Nigerian J. Anim. Sci. 2021, 23 (3): 126-139

Hay quality as influenced by fertilizer types, grass species and age at harvest during wet season in Abeokuta, sub-humid zone of Nigeria

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Target Audience: *Forage Agronomist, Livestock producers, Animal Scientists, and Commercial hay producers*

Abstract

This study was conducted to investigate effects of fertilizer types and age at harvest on quality of hay produced from Andropogon tectorum and Panicum maximum var Ntchisi during wet season in Abeokuta. The experiment was a spilt-spilt-plot design, consisting of three (3) fertilizer types [N.P.K 20:10:10 (NPK), Poultry manure (PM) and Aleshinloye organo-mineral fertilizer (AOM)] and control assigned to main plots, grass species (P. maximum (Ntchisi) and A. tectorum) allotted to the sub-plots and age at harvest (6 weeks and 8 weeks) assigned to sub-sub plots. Hay from the grasses were cured under shed for a period of 4-6 weeks until desirable moisture content was achieved, sub-samples were taken for analyses. Hay from AOM fertilized grasses had the higher values (10.01 %, 65.58 % and 25.33 %) for crude protein (CP), neutral detergent fibre (NDF) and hemicellulose respectively. Non-Fibre Carbohydrate (NFC) obtained from grasses in the control treatment was highest (17.38 %). Poultry manure fertilized grasses hay had the higher EE content (7.88 %). Panicum maximum (Ntchisi) had higher values of CP (10.01 %) and Ash (9.46 %) than A. tectorum. Andropogon tectorum recorded higher NDF (64.42 %) and hemicellulose (25.17 %) than P. maximum (Ntchisi). NPK fertilized grasses produced the highest ($p<0.05$) volumes of CO_2 and CH_4 gas (16.13 ml) and (9.87 ml) respectively and the higher organic matter digestibility (31.19 %) compared with the control. Therefore, Panicum maximum hay quality was better while AOM improved CP and moderate fibre of hay.

***Key words**: Fertilizer, species, hay, age, harvest, season*

Description of Problem

Livestock production depends majorly on the availability of high-quality feeds. This is influenced by climatic conditions, plant species and stage of maturity, soil, and the level of inputs by management (1, 2). Smallholder producers of ruminants, particularly cattle, sheep and goats, in Nigeria rely on unimproved natural pastures as the main feed source, backed up with crop residues after harvest (3). These animals in consequence grow slowly, produce little milk and reproduce at long intervals due to poor quality forage fed them with. The present poor production potential of pastures could be attributed to poor soil fertility, indiscriminate grazing and to poor management of natural grassland (4, 5, 6). This problem of poor nutrition is further aggravated particularly in the dry season when grassland productivity become greatly low (7).

Meanwhile, it has been established that economic gain makes a viable commercial livestock industry imperative to individuals and government, leading to the establishment of suitable sown pasture (3). Intensive livestock production system involves the use of forage species that must prove their superiority in terms of their bulk productivity (dry matter yield per unit area), palatability, chemical composition, nutrient availability, persistence under defoliation regimes and inclement climatic conditions, competition and compatibility with other forages in the pasture ecosystem (8, 9).

In the emerging shift in animal management systems towards confinement, because of much pressure on land and frequent encroachment of cultivated land by herders which has snowball to ethnic crises, a strategic forage management system and conservation techniques which will guarantee a regular supply of high-quality forages to the livestock is highly imperative (3).

Enough herbage could be made available during the rainy period, through proper pasture management techniques such as fertilizer application, adoption of proper defoliation regimes control of bushes and weeds (6). Consequently, resulted to conservation of excess forage materials for the lean season or off-season periods.

Attempts at enhancing the nutritive quality of the conserved forage, particularly nitrogen component has been through the use of nitrogen fertilizer (10). Animal manures are valuable source of nutrients, and its effects on the improvement of soil organic matter, soil structure and the biological life of the soil are well recognized particularly at high rates of application in on-station trials (11). Manure nitrogen and phosphorus are present in organic and inorganic forms, and are not totally available to plants. The organic forms must be mineralized first or converted into inorganic forms, consequently releasing nutrients gradually over time before they can be used by plants (12).

Since hay is one of the most versatile of stored forages that can be kept for long periods of time with little losses of nutrient if protected from weather and produced high dry matter intake when compared with silage (13). Therefore, a study was conducted to investigate effects of fertilizer type and age at harvest on the quality of hay produced from two grass species during wet season in Abeokuta, South western zone of Nigeria.

