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Effect of morphological stage and clipping intervals on quality and digestibility of tall fescue (*Festuca arundinacea* Schreb.) and *Setaria* (*Setaria anceps* Stapf.)

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Abstract
Four varieties of tall fescue (Hima-1, Hima-4, Hima-5 and EC-178182) and three varieties of *Setaria* (PSS-1, S-20 and S-92) were analyzed for variation in chemical composition *viz.,* dry matter, crude protein, neutral detergent fibre (NDF), acid detergent fibre (ADF), hemicellulose, oxalate content and *in vitro* dry matter digestibility (IVDMD) at different morpho-physiological stages and clipping intervals. In tall fescue the crude protein content (11.81%) and IVDMD (55.20%) were higher while NDF (63.65%), ADF (48.22%) and hemicellulose (15.46%) contents were low during early growth stages, however, the highest green fodder yield was observed during the month of July (73.23q/ha). In *Setaria* the crude protein content (10.92%) and IVDMD (62.34%) were high during early growth stages, but the same stages were also having high levels of oxalate (4.87%), which is one of the important anti-quality factor in *Setaria* associated with low milk production. With the advancing age there was decrease in the oxalate content in *Setaria*. The highest green forage yield in *Setaria* was observed during the month of August (100.51q/ha). The NDF, ADF and hemicellulose contents increased with the advancing stages. The results of the study revealed that to have balance among nutritive and anti-nutritive components *Setaria* should be harvested in the month of August and tall fescue in the month of March or April in mid hill Himalayan region.

Key words: Animal nutrition, Cell wall constituents, Crude protein, Forage crops, IVDMD, Oxalate, *Setaria*, Tall fescue

Introduction

Morpho-physiological stage and clipping interval are important factors influencing the quality of forages. Differences in chemical composition of different forage species with advancing growth need consideration while determining the optimum stage of utilization to derive maximum benefit without adversely affecting subsequent herbage productivity (Crowder and Chheda, 1982). Remarkable changes in chemical composition usually occur after extensive tissue differentiation has taken place. The overall quality of forage depends upon the relative proportion of high quality fractions. Forage quality is a major factor in influencing animal performance and it is commonly evaluated through chemical parameters such as crude protein and fibre components, closely related to forage digestibility. When forages are harvested several times during a growing season, the changes in environmental conditions affect distribution of forage between harvests. These effects may be particularly pronounced with perennial forage grasses that produce reproductive growth at one harvest and vegetative growth in subsequent harvests (Cherney and Volenec, 1992).

Tall fescue (*Festuca arundinacea* Schreb.), a native of Europe and North Africa is a perennial, cool-season bunchgrass grown for pasture, hay, and silage. It is renowned for its ability to withstand both drought and high temperatures, but its forage quality has been criticized from long (Sleper, 1985). In the recent years, many herbage quality attributes of tall fescue have been identified and researched. Changes in tall fescue quality are associated with leaf-stem ratio, stage of maturity and date of harvest.

Setaria (*Setaria anceps* Stapf.) is a native of Northern Rhodesia (Zambia) and has been developed for grazing and hay production (Anonymous, 1972). It is palatable and drought-resistant grass species and is better suited to the more shallow soils and lower rainfall situations. It has considerable tolerance to prolonged water logging and areas frequently inundated with flood water (Coleman and Wilsay, 1960) and irrigated areas (Dann, 1963). It has better *In vitro* digestibility (Hacker and Jones, 1969) and the cattle accept its stubble grazing (Redrup, 1967).

The perfect stage of harvesting having balance among nutritive and anti-nutritive components depend on several factors among which the geographical location, morpho-physiological stage and clipping interval play critical roles. The digestibility of forages is another component having direct relation with the growth phase. Therefore, the perfect harvesting period is an important factor for exploiting the full nutritive potential of forages. Considering above facts the present study was undertaken to investigate the effect of different morpho-physiological stages and clipping intervals on the nutritive quality of tall fescue and *Setaria*, the prominent grasses in mid hill Himalayan region.

