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COMPARATIVE RESIDUAL EFFECTS OF SOME ANIMAL MANURE ON THE NUTRITIVE QUALITY OF THREE TROPICAL GRASSES

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Abstract: A study was conducted at the Research Farm, College of Animal Science and Livestock Production, Federal University of Agriculture, Abeokuta, Nigeria to determine the comparative effects of four animal manures on the nutritional quality of *Panicum maximum* (Ntchisi), *P. maximum* (unimproved local variety) and *Brachiaria decumbens* three years after application. Cattle, sheep/goat, swine and poultry manures, which were allotted to main plot, were applied to the grasses planted at 0.5m x 0.5m spacing as sub plot with zero manure as control treatment in year 2009. The grasses were cut back to a height of 15cm above the soil in year 2011 followed by harvesting of two random quadrat samples of eight- week regrowth in the early (ERS) and mid-rainy (MRS) seasons for determination of the nutrient composition, *in vitro* gas production (IVGP) and *in vitro* dry matter digestibility (IVDMD). The crude protein (CP) values for the ERS and MRS ranged from 8.09-8.71 and 8.25-8.76 % respectively and was highest ($P<0.05$) for *P. maximum* (Ntchisi) fertilized with poultry manure for both seasons. The dry matter (DM) and ether extract (EE) values during the ERS were higher ($P<0.05$) for *B. decumbens* and *P. maximum* (Ntchisi) fertilized with cattle manure while the unfertilized *B. decumbens* and *P. maximum* (Ntchisi) respectively recorded higher and lower values for acid detergent lignin (ADL). The *P. maximum* (local) treated with small ruminant manure and *B. decumbens* under the control treatment respectively recorded higher values for cellulose and hemicellulose components during the ERS. The organic matter digestibility (OMD), short-chain fatty acids (SCFAs), metabolizable energy (ME) and IVDMD were significantly affected by manure type and grass species. The IVGP values for ERS was higher for the unfertilized *P. maximum* (Ntchisi) from 3 to 12 hours while the same grass fertilized with poultry manure recorded the higher values from 60 to 72 hours of incubation. It was concluded that poultry manure application to *P. maximum* (Ntchisi) holds promise for improved pasture production.
Keywords: Comparative, animal manures, chemical composition**,** *Panicum maximum* and *Brachiaria decumbens.*

Introduction

Application of mineral fertilizers to improve nutrient element availability in the soil for enhanced crop yield is a major practice by farmers all over the world (Ojeniyi, 1990). In many sub-Saharan African countries, however, fertilizers are expensive and inefficient distribution systems often make them unavailable to farmers. Indiscriminate use of fertilizers

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without pre-planting soil evaluation is another major problem which adversely affects soil chemical and physical properties (Nottidge *et al.* 2005). Consequently, prolonged use of mineral fertilizers on tropical soils has been associated with reduced crop yields, increased soil acidity and nutrient imbalance (Ojeniyi, 2002). The potential of combined use of organic and inorganic fertilizers in increasing crop yields while maintaining the soil physicochemical properties has been noted (Palm *et al.,* 1998). 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 (Adeleye *et al.,* 2010). Animal manure has been an age long important source of plant nutrients in West African Sahelian countries (Powel *et al.,* 1996). The manure contains both nitrate (NO_3^-) and ammonium (NH_4^+) ions that become available for plant uptake immediately after application and organic N which is slowly released as the organic matter become mineralized. In this context the effect of farm yard manure on crop yield was reported to be highest in the second or third year following application (Jokela, 1992). Similarly, organic manure proved more effective in enhancing the chemical composition of tropical pasture grasses when compared with those under urea fertilization (Arigbede *et al.,* 2011). However, there appears to be scarcity of research information on the comparative effect of different animal manures on the chemical composition of notable tropical grasses years after application in Southwest Nigeria. The Southwest, a predominantly crop producing part of Nigeria, is presently witnessing unprecedented increase in cattle population which may necessitate the use of sown pasture in the foreseeable future when such information might become veritable. This study therefore aims at determining the comparative effect of different animal manures on the nutritive quality of two *Panicum maximum* species and *Brachiaria decumbens* in Southwest Nigeria, three years after application.

