academicJournals

Vol. 8(33), pp. 4396-4401, 29 August, 2013
DOI: 10.5897/AJAR12.574
ISSN 1991-637X ©2013 Academic Journals
http://www.academicjournals.org/AJAR

African Journal of Agricultural Research

Full Length Research Paper

Investigation and comparison of the nutritional value and forage quality indicators in some rangeland's species at different vegetation forms from Kashan Province of Iran

Reza Dehghani Bidgoli[1]*, Gholam Ali Heshmati[1] and Marzieh Yousefi Najafabadi[2]

[1]Department of Rangeland Management, Gorgan University of Agricultural Sciences and Natural Resources, Gorgan 1573949138, Iran.
[2]Abouriham Campus, the University of Tehran, Pakdasht 3391653755, Iran.

Accepted 24 July, 2013

Information on different rangeland plants' nutritive values at various phonological stages is important in rangelands management. This information helps rangeland managers to choose proper grazing times to achieve higher animal performance without detrimental effects on the rangeland vegetations. Effects of various plant parts' phonological stages and vegetation types on reserve carbohydrates and forage quality indicators were investigated during the 2009 and 2010. Plant samples were collected in a completely randomized block (CRB) design. The species included, grasses (*Secale montanum* and *Festuco ovina*), forbs (*Lotus corniculatus* and *Sanguisorba minor*), and shrubs (*Kochia prosterata* and *Salsola rigida*). Aerial plant parts' samples were oven-dried at 80°C for 24 h, then analyzed for soluble carbohydrates, crude protein (CP), acid detergent fiber (ADF), dry matter digestible (DMD), and metabolizable energy (ME). Results showed that plants at the seedling stage had more reserve carbohydrates than the other, also from the three vegetation types (grass, forbs, and shrub), forbs contained more soluble carbohydrates than other vegetation types. Differences in soluble carbohydrate contents of different species at various phonological stages in 2 years were statistically significant. The forage quality indicators (CP, ADF, DMD, and ME) in the different species and in different vegetation types, were statistically significant at 2 years, except for the CP.

Key words: Grazing, soluble carbohydrate, protein, fiber, metabolizeable energy.

INTRODUCTION

Study of the chemical compounds in rangeland plants used for livestock feed, and information on the effects of the environmental conditions on changing these compounds are very important in rangelands management. Also, information on the forage feed value is essential for rangelands management because the forage feed value varies in different conditions (Biondini et al., 2006; Graza and Fulbright, 2008; Low and Andrews, 2007; Dongmei et al., 2005). On the other hand, the nutritional needs of the animals are different in various

*Corresponding author. E-mail: bidgol.r@gmail.com.

environmental conditions and at different physiological stages (McDowell, 2005; Norton and Waterfall, 2003; Shinde et al., 2000; Underwood, 2001).

Researchers believe that several factors affect the forage feed value. Sulc et al. (2009), Ayan et al. (2010), and White (2003) reported that the most important factor forchange in the forage feed value is the vegetation covers' growth stage, and the forage plants have different feed values at various phonological stages. Oddy et al. (1993) and Larbi et al. (2011) stated that the movement of the plant nutrients from the leaves and stems to roots and seeds is important for changes in forage feed value. Different rangeland plant species have been studied by several researchers and all of these investigators have reported that the differences in forage feed values in various plant species resulted in differences in plant metabolisms (Coyne and Cook, 1991; Davidson and Milthorpe, 1995; Graber, 1991; Deregibus et al., 2002; Hyder and Sneva, 2003). Different factors that affect forage feed values such as crude protein (CP), acid detergent fiber (ADF), neutral detergent fibre (NDF), and metabolizable energy (ME), have been studied by several investigators (Menke and Trlica, 1985, 1993; Moore and Biddingscomb, 1994; Orodho et al., 2000). Information on the compounds that provide food reserves in plants is very important for rangeland managers. The knowledge of how these compounds are made in plants and in which plant parts are concentrated more can be a great help in identifying the appropriate grazing time, number of grazing livestock, and the length of the grazing period. The lack of information and awareness may cause irreparable and irreversible damage to the rangeland plants. Physiological changes in different plants are different because various species in terms of growth rate, germination, type of the leaves, stems, roots, height, are different from each other. This is essential in a time that the rangeland management is based on the carbohydrate reserve and plant energy providing capability. Therefore, knowledge of carbohydrate production, transport, storage and use in plants can help the rangeland managers to take proper care of the pasture plant species (Mikic et al., 2010; Richards and Caldwell, 2005). The most important information for the balance in stoking rate and rangelands capacity is probably the knowledge about the forage quality and to determine the capacity of a pasture. It is required to determine the forage nutritive value, because animal performance in the grazing season has direct relationship with forage feed value. This information helps the rangeland managers to balance between the available forage and the animal's nutrition needs, and use these factors enable them to obtain maximum animal performance. The forage quality and its feed value in plants are affected by several factors, including vegetation stages, grazing intensity, and plant species. Therefore, the objective of this study was to compare various desert rangeland vegetation types (grasses, forbs, and shrubs) in terms of their nutritive values and forage quality at different phonological stages of growth.