Materials and Methods

The field experiment was conducted during year 2009 and 2010 at the Research Farm of CSK HPKV, Palampur, Himachal Pradesh representing mid hill Himalayan region having clay loam soil with pH 5.5. The experiment was laid out in Randomized Block Design with three replications in a plot size of 3x3 m^2. Four varieties of tall fescue (Hima-1, Hima-4, Hima-5 and EC-178182) and three varieties of *Setaria* (PSS-1, S-20 and S-92) were investigated during their growth season for nutritional and anti-nutritional components *viz.*, dry matter, crude protein, neutral detergent fibre (NDF), acid detergent fibre (ADF), hemicellulose, *in vitro* dry matter digestibility (IVDMD) and oxalate content (in *Setaria*) at different clipping intervals. Three 0.25 m^2 quadrates were cut from each plot during first fortnight of every month. Tall fescue was sampled during each month from March to July and *Setaria* from May to October for the determination of different components. The grass samples were brought in controlled conditions to laboratory and oven dried at 50^0C to the constant weight and ground in a Willey mill (1 mm sieve) and preserved for further analysis. Crude protein was estimated according to the method described in A.O.A.C. (1970). Cell wall constituents (ADF, NDF and hemicellulose) were estimated by the method given by Van Soest and Wiens (1967). IVDMD was evaluated by following the procedure given by Tilley and Terry (1963). Oxalates were determined by the method of Abaza *et al.* (1968). The data was statistically analyzed by the method given by Panse and Sukhatme (1985).

Results and Discussion

Maximum dry matter content was observed in tall fescue (Table 1) during July (26.89%) and minimum during the month of March (22.77%). High dry matter content during March (23.50%) and April (24.47%) was observed in variety Hima-1. During the month of June (26.27%) and July (27.10%), Hima-4 exhibited highest dry matter content. Maximum protein content was observed on clipping tall fescue during the month of April (11.95%) whereas, the minimum protein content was during the month of July (9.47%). EC-178182 exhibited maximum crude protein content during March (12.54%), April (12.25%) and May (11.08%). During June and July Hima-1, Hima-4 and Hima-5 exhibited maximum crude protein content. Maximum NDF content was observed on clipping tall fescue in the month of July (70.31%) and minimum was observed during the month of March (63.65%). Hima-5 exhibited minimum NDF content during March, April, May, and June. EC-178182 and Hima-4 which were statistically *at par* with Hima-5 showed minimum NDF content during May. Hima-1 was observed with high NDF content during April (66.26%) and May (68.20%) and minimum during July (69.40%).

Maximum ADF content was observed on clipping tall fescue in the month of July (52.11%) and minimum was observed in March (48.16%). Variety Hima-1 was observed with minimum ADF content during all the cutting intervals (March to July). Hima-4 revealed minimum ADF content during April. Hima-5 exhibited maximum ADF content during the months of March (50.93%), April (50.93%), May (50.60%) and July (53.06%). During May and July EC-178182 revealed maximum ADF content. Maximum hemicellulose content was observed on clipping tall fescue in the month of July (18.20%) and minimum was in the month of March (15.45%). Hima-1 exhibited higher hemicellulose content during April (19.20%), May (19.73%), June (19.46%) and July (19.06%). During March maximum hemicellulose content was observed in the variety Hima-4 (18.53%). Hemicellulose content was least in Hima-5 during all the clipping intervals (March to July). The dry matter digestibility in tall fescue was high during the months of March (55.2%) and April (54.55%), which declined during subsequent stages. EC-178182 revealed higher dry matter digestibility during May (53.00%), June (50.60%) and July (49.00%).

In *Setaria* grass, maximum dry matter content (Table 2) was observed during October (25.81%) and minimum was observed in May (23.86%).

Dry matter content was maximum in S-92 in clippings

Table 1. Variation in biochemical composition of Tall fescue at different clipping intervals

a. Variation in green fodder yield (q/ha)

Variety/Month	MARCH	APRIL	MAY	JUNE	JULY
HIMA-1	40.70	43.90	56.30	69.70	70.40
HIMA-4	41.90	47.70	58.70	67.87	73.60
HIMA-5	46.80	48.60	61.30	66.80	75.60
EC-178182	43.80	49.47	63.70	70.41	73.40
G.M.	43.21	47.40	60.00	68.68	73.23
SE(m)±	0.24	0.22	0.16	0.38	0.19
CD at 5%	0.97	0.91	0.67	1.52	0.77
C.V.%	1.13	0.96	0.56	1.11	0.53

