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Nutritive Value of Important Fodder Species in Successional Grassland Ecosystem in Manipur

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ABSTRACT

Nutritive components such as crude protein, crude fibre, cellulose, hemicellulose, lignin, nitrogen, phosphorus and potassium, of important fodder plant species in successional grassland in Manipur have been evaluated throughout the year. The amount of crude protein and fibre varied from 2.38% (January) to 25.75% (May) and 25.20% (January) to 69.87% (July), respectively in different species. Cellulose, hemicellulose and lignin contents also ranged from 37.19% (March) to 60.42% (May), 19.89% (March) to 44.59% (September) and 4.28% (March) to 28.21% (January), respectively, in different species across the months. The highest nutritive value of plant species i.e., nitrogen, phosphorus and potassium content was found to be during the rainy months of July/September. Out of 13 fodder plant species, *Desmodium triflorum* exhibited highest content for crude protein and nitrogen, *Fimbristylis dichotoma* for crude fibre, and potassium, *Arundinella setosa* for cellulose, *Bothriochloa intermedia* for *Hemicellulose*, *Dichanthium annulatum* for lignin, *Andropogon ascinodes* for phosphorus during the study period. These species are more palatable in early vegetative stage and considered excellent nutritious fodders.

Key words: Crude protein, Crude fibre, Cellulose, Hemicellulose, Lignin, Nitrogen, Phosphorous, Potassium

INTRODUCTION

Nutritive quality of forage is an important parameter in determining the nutrients of grasses/legumes in different plant species which are consumed by the herbivores. Grazing animals have access to a great variety of plant species in the grassland to select a diet. Grazing cattle require a diet rich with 10% crude protein on a dry matter basis and for mature cattle 7% crude protein for maintenance. The forage quality not only varies from species to species but also within different plant parts, stage of maturity, soil fertility and environmental conditions (Huston and Pinchak 1991, Fisher et al. 1995, Mislevy et al. 2003, Gonzalez-V 2005, Jouven et al. 2006). Fibre is a homogenous mixture of various macro-molecules. Most of these are structural polysaccharides (e.g., cellulose, hemicellulose and pectin). The nature and concentration of structural carbohydrates in plant cell wall are major determinants of forage quality. Usually carbohydrate contents of cell wall ranged from 30-80% of plant dry matter and vary as source of energy. Non-carbohydrates like aromatic compounds, lignins, non-digestible proteins and others are normally counted as fibre constituents in general for decomposition phenomenon. Two main components of grass, cellulose and lignin, play a key role in nutrient cycling of grassland ecosystem through microbial activity under favourable climatic conditions. Cellulose is also one of the most abundant organic compounds in the entire plant and animal kingdoms. It is the characteristic substance of plant cell wall, constituting 25 to 50% of cell wall organic material. Forage grass which content high amount of cellulose provide more energy to animals. The lignin content of the cell was is the major determinant of the extent to which it can be digested. Lignin is considered as an interfering factor in the enzymatic digestion of cellulose and other carbohydrates as well as proteins. High initial level of lignin also results in slow rate of decomposition.

Nitrogen is an element that frequently limits the growth of herbaceous vegetation in annual grassland even in dry years (Duncan and Reppart 1961). It is the most vital element which affects the structure and function of the grassland ecosystem. The knowledge of nitrogen concentration in various soil vegetation components at different stages of the life cycle of plant is considered as useful in determining the visual symptoms of nitrogen excess of deficiency (Embleton et al. 1959). In addition to its impact on the primary productivity and organic matter decomposition, nitrogen also affects a number of other ecosystem characteristics such as plant - water use efficiency, diet selection, nutritional status of consumer organisms and plant species composition. The protein value of diet is an expression of the capacity of the diet to provide adequate ammonia and essential- and non- essential amino acids to support protein synthesis at the rate permitted by the energy supply. In the vegetative stage of growth, protein level in grasses are usually high, and it is only as the plant approach maturity that low protein contents in both the temperate and tropical grasses pose a major limitation of forage quality for grazing animal. The phosphorus and potassium are also equally important element for the proper growth and development of plant. Nutritional quality of tropical grasses have been reported by several workers (Norton 1982, Yadava and Singh 1986, Minson 1990, Duru 1997, Wilman and Rezvani Maghaddam 1998, Mortenson et al. 2005, Lewis et al. 2006, Starks et al. 2006, Verma et al. 2008).

However, there is lack of information on nutritive quality of different plant species in grassland vegetation from North-East India. Therefore the present study deals with biochemical composition of grasses, legumes and sedges with special reference to crude protein, crude fibre, cellulose, hemicellulose, lignin, nitrogen, phosphorus and potassium in some of the important fodder plant species for different months throughout the year.