Materials and Methods

Experimental location

The field work was carried out at Directorate of University Farm (DUFARMS) and the chemical analyses were carried out at the laboratory of the Department of Pasture and Range Management, College of Animal Science and Livestock Production, Federal University of Agriculture, Abeokuta, Ogun state, Nigeria. The location lies within the latitude 7°10’N, longitude 3° 2’E and altitude 76 mm. It is located in the derived savannah zone of South- Western Nigeria. It has a humid climate with mean annual rainfall of about 1037 mm and temperature of about 34.7^0 C. The relative humidity ranges in the raining season (late March-October) and dry season (November-early March) is between 63-96%, respectively with an annual average 82% (14). The seasonal distribution of annual rainfall is approximately 44.96 mm in the late dry season (January-March); 212.4 mm in the early wet season (April-June); 259.3 mm in the late wet season (July-September) and 48.1 mm in the early dry season (October-December).

Land preparation

The land was cleared and ploughed, after which it was allowed to rest for a period of two (2) weeks before harrowing. The experimental land measuring 25 m x 22 m (550 m^2) was mapped after harrowing so that each plot measured 4 m x 4 m (16 m^2) with 1 m boundary between plots and 1 m between blocks.

Soil sample analysis

Soil samples were randomly collected after land preparation and before planting from representative spots of the entire experimental field by using diagonal sampling method before planting at the depth of 0-15 cm using soil auger to represent the topsoil. The samples were bulked per replicate, mixed thoroughly and sub-samples taken for analysis to determine the pre-planting nutrient status of the soil.

Field layout and experimental design

The experiment was factorial experimental arrangement (4 x 2 x 2) laid out as a spilt-spilt plot design. Three (3) fertilizer types (N.P.K 20:10:10, Aleshinloye organo-mineral and Poultry manure, with control) were assigned to the main plot measuring 9 m x 9 m, two grass species (*Panicum maximum* var Ntchisi and *Andropogon tectorum*) were assigned to the sub-plot measuring 9 m x 4 m, two harvesting time (6 weeks and 8 weeks) were allotted to sub-sub plot measuring 4 m x 2 m. In all, the experiment consists of 16 treatments combination which was replicated three times to give a total of 48 plots. Each plot was well pegged and tagged for identification of each treatment assigned.

Manure collection, analysis and application

Poultry manure used for in this study was sourced from a reputable poultry farm along Alabata road while inorganic fertilizer (NPK 20:10:10) and Aleshinloye organo-mineral fertilizers were sourced from an Agro-allied store in Abeokuta and Aleshinloye market in Ibadan respectively. Sub samples were collected from sourced manure, thoroughly mixed and air dried for laboratory analysis and analyzed to determine the content of nutrients present. The manure applied at a rate based on the nitrogen content of the manures. The rate of application was 120 kgN ha^{-1} and was manually raked into the soil for proper and efficient mineralization. The land was left for two weeks after manure application before planting of the grasses.

Sourcing of planting materials and planting

Andropogon tectorum was sourced from natural pasture around the Teaching and Research Farm environs while *P. maximum* (Ntchisi) was sourced from the introduction plot of the Department of Pasture and Range Management. Young plants (not more than 4 weeks old) were selected and uprooted, the vegetative parts were stripped off and the crowns split into daughter tillers. Crown split were planted by scooping some top soil and the crown split were inserted into the soil at angle 90^o. 0.5 x 0.5 m was the adopted method of spacing.

Harvesting of forage materials for hay production.

At the onset of rainy season, the plots were cut back to about 15 cm above ground level to stimulate new re-growth. Forage materials were harvested at 6 and 8 weeks after cut back at 20 cm above ground. From harvested forage materials, 1 kg samples were taken, chopped to about 4 cm, spread and air-dried on a concrete floor under a shed for a period of 4- 6 weeks until desirable moisture content was achieved, sub-samples weighing 100g were taken from the hay produced oven dried and kept for analysis.

Data collection

Physical characteristics of Hay

The physical/visual evaluation of hay produced was assessed by 5 men panel using the score card (15).

Chemical analyses

Dried samples of the harvested forage were milled and allowed to pass through a 1 mm sieve screen. The samples were analyzed for:

Proximate composition

The dry matter (DM), crude protein (CP), ether extract (EE), and Ash were determined according to A.O.A.C procedure (16). Non-fibre carbohydrate was obtained using the linear equation NFC = 100 **-** (CP + ASH + EE + NDF).

Fibre fractions determination

Neutral detergent fibre (NDF), acid detergent fibre (ADF), acid detergent lignins (ADL) were determined according to Van Soest procedure (17). Cellulose was taken as the difference between ADF and ADL while hemicellulose was calculated as the difference between NDF and ADF.

***In vitro* gas production**

The *in vitro* gas production was determined by Menke and Steingass procedure (18). In each, 200 ± 0.05 mg of the milled samples were weighed into 100 ml syringe as the only substrate (n = 3). In addition, triplicate bottles of incubation solution without substrate were included as blanks to assist in estimating the net gas production. Rumen contents were obtained from slaughtered cow from a reputable abattoir very early morning and used as inoculum and sieved with 4 layers cheese cloth. Macro and micro elements, reduction and resazurin dye solutions were mixed together with distilled water. This solution was mixed together in ratio 2:1 with the rumen fluid; 30 ml of the inoculums was drawn into the syringe. The syringes were placed in a water bath with shaker at a temperature regulated to 39^{o} C. The gas produced in each syringe was recorded at 3, 6, 9, 12, 18, 24, 30, 36, 42 and 48 h of incubation. Gas volume at each incubation time was expressed per unit of incubated dry matter (DM).

