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HERBAGE PRODUCTION AND NUTRITIVE VALUE OF ALPINE PASTURES IN UPPER KAGHAN VALLEY, KHYBER PAKHTUNKHAWA, PAKISTAN

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ABSTRACT

Grasses, forbs and shrubs of alpine pastures harvested at three different intervals from four different altitudinal zones (2925-4184 m), Basel, Jalkhad, Gittidas and Burawai in upper Kaghan valley, Pakistan, were assessed for herbage production and nutritive value. Sample collection was accomplished by cutting above ground biomass at a 0.5m height. The results showed that herbage production was significantly (P<0.001) higher (333 kg/ha) for grasses and shrubs (192 kg/ha) in Burawai than Basel and Gittidas. The total herbage production was maximum in Burawai (1003 kg/ha) and was minimum in Basel and Gittidas. Herbage production of grasses and forbs was higher at 2nd harvest and was also significantly (P<0.01) affected by location x herb and harvest x herb interactions. The crude protein (CP) was higher in shrubs (14.8%) and forbs (13.6%) as compared to grasses (12.3%). The CP was the highest in herbages in Basel at 1st harvest. *In vitro* dry matter digestibility (IVDMD) of herbage was significantly higher (P<0.001) at Basel and Burawai followed by Gittidas and Jalkhad showing higher value for shrubs (67.1%) than forbs (56.2%) and grasses (54.2%) which was significantly affected (P<0.01) by location x herb interactions. Shrubs had more DM than grasses and forbs. Forbs showed higher ash contents at 1st harvest and lower at 3rd harvest as compared to grasses and shrubs. Grasses had greater NDF, ADF and hemicellulose contents than forbs and shrubs. Results demonstrated that variations in herbage production, CP and IVDMD and cell wall fractions of herbage were attributed to plant composition of the sward and harvest stage of the herbages.

Keywords: Alpine pastures; herbage production; in vitro dry matter digestibility, Kaghan Valley; Nutritive value

INTRODUCTION

Around 65% of the total area of Pakistan, from altitudes of 0 to 4000 m, is rangelands. Their extent varies from 47% in Punjab province to 93% in Baluchistan province. Rangelands meet 60% of total feed requirements of small ruminants and 5% of the requirements of large ruminants. Only 4.8% of Pakistan is under forest while arid and semi arid area contributes 68% to the total land area of Pakistan (Rafique *et al*., 2013). This consists of 945.47 square km area which is one third of total area of district Mansehra. Major land uses are rangelands (50.6%), forest (24.6%) and agriculture (6%). Almost all the area of the valley is subjected to grazing with various intensity and frequency. Likewise, the alpine pastures in northern area like Hamalayan have been grazed for the centuries and are an important source of forage for livestock production (Hamayun *et al*., 2011).

The alpine pastures of Kaghan valley are a potential source of forage for livestock during summer season. In Khyber Pakhtunkhawa (KPK) province of Pakistan, large numbers of sheep and goat herders migrate along with livestock in early summer and return to lower elevations or plains in early autumn. These pastures usually belong to communities or Government and herders paying rent for the grazing alpine pastures. Rangeland in KPK constitutes about 50.6% of total area of the province (Zubair *et al*., 2006) and provides about 44% of the feed available to livestock in KPK, while crop residues and fodder crops contribute about 56% to the feed resource. Due to inadequate management of the rangeland in KPK, it has badly been over grazed, with the resultant replacement of palatable species by low quality vegetation which livestock does not relish (Bovolenta *et al*., 2008). As an important source of livestock nutrition, natural vegetation on grazing lands extends the capacity of KPK to support human life and bolsters its tenuous food security. In spite of the great environment and economic importance of grazing lands little has been done for their improvement (Qureshi *et al*., 2007).

Protein and digestibility value have been emphasized as major factors for pasture quality evaluation for animal performance (Seven and Cerci, 2006). Some studies reported better gain in weight of animals grazed on alpine pastures of Kaghan valley. Information on nutritive value of these pastures is scarce and in fragmented form and often assumptions are made

for estimating feed contribution from this important source.

