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Nutritional evaluation of Guinea grass (*Panicum maximum* Jacq.)

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Abstract

Nutritional evaluation of guinea grass (leaf and stem at different stages of growth and; hay prepared at post flowering stage) was undertaken with the objective to recognize the best stage of growth for harvest of the fodder. On the basis of proximate principles, cell and cell wall components and macro and trace mineral concentrations it was concluded that the green panic grass should be cut at 55 days of growth and the subsequent cuttings should also be taken at the same intervals. The study showed that the guinea grass hay prepared at post flowering stage was able to support growth in crossbred calves.

Key words: Guinea grass, calves, and metabolic studies.

Introduction

The major limitation affecting the productivity of our animals is the unavailability of adequate feeds/fodder resources (Anonymous, 1989). Whatever the superior germplasm may be, its intrinsic inherent merit can never be fully exploited until scientific feeding and management is not provided. Milk production is as such one of the vital factors for achievement of our objective to remove poverty from the rural areas of hills. The milk production on the contrary, depends primarily on the availability of good quality feeds and fodders. Himachal Pradesh is very much deficient in concentrates and green fodders. Because forage based milk production is highly economical, so we have to depend on forages for most of energy and protein requirements of our animals. In the low and mid-hill regions of Himachal Pradesh, the herbage obtained from natural grasslands serves as a predominant source of low-grade roughages, as green fodder during monsoon and in the form of hay during winter. The availability of these grasslands has also decreased because of high grazing pressure on one hand and their partial allotment to the landless people on the other hand. So to increase the quantity of green forage to the animals and decrease the amount of concentrate required, introduction of good quality perennial grasses is the only alternative.

The forage section of Department of Plant Breeding and Genetics has identified a superior strain of guinea grass (*Panicum maximum* Jacq.) namely PGG-9. The comprehensive information regarding its nutritional value, under mid-hill regions of the Pradesh is lacking. So the present study was undertaken with the objective to determine the most suited time of harvest by analyzing the grass in terms of proximate composition, cell and cell wall components and mineral composition at 15 days interval of growth. The second objective was to test grass hay by *in-vivo* digestibility-cum metabolic studies whether or not it can support growth in crossbred calves.

Material and Methods

Guinea grass was sown in the month of June when the first monsoon rain showers were received. The grass was fertilized with 20 kg N / ha as a basal dose. No irrigation was given during the entire period of growth. The first sampling was done 25 days after sowing. Subsequent samplings were done at 15 days interval, till the plants were fully mature. For the third and subsequent cuts, each sample was separated into leaf and stem. These samples were dried at 70^0 C and ground to pass through 1 mm sieve and preserved in polythene bags for further analysis. The samples were subjected to chemical analysis by following standard methods of AOAC (1984) and Goering and Van Soest (1970). The samples were also analyzed for Ca, P, Cu, Zn, Fe and Mn. Calcium determination was done by oxalate method 7.085 of AOAC (1984) and Phosphorus by HMSO (1973) from the filtrate obtained during silica determination. The rest of the

minerals were estimated by using Rank Hilger Atomic Absorption Spectrophotometer after wet digestion of samples with a mixture of perchloric acid and nitric acid (1:4).

For digestibility-cum-metabolic studies, the guinea grass was harvested at post flowering stage of growth and the hay was prepared after chopping the grass from 10-15 cm length. The cut forage was dried in the sun during the month of September / October.

The metabolic trial was conducted on five Jersey x Red Sindhi calves having 59.84 kg average body weight. During the entire experimental period, all the calves had free access to mineral salt lick and water was offered twice a day at 9000 and 1600 hours. A total feacal and urine collection method was followed for each trial. The animals were dewormed with Albendazole @ 5 mg / kg body weight. The selected animals were housed in a metabolic shed having mangers for individual feeding. The hay was offered twice a day at 9000 and 1700 hours. A six-day digestibility trial was conducted after a preliminary feeding period of 21 days. During the digestibility trial the animals were not even allowed the usual exercise.

The sampling of hay offered was done daily at the time of feeding. The residue samples were collected every morning before replenishing the mangers. The feaces of animals were collected individually, quantitatively and carefully, avoiding mixing of feaces with urine. Each, 24 hour collection of feaces of individual animal was weighed, mixed thoroughly and a sample was drawn for DM and other determinations. The fresh samples (1/50th to 1/100th of total) were preserved daily with 10 % H_2SO_4 for nitrogen estimation. Similarly, 24 hour urine was collected and measured and 1/100th of daily urine voided was preserved in 10%H_2S0_4 separately for each calf and pooled for nitrogen estimation.