The data obtained was fitted to the non-linear regression equation:

$V \text{ (ml/200mg DM)} = b\,(1-e^{-ct})$

Where V= potential gas production at time t, b= the volume of gas that evolved with time, and c= the fractional rate of gas production. Organic matter digestibility (OMD) was estimated as

OMD= 14.88 + 0.889GV+ 0.45 CP + 0.651 ash (18).

Short-chain fatty acids (SCFA) was estimated as

SCFA = 0.0239GV−0.0601 (19).

Metabolizable energy (ME) was calculated as

ME= 2.20 + 0.1357GV+ 0.057 CP + 0.002859 EE^2 (18).

Statistical analysis

Data collected were subjected to analysis of variance (ANOVA) using SAS (2009) R package (20) and the treatment means were separated using Duncan's multiple range test (21).

Experimental model

$Y_{ijklm} = \mu + M_j + G_k + (MG)_{jk} + H_l + (GH)_{kl} + (MGH)_{jkl} + \varepsilon_{ijklm}$

Y_{ijklm} = Observed value of the dependent variable

μ = Population mean

M_j = Effect of the j^{th} Main plot (Fertilizer type)

G_k = Effect of the k^{th} Sub-plot (Grass species)
$(MG)_{jk}$ = Effect of the j^{th} Main plot and the k^{th} Sub-plot
H_l = Effect of the l^{th} Sub-Sub-plot (Harvesting time)
$(GH)_{kl}$ = Effect of the k^{th} Sub-plot and the l^{th} Sub-Sub-plot
$(MGH)_{jkl}$ = Interaction of the j^{th} Main plot, k^{th} Sub-plot and l^{th} Sub-Sub-plot effects
ε_{ijklm} = Random residual error

Results and Discussion

Main effect of fertilizer types and age at harvest on physical characteristics of hay made from two grass species

The physical characteristics of hay made from two grass species as affected by fertilizer types and age at harvest was shown in Table 1. Scores recorded for leafiness and odour were not influenced significantly ($p>0.05$) by the fertilizer types, while colour and foreign materials were significantly different ($p<0.05$). Hay produced from Aleshinloye organo-mineral (AOM) fertilized grass materials recorded the highest score (13.54) for colour, while hay produced from poultry manured grass materials had the lowest score (10.00). In the case of foreign materials, hay produced from grass materials without fertilizer recorded the higher score (9.50), while that of AOM fertilized grass materials recorded the lower score (8.38). Considering the species type, it was revealed that only leafiness and odour were significantly affected ($p<0.05$). *Andropogon tectorum* recorded the higher scores (11.33 and 11.60) for leafiness and odour respectively, while *Panicum maximum* (Ntchisi) recorded the lower scores (9.52 and 9.38) for leafiness and odour respectively. Meanwhile, for the age at harvest, only foreign materials were ($p<0.05$) different and hay produced from the grass materials harvested at six weeks recorded the higher value (9.17), whereas those harvested at 8 weeks had the lower score (8.56).

Main effects of fertilizer types and age at harvest on proximate composition of hay produced from two grass species

Table 2 shows the main effects of fertilizer types and age at harvest on proximate composition of two grass species. It was observed that contents of crude protein (CP), ether extra (EE) and non-fibre carbohydrate (NFC) were significantly ($p<0.05$) affected by fertilizer types, whereas dry matter (DM) and Ash were not influenced ($p>0.05$) by the fertilizer types. The hay produced from fertilized grass materials were higher ($p<0.05$) than those hay made from unfertilized grass materials. The hay produced from AOM fertilized grass materials had the higher value (10.01 %) for CP content but statistically similar to that of NPK, while the hay produced from unfertilized grass materials recorded the lower value (7.91 %) for CP. More so, the hay produced from PM fertilized grass materials recorded the higher value (7.88 %) for ether extract (EE) while the hay produced from unfertilized grass materials had the lower value (5.38 %). Conversely, for the NFC, the hay produced from unfertilized grass materials had the higher value (17.38 %) while that of hay produced from PM fertilized grass materials recorded the lower value (9.65 %).

