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Effects of Animal Manures and Cutting Height on the Chemical Composition of Two *Panicum maximum* Varieties (Local and Ntchisi) Harvested at Different Stages of Growth

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ABSTRACT

An experiment was conducted to determine the effects of animal manures and cutting height on the chemical composition of two *Panicum maximum* varieties harvested at different stages of growth. The experiment was laid out as a split-split-split plot design with four manure types (cattle, swine, poultry, and control) assigned to the main plot, three stages of growth (8, 10, and 12 weeks) assigned to the sub-plots, three cutting heights (10, 15, and 20 cm above ground) allotted to the sub-sub-plot, and *P. maximum* varieties (Local and Ntchisi) allotted to the sub-sub-sub-plot with three replicates. Results showed that swine and cattle manure fertilized grasses recorded ($P<0.05$) higher crude protein (CP) content than the unfertilized and poultry manure fertilized grasses. The grasses defoliated at 8 weeks recorded higher CP (10.37%), ether extract (8.77%) and ash (9.60%) compared to those harvested at 10 and 12 weeks respectively. Ntchisi variety recorded higher ether extract (8.94%) and ash (9.58%) contents than the local variety. However, the neutral detergent fibre (NDF) and acid detergent fibre (ADF) of the grasses increased with advancement in the growth stage. Grasses cut at 15 cm had higher Ca (4.66 g kg^{-1}) while those cut at 20 cm recorded higher P (4.01 g kg^{-1}) concentration. The quality of the grasses

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was influenced by the interactions (manure × harvest time; manure × variety × cutting height; manure × cutting height × harvest time). Therefore, to harness the best nutritive *P. maximum* for the feeding of ruminants in Nigeria and other parts of the tropics, manure (cattle, swine, and poultry), harvest time, variety and cutting height, and their interactions are important factors to be considered.

Keywords: Animal manure, cutting height, macro-mineral, *Panicum maximum*, ruminants, stage of growth

INTRODUCTION

Panicum maximum is one of the dominant forage species in the humid and sub-humid zones of Nigeria. The grass plays a vital role in livestock production owing to its persistence, growth and quality under proper management through grazing or clipping (Olanite et al., 2014). The significance of *P. maximum* as one of the most relished feed resource by ruminants in Southwest Nigeria was the reason why it featured prominently in the early evaluation and grazing studies in the area (Ademosun, 1973; Akinyemi & Onayinka, 1982). Some of the characteristics that enhance high utilization of *P. maximum* by animals include high leaf production, particularly at the early stage of growth (Olanite et al., 2006), as well as resilience to grazing by ruminants.

Several animal manures have been reported as being suitable for soil amendment (Ewetola et al., 2016; Ojo et al., 2015) and for improving the nutritive quality of tropical plants. Swine manure, cattle dung, farmyard manure and poultry droppings are potential soil amendments for crop and pasture plants (Ahmed et al., 2012; Ojo et al., 2015; Sodeinde et al., 2009). Besides enhancing forage growth, organic manures also possess the capability to improve the physical, chemical, and microbial properties of the soil (Adesodun et al., 2005). Thus, fertilization of pastureland with organic manure sits well within the context of nutrient recycling and environmental protection. Ewetola et al. (2016) reported that application of organic manure directly to the soil helped in maintaining adequate level of organic matter, which was a critical component of soil fertility and productivity.

Several species of *P. maximum* have been subjected to different evaluation studies in southwest Nigeria over time (Bamikole et al., 2004; Ezenwa & Aken'Ova, 1998; Olanite et al., 2006). These studies have shown a strong relationship between extended cutting intervals and stage of growth with declined nutritive quality, but without manure application and consideration of different varieties. In contrast, short cutting intervals enhance nutritive quality of the grass. Options therefore vary on the cutting interval that would be consistent with maintaining high nutritive quality of *P. maximum.*

Panicum maximum Ntchisi is rarely used as a major forage in commercial livestock production in south western Nigeria. This is because it has to be established and managed, unlike the local variety which is freely available for use by livestock farmers. The need to establish pastures to cater for the increasing demand for animal products and ever increasing human population in the derived savannah zone of Nigeria will soon become unavoidable (Olanite et al., 2006). This will ultimately require research findings of this kind for management purpose. To this end - the utilization of *P. maximum* by farmers in Nigeria requires improved information on the relative performance of varieties, with regard to how they respond in terms of herbage quality, including nutrient content, to different types of organic manure, and to harvesting at different growth stages. The present study aims at investigating the effects of animal manures and cutting height on the chemical composition of Ntchisi and the locally available variety of *P. maximum,* harvested at different stages of growth with a view to make recommendations to commercial farmers on the nutritive value of the grass species; for livestock feeding which could further facilitate their use for feeding ruminants in Nigeria and other tropical regions.