Materials and Methods

Experimental site

The experiment was carried out at the Teaching and Research Farm, Federal University of Agriculture, Abeokuta (FUNAAB). The site is located in the derived savannah zone of Southwest Nigeria with rainfall ranges of 1200 - 1500 mm and mean monthly temperature ranges of 22.5^{o}C - 33.7^{o}C. Relative humidity during the rainy (late March - October) and dry (November - early March) season ranges between 63 - 96 % and 55 - 84 % respectively.

Experimental design and procedure

The experiment was established in June 2009 using randomized complete block design with three replicates. Treatments were arranged as 3 x 4 factorial with the factors including four animal manures [Cattle (CM) , Small ruminant (SRM), Swine (SM) and Poultry (PM)] and three grasses [*Panicum maximum* (Ntchisi),*Panicum maximum* (Local) and *Brachiaria decumbens*]. The treatment also included a control (i.e. zero manure) whereby the grasses were planted without any manure application. An inter-row spacing of 0.5m x 0.5m was used for the grasses. The manure was allotted to main plots measuring 15m x 15m each and grass species to sub-plots with the dimension of 4m x 15m each. There were fifteen treatment combinations in all. The plots were managed by manual weeding throughout the 2010 growing season and the grasses were allowed to fully grow and dry up on the field. The plots accidentally got burnt in early February 2011 but the grasses rapidly re-grew in the early rains beginning from early March 2011. The regrowth were cut back to a stubble height of about 15 cm in late March 2011to ensure uniform growth.

Forage sample collection

At eight weeks after the grasses were cut back, two random quadrat samples were harvested per plot for early rainy (April-June) season (ERS) and mid rainy (MRS) season, and sub samples were taken from the materials harvested. These were mixed thoroughly and single sub samples were taken, weighed and oven dry at $65^{o}C$ to remove moisture content. Thereafter, the dried samples were milled in the laboratory using stainless steel mill with 1mm-sieves.

Chemical analyses

Proximate composition

The dry matter content (DM %), crude protein (CP %), ether extract (EE %) and ash % were determined according to A.O.A.C. (2000) and Non-fibre carbohydrate (NFC %) was calculated.

Fibre fractions

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

In vitro gas digestibility

At each harvesting time, the *in vitro* gas production to estimate the digestibility of the grasses with different manure was determined according to the procedure of Menke and Steingass (1988). Gas production was recorded at 0, 3, 6, 9, 12, 24, 36, 48, 60 and 72 hours of incubation. The data obtained were fitted to the non-linear equation: $V\ (ml/200mgDM) = b\ (1 - e^{-ct})$; 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 (Menke and Steingass, 1988).

Short-chain fatty acids (SCFA) was estimated as

SCFA = 0.0239GV–0.0601 (Getachew *et al.,* 2004).

Metabolizable energy (ME) was calculated as

ME= 2.20 + 0.136GV+ 0.057 CP + 0.0029 EE^2 (Menke and Steingass, 1988).

Total gas volume at 24 hours of incubation (GV) was expressed as ml/200 mg, DM, CP and ash as g/kg OMD, ME as MJ/kgDM and SCFA as µmol/g DM

***In- vitro* dry matter digestibility (IVDMD)**

After 72 hours of digestion, the residues were filtered using filter paper by gravity and the residues were placed in the oven for drying at 65^0C for 24hours. The dry residues were weighed and digestibility was calculated using the equation as follows:

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

Statistical analysis

Data obtained were subjected to analysis of variance using the general linear model (GLM) procedure of SAS (1999) package in a 3 x 4 factorial arrangement with 3 field replicates. The model used was $Y_{ijkl} = \mu + M_i + S_j + (MS)_{ij}\sum_{ijk},$ where Y_{jkl} = observation; μ = population mean; M_i = effect of residual animal manures; S_j = effect of species; $(MS)_{ij}$ = Interaction effects of residual animal manures and species and $\sum_{ijk}$ = Residual error estimate. Differences among means with P<0.05 were accepted as representing statistically significant differences (Duncan, 1955).

Results and Discussion

The effects of animal manures on proximate composition of the grasses during the early rainy season as shown in Table 1 indicated that CP, EE and DM values were significantly (P<0.05) influenced by the manure as against ash and NFC that were not affected (P > 0.05).

