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Influence of manure application during cultivation on *in vitro* gas and post incubation parameters of nine *Pennisetum purpureum* varieties

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***Target Audience:** Forage and Range Scientists, Pasture Agronomists, Ruminant Nutritionists*

Abstract

Forages are generally available in the tropics yet the issue related with their utilization is low efficiency and nutritional contents whereby seasonal variations in pasture productivity were the significant constraint to their availability for use throughout the year. This research was carried out to evaluate the Influence of manure application during cultivation on in vitro gas production and post-incubation parameters of nine (9) different Pennisetum purpureum varieties. The experiment was a 9 x 3 factorial arrangement in split plot design which comprises of nine (9) P. purpureum varieties (Abeokuta 1, Abeokuta 2, F_1 Hybrid, Green Local, Purple Local, Sugarcane, South Africa, S_{13} and S_{15}) and three (3) manure types (control, swine and cattle). Results showed that the in vitro gas production of different P. purpureum varieties as affected by manure type were significant ($p < 0.05$). Unfertilized varieties had the highest volume of gas produced (17.14ml/200mgDM) at the end of the 48 hours incubation periods and the green local variety recorded the gas volume of 18.33ml/200mgDM at the end of the 48hours incubation. The post incubation parameters showed that manure type ($p>0.05$) had no effect on the short chain fatty acid (SCFA) and Metabolizable energy (ME) in the varieties of P. purpureum while the values for organic matter digestibility (OMD) was significantly ($p < 0.05$) ranged from 33.68% in unfertilized varieties to 35.72% when swine manure was applied. It is concluded that green variety of P. purpureum will be the best for ruminant feeding in this study.

***Keywords:** Forage; in vitro; manure type; nutritive quality; Pennisetum purpureum,*

Description of Problem

Forage is important to livestock production since it is a significant source of ruminant feed and nutrition for manageable animal protein and ruminant is the largest source of animal protein. Forage crops make up a significant part of the total agriculture land in Africa and give a basic nutrition supply for the livestock industry. Forages make up of more than 90% of the feed energy consumed by ruminants around the world. Grasses are the most abundant blossoming plants that are useful to man and they are one of the most significant sources of nutrients for domesticated ruminants during a large part of the year (1). The digestibility of the diverse grass species could be particularly unique, and is likewise impacted by area of origin, including temperature, light intensity, total precipitation, soil type, fertilization level, stage of maturity and conservation strategy (2; 3). Seasonal variations influence the availability of nutrients from the soil to forage species (4). The nutritional values of forage species are low in the dry seasons compared with the wet season (5).

The nutritive value of forage, as related with ruminants, might be regarded as the result of the intake of the forage and its digestibility, with intake being the more significant of the two parameters (6). Grasses have co-evolved with herbivores over a tremendous timeframe, and their structure and chemical composition are the result of evolutionary pressure to survive as component of a specific ecosystem. In fact, most plants have developed structures and mechanisms which impede predation, and Elephant grass (*Pennisetum purpureum*) is no exemption. Elephant grass (*Pennisetum purpureum*) is a perennial grass grown generally as a fodder crop and feed for the cut-and-carry (zero-grazing) dairy system (7) and constitute up to 80 % of forage for smallholder dairy farms (8). It is the forage of choice not only in the tropics but also worldwide (9) due to its desirable traits such as resilience to dry season and a wide scope of soil conditions, and high photosynthetic and water-use efficiency (10). With much consideration being directed towards research for improving the productivity of significant cereals crops (11), there has been comparatively little effort to improve Elephant grass a significant forage crop that has been grown over centuries and currently enjoys a multiplicity of uses besides conventional animal consumption (12).

Manure is an important source of nutrients for many smallholder farmers in Africa who cannot afford or those only using limited amounts of chemical fertilizer (13; 14; 15) and the economic value of animal manure depend on its ability to provide nutrients to crops. In many sub-Saharan African countries, however, fertilizers are expensive and inefficient distribution systems often make them unavailable to farmers. Indiscriminate use of fertilizers without pre-planting soil evaluation is another major problem which adversely affects soil chemical and physical properties. Several studies have indicated positive effects of organic manures on soil productivity which favours crop yield and product quality. In addition, organic manures have lesser negative effect on the soil's physicochemical properties compared with mineral fertilizers. Therefore, the objective of this research was to evaluate proximate composition and *in vitro* gas production of *Pennisetum purpureum* varieties as influenced by manure types.