Table 1: Main effects of fertilizer types and age at harvest on physical characteristics of hay produced from two grass species

Factors	Leafiness	Color	Odour	Foreign materials
Fertilizer types				
Control	11.25	11.13^{b}	11.25	9.50^{a}
AOM	9.75	13.54^{a}	9.46	8.38^{b}
NPK	10.88	11.13^{b}	11.50	8.63^{ab}
PM	9.83	10.00^{b}	9.75	8.96^{ab}
SEM	0.79	0.99	1.00	0.28
Grass species				
Andropogon tectorum	11.33^{a}	10.46	11.60^{a}	9.06
Panicum maximum (Ntchisi)	9.52^{b}	12.44	9.38^{b}	8.67
SEM	0.58	0.72	0.67	0.21
Age at harvest				
6 weeks	10.48	11.90	9.98	9.17^{a}
8 weeks	10.38	11.00	11.00	8.56^{b}
SEM	0.61	0.75	0.73	0.21
P-values				
SH	0.1663	0.0408	0.2818	0.0162
FS	0.0028	0.0262	0.0183	0.1143
FH	0.8532	0.2992	0.2634	0.0187
F x S x H	0.6254	0.1290	0.8139	0.2268

^{abcd}: means on the same column with different superscript are significantly (p<0.05) different
SEM: Standard error of the mean

In the case of species type, it was revealed that CP and ash contents were significantly (p<0.05) affected. The hay produced from *P. maximum* (Ntchisi) recorded the higher values (10.01 % and 9.46 %) for CP and ash respectively, while *A. tectorum* had the lower values (8.46 % and 8.08 %) for CP and ash contents respectively. The results revealed that age at harvest was not significantly (p>0.05) influenced the parameters determined.

Main effects of fertilizer types and age at harvest on fibre fractions of two grass species

The main effects of fertilizer types and age at harvest on fibre fractions of two grass species is shown in table 3. The mean values recorded that for ADF, ADL and cellulose were not significantly (p>0.05) influenced by the fertilizer type, while NDF and hemicellulose were different (p>0.05). Neutral detergent fibre recorded for the hay from AOM fertilized grass materials (65.58 %) was (p<0.05) higher when compared to the contents obtained from hay produced from unfertilized and NPK fertilized grasses. Contents of hemicellulose (25.33 %) recorded for hay produced from AOM fertilized grass materials was significantly (p<0.05) higher when compared to NPK fertilized grasses (19.25 %) but it was statistically similar when compared to the other treatments.

When comparing the two grass species, hay produced from *A. tectorum* produced (p<0.05) higher contents of NDF (64.42 %) and hemicellulose (25.17 %) relative to *P. maximum*, however, contents of ADF, ADL and cellulose recorded for both grasses were similar (p>0.05).

The age at harvesting did not influence (p>0.05) the contents of NDF, ADF, ADL, hemicellulose and cellulose.

Table 2: Effects of fertilizer types and age at harvest on proximate composition of hay produced from two grass species

Factors	DM	CP(%)	EE(%)	Ash(%)	NFC(%)
Fertilizer types					
Control	96.25	7.91^{b}	5.38^{b}	8.08	17.38^{a}
AOM	95.00	10.04^{a}	6.42^{ab}	8.13	9.83^{c}
NPK	96.38	9.85^{a}	7.63^{a}	9.38	13.90^{b}
PM	95.00	9.14^{ab}	7.88^{a}	9.50	9.65^{c}
SEM	0.64	0.83	0.91	0.67	1.91
Grass species					
A. tectorum	95.50	8.46^{b}	6.69	8.08^{b}	12.35
P. maximum	95.81	10.01^{a}	6.96	9.46^{a}	13.03
SEM	0.47	0.61	0.68	0.48	1.47
Age at harvest					
6 weeks	95.19	9.48	6.94	8.69	13.18
8 weeks	96.13	8.99	6.71	8.85	12.20
SEM	0.45	0.63	0.68	0.50	1.51
P-values					
SH	0.1450	0.0060	0.1805	0.4627	0.2141
FS	0.0018	<0.0001	0.0983	0.1089	<0.0001
FH	0.2546	0.0011	0.0189	0.7933	0.0300
F x S x H	0.0248	0.009	0.0001	0.0001	0.0124

^{abcd}: means on the same column with different superscript are significantly ($p<0.05$) different
AOM=Aleshinloye Organo Mineral
PM=Poultry Manure
DM: Dry matter
CP: Crude protein
EE: Ether extract
NFC: Non-fibre carbohydrate
SEM: Standard error of the mean

Effects of fertilizer types and age at harvest on *in vitro* gas production of hay from produced two grass species

The effects of fertilizer types, and age at harvest on *in vitro* gas production of two grass species is shown in table 4. The gas produced increased progressively from the 3rd to 48th hour of incubation, however values recorded at each interval was not influenced ($p>0.05$) by the fertilizer types, species and age at harvest. Carbon dioxide (CO_2) and Methane (CH_4) were influenced ($p<0.05$) by the fertilizer types. NPK fertilized grasses hay produced higher ($p<0.05$) volumes of CO_2 and CH_4 gas recording (16.13ml) and (9.87 ml) respectively.

Effect of fertilizer types, and age at harvest on *in vitro* post incubation kinetics of hay produced from two grass species

Table 5 shows effects of fertilizer types and age at harvest on *in vitro* post incubation kinetics of hay produced two grass species. Of all parameters recorded, OMD was the only parameter influenced ($p<0.05$) by the fertilizer types. Other parameters recorded did not differ ($p>0.05$) from each other when the treatment means were tested across the treatment groups. NPK fertilized grass hay had the higher organic matter digestibility (31.19 %)) than the control, but did not differ ($p>0.05$) from the other treatment groups.

