Herbage yield and chemical composition of four varieties of Napier (*Pennisetum purpureum*) grass harvested at three different days after planting

T. Ansah¹, E.L.K Osafo² and Hanne H. Hansen³

¹University for Development Studies, Faculty of Agriculture, Department of Animal Science Ghana

²Kwame Nkrumah University of Science and Technology, Faculty of Agriculture, Department of Animal Science Ghana

³Copenhagen University, Faculty of LIFE Sciences, Department of Large Animal Science Denmark

Corresponding author: Terry Ansah University for Development Studies, Faculty of Agriculture, Department of Animal Science P.O. Box 1882, Tamale. Ghana

ABSTRACT

An experiment was conducted to assess the herbage yield and chemical composition of 4 varieties of Napier grass (Pennisetum purpureum) harvested at 3 different days after planting. The varieties tested were obtained from ILRI (formerly ILCA) were Local, 16798, 16786 and 16840 and used in a 4x3 factorial arrangement of treatments with four replicate plots each. The herbage yield of the varieties were measured at 60, 90, 120 days after planting. The herbage of the varieties were harvested and separated into leaf and stem fractions. The results indicated that, dry matter (DM) herbage yield was significantly (P<0.05) higher for variety Local (41050 kg DM/ha) and 16798 (44,994 kg DM/ha) when compared to the other varieties. Harvesting at 120 days gave a significantly (P< 0.05) higher herbage yield (46,013 kg DM/ha) with the 60 days giving the lowest (22,489 kg DM/ha). Measurement from the chemical composition for the four varieties indicated that the Local variety yielded the highest CP (96.77 g/kg DM) and cellulose (420.8g/kg DM) compared with the other varieties. Hemicellulose was highest for varieties 16798 (252.3g/kg DM) compared to the other three varieties. The ADL was lower for variety 16798 (89.0g/kg DM) compared to the other varieties. Measurement from the chemical composition for the three harvesting days indicated that the 60 days harvest gave the highest CP (109.88 g/kg DM), lowest ADL (84.13g/kg DM) and the lowest DM (478.5g/kg). The cellulose fraction was highest for the 60 days harvest (427.6g/kg DM) with 120 days harvest recording the lowest (354.6g/kg DM). The hemicellulose fraction was lowest for the 60 days and highest for the 120 days after planting. Measurement from the chemical composition for the two fractions indicates that the leaf fraction recorded a higher CP (122.24g/kg DM) and lower ADL (105.83g/kg DM) compared to the stem. The stem fraction however recorded a higher cellulose fraction (406.9g/kg DM) compared to the leaf fraction. Hemicellulose was higher for the leaf fraction (240.0g/kg DM) compared to the stem fraction. The ADL was lowest for variety 16798. The herbage yield increased with increase in days after planting. The DM, hemicellulose and ADL increased with increase in days after planting. Crude protein and cellulose for the three different days after planting however decreased with increase in days after planting.. The results showed that varieties Local and 16798 had the highest CP and cellulose but lowest ADL contents. As expected, CP declined with age and NDF, ADF and ADL increased with increasing age of the grasses. Similarly, herbage yields were highest for Local and 16798 varieties. As expected, herbage yield increased but CP declined with age of the grasses. The DM for the leaf and stem fraction was almost the same. The CP and hemicellulose were higher for the leaf fraction. The cellulose and ADL were all lower for the leaf compared to the stem fraction. The results show the potential of Local and 16798 varieties as a ruminant feed in Ghana.

Keywords: Napier grass, harvest days, variety, yield, chemical composition

INTRODUCTION

Forages continue to represent the single most important feed resource for livestock in developed

and developing countries (Jung and Allen, 1995). Despite their important position in ruminant production, little effort is made to cultivate and conserve forage in Ghana. Most livestock producers depend largely on natural pastures and crop residue as a main source of feed. Natural pastures are usually affected by changes in the rainfall pattern. Ghana has two major seasons, the dry and wet season. In the dry season, most forages drop in quality (crude protein content and digestibility). After start of the rainy season, forage growth is stimulated and this early growth has a relatively high protein and carbohydrate content. This forage is useful for animal production, but is generally unavailable to freegrazing animals because of intensive cultivation of crops during this time. This calls for a conscious effort to cultivate forges particularly in Ghana. Selecting forage species for cultivation must take into consideration the yield, digestibility and nutrient composition.