The *P. maximum* (Ntchisi) that received PM manure recorded the highest value (8.71 %) for CP compared with *P. maximum* (Local) which was fertilized with CM that had the lowest CP value (8.09 %).The *P. maximum* (Ntchisi) and *B. decumbens* fertilized with CM and SM respectively recorded the highest value (7.0 %) for EE as against 1.0% for *P. maximum* (Local) which received SRM. The highest DM value (96.50 %) was recorded for *B. decumbens* fertilized with CM in comparison with the value of 93.0 % for *P. maximum* (Local) fertilized with SM which was lowest. As indicated in Table 2, the fibre composition of the grasses including NDF, ADF, ADL, cellulose (CEL) and hemicellulose (HEM) were significantly ($P < 0.05$) influenced by manure treatments and species. The *P. maximum* (Local) which received SRM recorded the highest values (64.0 % and 51.4 %) for NDF and ADF respectively, while *B. decumbens* fertilized with SM recorded the lowest value (58.0 %) for NDF and the same grass with SRM recorded the lowest value (41.45 %) for ADF. Furthermore, *P. maximum* (Local) fertilized with SRM had the highest CEL content (42.81 %) compared with *B. decumbens* under the control treatment with the lowest CEL value (19.97 %). However, the unfertilized *B. decumbens* recorded higher values (22.43 % and 29.60 %) for ADL and HEM respectively. Similarly, *P. maximum* (Ntchisi) under the control treatment recorded the lowest value (7.73 %) for ADL and *P. maximum* (Local) with SRM recorded the least value (22.65 %) for HEM.

The effects of animal manure on the proximate and fibre compositions of the three grass species during the mid-rainy season as indicated in Tables 3 and 4 were similar to observations for the early wet season. The CP and EE values were significantly ($P < 0.05$) different, while ash, non-fibre carbohydrate (NFC), DM were not different significantly ($P > 0.05$). The *P. maximum* (Ntchisi) fertilized with PM recorded the highest values (8.76 % and 5.00 %) for CP and EE, respectively, while, *P. maximum* (Ntchisi) with SRM recorded the lowest value (8.30 %) for CP and *P. maximum* (Ntchisi) fertilized with SM had the lowest value (2.00 %). The NDF, ADF, ADL, CEL and HEM compositions of the grasses were significantly ($P < 0.05$) influenced. The local *P. maximum* species fertilized with CM recorded the highest values for ADF and CEL (50.35 % and 42. 00 % respectively) compared with *B. decumbens* with PM which respectively had the lowest values (44.36 % and 27.91 %). Meanwhile, *B. decumbens* fertilized with PM had the highest values (16.45 % and 29.64 %) for both ADL and HEM respectively while the ADL value recorded for *P. maximum* (Ntchisi) with SM was 6.62 % and HEM for *P. maximum* (Local) with CM was 22.65 % both of which were lowest values.

The highest CP values were recorded for *P. maximum* (Ntchisi) fertilized with PM for both seasons which was an indication of a more positive effect of that manure on the grasses at both seasons of the year. This observation agrees with the earlier findings by Sodeinde *et al.* (2009) which indicated that PM application to *P. maximum* cv T58 harvested at six weeks of regrowth significantly enhanced leaf and stem production than the control treatment without manure. Poultry manure might have rapid organic matter decomposition, and quick release of nutrients, in the form of nitrogen and phosphorous for plant uptake because it contains higher concentrations of uric acid and phosphorus-bearing feed materials that could be readily available for further conversion into plant nutrients soon after application to soil. In addition, PM usually contains less fibre materials and its rate of microbial degradation and release of nutrients might therefore be hastened than its counterparts from other animals. Schegel (1992) had observed that poultry manure had the highest effect on N and P availability in the soil than the other animal manures. The CP values obtained in this study were within the range required for optimum performance of ruminants. According to Minson (1990), if the CP content of a feed is lower than 7% of DM, animal performance could decline due to low voluntary intake, lower rate of digestibility and negative nitrogen balance. The forage materials harvested during both seasons, however, had sufficient CP content to satisfy this minimum animal requirement as recommended by Minson (1990). During the early rainy season, *B. decumbens* and *P. maximum* (Ntchisi) fertilized with CM respectively recorded the highest values for DM and EE. Meanwhile, *P. maximum* (Ntchisi) fertilized with PM recorded the highest value for EE during mid-rainy season.

