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NUTRITIVE VALUE OF MARGINAL LAND GRASSES OF NORTHERN GRASSLANDS OF PAKISTAN

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Abstract

A study was conducted in the valley of Chagharzai in Bunair district lying in the north Trans-Himalayan moist zone occupying Malakand Division, North Western Frontier Province (NWFP), Pakistan to determine the nutritive value of locally available marginal land grasses. The study area lies between 34.42 to 34.66^{o} latitude and 72.62 to 72.78^{o} longitude, having a humid subtropical to temperate environment. The annual precipitation varies from 600 to 1000 mm, mainly during summer and spring. Twelve marginal land grasses were identified and analyzed for dry matter (DM), organic matter (OM), ash, crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF), hemi-cellulose, and lignin contents. The mean percentage values for DM, OM, ash, CP, NDF, ADF, hemi-cellulose and lignin at early bloom stage were 30.1±1.08, 27.6±0.92, 8.1±0.33, 8.7±0.39, 52.3±0.25, 25.8±1.36, 26.6±1.75 and 3.7±0.17, respectively. The mean percentage values for DM, OM, ash, CP, NDF, ADF, hemi-cellulose and lignin at mature stage were 39.4±0.75, 36.1±0.67, 8.2±0.28, 5.7±0.25, 60.9±2.04, 31.1±1.22, 29.8±2.27 and 4.5±0.19, respectively. In marginal land grasses highest ($p<0.05$) potential intake rate (PIR) was observed for *Cynodon dactylon* (55.25±12.26 g/4 minute) and the lowest PIR value was for *Andropogon squarrosus* (7.30±2.39 g/4 minute). The relative preference (RP) was highest for *Setaria pumila* (83.4±2.42%) and lowest for *Andropogon squarrosus* (2.25±0.66%). The mean *In vitro* dry matter digestibility (IVDMD) and metabolizable energy (ME) of marginal land grasses at early bloom stage were 58.4±2.05% and 7.74±0.29 MJ/kg DM, respectively, whereas, mean IVDMD and ME at mature stage were 43.3±1.89% and 5.64±0.25 MJ/kg DM, respectively. The chemical and structural composition, IVDMD, RP and PIR values indicate that marginal land grasses be fed to livestock with some supplementation for different levels of production and types of livestock.

Introduction

Livestock grazing represents a system of land management in non-agricultural marginal areas, whereas, on rangeland livestock grazing represents the most suitable land use (Jones & Martin, 1994). Rangelands support 30 million herds of livestock, which contribute US $ 400 million to Pakistan's annual export earnings (Anon., 2006). Past policies have often favored crops over livestock production, resulting in misuse of land having economically inefficient production potentials. Good pastures are being converted into croplands leaving increasingly poorer lands for livestock production (Pratt *et al.*, 1997), without thinking about the conservation of soil. There was no appreciation of the value of grasses and their ability to hold the soil against destructive erosion (Heath *et al*., 1985). In the northern areas of Pakistan, livestock contributes nearly 55% to the gross provincial income by the agriculture sector. The mostly hilly terrain (73%) of the province has little land for crop agriculture, hence, dependence on livestock is relatively high, particularly for rural subsistence (Anon., 1998). To match the maintenance requirements of livestock, there is a need of 13.5 and 110.3 million tons of crude protein (CP) and total digestible nutrients (TDN), respectively (Anon., 2006). However, present feed resources provide 40% CP and 75% TDN to the livestock (Younas & Yaqoob, 2005). The deficiency of nutrients leads to under nourishment, low productivity and predisposes the livestock to parasitism, epidemics and breeding problems. The improper utilization of rangelands has resulted in great changes in their ecosystem. The more palatable grass species are becoming extinct and are replaced by less palatable weeds (Humphreys, 1984). An indicator to range deterioration, in NWFP is the decline in range dependent sheep and goat population by 10.43% and 39.23%, respectively during 1986 and 1996 (Anon., 1996).

There is a handsome share of various grass species to the feeding regimens of animals during scarcity periods. For prolonged winter scarcity, the grasses are harvested from protected hillside rangelands and stored as hay. Grasses from fertile cropland sides and adjacent uneven areas are also cut several times during summer and are fed to livestock (Khan *et al.,* 2004). Marginal land grasses are, however, still the main way of procuring feed. Nutritive value of locally available marginal land grass species have never been explored. Therefore, this study was conducted to evaluate the nutritive value of the marginal land grasses of Northern grasslands of Pakistan.

