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Original Reasearch Article

Nutritional characteristics of nine *Pennisetum purpureum* varieties as affected by manure type in Southwest Nigeria

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Abstract

This experiment was carried out to evaluate the nutritive value of nine *Pennisetum purpureum* varieties as ruminant feed, with the application of organic manures. The research was 3×9 factorial arrangement in a split plot design. Experimental *P. purpureum* included Abeokuta 1, Abeokuta 2, F1 Hybrid, Green Local, Purple Local, Sugarcane, South Africa, S13 and S15, and three manure types (control, swine and cattle). Results showed that the *P. purpureum* fertilised with cattle dung had ($p < 0.05$) higher dry matter (91.92 %), crude protein (CP) content (9.78 %) and neutral detergent fibre (NDF) content (61.10 %) than other treatments. Fi hybrid variety recorded the highest CP (8.93 %) and lowest NDF (57.80 %) contents and purple local variety had the least CP (8.37 %) content. Cattle dung fertilised grasses recorded higher calcium (8.77 g/kg) and phosphorus (2.06 g/kg) content compare to its counterpart, South Africa variety of *P. purpureum* recorded the highest (9.81 g/kg) Ca content. This study shows that farmers who value high-quality feed would benefit from the cultivation of F1 hybrid variety of *P. purpureum* and cattle dung is recommended for the fertilisation of the varieties evaluated.

Keywords: chemical composition; forage; grass; location; manure

INTRODUCTION

The introduction of forage varieties with good nutritional characteristics (e.g., crude protein and digestibility) is a plausible approach for increasing forage availability (Maleko et al., 2019) to meet livestock nutrient requirement. However, studies reporting comparative differences between *Pennisetum purpureum* varieties are sparse in the literature. This limits our understanding of the differences in the nutritive quality and digestibility between varieties (Zailan et al., 2018).

Manure is an important source of soil nutrient that is adopted by smallholder farmers due to limited affordability to purchase chemical fertilisers (Olanite et al., 2010). More importantly, inefficient distribution systems, especially in sub-Saharan Africa, often make fertilisers unavailable to farmers, and this necessitate the application of manure to tropical soils with the aim of maintaining soil organic matter to improve soil fertility and productivity (Ewetola et al., 2016). In smallholder pasture production systems, farmyard manure from cattle, swine, sheep and goat (Ewetola et al., 2016) are potentially suitable for enhancing the yield and nutritive quality of tropical plants. In addition, organic manures have a far less reaching adverse effect on soil physicochemical properties compared with mineral fertilisers. Therefore, the application of organic manures to pasture crops enhances nutrient recycling, environmental protection, and sustainability of the farming system (Dele et al., 2016).

Some of the commonly propagated varieties include S13, S15, Dauro, Gero A, and Maiwa (Abubakar et al., 2015), as well as F1 hybrid (Adeyemi et al., 2015). In this study, new *P. purpureum* varieties namely Abeokuta 1 and 2 (wild varieties), Green Local and Purple Local were planted and compared against the commonly propagated varieties. This study was designed to evaluate the performance of nine *P. purpureum* varieties fertilised with different organic manures in terms of nutritive quality (i.e., proximate, fibre and mineral) as ruminants feed in Southwest Nigeria. We aim to generate new information regarding the nutritive value of the novel *P. purpureum* varieties in Southwest Nigeria.

MATERIALS AND METHODS

Experimental site and land preparation

This experiment was carried out at the Directorate of University Farm (DUFARM), while the laboratory analysis was conducted at the laboratory of Pasture and Range Management Department, both at the Federal University of Agriculture, Abeokuta (FUNAAB), Ogun State, Nigeria. The experimental land (1521 m^2) was cleared, followed by ploughing and the land was allowed to rest for a period of two weeks. Subsequently, the land was harrowed to achieve a relatively smooth soil surface. Prior to the application of manure to the experimental field, representative soil samples were collected (depth = 0.15 cm) to determine the physico-chemical characteristics of the soil. The samples were bulked per replicate, mixed thoroughly and sub-samples taken for the analysis (Table 1).