Forage digestibility depends mainly on the cellular content and the nature of the cell wall which is made up mainly of cellulose, hemicellulose and lignin. The cellulose in young grasses is almost completely digested by ruminants, but lignification decreases its digestibility with increasing maturity. Hemicellulose is composed of a mixture of different carbohydrates that vary in digestibility, whereas lignin is vastly resistant to rumen fermentation (Thorvaldsson, 2006). Inconsistent results have been reported on effects of fertilization on CP, NDF and ADF concentrations. Min *et al.* (2002) reported that application at rates of 410, 690, 830, and 970 kg N ha^{-1} increased CP concentration compared with the control treatment, with no effect on ADF and NDF. The results obtained in the present study confirmed these earlier reports as the NDF was not significantly affected by the manures as indicated by the forage materials harvested during the mid-rainy season. Other reports have also shown non-significant effects of increased N fertilization on the NDF concentration in forage plants (e.g. Rogers *et al.,* 1996; Cuomo and Anderson, 1996). Johnson, *et al.* (2001) reported that the NDF concentration linearly decreased with increasing N fertilization which appeared to be in conformity with the observation in the early rainy season in the present study. Adeli *et al*. (2005) also found that NDF concentration peaked at the low fertilizer rate and then decreased with increasing fertilizer levels. The grass species and manure type in this study had significant influence on the NDF content of the forages harvested during the early rainy season. The other fibre components (i.e. ADF, ADL, cellulose and hemicellulose) were significantly affected by manure types and species in both harvests. The ADF had highest value in the *P. maximum* (local) harvested from the plots fertilized with CM during the second cutting and the same grass but fertilized with SRM during the early rainy season recorded highest value. Lignin is the indigestible plant component, giving the plant cell wall strength and making it impermeable to water. The lower the lignin content of forage the higher its digestibility and utilization by animals and fertilizer treatments have been reported to have varied influences on the lignin content in forages. Holubek *et al*. (1999) observed that non-fertilized semi-natural grassland contained on average 5.50 to 6.08% lignin while the same grassland fertilized contained 5.77 to 6.20% lignin. According to Wolf and Boberfeld (2003) the value of ADL increased with increasing amounts of N, in tall fescue. The observations in the present study were fairly consistent. Even though the highest ADL value was recorded for the unfertilized *B. decumbens* that of the unfertilized *P. maximum* (Ntchisi) was lowest in early rainy season. During mid-rainy season the *B. decumbens* fertilized with poultry manure recorded the highest value and *P. maximum* (Ntchisi) fertilized with swine manure had the lowest value. The inconsistent values obtained might due to the poor performance of *B. decumbens* treated with SM and PM during the early rainy season. Generally, grasses that are fertilized with manure receive higher N which supports a fast rate of growth of the grasses, and as they advance in age due to improved nutrient availability, the stem proportion increases relative to the leaf. The stem, and to a lesser extent, the leaf, become rapidly fibrous and lignified, thus increasing the lignin content of the overall feed material. The higher value recorded for *B. decumbens* than *P. maximum* (Ntchisi) probably indicated more rapid lignification of the latter than the former grass. The higher ADL values in the first than the second harvest might be due to higher stem components in the earlier than the latter harvests. Even though the leaf to stem ratios of the grasses were not determined in this study, higher soil moisture at the time of the first harvesting (being the early rainy season) could have enhance rapid stem development. The *P. maximum* (local) treated with

SRM had the highest value for cellulose while unfertilized *B. decumbens* recorded the highest value for hemicellulose during the early rainy period. But in the second harvest, *P. maximum* (local) fertilized with CM recorded the highest and the lowest values for cellulose and hemicellulose respectively. *B. decumbens* fertilized with PM had the highest and the lowest values for hemicellulose and cellulose respectively. This shows that there is little or no difference in the cellulose and hemicellulose contents for both harvests.