Materials and Methods

Study area: The study was conducted in the valley of Chagharzai in Bunair district lying in the North Trans-Himalayan moist zone occupying Malakand Division, North Western Frontier Province (NWFP), Pakistan to determine the nutritive value of locally available marginal land grasses. The study area lies between 34.42 to 34.66^o latitude and 72.62 to 72.78^o longitude, having a humid subtropical to temperate environment. It extends from "Budhal" foothills (up to 800 meters altitude) in the south to "Burha Banr" in the north and northeast (more than 2000 meters altitude). Total surface area is approximately 209 square kilometer, with north and south parts divided by a mountain ridge known as "Sar Qala". The annual precipitation varies from 600 to 1000 mm, mainly during summer and spring. In general the irrigated agriculture in the area is confined to the narrow valley bottom and adjoining gentle slopes. The gentle slopes on mid hills are mainly used for rain fed (Barani) agriculture. The medium to steep hill slopes near the residences and gentle to medium hill slopes away from the residences are protected during wet summer season for forage harvest. The forage is harvested at a mature stage during early autumn and fed as hay to the wintering livestock. The steeper hill slopes near the residences are generally used for free grazing by settled livestock throughout the year. The steeper slopes away from residences are generally scrub/bush lands and natural forest mostly grazed by nomadic sheep and goat flocks. The lower elevation rangelands are grazed during winter season and by nomadic flocks, while tracking to and fro of alpine pastures graze the upper elevation rangelands.

Identification and sampling of grass species: A questionnaire was prepared and the farmers of various social groups at three elevations i.e., upper, middle and lower elevations were interviewed. They were asked about the names of grasses in local language (Pashtu), their season of use, location, elevations and aspects of their availability, species of animal fed and trends in their frequency. Ninety farmers (30 x 3, at each elevation) were interviewed in 9 villages (3 x 3, villages at each elevation). Based on the information generated by the farmers through the questionnaire, the samples of different grass species were collected and their specimens were sent to Pakistan Forest Institute, Peshawar, Pakistan for botanical identification. A total of 12 commonly available marginal land grass species were selected for detailed study. Samples of grass species harvested at early bloom and mature stages of growth were chopped to 2 to 3 cm in length, dried in air and stored in polythene bags for further analysis.

Nutritional value of marginal land grasses

Chemical and structural constituents: The air-dried samples were further dried in a forced draught oven at 60°C and were analyzed for dry matter (DM), organic matter (OM), ash and nitrogen (Anon., 1990). Grass samples were also analyzed for neutral detergent fiber (NDF), acid detergent fiber (ADF), hemi-cellulose and lignin (Van Soest & Robertson, 1990).

Palatability of marginal land grasses: Four mature local sheep of 2.5 years age (average body weight 40 kg) were purchased from the local livestock market and were drenched for internal parasites. The experiments for palatability measurement were conducted at Civil Veterinary Dispensary, “Deewana Baba” in District Bunair of Malakand Division. The sheep were adapted to the grass hay, trained in the experimental procedure by offering the test samples to them alone or in pairs daily. It took about five weeks to accustom them with the hay and to train them in the experimental procedure before any measurement was taken. During preliminary periods each animal was fed a diet of 800 g/day. The diet consisted of 80% mixed grass hay and 20% concentrate mixture. The diet contained 10% crude protein (CP) and 8.37 MJ/kg metabolizable energy (ME). The mineral elements were also added in the diet to meet the sheep requirement (Anon., 1985). The potential intake rate (PIR) for different forages was determined through the procedure adopted by Rehman (1995). Each forage species was offered to sheep for a set of comparisons consisting of four consecutive periods of one minute duration each at ten minutes interval. Sheep were offered forages in suitable plastic containers ensuring that part of forage was left over after one minute of intake. Relative preference (RP) was also evaluated in 95 days through the procedure used by Rehman (1995). The preference ranking of forages with in each group was determined by offering forages in pairs, initially with the forage having highest PIR and then with other forages, until all possible combination within a group was studied and similarly all forage groups were studied. Like PIR, RP test also consisted of a set of four consecutive period of one-minute duration each at 10 minutes interval. There was one-hour gap before a new set of comparisons was started with a maximum of 4 sets in a day. The containers of both forages in a pair were reversed for each successive comparison to avoid left or right hand bias. The preference for particular forage was determined by the standard procedure developed by Bell (1959) for two choice tests, as the intake of forage expressed as a percentage of the combined intake of both test and standard forage.

