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Effect of morphological stage and clipping intervals of Tall fescue (*Festuca arundinacea* Schreb.) and *Setaria* (*Setaria anceps* Stapf.) on biochemical composition and *in vitro* dry matter digestibility in mid hill Himalayan region

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Four varieties of Tall fescue and three varieties of *Setaria* 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 (11.81%) and IVDMD content (55.20%) were higher while NDF (63.65%), ADF (48.22%) and hemicellulose content (15.46%) were low during early growth stages. In *Setaria* the crude protein (10.92%) and IVDMD (62.34%) was 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-nutrient in *Setaria* associated with low milk production. With the advancing age there was decrease in the oxalate content in *Setaria*. The NDF, ADF and hemicellulose content increased with an increase in the age of plants. The results of the study revealed that to have balance among nutritive and anti-nutritive components *Setaria* should be harvested in the month of September and tall fescue in the month of March or April in mid hill Himalayan region.

Key words: Cell wall constituents, crude protein, *in vitro* dry matter digestibility (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. Herbage 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

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Table 1. List of varieties of tall fescue and *Setaria* undertaken for study.

Tall fescue	*Setaria*
Hima-1	PSS-1
Hima-4	S-20
Hima-5	S-92
EC-178182	

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 due to presence of oxalates. In the recent years, many herbage quality attributes of tall fescue have been identified and researched (Sleper, 1985). 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. On the other hand, it has considerable tolerance to prolonged water logging and areas frequently inundated with flood water (Coleman and Wilson. 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). In *Setaria* the *in vitro* digestibility *is* variable with different growth stages, which could affect milk production and animal health.

The perfect stage of harvesting having balance among nutritive and 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 utilizing 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 Himachal Pradesh Agricultural University, Palampur, India, 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 3×3 m^2. Four varieties of Tall fescue and three of *Setaria* 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* during the month of May, June, July, August, September and October for the determination of different components. The grass samples were brought in controlled conditions from laboratory oven dried at 50°C to the constant weight and ground in a Willey mill (1 mm sieve) and preserved in nylon bag 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). The different varieties of tall fescue and *Setaria* selected for the present study are listed in Table 1.

RESULTS

The data on variation in chemical composition of tall fescue and *Setaria* at different clipping intervals are presented in Figures 1 and 2, respectively.

The quality of the forage for livestock is extremely important. Determination of dry matter in forages is important to ensure that animals are receiving proper amount of nutrients through their diet. Maximum dry matter contents were observed during July (26.52%) 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.

Crude protein content is positively correlated with quality. The high-protein forages are generally high-quality forages. Maximum protein contents were observed on clipping tall fescue during the month of April (11.95%) whereas, the minimum protein content was during the month of July (9.55%). EC-178182 exhibited maximum crude protein content during March (12.54%), April (12.25%) and May (11.37%). During June and July Hima-1, Hima-4 and Hima-5 exhibited maximum crude protein content.

Fiber content of forages is inversely related to quality. Forages with high concentrations of fiber generally support less milk production than low-fiber forages because forages with high concentrations of fiber contain less available energy and are consumed in lesser amounts by livestock than the forages with low amounts of fiber. Neutral detergent fibre (NDF) is the percentage of cell wall material in the hay that is partially available to the animal and is made up of cellulose, hemicellulose,

