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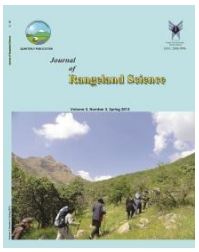

Full Length Article:

Variations in Forage Quality of Two Halophyte Species, *Camphorosma monspeliaca* and *Limonium iranicum* at Three Phenological Stages

Abbas Ahmadi[A], Masoud Gomarian[B], Mojdeh Sanjari[C]

[A]Department of Desert Management, Islamic Azad University, Arak Branch, Arak, Iran. (Corresponding Author). Email: a-ahmadi@iau-arak.ac.ir
[B]Department of Agronomy and Plant Breeding, Islamic Azad University, Arak Branch, Arak, Iran.
[C]M.Sc Student of Desert Management, Islamic Azad University, Arak Branch, Arak, Iran.

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Abstract. This study was conducted to compare forage quality of two native halophyte species *Camphorosma monspeliaca* and *Limonium iranicum* collected from Meighan saline rangelands near Arak city in center of Iran. Edible biomass of both species was sampled on three phonological stages (vegetative growth, full flowering and seed ripening). Forage quality indices such as Crude Protein (CP), Dry Matter Digestibility (DMD), Dry Matter Intake (DMI), Metabolizable Energy (ME), Acid Detergent Fiber (ADF), Neutral Detergent Fiber (NDF) and Phosphorus (P) were evaluated. The results indicated there were significant differences ($p<0.01$) between species and phenological stages. *L. iranicum* had the highest CP (14.62%) in vegetative stage while *C. monspeliaca* had the lowest CP (5.39%) in flowering stage. *C. monspeliaca* also exhibited the highest Relative Feeding Values (RFV=135.9), which was significantly different from those of *L. iranicum*. In both species, the CP, DMD and ME were decreased with progressing phonological stages while ADF and NDF, increased. Our findings showed that these halophyte species contain reasonable CP level which could provide N requirements of grazing animals whereas Phosphorus was deficient for sheep, suggesting supplementary feeding. The results support the good potential of halophytes and salt tolerant plants as source of livestock fodders and arid and semi-arid rangelands improvement.

Key words: Forage quality, Phenological stages, Halophytes, Relative feeding value

1. Introduction

There are about 163 halophyte and salt tolerant species in Iran which 53% of them belong to Chenopodiaceae family (Jafari, 1994). These plants play an important role as feed resources for livestock in saline marginal rangelands of central Iran. Saline areas and marginal rangelands that covered with halophyte shrubs, has a great role in supply forage for livestock as winter rangelands (Ahmadi and Sanadgol, 2010). Halophytes and salt-tolerant forages yield low to high edible biomass in saline lands where non halophyte species cannot grow (El- Shaer, 2010). Halophyte plant species vary considerably in their nutritive value. Information on forage quality of halophytes in each phenological stage could help range managers choose suitable plant species for cultivation and also determine suitable grazing time to achieve higher animal performance in saline rangelands (Esfahan *et al.*, 2010). Knowledge of the nutrient content of forage is useful for the determination of rangeland capacity and the appropriate timing for the entrance of animals in rangeland (Sharifi Rad *et al.*, 2013). In addition, knowledge of the nutritional value of forage in different phenological stages can be helpful for range managers to select suitable grazing times and stocking rates to extract maximum performance without damaging the existing vegetation (Asaadi and Dadkhah, 2010).

Factors that affect forage quality include species, growth stage, leaf-to-stem ratio, soil agents, climate, harvesting, diseases and pests (Arzani *et al.*, 2001). The most important factor influencing forage quality is growth stage (Ahmadi *et al.*, 2005). Among various common chemical determinations of plant materials, Crude Protein (CP), Dry Matter Digestibility (DMD), and Metabolizable Energy (ME) are mainly considered for evaluation of forage quality (Arzani *et al.*, 2004).

The potential feeding value and the nutritive characteristics of available browses in the natural rangelands of salty arid regions remains poorly investigated (Haddi *et al.*, 2009). So, the objective of this study was to assess the forage quality of two halophyte species growing in Meighan saline rangelands, Arak, Iran.