Feeding value of alpine pastures is highly variable and depends on the stage of growth, species and environmental conditions. Literature also emphasized that the nutritive values of herbage used for feeding livestock in different geo-ecological zones is not uniform and each region should generate its own inventory of feed resources. Thus, the present study was carried out to estimate herbage production and determine the nutritive value of different herbage species found in alpine pastures of upper Kaghan valley of Pakistan in order to get better understanding of their biodiversity.

MATERIALS AND METHODS

Study area and experimental design: Four alpine pasture locations namely; Basel, Jalkhad, Gittidas and Burawai in the upper reaches of Kaghan valley were selected for this study. The alpine pasture sites lie in the northern most portion of Mansehra district, KPK province of Pakistan and are oriented from north east to south west directions. The elevations of Burawai, Jalkhad, Basel and Gittidas pastures are 2955, 3080, 3161 and 3600 m, respectively. Herbage groups were harvested at three different intervals: July, August and September of the year 2012. Sample collection was accomplished by cutting above ground biomass at a height of 0.5 m similar to that grazed by small ruminants. Five different plots from each of the above pasture were randomly chosen as a replicate. A plot size measuring 1.5m×1.5m was demarcated in each locality thus making a total of 20 experimental plots. All the plots were fenced with barbed wire. A total of 180 pasture samples were collected from the four locations.

Identification of grasses, forbs and shrubs: Identification of grasses, forbs and shrubs was facilitated by Range Management Department, Pakistan Forest Institute. The grasses were distinguished by having hollow and jointed stem, fine and narrow leaves with larger parallel veins and fibrous and very small deep root system. The forbs were distinguished by having solid and non-jointed stems and broad leaves with net like veins and with tap root. While shrubs were identified by having woody stem that branch near the base, coarse leaves and long and coarse roots. The list of major herbage species studied is given in Table 1.

Herbage production: 1 m^2 inner area of each plot was harvested from all locations in three months and the collected biomass (leaves plus woody proportions) was stored in paper bags and immediately weighed for herbage production and manipulated for total production (kg/ha). Herbage production was calculated as under:

$$\text{Herbage prod. (kg ha}^{-1}) = \frac{\text{Herbage wt in 1 m}^2 \text{ x 10,000}}{1000}$$

Where Kg= kilogram, ha= hectare

Chemical analysis: The air dried herbage samples were ground in hammer mill (Thomas-Wiley Laboratory Mill, USA) to a fine particle size of less than 1 mm and analysed for dry matter (DM), crude ash (CA), crude protein (CP). Dry matter content was determined by the Weende procedure. The Kjeldahl method was used to determine nitrogen (AOAC, 2012) and CP was calculated by N x 6.25.

The neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL) were analyzed according to Van Soest *et al*. (1991) using an ANKOM 220 Fibre Analyzer (ANKOM Technology Corporation, NY, USA). The values of NDF and ADF were expressed including residual ash. Hemicellulose content was determined according to procedure of Van Soest and Robertson (1985).

In vitro dry matter digestibility (IVDMD) of herbages was determined according to Tilley and Terry (1963). Cow steer fitted with permanent ruminal cannula fed a mixture of maize fodder and wheat straw was used for collection of rumen liquor to carry out in vitro incubation of herbages. Incubation of samples (about 0.3 g) was carried out in triplicate. The filtered rumen liquor was mixed with McDougall's buffer in 1:3 proportions. Tubes containing 40 ml aliquot were incubated in laboratory incubator at 37 °C for 48 h. Three blank tubes without sample were also included in each run. All the possible measures were adopted to maintain anaerobic conditions during procedure and incubations. The contents during incubation were mixed two times by gentle shaking at 12 h interval. On termination of incubation, the tubes were centrifuged at 3000 rpm for 15 min. The supernatant was discarded carefully. The tubes with precipitate after drying at 70 °C for 48 h were cooled and weighed. The IVDMD was calculated using the equation:

$$\text{IVDMD (\%)} = \frac{\text{Initial DM input} - (\text{Residue} - \text{Blank})}{\text{Initial DM input}} \text{X100}$$