MATERIALS AND METHODS

Study area

The study site is located at Khongjom (24°152-24°452N latitude and 93°452-94°152E longitude) in Thoubal district of Manipur state at an altitude of 922 m amsl and 35 km from Imphal city. It is open grassland and a historical place, where Manipuris fought against British in 1891. The site is a part of an ecological park at presently. The climate of the area is monsoonic with warm moist summer and cool dry winter. The mean maximum temperature varies between 22.32°C (January) to 30.31°C (May) and mean minimum temperature between 4.76°C (January) to 22.26°C (July). The average relative humidity of air varies between 59.15% (March) to 82.64% (July). The mean minimum rainfall occurs during January (13.45 mm) and maximum during June (227.32 mm). The average annual rainfall is 1407.81mm .The year can be divided into three distinct seasons such as summer (March to May), rainy (June to October) and winter (November to February).

Plant samples were harvested monthly during March 2003 to February 2004 and oven dried at 80°C for 48 hours and grinded to a particle size <1 mm. Plant crude fibre, cellulose, hemicellulose and lignin content were determined by Tecator Fibertec I and M System (van Soest and Wine 1968). The total nitrogen (Kjeldahl's method), Phosphorus (Phosphomolybdic blue colorimetric method) and Potassium (Flame-Photometry method) were assessed using standard methods as suggested by Jackson (1958). The crude protein content of the plant was determined by multiplying the total nitrogen value with the factor 6.25.

RESULTS AND DISCUSSION

Crude protein

The concentration of crude protein in various plant species during different months is given in Table 1. Some of species such as *Andropogon ascinodes, Arundinella setosa, Bothriochloa intermedia, Cymbopogon flexuosus, C. martinii, Desmodium triflorum, Eulalia fastigiata, Heteropogon. contortus, Imperata cylindrical, Monocymbium ceresiiforme* and *Paspalum orbiculare* attained maximum concentration of crude protein (12.44 to 25.75%) during the month of May. Among these species *D. triflorum* had the highest crude protein content (25.75%) during the study period. This species is more palatable and rich in crude protein than grass species. Crude protein was highest in *D. annulatum* (12.44) and *F. dichotoma* (18.69%) during September whereas the minimum was during the month of January in all species except *A. setosa* and *C. flexuosus*. At maturity there is usually a decrease in the crude protein. This decrease is caused by an increased in the proportion of stem biomass, which has lower protein than the leaf fraction. The crude

Table 1. Variation in concentration of crude protein (%) in the live shoots of important fodder plant species

Name of species	Mar.'03	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.'04	Feb.	Mar.
Andropogon ascinodes	7.88	8.75	15.88	10.78	11.94	13.91	9.63	12.06	8.25	7.34	6.44	7.34	8.25
Arundinella setosa	9.75	10.25	15.06	11.59	12.44	13.75	10.75	11.31	7.56	8.06	8.56	8.97	9.38
Bothriochloa intermedia	10.63	12.72	14.81	12.50	10.19	12.03	13.88	10.47	7.06	6.25	5.44	8.37	11.31
Cymbopogon flexuosus	6.44	9.44	12.44	11.09	9.75	8.97	8.19	7.56	6.94	5.12	3.31	5.15	7.00
Cymbopogon martinii	7.63	10.66	13.69	12.81	11.94	7.84	3.75	6.90	10.06	8.50	6.94	7.59	8.25
Desmoduim triflorum	9.19	17.47	25.75	22.03	18.31	19.37	20.43	16.90	13.38	19.57	6.19	7.22	8.25
Dichanthium annulatum	3.56	5.68	7.81	8.31	8.81	10.62	12.44	9.75	7.06	4.72	2.38	3.81	5.25
Eulalia fastigiata	6.88	8.47	13.38	11.06	12.06	12.72	10.06	10.41	7.44	6.53	5.63	6.66	7.69
Fimbristylis dichotoma	9.19	11.75	14.31	14.37	14.44	16.56	18.69	14.19	9.69	8.00	6.31	7.34	8.38
Heteropogon contortus	6.19	10.66	15.13	13.50	11.88	9.72	7.56	7.03	6.50	5.62	4.75	5.84	6.94
Imperata cylindrica	7.06	11.43	15.81	14.47	13.13	11.78	10.44	8.90	7.37	6.90	6.44	6.91	7.38
Monocymbium ceresiiforme	5.13	5.72	7.75	6.56	6.81	7.28	6.31	6.84	5.94	4.56	3.19	4.47	5.75
Paspalum orbiculare	8.56	13.50	18.44	14.25	10.06	10.93	11.81	10.34	8.88	7.22	5.56	6.81	8.06

Table 2. Variation in concentration of crude fibre (%) in the live shoots of important fodder plant species