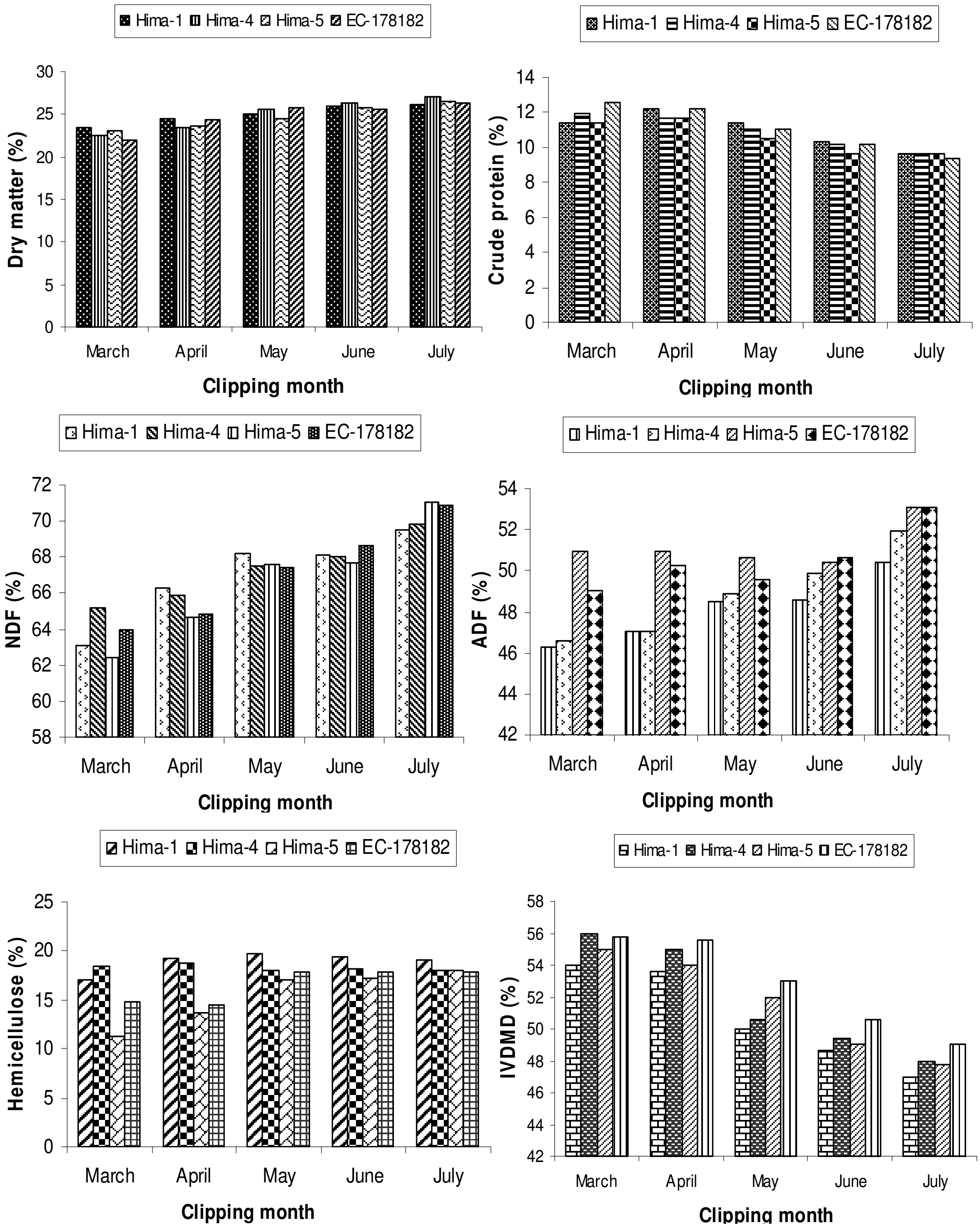

Figure 1. Variation in biochemical composition of tall fescue at different clipping intervals.

and lignin. As the NDF percentages increase, the dry matter intake will generally decline (meaning the animal will consume less). NDF content is very important because it estimates that fraction of forage that, if it is to be used by the animal, must first be broken down by gastrointestinal microorganisms. Maximum NDF content was observed on clipping tall fescue in the month of July (70.32%) and minimum was observed during the month