b. Variation in dry matter %

Variety/Month	MARCH	APRIL	MAY	JUNE	JULY
HIMA-1	23.50	24.47	25.06	25.90	26.13
HIMA-4	22.50	23.43	25.86	26.27	27.10
HIMA-5	23.10	23.63	24.50	25.76	26.46
EC-178182	22.00	24.30	25.70	25.63	26.36
G.M.	22.77	23.95	25.29	25.89	25.89
SE(m)±	0.55	0.18	0.36	0.11	0.11
CD at 5%	0.60	0.63	NS	0.38	0.38
C.V.%	1.32	1.33	2.52	0.74	0.74

c. Variation in crude protein %

Variety/Month	MARCH	APRIL	MAY	JUNE	JULY
HIMA-1	11.37	12.24	11.37	10.50	9.62
HIMA-4	11.95	11.66	11.08	10.20	9.33
HIMA-5	11.37	11.66	10.50	9.62	9.62
EC-178182	12.54	12.25	11.08	10.20	9.33
G.M.	11.80	11.95	11.00	10.13	9.47
SE(m)±	0.27	0.33	0.16	0.22	0.22
CD at 5%	NS	NS	NS	NS	NS
C.V.%	4.09	4.89	2.63	3.83	4.05

d. Variation in NDF %

Variety/Month	MARCH	APRIL	MAY	JUNE	JULY
HIMA-1	63.10	66.26	68.20	68.00	69.40
HIMA-4	65.13	65.86	67.50	68.00	69.80
HIMA-5	62.40	64.66	67.60	67.60	71.40
EC-178182	63.93	64.80	67.40	68.60	70.80
G.M.	63.65	65.40	67.68	68.08	70.31
SE(m)±	0.25	0.60	0.45	0.21	0.26
CD at 5%	0.86	NS	NS	NS	0.93
C.V.%	0.68	1.61	1.17	0.56	0.67

e. Variation in ADF %

Variety/Month	MARCH	APRIL	MAY	JUNE	JULY
HIMA-1	46.06	46.96	48.40	48.60	50.40
HIMA-4	46.60	47.06	48.86	49.86	51.93
HIMA-5	50.93	50.93	50.60	50.40	53.06
EC-178182	49.06	50.26	49.53	50.66	53.06
G.M.	48.16	48.83	49.36	49.88	52.11
SE(m)±	0.46	0.41	0.24	0.18	0.28
CD at 5%	1.59	1.42	0.86	0.62	0.86
C.V.%	1.66	1.46	0.87	0.63	0.96

f. Variation in hemi-cellulose %

Variety/Month	MARCH	APRIL	MAY	JUNE	JULY
HIMA-1	17.06	19.20	19.73	19.46	19.06
HIMA-4	18.53	18.83	18.00	18.13	17.93
HIMA-5	11.23	13.73	17.00	17.26	18.00
EC-178182	14.86	14.53	17.86	17.86	17.80
G.M.	15.45	16.56	18.15	18.18	18.20
SE(m)±	0.64	0.78	0.20	0.31	0.42
CD at 5%	2.24	2.73	0.72	1.10	NS
C.V.%	7.26	8.26	2.00	3.05	4.01

g. Variation in IVDMD %

Variety/Month	MARCH	APRIL	MAY	JUNE	JULY
HIMA-1	54.00	53.60	50.00	48.60	47.00
HIMA-4	56.00	55.00	50.60	49.40	48.00
HIMA-5	55.00	54.00	52.00	49.00	47.80
EC-178182	55.80	55.60	53.00	50.60	49.00
G.M.	55.20	54.55	51.40	49.40	47.95

Table 2. Variation in biochemical composition of *Setaria* at different clipping intervals

a. Variation in green fodder yield (q/ha)

Variety/Month	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER
PSS-1	70.90	80.40	87.90	93.40	77.00	67.80
S-20	80.40	90.90	97.80	103.70	87.30	70.40
S-92	82.70	73.40	100.60	107.80	89.00	72.70
GM	77.87	81.43	95.32	100.51	84.43	70.28
SE(m)±	0.32	0.26	0.34	1.98	0.16	0.58
CD at 5%	1.28	1.04	1.35	7.78	0.63	2.30
C.V.%	0.73	0.57	0.63	3.42	0.33	1.44

b. Variation in dry matter %

Variety/Month	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER
PSS-1	23.33	24.33	24.00	24.70	24.86	25.33
S-20	23.46	23.90	23.73	24.83	25.66	26.03
S-92	24.80	24.23	23.83	24.76	25.53	26.06
GM	23.86	24.15	23.85	24.76	25.35	25.81
SE(m)±	0.12	0.17	0.09	0.12	0.08	0.07
CD at 5%	0.47	NS	NS	NS	0.33	0.30
C.V.%	0.87	1.23	0.65	0.89	0.58	0.52