$$\text{Relative Preference (RP) \%} = \frac{\text{Amount of test forage eaten}}{\text{Amount of test + standard forage eaten}} \times 100$$

In vitro **dry matter digestibility (IVDMD) and metabolizable energy (ME) MJ/kg DM:** For the IVDMD determination, oven dried ground samples were incubated at 37±1°C for 48 hours between pH 6.7-7.0 in an all glass system using 45 ml of inoculums. The inoculums comprised of 36 ml of McDougal's artificial saliva and 9.0 ml of strained fresh rumen liquor from grass fed sheep. After incubation and centrifugation the residue was then treated for 48 hours with pepsin in weak acid (pH 2.0). The final residue was composed of undigested plant cell wall and bacterial debris and yield values were supposed to be comparable to *In vivo* apparent digestibility (Tilley & Terry, 1963). The IVDMD was used for calculating the metabolizable energy (ME) of grass species by the following equation (Anon., 1984).

ME (MJ/kg DM)= 0.15 IVDMD%
IVDMD% = 0.98 IVDMD% - 4.8

The average values for chemical composition, structural constituents, IVDMD and ME were integrated to develop a matrix of correlation (Steel *et al.*, 1997).

Results and Discussion

Identification of range grass species and their use pattern: The marginal land grasses included *Cynodon dactylon*, *Apluda mutica*, *Setaria pumila*, *Panicum turgidum*, *Pennisetum orientale*, *Digitaria sanguinalis*, *Saccharum spontaneum*, *Rottboellia exaltata*, *Arthraxon prionodes*, *Cenchrus ciliaris*, *Desmostachya bipinnata* and *Andropogon squarrosus. Setaria pumila*, *Pennisetum orientale* and *Rottboellia exaltata* were available at upper elevation while the remaining grasses were commonly available at all elevations. The use pattern of individual grass species can not be described, as most of them were harvested combinely and stored as hay or freely grazed. However, for the purpose of discussion in their use pattern, these can be grouped on the basis of range type they occupy. It was observed that *Cenchrus ciliaris* was the most common grass of the field boundaries having intermediate to deep loamy soils on southern aspect of lower and middle elevations. On the northern sites *Apluda mutica* (deep soils) occupied similar areas. *Desmostachya bipinnata* and *Cynodon dactylon* grasses were more commonly found on sandy soils, having high moisture contents. *Andropogon squarrosis* and *Saccharum spontaneum* were mainly steam-side loamy soil grasses.

The results of present study were in line with the findings of Leede (1998) who reported that in the subtropical zone of Leganai range (Bunair) Malakand division, the free grazing rangelands grasses include *Cymbopogon jwarancusa*, *Heteropogon contortus* and *Chrysopogon aucheri*. in Topdarra range of Bunair, *Chrysopogon*, *Themeda* and *Heteropogon* were the common grass species. It was observed that *Dichanthium annulatum* and *Cymbopogon schoenanthus* were the most common grasses covering field boundaries at low elevation and on deep soils having higher clay contents. On the other hand *Themeda anathera, Chrysopogon montanus*, *Chrysopogon aucheri* and *Heteropogon contortus* were commonly found on shallow soil hill slopes.

Chemical and structural constituents: The chemical constituents of marginal land grasses at early bloom and maturity are presented in Table 1. The DM contents of marginal land grasses at early bloom satage varied from 23.8% (*Desmostachya bipinnata)* to 36.9% (*Andropogon squarrosus*) and the mean was 30.1±1.08%. At mature

Table 1. Chemical constituents in marginal land grasses of northern glrasslands of Pakistan.