MATERIALS AND METHODS

Experimental Site and Land Preparation

The experiment was conducted at the Directorate of University Farms, Federal University of Agriculture, Abeokuta, Ogun State, Nigeria (7°58'N; 3°2°E) in the humid savannah agro-ecological zone. The area has a mean annual rainfall of 1230 mm with a bimodal distribution pattern of rainfall that attains peak in June/July and September/October with major dry season between November and March. The experimental area measured 656 m^2 (41 × 16 m), and was part of a virgin land which was opened for research purpose using machinery. The land was ploughed twice, followed by harrowing to smoothen the soil surface. The lumps of soil left after ploughing were also broken down through harrowing to ensure a finer finish, and good soil structure suitable for plant growth. Soil samples were collected from the experimental site at a depth of 0-15 cm (Table 1) to determine the physico-chemical characteristics of the soil prior to application of manure.

Table 1

Physico-chemical characteristics of the composite soil samples taken at 0-15 cm depth from the experimental site before planting

Chemical Properties	Values
pH	7.03
Total nitrogen (%)	0.11
Organic carbon (%)	1.29
C:N ratio	28.38
Available P (mg kg^{-1})	53.87
Acidity (cmol kg^{-1})	0.13
CEC	1.79

Table 1 *(Continue)*

Chemical Properties	Values
Exchangeable cations(cmol kg^{-1})	
Sodium (Na)	0.80
Potassium (K)	0.20
Calcium (Ca)	2.77
Magnesium (Mg)	2.72
Particle Size	
Sand (%)	77.93
Silt (%)	17.33
Clay (%)	4.73

Manure Collection, Analysis and Application

The manures used were: cattle, swine, poultry and control. The cattle and swine manures were collected at the College of Animal Science and Livestock Production (COLANIM) farm, poultry manure was sourced at Livelihood Support and Development Centre (SLIDEN Africa) farm located at Alabata Road. Samples of all the manures were collected and taken to the laboratory for determination of their nutrient content prior to application (Table 2). The manures were applied at 120 kg N per hectare. These manures were manually incorporated into the soil for proper and efficient mineralization. The field was left for two weeks after manure application before planting of the grasses.

Table 2
Nutrient composition of animal manures

Parameters	**Cattle**	**Swine**	**Poultry**
N (g kg^{-1})	15.6	16.9	30.2
P (g kg^{-1})	6.9	6.3	10.6
K (g kg^{-1})	7.3	7.6	10.3
Ca (g kg^{-1})	21.2	31.6	37.2
Mg (g kg^{-1})	11.7	19.2	17.3
Na (g kg^{-1})	1.1	1.6	2.1
Fe (mg kg^{-1})	614.6	650.7	630.9
Zn (mg kg^{-1})	54.8	81.2	75.4
Cu (mg kg^{-1})	29.1	27.3	32.7
Mn (mg kg^{-1})	321.9	260.3	217.9

Sourcing of Planting Materials and Planting

The two *P. maximum* varieties – a naturalized variety commonly referred to as local Panic (Olanite et al., 2006) and the Ntchisi variety which originated from East Africa (Skerman, 1977) were sourced from an open land and the introduction plot of the Department of Pasture and Range Management. The planting materials were separated into crown splits before planting at a spacing of 0.5 × 0.5 m. The inter and intra row spaces within the plots, as well as 2 m from the boundary of the plots were kept weed free throughout the research period in order to prevent weed invasion, as well as other forms of interference.