Results and Discussion

1. Chemical composition

The data regarding proximate composition of grass leaf and stem at 25 days of growth and then after every 15 days interval is presented in Table 1. The CP content of leaf and stem varied from 3.60 to 10.82 and 1.20 to 4.88 %, respectively. The CP concentration decreased with the increase in maturity, the highest at the earliest stage of growth. The CP of whole plant at 25 and 40 days of growth was 12.03 and 10.31 %, respectively. The leaf had higher CP due to the translocation of nutrients from stem to leaf,

Table 1. Proximate composition (% DM) of leaf and stem of guinea grass at different stages of growth

Growth stage (days)	Morphological component	CP	EE	CF	Total ash	NEF
25	Whole plant	12.03	4.71	29.94	12.28	41.04
40	Whole plant	10.31	4.07	31.03	10.95	43.64
55	Leaf	10.82	1.96	39.89	10.25	37.08
	Stem	4.88	5.96	42.77	8.98	37.41
70	Leaf	8.67	2.44	38.10	9.29	41.50
	Stem	2.68	5.82	48.38	8.75	34.37
85	Leaf	7.17	2.97	39.37	9.00	41.49
	Stem	1.38	3.83	49.72	4.57	40.50
100	Leaf	6.10	3.30	40.23	8.44	41.93
	Stem	1.20	1.91	51.79	4.75	40.35
115	Leaf	5.15	3.75	40.98	7.58	42.54
	Stem	1.20	1.42	52.90	4.17	40.31
130	Leaf	3.60	3.85	42.74	7.21	42.60
	Stem	1.20	0.84	52.97	2.92	42.07

DM- dry matter, CP- crude protein, EE- ether extract, CF- crude fibre, NFE- nitrogen free extract.

where metabolic activities are faster. This means that more leafy a forage, the more nutritious it is. The value of CP were close to that reported by Chauhan *et al.* (1980) and Gupta *et al.* (1980), higher than those reported by Sen *et al.* (1978) and Ranjhan (1991). However, Gomide *et al.* (1969) reported a higher CP in 28 days of whole plant as compared to that recorded in the present studies. The decrease in CP content of leaf and stem with maturity is well documented (Gomide *et al.* 1969, Alvares and Cheshmedzhiev, 1983, Ranjhan, 1991). There was a gradual increase in EE content in leaf (1.96 to 3.85%) and in the stem a reverse trend was observed (decreased from 5.96 to 0.84%). The EE content was in general agreement with that reported by Chauhan *et al.* (1980) and Singh (1990). The whole plant of guinea grass at 25 and 40 days of growth had CF content of 29.94 and 31.03 % respectively. The CF content of leaf and stem increased from 39.89 to 42.74 and 42.77 to 52.97%, respectively. The increasing trend of CF with advancing stage of maturity as observed in the present study corroborated with the observations of Gomide *et al.* (1969) and Alvares and Cheshmedzhiev (1983). Contrarily, decreasing trend of CF content in the mature plant was reported by Ranjhan (1991). No specific trend was observed in the NFE content of leaf and stem with the increase in maturity, because it is a calculated value. The NFE content of leaf was higher than that of stem at all the stages of growth indicating that the leafy fodders will have larger amount of easily available carbohydrates. The ash content increased slightly in leaf and stem with the increase in maturity.

A decline in CP content was observed in leaf and stem of guinea grass after 55 days of maturity. The grass had higher NFE and total ash and lower CF at this stage of growth. This indicated that the most nutritious fodder could be harvested at 55 days as the first cut. The subsequent cuts could be taken at the same interval.

The cell and cell wall constituents of guinea grass are given in Table 2. The NDF content increased from 59.8 to 69.2 and 68.78 to 77.80% in leaf and stem, respectively, with the advancement of maturity. High concentration of cell wall contents in the stem indicated low concentration of cell solubles in stem.