S. No	Grass name	Early bloom				Maturity			
		DM %	OM %	Ash %	CP %	DM %	OM %	Ash %	CP %
1.	*Cynodon dactylon*	30.4	28.1	7.6	11.4	38.8	35.6	8.2	7.2
2.	*Apluda mutica*	27.5	25.2	8.4	8.0	40.0	36.3	9.3	5.8
3.	*Setaria pumila*	29.5	27.0	8.5	8.9	37.9	35.0	7.6	6.6
4.	*Panicum turgidum*	26.7	25.0	6.2	9.7	38.6	35.4	8.2	6.1
5.	*Pennisetum orientale*	33.8	30.4	10.0	7.7	40.2	36.5	9.1	5.2
6.	*Digiteria sanguinalis*	28.6	26.3	8.0	10.0	36.2	34.0	6.2	6.2
7.	*Saccharum spontaneum*	36.4	32.8	9.9	9.4	43.5	40.0	8.1	5.3
8.	*Rottboellia exaltata*	32.9	29.8	9.3	8.1	41.9	38.8	7.3	4.9
9.	*Arthraxon prionodes*	26.7	24.9	6.6	9.0	38.0	34.4	9.4	6.9
10.	*Cenchrus ciliaris*	27.9	26.1	6.6	8.7	38.8	36.0	7.1	5.4
11.	*Desmostachya bipinnata*	23.8	22.0	7.4	6.7	34.7	31.7	8.7	4.4
12.	*Andropogon squarrosus*	36.9	33.8	8.3	6.2	43.9	39.8	9.4	4.3
	Mean ± SE	**30.1±1.08**	**27.6 ± 0.92**	**8.1±0.33**	**8.7±0.39**	**39.4±0.75**	**36.1±0.67**	**8.2±0.28**	**5.7±0.25**

DM= Dry matter, OM= Organic matter, CP= Crude protein stage, the DM contents in these grasses varied from 34.7% (*Desmostachya bipinnata)* to 43.9% (*Andropogon squarrosus)* and the mean was 39.4±0.75%. The OM at early bloom stage in these grasses varied from 22% (*Desmostachya bipinnata)* to 33.8% (*Andropogon squarrosus*) and the mean was 27.6±0.92%. At mature stage, the OM contents varied from 31.7% (*Desmostachya bipinnata)* to 40% (*Saccharum spontaneum)* and the mean was 36.1±0.67%. The ash contents of marginal land grasses at early bloom varied from 6.2% (*Panicum turgidum)* to 10.0% (*Pennisetum orientale*) and the mean was 8.1±0.33%. At mature stage, this variation had a range of 6.2% (*Digitaria sanguinalis*) to 9.4% (*Andropogon squarrosus)* and the mean was 8.2±0.28%. The CP at early bloom stage of marginal land grasses varied from 6.2% (*Andropogon squarrosus*.) to 11.4% (*Cynodon dactylon)* and the mean was 8.7±0.39%. At mature stage the CP contents decreased and the range was 4.3% (*Andropogon squarrosus)* to 7.2% (*Cynodon dactylon)* and the mean was 5.7±0.25%. Distel *et al*., (2005) reported that CP contents in different grass species declined with time.

The structural constituents of marginal land grasss are presented in Table 2. The NDF contents in marginal land grasses at early bloom varied between 40% (*Desmostachya bipinnata*) to 64% (*Rottboellia exaltata; Cenchrus ciliaris*) and the mean was 52.3±0.25%. At mature stage, NDF ranged between 52% (*Apluda mutica)* to 72% (*Saccharum spontaneum*) and the mean was 60.9±2.04%. The ADF contents at early bloom varied from 20% (*Cynodon dactylon*; *Setaria pumila*; *Desmostachya bipinnta*) to 32% (*Roittboellia exaltata)* and the mean was 25.8±1.36%. At mature stage ADF varied from 27 (*Cynodon dactylon*; *Setaria pumila*; *Desmostachya bipinnata*) to 38% (*Digitaria sanguinalis)* and the mean was 31.1±1.22%. The hemi-cellulose percentage of marginal land grasses at early bloom stage varied between 18% (*Digitaria sanguinalis*) to 36% (*Andropogon squarrosus*) and the mean was 26.6±1.75%. At mature stage, it varied between 18% (*Digitaria sanguinalis*) to 41% (*Saccharum spontaneum)* and the mean was 29.8±2.27%. The lignin contents of marginal land grasses at early bloom varied between 2.8% (*Setaria pumila)* to 4.6% (*Rottboelia exaltata*) and the mean was 3.7±0.17%. At mature stage lignin contents varied between 3.4% (*Cynodon dactylon)* to 5.7% (*Saccharum spontaneum)* and the mean was 4.5±0.19%.

