert to grams per kilogram. ADF was measured with the fiber tech system (AOAC, 1980). Dry matter digestibility was estimated by the formula DMD% = 83.58-0.824ADF% +2.626N% suggested by Oddy *et al*. (1983). Metabolically energy was predicted with the equation ME = 0.17DMD%-2 suggested by AOAC (1980). Effects of species and phenological stage were analyzed in a factorial arrangement of a completely randomized design with 5 replications of each species collected for each stage at each site.

Each plant yielded information on 2 (leaf and stem in phenological stages 1, 2 and 3) or 3 (leaf, stem and flower in stages 2 and 3) plant parts, thus plant part was included in the analysis as a subplot factor in a split plot arrangement. Locations were combined into 1 analysis following Cochran and Cox (1957). When factors interacted, simple effects were analyzed with a least significant difference test. Analysis of Variance (ANOVA) was used to determine the existence of differences in chemical composition of species and life forms.

Comparison of the species effect and phenological stages were carried out using Minitab statistical package. Duncan method was also used for comparison and grouping of nutrients.

RESULTS AND DISCUSSION

Based on the comparison of nutrient mean content (Table 1) the following results are suggested: significant differences were obtained between forage quality of *Eurotia ceratoides* and *Haloxylon aphyllum* species ($p<0.01$).

Crude protein: the results showed that there is a significant difference in protein content among growth stages of *Eurotia ceratoides* ($p<0.05$). The highest protein content was 13.36% in vegetative growth stage and the lowest value 10.15% was in seed ripening stage. The crude protein content of flowering stage was 11.58%. The results showed that crude protein among of *Haloxylon aphyllum* at vegetative growth stage and flowering stage were not significantly different but Seed ripening stage was significantly different ($p<0.01$) from vegetative growth and flowering stages. According to the results, significant differences were no observed among effect the species and phenological stages for CP contents. Figure 1 shows the measured protein content in 3 phenological stages.

ADF: The results revealed that the ADF percentage of *Eurotia ceratoides* the significant difference in different stages of plant growth ($p<0.05$). The highest ADF percentage was 30.50% in flowering stage and the lowest value (24.20%) was in vegetative growth stage. The ADF percentage of seed ripening stage was 26.4%. The results

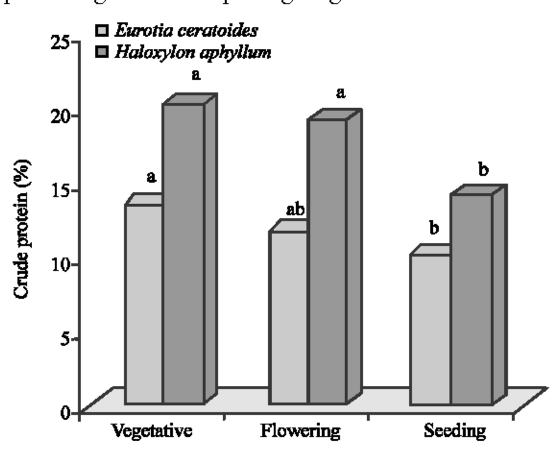

Fig. 1: Comparison of protein content in 3 vegetative growth stages

Table 1: The results of variance analysis (crude protein (CP), acid detergent fiber (ADF), dry matter digestibility (DMD) and Metabolizable Energy (ME) contents of forage species in different phenological stages

Properties	Treatment (source)	DF	Seq SS	Adj MS	F
Crude protein	Species	1	281.9830	281.9830	62.83**
	Stages	2	116.1570	58.0790	12.94**
	Species* stages	2	18.9900	9.4950	2.12^{NS}
	Error	20	89.7610	4.4880	
	Total	29	510.7450		
ADF	Species	1	2511.4500	2511.4500	182.89**
	Stages	2	54.4500	27.2300	1.98^{NS}
	Species* stages	2	171.0800	85.5400	6.23**
	Error	20	274.6500	13.7300	
	Total	29	3034.1700		
DMD	Species	1	2337.7100	2337.7100	202.73**
	Stages	2	61.3200	30.6600	2.66^{NS}
	Species* stages	2	131.1500	65.5800	5.69*
	Error	20	230.6300	11.5300	
	Total	29	2771.6800		
ME	Species	1	67.5485	67.5485	202.74**
	Stages	2	1.7730	0.8865	2.66^{NS}
	Species* stages	2	3.7914	1.8957	5.69*
	Error	20	6.6635	0.3332	
	Total	29	80.0917		

