Impact of fertilizer types on the nutritive quality of two tropical grass species harvested at different stages of growth during wet season

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Abstract

The use of inorganic fertilizers has been reported to have improved pasture productivity, however it has also attributed to soil toxicity, environmental pollution, mineral imbalance, and health hazards among many adverse effects. This made the adoption of organic fertilizers became best alternative to correct nutrients deficiencies in the soil due to their environmental friendly nature and less cost effectiveness. To investigate the comparative advantages of these two types of fertilizer, an experiment was conducted to evaluate the influence of fertilizer types on the nutritive quality of *Panicum maximum* var. Ntchisi and *Andropogon tectorum* harvested at 6 and 8 weeks during the wet season. The study was a factorial experiment (4 x 2 x 2), arranged in a split-split-plot design with three replicates. There were 16 treatments to include; fertilizer types (NPK, Aleshinloye organo-mineral fertilizer, poultry manure and control (no fertilizer)), grass species (*Panicum maximum* var. Ntchisi and *Andropogon tectorum*) and age at harvest (6 and 8 weeks). Fertilizer treatments were allotted to the main plots while grass species were allotted to sub-plots and again harvest age was allotted to sub-subplots. Sub-samples taken from harvested forage materials were oven dried, properly milled and analysed in the laboratory to determine proximate composition [crude protein (CP%), ash, ether extract (EE%)], fibre fractions [acid detergent fibre (ADF%), neutral detergent fibre (NDF%), acid detergent lignin (ADL%), Cellulose, and Hemicelluloses) and in vitro gas production. Fertilizer types significantly ($P < 0.05$) affected ADF, hemicellulose, cellulose and methane (CH_4). The grasses fertilized with NPK had the highest value (9.00mL) for CH_4 . Poultry manure (PM) fertilized grasses recorded the highest value for in vitro dry matter digestibility (IVDMD) (89.38%). *Andropogon tectorum* fertilized with PM harvested at 6 weeks recorded the highest value for IVDMD (93.00%) and the same grass fertilized with NPK, harvested at 6 weeks recorded the highest values (0.37 mL and 4.70%) for short chain fatty acid and metabolizable energy, respectively. Therefore, this study established that fertilizer applications had an influence on fibre fraction, methane and post-incubation parameters of the grasses investigated.

Keywords: Manure, *Panicum maximum*, *Andropogon tectorum*, chemical composition, in vitro digestibility, ruminant

Introduction

Livestock are generally kept for many motives, and these include regular supply of nutrient-rich animal source food (Murphy and Allen 2003), source of income for households, provision of manure from animal dung which ordinarily would have constitute nuisance to the environment, as well as enhancement of social status (Randolph *et al.*, 2007). The historical nomadism and transhumance migration remain the prevailing system of ruminant production in Nigeria (Akpa *et al.*, 2012). Over a long period of time, this system is characterized by the continuous movement of herdsman families and their herds from place to place, with availability of fodder, water and animal health condition as a determinant of their mobility.

Several efforts have been made to bring Nigeria's cattle producers into the fold of modern livestock production systems, but these proved abortive, leaving the cattle producers at the mercy of favourable weather and faulty government policies that impoverish instead of promoting their welfare and ensure provision of adequate feed resources for their animals (Iro, 1995). Many strategies have been adopted to address the prevailing crisis between communal farmers and herdsman in Nigeria such as mapping and demarcation of cattle routes and the ongoing promotion of grazing reserve and cattle ranching or colony, yet the situation still ascend to more devastating effects. This has been attributed to political and ethno-religious sentiments in most of the affected areas. Hence, commercialization of livestock production system, where cattle are largely produced based on market-oriented systems not limited to treasure motive, might still be considered as the lasting panacea to this escalating pandemonium that has claimed many lives and properties. In market-oriented systems, cattle and other small ruminants are fed with adequate good