Where IVDMD= In vitro dry matter digestibility

Statistical analysis: The data were analysed in SPSS 22.0 (2017) with the ANOVA using the split plot design at $P< 0.01$ significant level. The means were compared for significance of difference with the Duncan Multiple Range Test. Regression between CP and IVDMD was calculated with the Linear Regression Model (GLM) which was not significant. The statistical model is given in the following including main effects of locations, herbage type, harvesting frequency and their interaction for total yield and nutritive value parameters.

$$Y_{ijkl} = \mu + \alpha i + \beta_j + \gamma_k + (\alpha \times \beta \times \gamma)_l + \varepsilon_{ijkl}$$

Where;

Y_{ijkl} = is the i-th location, j-th herbage type, k-th harvesting frequency and their interaction (l- th).

μ = is the population constant and is common to all observations.
αi = is the effect of i-th location; i = 4
β_j = the effect of j-th herbage type; j= 3
γ_k = the effect of k-th harvesting frequency; k= 3
$(\alpha \times \beta \times \gamma)_l$ = the interaction (l) of i-th location, j-th herbage type and k-th harvesting frequency.
ε_{ijkl} = is the residual error

RESULTS AND DISCUSSION

Biomass production: Mean production of forbs (466.2 kg/ha) was higher as compared to grasses (197.5 kg/ha) and shrubs (81.5 kg/ha). Herbage production was significantly affected by location ($P<0.01$) and interaction between location and herbage type (Table 2). Relative contribution of different species of herbage types did not remain the same in all four locations which was supported by Mountousis *et al*. (2008) and Gorlier *et al.* (2012) who reported different pattern of herbage production in different altitudinal zones. The production of grasses was significantly ($P<0.001$) higher in Burawai (333 kg/ha) and Jalkhad (273 kg/ha) followed by Basel (141 kg/ha) and Gittidas (42.9 kg/ha). Also shrub production was higher ($P<0.05$) in Burawai as compared to Gittidas, Basel and Jalkhad. In contrast to present study, Rafique (1997) and Mohammad (1989) reported that average forage production of grasses, forbs and shrubs of alpine pasture of Saiful Maluk, was 163, 1688 and 1889 kg/ha, respectively. This variation in biomass production could be attributed to different factors such as topography and elevation of two alpine pastures involved in both studies. Generally calculation of carrying capacity is always based on available forage used by grazing animals for nutritional requirements. If a factor of 0.5 is used, then based on total herbage production results (2959 kg/ha) in present study, these alpine pastures are important for sustained pasture productivity. If an example of large ruminant animal weighing 400 kg as a standard livestock unit is considered, whose feed need is 2% of its body weight (BW). Then 1 livestock unit needs about 240 kg DM per month and for 3 months of growing seasons (from July to September), it will require 720 kg DM. This means that total herbage production from these alpine sites show that these alpine pastures have potential to meet the feed requirement of grazing animals during grazing season (July to September). In general, factors like soil topography, physicochemical composition such as soil texture and composition; soil pH, surface material, bulk density, soil fertility and different vegetation cover affect the production and distribution of herbage. The total herbage production was maximum at 2nd harvest (August) (Table 3). For grasses and forbs the 2nd harvesting interval showed the maximum production. Variation in the production due to herbage type at the monthly harvesting interval may suggest difference in the growth rate of grasses, forbs and shrubs. Mountousis *et al*. (2008) reported herbage production (1945 kg/ha) in July while (1101 kg/ha) in June, presenting the effect of short harvest interval on the herbage yield which may explain the inconsistency of harvest effect on production of three herbage types in the present study.

Dry matter and crude ash: Shrubs had more dry matter (DM) than grasses and forbs (Table 5). Among grasses, DM increased from 84.3 to 87.8%. DM ranged from 86.2 to 89.2% in forbs while shrubs showed DM contents from 87.4 to 90.8%. DM contents gradually increased with the advancing age in three herbs. DM contents was significantly different in grasses, forbs and shrubs at three harvests. It was observed that DM contents of herbage generally increased with maturity which was supported by Hussain and Durrani (2009) who observed increased DM contents with maturity of fodder plants.