Materials and methods

Experimental site

The research was carried out at the Directorate of University of Agriculture Farm (DUFARM) while the chemical analysis was carried out at the laboratory of Pasture and Range Management Department, Federal University of Agriculture, Abeokuta (FUNAAB). Ogun State, Nigeria.

Land preparation

The land (1521m^2) was cleared, followed by ploughing after which the land was allowed to rest for a period of two weeks before harrowing. Prior to planting, soil samples were randomly collected from the plots at the depth of 0-15 cm using soil auger to represent the topsoil. The soil samples were bulked per replicate, mixed thoroughly and sub-samples taken for analysis to determine the physico-chemical characteristics of the soil (Table 1).

Manure collection and application

The manure (swine and cattle dung) was collected at the Directorate of University of Agriculture Farm (DUFARM). The manures were collected 14 days before the application and sub-samples were taken from each manure type and analyzed prior to application to determine their nutrient composition. The rate of application was 300 kgN/ha and quantities of the manures were determined based on the nitrogen content of the manure and nutrient compositions as presented in Table 2

Experimental design and plot management

The study was carried out using 3 × 9 factorial arrangement in a split plot design comprising of three manure types (swine, cattle manure and control (No manure)) dimension was 14 × 14 m^2 as the main plot and 9 varieties of *Pennisetum purpureum* (Abeokuta 1 and 2 (wild varieties), F_1 Hybrid, Green Local, Purple Local, South Africa, Sugarcane, S_{13} and S_{15}) was 3 × 3 m^2 as sub-plot replicated three times. The inter-plot and intra-plot spaces were kept weed-free throughout the experimental period by hand weeding.

Sourcing of planting materials, planting and harvesting of forage plant

The planting material was sourced from Department of Agronomy (University of Ibadan). Stem of *P. purpureum* was planted after the manure application to the experimented plots. The forage plant were harvested at eight (8) weeks after planting by clipping to 15cm above the ground level, oven dried at 65^{o}C and stored for chemical analysis.

Laboratory analysis

Proximate composition: The contents of dry matter, crude protein, ether extract and ash were determined (Table 3) (16).

In vitro production: This was determined following the procedure of Menke and Steingass (17). A sensitive scale was used to measure 200mg of the milled grass samples in three replicates and then placed into 100ml graduated glass syringes. The rumen fluid (inoculum) was collected inside a pre-warmed flask (39^{0}C) early in the morning (6.00am) from culled cattle at an abattoir located in Odo eran, Abeokuta. The inoculum was strained through two layers of cheese cloth and mixed with sodium and ammonium bicarbonate buffer (35g $NaHCO_3$ plus 4g NH_4HCO_3 per litre) at a ratio of 1:2(v/v) to prevent lowering of the pH of the rumen fluid which could result in decreased microbial activities. Thirty (30) milliliters of the buffered inoculum were added to each syringe containing the milled grass samples. The syringes were positioned vertically in a water bath and kept at 39°C. A blank syringe containing 30ml of the buffered inoculum was included as a control. All the syringes were gently shaken after the commencement of incubation at regular intervals of 3hours for 48hours. Gas released was read directly on the graduated syringes at those intervals.

Data obtained from *in vitro* gas production was fitted to the non-linear equation of (18): V (ml/0.2 g DM) = GV (I-e-ct)

Where *V* is the potential gas production, GV is the volume of gas and *ct* is the fractional rate of gas production.

The post incubation parameters such as: Organic matter digestibility (OMD) was estimated as OMD = 14.88 + 0.889 GV + 0.45 CP + 0.651 ash (17). Short-chain fatty acids (SCFA) were estimated as SCFA = 0.0239 GV – 0.0601 (13). Metabolizable energy (ME) was calculated as ME = 2.20 + 0.136 GV + 0.057CP + 0.029EE^{2} (17).

