The Journal of Animal & Plant Sciences, 23(5): 2013, Page: 1223-1227
ISSN: 1018-7081

NUTRIETIVE EVALUATION AND *IN-SITU* DIGESTIBILITY OF IRRIGATED GRASSES

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ABSTRACT

The study aimed to determine the nutritive value of *Cenchrus ciliaris, Leptochloa fusca, Chloris gayana, Cynodon dactylon and Panicum colunum* grasses for ruminants. Five samples of each grass were taken and composite samples of each grass were oven dried at 55°C. Chemical analysis revealed that dry matter (DM) content varied from 11.38% (*C. gayana*) to 28.36% (*C. dactylon*). Maximum crude protein (11.3%) was observed for *C. ciliaris* while minimum (7.90%) was noted for *P. colunum*. Higher ash content (13.70%), hemicellulose (28.5%)and NDF (70.7%) contents were noted for C. *dactylon*. Gross energy value was optimum (3412.2 Kcal/kg) for *C. gayana* but minimum (2812.1 Kcal/kg) for *L.fusca*. The Ca, 1.6-4.0; P, 0.14-0.59; Mg, 0.26-0.84; Na, 5.0-10.5; and K, 11.6-27.2 g/kg of DM. However, Ca:P ratio varied from 4.55-16.36. Maximum *in-situ* DM digestibility (73.3%) and NDF digestibility (62.67%) were noted for *C.ciliaris*, while minimum *in-situ* DM digestibility (32.8%) and NDF digestibility (27.37%) were examined in *L. fusca*. Based on the findings of the present study, grasses as ruminant feed were ranked as *C. ciliaris> C. dactylon> C. gayana> L. fusca> P. colunum.*

Key words: evaluation, in situ, digestibility, grasses.

INTRODUCTION

Pakistan is deficient in forage and concentrates feed for a huge livestock population. Existing feed resources are only providing 62 and 74% of required crude protein and total digestible nutrients, respectively, resulting low productivity of livestock in the country (Sarwar *et al*., 2009). Grasses are the C_4 plants which contain most extensive, much needed and familiar component of range vegetation especially in extreme climates of the range areas. Grasses are more easily accessible, better in taste and quicker in digestion than shrubs and trees (Quraishi, 1999). Ecosystems having rather less extreme climate have typical perennial grasses. These grasses have a quality of quick resprouting because they have special ecological features and moderate grazing. Natural flora of Pakistan contains some very good forage grasses. Need of time is to propagate them through artificial seeding and stump planting (Quraishi, 1999).

The efficiency of range livestock is based on properly utilization of the range forage for optimum production. Minerals are necessary both for the growth and development of plants as well as for the growth, maintenance and productivity of grazing animals in the range areas. The mineral composition of range plants depends upon various environmental factors such as geographic aspects, climate, soil minerals, grazing stress, seasonal changes and the ability of plant to get minerals from soil (Ganskopp and Bohnert, 2003; Khan *et al*., 2006). It has been concluded that minerals deficiency results in poor animal health, productivity and reproductive faults even if sufficient green fodder is present (Tiffany *et al*., 2000). It was observed that mineral composition of grasses changed seasonally, especially in dry climate. In productivity of grazing livestock, both the excess and deficiency of minerals are the major constraints (Ganskopp and Bohnert, 2003). Grasses offer a potential alternative forage source for ruminants in tropical countries, especially in slump periods when quantity and quality of fodder are in limited. Use of grasses harvested at pre-bloom stage can help to minimize the wide gap between availability and supply of nutrients resulting to improve livestock productivity. Therefore, grasses have considerable potential in supporting economical livestock production in developing countries. However, a little information regarding the nutritive value of grasses widely used in the country is available, so this study was launched to envisage the nutritive evaluation of grasses by their chemical composition, mineral profile and *in-situ* digestibility to assertion their fitness to ruminant feeding.

MATERIALS AND METHODS

Collection of samples: Five plants each of five grasses (*Cenchrus ciliaris, Leptochloa fusca, Chloris gayana, Cynodon dactylon and Panicum colunum*) were collected from districts of Faisalabad and Sargodha, Pakistan. Approximately 1.5 kg composite sample was taken for each grass. Their samples were dried in an oven at 55°C for 48 hours and stored in polythene bags.