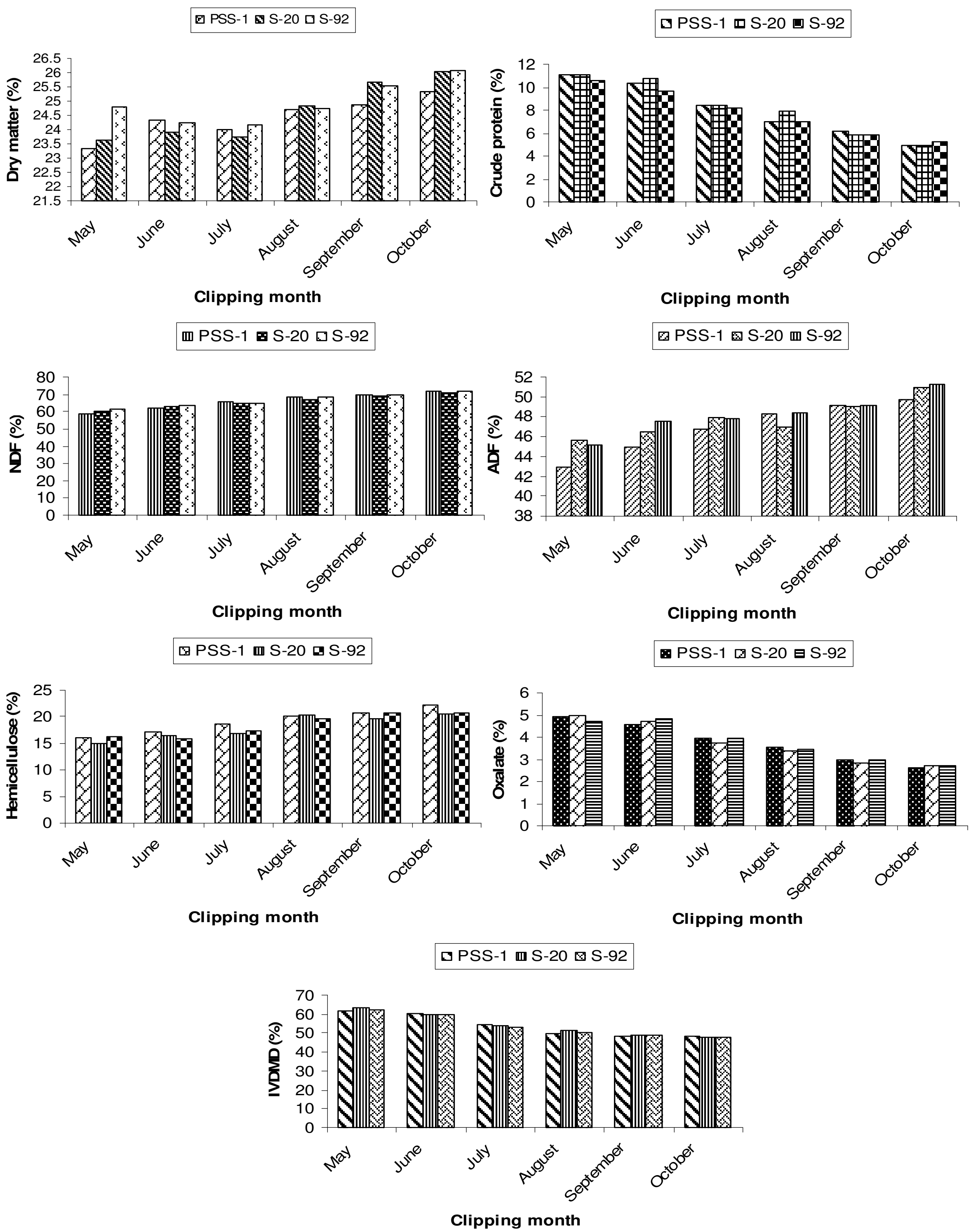

Figure 2. Variation in biochemical composition of *Setaria* at different clipping intervals.

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 (66.27%) and May (68.20%) and minimum during July (69.47%).

Acid detergent fibre (ADF) is the percentage of highly indigestible plant material in forage comprised of cellulose and lignin. A low ADF value indicates greater digestibility and therefore better quality hay. ADF values are important because they reflect the ability of an animal to digest the forage. As ADF increases, digestibility usually decreases. Maximum ADF content was observed on clipping tall fescue in the month of July (52.12%) and minimum was observed in March (48.22%). 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 (53.07%). During May and July EC-178182 revealed maximum ADF content.

Hemicellulose refers to various polysaccharides that are tightly associated with the surface of the cellulose microfibril. The difference of NDF and ADF content gives the hemicellulose 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 (15.46%). Hima-1 exhibited higher hemicellulose content during April (19.20%), May (19.73%), June (19.47%) and July (19.07%). During March maximum hemicellulose content was observed in the variety Hima-4 (18.53%). Hemicellulose contents were 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 was observed during October (25.81%) and minimum was observed in May (23.92%). Dry matter content was maximum in S-92 in clippings of May (24.80%), July (24.17%) and October (26.07%). S-20 also exhibited maximum dry matter content during August (24.83%) and September (25.67%). 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 July (10.92%) 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 (60.20%). S-92 exhibited maximum ADF content during June (47.57%), August (48.47%) and October (51.27%) 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% during May and October clippings, respectively. PSS-1 exhibited maximum hemicellulose content during the clipping intervals June (17.13%), July (18.67%), September (20.67%) and October (22.13%). In *Setaria* highest hemicellulose content was observed during October (21.11%) and minimum in the month May (15.67%).

Oxalate is a common constituent of plants and accumulates primarily as soluble oxalate, insoluble calcium oxalate, or a combination of these two forms. This compound is of much concern because of health-related hazards due to high oxalate levels in food and animal feed (Libert and Franceschi, 1987). In *Setaria*, oxalate is major anti-nutrient associated with lowering milk production in feeding animals. In the present study, oxalate content in the clipping during the month of May varied from 4.72 (S-92) to 4.98% (S-20) and during October from 2.61 (PSS-1) to 2.72% (S-20). 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 (60.27%), July (54.20%) and October (48.70%) clippings. S-92 had maximum dry matter digestibility in the month of September (49.20%).

DISCUSSION

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 (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 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. This general decline with age in the oxalate concentration of whole plant material can be partly explained by the increase in the proportion of stem, which contain less oxalate than the leaves. 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. 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. Thus, feeding the livestock at appropriate growth stages could result in better animal health and productivity.

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