Napier grass, (*Pennisetum purpureum*) also known as "elephant grass" is native to Africa and has been used extensively in Kenya to improve upon small holder dairy production. Napier grass is the main fodder grown by over 70% of smallholder farmers in Kenya. (Staal *et al.*, 1998) Napier grass has been the most promising and high yielding fodder giving dry matter yields that surpass most other tropical grass. A yield of 85.4 tons/hectare without fertilizer application and a record high yield of 130 tons/hectare with 1320 kg/ha of nitrogen fertilizer application have been recorded (Boonman, 1993).

Herbage yield of Napier grass may be affected by the harvesting day after planting. Generally, as grass ages, herbage yield is increased due to the rapid increase in the tissues of the plant (Minson, 1990. Generally leaves of grasses have been reported to contain more crude protein and cell contents than the stem (Reid *et al.*, 1973).

The current study seeks to investigate the effect of different harvest days after planting (60, 90, 120 days) on the herbage yield and chemical composition of four different varieties of leaf and stem fractions of Napier grass cultivated in the in the Ashanti Region of Ghana.

MATERIALS AND METHODS

The experiment was conducted between March, 2008 and June, 2009 at the Department of Animal Science of the Kwame Nkrumah University of Science and Technology (KNUST) Kumasi.

Location and climate of study area: The Department of Animal Science Farm of the Kwame

Nkrumah University for Science and Technology (KNUST) Latitude 06⁰ 41N, longitude 01⁰ 33W and altitudes 261.4 above mid sea level (MSL)) was the site used to grow the grasses. Chemical analyses of the samples were done at the Animal Nutrition Laboratory of the Department of Animal Science, KNUST.

The site for the study falls within the moist semideciduous forest belt of Ghana and with a bimodal rainfall pattern. The annual rainfall averages about 1194mm. The major wet season extends from March to July with the peak rainfall in April and May. The minor wet seasons begins in September and ends in November after a short dry season in August. The major dry season is from December through January to February (Osafo, 1976). The mean maximum and minimum temperature for the site were 34.0°C and 21.4°C respectively.

Soil Description: The soils of the experimental site consist mainly of the Asuansi Series, belonging to the Kumasi-Asuansi/Nta-Ofin Compound association developed over Cape Coast granite under moist semi-deciduous forest. The soils consist of yellowish red moderately sandy loams and clays and occur on gentle to moderately steep upper to middle slopes. The diagnostic properties include ustic moisture regime, Ochric A horizon, low base saturation and low cation exchange capacity. The soil reaction is extremely acid.

Source of planting material: The planting materials used for this study were made up of three varieties obtained from International Livestock Center for Africa (ILCA) now the International Livestock Research Institute (ILRI) which had been maintained in a herbarium at the KNUST and a local variety from Ghana. The four varieties were selected based on the study conducted by Dzimale (2000) at the same site.

Experimental layout, design and treatments: A 4x3 factorial in a completely randomized design (CRD) was used in the herbage yield study. The main factors were variety, comprising;of 16786, 16798 and 16840 from ILRI and the local variety and harvesting days (3); 60, 90, and 120 days. There were four replicate plots for each treatment.

In all, a total of sixteen (16) plots with each measuring 36m² were used for the planting. Each treatment had four replicates. The intra and inter row spacing were 0.5m and 1m respectively.

Experimental land preparation, planting and maintenance: The plot was ploughed and harrowed with a tractor. The field was divided into sixteen (16) plots with each plot measuring $36m^2$. The intra and inter row spacing were 0.5m and 1.0m respectively. Each plot had 12 rows. The parent plant was cut into stems with a minimum of three nodes per cutting for planting and were planted 15-20cm deep at angle of about 30° - 45° . Weeding was carried out 40 days after planting.

Harvesting procedure and data collection: At each harvesting day (60, 90 and 120days), an area of 9m² (1.5m×6m) was randomly selected and harvested with a machete. A stump (stubble height) of 15cm was left behind after harvesting.