Manure collection and application

In this study, the organic soil amendments used were swine manure, cattle dung and control. The swine manure and cattle dung was collected at the Directorate of University of Farm (DUFARM). The manures were collected 14 days before application. Sub-samples were taken from each manure type and subjected to laboratory analysis to determine their nutrient composition. Based on the N content of the manures (Table 1), the rate of application adopted in this study was 300 kg N. The manures were spread on the plots and manually incorporated into the soil for proper mineralisation. The grass was sown in the plots after two weeks of manure application.

Experimental design, treatments and plot management

The research was carried out using 3×9 factorial arrangement in a split plot design. The main plot (manure types (swine, cattle dung and control (No manure)) dimension was 14×14 m^2 and sub-plot (varieties (Abeokuta 1 and 2 (wild varieties), F$_1$. Hybrid, Green Local, Purple Local, South Africa, Sugarcane, S13 and S15)) was 3×3 m^2 replicated three times. The inter-plot and intra-plot spaces were kept weed-free throughout the experimental period by hand weeding. The forage plants were harvested at eight (8) weeks after planting by clipping to 15 cm above the ground level and the collected samples were stored for laboratory analysis.

Table 1. Physico- chemical characteristics of the composite soil samples taken at 0–15 cm depth from the experimental site before planting and nutrient composition of animal manures

Chemical properties	Values	Parameters	Cattle	Swine
pH	6.99	N (g/kg)	15.91	17.30
Total nitrogen (%)	0.14	P (g/kg)	7.13	6.69
Organic carbon (%)	1.33	K (g/kg)	6.98	7.92
C:N ratio	27.35	Ca (g/kg)	20.50	29.96
Available P (mg/kg)	51.77	Mg (g/kg)	13.31	19.93
Acidity (cmol/kg)	0.15	Na (g/kg)	1.50	2.10
CEC	1.84	Fe (mg/kg)	599.30	637.50
Exchangeable cations (cmol/kg)		Zn (mg/kg)	61.40	89.81
Sodium (Na)	0.75	Cu (mg/kg)	28.19	26.35
Potassium (K)	0.22	Mn (mg/kg)	310.92	259.17
Calcium (Ca)	2.65			
Magnesium (Mg)	2.53			
Particle size				
Sand (%)	75.99			
Silt (%)	16.90			
Clay (%)	4.62			

Laboratory analysis

The contents of dry matter, crude protein, ether extract and ash were determined according to the standard procedure of AOAC (2010). Neutral detergent fibre (NDF), acid detergent fibre (ADF), acid detergent lignin (ADL) was determined according to Van Soest et al., (1991). Mineral contents (Ca, K, P, Mg, Cu and Fe) were determined according to Fritz and Schenk (1979).

Statistical analysis

Data collected were subjected to a two-way analysis of variance and the treatment means were separated using Duncan's Multiple Range Test using SAS (1999) package.

RESULTS

The effect of manure type on the proximate and fibre composition of the nines *P. purpureum* varieties was significant ($p < 0.05$) except ether extract (EE) content (Table 2). Cattle dung fertilised grasses recorded higher dry matter (DM) (91.92%) and CP (9.78%) while the least CP (7.73%) was observed in unfertilised grasses. The grasses fertilised with swine manure had higher ash content (12.80%) than other treatments. Cattle dung fertilised grasses recorded the highest value (61.10%) for NDF while the unfertilised varieties had the lowest value (57.61%) and swine manure fertilised *P. purpureum* varieties had highest (34.78%) ADF content and higher (9.78%) ADL content was recorded for the unfertilised *P. purpureum* varieties with the least (7.28%) content observed in swine manure fertilised *P. purpureum* varieties.

There were also significant ($p < 0.05$) differences in proximate and fibre composition of the varieties. Dry matter content was higher for sugarcane variety (93.13%) and the least value (90.66%) was recorded for the South Africa variety. Notably, Abeokuta 2, Green local and S13 *P. purpureum* varieties recorded statistically similar DM content. Higher CP contents was observed for FI hybrid (8.93%) > Sugarcane (8.90%), > Abeokuta 2 (8.87%) varieties while other varieties are not significantly ($p > 0.05$) differ in their CP concentration. The highest (61.46%) NDF was observed in S15 variety and lowest value of 57.80% was recorded in F1 hybrid and there was no significantly ($p > 0.05$) different in ADF contents among all the *P. purpureum* varieties except for Green local which had a lower value (30.74%) (Table 2).