Name of species	Mar.'03	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.'04	Feb.	Mar.
Andropogon ascinodes	38.94	41.07	43.21	45.26	47.32	46.21	45.11	44.21	43.31	40.73	38.15	40.21	42.28
Arundinella setosa	54.48	57.31	60.15	61.37	62.60	61.80	61.01	60.46	59.92	58.67	57.43	57.93	58.19
Bothriochloa intermedia	31.44	32.79	34.15	35.79	37.43	35.77	34.11	32.62	31.14	29.70	28.27	30.24	32.21
Cymbopogon flexuosus	51.39	51.30	51.21	51.19	54.18	52.16	50.14	48.99	47.84	50.06	52.29	51.25	50.21
Cymbopogon martinii	51.86	51.60	51.34	52.29	53.24	51.57	49.91	50.09	50.27	50.66	51.06	50.60	50.14
Desmoduim triflorum	53.29	52.78	52.28	53.23	54.19	53.18	52.17	53.69	55.21	54.19	53.18	53.64	54.10
Dichanthium annulatum	46.27	46.14	46.01	47.19	48.37	48.14	47.91	47.11	46.32	45.22	44.12	44.71	45.31
Eulalia fastigiata	48.14	47.59	47.04	47.63	48.23	49.32	50.41	51.16	51.91	49.97	48.03	48.63	49.24
Fimbristylis dichotoma	64.19	66.71	69.24	69.55	69.87	67.34	64.81	65.04	65.27	65.08	64.90	66.14	67.38
Heteropogon contortus	57.92	54.59	51.27	52.74	54.21	52.14	51.08	50.64	50.21	52.79	55.38	56.29	57.20
Imperata cylindrica	59.95	60.08	60.21	65.03	62.19	61.31	60.43	59.96	59.49	58.84	58.20	57.02	59.72
Monocymbium ceresiiforme	30.01	31.79	33.57	34.42	35.28	36.24	37.21	36.87	36.54	32.38	28.23	28.68	29.14
Paspalum orbiculare	29.21	29.34	29.47	30.47	31.48	30.96	30.44	29.53	28.62	26.91	25.20	27.06	28.92

protein content of both the leaf and stem fractions decreases with age.

In the present investigation, there are two maximum content periods, one in May in eleven plant species including a leguminous plant and another in September in two plant species including a sedge plant. In vegetative stage of growth, protein level in grasses is usually high and only as the plant approach maturity that low protein in both temperate and tropical grasses pose a major limitation of forage quality for grazing animals (Norton 1982). In the present study, crude protein content of different plant species increased considerably during the vegetative stage of growth and reaching peak value during the flowering stages. Norton (1982) also reported that grasses usually contain less crude protein than legumes. *D. triflorum*, a leguminous plant showed the highest value (25.75%) of crude protein among the selected dominant fodder plant species. Norton (1982) reported that less than 20% of tropical grass has crude protein content above 15%. In the present study, *A. ascinodes, A. setosa, F. dichotoma I. cylindrica* and *P. oriculare* exhibited above 15% crude protein. Minson (1990) reported crude protein concentration ranges from 2 to 27% of the dry matter of 560 tropical grasses from different parts of the world according to stage of growth and level of soil fertility. The crude protein concentration of plants in the present investigation falls within this range.

Crude fibre

Crude fibre has been the most common fraction to designate the structural carbohydrate content of the herbage although neither hemicellulose nor pectins are included in this fraction. Among the 13 plant species studied, 9 species i.e., *A. ascinodes, A. setosa, B. intermedia, C. flexuosus, C. martinii, D. triflorum, D. annulatum, F. dichotoma* and *P. orbiculare* exhibited maximum crude fibre range from 31.48 to 69.87% in the month of July (Table 2). Maximum fibre content was at the time of maximum vegetative growth. *H. contortus* had maximum crude fibre concentration at the early stage of growth i.e., March (57.92%) while the remaining months it varied throughout the study period. The concentration of crude fibre in *I. cylindrica* exhibited maximum peak in June (65.03%) while minimum value in February (57.02%). The concentration of crude fibre in *M. ceresiiforme* consistently increased from March (30.01%) onward till it attains a peak in September (37.21%) and then declined till January (28.23%) with a slight increased in later two months. *E. fastigiata* exhibited maximum concentration of crude fibre is recorded in November (51.91%) while minimum value is found in the month of May (47.04%).

Cellulose

Cellulose in young grasses may account for as little as 15% of dry weight basis. In the present study *A. ascinodes, A. setosa, C. flexuosus, C. martinii, D. triflorum, E. fastigiata, F. dichotoma, H. contortus,I. cylindrica,* and *M. ceresiiforme* exhibited maximum concentration of cellulose varying between 47.35 to 60.42% in the month of May. Most of the species have maximum cellulose concentration in the vegetative stage (Table 3). In case of *B. intemredia* exhibited highest concentration of cellulose in the month of July (58.24%) and minimum in March (41.24%). *D. annulatum* attained a maximum peak in March (43.50%) and minimum in January (35.24%). The concentration of cellulose in *P. orbiculare* varied throughout the year.

Hemicellulose

Hemicelluloses also one of the major polysaccharides in plant cell wall. In the present study *A. ascinodes, C. flexuosus, C. martini, D. annulatum, H. contortus* and *M. ceresiiforme* exhibited peak concentration of hemicellulose in July (38.01 to 42.19%) and minimum in March (26.40 to 35.50%) whereas *B. intermedia, D. triflorum, E. fastigiata, F. dichotoma* and *P. orbiculare* showed their maximum concentration of hemicellulose in September (37.41 to 44.59%) and minimum in January (35.59 to 37.98%). The maximum concentration of hemicellulose in *A. setosa* was in November (36.30%) and for *I. cylindrica* in May (49.09%), whereas minimum was in January (26.04%) and March (26.16%), respectively, for these species (Table 4).