Treatments, Experimental Design and Plot Layout

The experiment comprised four factors which were four manure types (cattle, poultry, swine and control i.e. no application of manure), two *P. maximum* varieties (Local and Ntchisi); three stages of growth (8, 10, and 12 weeks) and three cutting heights (10 cm, 15 cm and 20 cm) respectively. The manure types were assigned to the main plots (41 × 4 m), the stages of growth assigned to the sub plots (4.5 m × 4 m), cutting heights were assigned to the sub-sub plots (4.5 m × 1 m) and the grass varieties were allotted to the sub-sub-sub plots (1 m × 1 m). The treatments were replicated thrice giving a total of 216 plots, with each plot having a dimension of 1 m × 1 m. The space between the replicates was 2 m and 0.5 m spacing was maintained between the treatments.

Sample Collection and Preparation

Grass samples were harvested at 8, 10 and 12 weeks after planting while clipping was done at 10, 15, and 20 cm from the ground level. Sub samples were taken, packed and oven dried at 65^{o}C to a constant weight and subsequently milled to pass 1mm sieve and stored for analysis.

Chemical Analysis

The content of dry matter (DM), crude protein (CP), ether extract (EE i.e. fat) and ash (inorganic minerals) were determined according to Association of Official Analytical Chemists (AOAC) (2010), while the neutral detergent fibre (NDF), acid detergent fibre (ADF), acid detergent lignin (ADL), hemicellulose (HEM), and cellulose (CELL) were determined according to the procedure of Van Soest et al. (1991).

Mineral Composition Analysis. The milled samples of the grasses were used for mineral analysis of Calcium (Ca), Potassium (K), Phosphorus (P), and Magnesium (Mg). The concentration of K was estimated with a flame photometer while the concentrations of Ca, P and Mg were determined using atomic absorption spectrophotometry (Fritz & Schenk, 1979) after wet digestion in 15 ml nitric acid and 5 ml hydrochloric acid.

Statistical Analysis

All data collected were subjected to four-way analysis of variance (ANOVA) using the split-split-split plot design in R Statistics (R Core Team, 2015). Significant differences between individual means were separated using Duncan's Multiple Range Test.

RESULTS

Manure type ($P<0.05$) affected the proximate composition of the two grass varieties except for dry matter (DM) content (Table 3). The crude protein (CP) content of the grasses ($P<0.05$) ranged from 8.83% in the unfertilized grasses to 10.77% in swine manure fertilized grasses. Cattle manure fertilized grasses and those fertilized with swine manure obtained higher statistically similar values (10.92% and 10.25%) for ether extract (EE), and the lowest (5.92%) was recorded for the unfertilized grasses. The values recorded for ash ranged from 8.52% for poultry fertilized grasses to 10.50% in the unfertilized grasses. However, the ash values observed for swine manure and poultry manure fertilized grasses were statistically similar.

The DM and EE content of the grasses were ($P<0.05$) influenced by cutting height. The grasses harvested at 10 cm and 15 cm height had statistically similar values (94.27% and 94.20%) for DM, while those harvested at 20 cm recorded the lowest value (92.54%). The grasses cut at 10 cm height recorded higher EE (8.77%) than those cut at 15 cm height above the ground.

Grasses harvested at 8 weeks recorded the highest CP and EE values (10.37 % and 9.13 %) respectively, while the least values (9.48 % and 7.67 %) were observed for those harvested at 12 weeks of age, but statistically similar to those harvested at 10 weeks for CP. In contrast, grasses harvested at 8 and 12 weeks recorded the highest value (9.54 %) for ash content, while those clipped at 10 weeks had the least value (9.08 %) for the same parameter.

Table 3

Effect of manure type and cutting height on the proximate composition (%) of two P. maximum *varieties (local and Ntchisi) harvested at different stages of growth*

Factors	DM	CP	EE	ASH
Manure				
Cattle	92.97	10.60[a]	10.92[a]	9.94[b]
Swine	93.77	10.77[a]	10.25[a]	8.58[c]
Poultry	94.08	8.97[b]	6.56[b]	8.52[c]
Control	93.86	8.83[b]	5.92[b]	10.50[a]
SEM	0.45	0.29	0.33	0.21