MATERIALS AND METHODS

Plant materials and sample collections

In this study, 6 plant species that were harvested from Kashan rangelans of Iran were investigated. The species included, 2 grasses (*Secale montanum* and *Festuco ovina*), 2 forbs (*Lotus corniculatus* and *Sanguisorba minor*), and 2 shrubs (*Kochia prosterata* and *Salsola rigida*). Each plot species was replicated 5 times and each replicated plot contained 5 plants. Therefore, for each species 25 plants were selected (each 5 plants were considered one replication). Plant species were harvested from the natural rangeland habitats. The samples were dried in the shade at room temperature. As the respiration and photosynthesis in clipped plants continue after the clipping for a few minutes and this affects the soluble carbohydrates in order to measure their soluble carbohydrates' contents, the plant materials should have either been dried immediately or stored in a cool place. Therefore, the mobile freezer was used, and the frozen plant samples were used for chemical analysis. Then, plant materials were put in the oven and dried at 80°C for 24 h, except the plant samples that were used for the forage quality analysis which were dried in the room temperature. All the plant materials were ground. The plant sampling dates in the 2 years were different, because the plants started their growth with a few days late in the second year. The following measurements were performed on the samples.

Measurement of the chemical compounds

For the measurement of the soluble carbohydrates, the Phenol-H_2SO_4 (Sulphuric acid) method was used. In this method, 0.5 g dried plant sample was taken and 15 ml Ethanol 80% was added to it, heated at 75°C for 5 min by a heater, then centrifuged at 3000 rpm for 10 min. Then, the centrifuge was turned off and the clear solution in the flask was separated. This was repeated for 2 replications. The aliquots taken from these 2 replications were mixed and put in an oven at 70-80°C. After 1 h, its volume was raised to 100 ml by adding distilled water. Then, 4.7 ml $Ba(OH)_2$ (Barium hydroxide) was added to it. After 3 min, 5 ml $ZnSO_4$ (Zinc sulfide) was added to it and thoroughly mixed. A 35 ml of this thoroughly mixed solution was centrifuged at 3000 rpm for 10 min and 2 ml of this aliquot was used for Spectrophotometry at 485 nm (nana-meter). In this study, 2 ml H_2O and 2 ml H_2SO_4 were used for control. Data obtained with this method were on ppm (mg L^{-1}) units and the following formula was used to convert the data to carbohydrate in the plant dry mater.

$$\%C = (V/106.DM)*100$$

Where, C is the soluble carbohydrates, V is the volume of the soluble carbohydrates that was obtained by spectrophotometry in ppm (mg kg^{-1}), and DM is grams (g) dry mater that was used for soluble carbohydrates measurement by this method.