quality forage materials that would ensure year-round production without any remarkable decline in body weight gain and milk production. This is more feasible with the establishment of sown pastures where grown forage species can be managed and manipulated to meet market goals. In order to ensure high productivity of cattle by mitigating the problems of poor nutrition for livestock associated with pastoral systems, the use of improved or sown and purposely managed pastures have been recommended (Olanite, 2002; Onifade *et al.*, 2005). One major factor militating against the adoption of sown pasture is the generally low nutrient status of tropical soils, most importantly nitrogen and phosphorus (Martinez-Sanchez, 2005), since productivity and persistence of grass depends on soil fertility, fertilizer application, moisture availability and cutting management. Among these factors, fertilizer application and grazing control can easily be managed to improve the productivity of sown pastures. Meanwhile, application of mineral fertilizers has been attributed to detrimental effects such as soil acidity, mineral imbalance, soil toxicity, environmental pollution and health hazards, and this consequently increase the adoption of organic fertilizer that are readily available and environmental friendly. However, limitation to the use of organic fertilizer has been linked to its bulkiness and slow release of nutrients in the early years of application. Thus, providing an alternative means of enhancing the nutritive quality of forages through the use of soil amendment materials that have the potential to improve soil fertility in a friendly manner have become germane to forage agronomists. Therefore, this experiment was designed to evaluate the effects of fertilizer types on the nutritive quality of *P. maximum* var. Ntchisi and *Andropogon tectorum* during rainy season, in Abeokuta Southwest Nigeria.

Materials and methods

Experimental site

The study was conducted at the Teaching and Research unit of the Directorate of University Farms (DUFARMS) and Laboratory of the Department of Pasture and Range Management, Federal University of Agriculture, Abeokuta, Ogun State, Nigeria. The site lies within the savanna agro-ecological transition zone of Southwest Nigeria (latitude 7.2°N , longitude 3.5°E) with average annual rainfall of 1037mm (Google Earth, 2015).

Soil analysis

Immediately after land preparation, five soil samples were randomly collected from the experimental field at the depth of 0-15 cm with the aid of soil auger to represent the top soil. The samples were pooled together, mixed thoroughly and three sub-samples were taken for analysis to determine the pre-planting nutrient status of the soil at International Institute of Tropical Agriculture (IITA), Ibadan.

Experimental design

A total of 1320 m² land area was mapped out for the experiment. The study was a factorial experimental arrangement (4 x 2 x 2) laid out in a split-split-plot design with three replicates. The dimension of the main plot was 9 m x 9 m, sub-plot was 9 m x 4 m and sub-sub-plot was 4 m x 4 m. The space between sub-plots and sub-sub-plots was 1 m while that between the main plots was 2 m, and the replicates were spaced 3 m apart. There were 16 treatments obtained from the three factors as follows: manure types (4), grass species (2) and harvest age (2). Fertilizer treatments were allotted to the main plots, grass species were allotted to sub-plots while harvest age was allotted to sub-sub plots. The fertilizer types were N.P.K. 20:10:10 (NPK), Aleshinloye organo-mineral (AOM), poultry manure (PM) and control (no fertilizer). These were applied at the rate of 120 kgN/ha based on their nitrogen content. The grasses were

Panicum maximum (Ntchisi) and *Andropogon tectorum* which were harvested at 6 and 8 Weeks After Cut (WAC). The treatments were as follows:

T₁ = NPK + *P. maximum* + 6 WAC T₂ = NPK + *P. maximum* + 8 WAC

T₃ = NPK + *A. tectorum* + 6 WAC T₄ = NPK + *A. tectorum* + 8 WAC

T₅ = AOM + *P. maximum* + 6 WAC T₆ = AOM + *P. maximum* + 8 WAC

T₇ = AOM + *A. tectorum* + 6 WAC T₈ = AOM + *A. tectorum* + 8 WAC

T₉ = PM + *P. maximum* + 6 WAC T₁₀ = PM + *P. maximum* + 8 WAC

T₁₁ = PM + *A. tectorum* + 6 WAC T₁₂ = PM + *A. tectorum* + 8 WAC

T₁₃ = CONTROL + *P. maximum* + 6 WAC

T₁₄ = CONTROL + *P. maximum* + 8 WAC

T₁₅ = CONTROL + *A. tectorum* + 6 WAC

T₁₆ = CONTROL + *A. tectorum* + 8 WAC

Harvesting of forage materials

Samples were harvested at 6 and 8 weeks after cut back using 1m² quadrat. 500g sub-samples were taken; packed and oven dried at 65°C to constant weight. After drying, samples were ground to pass a 2 mm sieve using milling machine and stored for further chemical analysis.

Determination of proximate composition

The contents of dry matter (DM %), crude protein (CP), ether extract (EE) and ash were determined according to AOAC (2000). Non-fibre carbohydrates (NFC) was calculated as $\text{NFC} = 100 - (\text{CP} + \text{ash} + \text{EE} + \text{NDF})$.