Lignin

Lignin content increased with increase in age of the plant species. It generally varies from 3 to 6% on dry weight basis in young immature grasses and legumes. In the present study, majority of the plant species i.e., *A. ascinodes, A. setosa, B. intermedia C. flexuosus, C. martini, D. triflorum, D. annulatum,*

Table 3. Variation in concentration of cellulose (%) in the live shoots of important fodder plant species

Name of species	Mar.'03	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.'04	Feb.	Mar.
Andropogon ascinodes	40.24	44.08	47.92	46.12	44.32	42.33	40.34	39.92	39.51	38.69	37.88	38.72	39.57
Arundinella setosa	48.14	54.28	60.42	59.76	59.10	58.55	58.01	56.86	55.72	49.92	44.12	45.67	47.23
Bothriochloa intermedia	41.24	47.21	53.19	55.71	58.24	53.23	48.23	50.03	51.84	52.51	53.18	47.63	42.09
Cymbopogon flexuosus	40.24	42.48	44.73	43.42	42.11	40.30	38.49	39.15	39.82	39.51	39.21	38.20	37.19
Cymbopogon martinii	38.51	43.46	48.21	46.82	45.24	44.21	43.18	42.61	42.04	40.12	38.20	37.54	36.88
Desmoduim triflorum	42.80	46.90	51.01	50.16	49.32	47.87	46.43	45.31	44.19	43.66	43.14	42.20	41.26
Dichanthium annulatum	43.50	43.03	42.56	41.89	41.23	42.97	44.72	42.21	39.71	37.47	35.24	37.33	39.42
Eulalia fastigiata	48.47	50.87	53.27	52.14	51.02	48.77	46.52	45.19	43.87	45.09	46.31	47.06	47.82
Fimbristylis dichotoma	40.72	43.46	46.20	45.56	44.92	43.51	42.11	43.41	44.71	44.96	45.21	42.57	39.94
Heteropogon contortus	42.23	44.79	47.35	46.18	45.01	43.68	42.35	41.82	41.30	44.07	46.84	43.85	40.87
Imperata cylindrica	40.01	42.97	45.94	44.57	43.21	42.21	41.22	39.99	38.77	39.44	40.11	39.34	38.57
Monocymbium ceresiiforme	43.25	46.99	50.74	48.76	46.78	46.22	45.67	44.82	43.97	43.30	42.63	41.53	40.44
Paspalum orbiculare	37.29	39.35	41.42	41.21	41.01	43.65	46.29	45.28	44.28	42.19	39.51	38.73	37.95

Table 4. Variation in concentration of hemicellulose (%) in the live shoots of important fodder plant species

Name of species	Mar.'03	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.'04	Feb.	Mar.
Andropogon ascinodes	30.22	34.22	38.23	39.27	40.31	38.78	37.25	37.15	37.06	36.58	36.11	33.74	31.38
Arundinella setosa	28.54	30.90	33.26	33.62	33.98	34.44	34.90	35.51	36.13	31.08	26.04	22.96	19.89
Bothriochloa intermedia	39.48	40.34	41.20	38.47	35.75	40.17	44.59	41.91	39.24	37.41	35.59	34.32	33.05
Cymbopogon flexuosus	30.21	33.61	37.02	38.03	39.05	38.37	37.70	36.93	36.17	35.97	35.78	34.88	33.98
Cymbopogon martinii	33.31	34.59	35.87	37.03	38.19	35.52	32.85	32.76	32.67	34.02	35.37	35.98	36.60
Desmoduim triflorum	33.54	34.40	35.27	36.18	37.10	37.73	38.36	38.18	38.00	37.41	36.83	36.34	35.85
Dichanthium annulatum	26.40	32.41	38.43	38.64	38.86	37.03	35.21	36.58	37.96	35.25	32.55	30.94	29.33
Eulalia fastigiata	28.31	31.09	33.87	34.82	35.78	36.59	37.41	37.30	37.19	36.52	35.86	33.43	31.01
Fimbristylis dichotoma	39.14	38.77	38.41	39.61	40.81	41.27	41.74	34.86	38.08	38.03	37.98	36.87	35.77
Heteropogon contortus	30.61	33.31	36.01	37.01	38.01	37.91	37.82	37.52	37.22	33.55	29.88	29.95	30.03
Imperata cylindrica	26.16	37.62	44.09	45.09	41.10	40.99	40.86	39.48	38.08	36.31	34.55	30.42	26.29
Monocymbium ceresiiformee	35.50	37.13	38.76	40.47	42.19	41.73	41.27	41.09	40.92	39.89	38.87	37.66	36.45
Paspalum orbiculare	34.74	35.59	36.45	36.79	37.14	38.88	40.63	40.56	40.49	34.45	38.42	32.96	36.97

Table 5. Variation in concentration of lignin (%) in the live shoots of important fodder plant species