Measurement of the CP (crude protein)

Measurement of the CP in these plant species was conducted by evaluation of the N content of the plants, assuming that all the proteins in the plants contained 16% nitrogen (16% N) and all the nitrogen was used for protein synthesis. Then, the following formula (Bidlock and Devald, 1999) was used to calculate the CP.

$$CP\% = 100/16* \%N = 6.25*\%N$$

Bidlock and Devald (1999) stated that this formula includes the non-protein nitrogen too, thus, the amount of the calculated protein by

Table 1. Analysis of variance of forage quality indicators.

Years	Variable sources	df	Mean squares			
			CP%	DMD%	ME%	ADF%
2009	SP	4	247.7**	735.5**	7.6**	495.8**
	Ps(SP)	11	144.9**	211.4**	5.8**	169.5**
	Error	70	0.431	1.02	0.731	1.12
	CV%	-	4.91	2.54	6.49	1.51
2010	SP	3	140.6**	520.6**	14.4**	266.5**
	Ps(SP)	10	145.2**	122.7**	2.6**	66.9**
	Error	42	0.124	0.281	0.107	0.169
	CV%	-	2.66	1.62	2.24	0.48

**: Significant at the 1% probability level, SP: Species, PS: Phonological stages, CV%: Coefficient of variation.

this formula is more than the actual protein. Therefore, measurement of the CP content of the plants by this formula is over estimated. This method is known as Kjeldahl 2. *2-4- Measurement of the ADF (Acid Detergent Fiber)* To measure the ADF content of the plants, the Fibertec was used. For this purpose, 1 g of the ground sample was put into glass tubes in the Fibertec. Then, 100 ml ADS (Acid Detergent Solution) was added and boiled for 1 h. For preparation of the ADS, 20 g $BrNH_4(CH_3)_3$ (Three methyl bromide) was mixed with 10 ml H_2SO_4 (Sulfuric acid). After 1 h, all the substances in the solution were disappeared, except the cellulose, lignin, and the minerals. Then, the samples were washed with distilled water and acetone in the cold extraction device and placed in the oven at 120°C for 2 hours. Afterwards, the sample weights were measured with a digital scale (LDG3015ST LG, Korea), and the samples were put in an electric furnace (WEFC series, China) at 500°C for 3 h. In the electric furnace, all of the sample's cellulose and lignin were burnt and only the minerals were remained. These samples were taken out of the electric furnace and their weights were measured with a digital scale. By comparing the weights of the samples before and after the electric furnace, the ADF was obtained using the following formula:

$$\text{ADF \%} = \left(\frac{(\text{Samples' weight before the electric furnace}) - (\text{Samples' weight after the electric furnace})}{\text{Initial sample weight (1 g)}}\right) \times 100$$

This method of the ADF measurement is according to the Association of the Official Analytical Chemists (AOAC) formula.

Measurement of dry matter digestible (DMD)

To measure the DMD, the following formula was used (Fonnesbeck and Davidson, 1985).

DMD%= 88.9N-0.779ADF

Where, DMD is digestible dry matter and ADF is acid detergent fiber. Therefore, DMD is directly related to plant nitrogen (N) content and inversely related to plant ADF content.

Measurement of metabolizable energy (ME)

After the DMD was found, the following formula was used to calculate the ME in *MJ* unit.

ME=0.17DMD%-2

RESULTS AND DISCUSSION

Forage quality indicators

The results of the analysis of variance (ANOVA) showed the mean values of the four important indicators of the forage quality included CP, ADF, ME, and DMD were significant, except for ME in 2009, at the 0.01 probability level (Table 1). The species were different in this regard (Figures 1 and 2). These results were as follows.

Crude protein (CP)%

As shown in Figures 1 and 2, for the 2009 and 2010, respectively, forbs had the highest CP and shrubs the lowest.

Metabolizable energy (ME)

The mean values of the ME in 2009 and 2010 showed these values were the same for the grass and the forbs and the mean values of the shrubs were less than that of the grass and the forbs in 2009 (Figure 1). However, in the second year (2010), forbs had higher ME than the shrubs (Figure 2). As seen in Figure 2, since grasses were annual, there was no grass cover in the second year (2010) and as a result no data were recorded for the grasses in the second year.