Determination of fibre fractions

Neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL) were determined according to Van Soest *et al.* (1991) while cellulose was calculated as the difference between ADF and ADL and hemicellulose as the difference between NDF and ADF.

In vitro gas production and post-incubation parameters

The *in vitro* gas production of the forage

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samples was determined following the procedure of Menke and Steingass (1988). Briefly, 200 ± 0.05 mg of the milled samples were weighed into 100 ml graduated glass syringes as the only substrate ($n = 3$). In addition, triplicate bottles of incubation solution without substrate were included as blanks to estimate the net gas production. Rumen contents were obtained from slaughtered cow from a reputable abattoir very early in the morning, used as inoculum and sieved with four layers cheese cloth into a pre-warmed, insulated bottle in the laboratory. Macro and micro elements, reduction and buffer solutions were mixed together with distilled water. These solutions were mixed together at the ratio of 2:1 with the rumen fluid; 30 ml of the inoculums were drawn into the syringes. The syringes were placed in a water bath with shaker at a temperature regulated to 39°C . The gas produced in each syringe was observed and recorded at 3, 6, 9, 24, 36, and 48 hours of incubation. Gas volume at each incubation time was expressed per unit of incubated dry matter (DM). Organic matter digestibility (OMD) was estimated as; $\text{OMD} = 14.88 + 0.889\text{GV} + 0.45\text{CP} + 0.651\text{Ash}$ (Menke and Steingass, 1988). Short-chain fatty acids (SCFA) was estimated as $\text{SCFA} = 0.0239\text{GV} - 0.0601$ (Getachew *et al.*, 2004). Metabolizable energy (ME) was calculated as $\text{ME} = 2.20 + 0.1357\text{GV} + 0.057\text{CP} + 0.002859\text{EE}^2$ (Menke and Steingass, 1988). Total gas volume (GV) was expressed as ml/200mg DM, CP and Ash as g/kg DM, ME as MJ/kg DM and SCFA as $\mu\text{mol/g DM}$.

In vitro dry matter digestibility (IVDMD)

After 48 hours of incubation, the contents of the syringes were decanted into pre-weighed aluminum crucibles and oven-dried at 105°C to constant weight. The dry residues were weighed and digestibility was calculated using this equation:

$$\text{IVDMD (\%)} = \frac{\text{Initial DM input} - \text{DM residue} - \text{Blank}}{\text{Initial DM input}} \times 100$$

Statistical analysis

The laboratory data collected were subjected to analysis of variance using R Statistical package and significant means were separated using Duncan's Multiple Range Test (Duncan, 1955) at 5% probability level.

Experimental Model

$$Y_{ijkl} = \mu + F_i + S_j + H_k + (FS)_{ij} + (FH)_{ik} + (SH)_{jk} + (FSH)_{ijk} + \epsilon_{ijkl}$$

μ = population mean

F_i = effect of fertilizer types

S_j = effect of grass species

H_k = effect of harvest age

$(FS)_{ij}$ = interaction of fertilizer types and grass species effects

$(FH)_{ik}$ = interaction of fertilizer types and harvest age effects

$(SH)_{jk}$ = interaction of grass species and harvest age effects

$(FSH)_{ijk}$ = interaction of fertilizer types, grass species and harvest age effects

ϵ_{ijkl} = Residual error estimate

Results and discussion

The physico-chemical characteristics of the soil samples taken at 0-15 cm depth on the experimental site before planting are shown in Table 1. The initial nitrogen content of the soil indicated that it was available in limited quantity and this justified the application of varying fertilizers to the soil in order to enhance the quality of planted grasses especially in terms of crude protein. The pH (6.5) of the soil is closer to neutral making it slightly acidic in nature which is favourable to microbial activities.

The mean values of DM (%) were affected significantly ($P < 0.05$) by all the factors under study, while ash (%) content ($P < 0.05$) differed due to the influence of grass species only (Table 2). Poultry manure

fertilized grasses had the highest DM (94.88 %), while those fertilized with NPK recorded the lowest value (90.25 %). *Andropogon tectorum* recorded higher DM (93.50 %) than *P. maximum*. With regard to

age at harvest, grasses harvested at 6 weeks recorded higher DM (93.19 %) than those harvested at 8 weeks. *Panicum maximum* had higher ash content (7.81 %) than *A. tectorum*.