There was a significant ($p < 0.05$) different in manure × variety effect on the proximate and fibre composition of the nines *P. purpureum* varieties (Table 3). The CP contents significantly ($p < 0.05$) ranged from 7.34% in unfertilised Purple local variety to 10.72% in F1 hybrid variety fertilised with cattle dung and Ether extract content was higher (5.75%) for S15 variety fertilised with cattle dung and lowest (3.29%) content recorded in Green local variety fertilised with the same manure. S15 variety fertilised with cattle dung had the highest (66.50%) NDF content and the least content

Table 2. Main effects of manure type and variety on the proximate and fibre composition (%) of nine varieties of *Pennisetum purpureum*

Factors	Dry matter	Crude protein	Ether extract	Ash	NDF	ADF	ADL
Manure types							
Cattle	91.92^{a}	9.78^{a}	4.44	11.36^{b}	61.10^{a}	32.52^{b}	8.13^{b}
Control	91.38^{b}	7.73^{c}	4.28	10.55^{c}	57.61^{c}	29.78^{c}	9.78^{a}
Swine	91.45^{b}	8.60^{b}	4.28	12.80^{a}	59.11^{b}	34.78^{a}	7.28^{c}
SEM	0.24	0.10	0.13	0.13	0.34	0.24	0.27
Varieties							
Abeokuta 1	91.07^{cd}	8.75^{ab}	4.05^{bc}	11.19^{d}	59.39^{bc}	32.39^{a}	6.81^{d}
Abeokuta 2	91.76bc	8.87^{a}	4.81^{a}	11.02^{d}	58.87^{cd}	32.36^{a}	8.24^{bc}
F_1 Hybrid	92.14^{abc}	8.93^{a}	4.38^{abc}	11.40^{bcd}	57.80^{d}	32.95^{a}	10.22^{a}
Green Local	91.79^{bc}	8.71^{ab}	3.83^{c}	12.10^{a}	60.31^{b}	30.74^{b}	7.78^{c}
Purple Local	92.06^{abc}	8.37^{b}	4.31^{abc}	11.29^{cd}	59.21^{bc}	32.88^{a}	7.57^{cd}
Sugarcane	93.13^{a}	8.90^{a}	3.77^{c}	11.85^{abc}	57.96^{d}	32.55^{a}	8.98^{b}
South Africa	90.66^{d}	8.61^{ab}	4.69^{a}	11.91^{abc}	59.13^{c}	32.00^{a}	8.54^{bc}
S13	91.75^{bc}	8.58^{ab}	4.58^{ab}	11.95^{ab}	59.33^{bc}	33.00^{a}	8.33^{bc}
S15	92.88^{ab}	8.61^{ab}	4.73^{a}	11.42^{bcd}	61.46^{a}	32.38^{a}	8.88^{b}
SEM	0.42	0.28	0.22	0.33	0.64	0.66	0.48

$^{a, b, c, d}$: Means in same column with different superscript are significantly ($p < 0.05$) different
SEM = Standard Error of the Mean, NFC = Non-fibre carbohydrate, NDF = Neutral detergent fibre, ADF = Acid detergent fibre, ADL = Acid detergent lignin

Table 3. Interaction effect of manure type and variety on the proximate composition of nine varieties of *Pennisetum purpureum*