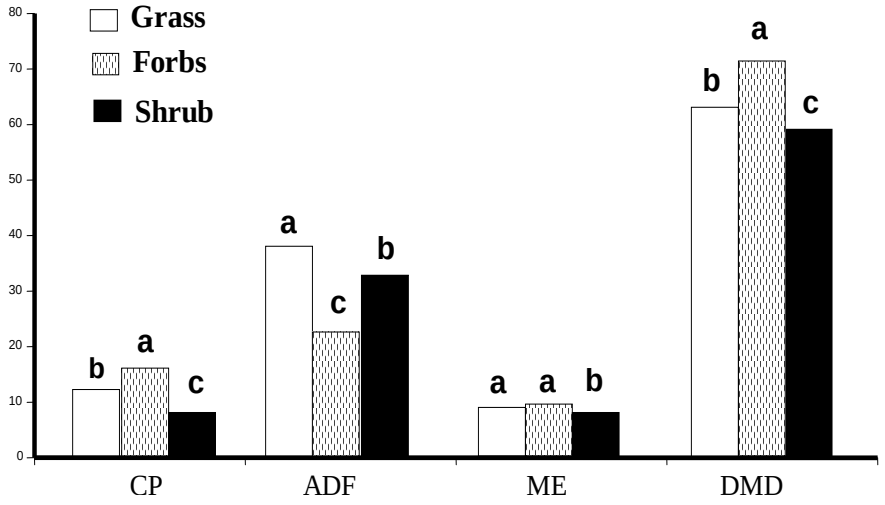

Figure 1. The average percentage of the indicators of the forage qualities (CP, ADF, ME, and DMD) in the three vegetation cover types (Forbs, Grass, and Shrub) in 2009.

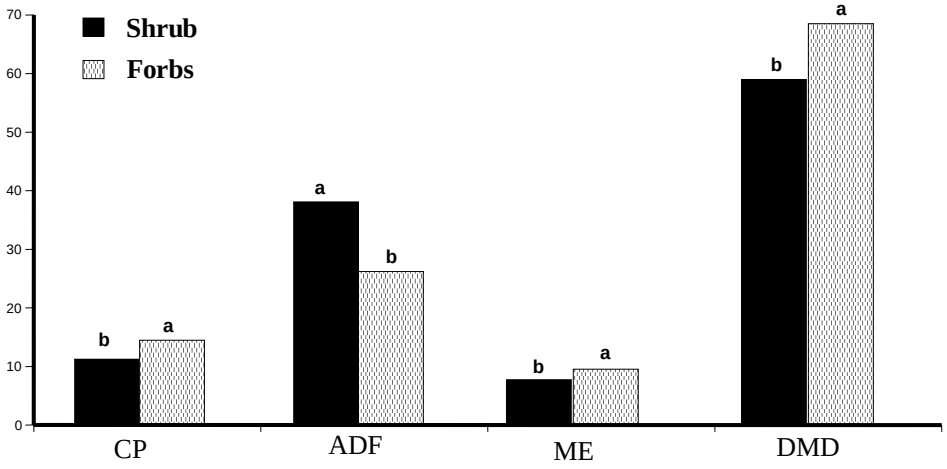

Figure 2. The average percentage of the indicators of the forage qualities (CP, ADF, ME, and DMD) in the two vegetation cover types (Forbs and Shrub) in 2010.

Percent of digestible dry matter (DMD%)

The results of the analysis of variance (ANOVA) indicate that the mean values of DMD for various species were different in both years (2009 and 2010). Forbs had the highest mean of DMD in both years (2009 and 2010) and shrubs had the lowest (Figures 1 and 2).