Statistical analysis

Data collected were subjected to two-way analysis of variance and the treatment means were separated using Duncan's Multiple Range Test using SAS (19) package.

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

Chemical properties	Values
pH	6.99
Total nitrogen (%)	0.14
Organic carbon (%)	1.33
C:N ratio	27.35
Available P (mg/kg)	51.77
Acidity (cmol/kg)	0.15
CEC	1.84
Exchangeable cations (cmol/kg)	
Sodium (Na)	0.75
Potassium (K)	0.22
Calcium (Ca)	2.65
Magnesium (Mg)	2.53
Particle size	
Sand (%)	75.99
Silt (%)	16.90
Clay (%)	4.62

Table 2: Nutrient composition of animal manures

Parameters	Cattle	Swine
N (g/kg)	15.91	17.30
P (g/kg)	7.13	6.69
K (g/kg)	6.98	7.92
Ca (g/kg)	20.50	29.96
Mg (g/kg)	13.31	19.93
Na (g/kg)	1.50	2.10
Fe (mg/kg)	599.30	637.50
Zn(mg/kg)	61.40	89.81
Cu(mg/kg)	28.19	26.35
Mn(mg/kg)	310.92	259.17

Table 3: Proximate composition (%) of nine varieties of *Pennisetum purpureum* as affected by manure types

Factors	Dry matter	Crude protein	Ether extract	Ash
Manure types				
Cattle	91.92^{a}	9.78^{a}	4.44	11.36^{b}
Control	91.38^{b}	7.73^{c}	4.28	10.55^{c}
Swine	91.45^{b}	8.60^{b}	4.28	12.80^{a}
SEM	0.24	0.10	0.13	0.13
Varieties				
Abeokuta 1	91.07^{cd}	8.75^{ab}	4.05^{bc}	11.19^{d}
Abeokuta 2	91.76^{bc}	8.87^{a}	4.81^{a}	11.02^{d}
F_1 Hybrid	92.14^{abc}	8.93^{a}	4.38^{abc}	11.40^{bcd}
Green Local	91.79^{bc}	8.71^{ab}	3.83^{c}	12.10^{a}
Purple Local	92.06^{abc}	8.37^{b}	4.31^{abc}	11.29^{cd}
Sugarcane	93.13^{a}	8.90^{a}	3.77^{c}	11.85^{abc}
South Africa	90.66^{d}	8.61^{ab}	4.69^{a}	11.91^{abc}
S13	91.75^{bc}	8.58^{ab}	4.58^{ab}	11.95^{ab}
S15	92.88^{ab}	8.61^{ab}	4.73^{a}	11.42^{bcd}
SEM	0.42	0.28	0.22	0.33

^{a,b,c,d}: Means in same column with different superscript are significantly ($p<0.05$) different
SEM = Standard Error of the Mean
Source: Okukenu *et al.* (2021)

Table 4: Main effects of manure types and varieties on the *in vitro* gas production (ml/200mg DM) of nine varieties of *Pennisetum purpureum*