Manure	Varieties	Dry matter	Crude protein	Ether extract	Ash	NDF	ADF	ADL
Cattle	**Abeokuta 1**	92.93^{abcde}	9.45^{bcd}	3.64^{def}	11.07^{ghij}	57.86^{de}	33.29^{bcd}	6.71^{de}
	Abeokuta 2	93.64^{ab}	10.21^{ab}	5.64^{ab}	11.36^{efghi}	58.57^{cde}	33.29^{bcd}	7.29^{cde}
	F1 Hybrid	92.43^{abcdefg}	10.72^{a}	3.58^{def}	10.58^{hij}	59.15^{cd}	32.85^{cde}	11.15^{a}
	Green Local	93.00^{abcde}	9.91^{b}	3.29^{f}	11.78^{cdefgh}	64.84^{ab}	33.29^{bcd}	7.56^{cde}
	Purple Local	94.50^{a}	9.34^{bcdef}	5.00^{abc}	11.00^{hij}	59.00^{cd}	32.00^{defg}	9.00^{bc}
	Sugarcane	93.50^{abc}	9.62^{bc}	4.25^{cdef}	11.25^{fghi}	60.50^{c}	32.00^{defg}	7.50^{cde}
	South Africa	89.75^{i}	9.63^{bc}	5.00^{abc}	11.50^{defgh}	60.00^{cd}	31.00^{fgh}	8.00^{cd}
	S13	92.75^{abcdef}	9.38^{bcde}	4.25^{cdef}	12.25^{bcdefg}	63.50^{b}	32.50^{def}	8.00^{cd}
	S15	93.75^{ab}	9.78^{bc}	5.75^{a}	11.50^{defgh}	66.50^{a}	32.50^{def}	8.00^{cd}
Control	**Abeokuta 1**	90.58^{ghi}	7.35^{k}	4.36^{cdef}	10.29^{ijk}	60.00^{cd}	28.42^{j}	6.58^{de}
	Abeokuta 2	90.22^{hi}	7.80^{ijk}	4.64^{abcde}	9.29^{k}	5857^{cde}	28.42^{ij}	10.58^{ab}
	F1 Hybrid	92.00^{bcdefgh}	7.37^{k}	4.56^{bcde}	11.13^{ghij}	55.75^{f}	31.00^{fgh}	12.00^{a}
	Green Local	91.36^{defghi}	7.64^{jk}	3.71^{def}	10.93^{hij}	56.57^{ef}	25.93^{k}	7.29^{cde}
	Purple Local	90.93^{efghi}	7.34^{k}	4.42^{cdef}	10.36^{ijk}	59.64^{cd}	30.64^{gh}	6.71^{de}
	Sugarcane	92.88^{abcde}	8.57^{efghi}	3.56^{def}	11.31^{efghi}	58.87^{cd}	31.00^{fgh}	11.13^{a}
	South Africa	90.58^{ghi}	8.11^{ghijk}	4.36^{cdef}	10.64^{hij}	55.15^{f}	31.22^{efgh}	10.93^{a}
	S13	90.75^{fghi}	7.43^{k}	4.50^{cde}	11.00^{hij}	55.00^{f}	31.00^{fgh}	11.00^{a}
	S15	93.12^{abcd}	7.96^{hijk}	4.44^{cdef}	10.00^{jk}	58.87^{cd}	30.13^{hi}	11.13^{a}
Swine	**Abeokuta 1**	89.73^{i}	9.44^{bcd}	4.15^{cdef}	12.20^{bcdefg}	60.30^{c}	35.45^{a}	7.15^{cde}
	Abeokuta 2	91.43^{cdefghi}	8.61^{defghi}	4.15^{cdef}	12.43^{bcdef}	59.45^{cd}	35.15^{a}	6.85^{de}
	F1 Hybrid	92.00^{bcdefgh}	8.70^{defgh}	5.00^{abc}	12.50^{abcde}	58.50^{cde}	35.00^{ab}	7.50^{cde}
	Green Local	91.00^{defghi}	8.59^{defghi}	4.50^{cde}	13.60^{a}	59.50^{cd}	33.00^{cde}	8.50^{cd}
	Purple Local	90.75^{fghi}	8.43^{ghij}	3.50^{ef}	12.50^{abcde}	59.00^{cd}	36.00^{a}	7.00^{de}
	Sugarcane	93.00^{abcde}	8.50^{fghij}	3.50ef	13.00^{ab}	58.00^{de}	33.00^{cde}	7.00^{de}
	South Africa	91.64^{bcdefghi}	8.10^{ghijk}	4.71^{abcd}	13.60^{a}	58.71^{cd}	35.42^{a}	8.00^{cd}
	S13	91.75^{abcdefghi}	8.93^{cdefg}	5.00^{abc}	12.60^{abcd}	59.50^{cd}	35.50^{a}	6.00^{e}
	S15	91.75^{bcdefghi}	8.11^{ghijk}	4.00^{cdef}	12.75^{abc}	59.00^{cd}	34.50^{abc}	7.50^{cde}
SEM		0.15	0.93	0.08	0.11	0.24	0.23	0.18