ADF%

In the first year (2009), grasses had the highest ADF mean values and forbs had the lowest (Figure 1). However, since there were no data for the grass species in the second year (2010) and only shrubs and forbs were analyzed in the second year, shrubs had higher ADF than the forbs (Figure 2). The results of all the indicators together are presented in Figures 1and 2 for the years 2009 and 2010, respectively, with the exception that in the second year (2010), the comparison was done only between the forbs and the shrubs, because the grasses were annual, therefore, there were no data available for the grass species in the second year (2010).

Soluble carbohydrate reserves in vegetation cover types

The soluble carbohydrates values were different in the 6 studied species and their mean values were significantly different at the 0.01 probability level (Figure 3). *Sanguisorba minor* in the first year (2009) and *Lotus*

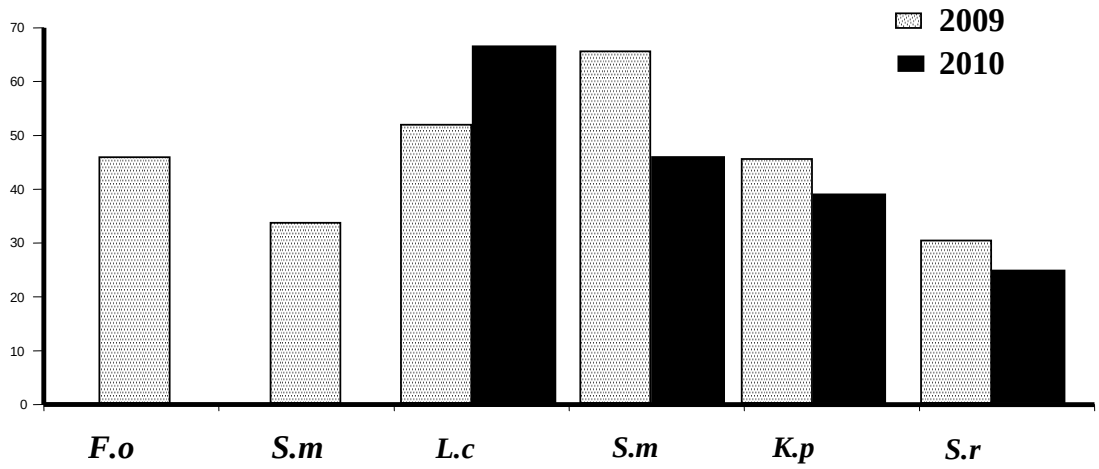

Figure 3. Soluble carbohydrates (g kg^{-1}) in rangelands species in 2009 and 2010.

corniculatus in the second year (2010) had the highest soluble carbohydrate contents, while *Salsola rigida* had the lowest in both years. Duncan Multiple Range test indicated that the 6 species laid in 6 different statistical groups in 2009 and in 4 different groups in 2010. Since the studied grasses were annual species, the data on the grasses were taken only in 2009. The results of this study indicates that the entry and the exit of the animals to the pastures and animals performance during the livestock grazing season are under the direct influence of soluble carbohydrate reserves in rangelands species. Study of the vegetation cover types showed that forbs, grasses, and shrubs have different carbohydrate reserve contents. Therefore, management of the rangelands that contain these three types of vegetation covers should be done with close attention. The forage quality indicators, including DMD, ME, ADF, and CP in various species were different. It seems, in different plant species, the main constituents of the plants structure such as type of roots and leaves, leaves arrangement, stems length, and growth rates determine the quality of the plants.

Changes in the chemical compounds in these 6 rangelands species showed that vegetation cover type is the most important effective factor on forage quality. Therefore, according to these results, in order to improve the rangelands conditions and selecting suitable grazing system and grazing time, the following two factors are essential.

REFERENCES

Ayan I, Mut H, Onal-Asci O, Basaran U, Acar Z (2010). Effects of manure application on the chemical composition of rangeland. J. Anim. Veter. Adv. 9(13):1852-1857.

Bidlock, Devald (1999). Forage quality of 10 eastern grama grass. J. Range Manag. 52:661-665.

Biondini M, Pettit R, Jones V (2006). Nutritive value of forage on study soils as affected by tebuthiurn. J. Range Manage, 39(5):396-399.