Table 2. Cell and cell wall constituents (% DM) of leaf and stem of guinea grass at different stages of growth

Growth stage (days)	Morphological component	NDF	CC	ADF	Hemicellulose	Cellulose	ADL	Silica
25	Whole plant	60.80	39.20	36.36	24.44	29.48	4.86	2.02
40	Whole plant	62.00	38.00	41.86	20.14	33.21	5.49	3.16
55	Leaf	59.80	40.20	36.20	23.60	28.30	5.01	2.89
	Stem	66.78	31.22	41.07	27.71	31.01	6.39	3.67
70	Leaf	64.40	35.60	38.20	26.20	29.90	5.12	3.018
	Stem	69.85	30.15	41.40	28.45	30.85	6.55	4.00
85	Leaf	66.80	33.20	40.40	26.40	31.12	5.80	3.48
	Stem	73.00	27.00	43.60	29.40	33.16	6.87	3.57
100	Leaf	67.60	32.40	41.20	25.40	31.10	6.30	3.80
	Stem	73.80	26.20	44.80	29.00	32.26	7.08	3.46
115	Leaf	68.40	31.60	40.80	27.60	30.62	6.40	3.78
	Stem	74.93	25.07	45.40	29.53	32.50	7.42	3.48
130	Leaf	69.20	30.80	41.80	27.40	30.95	6.72	4.13
	Stem	77.80	22.20	48.80	29.00	35.21	7.81	1.78

NDF-neutral detergent fibre, CC- cell constituents, ADF- acid detergent fibre, ADL- acid detergent lignin.

It is evident that the young tissue was comparatively a better energy source for rumen microorganisms. Increasing trend in the cell wall constituents due to plant maturity have also been reported by Gupta and Chopra (1979) in guar fodder, Gupta and Pardhan (1975) in legumes and Nandra *et al.* (1983) in case of sorghum. However, Dogra and Sud (1985), Singh (1990), and Ranjhan (1991) reported a high value of cell wall in guinea grass. The differences in NDF constituents may be due to differences in cultivar and the stage of harvest. Mendez *et al.* (1988) reported an increase in NDF, ADF, and lignin with the increasing cuttings in guinea grass. The leaf had lower ADF content indicating their high potential as energy source.

Hemicellulose and cellulose are the major polysaccharides in the cell wall. Chauhan *et al.* (1980) reported 24.68 to 26.40% hemicellulose and 32.93 to 34.14 % cellulose in 5 strains of guinea grass. The hemicellulose content observed in the present studies was in agreement with those observed by Dogra and Sud (1985) but less than those reported by Singh (1990) and Ranjhan (1991). However, cellulose was in line with the observations by Dogra and Sud (1985) and Singh (1990). The recorded lignin content was analogous to the values reported by Gupta *et al.* (1980) and Singh (1990). Seigal (1968) reported that more structural carbohydrates and lignin are synthesized and deposited in the cell wall during the later stages of growth. The structural carbohydrates in the wall of sclerenchyma and some vascular cells are bound at random points by covalent and hydrogen bonds to lignin (Van Soest, 1982). So it is implied that the stem and mature tissue is less digestible. However, lignin content of different grasses and legume species is not an accurate guide to cell wall digestibility (Minson, 1971). The results showed that more of the structural carbohydrates and lignin were present in the cell wall of plants at later stages of growth than in the initial stages, which will adversely affect the digestibility of fodder. The silica content also increased in both leaf and stem, with maturity. The nutritional superiority of 55 days of guinea grass was confirmed because of comparatively lower levels of incriminating and higher levels of desirable nutrients.

The macro and trace mineral content of leaf and stem of guinea grass is given in Table 3. The calcium level decreased with maturity from 1.88 to

Table 3. Macro (% DM) and trace minerals / kg DM) of leaf and stem of guinea grass at different stages of growth

Growth stage (days)	Morphological component	Ca	P	Cu	Zn	Fe	Mn
25	Whole plant	1.62	0.32	23.70	39.80	343.0	45.00
40	Whole plant	1.11	0.20	22.25	51.00	340.0	88.00
55	Leaf	1.88	0.24	23.00	34.90	297.0	59.50
	Stem	0.87	0.15	14.35	34.70	243.0	42.00
70	Leaf	1.75	0.22	15.10	34.75	260.0	52.00
	Stem	0.75	0.13	12.35	23.40	180.0	29.00
85	Leaf	1.65	0.11	14.35	34.35	190.0	50.50
	Stem	0.71	0.09	12.90	18.90	160.0	28.50
100	Leaf	1.02	0.01	14.10	33.19	177.0	48.18
	Stem	0.68	0.06	10.90	18.90	142.0	23.50
115	Leaf	0.76	0.01	13.94	33.15	159.0	47.00
	Stem	0.66	0.04	10.75	18.90	134.5	20.50
130	Leaf	0.68	0.01	13.65	32.00	143.0	44.00
	Stem	0.22	0.01	10.75	18.00	129.0	18.30