Ash contents of forbs were greater than those of shrubs and grasses (Table 5). This general trend was also observed by Ammar *et al*. (1999). In present study, ash contents varied from 7.9 to 9.5% in grasses showing the lowest ash contents, 12.7 to 15.4% in forbs presenting highest ash contents. In all three herbages, the highest ash contents were at first harvest (July) and lowest at 3rd harvest (September) were recorded. Ash contents are very important for balanced growth of animals. The present findings agreed with Bayble *et al.* (2007) who reported low ash contents with maturity of plants.

Crude protein content: Shrubs had higher ($P<0.001$) crude protein (CP) contents than grasses but are not different from forbs. In line with present CP values, Jasra and Johnson (2000) found similar trend of CP contents in shrubs, forbs and grasses of grassland of high-land in Baluchistan. Generally even in the dry season, CP tends to decrease from 10% CP in different parts of fodder trees and shrubs. The present CP values (12.3%) in grasses of alpine pastures are higher than reported by Sultan *et al.* (2007) in marginal grasses of Pakistan, however Tufarelli *et al*. (2010) also reported CP in grasses in same range. The mean herbage CP in the four locations; Basel, Jalkhad, Gittidas and Burawai were 16.6, 11.9, 11.3, and 12.3% in DM, respectively while mean CP in plants at 1st, 2nd and 3rd harvests was 14.4, 12.8 and 12.5% in DM, respectively. It is generally accepted that CP content in the plants at vegetative stage is high and thereafter starts declining with advancement in growth stage (Mountousis *et al*., 2008; Tufarelli *et al*., 2010). The CP value of the herbage is of particular importance to ruminant animals both for proper rumen function and for synthesis process in the animal body. According to NRC (1985), CP levels in dry matter of forage or diet of ewes and growing lambs should be 9.4 and 12.8%, respectively. It is therefore inferred that CP concentrations in the present herbage are satisfactory and meet protein requirement of all classes of

sheep and goats growing on alpine pasture in the upper Kaghan valley. This confirmed the common observations that sheep and goats returning from alpine pasture at the end of grazing season always had remarkable gain in the body weight.

***In vitro* dry matter digestibility:** *In vitro* dry matter digestibility (IVDMD) values of herbage were maximum (P<0.05) at Basel and Burawai followed by Gittidas and Jalkhad (Table 5). The difference in IVDMD among the four experimental sites could have resulted due to factors described earlier. There were large variations in the relative distribution of grasses, forbs and shrubs at four sites and this was apparently one of the main factors for variations in IVDMD of herbage. Shrubs exhibited more (P<0.05) IVDMD than grasses and forbs. The IVDMD results of forbs and shrubs are supported by Rafiq *et al*. (2013) who also reported higher values of IVDMD for forbs (55%) and shrubs (60%) than grasses (52%). The IVDMD values are in line with the results of Zubair *et al*. (2006) who found significant IVDMD values due to locations by reporting 45.5 and 52.8% IVDMD in Jaba and alpine pastures, respectively. The IVDMD values are primarily influenced by the growth stage of herbs relative to CP content

The IVDMD of grasses, forbs and shrubs did not change with harvesting intervals and remained same with all three harvests which may be attributed to short interval of 30 days between each harvest which did not allow the plants to reach maturity. Same trend was reported by Aharoni *et al*. (2009) who recorded (52.5%) in summer (June) and 50.7% in autumn (September). Generally, digestibility declines as plant matures. General trends of seasonal variation of fibre content indicates that as the plant matures, its NDF and lignin contents increase and its digestibility decreases (Moreira *et al*., 2004; Bovolenta *et al*., 2008). Variations in yield, CP content and IVDMD of herbage among the four experimental sites are attributed to plant composition of the sward that showed different proportions of grasses, forbs and shrubs in the present study.

Neutral detergent fibre : Neutral detergent fibre **(**NDF) concentration of grasses was higher than forbs and shrubs at three harvest stages (Table 5). It was observed that NDF value was maximum at 3rd harvest stage (September cut) in grasses (68.5%), forbs (66.5%) and shrubs (46.7%) while it was minimum at 1st harvest (July cut) in three herbage groups. The NDF results in present study agree with Sultan *et al*. (2007); Bogale *et al.* (2008); Hussain and Durrani *et al*. (2009), who reported higher NDF concentration with maturity of plants. Our study showed a tendency for increasing NDF value with plant maturity. The lower value of NDF (less than 50%) in shrubs during three harvests indicated low energy value of alpine pastures in Kaghan valley for sheep and goats which may suggest energy rich feed for grazing livestock to improve animal productivity.