Table 3 *(Continue)*

Factors	DM	CP	EE	ASH
Cutting Height				
10cm	94.27[a]	10.06	8.77[a]	9.60
15cm	94.20[a]	9.82	8.04[b]	9.31
20cm	92.54[b]	9.51	8.42[ab]	9.25
SEM	0.36	0.28	0.39	0.21
Harvest Time				
8 weeks	93.85	10.37[a]	9.13[a]	9.54[a]
10 weeks	93.60	9.53[b]	8.44[b]	9.08[b]
12 weeks	93.56	9.48[b]	7.67[c]	9.54[a]
SEM	0.40	0.27	0.38	0.20
Variety				
P. maximum (Local)	93.88	9.70	7.88[b]	9.19[b]
P. maximum (Ntchisi)	93.45	9.88	8.94[a]	9.58[a]
SEM	0.32	0.23	0.31	0.17
Cutting H × Har Time	0.9749	0.0796	0.0557	0.0013
Manure × Cutting H	0.8104	0.6484	0.0008	<0.0001
Variety × Cutting H	0.4426	0.2834	0.1391	0.9438
Manure × Har Time	<.0001	0.2520	<0.0001	<.0001
Variety × Har Time	0.0014	0.4100	0.0059	0.0357
Manure × Variety	0.3727	0.0172	0.4728	<0.0001
Manure × Cut H ×Har T	<0.0001	0.0056	0.0815	0.0020
Var × Cut H × Har T	0.1369	0.0017	0.4757	0.0965
Manure ×Var × Cut H	0.0066	0.0691	0.0243	0.1003
Manure ×Var × Har T	0.3098	0.6291	0.1137	0.0255

[a,b,c] means in the same column with different superscripts are significantly different (P<0.05) SEM = Standard error of mean, DM = Dry matter, CP = Crude protein, EE = Ether extract, ASH = Ash. P values are reported for the interactions

The influence of variety was (P<0.05) pronounced only in the EE and ash content of the grasses. *P. maximum* Ntchisi recorded (P<0.05) higher values (8.94% and 9.58%) for ether extract and ash, while the local variety recorded the lowest values (7.88 % and 9.19 %).

The DM content of the grasses was significantly affected by manure × harvest time, variety × harvest time, manure ×

cutting height × harvest time and manure × variety × cutting height. The CP content was affected by manure × variety, manure × cutting height × harvest time, and variety × cutting height × harvest time. Cutting height × harvest time, manure × cutting height, manure × harvest time, variety × harvest time, and manure × variety × cutting height had significant effect on the EE content of the grasses.

The values recorded for acid detergent fibre (ADF) ranged from 47.61% for cattle manure fertilized grasses to 57.61% in the unfertilized grasses (Table 4). Nonetheless, grasses fertilized with swine and poultry manure recorded statistically similar values. Swine manure fertilized grasses had the highest value (14.44 %) for acid detergent lignin (ADL) while cattle (12.22%) and poultry (11.67%) manure, as

Table 4
Effect of manure type and cutting height on the fibre composition (%) of two P. maximum *varieties (local and Ntchisi) harvested at different stages of growth*

Factors	NDF	ADF	ADL	HEM	CELL
Manure Types					
Cattle	62.00	47.61[c]	12.22[b]	14.38[d]	45.39[a]
Swine	75.27	55.78[b]	14.44[a]	19.50[b]	41.33[b]
Poultry	76.06	52.50[b]	11.67[b]	23.56[a]	40.83[b]
Control	74.33	57.61[a]	12.17[b]	16.72[c]	45.44[a]
SEM	0.70	0.80	0.55	0.90	0.90
Cutting Height					
10 cm	64.21	45.92	13.13	18.29	42.79
15 cm	74.29	56.25	12.21	18.04	44.04
20 cm	74.75	55.46	12.54	19.29	42.92
SEM	0.68	0.74	0.49	0.88	0.83
Harvest Time					
8 weeks	65.62[b]	47.79[b]	12.25	17.83	45.54[a]
10 weeks	73.63[ab]	55.08[a]	12.33	18.54	42.75[b]
12 weeks	74.00[a]	54.75[a]	13.29	19.25	41.45[b]
SEM	0.68	`	0.49	0.88	0.80