2. Materials and Methods

The research was conducted at marginal rangelands of Meighan playa near Arak, Iran (49° 50' E and 34° 9' N), at an elevation of 1650 m (Fig. 1). The long-term annual average rainfall in the area is 261 mm and the mean air temperature is 14°C. The site is characterized by flat topography and halophytes and salt tolerant botanical composition. The climate of the area is characterized as semi-arid with cold winters. The soil texture is clay to sandy- clay- loam. Plant samples were harvested from two species of Meighan saline rangelands included:

Camphorosma monspeliaca (Chenopodiaceae) and *Limonium iranicum* (Plumbaginaceae). These plants are relatively palatable for domestic animals (sheep and goats). Edible biomass of both species were sampled by clipping the above-ground biomass at a height of 2 cm above-ground level on three phonological stages (vegetative growth, full flowering and seed ripening).

All samples were oven-dried to 70°C for 24 h, milled to pass through a 0.5 mm screen and kept for subsequent chemical analyses (AOAC, 1990). For forage quality evaluation, CP, DMD and ME, DMI, ADF, NDF and phosphorus were determined. CP was determined by the Kjeldahl method (N x 6.25), NDF and ADF was measured by Van Soest (1963). DMD was estimated using Oddy *et al.* (1983) (Equation 1): as

DMD%=83.58−0.824ADF%+2.626N%

The ME was predicted with the (Equation 2).

ME= 0.17 DMD% -2, (AOAC, 1990). The Relative Feeding Value (RFV) was

calculated as DMD multiplied by Dry Matter Intake (DMI) divided by 1.29 (Undersander and Moore, 2008).

The collected data were statistically analyzed using a split plots design based on completely randomized design with three replications. Two factors were phenological stages and species. The means comparisons were made using DMRT method using SAS software.

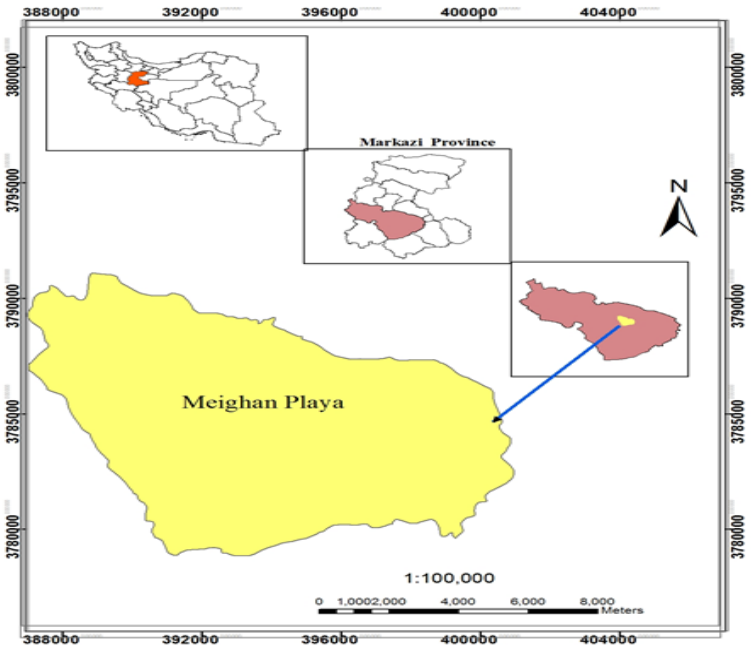

Fig. 1. The geographical location of study area

3. Results

The results of analysis of variance showed significant differences ($p<0.01$) between species and phenological stages (Table 1). *L. iranicum* had the highest CP (14.62%) in vegetative stage while *C. monspeliaca* had the lowest one (5.39%) in flowering stage. In both species, the values of CP, DMD and ME decreased with progressing phonological stages while ADF and NDF, increased (except for seed ripening stage of *C. monspeliaca*. For phosphorus contents the *C. monspeliaca* had higher phosphorus values (0.08%) than that the other species. There were also significant differences for ME and DMI between species in which *C. monspeliaca* had the higher ME but *L. iranicum* had higher DMI. In addition, the maximum values of DMD were belonged to *L. iranicum* in vegetative stage (67.33%).