0.68 in leaf and from 0.87 to 0.22 percent in stem. The calcium concentration recorded in the present study was much higher than were reported by Perdomo *et al.* (1977) mainly because of the differences in morphological components and harvesting stages. The phosphorous content decreased from 0.24 to 0.01 percent in leaf and 0.15 to 0.01 percent in stem. The leaf had a higher phosphorous concentration than that of the stem in early stages, but at 100 days of maturity the reverse was true, and at 130 days, both the leaf and stem had same amount of phosphorous. The whole plant had comparable level of phosphorous as reported by Gupta *et al.* (1980) and Perdomo *et al.* (1977). The trace minerals, Cu, Zn, Fe and Mn showed a declining trend with maturity in both leaf and stem. The decrease in level of Cu, Zn, Fe and P with maturity had also been reported by Viera *et al.* (1980), in Fe, Cu, Mn and P by Gupta and Chopra (1979), in Cu and Zn by Perdomo *et al.* (1977). However, inconsistent changes were found by Kabaiza and Smith (1988). Gupta *et al.* (1980) noted highest amount of minerals in first cutting and lowest in the sixth cutting. Decrease in the mineral content as the growth advanced has been ascribed to the dilution factor, since the structural carbohydrates of the plant increase with maturity (Beeson and McDonald, 1951).

Keeping in view the recommended (ARC, 1965) requirements of dairy cattle for Ca (0.25 %), P (0.20%), Fe (30 ppm), Cu (10 ppm), Mn (40 ppm) and Zn (20-40 ppm), the whole plant of guinea grass (at 25 and 40 days of growth) contained appreciably higher levels of Ca, P, Fe, Cu, Zn and Mn. Stem was found to be marginally deficient in Ca at 130 days of growth. It had lower levels of Zn after 70 days. Leaf and stem were rich in Fe at all stages of growth but deficient in Mn after 85 and 55 days of maturity.

The overall perusal of data suggested that the grass was able to meet the recommended mineral requirements for maintenance (ARC, 1965) except Cu and Mn whose levels were low at 55 days of growth.

2. Digestibility-cum metabolic studies

The grass hay offered had 90% dry matter, 11.17 % CP, 11.61 % total ash, 39.05 % CF, 1.77 % EE, 36.36 % NFE, 78.22 % NDF, 44.66 % ADF, 5.30 % ADL, 33.56 % hemicellulose, 36.10 % cellulose and 3.20 % silica. The nutrient utilization in calves fed hay prepared from guinea grass is shown in Table 4. The dry matter intake (DMI) was observed to be 2.689 kg/100kg body weight. The voluntary intake observed in the present study was higher than those reported by Adu and Adamu (1982). Mendez *et*

Table 4. Nutrient utilization in calves fed guinea grass hay

Sr.No.	Parameter	
I.	Body weight	
	a) Initial	59.84 ± 1.17
	b) Final	60.94 ± 1.26
II.	Dry matter intake	
	a) Kg/h/d	1.616 ± 0.37
	b) Kg/100kg bw	2.689 ± 0.028
	c) g/kg bw $^{0.75}$	75.112 ± 0.93
III.	Apparent digestibility (%)	
	a) DM	54.83 ± 3.03
	b) CP	51.62 ± 5.94
	c) CF	70.82 ± 2.51
	d) EE	41.79 ± 1.84
	e) NFE	45.21 ± 3.50
	f) NDF	65.00 ± 2.47
	g) ADF	56.79 ± 2.19
	h) Hemicellulos	78.11 ± 4.75
	i) Cellulose	67.37 ± 2.19
	j) Lignin	12.29 ± 1.57

al. (1988) reported a decrease in voluntary intake with the increase in cutting interval. The differences might be attributed to the stage of harvesting, cultivar and agro-climatic conditions and to the differences in chemical composition.

The digestibility of DM was 54.83 %, which was within the range reported by Chauhan *et al.* (1980) and Alvares and Cheshmedzhiev (1983). However, it was higher than that reported by Velloso *et al.* (1983). The digestibility of CP was comparable to those reported by Butterwoth (1967), Alvarres and Cheshmedzhiev (1983) and Chuahan *et al.* (1980) and, lower than those reported by Shivaramaiha and Sampath (1981).