Table 4 *(Continue)*

Factors	NDF	ADF	ADL	HEM	CELL
Variety					
P. maximum (Local)	65.44[b]	47.63[b]	13.89	17.80	45.02[a]
P. maximum (Ntchisi)	73.39[a]	54.11[a]	13.45	19.27	41.47[b]
SEM	0.55	0.58	0.40	0.72	0.66
Cutting H × Har Time	0.9454	0.1217	0.2276	0.1641	0.9100
Manure × Cutting H	0.2756	0.1730	0.5257	0,0868	0.2438
Variety × Cutting H	0.1057	0.8118	0.3008	0.0723	0.5957
Manure × Har Time	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Variety × Har Time	0.8140	0.0241	0.0085	0.1087	0.9019
Manure × Variety	0.2380	0.1725	0.2489	0.1296	0.4573
Manu × Cut H × Har T	0.4907	0.0037	0.0066	0.0098	0.1689
Var × Cut H × Har T	0.4395	0.0498	0.8067	0.0307	0.4621
Maunre × Var × Cut H	0.8226	0.3123	0.0044	0.3143	0.1958
Manure × Var × Har T	0.4373	0.0438	0.1328	0.0672	0.2794

[a,b,c]: means in the same column with different superscripts were significantly different, (P<0.05) SEM = Standard error of mean, NDF =Neutral detergent fibre, ADF = Acid detergent fibre, ADL = Acid detergent lignin HEM = Hemicellulose, CELL = Cellulose. P values are reported for the interactions

well as the unfertilized grasses (12.17%) recorded values that were statistically at par. Meanwhile, grasses fertilized with poultry manure obtained the highest value (23.56 %) for hemicellulose (HEM), while those fertilized with cattle manure had the lowest value (14.38 %). In contrast, the unfertilized grasses and those amended with cattle manure had similar values (45.44 % and 45.39%) for cellulose (CELL) while grasses fertilized with poultry and swine manure recorded significantly lower values (40.83% and 41.33%). Cutting height did not influence the fibre composition of the grasses significantly (P>0.05). However, stage of growth (P<0.05) affected the neutral detergent fibre (NDF), ADF, and CELL content of the grasses. The grasses harvested at 12 weeks recorded higher NDF (74.00%) than those harvested at 8 weeks of growth (65.62%). Similarly, the values recorded for ADF was (P<0.05) higher for the grasses harvested at 10 and 12 weeks (55.08% and 54.75%), and the least (47.79 %) was observed for those harvested at 8 weeks. The grasses harvested at 8 weeks recorded the highest value (45.54%) for CELL content while those harvested at 10 and 12 weeks had similar values. The effect of variety was significant (P<0.05) on the NDF, ADF and CELL content of the grasses. *P. maximum* Ntchisi recorded higher values

(73.39 % and 54.11%) for NDF and ADF, and the local variety was observed for higher CELL content.

The interaction between manure × harvest time was (P<0.05) for all the fibre component of the grasses. Other significant (P<0.05) interactions are: variety × harvest time (P=0.0241) for ADF, manure × cutting height × harvest time (P=0.0037) for ADF, variety × cutting height × harvest time (P=0.0498) for ADF, manure × variety × harvest time (P=0.0438) for ADF, variety × harvest time (P=0.0085) for ADL, manure × cutting height × harvest time (P=0.0066) for ADL, manure × variety × cutting height (P=0.0044) for ADL and variety × cutting height × harvest time (P=0.0307) for HEM.

The unfertilized grasses recorded higher potassium (K) concentration (35.01 g kg^{-1}) while the lowest concentration was observed for poultry manure fertilized grasses (Table 5). The grasses fertilized with cattle and swine manure, as well as the unfertilized grasses recorded (P<0.05) higher values for calcium (Ca) (4.90 g kg^{-1}, 4.60 g kg^{-1}, and 4.37 g kg^{-1}) and the least value was recorded for poultry manure fertilized grasses (3.22 g kg^{-1}). With regard to cutting height, phosphorus (P) and Ca content of the grasses were (P<0.05) affected. The grasses harvested at 20 cm height recorded higher P than those harvested at 10 cm height above ground. In contrast, Ca concentration was higher for the grasses cut at 15 cm height (4.66 g kg^{-1}) than those defoliated at 10 cm height (3.74 g kg^{-1}).