Chemical composition: Proximate analysis of the grasses was done according to AOAC (2000). The DM was calculated by keeping the samples in forced air oven till constant weight. The crude protein (CP) was measured by Kjeldhal apparatus. Ash was calculated by burning the samples in furnace while organic matter (OM) was calculated by difference. The NDF, acid detergent fiber (ADF) and acid detergent lignin (ADL) were determined by the method as described by Van Soest *et al*. (1991). The Ca and Mg were determined by titration method. The Na and K were measured by Flame photometer. The P was estimated by atomic absorption spectrophotometery. Gross energy (GE) of grasses was measured by using bomb calorimeter (Sergio and Filho, 2005). All chemical analyses were done in triplicate.

Table 1. Botanical names of different experimental grasses

No	Local Names	Botanical Names
i	Dhaman grass/ Bermuda grass	*Cenchrus ciliaris*
ii	Kallar grass	*Leptochloa fusca*
iii	Rhodes grass	*Chloris gayana*
iv	Khabal grass /Bermuda grass	*Cynodon dactylon*
v	Swank grass	*Panicum colunum*

In-situ digestion kinetics:

Feeding regimen of bull: A mature ruminally cannulated buffalo bull was used to study *In-Situ* digestion kinetics of grasses. The bull was fed a blend of sorghum fodder supplemented with concentrate to meet the nutritional requirements. The *In-Situ* digestion trial was 45 days long. Initial 15 days were adjustment phase, which helped in proper microbial development in the rumen and the following 30 days were meant for the *In-Situ* incubation in the rumen.

Nylon bags having size of 10x25 cm with an average pore size 60 µm were used for determination of rate, lag and extent of disappearances of dry matter (DM) and neutral detergent fiber (NDF) from the grasses samples in the bags. The size of grasses particles was kept 2 mm by Wiley mill. Each bag contained 5 g of sample. These bags were placed in the rumen in a reverse sequence and all bags were removed at the same time to reduce variation associated with the washing procedure. For each grass, 3 bags were inserted. Fermentation time for each bag was 0, 1, 2, 4, 6, 12, 24, 36, 48 and 72 h. After removing these bags from the rumen, the bags were washed by running tap water. These bags were then dried in forced air oven at 60^{o}C till constant weight. The dried residues had been transferred into bottles and stored for analysis.

Estimation of digestibility, lag time, rate and extent of disappearance: Rate of disappearance of DM and NDF were determined by subtracting the indigestible residue i.e. the 72 hours residue from the amount in the bag at each point and then regressing the natural log (Ln) of that value against time. Digestibility of DM and NDF was measured at 48 h. The lag time was determined by the following equation (Sarwar *et al*., 1998)

Lag Time (h) = (LN 100) – Intercept / Rate of digestion

Extent of DM and NDF disappearance was determined at 72 hours of incubation. The lag time is the initial phase during which either no digestions occur or it occurs at a greatly reduced rate.

Statistical analysis: The data collected was analyzed by using analysis of variance technique (ANOVA) in a completely randomized design and means were compared by least significant difference (SPSS, 1999).

RESULTS AND DISCUSSION

Chemical composition: Chemical composition of grasses is presented in table-2. The DM contents varied from 11.38% (*C. gayana*) to 28.36% (*VC. dactylon*). Highest CP value (11.38%) was observed for *C. ciliaris* while, lowest CP concentration (7.90%) for *P. colunum*. The NDF contents varied from 63% (*C. gayana*) to 70.7% (*C. dactylon*). Lowest ADF (40.5%) was observed for *C. gayana* and highest (46.3%) for C. Ciliaris. Hemicellulose ranged from 21.2% (C. Ciliaris) to 28.5% (*C. dactylon*).The ADL varied between 3% (*C. dactylon*) to 6.6% (*L. fusca*). Highest ash (13.70%) were noticed for *L. fusca* and lowest (9.84%) for *C. ciliaris*. Gross energy value ranged from 2812.1 kcal/kg (*L. fusca*) to 3201.4 kcal/kg (*C. ciliaris*). The chemical composition of grasses analyzed provide a good source to be used as the nutrient source of ruminant feed.