ADF digestibility was observed to be 56.79 % whereas digestibility coefficient of hemicellulose, cellulose and lignin were 78.11, 67.37 and 12.29 %, respectively. The lignin digestibility of guinea grass hay was lower compared to that of green panic hay (Wadhwa and Dogra, 2004). This meant that the nature of bonding to carbohydrate fraction was probably different from that found in green panic hay and was more inhibitory to digestion in guinea grass. The digestion of hemicellulose is a complex affair, since hemicellulose is made up of various sugars with glycosidic linkages (Van Soest, 1982). A hemicellulolytic bacterium must bring its degradation enzymes into close association with both cellulose and lignin within the cell wall. Lignin could limit the digestion of polysaccharides by inhibiting the attachment of rumen microorganisms to cell wall (Akin, 1979) and physiologically incrusting the polysaccharides, thereby preventing enzyme attack (Van Soest, 1982). The microbes must first disrupt the hydrogen bonds and the decreased hydrogen bonding could be controlling (Colvin and Sowden, 1985) the rate at which fermentation, swelling, loss in tensile strength, transverse cracking and lowering the degree of polymerization in cellulose prior to release of glucose and cellobiose by cellulase enzyme.

The nitrogen intake was 30.94 g / h /d and the nitrogen retained as a percentage of nitrogen digested was 85.65%, indicating a good quality protein in guinea grass and also showed that the forage could support the maintenance requirements of growing calves. The nitrogen retention as percentage of total nitrogen consumed is indicative of the total usefulness of nitrogen in the diet in maintaining the body of the animal. However, the value does not explain the magnitude of many aspects of nitrogen metabolism occurring in the body tissues and in the gastro-intestinal tract. The TDN content of guinea grass hay was lower than that of green panic hay (Wadhwa and Dogra 2004). Higher nitrogen retention even at low energy level compared to that of green panic hay indicated a better quality protein in guinea grass hay. The metabolic studies revealed that guinea grass hay prepared at full bloom stage could sustain animal production.

Conclusion

The guinea grass should be cut at 55 days of growth and subsequent cuts should be taken at the same intervals. The guinea grass hay could sustain animal production due to a good quality protein.

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Table 5. Nitrogen utilization & nutritive value in calves fed guinea grass hay

Sr.No.	Parameter	
A.	Nitrogen utilization	
1.	Nitrogen intake g/h/d	30.94 ± 0.79
2.	Nitrogen excreted g/h/d	
a.	Through faeces	13.67 ± 1.13
b.	Through urine	3.51 ± 0.14
3.	Nitrogen excreted (%NI)	
a.	Through faeces	44.02 ± 3.13
b.	Through urine	11.34 ± 0.34
4.	Nitrogen retained g/h/d	+13.78 ± 0.97
5.	NR/NI (%)	44.63 ± 3.09
6.	NR/Nitrogen digested (%)	79.74 ± 6.39
B.	Nutritive value	
1.	DCP (%) in hay offered	5.76 ± 0.66
2.	DCP intake/d (kg)	0.099 ± 0.011
3.	*DCP intake (kg/100kg w)*	0.167 ± 0.019
4.	DCP intake/kg $w^{0.75}$(g)	4.64 ± 0.54
5.	TDN (%) in hay offered	51.51 ± 2.69
6.	TDN intake / day (kg)	0.835 ± 0.044
7.	TDN intake (kg/100kg w)	1.398 ± 0.072
8.	TDN intake (g/kg $w^{0.75}$)	38.84 ± 1.98

NI- nitrogen intake, NR- nitrogen retained.

References

AOAC 1984. *Official Methods of Analysis*. Association of Official Analytical Chemists, 14th edn, Arlington, Virginia.

Adu, I. F. and Adamu, A. M. 1982. The nutritive value and utilization of three tropical grass hays by sheep. *Tropical Grassland* 16: 29-33.

Akin, D.E. 1979. Microscopic evaluation of forage digestion by rumen microorganisms. A review. *Journal of Animal Science* 48:701-10.

Alvares, K. M. and Cheshmedzhiev, B. V. 1983. Zootechnical characteristics of guinea grass (*P. maximum* Jacq.) *Zhivotnov dni Nauki* 20: 65-74.

Anonymous 1989. *Statistical Outline of Himachal Pradesh.* Economics and Statistics Department, Himachal Pradesh.

ARC 1965. The Nutrient Requirements of Farm Livestock No.2. Ruminants. Agricultural Research Council. London.

Beeson, K. C. and McDonald, H. A. 1951. Absorption of mineral elements by forage plants. III. The relations of stage of growth to the micro element contents of timothy and some legume. *Agronomy Journal* 43: 589.

Chauhan, T. R., Sidhu, B. S. and Chopra, A. K. 1980. Note on comparative nutritive value of five strains of guinea grass *(Panicum maximum)* for buffalo calves. *Indian Journal of Animal Sciences* 50: 525-27.