Table 1. The interaction effects between phenological stage and two forage species in quality traits

Species name	Phenological stage	CP%	ADF%	NDF%	P%	DMD%	ME5%	DMI	RFV
C. monspeliaca	Vegetative	11.43^{b}	30.64^{e}	41.93^{d}	0.070^{d}	65.03^{b}	9.05^{b}	2.86^{c}	144.26^{c}
	Flowering	5.39^{f}	37.89^{c}	47.60^{c}	0.077^{c}	59.38^{d}	8.09^{d}	2.52^{d}	116.05^{d}
	Ripening	5.61^{e}	31.63^{d}	40.53^{e}	0.100^{a}	64.26^{c}	8.92^{c}	2.96^{b}	147.48^{b}
L. iranicum	Vegetative	14.62^{a}	27.68^{f}	23.92^{f}	0.060^{e}	67.33^{a}	9.44^{a}	5.01^{a}	261.81^{a}
	Flowering	8.57^{d}	54.68^{b}	56.15^{b}	0.079^{b}	46.30^{e}	5.87^{e}	2.13^{e}	76.71^{e}
	Ripening	10.51^{c}	72.34^{a}	72.65^{a}	0.077^{c}	32.54^{f}	3.53^{f}	1.65^{f}	41.67^{f}

Different letters indicate significant differences at ($P < 0.01$)

4. Discussion

The fodder quality of halophytes plants depends on a combination of climate, soil, and plant factors. Halophytes have the advantage of tolerating high salt levels in the saline lands and have economic potentialities in the arid and semi-arid areas (Zahran, 1993; El Shaer, 1999). These authors, also, reported that with advancing maturity of halophytes, the contents of silica, Cell Wall Constituents (CWC), cellulose and lignin increased while CP, phosphorus and gross energy decreased. The reduction in the rate of DMD was associated with plant aging is likely due to the increase of the proportions of structural to non-structural carbohydrates. Arzani *et al.* (2006) also reported that with progress of plant growth, structural carbohydrates such as celluloses, hemicelluloses and lignin, are increased. Therefore, maturity of plants and an increase in structural carbohydrates cause higher fiber amounts in forage.

The results of present study showed that with progressing growth stage, CP, DMD and ME were reduced. The results are similar with results obtained by (Panahi *et al.*, 2012; Arzani *et al.*, 2004; El-Shaer, 2010; Uzun, 2010, Esfahan *et al.*, 2010; Ahmadi *et al.*, 2005). According to Arzani *et al.* (2004), reduction the DMD and ME with maturity of plants is due to increasing structural tissues in stems. Of course, DMD and ME of *C. monspeliaca* was higher in seed ripening stage; Arzani *et al*. (2004) and Panahi *et al*. (2012) stated that increasing DMD and ME in some species when seeds are matured is due to relatively high amounts of digestible carbohydrates in seeds.

ADF and NDF contents increased with plant maturity, too. Panahi *et al.* (2012) also reported that ADF and NDF increased with plant growth in three *Salsola* species.

Sharifi Rad *et al.* (2013) believed that quality and nutritional value are directly related to CP, DMD and ME in plants and tend to show opposing trends to ADF and CF that it agreed with our results. In this study, forage quality was highest when both halophytic species were in the vegetative stage, decreasing dramatically as the plants matured. Based on RVF, *C. monspeliaca* had higher forage quality than *L. iranicum* in flowering and seed ripening stage. Uzun (2010) found that RFV of *Hordeum bulbosum* was significantly affected by the stage of maturity; as the plant matured RFV decreased. Supplementary feeding, particularly with energy supplements, is recommended for small ruminants grazing such halophytes during dry seasons and prolonged drought period (El Shaer, 2010). *L. iranicum* had higher CP level which could cover N requirements of grazing animals. In our study, CP and ME contents were sufficient to meet ewes maintenance and lactation requirements during any time of the year. Phosphorus was deficient for ewes, suggesting supplements would be necessary to adjust the high Ca/P ratio in their diet. Ewes require 7 to 9% CP for maintenance and 10 to 12% for lactation. They also need 0.15% to 0.20% P for maintenance and 0.25 to 0.30% for lactation (Holechek *et al.*, 2001). El-Shantawi and Mohawesh (2000) reported that the introduction of saltbush (*Atriplex halimus* L.) into semiarid grassland of Jordan would elevate the nutritive plain of livestock and possibly minimize the need for grain supplements during summer and autumn.