	Time (hr)								
Factors	3	6	12	18	24	36	39	42	48
Manure types									
Cattle	2.00	2.00^{b}	3.77	5.77	9.25	12.74^{b}	13.03^{b}	13.70^{c}	14.88^{c}
Control	2.00	2.22^{a}	2.66	6.03	9.55	14.07^{a}	14.96^{a}	15.77^{a}	17.14^{a}
Swine	2.00	2.00^{b}	3.14	5.07	9.07	14.14^{a}	14.51^{a}	15.11^{b}	16.14^{b}
SEM	0.00	0.04	0.22	0.36	0.54	0.52	0.51	0.49	0.51
Varieties									
Abeokuta 1	2.00	2.00^{b}	3.33	5.44^{bc}	8.55^{bc}	13.66^{ab}	14.00^{ab}	15.00^{ab}	16.22^{abc}
Abeokuta 2	2.00	2.00^{b}	3.44	4.66^{bc}	6.77^{c}	10.88^{c}	11.66^{c}	12.44^{c}	14.33^{c}
F_1 Hybrid	2.00	2.00^{b}	3.66	6.00^{abc}	10.66^{ab}	14.33^{ab}	14.66^{ab}	15.33^{ab}	16.33^{abc}
Green Local	2.00	2.66^{a}	3.88	6.44^{ab}	11.33^{a}	15.33^{ab}	15.88^{a}	17.00^{a}	18.33^{a}
Purple Local	2.00	2.00^{b}	3.44	4.55^{c}	8.77^{abc}	13.66^{ab}	15.00^{ab}	15.66^{ab}	16.77^{ab}
South Africa	2.00	2.00^{b}	3.88	7.44^{a}	11.22^{a}	15.66^{a}	15.66^{a}	15.88^{ab}	16.44^{abc}
Sugarcane	2.00	2.00^{b}	3.77	6.33^{ab}	9.77^{ab}	13.44^{ab}	13.77^{ab}	14.33^{bc}	15.88^{bc}
S_{13}	2.00	2.00^{b}	3.66	6.44^{ab}	10.55^{ab}	14.00^{ab}	14.44^{ab}	15.00^{ab}	15.77^{bc}
S_{15}	2.00	2.00^{b}	2.88	5.44^{bc}	9.11^{abc}	13.11^{b}	13.44^{bc}	14.22^{bc}	15.77^{bc}
SEM	0.00	0.03	0.29	0.42	0.65	0.60	0.63	0.59	0.62

$^{a, b, c}$: Means in same column with different superscripts are significantly ($p<0.05$) different
SEM = Standard Error of Mean;

Results

The gas production profiles of the *P. purpureum* varieties as affected by the manure application were significant ($p<0.05$). There were steady increases in the volume of gas produced as incubation period extended from 3 to 48hrs. The unfertilized varieties had the highest ($p<0.05$) volume of gas production throughout the incubation period which recorded 17.75 ml/200mgDM at the end of 48hrs incubation. Among the varieties, green local variety recorded the highest ($p<0.05$) volume of gas production of 18.33 ml/200mgDM at the end of 48hrs incubation period (Table 4).

The gas production profiles as affected by the interaction between manure application and varieties are significant ($p<0.05$). The lowest (2.00ml/200mgDM) volume of gas produced at 3hrs incubation periods from the *P. purpureum* varieties in this study was observed in all the varieties with or without manure application while the highest (21.00ml/200mgDM) volume of gas produced during incubation was obtained in both unfertilized purple local and green local varieties at the end of 48hrs incubation period (Table 5).

The results on post incubation parameters showed that manure application had no effect ($p>0.05$) on the short chain fatty acid (SCFA) and Metabolizable energy (ME) in the varieties of *P. purpureum*. Meanwhile, the values for organic matter digestibility (OMD) was significantly ($p<0.05$) ranged from 33.68% in unfertilized varieties to 35.72% in varieties fertilized with swine manure. The effect of varieties on the post incubation parameters were significant ($p<0.05$). The values for SCFA significantly ($p<0.05$) ranged from 0.10µmol in Abeokuta 2 variety to 0.21µmol in green local variety while ME values ranged from 2.50 in Abeokuta 2 variety to 2.66 in South Africa and green local varieties while OMD had the highest ($p<0.05$) value (36.88%) in green local variety with the least value (32.08%) in Abeokuta 2 variety (Table 6).

Table 5: Interaction effects of manure types and varieties on the *in vitro* gas production (ml/200mg DM) of *Pennisetum purpureum*