Table 3: Main effects of fertilizer types and age at harvest on fibre fractions of two grass species

Factors	NDF	ADF	ADL	Hemicellulose	Cellulose
Fertilizer types					
Control	61.25^{b}	40.83	7.25	20.42^{ab}	33.58
AOM	65.58^{a}	40.25	6.00	25.33^{a}	34.25
NPK	59.25^{b}	40.00	7.38	19.25^{b}	32.63
PM	63.83^{a}	43.25	5.75	20.58^{ab}	37.50
SEM	1.45	2.11	0.79	2.10	2.32
Grass species					
A. tectorum	64.42^{a}	39.25	6.88	25.17^{a}	32.38
P. maximum	60.54^{b}	42.92	6.31	17.63^{b}	36.60
SEM	1.12	1.47	0.58	1.28	1.62
Age at harvest					
6 weeks	61.71	40.92	6.19	20.79	34.73
8 weeks	63.25	41.25	7.00	22.00	34.25
SEM	1.17	1.53	0.59	1.55	1.69
P-values					
SH	0.4415	0.6616	0.2923	0.3665	0.4095
FS	<0.0001	0.0070	0.7080	0.0497	0.0164
FH	0.0726	0.1777	0.7552	0.7335	0.2735
F x S x H	0.006	0.3717	0.4284	0.089	0.2370

^{abcd}: means on the same column with different superscript are significantly ($p<0.05$) different
AOM=Aleshinloye Organo Mineral
PM=Poultry Manure
NDF: Neutral detergent fibre
ADF: Acid detergent fibre
ADL: Acid detergent lignin
SEM: Standard error of the mean

Table 4: Effect of fertilizer types and age at harvest on *in vitro* gas production of hay produced two grass species

	3	6	9	12	18	24	30	36	42	48	CO_2	CH_4
Factors	Hours of incubation (h)											
Fertilizer types												
Control	6.00	7.26	8.00	8.26	9.00	10.00	13.76	16.00	18.26	20.50	14.88^{b}	5.62^{b}
AOM	5.50	6.00	7.76	7.76	8.50	10.76	13.50	16.76	19.00	21.76	15.63^{a}	6.13^{b}
NPK	7.26	8.26	9.26	9.76	11.26	13.00	17.00	20.00	23.26	26.00	16.13^{a}	9.87^{a}
PM	6.26	6.76	7.76	8.00	9.00	10.00	12.50	16.00	18.50	20.76	14.88^{b}	5.88^{b}
SEM	1.02	1.12	1.18	1.20	1.24	1.46	1.72	1.92	2.18	2.28	0.24	2.04
Grass species												
A. tectorum	6.62	7.38	8.62	8.88	9.88	11.26	14.62	17.76	20.26	23.00	15.31	22.00
P. maximum	5.88	6.76	7.76	8.00	9.00	10.62	13.76	16.62	19.26	21.50	15.44	21.94
SEM	0.70	0.78	0.82	0.84	0.88	1.04	1.24	1.36	1.56	1.64	0.20	0.40
Age at Harvest												
6 weeks	6.00	7.00	8.00	8.38	9.50	10.88	14.62	18.00	20.88	23.50	15.63	22.38
8 weeks	6.50	7.12	8.38	8.50	9.38	11.00	13.76	16.38	18.62	21.00	15.13	21.56
SEM	0.72	0.80	0.82	0.84	0.88	1.04	1.24	1.36	1.56	1.62	0.20	0.38
P-values												
SH	0.4928	0.3585	0.2818	0.3902	0.1651	0.2223	0.2433	0.1150	0.1509	0.1322	0.3077	0.9556
FS	0.7725	0.9449	0.8255	0.8012	0.8960	0.8124	0.9220	0.8294	0.9431	0.8489	0.0346	0.5801
FH	0.7102	0.7672	0.8443	0.8723	0.7608	0.3603	0.3635	0.2934	0.2592	0.2245	0.8481	0.6024
F x S x H	0.7873	0.9341	0.8205	0.9453	0.9054	0.8370	0.9592	0.9555	0.6628	0.9991	0.0004	0.9075

^{abcd}: means on the same column with different superscript are significantly ($p<0.05$) different AOM=Aleshinloye Organo Mineral
SEM: Standard error of mean

Discussion

One of the major characteristics of hay which attract the buyers is the visual features, even though the hay that possess best physical quality does not necessarily imply good hay in terms of nutrient status (15). The hay produced from the materials harvested on the plots that received AOM fertilizer had the best physical quality in terms of colour and foreign materials. This could be attributed to high biomass yield which was a resultant of better growth performance enhanced due to proper release of nitrogen from this fertilizer. Considering the species types, *Andropogon tectorum* gave the best physical quality in terms of leafiness and odour, this could be attributed to higher vegetative part (broader leaves) of this species relative to *Panicum maximum* (Ntchisi). Age at harvest did not affect the physical quality of the hay, this is an indication that irrespective of the age of harvested forage materials use to make hay, it does not influence the acceptability of the conserved materials by the ruminant through the sense of visual appraisal. This, consequently allow the farmers to conserve the forage materials at the age, where an appreciable quantity would be achieved.