Table 1: Physico -chemical characteristics of the soil samples taken at 0-15 cm depth on the experimental site before planting

Chemical/Physical properties	Values
pH	6.5
Total nitrogen (%)	0.095
Organic carbon (%)	1.55
Available P (mg/kg)	4.11
Acidity (cmol/kg)	0.00
Exchangeable bases	
Exchangeable cations (cmol/kg)	14.67
Sodium (Na)	0.08
Potassium (k)	1.75
Calcium (Ca)	11.52
Magnesium (Mg)	1.31
Micro nutrient (mg kg⁻¹)	
Zinc (Zn)	77.47
Copper (Cu)	10.51
Manganese (Mn)	43.08
Iron (Fe)	43.08
Particle sizes (%)	
Sand	79
Silt	10
Clay	11

Table 2: Main effects of fertilizer types and age at harvest on the proximate composition of *Panicum maximum* and *Andropogon tectorum* during the early rainy- season

Proximate composition (%)					
Factor	DM	CP	EE	ASH	NFC
Fertilizer types					
Control	92.63 ^{ab}	10.07	4.58	6.88	24.22
AOM	92.38 ^{bc}	12.21	5.42	6.00	18.62
NPK	90.25 ^c	10.58	5.50	5.75	21.67
PM	94.88 ^a	11.33	6.08	6.88	18.71
SEM	0.75	0.97	0.82	0.81	2.10
Grass species					
<i>A. tectorum</i>	93.50 ^a	11.22	5.29	4.94 ^b	21.92
<i>P. maximum</i>	91.56 ^b	10.88	5.50	7.81 ^a	19.69
SEM	0.60	0.70	0.59	0.49	1.46
Harvest age					
6weeks	93.19 ^a	12.00	5.42	6.38	22.45
8weeks	91.88 ^b	10.10	5.38	6.38	19.15
SEM	0.62	0.67	0.59	0.56	1.50

^{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 extra
NFC= Non fibre carbohydrate

AOM=Aleshinloye organo-mineral fertilizer PM=Poultry manure, NPK=N.P.K. 20:10:10

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There were significant differences in the mean values of acid detergent fibre (ADF), hemicellulose and cellulose as affected by fertilizer types (Table 3). Similarly, all the fibre fractions were significantly influenced by age at harvest except hemicellulose but the effect of grass species was pronounced on the mean values of cellulose. The grasses fertilized with PM and NPK recorded the highest values of 26.00 % and 30.00 %, respectively for hemicellulose and cellulose. Those fertilized with NPK and the control

treatment (i.e. no fertilizer) had the lowest values (19.75 % and 24.50 %) respectively. The NPK fertilized grasses recorded the highest value (36.75 %) for ADF and the lowest was observed for the unfertilized grasses (30.75 %). For grass species, *A. tectorum* had higher value (28.13 %) for cellulose while *P. maximum* recorded lower value (24.91 %). The forages harvested at 8 weeks recorded higher values (59.00 %, 36.29 %, 7.13 % and 31.29 %) for NDF, ADF, ADL and cellulose than those harvested at six weeks.

Table 3: Main effects of fertilizer types and age at harvest on fibre fractions (%) of *Panicum maximum* and *Andropogon tectorum* during the early-wet season

Factors	Fibre fractions (%)				
	NDF	ADF	ADL	Hemicellulose	Cellulose
Fertilizer types					
Control	54.25	30.75 ^b	6.25	23.50 ^{ab}	24.50 ^b
AOM	57.75	31.83 ^b	5.75	25.93 ^{ab}	26.08 ^{ab}
NPK	56.50	36.75 ^a	6.75	19.75 ^b	30.00 ^a
PM	57.00	31.00 ^b	5.50	26.00 ^a	25.50 ^{ab}
SEM	1.41	1.73	1.08	1.70	2.30
Grass species					
<i>A. tectorum</i>	56.63	33.63	5.50	23.00	28.13 ^a
<i>P. maximum</i>	56.13	31.54	6.63	24.59	24.91 ^b
SEM	1.02	1.34	0.76	1.30	1.60
Age at harvest					
6weeks	53.75 ^b	28.88 ^b	5.00 ^b	24.88	21.75 ^b
8weeks	59.00 ^a	36.29 ^a	7.13 ^a	22.71	31.29 ^a
SEM	0.88	1.15	0.73	1.28	1.41

^{a, b} means in the same column with different superscripts are significantly different (P<0.05)

SEM= Standard error of mean, NDF: Neutral detergent fibre, ADF: Acid detergent fibre, ADL: Acid detergent lignin