Herbage yield (DM) of Napier grass: For each variety at each harvesting day, the total harvest per plot of fresh forage was weighed and sub samples taken from each variety and chopped into short lengths (2-5cm) for dry matter determination using the AOAC (1990) procedure. This involves drying in an oven at 60°C for 48hours. Herbage yield of each variety was calculated on dry matter basis by multiplying the percentage dry weight of the sub samples from the whole fraction to the fresh weight of the varieties per 9m² and converted to hectares.

Sample preparation for chemical analysis: The four varieties, three harvesting days and two fractions of Napier grass samples were dried at 60[°]C for 48hours and ground using a laboratory mill (Wiley mill) to pass through 1mm sieve screens for laboratory analysis.

Procedure for chemical analysis: The AOAC (1990) procedure was used in the determination of DM, CP, ash and OM. In determining the DM, 200g of each sample of Napier grass was taken and chopped into short lengths (2-5cm). They were then placed in an oven at 60° C for 48hours. The weight after drying is the dry matter (DM).

The CP was calculated as $6.25 \times N$ (Nitrogen). The nitrogen was obtained using the micro-Kjeldahl technique. The ash component was determined by igniting 2gm of napier grass sample in a muffle furnace at 600° C for 4hours. The residue after burning in the furnace is the ash. The OM was determined by subtracting the ash component from the initial weight of the sample before ashing.

The method of Van Soest *et al.*, (1991) was used to determine neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL). Hemicellulose was calculated by subtracting the ADF from the NDF content (NDF-ADF=Hemicellulose) whilst the cellulose was determined by subtracting the ADL from the ADF content (ADF-ADL=Cellulose).

Statistical analysis: The data gathered was subjected to analysis of variance using Genstat discovery edition 3. The difference in mean was compared using the standard error of difference (SED). The results were presented in the form of tables.

RESULTS

Table 1 below shows the chemical composition of the four varieties of Napier grass. Variety 16786 had the highest dry matter of 521.52g/kg with variety 16798 recording the lowest of 482.52g/kg. The organic matter content was highest for variety 16840 (939.93g/kg DM) with variety16786 recording the lowest of 930.77g/kg DM. The local variety recorded the highest crude protein (CP) of 96.77g/kg DM while variety 16786 recorded the lowest crude protein of 85.35g/kg DM. The NDF values for the four varieties ranged between 745.00 to 728.17 g/kg DM with Local variety recording the lowest of 728.17g/kg DM. ADF, from table 4 ranged from 532.67 to 471.33 with variety 16798 recording the lowest of 471.33g/kg DM. The ADL was low in both the local (11.83g/kg DM) and 16798 (89.00g/kg DM) varieties. Hemicellulose and cellulose composition ranged between 252.33 to 195.5g/kg DM and 420.83 to 360.33g/kg DM respectively.

Table 2 below shows the chemical composition of three different harvesting days. The dry matter, organic matter, NDF, ADF, ADL and hemicellulose increased with increase in harvesting days (60<90<120days) whilst the crude protein and cellulose showed a decreasing trend with increase in harvesting days (60>90>120days).

Table 3 shows the chemical composition for the leaf and stem fractions of Napier grass. The leaf fraction recorded lower values for dry matter, organic matter, NDF, ADF, cellulose and ADL compositions whilst the stems recorded higher values. The leaf fraction also recorded higher values for crude protein and hemicellulose compositions with the stems recording the lowest. Table 4 shows the results of the effect of variety and harvesting dates on total herbage yield, tillering and plant height.