The NDF, ADF, and lignin contents in marginal land grasses were lower than the free grazing rangeland grasses, indicating relatively smaller stem proportion in the anatomy of marginal land grasses. All the structural constituents (NDF, ADF, hemi-cellulose and lignin) increased in grasses from early bloom to maturity stage. According to Cherney *et al*., (1993), the tropical grasses generally showed an increase in structural constituents with increasing maturity. Bourquin *et al*., (1994) reported 72.4% NDF and 43.8% ADF in the orchard grass on DM basis. Sanderson *et al*., (1989) observed a difference of 3l.4 to 66.8% in NDF contents of alfalfa in two different years. In the stem of alfalfa grass the NDF concentration ranged from 21 to 68%. According to Cherney *et al*., (1990), NDF and ADF tended to be lower in inflorescence than in other morphological components. ADF was also reported higher in stem than in blade and sheath of leaves.

The findings of this study were in line with those of Cherney *et al*., (1993) who also reported an increase in all fiber constituents with increasing maturity. They reported that lignin was proportionately higher in stem than other parts of the plants. Brown *et al.*, (1984) reported that the soil fertility could also influence grass lignin concentration.

Table 2. Structural constituents in marginal land grasses of northern glrasslands of Pakistan.

S. No	Grass name	Early bloom				Maturity			
		NDF %	ADF %	Hemi-cellulose %	Lignin %	NDF %	ADF %	Hemi-cellulose %	Lignin %
1.	*Cynodon dactylon*	48	20	28	3.0	57	27	30	3.4
2.	*Apluda mutica*	46	23	23	3.2	52	29	23	4.1
3.	*Setaria pumila*	44	20	24	2.8	53	27	26	3.9
4.	*Panicum turgidum*	55	22	33	3.5	61	35	26	3.7
5.	*Pennisetum orientale*	54	30	24	4.2	60	34	26	4.5
6.	*Digiteria sanguinalis*	49	31	18	3.8	56	38	18	3.9
7.	*Saccharum spontaneum*	58	28	30	4.5	72	31	41	5.7
8.	*Rottboellia exaltata*	64	32	32	4.6	69	33	36	5.4
9.	*Arthraxon prionodes*	44	26	18	3.2	53	28	25	5.5
10.	*Cenchrus ciliaris*	64	31	33	3.9	69	33	36	5.4
11.	*Desmostachya bipinnata*	40	20	20	3.6	61	27	34	3.8
12.	*Andropogon squarrosus*	62	26	36	4.2	68	31	37	4.6
	Mean ± SE	**52.3±0.25**	**25.8±1.36**	**26.6±1.75**	**3.7±0.17**	**60.9±2.04**	**31.1±1.22**	**29.8±2.27**	**4.5±0.19**

NDF= Neutral detergent fiber, ADF= Acid detergent fiber

Palatability of marginal land grasses: Palatability refers to the relish with which feed is consumed as stimulated by the sensory impulses (Heath *et al*., 1985).The potential intake rate (PIR) and relative preference (RP) are considered the main indicators for palatability (Rehman, 1995). The PIR and RP of 12 marginal land grasses are presented in Table 3. The average PIR (grams consumed during 4 minutes per sheep) was the highest for *Cynodon dactylon* (55.25±12.26 g/4 minute) followed by *Apluda mutica* (51.50±15.03 g/4 minute), *Setaria pumila* (49.50±8.87 g/4 minute) and *Panicum turgidum* (47.8±8.81 g/4 minute). The lowest PIR values were for *Andropogon squarrosus* (7.3±2.29 g/4minute). The RP was the highest for *Setaria pumila* (83.4±2.42%) followed by *Panicum turgidum* (74.95±0.62%), *Apluda mutica* (71.53±0.73%) and *Cynodon dactylon* (68.63±1.88%). The lowest RP was observed for *Andropogon squarrosus* (2.25±0.66%). Among the marginal land grasses *Cynodon dactylon* despite of its higher PIR values showed relatively lower RP. This might be due to the presence of an essential oil (piperitone) that made it less palatable. This essential oil is responsible for the peculiar smell and taste of the grass (Rehman, 1995) and might decrease its relative preference despite of its higher PIR. The PIR was more strongly affected by the degree of tenderness and stage of growth while the RP seemed to be more affected by the intrinsic chemical factors, hence when the grass was offered in pair with other forages having no such repellent essential oil, the other forage showed higher RP value despite of their lower PIR.