The nutrient value of rangeland 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. Results indicates the high potential of marginal rangelands of playas in supply forage for endemic races

of goats and sheep in central deserts of Iran especially in autumn and winter as the most suitable period for animal grazing. The results support the good potential of halophytes and salt tolerant plants as source of livestock fodders and arid and semi-arid rangelands improvement. Many halophytes could be considered as potential sources of Nitrogen and or major minerals for sheep and goats fed on low quality diets. However, energy supplementation of halophytes-containing diets is necessary to overcome nutrient requirements of animals. Such salt-tolerant plants could be used successfully and safely as good quality winter fodders to solve the problems of feed shortage during summer and autumn seasons and, also, to increase the economical benefits of the marginal saline resources in Iran for local communities that needs to be further explored and developed.

5. Acknowledgment

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تغییرات در کیفیت علوفه دو گونه شورپسند، *Camphorosma monspeliaca* و *Limonium iranicum* در سه مرحله رشد فنولوژیکی

عباس احمدی[الف]، مسعود گماریان[ب]، حمید ترنج زر[ج]، معصومه سنجری[د]

[الف] دانشگاه آزاد اسلامی، واحد اراک، گروه مدیریت مناطق بیابانی، اراک، ایران (نگارنده مسئول). پست الکترونیک a-ahmadi@iau-arak.ac.ir

[ب] دانشگاه آزاد اسلامی، واحد اراک، گروه زراعت و اصلاح نباتات، اراک، ایران

[ج] دانشگاه آزاد اسلامی، واحد اراک، گروه مدیریت مناطق بیابانی، اراک، ایران

[د] دانشجوی کارشناسی ارشد مدیریت مناطق بیابانی، دانشگاه آزاد اسلامی، واحد اراک، ایران

چکیده. این مطالعه به منظور مقایسه کیفیت علوفه دو گونه شورپسند بومی مراتع شورروی کویر میقان اراک شامل ***Camphorosma monspeliaca*** و ***Limonium iranicum*** انجام گرفت. زی توده هوایی این گونه‌ها در سه مرحله رشد فنولوژیکی (رشد رویشی، گلدهی کامل و رسیدن بذر) جمع‌آوری گردید. شاخص‌های کیفیت علوفه شامل پروتئین خام (CP)، درصد ماده خشک قابل هضم (DMD)، درصد ماده خشک مصرفی(DMI)، دیواره سلولی عاری از همی سلولز (ADF)، دیواره سلولی عاری از همی سلولز (NDF)، انرژی متابولیسمی (ME)، فسفر و ارزش غذایی نسبی (RFV) برای گونه‌های مختلف تعیین گردید. نتایج حاکی از وجود اختلاف معنی‌دار بین گونه‌های مورد مطالعه و مراحل مختلف رشد فنولوژیکی بود. گونه ***L. iranicum*** دارای بیشترین میزان پروتئین خام در مرحله رشد رویشی (۱۴/۶۲ درصد) بود، در حالی که گونه ***C. monspeliaca*** در مرحله گلدهی کمترین میزان پروتئین (۵/۳۹ درصد) را دارا بود. همچنین بیشترین ارزش غذایی نسبی (۱۳۵/۹) برای گونه ***C. monspeliaca*** محاسبه گردید که به طور معنی داری با گونه ***L. iranicum*** تفاوت داشت. در هردو گونه شاخص های CP، DMD و ME با پیشرفت مراحل فنولوژی کاهش و شاخص های ADF و NDF افزایش یافتند. یافته‌های این تحقیق نشان داد که گونه‌های شورپسند محتوی سطوح قابل اطمینانی از پروتئین هستند که قادر است میزان ازت مورد نیاز دام چرا کننده را تأمین نماید اما میزان فسفر برای گوسفند ناکافی بوده و بر ضرورت استفاده از مکمل‌های غذایی تأکید می‌شود. نتایج همچنین قابلیت خوب گیاهان شورپسند و مقاوم به شوری را به عنوان منبع علوفه دام و نیز اصلاح و احیای مراتع خشک و نیمه خشک تبیین می‌نماید.

کلمات کلیدی: کیفیت علوفه، مراحل رشد فنولوژیکی، گیاهان شورپسند، ارزش غذایی نسبی