Table 1 Effect of variety	on the	chemical	composition
of Napier grass			

Variety						
Item	Local	16786	16798	16840	s.d.	
DM (g/kg)	483.8	521.5	482.6	512.1	45.9	
OM (g/kg DM)	939.8	930.8	931.8	939.9	24.6	
Ash (g/kg DM)	60.2	69.2	68.2	60.1	24.6	
CP (g/kg DM)	96.8	85.4	92.9	93.1	34.8	
NDF (g/kg DM)	728.2	745.0	723.7	743.0	45.3	
ADF (g/kg DM)	532.7	505.5	471.3	498.5	60.7	
Hemi cellulose (g/kg DM)	195.5	239.5	252.3	245.2	48.5	
Cellulose (g/kg DM)	420.8	375.8	382.3	360.3	63.9	
ADL (g/kg DM)	111.8	129.7	89.0	138.2	37.4	

CP=Crude protein, NDF=Neutral detergent fiber, ADF=Acid detergent fiber, OM=Organic matter, DM=Dry matter ADL=Acid detergent lignin, s.d=Standard deviation.

The results show that the Local and 16798 varieties had significantly (P<0.05) higher total herbage yield, total leaf yield and total leaf stem compared to the 16840 and 16786. All the varieties had more leaves compared to stems. The tiller number for the varieties was not significantly different (P>0.05). Variety 16798 gave a significantly lower (P<0.05) plant height compared to the other three varieties. Table 4 below shows the effect of harvest days after planting on herbage yield, total leaf yield, total stem yield, total number and plant height. Total herbage yield, total

leaf and total stem yields were significantly different (P<0.05) for all the harvesting days. Harvesting at 60 days gave the lowest (22489 kg DM /ha) dry matter yield with 120 days yielding the highest herbage (46013kg/ha DM). Total herbage yield increased with increase in harvesting day (60 days < 90days < 120days). The tiller numbers did not differ significantly (P>0.05) for the three harvest days. The plant height increased significantly (P<0.05) as the plant aged.. There was also an increase in harvest days

Table 2 Effect of harvesting day on the chemical	
composition of Napier grass	

Harvesting day						
Item	60	90	120	s.d.		
DM (g/kg)	478.5	506.3	511.1	45.9		
OM (g/kg DM)	944.9	933.2	928.6	24.6		
Ash (g/kg DM)	71.4	66.8	55.0	24.6		
CP (g/kg DM)	109.9	86.3	79.9	34.8		
NDF (g/kg DM)	686.0	720.3	765.1	45.3		
ADF (g/kg DM)	488.6	505.6	511.8	60.7		
Hemi cellulose (g/kg DM)	208.3	231.7	259.5	48.5		
(g/kg Elw)						
Cellulose (g/kg DM)	427.6	372.3	354.6	63.9		
,						
ADL (g/kg DM)	84.1	116.4	151.0	37.4		

CP=Crude protein, NDF=Neutral detergent fiber, ADF=Acid detergent fiber, OM=Organic matter, DM=Dry matter ADL=Acid detergent lignin, s.d=Standard deviation.

DISCUSSION

Effect of variety on the chemical composition and herbage yield of Napier grass (*Pennisetum purpureum*): The difference in the chemical composition recorded for the 4 varieties agrees with Dzimale (2000) who reported similar results for the same varieties. The high dry matter recorded for variety 16786 and 16840 suggest that less moisture is present in the grass and will therefore reduce the rate at which the grass deteriorate when stored. However, it was realized that these same varieties had the highest lignin content implying that though they had a high dry matter, the high lignin content is going to bind the cellulose and hemicellulose and prevent them from being digested and utilized efficiently by the rumen microbes. The Local variety and variety 16798 which had a lower dry matter content yielded a lower lignin and high cellulose compared to the variety 16786 and 16840. This means that a farmer will need to consider quantity and quality, balancing the need for a large quantity of low quality feed against the need for lesser amounts of higher quality feed. All the 4 varieties recorded a CP level higher than the critical level of 7% (70g/kg) which is necessary for voluntary feed intake in ruminants (Nori et al., 2009)

Though variety 16786 and 16840 recorded the highest dry matter, it yielded the lowest herbage yield. Varieties local and 16798 recorded about 2 times the herbage yield recorded for 16786 and 16840. The high leaf fraction recorded for varieties local and 16798 means that digestibility will be higher for those 2 varieties compared to the 16786 and 16840. High digestibilities have been reported for leaves when compared to stem fractions. Even though variety 16798 gave the lowest height, it ended up with a significantly higher total herbage yield.