Correlation of palatability with chemical constituents, structural constituents and IVDMD is presented in Table 5. The RP and PIR were positively correlated (r=0.84) with each other across all grasses studied. These results supported the findings of Rehman (1995) who suggested PIR as a useful indicator of preference. The results of present study revealed that although the PIR and RP were correlated with each other, their major determinant affects both the parameters differently. The PIR was influenced by the degree of tenderness, while RP was influenced by chemical factors. The present study suggests that more precise prediction equations can be developed if concentrations of sugars and chemical factors were integrated.

Kenney & Black (1984) reported that when effects of taste and odor are removed, sheep preferred diet having faster intake rates. The IVDMD showed positive correlation with both RP and PIR across all the grasses (r=0.65, 0.43). The CP contents had positive correlation with RP (r=0.48) and with PIR (r= 0.53) .These results supported the findings of Provenza *et al*., (1996) who reported that lambs preferred food having higher CP contents. The ADF showed positive correlation with RP (r=0.45) and PIR (r=0.42), whereas NDF, hemi-cellulose and lignin contents showed negative correlation with RP and PIR (Table 5). The results of present study were in agreement with Rehman (1995) who reported that NDF and lignin had negative correlation with both RP and PIR across all the species. The rapid accumulation of cell wall contents, fast lignification of cell wall and rapid reduction in CP levels may allow the unpalatable grass to avoid grazing since an early stage of re-growth. Fibrousness reduced intake rate because of the associated reduction in bite size to properly sever forage and the associated increase in chewing time necessary to adequately process the forage (Laca *et al*., 2001). Lignin and CP contents interfered with the digestion of structural carbohydrates, the former by acting as a physical barrier to rumen microbial enzymes (Moore & Jung, 2001) and the later by limiting rumen microbial growth (Orskov, 1982). The factors affecting palatability need more investigation (Pratt *et al*.,1997).

Table 3. Potential intake rate (PIR) and relative preference (RP) of marginal land grasses of Northern grasslands of Pakistan.

S. No	Grass name	PIR (g/4 minute) ± SE*	RP (%) ± SE**
1.	*Cynodon dactylon*	55.25±12.26 [a]	68.63±1.88 [b]
2.	*Apluda mutica*	51.50±15.03 [a]	71.53±0.73 [c]
3.	*Setaria pumila*	49.50±8.87 [ab]	83.40±2.42 [a]
4.	*Panicum turgidum*	47.80±8.81 [ab]	74.95±0.62 [a]
5.	*Pennisetum orientale*	47.50±6.23 [ab]	52.00±1.92 [a]
6.	*Digiteria sanguinalis*	47.00±10.41 [ab]	63.55±0.93 [b]
7.	*Saccharum spontaneum*	42.00±12.77 [ab]	43.08±1.33 [e]
8.	*Rottboellia exaltata*	41.00±10.11 [ab]	32.15±0.86 [c]
9.	*Arthraxon prionodes*	39.00±8.97 [abc]	54.42±1.86 [d]
10.	*Cenchrus ciliaris*	38.80±6.75 [abc]	46.55±0.67 [d]
11.	*Desmostachya bipinnata*	36.50±8.41 [cd]	32.75±0.85 [g]
12.	*Andropogon squarrosus*	7.30±2.39 [d]	2.25±0.66 [h]

SE = Standard error
*Each figure represent mean (± standard error of the mean) of 4 samples
*Figures having different letters are significant (p<O.05) within the same forage grass
**Each figure represent mean (± standard error of the mean) of 48 comparisons
Figures having different letters are significant (p<0.05) within the group

Table 4. Digestibility and metabolizable energy of marginal land grasses of Northern grasslands of Pakistan.