The findings of the present study are in line with those of Rahim *et al*. (2008) who analyzed range grasses and reported DM upto 38%. The highest value of CP was in contrary to the study of Ramirez *et al*., (2004) who evaluated different grasses and found highest value of CP as 12%. Sultan (2007) who found that the CP at early bloom stage of marginal land grasses varied from 6.2% (*Andropogon squarrosus*.) to 11.4% (*Cynodon dactylon).* The value of CP differs either due to age of plant (Distel *et al*., 2005) or may be due to seasonal effect (Dittberner and Olson, 1983). Dittberner and Olson (1983) concluded that *B. gracilis* (aerial fresh, immature) had CP values of 11% in spring but 6% in winter. Soil fertility can be another cause of change in protein value in the forages.

Bourquin *et al*., (1994) reported 72.4% NDF and 43.8% ADF in the Orchard grass. The difference in the observations of NDF and ADF values maybe due to age of maturity of grasses (Cherney *et al*., 1993). Borreani *et al*. (2003) studied the nutritive value of Sulla (*Hedysarum coronarium* L.) at vegetative and seed set morphological stages. They reported that NDF contents increased from 20 to 61 % with advancing maturity. However, Kramberger and Klemen (2003) found that *Cerastium holosteoides* grass harvested in summer contained significantly higher NDF and ADF values as compared to those grasses harvested in spring.

Sultan *et al.* (2007) found that the lignin contents of marginal land grasses at early bloom varied between 2.8% to 4.6%. At mature stage lignin contents varied between 3.4% to 5.7%. The cell wall lignin increased in leaves (45 to 60 %) and stem (55 to 70 %) with advancing grass age (Kilcher and Troelson, 1973). Brown *et al.*, (1984) reported that the soil fertility could also influence grass lignin concentration. According to Mbwile and Uden, (1997) lignin in forages mainly affected by age of the plant and the season of the cut. Cook and Harris (1968) observed that grasses had higher GE than shrubs. A wide range in predicted metabolizeable energy maybe due to different agronomic conditions at different farms (Khanam *et al*., 2007).

Table 2. Chemical composition of grasses at pre-bloom stage (%)

Botanical Names	DM	OM	CP	NDF	ADF	HC	ADL	Ash	G.E
C. ciliaris	21.75	90.16	11.13	67.5	46.3	21.2	4.8	9.84	3201.4
L. fusca	18.75	85.30	9.00	66.5	43.1	23.4	6.6	13.70	2812.1
C. gayana	11.38	89.91	9.34	63.0	40.5	22.5	3.5	10.09	3412.2
C. dactylon	28.36	88.44	10.53	70.7	42.2	28.5	3.0	11.56	2994.6
P. colunum	22.41	86.39	7.90	63.3	41.5	21.8	4.3	13.41	2990.3

DM, OM, CP, NDF, ADF, HC and ADL stand for dry matter, organic matter, crude protein, nutrient digestible fiber, acid detergent fiber, hemi cellulose and acid detergent lignin respectively.

Mineral profile: Mineral profile of grasses is presented in table-3. The Ca content varied from 1.6-4.0g/kg of DM and are enough to meat the dietary requirement of livestock that must remain with in the range of 1.7-4.2g/kg of DM (Anon., 1975). The P content range from 0.14g/kg(*C. ciliaris*) to 0.59g/kg (*C. gayana*) of DM. The value of P observed in this study were low than the dietary requirements of diet dry matter (3.1-4.0g/kg of DM) recommended by NRC (2001) and were also lower than the maximum value (3.88g/kg) of P examined for most of the tree leaves reported earlier (Mandal, 1997). However this factor can be overcome by feeding cereal byproducts supplemented diets containing low Ca and high P (Prakash *et al*., 2009). The Mg level varied from 0.26g/kg (*C. ciliaris*) to 0.84g/kg of diet DM (*L. fusca*) and were lower than the required level (1.2-1.8g/kg) of diet DM of Mg for sheep. The Na value was lower (5g/kg) for *C. gayana* and *P. colunum* but higher (10.5g/kg) for *L. fusca*.