Effect of different harvesting days on the chemical composition and herbage yield of Napier grass (*Pennisetum purpureum*): The increase in dry matter, ADF, NDF and ADL with increase in harvest day agrees with the report of Bayble (2007) who recorded a similar trend when Napier grass was harvested at 60, 90 and 120 days and should be expected with increasing grass maturity.

Barnes, Hetta and Martinsson (2007) reported an increase in DM, ADF, NDF and ADL with an increase in maturity date in timothy grass (*Phleum pratense*).

Kramberger and Klemencic (2003) and Peiretti (2009) reported similar result in *Cerastiem holosteoides* and sunflower (*Carthamus tinetories L.*) respectively when harvested at increasing maturity dates.

Fraction						
ltem	Leaf	Stem	s.d.			
DM (g/kg)	499.9	500.0	45.9			
OM (g/kg DM)	922.4	948.8	24.6			
Ash (g/kg DM)	77.6	51.2	24.6			
CP (g/kg DM)	122.2	61.8	34.8			
NDF (g/kg DM)	708.6	761.7	45.3			
ADF (g/kg DM)	468.5	535.4	60.7			
Hemi cellulose (g/kg DM)	240.0	226.3	48.5			
Cellulose (g/kg DM)	362.8	406.9	63.9			
ADL (g/kg DM)	105.8	128.5	37.4			

Table	3	Effect	of	fraction	(Leaf	and	Stem)	on	the
chemi	cal	compo	ositi	on of Nap	oier gra	ass			

CP=Crude protein, NDF=Neutral detergent fiber, ADF=Acid detergent fiber, OM=Organic matter, DM=Dry matter, ADL=Acid detergent lignin, s.d=Standard deviation.

The CP decreased with an increase in harvest day. This result agrees with Bayble (2007), Kranberger and Klemencic (2003) and Peiretti (2009). It was observed that the C.P levels decreased by 27% from the 60 day harvest to the 120 days

Even though the 60 day harvest yielded the highest cellulose and CP, it recorded the lowest herbage yield, plant height and tiller numbers. The increase in herbage yield with an increase in harvesting days could be attributed to the increase in tiller number, leaf formation, leaf elongation as well as stem development (Robertson *et al.*, 1976).

Treatment		Total Herbage Yield (kg DM/ha)	Herbage (kg DM/ha) Yield (kg		Tiller number	Plant height (m)	
Variety	Local	41050.2ª	23173.0 ^a (56.5%)	17877.0 ^a (43.5%)	8.17	5.65 [°]	
	16786	28589.1 ^b	15659.0 ^b (54.8%)	12930.0 ^b (45.2%)	8.04	5.61 ^d	
	16840	24863.8 ^b	12514.0 ^b (50.3%)	12349.0 ^b (49.7%)	7.20	5.70 ^a	
	16798	44994.4 ^a	24091 ^a (53.5%)	20903.0 ^a (46.5%)	8.40	5.39 ^b	
s.e.d	•	3693.4	1912.6	2127.5	0.55	0.01	
Harvest days	60	22489.7 ^a	12133.0 ^a (54.0%)	10366.0 ^a (46.1%)	7.53	1.91 ^a	
-	90	36121.2 ^b	19273.0 ^b (53.4%)	16848.0 ^b (46.6%)	7.83	7.24 ^b	
	120	46012.5 ^c	25182.0 ^c (54.7%)	20831.0 ^c (45.3%)	8.50	7.61 [°]	
s.e.d	•	3198.6	1656.4	1842.5	0.45	0.09	

Table 4 Effect of variety and harvesting day on herbage yield

Mean with different superscript in the same column are significantly different at P<0.05; Figures in parenthesis are a percentage leaf or stem of the total herbage; s.e.d: Standard error of difference

Effect of fraction on the chemical composition of Napier grass (*Pennisetum purpureum*): The dry matter for the leaf and stem were almost the same (Table 4). The relatively higher cellulose fraction recorded for the stem fraction could result in a higher digestibility for the stem fraction.

The CP in the leaf fraction is almost twice that of the stem fraction. A similar trend was observed by Tang *et al.*, (2008).