Acid detergent fibre: Acid detergent fibre (ADF) contents of grasses were significantly (P<0.001) higher than forbs and shrubs at 1st and 3rd harvests of the herbs (Table 5). ADF contents of grasses, forbs and shrubs at 1st harvest were 34.2, 32.7 and 25.6%, respectively while at 3rd harvest were 40.6, 39.4 and 35.8%, respectively. The trend of ADF value was almost similar to that of NDF value at early and late harvest stages. The present results are supported by Sultan *et al*. (2007), who also reported increased ADF with maturity of plants.

Hemicelluloses: Grasses presented greater hemicellulose contents than forbs and shrubs in general (Table 5). Hemicellulose contents in grasses ranged from 18.4 to 29.4% by showing lower value at 1st harvest and higher at 3rd harvest. Although hemicellulose contents in forbs and shrubs were lower than grasses but followed the same pattern of decrease and increase in hemicelluloses contents at three harvests. Factors like season and stage of plant maturity exert some variations in complex carbohydrates. Ruminant's diet consists of major portion of forages as they can efficiently use cellulose and hemicellulose due to presence of rumen microbes which are more capable of digesting these structural components of forage (Holecheck *et al*., 1998).

Acid detergent lignin: The present study showed that acid detergent lignin (ADL) value was significantly (P<0.001) greater in shrubs than forbs and grasses at 3rd harvest (Tables 5). The present ADL findings are in line with those of Robles and Boza (1993) who also observed higher ADL contents in shrubs compared to forbs and grasses. A general pattern of increasing ADL contents from 1st to 3 rd cut was observed in the present study. The ADL value ranged from 3.9 to 4.9% in grasses showing the highest value at 3rd harvest stage. Likewise in forbs, a maximum of 9.3% ADL was recorded at late harvest while minimum (4.4%) at early cut (1st harvest). Among herbs, shrubs exhibited highest ADL value ranging from 5.4 to 14.7% indicating increasing tendency from early to late harvest. This might be due to an increase in lignin contents in stem with aging of plant which may affect palatability and therefore animal feed intake (Kramberger and Klemencic, 2003).

Table 1. Composition of the herbage species present in the studied sites of Kaghan valley, Pakistan

Herbage species		
Grass	Forbs	Shrubs
Agrostis gigantea	*Astragalus leucephalus*	*Astragalus candolleenus*
Dactylus glomerata	*Anaphalis contorta*	*Artemisia vulgaris*
Poa alpine	*Chenopodium album*	*Ephedra procera*
Poa annua	*Fragaria vesca*	*Rosa webbiana*
	Galium aparine,	
	Nepeta spicata	
	Trifolium repens	
	Trifolium pratense	

Table 2. Herbage production (kg/ha) at different pasture locations of Kaghan valley during mid to late summer

Location	Herb				
	Grasses	Forbs	Shrubs	Total	Loc x Herb
Basel	141.0^{b}	355.9	62.0^{ab}	558.0	
Jalkhad	273.0^{a}	475.9	72.0^{ab}	820.0	P<0.01
Gittidas	42.9^{c}	553.9	0.0^{b}	578.0	
Burawai	333.0^{a}	478.9	192.0^{a}	1003.0	
Mean	197.5	466.2	81.5	G. total	2959
Significance level	P<0.001	NS*	P< 0.05		

Means in same column with different superscripts are different (P<0.05).
NS* = non-significant, each value is a mean of three harvests (July to September).

Table 3. Herbage production (kg/ha) obtained at different harvesting intervals from different pasture locations of Kaghan valley

Harvest	Grasses	Forbs	Shrubs	Total	Harvest x Herb
1st	72.0^{c}	219.8^{c}	82.5	374.2	
2nd	297.8^{a}	690.0^{a}	93.8	1081.5	P<0.01
3rd	192.8^{b}	472.5^{b}	68.3	733.5	
Mean	187.5	460.8	81.5		
Significance Level	P<0.001	P<0.001	NS*		

Harvesting= 1st (during July), 2nd (during August) and 3rd (during September).
Means in same column with different superscripts are different (P<0.05).
NS* = non significant, each value is a mean of four locations.