Table 5: Effect of fertilizer types and age at harvest on *in vitro* post incubation kinetics of hay produced from two grass species

Factors	OMD	SCFA	ME
Fertilizer types			
Control	28.15^{b}	0.07	2.93
AOM	29.47^{ab}	0.07	3.00
NPK	31.19^{a}	0.10	3.16
PM	29.62^{ab}	0.07	2.95
SEM	0.86	0.02	0.10
Grass species			
A. tectorum	28.95	0.08	3.03
P. maximum	30.26	0.07	2.99
SEM	0.62	0.01	0.07
Age at Harvest			
6 weeks	29.64	0.07	3.01
8 weeks	29.58	0.08	3.01
SEM	0.64	0.01	0.07
P-values			
SH	0.0688	0.2763	0.2204
FS	0.6917	0.7621	0.8531
FH	0.6145	0.3788	0.3585
F x S x H	0.8445	0.9441	0.9693

^{abcd}: means on the same column with different superscript are significantly ($p<0.05$) different
AOM=Aleshinloye Organo Mineral
PM=Poultry Manure
OMD: Organic matter digestibility
SCFA: Short chain fatty acids
ME: Metabolizable energy
SEM: Standard error of the mean

The increase in CP values with fertilizer application relative to the control treatment as observed in this study is an evidence that fertilization enhanced the nitrogen content of the soil,which in turn uptake by planted forage for better vegetative development. This observation is consistent with what was previously reported by (22) that increase in crude protein contents with increasing nitrogen availability. The author also reported that contents of ether extract and ash were also increased with greater fertilizer application which is similitude to the trend noticed in this study for EE except the ash content that was not influenced by fertilizer treatments (23). This agrees with the findings of (24) that fertilizer types did not affect proximate parameters. This might be linked to increased cell contents of those materials harvested from the plots that received fertilizer. This contradicts the findings by (25) reported that green fodder yield, fibre and total ash contents were increased with various nitrogen rates. The variation might be due to differences in soil fertility status in the both studies.

The lower content of CP and ash recorded for *A. tectorum* relative to *P. maximum* might be due to a decline in total ash content of forages from fertilized pasture which brings about earlier dilution and translocation of different minerals associated with vegetative portion of the plant (leaf portion) to roots at late stage of maturity as described by (26).

Concentration of crude protein and proximate composition alone is not a fully satisfactory predictor of forage nutritive quality across a broad range of growing conditions and other factors such as concentrations of cell-wall constituents (i.e., fibre) are generally more important than CP concentration as determinants of forage nutritive quality (27). Concentration of NDF across the fertilizer-source treatments recorded in this study (65.58- 59.25 %) was slightly differed to those reported by (23) and (28) ranges of (62.00 to 65% NDF in three tropical grass species and 63.9 to 66.7 % NDF in Johnson grass that had been fertilized with swine effluent, respectively). Although, the value (61.25%) obtained in the plots without fertilizer was slightly higher than the least value obtained in those plots that received NPK fertilizer treatments. Meanwhile, the range of NDF values observed in this study was slightly higher than that of (24) who reported the NDF values (57.75-54.25%) of fresh forage materials. This variation could be attributed to presence of high moisture content in the fresh forage as compared with the hay sample that has relatively low moisture content due to dehydration. This agrees with the findings by (29) who reported that NDF contents of hay sample was increased as the storage advances due further drying during storage period.

The mean value recorded in the hay produced from the fertilizer treatment that had least NDF value which was higher than the control. These increases in the NDF contents might likely depression intake when such materials were offered to ruminants.

The recorded values for ADF were similar to those recorded by (30) who observed a mean concentration of 39.2% ADF in Johnson grass across multiple fertilizer-application rates, and harvests, more so, (30) also reported that application of different fertilizer source failed to register a significant influence on ADF concentration in Johnson grass. Values for hemicellulose were similar to those reported by (30) reported a mean value of 25.8 % hemicellulose in Johnson grass fertilized with swine effluent, however other parameters were in contrast to the findings by, (30) who reported no fertilizer-source effect on hemicellulose concentration in stands of pure Johnson grass which was not so for the results gotten in this study.