AOM=Aleshinloye organo-mineral fertilizer

PM=Poultry manure, NPK=N.P.K. 20:10:10

In this study, fertilizer types did not (P>0.05) affect the volume of gas produced throughout the incubation period (Table 4). In contrast, methane (CH₄) was significantly influenced by fertilizer types, with NPK fertilized grasses recording the highest value (9.00mL) while the unfertilized grasses were noted for the lowest value (2.75mL). Meanwhile, the mean values for grass species and age at harvest did not significantly differ for

methane and the volume of gas produced. Gas volume differed significantly at 6, 24, 30, 36, 42, and 48 hours of incubation under the interaction of the factors imposed in this study (Table 5). At 6 and 24 hours of incubation, *A. tectorum* fertilized with NPK and harvested at 6 weeks produced the highest gas volumes (12.00 and 18.00 ml/200mg DM), while *P. maximum* (Ntchisi) fertilized with AOM and harvested at 6 weeks, and *A. tectorum*

fertilized with AOM and harvested at 8 weeks recorded the lowest values (3.00 and 9.00ml/200mg DM) respectively. From 30 – 42 hours of incubation, *A. tectorum* fertilized with NPK and AOM, and harvested at 6 weeks recorded significantly higher gas volumes compared to other treatments. At 48 hours of incubation, the higher and lower volumes of gas produced were recorded for *A. tectorum* fertilized with AOM, and harvested at 6 weeks (24.00

ml/200mg DM) and the same grass fertilized with AOM, and harvested at 8 weeks (12.00 ml/200mg DM). In contrast, *A. tectorum* fertilized with AOM and harvested at 6 weeks recorded the highest value (13.00 ml/200mg DM) for the methane gas produced during the hours of incubation. Meanwhile, unfertilized *A. tectorum* harvested at 8 weeks recorded the least value (1.00ml/200mg DM) for methane gas production.

Table 4: Main effects of fertilizer types and age at harvest on *in vitro* gas production and methane of *Panicum maximum* and *Andropogon tectorum* during the early rainy-season

<i>Panicum maximum</i> and <i>Anudopogon tectorum</i> during the early rainy-season									
Factors	Period of incubation (hrs)								Methane (ml)
	6	12	18	24	30	36	42	48	
Fertilizer types									
Control	7.00	8.50	10.67	13.00	15.50	15.75	16.75	17.75	2.75 ^c
AOM	5.75	8.00	10.25	12.50	14.00	15.50	16.50	17.25	8.50 ^{ab}
NPK	8.50	9.17	12.25	14.42	16.00	17.25	18.25	20.50	9.00 ^a
PM	8.13	9.25	10.75	12.50	13.75	15.00	16.00	17.50	4.50 ^{bc}
SEM	1.21	1.28	1.12	1.03	1.16	1.29	1.42	1.57	1.45
Grass species									
<i>A. tectorum</i>	7.56	9.13	11.21	13.13	14.50	15.50	16.75	17.88	5.63
<i>P. maximum</i>	7.13	8.33	10.75	13.08	15.13	16.25	17.00	18.63	6.75
SEM	0.87	0.89	0.80	0.76	0.88	0.95	1.03	1.14	1.16
Age at Harvest									
6 weeks	7.69	9.08	11.71	13.88	15.38	16.63	18.00	19.38	7.75
8 weeks	7.00	8.38	10.25	12.33	14.25	15.13	15.75	17.13	4.63
SEM	0.87	0.89	0.78	0.75	0.87	0.94	1.02	1.13	1.12

a, b, c: means in the same column with different superscripts are significantly different (P<0.05)

SEM= Standard error of mean

AOM=Aleshinloye organo-mineral fertilizer

PM=Poultry manure, NPK=N.P.K. 20:10:10

All the post incubation parameters were not affected (P>0.05) by fertilizer type except IVDMD (Table 6). Higher value for IVDMD (89.38%) was recorded for PM fertilized grasses while all other treatments had statistically similar values. Under the influence of grass species, *A. tectorum* recorded higher value for IVDMD while OMD was higher for *P. maximum* (Ntchisi). All the parameters were significantly

(P<0.05) affected by the interaction of the factors imposed except for organic matter digestibility (OMD) (Table 7). *Andropogon tectorum* fertilized with PM, and harvested at 6 weeks recorded the highest value for IVDMD (93.00%), and the same grass fertilized with NPK and harvested at 6 weeks recorded the highest values (0.37 µmol and 4.70%) for short chain fatty acid and metabolizeable energy respectively.