Name of species	Mar.'03	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.'04	Feb.	Mar.
Andropogon ascinodes	12.54	14.41	16.28	17.23	18.18	20.34	22.51	22.97	23.43	24.72	26.01	12.03	13.05
Arundinella setosa	4.32	5.01	6.32	6.62	6.92	7.00	7.09	7.62	8.15	13.99	19.84	4.48	5.12
Bothriochloa intermedia	4.28	4.78	5.29	5.65	6.01	6.59	7.18	8.05	8.92	10.07	11.23	5.03	4.28
Cymbopogon flexuosus	12.54	15.59	18.65	18.83	19.01	21.41	23.81	23.91	24.01	24.51	25.01	10.11	13.11
Cymbopogon martinii	14.18	14.70	15.23	16.68	18.14	21.07	24.01	24.65	25.29	25.86	26.43	11.15	13.52
Desmoduim triflorum	12.40	12.80	13.20	13.54	13.89	14.55	15.21	16.51	17.81	18.92	20.03	10.12	12.89
Dichanthium annulatum	14.10	16.67	18.25	18.69	20.11	20.71	21.32	21.82	22.33	25.27	28.21	12.00	16.43
Eulalia fastigiata	11.24	11.77	12.31	12.89	13.48	14.77	16.07	17.50	18.94	23.38	27.83	10.38	12.17
Fimbristylis dichotoma	11.14	12.36	13.59	13.93	14.27	15.21	16.15	16.73	17.31	17.06	16.81	9.76	11.02
Heteropogon contortus	13.14	14.17	15.21	16.11	17.02	18.42	19.83	20.65	21.48	22.38	23.28	11.83	12.21
Imperata cylindrica	14.74	15.85	16.97	17.50	18.04	19.08	20.12	21.65	23.15	24.24	25.34	12.89	16.14
Monocymbium ceresiiformee	9.25	9.87	10.50	10.76	11.03	12.04	13.06	14.08	15.11	17.79	20.49	7.39	10.11
Paspalum orbiculare	8.25	9.30	10.35	11.81	11.81	12.44	15.08	14.15	15.23	15.90	16.57	6.82	8.08

Table 6. Variation in concentration of nitrogen (%) in the live shoots of important fodder plant species

Name of species	Mar.'03	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.'04	Feb.	Mar.
Andropogon ascinodes	1.23	1.38	2.24	1.74	1.91	2.02	1.54	1.78	1.32	1.12	0.92	1.09	1.26
Arundinella setosa	1.56	1.64	2.41	1.85	1.99	2.02	1.72	1.81	1.21	1.27	1.34	1.42	1.50
Bothriochloa intermedia	1.70	2.03	2.37	2.00	1.63	1.9	2.22	1.67	1.18	1.02	0.87	1.34	1.81
Cymbopogon flexuosus	1.03	1.51	1.99	1.78	1.58	1.44	1.31	1.21	1.11	0.82	0.53	0.85	1.12
Cymbopogon martinii	1.08	1.15	2.19	1.70	1.22	2.12	1.91	1.65	1.40	1.52	1.01	1.11	1.32
Desmoduim triflorum	1.47	2.79	4.12	3.52	2.93	3.10	3.27	2.70	2.14	1.56	0.99	1.16	1.32
Dichanthium annulatum	0.57	0.91	1.25	1.33	1.41	1.70	1.99	1.56	1.13	0.75	0.38	0.61	0.84
Eulalia fastigiata	1.10	1.13	2.14	1.62	1.93	2.03	1.16	1.66	1.19	1.04	0.90	1.06	1.23
Fimbristylis dichotoma	1.47	1.88	2.29	2.46	2.63	2.76	2.99	2.27	1.55	1.28	1.01	1.17	1.34
Heteropogon contortus	0.99	1.70	2.42	2.16	1.90	1.55	1.21	1.14	1.04	0.90	0.76	0.93	1.11
Imperata cylindrica	1.13	1.83	2.53	2.70	2.10	1.88	1.67	1.42	1.18	1.10	1.03	1.11	1.18
Monocymbium ceresiiformee	0.02	0.91	1.24	1.05	1.09	1.16	1.01	1.09	0.95	0.73	0.51	0.71	0.92
Paspalum orbiculare	1.37	1.20	1.89	1.32	1.61	1.75	0.89	1.65	1.42	1.15	1.03	1.09	1.29

E. fastigiata, H. contortus, I. cylindrica, M. ceresiiforme and *P. orbiculare* exhibited maximum amount of lignin in January (11.23 to 28.21%) and minimum in May (4.48 to 12.89%). *F. dichotoma* exhibited a peak concentration of lignin in November (17.31%) and minimum in February (9.76%) (Table 5).

In the present study, the highest concentration of cellulose, hemicellulose and lignin is present in *A. setosa* (60.42%), *B. intermedia* (44.59%) and *D. annulatum* (28.21%), respectively, among the selected plant species. Cellulose was maximum during warm (summer) season, hemicellulose in July (rainy season) and lignin in January (dry winter season) during the study period. Osbourn (1980) and Bosch et al. (1992) have reported that with increasing age of maturity the proportion of cell wall components of the grass (cellulose, hemicellulose and lignin) increases, whereas the proportion of cell contents decreases.