c. Variation in crude protein %

Variety/Month	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER
PSS-1	11.08	10.20	8.45	7.00	6.12	4.95
S-20	11.08	10.50	8.45	7.87	5.83	4.95
S-92	10.50	9.62	8.16	7.00	5.83	5.25
GM	10.88	10.10	8.35	7.29	5.92	5.05
SE(m)±	0.26	0.16	0.26	0.07	0.16	0.26
CD at 5%	NS	0.66	NS	0.08	NS	NS
C.V.%	4.21	2.90	5.55	0.05	4.89	9.18

d. Variation in NDF %

Variety/Month	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER
PSS-1	58.80	62.13	65.40	68.26	69.80	71.80
S-20	60.26	62.86	64.73	67.26	68.73	71.33
S-92	61.33	63.46	65.13	68.13	69.73	72.00
G.M	60.13	62.82	65.08	67.88	69.42	71.71
SE(m)±	0.51	0.34	0.46	0.12	0.46	0.35
CD at 5%	NS	NS	NS	0.50	NS	NS
C.V.%	1.48	0.95	1.25	0.33	1.15	0.86

e. Variation in ADF %

Variety/Month	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER
PSS-1	42.86	45.00	46.73	48.26	49.13	49.66
S-20	45.60	46.46	47.93	47.00	49.00	50.86
S-92	45.13	47.66	47.86	48.46	48.80	51.26
G.M	44.53	46.37	47.51	47.91	48.97	50.60
SE(m)±	0.51	0.32	0.17	0.21	0.35	0.32
CD at 5%	2.03	1.26	0.68	0.84	NS	NS
C.V.%	2.03	1.20	0.63	0.78	1.24	1.12

f. Variation in hemi-cellulose %

Variety/Month	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER
PSS-1	16.60	17.13	18.66	20.00	20.66	22.13
S-20	14.86	16.40	16.80	20.26	19.73	20.46
S-92	14.53	15.80	17.26	19.66	20.66	20.73
G.M	15.11	16.44	17.57	19.97	20.35	21.11
SE(m)±	0.39	0.58	0.33	0.22	0.47	0.67
CD at 5%	NS	NS	1.30	NS	NS	NS
C.V.%	4.48	6.13	3.27	1.95	4.06	5.51

g. Variation in oxalate %

Variety/Month	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER
PSS-1	4.92	4.54	3.79	3.56	2.94	2.61
S-20	4.97	4.72	3.72	3.39	2.84	2.71
S-92	4.72	4.80	3.92	3.43	2.98	2.71
G.M	4.87	4.68	3.81	3.45	2.92	2.68
SE(m)±	0.02	0.06	0.11	0.01	0.03	0.03
CD at 5%	0.08	NS	NS	0.05	NS	NS
C.V.%	0.79	2.37	5.36	0.68	2.30	2.16

h. Variation in IVDMD %

Variety/Month	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER
PSS-1	61.80	60.26	54.20	49.43	48.46	48.70
S-20	63.13	59.80	54.00	51.40	49.06	47.76
S-92	62.10	59.56	53.33	50.33	49.20	47.66
G.M.	62.34	59.87	53.84	50.38	48.90	48.04

of May (24.80%), July (23.83%) and October (26.06%). S-20 also exhibited maximum dry matter content during August (24.83%) and September (25.66%). PSS-1 revealed highest dry matter content during June and August. S-92 and S-20 revealed maximum dry matter content during October.

The crude protein in *Setaria* was maximum in the month of May (10.88%) and minimum during the month of October (5.05%). PSS-1 and S-20 revealed high crude protein content during May, June, July, August and September. S-92 exhibited maximum crude protein content during October (5.25%). NDF in *Setaria* varieties was maximum in the month of October (71.71%) and minimum during May (60.13%). S-92 exhibited maximum ADF content during June (47.86%), August (48.46%) and October (51.26%) clippings. S-20 exhibited maximum ADF content during May (45.60%) and July (47.93%). During September PSS-1 revealed high ADF content. Maximum ADF content was observed in October (50.60%) and minimum was observed in the month of May (44.53%). Among different *Setaria* varieties, PSS-1 exhibited minimum ADF content during clippings in the month of May, June, July and October. During the month of August, S-20 was observed with minimum ADF content. The hemicellulose content revealed variations from 14.87 to 16.20 and 20.47 to 22.13 per cent during May and October clippings, respectively. PSS-1 exhibited maximum hemicellulose content during the clipping intervals June (17.13%), July (18.66%), September (20.66%) and October (22.13%). In *Setaria* highest hemicellulose content was observed during October (21.11%) and minimum in the month May (15.1%).