		Time (hr)								
Manure types	Varieties	3	6	12	18	24	36	39	42	48
Cattle	Abeokuta 1	2.00	2.00^{b}	3.33^{abc}	5.33^{bcde}	8.67^{abcdef}	12.00^{de}	12.00^{fg}	12.66^{ef}	14.00^{cde}
	Abeokuta 2	2.00	2.00^{b}	4.00^{abc}	4.66^{cde}	7.33^{cdef}	11.33^{e}	11.33^{fg}	12.66^{ef}	14.00^{cde}
	F1 hybrid	2.00	2.00^{b}	3.33^{abc}	4.66^{cde}	8.67^{abcdef}	12.67^{cde}	12.67^{efg}	13.33^{def}	15.33^{cde}
	Green local	2.00	2.00^{b}	3.33^{abc}	6.66^{abcd}	10.67^{abcd}	14.00^{abcde}	14.67^{bcdefg}	16.00^{abcde}	16.67^{bcde}
	Purple local	2.00	2.00^{b}	3.33^{abc}	5.33^{bcde}	8.67^{abcdef}	11.33^{e}	12.67^{efg}	13.33^{def}	13.33^{de}
	Sugar cane	2.00	2.00^{b}	4.00^{abc}	6.00^{abcde}	10.67^{abcd}	14.00^{abcde}	14.00^{cdef}	14.00^{bcdef}	17.00^{abcde}
	South Africa	2.00	2.00^{b}	4.00^{abc}	6.66^{abcd}	10.00^{abcde}	12.67^{cde}	12.67e^{fg}	12.66^{ef}	13.33^{de}
	S_{13}	2.00	2.00^{b}	4.66^{ab}	6.66^{abcd}	10.67^{abcde}	13.00^{abcde}	13.00^{cdefg}	14.67^{bcdef}	15.33^{cde}
	S_{15}	2.00	2.00^{b}	4.00^{abc}	6.00^{abcde}	8.67^{abcdef}	13.00^{abcde}	13.33^{defg}	14.00^{cdef}	16.00^{bcde}
Control	Abeokuta 1	2.00	2.00^{b}	4.00^{abc}	7.00^{abcd}	11.00^{abcd}	17.00^{ab}	18.00^{ab}	19.00^{a}	20.00^{ab}
	Abeokuta 2	2.00	2.00^{b}	3.00^{abc}	4.00^{de}	5.00^{f}	10.00^{e}	11.00^{g}	12.00^{f}	13.00^{e}
	F1 hybrid	2.00	2.00^{b}	3.00^{abc}	4.00^{de}	5.00^{f}	10.00^{e}	11.00^{g}	12.00^{f}	13.00^{e}
	Green local	2.00	4.00^{a}	5.00^{a}	8.00^{ab}	12.00^{ab}	16.00^{abcd}	17.00^{abcd}	19.00^{a}	21.00^{a}
	Purple local	2.00	2.00^{b}	5.00^{a}	5.00^{bcde}	11.00^{abcd}	17.00^{ab}	19.00^{a}	19.00^{a}	21.00^{a}
	Sugar cane	2.00	2.00^{b}	4.00^{abc}	7.00^{abcd}	10.00^{abcde}	13.00^{bcde}	14.00^{cdef}	15.00^{bcdef}	17.00^{abcde}
	South Africa	2.00	2.00^{b}	4.00^{abc}	7.00^{abcd}	11.00^{abcd}	17.00^{ab}	17.00^{abcd}	17.00^{abcd}	18.00^{abc}
	S_{13}	2.00	2.00^{b}	3.00^{abc}	6.00^{abcde}	9.00^{abcdef}	12.00^{de}	12.00^{fg}	13.00^{ef}	14.00^{cde}
	S_{15}	2.00	2.00^{b}	2.00^{c}	5.00^{bcde}	10.00^{abcde}	14.00^{abcde}	15.00^{bcdef}	15.00^{abcde}	18.00^{abc}
Swine	Abeokuta 1	2.00	2.00^{b}	2.66^{bc}	4.00^{de}	6.00^{ef}	12.00^{de}	12.00^{fg}	13.33^{bcdef}	14.67^{cde}
	Abeokuta 2	2.00	2.00^{b}	3.33^{abc}	5.33^{bcde}	8.00^{bcdef}	11.33^{e}	12.67^{efg}	12.66^{ef}	16.00^{bcde}
	F1 hybrid	2.00	2.00^{b}	4.00^{abc}	7.33^{abc}	12.66^{a}	16.00^{abcd}	16.67^{abcd}	17.33^{abc}	17.33^{abcd}
	Green local	2.00	2.00^{b}	3.33^{abc}	4.66^{cde}	11.33^{abc}	16.00^{abcd}	16.00^{abcde}	16.00^{abcde}	17.33^{abcd}
	Purple local	2.00	2.00^{b}	2.00^{c}	3.33^{e}	6.67^{def}	12.67^{cde}	13.33^{defg}	14.67^{bcdef}	16.00^{bcde}
	Sugar cane	2.00	2.00^{b}	3.33^{abc}	6.00^{abcde}	8.67^{abcdef}	13.00^{abcde}	13.33^{defg}	14.00^{cdef}	14.67^{cde}
	South Africa	2.00	2.00^{b}	3.66^{abc}	8.66^{a}	12.66^{a}	17.33^{a}	17.33^{abc}	18.00^{ab}	18.00^{abc}
	S_{13}	2.00	2.00^{b}	3.33^{abc}	6.66^{abcd}	12.66^{a}	16.67^{abc}	17.33^{abc}	17.33^{abc}	18.00^{abc}
	S_{15}	2.00	2.00^{b}	2.66^{bc}	5.33^{bcde}	8.67^{abcdef}	12.00^{de}	12.00^{fg}	12.66^{ef}	13.33^{de}
SEM		0.00	0.42	0.13	0.20	0.31	0.31	0.31	0.30	0.32