$^{a, b, \dots k}$: Means in same column with different superscript are significantly ($p < 0.05$) different
SEM = Standard Error of Mean, NFC = Non-fibre carbohydrate, NDF = Neutral detergent fibre, ADF = Acid detergent fibre, ADL = Acid detergent lignin

(55.00 %) were recorded in S13 variety with no manure application. The highest (36.00 %) ADF content was recorded for the Purple local variety fertilised with swine manure and the unfertilised Green local variety had the least (25.93 %) content.

Manure types significantly ($p < 0.05$) influenced the mineral contents of the *P. purpureum* varieties (Table 4). All mineral contents were higher in the grasses fertilised with swine manure except for calcium and phosphorus, where cattle dung fertilised grasses recorded higher calcium (8.77 g/kg) and phosphorus (2.06 g/kg) contents. Whereas, South Africa variety of *P. purpureum* recorded the highest (9.81 g/kg) Ca content and Abeokuta 1 variety had highest K (73.71 g/kg) and P (4.15 g/kg) contents compared to other varieties. Under the interaction of the factors imposed in our study, Ca content ranged from 6.01 g/kg in unfertilised Abeokuta 2 variety to 10.61 g/kg in F1 hybrid variety fertilised with cattle dung (Table 5). Magnesium was ($p < 0.05$) higher (7.05 g/kg) in S13 fertilised with swine manure and the lowest (2.76 g/kg) was recorded in the same variety with no manure input. Abeokuta 1 variety fertilised with swine manure had the highest K (78.65 g/kg) while the same variety fertilised with cattle dung recorded the highest (8.69 g/kg) P content while S13 fertilised with swine manure recorded the highest content for both Fe (624.80 mg/kg) and Cu (17.67 mg/kg).

DISCUSSION

In pasture production systems, the application of organic manure potentially improves soil fertility and consequently translates into the production of high quality forages (Lamidi and Ologbose, 2014). The crude protein (CP) content recorded for the *Pennisetum purpureum* grasses in this study as influenced by manure

Table 4. Main effect of manure type and variety on the mineral contents of nine varieties of *Pennisetum purpureum*

Factor	Ca	Mg	K	P	Fe	Cu
	g/kg				mg/kg	
Manure types						
Cattle	8.77^{a}	4.29^{c}	57.37^{b}	2.06^{a}	85.04^{c}	4.84^{b}
Control	7.75^{c}	4.67^{b}	49.09^{c}	1.34^{c}	111.08^{b}	4.81^{b}
Swine	7.81^{b}	5.77^{a}	60.47^{a}	1.62^{b}	320.70^{a}	9.36^{a}
SEM	0.19	0.17	1.97	0.26	19.49	0.68
Varieties						
Abeokuta 1	7.72^{c}	5.16^{c}	73.71^{a}	4.15^{a}	132.16^{g}	5.07^{d}
Abeokuta 2	7.49^{h}	5.29^{b}	61.48^{c}	1.33^{e}	201.44^{e}	9.16^{a}
F_1 Hybrid	8.85^{b}	5.33^{a}	51.04^{f}	1.25^{f}	105.49^{h}	4.53d^{e}
Green Local	7.34^{l}	4.65^{g}	58.33^{d}	1.99^{b}	88.67^{i}	3.56^{f}
Purple Local	7.56^{g}	5.07^{e}	51.03^{g}	0.96^{i}	139.51^{f}	6.18^{c}
South Africa	9.81^{a}	5.08^{d}	51.09^{e}	1.45^{d}	216.07^{c}	4.71d^{e}
Sugarcane	8.43^{c}	4.32^{h}	61.97^{b}	1.22^{g}	220.00^{b}	6.29^{c}
S13	7.58^{f}	4.29^{i}	48.69^{h}	1.20^{h}	269.09^{d}	9.09^{a}
S15	8.19^{d}	4.65^{g}	43.49^{h}	1.50^{c}	208.09^{d}	8.47^{b}
SEM	0.25	0.32	2.61	0.26	42.99	1.16

$^{a \dots l}$: Means in the same column with different superscript are significantly ($p < 0.05$) different.