Colvin, J. R. and Sowden, L. C. 1985. The three dimensional morphology of aggregates of native cotton cellulose microfibrils. *International Journal of Micromolecules* 7: 214-18.

Dogra, K. K. and Sud, R. G. 1985. Cell wall composition and *in vitro* digestibility of certain tropical and sub-tropical grasses. *Forage Research* 11: 69-71.

Goering, H. K. and Van Soest, P. J. 1970. Forage Fibre Analysis: Apparatus, reagents, procedures and some applications. Agriculture Handbook No. 379, USDA, ARS, Washington, D.C.

Gomide, J. A., Noller, C. H. Mott, G. O. Conrad, J. H. and Hill, D. L. 1969. Effect of plant age and nitrogen fertilization on the chemical composition and *in vitro* cellulose digestibility of tropical grasses. *Agronomy Journal* 4: 85-95.

Gupta, A. K., Nandra, K. S., Sidhu, B. S. and Chopra, A. K. 1980. Yield performance, composition and dry matter digestibility of some promising strains of guinea grass *(Panicum maximum). Journal of Research,* Punjab Agricultural University 17: 163-68.

Gupta, B. K. and Chopra, A. K. 1979. Effect of the stage of maturity on cell wall constituents and mineral composition of the guar fodder. *Journal of Research,* Punjab Agricultural University 16: 479-81.

Gupta, P. C. and Pradhan, K. 1975. A note on the comparative nutritive value of legume and non legume forage. *Indian Journal of Animal Sciences* 45:290-92.

H. M. S. O. 1973. The Analysis of Agricultural Materials. MAFF. Technical Bulletin No. 27, London.

Kabaiza, E. and Smith, O. B. 1988. The effect of age of re-growth on content and release of manganese, iron, zinc and copper from four tropical forages incubated *in sacco* in rumen of sheep. *Animal Feed Science and Technology* 20:171-76.

Mendez-Cruz, A. V., Carchado, J. N. and Siberio-Torres, V. 1988. Storage and digestibility, voluntary intake and chemical components of hay of the five tropical grasses. *Journal of Agriculture of the University of Puerto Rico* 72: 531-43.

Nandra, K. S. Tiwana, M. S. and Chopra, A.K. 1983. Chemical composition, in vitro dry matter digestibility and yield of sorghum fodder at different stages of growth. *Journal of Research,* Punjab Agricultural University 20: 390-93.

Neilson, M. J. and Richards, G. N. 1978. The fate of soluble lignin-carbohydrate complex produced in the bovine rumen. *Journal of Science, Food and Agriculture* 29: 513-19.

Perdomo, J. T., Shirley, R. L. and Chicco, C. F. 1977. Availability of nutrient minerals in four tropical forage fed freshly chopped to sheep. *Animal Science* 45:1114-19.

Ranjhan, S.K. 1991. Chemical composition and nutritive value of Indian feeds and feeding of farm animals. ICAR, New Delhi.

Sen, K.C., Ray, S.N. and Ranjan, S.K. 1978. Nutritive value of Indian cattle feeds and the feeding of animals. 6th Edition, ICAR, New Delhi.

Siegal, S. M. 1968. **In:** Comprehensive biochemistry, vol. 26, part A, pp 1-51 (Ed.) Flerkin, M. and Stotz, E. H. Elsiever Publishing Company, New York.

Singh, B. 1990. Studies on the degradation kinetics *of* locally available forages. *Ph.D. Thesis*, HPKV Palarnpur.

Van Soest, P. J. 1982. *Nutritional Ecology of the Ruminants.* O and B Inc., Corvallis, Oregon, pp 211-29.

Velloso, L. Procknor, M. and Strazzacappa, W. 1983. Estimation of forage availability and nutritive value of guinea grass (*Panicum maximum* Jacq.) 2. The dry season. *Boletium de Industria Animal* 40:149-58.

Viera, J. D., Hagg, H. P., Corsi, M. and Bose, M. L. 1980. Yield, digestibility coefficient of dry matter and concentration of nutrient in *Panicum maximum* Jacq. in relation to cutting at 30, 40, 60 and 75 days of age. *Escola Superiorde Agricultura "Luiz de Queiroz"* 37: 419-41.

Wadhwa, D. R. and Dogra, K. K. 2004. Nutritional evaluation of Green panic *(Panicum maximum* var. *trichoglume*) grass. *SAARS Journal* (In Press).