CONCLUSION: The Local and variety 16798 produced a significantly higher yield among the four varieties and the 120 day harvest also recorded the highest yield among the 3 harvest days. However, the 60 day harvest had the highest cellulose and lowest lignin content. The balance of quantity versus quality is noted between varieties Local and variety 16798 with more cellulose but less dry matter yield and varieties 16786 and 16840 with a greater yield but greater lignin content.

All the varieties recorded a CP level above the critical 70g/kg required for voluntary intake in ruminants and therefore could be suitable for feeding small ruminants in Ghana.

Variety 16798 recorded the lowest lignin content among the four varieties.

The leaf fraction recorded the highest CP compared to the stem fraction however; the stem fraction recorded the highest cellulose fraction.

ACKNOWLEDGEMENT

The first author will like to thank the University for Development Studies (UDS), Tamale for providing partial funding to help complete the study and the Danish Development Research Network, and University of Copenhagen, Denmark for travel scholarship and assistance with laboratory and library facilities.

REFERENCES

- AOAC, (1990) Official methods of analysis of Association of Official Analytical Chemists (16th edition), Washington, DC.
- Boonman, J.G., (1993). East Africa's grasses and fodders: Their ecology and husbandry. Kluwer Academic Publishers, Dortrecht, Nethelands.pp.343.
- Dzimale, G.J.K (2000) Herbage yield and Nutritive Value of ten Varieties of Elephant grass, *Pennisetum purpureum,* in Ashanti Region of Ghana. A thesis submitted to the school of postgraduate studies, Kwame Nkrumah University of Science and Technology, Kumasi, In partial fulfillment of the requirements for the MSc. (Animal science) Degree.

- Glover, J. and Dougall, H. W (1960) The apparent digestibility of the non-nitrogenous components of ruminants feeds, J. Agric. Sci. (Camb.) 55, 391-394.
- Milford, R. and Minson, D. J (1966) The feeding value of tropical pastures. In W. Davies and C. L. Skidmore (eds), Tropical pastures, Faber and Faber: London, Ch. 7.
- Minson, D.J., (1990) Forage in ruminant nutrition. Academic Press, San Diego, CA, 482 pp.
- Nori H, Sani S A and Tuen A A 2009: Chemical and physical properties of Sarawak (East Malaysia) rice straws. *Livestock Research for Rural Development. Volume 21, Article #122.*
- Peiretti, P. G (2009). Effect of growth stage on chemical composition, organic matter digestibility, gross energy and fatty acid content of sufflower (Carthamus tinctorius L.) Livestock Research for Rural Development 21 (12) 2009
- Reid, R. L., Post, A. J., Olsen, F. J. and Mugerwa, J. S (1973) Studies on the nutritional quality of grasses and legumes in Uganda. I. Application of *in vitro* digestibility techniques to species and stage of growth effects, *Trop. Agric. (Trin.)* 50, 1-15.

- Robertson, A. D. Humphreys, L. R. and Edwards, D. G. (1976) Influence of cutting frequency and phosphorus supply on the production of stylosanthes humilis and Arundinaria pusilla at Khon Kaen, north-east Thailand, Tropical Grassland 10, 33-39.
- Staal, S., Chege, L., Kenyanjui, M., Kimari, A., Lukuyu, B., Njubi, D., Owango, M., Tanner, J., Thorp, W. & Wambugu, M. (1998). A cross-sectional survey of Kiambu District for the identification of target groups of smallholder dairy producers. KARI/ILRI collaborative project research report, Nairobi, Kenya
- Tang S. X, Gan J, Sheng L. X, Tan Z. L, Tayo G.O, Sun H. Z, Wang M, and Ren G.P (2008) Morphological fractions , chemical compositions and *in vitro* fermentation characteristics of maize stover of five genotypes. Animal 2008 Vol.2 Number 12 Pp1772-1779.
- Taye Bayble, Solomon Melaku, N K Prasad (2007) Effects of cutting dates on nutritive value of Napier (*Pennisetum purpureum*) grass planted sole and in association with Desmodium (*Desmodium intortum*) or Lablab (*Lablab purpureus*). Livestock Research for Rural Development 19 (1) 2007.