Table 5. Interaction effect of manure types and varieties on the mineral contents of nine varieties of *Pennisetum purpureum*

Manure	Varieties	Ca	Mg	K	P	Fe	Cu
		g/kg				mg/kg	
	Abeokuta 1	7.29^{r}	4.80^{n}	78.51^{c}	8.69^{a}	29.20^{w}	1.33^{q}
	Abeokuta 2	8.29^{j}	6.51^{b}	53.31^{m}	1.30^{j}	326.60^{e}	16.00^{b}
	F1 Hybrid	10.61^{a}	4.82^{m}	49.52^{s}	0.93^{r}	77.01^{r}	4.80^{kl}
	Green Local	8.78^{e}	4.71^{o}	55.60^{j}	1.85^{f}	28.40^{w}	1.47^{q}
Cattle	**Purple Local**	8.24^{k}	4.11^{s}	58.47^{h}	0.97^{q}	40.40^{v}	1.47^{q}
	Sugarcane	8.51^{n}	2.99^{v}	62.30^{f}	0.83^{s}	108.40^{o}	4.53^{klm}
	South Africa	10.01^{b}	4.32^{r}	60.24^{g}	1.67^{g}	29.00^{w}	1.07^{q}
	S13	8.62^{g}	3.06^{u}	48.10^{v}	1.51^{h}	116.27^{n}	7.07^{gh}
	S15	8.56^{h}	3.27^{t}	50.25^{p}	0.85^{s}	100.27^{p}	5.80^{ij}
	Abeokuta 1	8.29^{k}	5.01^{k}	56.31^{i}	0.24^{v}	75.73^{r}	3.33^{nop}
	Abeokuta 2	6.01^{u}	3.06^{u}	52.47^{n}	1.95^{m}	107.53^{o}	4.00^{lmn}
	F1 Hybrid	7.82^{p}	4.94^{l}	55.30^{k}	1.16^{n}	72.87^{s}	3.80^{mno}
	Green Local	7.19^{s}	4.60^{q}	49.67^{r}	2.91^{c}	64.67^{u}	2.99^{op}
Control	**Purple Local**	7.79^{p}	5.91^{e}	40.10^{x}	0.77^{u}	202.67^{g}	9.87^{de}
	Sugarcane	8.73^{f}	4.71^{o}	52.31^{o}	0.85^{s}	148.93^{m}	5.93^{ij}
	South Africa	9.73^{c}	5.31^{h}	43.31^{w}	1.49^{i}	88.53^{q}	3.87^{lmno}
	S13	6.12^{u}	2.76^{w}	52.31^{o}	0.81^{t}	67.33^{t}	2.53^{p}
	S15	8.01^{o}	5.71^{f}	40.12^{x}	2.64^{d}	171.47^{j}	7.07^{gh}
	Abeokuta 1	7.60^{e}	5.65^{g}	86.31^{a}	3.52^{b}	291.53^{e}	10.53^{c}
	Abeokuta 2	8.16^{l}	6.32^{c}	78.65^{b}	1.53^{h}	169.20^{k}	7.47^{g}
	F1 Hybrid	8.11^{m}	6.24^{d}	48.31^{t}	1.67^{g}	166.53^{l}	5.00^{jk}
	Green Local	6.07^{v}	4.65^{p}	69.71^{e}	1.23^{k}	172.93^{i}	6.27^{hi}
Swine	**Purple Local**	6.63^{l}	5.2^{p}	54.51^{l}	1.14^{o}	175.47^{h}	7.20^{gh}
	Sugarcane	8.06^{n}	5.25^{i}	71.29^{d}	1.99^{e}	402.67^{c}	8.4^{f}
	South Africa	9.69^{d}	5.65^{p}	49.71^{q}	1.21^{l}	530.67^{b}	9.20^{ef}
	S13	8.01^{o}	7.05^{a}	45.67^{t}	1.29^{j}	624.80^{a}	17.67^{a}
	S15	8.01^{o}	5.91^{e}	40.11^{x}	1.03^{p}	352.52^{d}	12.53^{d}
SEM		0.02	0.13	1.32	0.17	16.83	0.47