Table 5: Interaction effects of fertilizer types and age at harvest on *in vitro* gas production and methane of *Panicum maximum* and *Andropogon tectorum* during the early rainy-season

Treatments			Period of incubation (hrs)								Methane (ml)
Harvest age	Grass species	Fertilizer types	6	12	18	24	30	36	42	48	
6 wks	<i>A. tectorum</i>	Control	7.00 ^{ab}	8.00	10.67	13.00 ^{ab}	13.00 ^{ab}	14.00 ^{ab}	15.00 ^{ab}	16.00 ^{abc}	2.00 ^{bc}
		AOM	7.00 ^{ab}	10.00	14.00	16.00 ^{ab}	19.00 ^a	21.00 ^a	23.00 ^a	24.00 ^a	13.00 ^a
		NPK	12.00 ^a	14.00	16.00	18.00 ^a	19.00 ^a	21.00 ^a	22.00 ^a	23.00 ^{ab}	11.00 ^{ab}
	<i>P. maximum</i>	PM	7.50 ^{ab}	8.00	10.00	12.00 ^{ab}	13.00 ^{ab}	14.00 ^{ab}	16.00 ^{ab}	17.00 ^{abc}	6.00 ^{abc}
		Control	7.00 ^{ab}	8.00	11.00	13.00 ^{ab}	18.00 ^{ab}	18.00 ^{ab}	20.00 ^{ab}	21.00 ^{abc}	5.00 ^{abc}
		AOM	3.00 ^b	7.00	10.00	13.00 ^{ab}	13.00 ^{ab}	15.00 ^{ab}	15.00 ^{ab}	15.00 ^{abc}	10.00 ^{ab}
8 wks	<i>A. tectorum</i>	NPK	7.00 ^{ab}	5.67	10.00	13.00 ^{ab}	14.00 ^{ab}	14.00 ^{ab}	16.00 ^{ab}	19.00 ^{abc}	9.00 ^{ab}
		PM	11.00 ^{ab}	12.00	12.00	13.00 ^{ab}	14.00 ^{ab}	16.00 ^{ab}	17.00 ^{ab}	20.00 ^{abc}	6.00 ^{abc}
		Control	6.00 ^{ab}	8.00	9.00	11.00 ^{ab}	12.00 ^{ab}	12.00 ^b	12.00 ^b	13.00 ^{bc}	1.00 ^c
	<i>P. maximum</i>	AOM	6.00 ^{ab}	8.00	8.00	9.00 ^b	10.00 ^b	11.00 ^b	12.00 ^b	12.00 ^c	3.00 ^{abc}
		NPK	7.00 ^{ab}	8.00	11.00	13.00 ^{ab}	15.00 ^{ab}	16.00 ^{ab}	18.00 ^{ab}	21.00 ^{abc}	8.00 ^{abc}
		PM	8.00 ^{ab}	9.00	11.00	13.00 ^{ab}	15.00 ^{ab}	15.00 ^{ab}	16.00 ^{ab}	17.00 ^{abc}	4.00 ^{abc}
SEM		Control	8.00 ^{ab}	10.00	12.00	15.00 ^{ab}	19.00 ^a	19.00 ^{ab}	20.00 ^{ab}	21.00 ^{abc}	6.00 ^{abc}
		AOM	7.00 ^{ab}	7.00	9.00	12.00 ^{ab}	14.00 ^{ab}	15.00 ^{ab}	16.00 ^{ab}	18.00 ^{abc}	8.00 ^{abc}
		NPK	8.00 ^{ab}	9.00	12.00	13.67 ^{ab}	16.00 ^{ab}	18.00 ^{ab}	17.00 ^{ab}	19.00 ^{abc}	8.00 ^{abc}
		PM	6.00 ^{ab}	8.00	10.00	12.00 ^{ab}	13.00 ^{ab}	15.00 ^{ab}	15.00 ^{ab}	16.00 ^{abc}	2.00 ^{bc}
			2.36	2.44	2.17	1.79	1.91	2.09	2.24	2.60	2.42
^{a, b, c} means in the same column with different superscripts are significantly different (P<0.05) SEM= Standard error of mean AOM=Ale shinloye organo-mineral fertilizer, PM=Poultry manure NPK=N.P.K.20:10:10											

^{a, b, c}: means in the same column with different superscripts are significantly different ($P < 0.05$) SEM = Standard error of mean AOM = Ale
 mineral fertilizer, PM = Poultry manure
 NPK = N.P.K. 20:10:10