*Significant in 0.05, **Significant in 0.01, NS = Not Significant

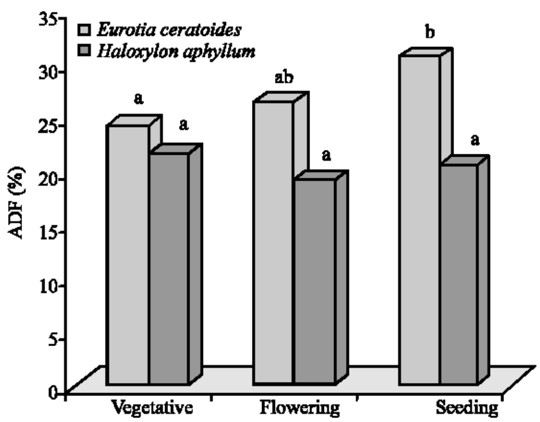

Fig. 2: Comparison of ADF (%) in 3 vegetative growth stages

indicated that the ADF percentage of *Haloxylon aphyllum* was not significantly different in 3 phenological stages. The highest ADF percentage was 21.61% in vegetative growth stage and the lowest value (19.02%) was in flowering stage.

The ADF percentage of Seed ripening stage was 20.32%. There were significant differences between effect the species and phenological stages for ADF contents (p<0.01). Figure 2 shows ADF (%) of the plants in different phenological stages.

Percentage of Digestible Dry Matter (DMD): The results of statistical analysis showed that DMD content of plant tissues of *Eurotia ceratoides* in different vegetative stages have significant differences (p<0.05). So, the

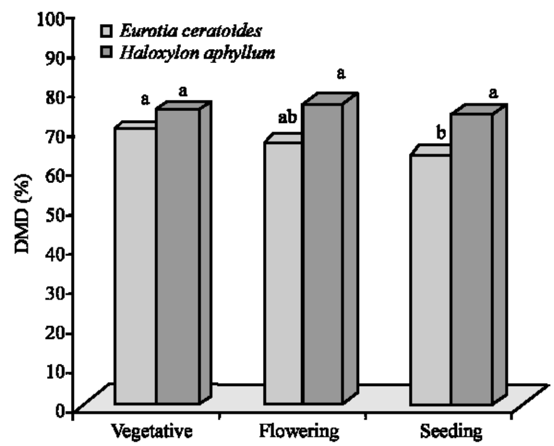

Fig. 3: Comparison of DMD content in three vegetative growth stages

highest value of DMD (%) in vegetative growth stage was 69.26% and the lowest value in flowering stage was 63.31%. DMD content of fruits was also 66.10%. No significant difference was observed in DMD content of *Haloxylon aphyllum* species (Fig. 3). According to the results, significant differences were observed among effect the species and phenological stages for DMD contents (p<0.05).

Metabolic Energy (ME): The ME content in different vegetative stages of *Eurotia ceratoides* species shows significant differences (p<0.05). The highest value of ME in vegetative stage was 9.77% while the lowest value in flowering period was 8.76%. Furthermore, the ME of fruit

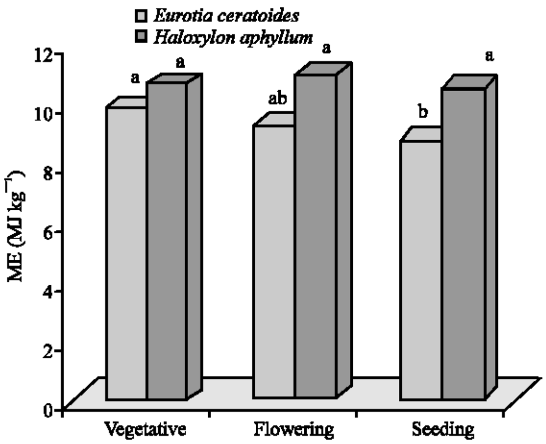

Fig. 4: Comparison of ME content in three vegetative growth stages *Means in columns of the same color in a species and phenological stages with different superscripts (a-c) are different ($p<0.05$)

was measured 9.23%. Figure 4 shows the average value of ME in tissues of the plant in various phenological stages. No significant difference was observed in ME content of *Haloxylon aphyllum* species (Fig. 3). According to the results, significant differences were observed among effect the species and phenological stages for ME contents ($p<0.05$).

Arid and semi-arid regions of Iran have diverse and rich collection of plants. Vegetation cover of such regions has high resistance to difficult environmental condition. Also, the forage, nutritional, industrial, medicinal and conservative values of these plants are of high importance. The nutrient value of range forage depends on plant composition and stage of growth. The close matching of nutrients requirements and feed quality is necessary for efficient animal production. This study suggests that adequate nutrients are available in vegetation communities including the evaluated species.

Range forage quality has spatial and temporary variations. The chemical analysis of range forage plants serves as a comparative measure of differences between species and changes with season or phenology. Rangelands of Sabzevar in poor condition usually supply livestock during fall and winter. However, forage quality declines as plants mature.