Table 5

Effect of manure type and cutting height on the macro-mineral concentration (g kg^{-1}) of two P. maximum *varieties (local and Ntchisi) harvested at different stages of growth*

	Phosphorus	Potassium	Magnesium	Calcium
Factors		g kg^{-1}		
Manure Types				
Cattle	4.28	32.75^{ab}	2.03	4.90^{a}
Swine	4.34	32.52^{ab}	2.05	4.61^{a}
Poultry	3.73	31.61^{b}	1.69	3.22^{b}
Control	4.04	35.01^{a}	1.91	4.37^{a}
SEM	0.03	0.97	0.13	0.04
Cutting Height				
10 cm	3.73^{b}	33.73	1.80	3.74^{b}
15 cm	4.01^{ab}	32.66	1.97	4.66^{a}
20 cm	4.55^{a}	32.52	1.99	4.42^{ab}
SEM	0.02	0.88	0.11	0.03

Table 5 *(Continue)*

	Phosphorus	Potassium	Magnesium	Calcium
Factors		g kg^{-1}		
Stage of Growth				
8 weeks	3.44^b	33.39	2.18^a	5.13^a
10 weeks	4.90^a	33.80	1.51^b	2.13^b
12 weeks	3.95^b	31.71	2.07^a	5.56^a
SEM	0.02	0.71	0.09	0.03
Varieties				
Local	3.90	31.98^b	1.88	4.18
Ntchisi	4.30	33.96^a	1.95	4.37
SEM	0.02	0.85	0.11	0.03
Cutting H × Har Time	<0.0001	0.3300	<0.0001	<0.0001
Manure × Cutting H	0.1650	0.1860	0.1470	0.0053
Variety × Cutting H	0.0223	0.0133	0.3710	0.2890
Manure × Har Time	<0.0001	<0.0001	<0.0001	<0.0001
Variety × Har Time	<0.0001	<0.0001	0.0002	<0.0001
Manure × Variety	0.264	0.0007	0.2580	0.0074
Manu × Cut H × Har T	<0.0001	<0.0001	0.0018	<0.0001
Var × Cut H × Har T	<0.0001	<0.0001	0.0060	<.0001
Maunre × Var × Cut H	0.0090	0.0027	0.2180	0.0044
Manure × Var × Har T	<0.0001	<0.0001	<0.0001	<0.0001

^{a,b,c}: means in the same column with different superscripts were significantly different (p<0.05)
SEM=Standard Error of Mean. P values are reported for the interactions.

All the macro minerals investigated were influenced by stage of growth except for K. The highest P concentration was observed for the grasses harvested at 10 weeks (4.90 g kg-^{1}). However, P concentration recorded for the grasses defoliated at 8 and 10 weeks were statistically similar. Magnesium (Mg) concentration observed for the grasses harvested at 8 and 12 weeks were statistically at par and the lowest was noted for those cut at 10 weeks of growth (1.51 g kg^{-1}). Higher (P<0.05) Ca content was recorded for the grasses clipped at 8 and 12 weeks, with the least observed for those harvested at 10 weeks. The effect of variety was only significant on the K content of the grasses with Ntchisi variety recording higher concentration (33.96 g kg^{-1}) compared to that (31.98 g kg^{-1}) observed for the local variety.

There were significant interactions between manure × harvest time, variety × harvest time, and manure × variety × harvest time for all the macro mineral concentration of the grasses. With the exception of K, the effect of cutting height × harvest time was observed on all other mineral content of the grasses. Phosphorus, K, and Ca were significantly affected by manure × cutting height × harvest time and variety × cutting height × harvest time.

DISCUSSION

The result from this study revealed that the CP content of the grasses under the influence of manure type was above the minimum requirement for maintenance of ruminant animals. These values were also above the minimum range of 6.50 – 8.00% prescribed for optimal performance of tropical ruminant animals (Minson, 1981). The highest CP recorded for the grasses fertilized with cattle and swine manure might be linked to high nitrogen content in the manure (Chantigny et al., 2007), and this suggests that manure mineralization takes place at different rates relative to the donor animal. Thus, our result further ascertains that swine manure promotes high accumulation of CP and this corroborates earlier reports (Ojo et al., 2013; Olanite et al., 2006).