The K value was highest (27.2g/kg) in *P. colunum* but lowest (11.6g/kg) in *L. fusca*. Dietary requirement of K for dairy cattle is 8g/kg of diet DM (NRC, 2001). However maximum tolerable value of K is 30g/kg of diet DM (NRC, 1980) and these grasses were found well suited for feeding.

Table 3. Mineral composition of grasses at pre-bloom stage (g/kg of DM).

Botanical Names	Ca	P	Mg	Na	K	Ca:P
C. ciliaris	1.6	0.14	0.26	10.0	12.7	10.67
L. fusca	3.6	0.22	0.84	10.5	11.6	16.36
C. gayana	4.0	0.59	0.72	5.0	17.7	6.78
C. dactylon	1.6	0.22	0.34	7.5	16.6	7.27
P. colunum	2.0	0.44	0.43	5.0	27.2	4.55

***In-situ* DM and NDF digestibility:** Highest DM (73.3%) and NDF (62.67%) digestibility was found in *C. ciliaris*, lower DM (32.8%) and NDF (27.37%) digestibility values were observed in *L. fusca*. The decline in digestibility value is due to the increase of cell wall proportion and lignin concentration (Van Soest, 1994). Digestibility of vegetative Rhodes grass, as with other C_4 grasses, is limited by its high NDF content and the chemical bonds between its cell wall polysaccharides, lignin and phenolic acids (Akin and Hartley, 1992).

Table 4. *In-situ* digestibilities of grasses at 48h

Botanical Names	DM Digestibility%	NDF Digestibility%
C. ciliaris	73.3[a]	62.67[a]
L. fusca	32.8[e]	27.37[e]
C. gayana	48.5[d]	44.47[d]
C. dactylon	53[c]	50.70[c]
P. colunum	66.2[b]	57.27[b]
Standard error	3.23	2.9

Contrary to our findings, Mushtaque (2004) examined 56.4% NDF digestibility. The difference in digestibility values is probably due to lignification and maturity which interferes the digestion of structural carbohydrates by acting as a physical barrier to rumen microbial enzymes (Moore and Jung, 2001). Van Soest (1994) observed the existence of a negative curvilinear relationship between lignin content and NDF digestibility. Van Soest (1996) also observed a linear negative relationship between ADF content and fiber digestibility of forages growing during the spring, but not in those growing from mid-summer to autumn.

***In-situ* DM and NDF digestion kinetics:** Dry matter digestion kinetics are presented in table-5 In case of lag time, lowest was (1.91 h) for *C. ciliaris* and highest (5.19 h) for *L. fusca*. Highest rate of disappearance (6.95%/h) was recorded for *C. ciliaris* whereas, lowest (5.05%/h) was found in *L. fusca*. The extent of digestion was maximum (75.8%) in case of *C. ciliaris* and minimum (48.6%) in case of *L. fusca*. Mushtaque (2004) found the rate of disappearance and extent of digestion in whole plant of *C. ciliaris* were 4.5% and 70.3 %, respectively and Lag time was 0.5 h for dry matter of the grass. According to Cherney *et al*. (1993) lag time associated with early harvest dates might be because of the high proportion of cell soluble material of the grasses. Sanderson *et al*. (1989) observed decrease in extent of digestion with plant age. NDF digestion kinetics is presented in table-6. Lag time range from 1.36h (*P. colunum*) to 4.19% (*L. fusca*, *C. gayana*). Rate of disappearance ranged from 4.70%/h (*C. gayana*) to 6.60%/h (*P. colunum*). However, extent of digestion was maximum (69.22%) in *C. ciliaris* and minimum (31.77%) in *L. fusca*. Mushtaque (2004) reported different values of digestion kinetics. The difference in digestibility values is