S. No	Grass name	Early bloom		Maturity	
		IVDMD %	ME MJ/kg DM	IVDMD %	ME MJ/kg DM
1.	*Cynodon dactylon*	63.1	8.54	55.4	7.41
2.	*Apluda mutica*	60.2	8.12	48.6	6.40
3.	*Setaria pumila*	67.7	9.25	44.5	5.82
4.	*Panicum turgidum*	58.4	7.87	40.4	5.23
5.	*Pennisetum orientale*	69.3	7.99	43.5	5.69
6.	*Digiteria sanguinalis*	59.3	7.99	42.6	5.52
7.	*Saccharum spontaneum*	47.6	6.28	34.6	4.35
8.	*Rottboellia exaltata*	48.2	6.36	36.4	4.65
9.	*Arthraxon prionodes*	60.4	8.16	51.5	6.86
10.	*Cenchrus ciliaris*	58.6	7.91	36.6	4.65
11.	*Desmostachya bipinnata*	64.3	8.75	47.6	6.28
12.	*Andropogon squarrosus*	43.2	5.65	37.3	4.77
	Mean ± SE	**58.4±2.05**	**7.74±0.29**	**43.3±1.89**	**5.64±0.25**

IVDMD = *In vitro* dry matter digestibility ME = Metabolizable energy

Table 5. Correlation matrix among relative preference, potential intake rate, digestibility, crude protein and structural constituents of marginal land grasses of Northern grasslands of Pakistan.

	PIR	IVDMD	CP	NDF	ADF	Hemi-cellulose	Lignin
RP %	+0.84	+0.65	+0.48	-0.52	+0.45	-0.45	-0.83
PIR	-	0.43	+0.53	-0.36	+0.42	-0.22	-0.65
IVDMD	-	-	+0.03	-0.80	-0.68	-0.59	-0.59

In vitro **dry matter digestibility (IVDMD) and metabolizable energy (ME):** The mean IVDMD and derived ME values for marginal land grasses at early bloom and maturity are presented in Table 4. The IVDMD value for marginal land grasses at early bloom stage ranged from 43.2% (*Andropogon squarrosus)* to 67.7% (*Setaria pumila)* and the mean was 58.4 ± 2.05%. The derived ME value had a range from 5.65 MJ/kg DM (*Andropogon squarrosus*) to 9.25 MJ/kg DM *(Setaria pumila)* with a mean of 7.74±0.29 MJ/kg DM. The IVDMD values of marginal land grasses at maturity ranged from 34.6% (*Saccharum spontaneum)* to 55.4% (*Cynodom dactylon*) and the mean was 43.3±1.89%. The derived ME value at maturity ranged from 4.35 MJ/kg DM (*Saccharum spontaneum)* to 7.41 MJ/kg DM (*Cynodom dactylon*) and the mean was 5.64±0.25 MJ/kg DM. The 1VDMD was positively correlated with CP (*r*= +0.03) and negatively correlated with NDF (*r*= -0.80), ADF (*r*= -068), hemi-cellulose (*r*=-059) and lignin (*r*= -0.59) in marginal land grasses. The IVDMD decreased with increasing maturity of the plants and similar findings were reported by Skerman & Riveros (1990) who found a fall of 0.1 to 0.2% DM digestibilities per day with maturity of pasture grasses. Buxton (1989) reported that the proportion of stem in a grass approaching maturity was the main morphological factor determining the digestibility. Gabrielsen *et al*., (1990) and Van Soest (1965) reported that NDF, ADF and lignin concentration increased with maturity while IVDMD and CP declined. Revell *et al*., (1994) reported a positive correlation between CP and digestibility, whereas, Cherney *et at*., (1990) observed negative correlation of IVDMD with NDF, ADF and lignin. The results of our study were in line with those of Van Soest (1978) who reported poor relationship of NDF with digestibility. Lichtenberg & Hemken (1985) also reported that per unit increase in lignin often resulted in a three to four unit decrease in DM digestibility. It had been reported that cell wall component NDF, ADF and lignin were negatively correlated with IVDMD in tree leaves (Mowatt *et at.*, 1969, Kundu & Sherma,1988; Perveen, 1998).

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