Volume of gas produced has been reported to have a negative correlation with the fibre constituents present in the forage materials (31). Volume of cumulative gas produced was not influenced by the fertilizer types, species and age at harvest as shown in this study. However, methane and CO_2 gas produced were the highest in the N: P: K fertilized hay, ranges from (9.87 ml/ to 5.62 ml) and (16.13-14.82 ml) respectively. AOM fertilizer had the lower value for CH_4 when compared with N: P: K indicating that hay produced from AOM fertilized grass will reduced the methane gas released to the environment when such materials were offered to ruminants. This in directly reducing the contribution of the livestock industry to green house gas emission, which has been a serious challenge to this sector globally. Short chain fatty acids are volatile fatty acids (VFA) and their presence denote energy is available in a feedstuff. These observations imply that both grasses were similar in degradation and digestibility, this was evident in the volume of gas recorded for both grasses. In another study conducted by (32), the authors explained that SCFA is one of the end products of rumen fermentation, and that a high volume of gas is produced when substrate is fermented, this is evident by the higher volume of gas reported for the same parameter in this study.

Conclusion and Applications

Based on the results of this study, the following conclusions and applications were made.

1. Higher leafiness, and better odour was obtained from hay made with *Andropogon tectorum*
2. Aleshinloye organo-mineral (AOM) fertilized grass hay produced the highest crude protein (CP) content. *Panicum maximum* recorded the higher CP and ash contents than *Andropogon tectorum.* Poultry manure and AOM fertilized grasses hay had the highest neutral detergent fibre (NDF) contents. *Andropogon tectorum* hay produced higher NDF constituent relative to *Panicum maximum* hay
3. Highest methane, carbon dioxide and OMD were obtained in hay produced from the grasses fertilized with NPK
4. *Panicum maximum* (Ntchisi) should be used to produce quality hay for feeding ruminants under intensive management system.
5. Aleshinloye organo-mineral fertilizer should be utilized to improve the nitrogen content of the soil to enhance biomass yield for conserved forage harvested during wet season. 8 weeks age at harvest should be adopted for high dry matter production of the hay with good nutritive quality.

Acknowledgments

We appreciate the contributions of academic staff, Laboratory technologists and final under graduate students (2014/2015 Academic Session) of the Department of Pasture and Range Management, Federal University of Agriculture, Abeokuta, who supported the research team during the period of this study.

References

1. Wallah, M. O., Adesogan, A. T., Sollenberger, L. E., Vendramini, J. M. B. and Dubeux, Jr., J. C. B. (2018). Factors affecting forage quality. Florida Forage Handbook. http://edis.ifas.ufl.edu

2. Fulgueira, C. L., Amigot, S. L., Gaggiotti, M., Romero, L. A. and Basilico, J. C. (2007). Forage quality: Testing techniques for forages. *Global Science Books fresh produce* 1(2): 121-131. https//www.researchgate.net/publication/228478265.
3. Bamikole, M. A., and Babayemi, O. J. (2004). Feeding goats with Guinea grass-Verano stylo and nitrogen fertilized grass with energy concentrate. *Archivos de Zootecnia.* 53: 13-23.
4. Getabalew, M. and Alemneh, T. (2019). Factors affecting the productivity of Rangelands. *Journal of Plant Sciences and Agricultural Research*, 3(1): 19.
5. Schafer, D. (2018). Biotic and Abiotic factors in savanna Grassland. Sciencing. https//:sciencing.com.
6. Dev, I. (2001). Problems and prospects of forage production and utilization of Indian Himalaya. ENVIS Bulletin: *Himalayan Ecology and Development* 9(2): 1-13.
7. Oloyo, R. A. and Ilelaboye, N. O. A. (2002). Nutritive quality evaluation of seeds of some lesser-known crops. *Journal of Animal Production Research* 18(1 and 2): 11-18.
8. Okwori, A. I. and Abdulsalam, M. (2017). Performance of some forage grass species in the Southern Guinea savannah agro-ecological zone in Nasarawa state of Nigeria. World Scientific News 83(2017) 92-118 EISSN 2392-2192 available online at www.worldscientificnews.com.
9. Muhammad, I. R. and Abubakar, S. A. (2004). Establishment and Management of sown pastures. In proceeding of training workshop on pasture and range management in Nigeria, held at the National Animal Production Research Institute, Ahmadu Bello University, Zaria, 10-14 October, 2004.
10. Bamikole, M. A. (2003). Macro-minerals bioavailability study in goats fed forages of nitrogen fertilized Guinea grass and Guinea grass-Verano stylo mixture. *Livestock Research for Rural Development* 15 (12):1-4.
11. Gabriel, W. Q. (2010). Effect of organic and inorganic fertilizer and their combinations on the growth and yield of maize in the semi-deciduous forest zone of Ghana. M. Sc. Thesis, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana.
12. Ewetola, I. A. (2013). Effects of Residual animal manure on re-growth potential, dry matter yield and nutritive quality of three grasses in Abeokuta, Nigeria. M. Agric. Dissertation. Federal University of Agriculture, Abeokuta, Ogun State, Nigeria 127 Pp.
13. Wilkinson, J. M. (2016). Fifty years progress in forage conservation and challenges for the future. School of Biosciences, University of Nottingham, Sutton Bonington Campus, Loughborough, Leicestershire, LE12 5RD, United Kingdom. j.mike.wilkinson@gmail.com.
14. Google Earth. (2015). Directorate of University Farms, Federal University of Agriculture, Abeokuta. Retrieved from http://www.google.com/maps/place/Federal+ University +of +Agriculture + Abeokuta/@7.2342797,3.4389292,20z/data=!4m2!3m1!1s0x103a37c0008d6809:0x62771eac522d2734.
15. Vough, L. R. (2000). Evaluating hay quality. Maryland Cooperative Extension, University of Maryland College Park-Eastern shore. Pp5.
16. AOAC. (1995). Official methods of analysis 16th Ed. Association of official analytical Chemists. Washington DC, USA.
17. Van Soest, P. J., Robertson, J. B., Lewis, B. A. (1991). Methods for dietary fibre,