$^{a, b, c, d, ...g}$: Means in same column with different superscripts are significantly ($p<0.05$) different. SEM = Standard Error of Mean;

Table 6: Main effects of manure types and varieties on the post incubation parameters of nine varieties of *Pennisetum purpureum*

Factors	SCFA (µmol)	ME ($MJ\ kg^{-1}$)	OMD (%)
Manure types			
Cattle	0.16	2.59	34.96^{a}
Control	0.16	2.59	33.68^{b}
Swine	0.17	2.60	35.72^{a}
SEM	0.01	0.02	0.52
Varieties			
Abeokuta 1	0.14^{cd}	2.56^{bc}	33.66^{bc}
Abeokuta 2	0.10^{d}	2.50^{c}	32.08^{c}
F_1 Hybrid	0.17^{abc}	2.59^{ab}	34.64^{ab}
Green Local	0.21^{a}	2.66^{a}	36.88^{a}
Purple Local	0.15^{bcd}	2.57^{bc}	33.95^{bc}
South Africa	0.20^{ab}	2.66^{a}	36.65^{a}
Sugarcane	0.17^{abc}	2.60^{ab}	35.16^{ab}
S_{13}	0.19^{abc}	2.63^{ab}	35.81^{ab}
S_{15}	0.16^{abcd}	2.58^{abc}	34.26^{bc}
SEM	0.02	0.09	0.82

a, b, c, d: Means in same column with different superscripts are significantly ($p<0.05$) different

The effect of interaction of manure application and varieties on the post incubation parameters was significant ($p<0.05$). SCFA value ranged from 0.08µmol in Abeokuta 1 variety fertilized with swine manure to 0.60µmol in unfertilized Abeokuta 2 variety while unfertilized Abeokuta 2 variety had the least ($2.43MJ\ kg^{-1}$) ME content and F_1 hybrid and S_{13} varieties fertilized with swine manure recorded the highest ($2.71MJ\ kg^{-1}$) and South Africa variety fertilized with swine manure had the highest (38.70%) OMD value (Table 7).

Discussion

The *in vitro* gas production technique is a useful tool in determining the dietary benefit of forages because the volume of gas produced by forage species reflects the end products of the fermentation of its substrate to volatile fatty acids (VFA), microbial biomass and neutralization of the VFA, thereby demonstrating the nutritional value of such forage (20). The results from this study were in agreement with the findings of (21) which showed that the gas volume of unfertilized varieties is higher than those fertilized with manure. This might be due to the fermentation of protein in the fertilized varieties as higher nitrogen content might cause the production of ammonia which inhibits the CO2 release from the carbonate buffer (22). The higher gas volume observed in unfertilized varieties could also be attributed to the higher non-fibre carbohydrate (NFC) content as was suggested by (23, 24) that gas production is regarded as an indicator of carbohydrate degradation. Likewise, gas production is essentially the result of fermentation of carbohydrate to acetate, propionate and butyrate. It was reported by (25) that gas production is a result of substantial changes in carbohydrate fractions while (26) reported that gas production from protein fermentation is generally little when compared with carbohydrate fermentation while contribution of fat to gas production is negligible which might be the explanation for the higher gas volume observed in the unfertilized varieties in this study. The total gas volume as influenced by the varieties of the *P. purpureum* is similar to that reported by (21) in which there is different in the total gas produced by varieties of *P. maximum*. This also could be related with the different NFC content of *P. purpureum* varieties. Gas production is a reflection of the generation of short chain fatty acids (SCFA) and microbial mass (27; 28). The short chain fatty acids (SCFA) evaluated from the gas production in this study relatively lower than that reported by (21). The SCFA value is an indication that the nutrients in grasses will be promptly used after digestion for maintenance and production. Metabolizable energy (ME) is a good index for estimating the quality of feeds especially forages. The metabolizable energy (ME) and Organic matter digestibility (OMD) value of the grass species obtained in this present study were lower than the report of (21) when diverse manure was applied on *P. purpureum* and *P. maximum*.