Table 6: Main effects of fertilizer type and age at harvest on *in vitro* dry matter digestibility and other post incubation parameters of *Panicum maximum* and *Andropogon tectorum* during the early rainy-season

Factors	IVDMD (%)	OMD (%)	SCFA (mL)	ME(MJ/kg)
Fertilizer types				
Control	88.00 ^{ab}	35.39	0.24	3.98
AOM	86.50 ^b	35.45	0.25	4.03
NPK	88.25 ^b	36.20	0.28	4.23
PM	89.38 ^a	35.57	0.24	3.97
SEM	0.64	1.07	0.02	0.14
Grass species				
<i>A. tectorum</i>	88.88 ^a	34.81 ^b	0.25	4.06
<i>P. maximum</i>	87.19 ^b	36.49 ^a	0.25	4.05
SEM	0.48	0.76	0.02	0.10
Harvest age				
6 weeks	87.75	36.77	0.27	4.16
8 weeks	88.31	34.54	0.23	3.94
SEM	0.52	0.74	0.02	0.10

a, b: means in the same column with different superscripts are significantly different (P<0.05)

SEM= Standard error of mean, IVDMD=*in vitro* dry matter digestibility, OMD= Organic matter digestibility, SCFA= Short chain fatty acids, ME= metabolizable energy

AOM=Aleshinloye organo-mineral fertilizer

PM=Poultry manure, NPK=N.P. K. 20:10:10

Table 7: Interaction effects of fertilizer types and age at harvest on *in vitro* dry matter digestibility and other post incubation parameters of *Panicum maximum* and *Andropogon tectorum* during the early rainy-season

Treatments			IVDMD (%)	OMD (%)	SCFA (mL)	ME(MJ/kg)
Harvest age	Grass species	Fertilizer types				
6 weeks	<i>A. tectorum</i>	Control	89.00 ^d	37.20	0.32 ^{ab}	4.47 ^{ab}
		AOM	89.00 ^d	34.52	0.25 ^{ab}	4.04 ^{ab}
		NPK	85.00 ^h	35.85	0.37 ^a	4.70 ^a
		PM	93.00 ^a	34.82	0.23 ^{ab}	3.91 ^{ab}
	<i>P. maximum</i>	Control	86.00 ^g	37.78	0.25 ^{ab}	4.05 ^{ab}
		AOM	87.00 ^f	38.08	0.25 ^{ab}	4.03 ^{ab}
		NPK	89.00 ^d	36.92	0.25 ^{ab}	4.05 ^{ab}
		PM	84.00 ⁱ	38.96	0.25 ^{ab}	4.04 ^{ab}
8 weeks	<i>A. tectorum</i>	Control	89.00 ^d	32.86	0.16 ^b	3.49 ^b
		AOM	84.00 ⁱ	33.48	0.20 ^{ab}	3.75 ^{ab}
		NPK	90.00 ^c	36.63	0.25 ^{ab}	4.05 ^{ab}
		PM	92.00 ^b	33.14	0.25 ^{ab}	4.04 ^{ab}
	<i>P. maximum</i>	Control	88.00 ^e	33.73	0.23 ^{ab}	3.91 ^{ab}
		AOM	86.00 ^g	35.71	0.30 ^{ab}	4.29 ^{ab}
		NPK	89.00 ^d	35.41	0.27 ^{ab}	4.11 ^{ab}
		PM	88.50 ^{de}	35.34	0.23 ^{ab}	3.90 ^{ab}
			0.05	1.88	0.04	0.25

a, b, c, d, e, f, g, h, i: means in the same column with different superscripts are significantly different (P<0.05) SEM= Standard error of mean, IVDMD=*in vitro* dry matter digestibility, OMD= Organic matter digestibility, SCFA= Short chain fatty acids, ME= metabolizable energy