neutral detergent fibre, and non-starch polysaccharides in relation to animal nutrition. *Journal of dairy science* 74(10),3583-3597.

18. Menke, K. H. and Steingass, H. (1988). Estimation of the energetic feed value from chemical analysis and in vitro gas production using rumen fluid. *Animal Research and Development* 28:7-55.
19. Getachew, G., Robinson, P. H., DePeters, E. J., Taylor, S. J. (2004). Relationship between chemical composition, dry matter degradation and in vitro gas production of several ruminant feeds. *Animal Feed Science Technology* 111(1-4): 41-56.
20. Muenchen, R. A. (2009). R for SAS and SPSS users. Doi:10.1007/978-0-387-09418-2 Edition: 1st. Publisher: Springer. ISBN: 978-0-387-09417-5.
21. Duncan, D. B. 1955. Multiple Range and Multiple F-Test. *Biometrics*, 11, 1-5.
22. Sodeinde, F. G., Akinlade, J. A., Aderinola, O. A., Amao, S. R., Alalade, J. A. and Adesokan, A.T. (2009). Effect of poultry manure on proximate composition and in vitro gas production of *Panicum maximum* cv T 58 in the derived savanna zone of Nigeria. *Pakistan Journal of Nutrition* 8(8):1262-1265, 2009 ISSN 1680-5194.
23. Olanite, J. A., Ewetola, I. A., Onifade, O. S., Oni, O. A., Dele, P. A., and Sangodele, O. T. (2014). Comparative residual effects of some animal manure on nutritive quality of three tropical grasses. *International Journal of Science Environment and Technology*, Vol. 3, 2014, 1131-1149.
24. Ewetola, I. A., Amisu, A. A., Jimoh, S. O., Muraina, T. O., Olanite, J. A. and Arigbede, O. M. (2020). Impact of fertilizer types on the nutritive quality of two tropical grass species harvested at different stages of growth during wet season. *Nigerian Journal of Animal Production* 47(3):309-322.
25. Safdar, Z. (1997). Optimization of Nitrogen and its effect on yield and quality of maize fodder. M. Sc. (Hons.) Agric. Thesis., Dept. Agron., University. Agric., Faisalabad.
26. Maynard, A. L., Loosli, K. J. and Hintz, F. H. (1981). Animal Nutrition. 7th edition Tata McGraw - Hill Publishing Company Limited. New Delhi, India.
27. Rohweder, D. A., Barnes, R. F. and Jorgensen, N. (1978). Proposed hay grading standards based on Laboratory Analyses for Evaluating quality. *Journal of Animal Science* 47: 747-759.
28. Adeli, A. and Varco, J. J. (2001). Swine lagoon effluent as a source of nitrogen and phosphorus for summer forage grasses. *Agronomy Journal* 93: 1174-1181.
29. Ewetola, I. A. (2018). Evaluation of growth, yield and nutritive quality of fertilized *Panicum maximum* and *Andropogon tectorum* and their hay produced through different drying techniques. Ph.D Thesis Submitted to Department of Pasture and Range Management, College of Animal and Livestock Production, Federal University of Agriculture, Abeokuta, Nigeria. Pp 177.
30. Adeli, A., Sistani, K. R., Bal'a, M. F. and Rowe, D. E. (2005). Phosphorus dynamics in broiler litter-amended soils. *Communication in Soil Science and Plant Analysis* 36(9-10):1099-1115.
31. Dele, P.A., Jolaosho, A. O., Arigbede, O. M., Ojo, V. O. A. and Amole, T. A. (2013). Chemical composition and in vitro gas production of silage from Guinea grass, cassava peel and cashew apple waste at different periods of ensilage. *Pakistan Journal of Biological Sciences* 16(23): 1801-1805.

32. Ajayi, F. T. and Babayemi, O. J. (2008). Comparative *in vitro* evaluation of mixtures of *Panicum maximum* cv. Ntchisi with stylo (*Stylosanthes guianensis*), Lablab (*Lablab purpureus*), Centro (*Centrosema pubescens*) and Histrix (*Aeschnomene histrix*). *Livestock Research for Rural Development* 20 (6) 2008. www.lrrd.org.