Table 4. Mean crude protein (CP) and in vitro dry matter digestibility (IVDMD) values of different herbages at different locations and harvests

		CP (% in DM)	IVDMD (%)
Herbs	Grass	12.3^{b}	54.2^{b}
	Forb	13.6^{ab}	56.2^{b}
	Shrub	14.8^{a}	67.1^{a}
SEM		0.59	3.47
Significant level	Herb	(P<0.001)	(P<0.001)
Location	Basel	16.6^{a}	63.7^{a}
	Jalkhad	11.9^{b}	44.9^{c}
	Gittidas	11.3^{b}	53.3^{b}
	Burawai	12.3^{b}	60.9^{a}
SEM		0.96	3.70
Significant level	Location	(P<0.001)	(P<0.001)
	Loc x Herb	NS	(P<0.001)

Harvest	1st	14.3[a]	59.4
	2nd	12.8[b]	56.4
	3rd	12.5[b]	53.5
Significant level	Harvest	0.45	1.42
	Harvest x Herb	(P<0.001)	NS
		NS	NS

Means in same column with different superscripts are different (P<0.05).
NS = non-significant.

Table 5. Chemical composition (%) of different herbages sampled from different harvests.

Herb	Harvest	*DM	Ash	NDF	ADF	Hemi-cellulose	ADL
Forb	1st	86.2[bc]	15.4[a]	60.1[c]	32.7[c]	13.5[a]	4.4[c]
	2nd	87.4[b]	14.1[ab]	62.2[b]	34.4[b]	12.5[ab]	6.3[b]
	3rd	89.2[a]	12.7[c]	66.5[a]	39.4[a]	11.9[bc]	9.3[a]
SEM		0.71	0.63	1.53	1.64	0.37	1.73
P-value		0.001	0.001	0.001	0.001	0.001	0.001
Shrub	1st	86.2[bc]	15.4[a]	60.1[c]	32.7[c]	13.5[a]	4.4[c]
	2nd	87.4[b]	14.1[ab]	62.2[b]	34.4[b]	12.5[ab]	6.3[b]
	3rd	89.2[a]	12.7[c]	66.5[a]	39.4[a]	11.9[bc]	9.3[a]
SEM		0.71	0.63	1.53	1.64	0.37	1.73
P-value		0.001	0.001	0.001	0.001	0.001	0.001
Shrub	1st	87.4[c]	13.1[a]	37.3[c]	25.6[c]	10.4[c]	5.4[c]
	2nd	89.3[ab]	12.4[ab]	44.5[b]	33.8[b]	12.1[ab]	10.6[b]
	3rd	90.8[a]	10.5[c]	46.7[a]	35.8[a]	12.7[a]	14.7[a]
SEM		0.66	0.63	2.32	2.55	0.56	2.21
P-value		0.001	0.001	0.001	0.001	0.001	0.001

Harvesting= 1st (during July), 2nd (during August) and 3rd (during September).
Means within same column with different superscripts are different (P<0.05).
*DM= dry matter, NDF= neutral detergent fibre, ADF= acid detergent fibre, ADL= acid detergent fibre.

Conclusions and recommendations: Among the three investigated herbage types, forbs showed maximum production; the nutritive value of shrubs (CP and IVDMD) remained higher than other two herbages. Shrubs had more DM than grasses and forbs. Forbs showed higher ash contents as compared to grasses and shrubs. Grasses had greater amount of cell wall fractions (NDF, ADF and hemicellulose) than forbs and shrubs while shrubs were generally higher in ADL contents than grasses and forbs.

Comparatively, lower total herbage production suggests great potential for increasing the carrying capacity in upper Kaghan valley.

Feeding value of plant can be fully evaluated on the basis of chemical composition and *in vivo* trials to determine palatability. It is therefore recommended that feed intake trials with sheep and goats should be carried out for the three herbage groups viz grasses, forbs and shrubs to determine their nutritive quality.

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