Nitrogen

The concentration of nitrogen in various plant species during different months is given in Table 6. Nitrogen content increased consistently from March (1.23%) onward and attained peak value in May (2.24%) then varied in *A. ascinodes*. Maximum concentration of nitrogen in *A. setosa* was in May (2.41%) and minimum in November (1.21%). *B. intermedia* had maximum nitrogen concentration in May (2.37%) and minimum in January (0.87%). While the concentration of nitrogen in *C. flexuosus* consistently increased from March (1.03%) onward upto May (1.99%) and thereafter decreased till January (0.53%), in *C. martinii* highest nitrogen concentration was in May (2.19%) and minimum in January (1.01%). *D. triflorum* had highest nitrogen concentration during May (4.12%) and minimum in January (0.99%) and then a second peak in September (3.27%). *D. annulatum* and *E. fastigiata* had a maximum concentration of nitrogen in September (1.99%) and in May (2.14%), whereas the minimum nitrogen concentration are recorded in March (0.57%) and January (0.90%), respectively. The highest nitrogen concentration in *F. dichotoma* was in September (2.99%) and least in January (1.01%). *H. contortus* had highest nitrogen concentration during May (2.42%) while the least concentration is in January (0.76%). The concentration of Nitrogen in *I. cylindrica* increased from March (1.13%) till May (2.53%), the peak flowering month. *M. ceresiiforme* exhibited the maximum nitrogen concentration in the month of May (1.24%) and minimum in March (0.02%). The concentration of nitrogen in *P. orbiculare* was maximum in May (1.89%) and minimum in January (1.03%).

Among the selected dominant plant, 11 plant species i.e., *A. ascinodes, A. setosa, B. intermedia, C. flexuosus, C. martini, D. triflorum, E. fastigiata, H. contortus, I. Cylindica, M. ceresiiforme* and *P. orbiculare* exhibited maximum nitrogen concentration in the month of May which shows that these species contains more nitrogen concentration during the vegetative stage and both *D. annulatum* and *F. dichotoma* had maximum nitrogen concentration in the month of September. Among the selected dominant fodder plant species *D. triflorum,* a leguminous plant, showed the maximum (4.12%) nitrogen concentration followed by *I. cylindrica* (2.53%, highest among the grass species) and least by *M. ceresiiforme* (0.02%) in the month of March. *F. dichotoma* exhibited highest nitrogen concentration among the sedges. It has been observed that the nitrogen concentration of the live shoot of the selected dominant fodder species decreased with the increased in the age of plant.

The decreased of nitrogen concentration after the rainy season reflects the maturation of the species, seed dispersions. Similar observation was also reported from other annual grasslands (Woodmansce and Duncan 1980). On the seasonal basis, the moist summer season is the most favourable season for nitrogen accumulation in the live biomass which is followed by rainy and winter seasons. As the rate of growth of vegetation is higher during summer season, there may be maximum upward translocation of nitrogen from the soil through roots. Woodmansce and Duncan (1980) also reported, from an annual grassland vegetation complex in the lower foothills of Central California, that the dominant species (grass, forb and legume) exhibited their highest value of nitrogen concentration early in the growing season, when biomass was small and attained lowest values immediately following the senescence stage. In the present study almost all the selected dominant fodder plant species shows increase in the nitrogen concentration from young vegetative stage and attaining maximum in their flowering stages and then decreased throughout the rest of the period.

Phosphorus

The concentration of phosphorus in various plant species in different months is given in Table 7. The phosphorus concentration in *A. ascinodes* was maximum in September (0.21%) and minimum in January (0.053%). While *A. setosa* had maximum phosphorus concentration in September (0.190%) and minimum in December (0.053%), *B. intermedia* had highest phosphorus concentration in May (0.167%) and lowest in March (0.058%). Maximum concentration of phosphorous in *C. flexuosus* was in September (0.099%) and minimum in March (0.055%) and in *C. martinii* it was in March (0.13%) and in November (0.042%). While *D. triflorum* had maximum phosphorus in September (0.183%) and minimum in November (0.087%), *D. annulatum* had the maximum in January (0.152%) and minimum in July (0.035%). The highest concentration of phosphorus in *E. fastigiata* was in July (0.137%) and lowest in March (0.045%). *F. dichotoma* had maximum phosphorus during July (0.143%) and minimum in November (0.074%). *H. contortus* also had maximum phosphorus during March (0.153%) and minimum during September (0.043%) while *I. cylindrica* exhibited maximum during May (0.155%) and minimum during September and January (0.063%). The phosphorus concentration in *M. ceresiiforme* increased from March onward and attained the peak in November (0.183%). Maximum phosphorus concentration in *P. orbiculare* was in March (0.153%) and minimum during January (0.075%).