$^{a, b, c \dots x}$: Means in the same column with different superscript are significantly ($p < 0.05$) different.

type fell within the range of 88.95–101.6 g/kg reported by (Dele, 2012) for *Panicum maximum* and *Pennisetum purpureum* when different manures were applied. The higher CP content recorded for cattle dung fertilised *P. purpureum* is in agreement with earlier reports (Dele, 2012) and this could be ascribed to the high carbon content in the manure (Dele, 2012). In addition, the observed difference in the effect of the manure types on the CP content of the grasses suggests that the rate of mineralisation differ for manures obtained from various animal species. Meanwhile, all the manure types evaluated in this study promote the production of adequate CP in the grasses. The *P. purpureum* varieties had CP content that surpasses the critical limit of 7%, below which the intake of forages by ruminants, rumen microbial activities, and the optimum performance of tropical ruminant animals would be adversely affected (Van Soest, 1994).

The structural constituent of the grasses is affected by manure type. The values recorded for NDF and ADF of the *P. purpureum* varieties under the influence of manure type is higher than that reported by Dele (2012) when *P. maximum* and *P. purpureum* were fertilised with cattle and swine manure. The effect of variety showed that NDF and ADF contents are lower than those reported by and (Dele, 2012) for *P. maximum* and *P. purpureum.* However, the NDF values fell within the range of 600 to 650 g/kg suggested as the critical limit above which the efficiency of tropical forage utilisation by ruminants would be impaired (Muia, 2000). Also, the ADL content as affected by manure types in this study concurs with the report of Dele (2012). The moderate fibre contents of the *P. purpureum* varieties in this study could help facilitate the colonisation of ingesta by rumen micro-organisms which might lead to higher fermentation rates, hence improving digestibility, intake and animal performance (Maleko et al., 2019).

Minerals are required by both plants and animals in critical and balanced amount. According to Onwuka and Akinsoyinu (1988), the presence of mineral elements in animal feed is vital for the metabolic processes of the animals. The content of calcium in the *P. purpureum* varieties as influenced by manure type is higher than that reported by Dele (2012) in which unfertilised grass had the highest Ca content. In addition, the Ca content recorded in this study is above 8 g/kg recommended for grazing animals (Underwood, 1981). Mg contents of the *P. purpureum* varieties is in line with the findings of Dele (2012) in which varieties fertilised with swine manure had the highest Mg content but higher than Mg level reported by Dele (2012) and this might be as a result of locational differences where the research was carried out. Although the values were high enough to meet the Mg requirement for beef cattle (Khan et al., 2007) and higher than the recommended requirement of growing lambs and lactating ewes (Meschy, 2000). The Cu content as affected by manure type was in line with the finding of Dele (2012) whose reported that there was no effect of manure on the Cu content of *P. maximum* and *P. purpureum*. The varietal effect on the Cu content is higher than the range of 4–8 mg/kg reported by MacPherson (2000). Iron content of the *P. purpureum* varieties as affected by manure type in this study is higher than that of Dele (2012).

CONCLUSION AND RECOMMENDATIONS

The results of this study indicate that the *Pennisetum purpureum* fertilised with cattle dung had the highest crude protein and neutral detergent fibre, and lowest lignin content. Farmers in southwestern Nigeria are encouraged to cultivate F1 hybrid, South Africa and sugarcane varieties as suitable forages for smallholder ruminant production due to their superiority in terms of CP, and NDF. Also, cattle dung is recommended as a good soil amendment when the aforelisted *P. purpureum* varieties are cultivated.

CONFLICT OF INTEREST

The authors declared no conflicts of interest with respect to research, authorship and publication of this article.

ETHICAL COMPLIANCE

The authors have followed the ethical standards in conducting the research and preparing the manuscript.

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