Coyne P, Cook C (1991). Seasonal carbohydrate reserve cycles in eight desert range species. J. Range Manage. 23(6):438-444.

Davidson J, Milthorpe F (1995). Carbohydrate reserves in the re-growth of cocksfoot (*Dactylis glomerata* L.). J. Plant Physiol. 20:15-18.

Deregibus V, Trlica J, Jameson D (2002). Organic reserves in herbage plants: Their relationship to grassland management. J. Agron. 60(5):315- 444.

Dongmei X, Weixian C, Sigia G, Xiangyun X (2005). Studies on feeding value for five psammophyte shrub in Ningxin region. Proceedings of the XIX International Grassland Congress, Feb18-24, Sao Paulo, Brazil. pp. 155-165.

Fonnesbeck A, Davidson l (1985). The role of carbohydrate reserves in regeneration of plants. J. Agric. Sci. 9:767-777.

Graber L (1991). Food reserves in relation to other factors limiting the growth of grasses. J. Plant Physiol. 6:43-71.

Graza A, Fulbright RE (2008). Comparative chemical composition of Armed saltbush and Fourwing saltbush. J. Range Manage. 41(5):401-413.

Hyder D, Sneva A (2003). Morphological and physiological factors affecting the grazing management of crested wheatgrass. J. Crop Sci. 23:267-271.

Larbi A, Abd A, Moneim E, Nakkoula H, Jammalb B, Hassana S (2011). Intra-species variations in yield and quality in *Lathyrus* species: (*L. sativus* L.*)*. J. Anim. Feed Sci. Technol. 161 (20):9–18.

Low S, Andrews C (2007). A service for estimating the nutritive value of forages, temperate pasture, their production, use and management. J. Plant Prod. 40(7):301-309.

McDowell L (2005). Nutrition of grazing ruminants in warm climates. Academic Press, New York, USA, 40:311-329.

Menke J, Trlica J (1985). Carbohydrate reserves, phonology and growth cycles of nine Colorado range species. J. Range Manage. 34:269-277.

Menke J, Trlica J (1993). Effects of single and sequential defoliation on the carbohydrate reserves of four range species. J. Range Manage. 36:70-74.

Mikic A, Mihailovic V, Cupina B, Krstic G, Vasiljevic S, Milic D (2010). Forage and seed yield components in four French landraces of grass species (*Lathyrus sativus* L.). Sustainable Use of Genetic Diversity in Forage and Turf Breeding. Springer Netherlands, Dordrecht, pp. 127–130.

Moore R, Biddingscomb F (1994). The effects of grazing on grassland. J. Agric. Sci, 23:221-235.

Norton B, .Waterfall R (2003). The nutrient value of *Tipuna tiou* and *Calliandra calochrasus* as supplements to low-quality straw for goats. Small Ruminant Res. 38(2):175-182.

Oddy V, Robards S, Low S (1993). Prediction of in vivo dry matter digestibility from the fiber and nitrogen content of a feed. J. Food Sci. 50(5):113-119.

Orodho A, Trlica J, Bonham C (2000). Long-term heavy grazing effects on soil and vegetation in the Four Corners Regions. J. Range

Manage. 65:260-275.
Richards J, Caldwell M (2005). Soluble carbohydrates, concur-rent photosynthesis and efficiency in re-growth following defoliation: A field study with *Agropyron* species. J. Plant Physiol. 22:907-920.
Shinde A, Sankhyan K, Bhatta R, Verma D (2000). Seasonal changes in nutrient intake and its utilization by goats in a semi-arid region of India. J. Agric. Sci. 135:429-436.
Sulc R, Albrecht B, Owens V (2009). A Simple method for estimating alfalfa fiber content in the field. Proceedings of the IV International Grassland Congress, J. Agric. Sci. 115:129-135.
Underwood E (2001). The mineral nutrition of livestock. J. Range Manag. 42 (4):321-330.
White L (2003). A review of carbohydrate reserves of bunch grasses. J. Range Manage. 26:13-18.