Table 7: Interaction effects of manure types and varieties on the post incubation parameters of *Pennisetum purpureum*

Manure types	Varieties	SCFA (µmol)	ME (MJ kg^{-1})	OMD (%)
Cattle	Abeokuta 1	0.15^{abcd}	2.57^{abcdef}	34.02^{bcd}
	Abeokuta 2	0.16^{bcd}	2.53^{bcdef}	33.35^{cd}
	F1 hybrid	0.15^{abcd}	2.57^{abcdef}	34.21^{bcd}
	Green local	0.19^{ab}	2.64^{abcd}	2.64^{abcd}
	Purple local	0.15^{abcd}	2.57^{abcdef}	34.29^{abcd}
	Sugar cane	0.19^{ab}	2.64^{abcd}	35.77^{abcd}
	South Africa	0.18^{abc}	2.62^{abcde}	36.02^{abcd}
	S_{13}	0.18^{abc}	2.62^{abcde}	36.16^{abc}
	S_{15}	0.14^{abcd}	2.57^{abcdef}	34.53^{abcd}
Control	Abeokuta 1	0.20^{ab}	2.64^{abcd}	34.69^{abcd}
	Abeokuta 2	0.60^{d}	2.43^{f}	28.94^{e}
	F1 hybrid	0.11^{bcd}	2.49^{cdef}	31.58^{de}
	Green local	0.23^{a}	2.68^{ab}	36.16^{abc}
	Purple local	0.20^{ab}	2.64^{abcd}	34.69^{abcd}
	Sugar cane	0.18^{abc}	2.61^{abcde}	2.61^{abcde}
	South Africa	0.20^{ab}	2.64^{abcd}	35.23^{abcd}
	S_{13}	0.16^{abcd}	2.57^{abcdef}	33.17^{cd}
	S_{15}	0.18^{abc}	2.61^{abcde}	33.85^{bcd}
Swine	Abeokuta 1	0.08^{cd}	2.47^{ef}	32.29^{cde}
	Abeokuta 2	0.13^{abcd}	2.54^{bcdef}	33.97^{bcd}
	F1 hybrid	0.24^{a}	2.71^{a}	38.15^{ab}
	Green local	0.21^{ab}	2.66^{abc}	38.06^{ab}
	Purple local	0.09^{bcd}	2.49^{def}	32.88^{cde}
	Sugar cane	0.15^{abcd}	2.56^{abcdef}	34.89^{abcd}
	South Africa	0.24^{a}	2.70^{a}	38.70^{a}
	S_{13}	0.24^{a}	2.71^{a}	38.16^{ab}
	S_{15}	0.15^{abcd}	2.56^{abcdef}	34.42^{abcd}
SEM		0.01	0.01	0.03

$^{a, b, c, d, ... k}$: Means in same column with different superscripts are significantly ($p<0.05$) different. SEM = Standard Error of Mean;

Conclusion and Applications

1. Unfertilized varieties of *P. purpureum* and green local variety had the highest *in vitro* gas production while varieties fertilized with swine manure and green local variety had the highest post incubation parameter.
2. Green local of *P. purpureum* is also

recommended as a good forage resource for ruminants.

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