Both *C. martini* and *P. orbiculare* exhibited highest phosphorus concentration in the month of March whereas *B. intermedia* and *I. cylindrica* attained their maximum in the month of May. Out of 13 species, 3 species attained their peak value of phosphorus concentration in the month of March, 2 species each in May and July. *A. ascinodes, A. setosa, C. flexuosus* and *D. triflorum* exhibited the highest value of phosphorus concentration in the month of September (0.201%), that is during the mature stage of plant growth. *D. annulatum*, *H. contortus* and *M. ceresiiforme* exhibited the highest phosphorus concentration in the month of November, January and March, respectively.

Potassium

The concentration of potassium in various fodder plant species in different months is given in Table 8. In *A. ascinodes* it consistently increased from March (0.062%) till July (0.113%) and then decreased gradually upto January (0.048%). *A. setosa* had maximum potassium concentration during July (0.167%) and decreased upto January-February (0.065%). In *B. intermedia* it increased from March (0.073%) to July (0.124%) and then decreased. The maximum concentration potassium in *C. flexuosus* was in September (0.116%) and minimum in January (0.025%). However, *C. martinii* had maximum potassium concentration in November (0.112%) and minimum in July (0.013%) while *D. triflorum* had it in July (0.115%) and lowest in January (0.042%). *D. annulatum* attained maximum potassium concentration during July (0.118%) and minimum during May (0.044%). Maximum concentration of potassium in *E. fastigiata* was recorded in May (0.121%) and minimum during January (0.039%). In *F. dichotoma* it was 0.093% in March, reached maximum in July (0.212%) and then decreased till December (0.053%). *I. cylindrica* had maximum concentration of potassium in March (0.084%) and minimum during November (0.023%). While *M. ceresiiforme* had highest potassium concentration during May (0.087%) and lowest during January (0.020%), *P. orbiculare* had it during November (0.114%) and during January (0.076%), respctively.

Among 13 species, *A. ascinodes, A. setosa, C. martini, D. triflorum, D. annulatum* and *F. dichotoma* exhibited maximum potassium concentration in July and remaining in different months. Among the dominant fodder species, *F. dichotoma* exhibited the highest value of potassium concentration during the month of July (0.212%). This species is more palatable than other species.

Minerals are essential to animal nutrition. In the present investigation, the nutritional value of herbage mass indicated by the concentration of different parameters is maximum during warm-season. According to Sanchez (1976) warm-season perennial grasses are extremely important to the world-wide

Table 7. Variation in concentration of phosphorus (%) in the live shoots of important fodder plant species

Name of species	Mar. '03	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.'04	Feb.	Mar.
Andropogon ascinodes	0.127	0.107	0.087	0.139	0.192	0.196	0.201	0.159	0.118	0.085	0.053	0.088	0.124
Arundinella setosa	0.063	0.101	0.140	0.105	0.070	0.130	0.190	0.150	0.110	0.118	0.126	0.098	0.071
Bothriochloa intermedia	0.074	0.120	0.167	0.135	0.103	0.117	0.131	0.124	0.118	0.116	0.115	0.086	0.058
Cymbopogon flexuosus	0.055	0.061	0.067	0.077	0.087	0.093	0.099	0.090	0.082	0.073	0.063	0.082	0.101
Cymbopogon martinii	0.131	0.111	0.097	0.096	0.101	0.087	0.073	0.057	0.042	0.077	0.111	0.099	0.087
Desmoduim triflorum	0.143	0.151	0.159	0.166	0.173	0.178	0.183	0.135	0.087	0.091	0.095	0.099	0.103
Dichanthium annulatum	0.061	0.072	0.083	0.059	0.035	0.053	0.072	0.105	0.138	0.145	0.152	0.119	0.087
Eulalia fastigiata	0.113	0.111	0.110	0.123	0.137	0.123	0.118	0.102	0.087	0.075	0.063	0.052	0.045
Fimbristylis dichotoma	0.113	0.118	0.124	0.133	0.143	0.119	0.095	0.084	0.074	0.092	0.110	0.117	10.15
Heteropogon contortus	0.141	0.132	0.124	0.090	0.057	0.050	0.043	0.065	0.087	0.105	0.124	0.138	0.153
Imperata cylindrica	0.107	0.131	0.155	0.147	0.140	0.101	0.063	0.091	0.120	0.091	0.063	0.078	0.093
Monocymbium ceresiiformee	0.133	0.137	0.142	0.148	0.154	0.163	0.173	0.178	0.183	0.135	0.087	0.099	0.112
Paspalum orbiculare	0.153	0.140	0.127	0.119	0.112	0.122	0.134	0.105	0.077	0.093	0.075	0.092	0.110

Table 8. Variation in concentration of potassium (%) in the live shoots of important fodder plant species