The results showed the evaluated forage species had different nutritive values. As Cook and Stubbendieck (1986) reported the chemical content of plant species may differ because of an inherent ability to withdraw certain nutrients from the soil and to concentrate them in tissues. Plants may also vary in susceptibility to leaching or may produce different proportions of leaves, stems and flower stalks at various stages of maturity or because of previous grazing treatments (Arzani, 1994; Ghodsi Rasi and Arzani, 1997; Arzani *et al*., 2004).

Seasonal changes of CP during different phenological stages were reported by White (1983), Akbarinia and Koocheki (1992) and Arzani *et al*. (1998). They found that when plants became older, CP declined. In this study, CP of *Eurotia ceratoides* and *Haloxylon aphyllum* species was different between phenological stages. The comparison of crude protein content of the plants indicates the decreasing trend of protein to 24.01 and 30.58% during the plant development stages, respectively. The average content of measured crude protein of *Eurotia ceratoides* and *Haloxylon aphyllum* species showed 11.7 and 17.83% in three vegetative growth stages which confirms the results of research conducted by Azarnivand (1998). This fact indicates the high value of protein in *Eurotia ceratoides* and *Haloxylon aphyllum* and shows the forage values of the plants for livestock feeding.

Plants had CP content above 10%. So considering NRC (1985) these plants meet sheep nutrition requirements for maintenance and protein is not a limiting nutrient factor for livestock production that include such vegetation composition. El-Shatnawi and Mohawesh (2000) suggested that ewes require 7-9% CP for maintenance and 10-12% for lactation. Adequate CP content of forage for dry mature cows was cited as >5.9% by White (1983). Based on ranges of CP values recommended for maintenance of many wild and domestic herbivores by French *et al*. (1955), Thorne *et al*. (1976), Schwartz *et al*. (1977) and NRC (1978, 1981, 1984); 7.5% CP was accepted as an adequate forage quality threshold by Ganskopp and Bohnert (2001).

The results of measured ADF of *Eurotia ceratoides* showed significant differences in phenological stages. Also, ADF showed an increasing trend (18.37%) during the development stages which is in accordance with the results of Baghestani Meybodi (2003) but ADF of *Haloxylon aphyllum* was not different in phenological stages. Muqaddam (1998) reported that the nutrient value of bushy trees and woody plant lower change than of forbs and grasses.

In contrast, bushy trees and woody plant have a longer growing season and maintain their nutritive values longer and some evergreen shrubs remain highly nutritious year round. Shrubs may play an important role in meeting the grazing animal's needs for protein and vitamins when herbaceous forage is dormant or lacking in these components. Dry matter digestibility of plant parts mainly decreased with growth progress and DMD for

Eurotia ceratoides in phenological stages were different. This agreed with results obtained by Akbarinia and Koocheki (1992). They reported that a reduction of DMD with maturity of plants is due to increasing structural tissues in stems. Pinkerton (1996) also reported a close relationship between digestibility and cell wall characteristics. In contrast, the chemical structure of cell walls changes with plant growth. As plant growth continues, fiber content increases and digestibility decreases. Reduction of digestibility in matured plants also was reported by Kashki (2001) and Linn and Kuehn (1994). There was no different DMD content of *Haloxylon aphyllum* species in phenological stages.

In the experiment for different species DMD values of forages are above 60%. Generally, about 50% digestibility is sufficient for animal maintenance (Victor, 1981; White, 1983; Gonzalez-Hernandez and Silva-Pando, 1999). The results of measured ME showed significant differences for *Eurotia ceratoides* in phenological stages.

Information on ME content could guide range managers to estimate forage requirements of grazing animals based on energy required for particular physiological status. The basic energy requirement for maintenance of sheep is derived from the metabolic weight relationship: Kcal required = $70W^{0.75}$ where W is the weight of animal in kilograms (Stoddart *et al*., 1975).

CONCLUSION

The nutrient value of range forage depends on plant composition and stage of growth. The close matching of nutrients requirements and feed quality is necessary for efficient animal production. This study suggests that adequate nutrients are available in vegetation communities including the evaluated species. However, most vegetation communities of Sabzevar and Sisab are classified as poor condition because of severe overgrazing (MAIR, 1988).

Therefore in their improvement plans, grazing strategies should be developed to reduce pressure on plant species and to improve botanical composition of grazing area. We suggest that rangelands with a diversity of good forage quality species that exploit all levels of the soil profile will provide adequate forage quality for longer time periods than rangeland with poor diversity. Due to diversity of native plant communities and limitation in time, cost and variety of factors indicating forage quality based on relationship between factors investigated in this experiment and also finding of Kaboli (2001), N and ADF are the best factors that should be measured for nutritive evaluation of forage.

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