Oxalate content in the clipping's of *Setaria* during the month of May varied from 4.72 (S-92) to 4.97 (S-20) per cent and during October from 2.61 (PSS-1) to 2.71 (S-20) per cent. Minimum value for oxalate was observed in the month of October (2.68%), whereas its value was highest in the month of May (4.87%). S-92 exhibited minimum oxalate content during May. In June PSS-1 exhibited minimum oxalate content. S-20 revealed minimum oxalate content during August. No significant variation was observed among *Setaria* varieties for oxalate content during the month of August, September and October.

In vitro dry matter digestibility also revealed significant variations during different clipping intervals. Maximum dry matter digestibility was observed during the month of May (62.34%) and low digestibility was observed in the month October (48.04%). S-20 exhibited maximum IVDMD during May (63.13%) and August (51.40%), PSS-1 during June (60.26%), July (54.20%) and October (48.70%) clippings. S-92 had maximum dry matter digestibility in the month of September (49.20%).

Crude protein content generally decreases with the advancement of plant growth due to synthesis of structural carbohydrates with advancing plant age. The decline in crude protein concentration is also attributed to reduction in leaf to stem ratio with advancing age. These findings are consistent with previous studies (Jafari *et al.,* 2010; Mushtaque *et al.*, 2010; Desouza *et al.,* 2010; Campbell 2007; Sleugh *et al.*, 2001; Sarwar and Nisa, 1999; Griffin and Jung, 1983; El-Shatnawi and Al-Qurran, 2003; Gupta and Sagar, 1987). The increase in the concentrations of NDF with increasing plant age is due to decreased leaf to stem ratio, synthesis of more cell wall contents and declined cell contents. Similar results were reported by Dabo *et al.* (1988), Mero and Udden (1998), Gupta and Sagar (1987), Kallenbach *et al.* (2002) and Borreani *et al.* (2003). The increase in ADF content increased with advancing plant age. Advancing concentration may be attributed to decreased leaf to stem ratio with advancing plant age. Similar results were presented by Balabanli *et al.* (2010), Dauglas *et al.* (2010), Clark *et al*. (2010), Dong *et al.* (2003), Dabo *et al.* (1988), Kramberger and Klemen (2003) and Madakadze *et al.* (1999).

Tall fescue grass had highest protein content as well as protein digestibility in the month of April and minimum fibre content in March, whereas, *Setaria* revealed highest protein in July and minimum fibre content and maximum dry matter digestibility in May. Low oxalate content was observed in the month of October, whereas highest contents were in the month of May. Oxalate content declined with advancing plant growth. Similar results were observed by Rahman *et al.* (2009) in napier grass. Decrease in IVDMD content with advancing maturity of the forages may be attributed to the lignification of cell wall (Van Soest, 1965).

In tall fescue, among different varieties Hima-4 was superior over others for dry matter content, Hima-1 for crude protein and ADF, Hima-5 for NDF and hemicellulose and EC-178187 for *in vitro* dry matter digestibility during all the clipping intervals (March to July). In *Setaria*, S-92 was superior over others for dry matter content, S-20 for crude protein and hemicellulose and PSS-1 for ADF during all the clipping intervals (May to October). However, for NDF, oxalate and IVDMD content all the varieties of *Setaria* were statistically *at par*.

Thus, the present study revealed that the quality of the forages is highly influenced by harvesting stages. In the mid-hill Himalayan conditions the dry matter, NDF, ADF and hemicellulose content increased while crude protein, IVDMD and oxalate decreased with an increase in the age of plants. Tall fescue grass retains maximum nutritive value during the month of March and April. However, in *Setaria* the nutrients are in the right proportion in the month of May or July, but oxalate content is simultaneously high, which is not desirable despite of other merits. Harvesting of *Setaria* in the month of August could maintain a better balance in nutritive composition in terms of nutritional as well as anti-nutritional components. Further, harvesting grass after the month of September, when the oxalate content are low, shall not be appropriate as that stage of grass has high fibre and low protein content and will not be appropriate to meet the nutritional requirements of the livestock.

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