AOM=Aleshinloye organo-mineral fertilizer

PM=Poultry manure

NPK=N.P.K. 20:10:10

Discussion

The fertilizer types did not affect the CP and ash content of the grass species, and this could be attributed to unavailability of nitrogen and other macro minerals for plant uptake, which could have been leached away from the soil due to rainfall or other environmental factors affecting plant nutrient uptake (Sun *et al.*, 2008). Our result is in agreement with Yossif and Ibrahim (2013) who reported that CP, crude fibre, and ash content of *Chloris gayana* were not influenced by fertilizer application. In contrast, Hassan-Amin (2011) submitted that the CP and crude fibre of fodder maize were affected by varying nitrogen sources (urea, nitrophoska (NPK), ammonium sulphate nitrate (ASN) and ammonium sulphate (AS)). In our view, the observed variation might be as a result of the season considered in this study, which was not adjudged in the former studies. *P. maximum* (Ntchisi) recorded higher ash content than *A. tectorum* and this could be attributed to higher genetic potential for mineral uptake in the former than the latter grass. This corroborates earlier report by Macpherson (2000) that mineral content of forages varies widely with soils, forage species, grassland management and climatic conditions. The mean ash values observed in this study were below those reported by Olanite *et al.* (2014) and Jimoh *et al.* (2015) for *P. maximum* (Local and Ntchisi). The difference in the former and present study could be related to variations in soil mineral concentrations and age at harvest (Zhao, 2014). Neutral detergent fibre was not influenced by fertilizer types in this study, and this is not in conformity with the findings by Johnson *et al.* (2001) and Adeli *et al.* (2005) who reported that fertilizer application significantly decreased the NDF content of *Cynodon dactylon* with increase in application rate. However, the observation in this study support previous

reports that fertilizer application had no effect on NDF contents of native grasses (Anderson *et al.*, 1993; Rogers *et al.*, 1996; Cuomo and Anderson, 1996). Conversely, ADF, hemicellulose and cellulose were affected by fertilizer types, and this is in agreement with Balabanli *et al.* (2010) and Hassan (2015). Higher ADF was recorded for NPK fertilized grasses compared to other treatments. Of note, ADF contains cellulose and lignin, with the former being partially digestible while the latter are indigestible plant constituent, and this adduced to the attribution of ADF to digestibility. Supporting evidence from quantum number of researchers have shown that forage materials with higher ADF content will be poorly digested when fed to the animals and this consequently lead to poor animal performance. This is due to the ligno-cellulose complex that is formed when plant materials have been lignified, thereby making it recalcitrant for rumen microbes to degrade the material. The higher methane values recorded for grasses fertilized with N.P.K, AOM and PM than those under the control treatment was an indication that the amount of nitrogen released greatly influenced methane production. Meanwhile, the trend observed indicated that among all the fertilizers used, NPK fertilized grasses had the highest methane production. This suggests that application of inorganic fertilizer contribute more to the release of methane into the environment. More importantly, our dataset justifies that organic fertilizer is more environmental friendly as shown in the amount of methane produced by PM fertilized grasses. Nevertheless, the higher methane production recorded by NPK fertilized grasses could be premised on improved performance of the grasses, which resulted in development of more structural components than other treatments. This observation did not conform to the finding by Lovett (2014)

who obtained decreased total gas production, methane production and organic matter digestibility with increased N fertilizer application. The variability in these two results might be linked to different fertilizer used, or perhaps the stages at which the harvesting was done. However, another experiment by Sodeinde *et al.* (2009) reported increased methane production for the stem component of *P. maximum* cv T 58 with increased NPK fertilizer application. It is noteworthy that methane production represents energy loss to animals and many tropical feed stuffs have been reported to have increased methanogenesis i.e. production of methane by microbes (Babayemi and Bamikole, 2006; Sodeinde *et al.*, 2009). The higher volume of methane recorded by NPK and AOM fertilized grasses are thus an indication of the extent of energy loss to ruminants when these fertilizers are used to enhance the DM productivity of the grasses. The metabolizable energy (ME) and short chain fatty acid (SCFA) values recorded in the present study are below the values reported by Sodeinde *et al.* (2009); Bezabih *et al.* (2014) and Adeoye *et al.* (2015). This variation might be as a result of differences in the stage of maturity at which the forages were harvested in the various studies, since the level of ME in forage is directly related to the extent of fibre in the forage.

Conclusion

This study revealed that the crude protein and ash contents of the grasses were not influenced by fertilizer types and age at harvest. Our result further affirms that organic (poultry manure) but not inorganic fertilizer (NPK) was more environmentally friendly as indicated in the volume of CH₄ gas produced during incubation. However, relative to the fast nutrient release to pasture sod by inorganic fertilizers, further research is required to determine the effect

of different rates of NPK fertilizer application on methane production of tropical grass species at different seasons, to ascertain the threshold of application that will be environmental friendly, with attendant improvement in the nutritive quality and digestibility of the grasses. The *in vitro* dry matter digestibility of *A. tectorum* could be enhanced through fertilization with poultry manure and harvesting at six weeks of age.

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