Name of species	Mar. '03	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.'04	Feb.	Mar.
Andropogon ascinodes	0.062	0.074	0.087	0.100	0.113	0.089	0.083	0.072	0.062	0.055	0.048	0.053	0.059
Arundinella setosa	0.073	0.079	0.085	0.126	0.167	0.155	0.143	0.116	0.089	0.077	0.065	0.065	0.068
Bothriochloa intermedia	0.045	0.059	0.074	0.099	0.124	0.113	0.103	0.093	0.083	0.063	0.043	0.054	0.065
Cymbopogon flexuosus	0.051	0.073	0.095	0.098	0.102	0.109	0.116	0.097	0.087	0.051	0.025	0.036	0.047
Cymbopogon martinii	0.072	0.078	0.085	0.049	0.013	0.062	0.085	0.098	0.112	0.078	0.045	0.056	0.063
Desmoduim triflorum	0.065	0.084	0.103	0.109	0.115	0.094	0.073	0.080	0.087	0.072	0.057	0.065	0.073
Dichanthium annulatum	0.087	0.065	0.044	0.081	0.118	0.107	0.096	0.085	0.074	0.068	0.062	0.070	0.079
Eulalia fastigiata	0.050	0.085	0.121	0.113	0.105	0.094	0.084	0.073	0.063	0.051	0.039	0.048	0.058
Fimbristylis dichotoma	0.096	0.105	0.115	0.163	0.212	0.146	0.080	0.072	0.065	0.053	0.065	0.075	0.085
Heteropogon contortus	0.032	0.045	0.059	0.073	0.088	0.080	0.073	0.060	0.053	0.039	0.025	0.131	0.036
Imperata cylindrica	0.071	0.063	0.056	0.060	0.064	0.052	0.064	0.034	0.023	0.030	0.038	0.061	0.084
Monocymbium ceresiiformee	0.032	0.059	0.087	0.076	0.065	0.054	0.043	0.035	0.028	0.024	0.020	0.024	0.029
Paspalum orbiculare	0.076	0.080	0.084	0.093	0.103	0.082	0.106	0.100	0.114	0.102	0.088	0.089	0.108

tropical livestock industry. Warm-season grasses are generally considered to be high quality than temperate grasses or legumes (Skerman and Riveros 1990); because of their higher cell wall content during the warm-season grasses have low digestibility. In the present study, the concentration of crude protein ranged from 2.38 to 25.75% in grasses in different months. *Desmodium triflorum*, *Fimbristylis dichotoma*, *Paspalum orbiculare*, *Andropogon ascinodes* and *Arundinella setosa* are highly nutritive and these contain high percentage of crude protein during the study period. Holchek et al. (2001) has also reported that the concentration of crude protein falls from 10-12% to 7-8% or lower. Therefore the value of crude protein in the present study is markedly higher than that from other studies.

Cymbopogon flexuosus, Eulalia fastigiata, Imperata cylindrica, Heteropogon contortus, Dichanthium annulatum and *Arundinella setosa* are highly productive grass species which could be utilized for reseeding in degraded and wasteland areas for the welfare of grazers. Besides, higher forage productive value, these grasses are also highly palatable at the early vegetative stage among the different plant species. The leguminous plant i.e., *Desmodium triflorum* highly rich in crude protein, more palatable and easily digestible among the plant species studied in the present study contributes fodder value whereas *Fimbristylis dichotoma*, a sedge plant which has more fibre content among the mixed grass species also contributes to the staple animal diet. *Arundinella setosa, Bothrichloa intermedia* and *Dichanthium annulatum* exhibited highest value for cellulose, hemicellulose and lignin, respectively. Young shoots of these species are also highly palatable. Apart from nitrogen, phosphorus is considered to be major limiting factor for plant productivity in Savannas (Hogberg 1989). Nitrogen is quantitatively the most important nutrient that majority of plants acquire from the soil accounting for up to 80% of the total ion uptake of roots (Marschner 1995). In the present investigation, the concentration for nitrogen ranges from 0.38 to 2.99%, phosphorus from 0.035 to 0.201% and potassium from 0.020 to 0.212% in different species. Most of the species exhibited maximum nitrogen concentration in early summer season (May). Nitrogen content is found greatest in spring and early summer and decreased as plants matured and environmental stress increased (Haferkamp et al. 2005). The phosphorus concentration varied in different seasons although majority of the species exhibited high concentration in wet season (September). A major factor causing differences in phosphorus content of pasture is the stage of growth. The digestibility and nutritive value of grasses are influenced significantly by the stage of maturity (Kellems and Church 1998).

CONCLUSION

Minerals are essential to animal nutrition. In the present investigation, the nutritional value of some important herbage species shows the maximum concentration of different nutritional indicators were during warm-season. Warm-season perennial grasses are extremely important to the world-wide tropical livestock industry and are generally considered to be high quality than temperate grasses or legumes because of their higher cell wall content during the warm-season grasses have low digestibility. *Cymbopogon flexuosus, Eulalia fastigiata, Imperata cylindrica, Heteropogon contortus, Dichanthium annulatum* and *Arundinella setosa* are highly productive grass species which could be utilized for reseeding in degraded and wasteland areas for the welfare of grazers. Besides, higher forage productive value and these grasses are also highly palatable at the early vegetative stage among the different plant species. The digestibility and nutritive value of grasses are influenced significantly by the stage of maturity.

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