The CP content of the grasses was not influenced by cutting height and this agrees with the report by Wijitphan et al. (2009) on the CP of King Napier grass investigated in Thailand. Higher CP was noted for grasses harvested at 8 weeks of growth than for those harvested at 10 and 12 weeks with similar CP contents. The observed decline in the CP content of the grasses could be attributed to decrease in leaf stem ratio and increase in cell wall content of the grasses with advancement in growth stage. The range of values recorded by the two varieties of *P. maximum* investigated in this study showed that *P. maximum* Ntchisi recorded higher EE and ash content values than the local variety, suggesting that Ntchisi variety could provide ruminants with more energy and total inorganic mineral content. This could be ascribed to the fact that Ntchisi is an improved variety over the local panic, a naturalized variety (Olanite et al., 2006).

The interaction effect of variety × cutting height × harvest time and manure × variety observed on the CP content of the grasses agrees with the report by Assefa and Ledin (2001) and Chaves et al. (2006) that fertilizer, harvest time, and variety rank among the factors that determined the quality of forage. A similar result was reported by Mohajer et al. (2012) when three varieties of common millet (*Panicum miliaceum*) were harvested at three phonological growth stages (booting, milky, and seed maturity). However, proportional changes in plant nutrient composition is an important consideration when pastures are managed for the production of high nutrient intake for ruminant animals (Chaves et al., 2006).

Not only do the NDF and ADF fractions of the grasses differ at 8 and 12 weeks of age but also increased, and this could be premised on increase in the cell wall content and a decrease in the leaf-stem ratio of the grasses which consequently lead to accumulation of lignin (Moore & Jung, 2001). From this point of view, the grasses harvested at 8 weeks of growth are of higher nutritional value which could promote better intake. Values recorded for ADF under the influence of manure type were slightly above the range of 29.78%-32.52% reported by Okukenu et al. (2017) when nine varieties of *Pennisetum purpureum* were evaluated in the derived savanna of Nigeria. The observed disparity could be attributed to difference in manure application rate. Moreover, the low level of lignin recorded for the grasses as affected by manure type suggests that the cellulose content of the grasses would be moderately digestible, since increased lignin in forages limits the digestibility of cellulose (Hatfield et al., 1999; Moore & Hatfield, 1994). The ADF and ADL values observed were slightly higher than those reported by Ojo et al. (2015) when similar manure types were applied to Pennisetum hybrid.

Compared with our results, Fernendes et al. (2014) recorded slightly lower ADF values for *P. maximum* genotypes fertilized with dolomitic lime in the Brazilian savannah. The observed difference could be partly due to the use of different soil amendments in the former and present study. Doubtless, higher NDF content of the local variety was due to the presence of higher proportion of stem material in the forage, and this may not have much interference with the digestibility of the plant at a younger age; since tender stems could be as digestible as the leaves. More importantly, the advancement in the age of the plants also affects the leaves as they become more fibrous and less digestible. The effect of cutting height was not observed on the fibre fractions of the grasses. Earlier reports (Ojo et al., 2015, Zetina-Cordoba et al., 2013) showed that nutritive quality declined as the cutting interval extends as depicted by the CP, NDF and ADF components of the grasses. However, there was a slight deviation in the result obtained in this study as the NDF and ADF fluctuate between 8 and 10 weeks of growth probably due to alterations in leaf: stem ratio.

The effect of variety influenced all the fibre fractions of the grasses except for ADL and HEM. The values observed for CELL content of the grasses as affected by stage of growth were slightly higher than (25.65%-39.26%) reported by Ojo et al. (2013) for *P. maximum*. The observed disparity could be hinged on the application of (N: P: K 15:15:15) at 200 kg N/ha in the former study, as well as the time of application. Moreover, grasses harvested at 12 weeks of growth recorded higher bulk of fibre (NDF and ADF) , and this implies high lignification as a result of the development of more structural components which makes the materials undesirable for feeding ruminants at high maturity stage. This would most likely result in decreased digestibility and acceptance of such forage materials by ruminants.