Table 5. *In-Situ* dry matter digestion kinetics of different irrigated grasses

Name	Lag time (h)	Rate (%/h)	Extent (at 72 h)
C. ciliaris	1.91^{d}	6.95^{a}	75.8^{a}
L. fusca	5.19^{a}	5.05^{c}	48.6^{b}
C. gayana	3.25^{b}	5.1^{c}	67^{b}
C. dactylon	2.15^{c}	6.71^{b}	53.9^{c}
P. colunum	3.12^{b}	6.88^{a}	67.5^{b}
Standard error	0.30	0.16	2.65

probably due to lignification and maturity which interferes the digestion of structural carbohydrates by acting as a physical barrier to rumen microbial enzymes (Moore and Jung, 2001). Van Soest (1994) observed the existence of a negative curvilinear relationship between lignin content and NDF digestibility. Van Soest (1996) also observed a linear negative relationship between ADF content and fiber digestibility of forages growing during the spring, but not in those growing from mid-summer to autumn.

Table 6. In situ neutral detergent fiber digestion kinetics of different grasses

Name	Lag time (h)	Rate (%/h)	Extent (at 72 h)
C. ciliaris	3.16^{b}	6.15^{b}	69.22^{a}
L. fusca	4.19^{a}	5.52^{d}	31.77^{e}
C. gayana	4.19^{a}	4.70^{e}	51.40^{d}
C. dactylon	3.15^{b}	5.87^{c}	56.45^{c}
P. colunum	1.36^{c}	6.60^{a}	59.57^{b}
Standard error	0.30	0.10	2.65

Conclusion: On the basis of results regarding chemical composition, grass energy and *in-situ* digestibility, grasses for use as ruminant feed were ranked as *C. ciliaris> C. dactylon> C. gayana> L. fusca> P. colunum.* The concentration of P and mg among these grasses were less than required level. Due to wide Ca to P ratio, supplementing cereal by products having high level of P is recommended when fed these grasses to ruminants.

REFERENCES

Akin, D.E. and R.D. Hartley (1992). Crop quality and utilization. Crop Sci. 32: 1116–122.

Anonymous (1975). Nutrient Requirements of Domestic Animals-Nutrient Requirement of Sheep. (5th revised Ed.) National Research Council. National Academy of Science, Washington, DC.

AOAC (2000). Official methods of analysis. Association of Analytical Chemists. 15th edition. Arlington Virginia, USA.

Borreani, G., P.P. Roggero, L. Sulas and M.E. Valente (2003). Quantifying morphological stage to predict the nutritive value in Sulla (*Hedysarum coronarium* L.). Agronomy J. 95:1608.

Bourquin, L.D., E.C. Tibgemeyer, J.V. Milgen and J.C. Fahey Jr. (1994). Forage level and particle size effects on orchard grass digestion by steers: II. Ruminal digestion kinetics of cell wall components. J. Anim. Sci. 72:759-67.

Brown, P.H., R.D. Graham and D.G.D. Nicholas (1984). The effect of manganese and nitrate supply on the level of phenolics and lignin in young wheat plant. Plant Soil. 81:437-440.

Cook, C.W. and L. Harris (1968). Nutritive value of seasonal ranges. Utah Agric. Exp. Sta. Utah State University Bull. 472: 55 pp.

Distel, R.A., N.G. Didoné and A.S. Moretto (2005). Variations in chemical composition associated with tissue aging in palatable and unpalatable grasses native to central Argentina. J. Arid Environ., 62:351-357.

Dittberner, P.L and M.L. Olson (1983). The Plant Information Network (PIN) Data Base: Colorado, Montana, North Dakota, Utah.

Ganskopp, D. and D. Bohnert (2003). Mineral concentration dynamics among 7 northern Great Basin grasses. J. Range Manage. 56:174-184.

Khan, Z. I., M. Ashraf and E. E. Valeem (2006). Forage mineral status evaluation: The influence of pasture. Pakistan J. Bot. 38:1043-1057.

Khanum, S. A., T. Yaqoob, S. Sadaf, M. Hussain and M. A. Jabbar (2007). Nutritional evaluation of various feedstuffs for livestock production using *in vitro* gas method. Pakistan Vet. J., 27:129-133.

Kilcher, M.R. and J.E. Troelsen (1973). Contribution of stems and leaves to the composition and nutrient content of irrigated bromegrass at different stages of development. Can. J. Plant Sci. 53:767.

Kramberger, B. and S. Klemen (2003). Effect of harvest date on the chemical compostion and nutritive value of Ceradtium holosteoides. Grass and Forage Sci. 58:12.

Mushtaque, M (2004). Influence of Morphological stage of range grasses on chemical composition and in-situ digestion kinetics in Buffalo Bulls. Thesis PhD. Institute of Anim. Nutrition and Feed Technol. Univ. of Agric. Faisalabad.

National Research Council (1980). Mineral tolerance of domestic animals. National Academy of Sciences, Washington, DC.

NRC (2001). Nutrient Requirements of Dairy Cattle. 7^{th} rev. ed., National. Acad. Sci., Washington, DC.

Pasha, T. N. (1998). Feed Resources for Livestock and Poultry in Punjab, Pakistan. German agency of technical cooperation (GTZ), Livestock and Dairy Development Department, Government of the Punjab, Pakistan.

Quraishi, M. A. A (1999). Range Management in Pakistan. University of Agriculture, Faisalabad.

Rahim, I. R., J. I. Sultan, M. Yaqoob, H. Nawaz, I. Javed and M. Hameed (2008). Mineral profile, palatability and digestibility of marginal land grasses of trans-himalayan grasslands of Pakistan. Pakistan J. Bot. 40(1):237-248.

Ramirez, R.J., G.F.W. Haenlein, C.G. Garcia-Castillo, M.A. Nunez-Gonzalez (2004). Protein, lignin and mineral contents and *In-Situ* dry matter digestibility of native Mexican grasses consumed by range goats. Small Ruminant Research. 52:261–269.

Sanderson, M. A., J. S. Homstein and W. F. Wedin (1989). Alfalfa morphological stages and its relation to *In-Situ* digestibility of detergent fiber fraction of stems. Crop Sci. 29:1415-1319.

Sarwar, M., A. Javaid, Mahr-un-Nisa and S. A. Bhatti (2009). Food security from existing resources. Proc. Agriculture: Challenges, opportunities and options under free trade regime. Organized by WTO and Agriculture policy forum held at University of Agriculture, Faisalabad on May 28-29, 2008.

Sarwar, M., Mahr-un-Nisa and M. A. Sial (1998). Factors affecting digestion kinetics of forages in ruminants (A review). Pakistan Vet. J. 18:58-62.

Sultan, J. I., I. Rahim, H. Nawaz and M. Yaqoob (2007). Nutritive value of marginal land grasses pf northern grassland of Pakistan. Pakistan J. Bot. 39:1071-1082.

Sergio, L. G. and N. Filho (2005). The effects of increasing levels of roughage on coefficients of nutrient digestibility in the collared peccary (Tayassu tajacu). Anim. Feed Sci. Technol. 120:151-157.

SPSS (1999). SPSS user's guide. Release 10.01 edition. SPSS Inc.

Tiffany, M. E., L. R. McDowell, G. A. O. Connor, H. Nguyen, F. G. Martin, N. S. Wilkinson and E. C. Cardoso (2000). Effects of pasture applied biosolids on forage and soil concentration over a grazing season in North Florida. I. Macrominerals, Crude protein and *in vitro* digestibility. Commun. Soil Sci., Plant Analysis. 31:201-203.

Underwood, E. J. and N. F. Suttle (1999). The mineral nutrition of livestock. 3rd edition. CAB International, Wallingford, UK.

Van Soest, P. J. (1996). Environment and forage quality. In: Proceedings of Cornell Nutrition Conference for Food Manufacturers, 58, Cornell University, Ithaca, NY, USA, pp. 1–9.

Van Soest P. J. (1994). Nutritional Ecology of the Ruminant, pp. 177–195. Cornell University Press, New York.

Van Soest, P. J., B. Robertson and B. A Lewis (1991). Method for dietary fiber, neutral detergent fiber and non-starch polysaccharides in relation to animal nutrition. J. Dairy Sci. 74:3583-3597.