Johnson et al. (2001) reported a significant interaction effect of N fertilization and harvest date for NDF content of three tropical forage species (Bahia grass, Bermuda grass, and Star grass), while Mohajer et al. (2012) reported non-significant effect of variety × growth stage for ADF content of three varieties of common millet (*P. miliaceum*). Our data agrees with the former report, but contradicts the latter. However, in this study, all the fibre fractions of the grasses were significantly influenced by the interaction of manure × harvest time and this is not in consonance with the report by Anderson et al. (2013) who reported no variation in the CELL, HEM, and lignin content of switch grass under the influence of harvest time × nitrogen sources. This could be attributed to differences in forage species, nitrogen sources, as well as application rate.

The level of minerals in plants depends on the interactions among a number of factors including soil type, plant species, dry matter yield, grazing management and climate (Khan et al., 2005). However, Olanite et al. (2006) submitted that stage of maturity was undoubtedly a critical factor that impacted forage mineral composition. The values recorded for Ca content of the grasses as influenced by manure type, cutting height, and stage of growth in this study is suitable to meet the recommended requirement for different ruminant animals which ranges from 1.8 to 8.2 g kg^{-1} as reported by McDowell (1992). Reuter and Robinson (1997) also suggested Ca requirement for maintenance of growing and lactating sheep to be 1.2-2.6 g kg^{-1} which the grasses evaluated could provide. McDowell and Valle (2000) reported that inadequate intake of Ca was capable of causing weakened bones, slow growth, low milk production and tetany (convulsions) in severe deficiencies. Following the report of McDowell (1992), the grasses under study have suitable Mg content under the influence of growth stage as the requirements for different ruminant animals were put between 1-2 g kg^{-1}. Although 2 g Mg kg^{-1} DM is adequate to meet the Mg requirements in most situations, cows and ewes near parturition may need extra Mg (10 to 30 g Mg/cow/day or 2 to 3 g Mg/ewe/day) relative to their physiological status (Mayland, 1999). The Mg concentration of the grasses in this study as influenced by stage of growth is in agreement with the findings by Cheema et al. (2011) with regard to ruminant requirement. Low concentration of Mg in grasses can lead to hypomagnesemia (grass tetany) which is probably the most important metabolic problem in ruminants and is characterized by low blood plasma Mg concentrations (<0.4 mmol L”) and most assuredly by low urinary Mg concentrations (< 0.8 mmol L”) (Mayland, 1999). The grasses analysed in this study have the ability to meet up with this requirement.

Minimum critical levels of K for animals may be in the range of 5 to 10 g kg^{-1} DM. However, it has been suggested that ruminants with high producing ability in terms of milk and other animal products may require K level above 10 g kg^{-1} under stress situation particularly heat stress (McDowell, 1985), which the varieties of *P. maximum* evaluated in this study could supply. The high K content in these grasses ascertain water balance and osmotic pressure regulation, acid-base balance, and muscle contraction for ruminants (Olanite et al., 2018). There is paucity of information on K deficiency for ruminants grazing exclusively on forages. Meanwhile, Farhad (2012) reported that high potassium forages and low sodium chloride diets appeared to contribute more to reproductive losses in herbivores. The authors concluded that excess K in forages lead to deficiency of other minerals, with attendant suppression of immunity.

The values recorded for P content of the grasses as influenced by cutting height and stage of growth in this study is suitable to meet the recommended requirement for different ruminant animals which ranges from 1.8 to 4.8 g kg^{-1} as reported by McDowell (1992). For grazing livestock, the most prevalent mineral-element deficiency throughout the world are those related to P (Underwood, 1981), with higher occurrence in the tropics. The P status of forages could vary widely due to a number of factors including cutting height and stage of growth as observed in our data.

CONCLUSION

The general indication from this study affirms that *P. maximum* Ntchisi is undoubtedly superior to the local variety in terms of chemical composition, particularly when fertilized with swine or cattle manure, clipped at 10 cm above the ground, and at 8 weeks of growth. The nutritive quality of *P. maximum* was influenced by the interactions (manure × harvest time; manure × variety × cutting height; manure × cutting height × harvest time). *Panicum maximum* Ntchisi can meet the high energy required for growth and maintenance by ruminants, with sufficient inorganic minerals for enhanced metabolic and other body functions compared to the local variety. Hence, there is benefit in the continuous use of *P. maximum* varieties for the feeding of ruminants in Nigeria and other tropical regions.

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