The effects of animal manure and species shows that the values for fermentation of the insoluble fraction (b), gas production rate constant (c), *in vitro* dry matter digestibility (IVDMD), organic matter digestibility (OMD), short chain fatty acids (SCFAs) and metabolizable energy (ME) were significantly (P < 0.05) different (Table 5). The *P. maximum* (Ntchisi) under the unfertilized control treatment recorded the highest values (10.38 ml/200/mgDM, 38.36 % and 4.71 MJ/kg) for b, OMD and ME respectively while *P. maximum* (Local) fertilized with CM had the highest (94.00 %) and the lowest (3.31 ml/200/mgDM) values for IVDMD and b respectively and *P. maximum* (Local) fertilized with PM recorded the lowest value (80.00 %) for IVDMD. The *P. maximum* (Local) fertilized with SRM had the highest value (2.80 ml/hr) and unfertilized *P. maximum* (Ntchisi) recorded the least value (0.00 ml/hr) for c. *P. maximum* (Ntchisi) fertilized with SM had the lowest values (27.91%, 0.01µmol/gDM and 3.10 MJ/kg) for OMD, SCFAs and ME respectively. Meanwhile, unfertilized *B. decumbens* recorded the highest value (0.41µmol/gDM) for SCFAs. The effects of animal manure and grass species were significant (P < 0.05) for *in vitro* gas production volume through the hours of incubation (Table 6). The unfertilized *P. maximum* (Ntchisi) recorded the highest values (12.00 – 14.50 ml/200mgDM) from 3-12 hours, while *P. maximum* (Ntchisi) fertilized with SRM recorded the lowest values (0.00 - 2.50 ml/200mgDM) from 3 to 9 hours of incubation. At 24 to 60 hours of incubation, *B. decumbens* under the control treatment recorded 19.50 – 37.50 ml/200mgDM which were lower than 37.50 – 41.50 ml/200mgDM recorded by *P. maximum* (Ntchisi) fertilized with PM at 60 to 72 hours of incubation. The values for c, IVDMD, OMD, SCFA and ME () were significantly (P < 0.05) different during the mid-rainy season. *P. maximum* (Ntchisi) fertilized with CM had the highest value (2.29 ml/hr) and *B. decumbens* fertilized with SM or PM recorded the lowest value (0.07 ml/hr) for c. In the case of IVDMD, the *P. maximum* (Local) fertilized with CM had the highest value (91.00%) and *P. maximum* (Ntchisi) with SRM had the lowest value (78.50%). *Brachiaria decumbens* fertilized with PM recorded the highest values (43.10%, 0.42 µmol/gDM and 5.42 MJ/KgDM) for OMD, SCFAs and ME respectively, while the unfertilized *P. maximum* (Ntchisi) recorded the lowest values. The effects of residual animal manure and species on *in vitro* gas production volume (ml/200mgDM) of three grass species during mid-rainy season as shown in Table 8 indicated significant difference ($P<0.05$) in gas volumes produced for all hours of incubation. The highest gas volume was recorded for *B. decumbens* fertilized with PM recorded highest values (9.00-40.00 ml/200mgDM) and the lowest value (0.00-1.00 ml/200mgDM) for *P. maximum* (Ntchisi) fertilized with SRM from 3 to 6 hours of incubation.

CONCLUSION

The results of this study suggest that the *P. maximum* (Ntchisi) fertilized with poultry manure have the potential to improve pasture and hence, ruminant production in a sustainable agricultural system. The use of *P. maximum* (Ntchisi) in sown pasture for its high quality when fertilized with poultry manure should therefore be encouraged especially for smallholder ruminant production system prevalent in developing countries.

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Table 1: Effect of residual animal manure on the proximate composition of the three grass species during the early rainy season

TREATMENT		PARAMETERS				
MANURE TYPE	GRASS SPECIES	DM (%)	CP (%)	EE (%)	ASH (%)	NFC (%)
Cattle	*P. maximum* (Ntchisi)	94.50[abc]	8.20[cde]	7.00[a]	10.85	12.95
	P. maximum (Local)	95.50[ab]	8.09[e]	2.50[c-f]	9.80	20.61
	Brachiaria decumbens	96.50[a]	8.15[de]	4.50[bc]	10.50	15.85
Swine	*P. maximum* (Ntchisi)	95.50[ab]	8.35[bcd]	2.00[c-f]	10.15	18.51
	P. maximum (Local)	93.00[c]	8.50[ab]	2.00[c-f]	8.40	17.10
	Brachiaria decumbens	93.50[bc]	8.50[ab]	7.00[a]	10.15	16.35
Small ruminant	*P. maximum* (Ntchisi)	94.50[abc]	8.25[cde]	4.00[bcd]	11.55	13.21
	P. maximum (Local)	93.50[bc]	8.36[bcd]	1.00[f]	9.45	17.20
	Brachiaria decumbens	95.50[ab]	8.53[ab]	3.00[b-f]	10.85	17.63
Poultry	*P. maximum* (Ntchisi)	94.00[bc]	8.71[a]	5.00[ab]	9.80	15.84
	P. maximum (Local)	95.50[ab]	8.32[b-e]	2.50[c-f]	8.75	17.43
	Brachiaria decumbens	94.50[abc]	8.36[bcd]	3.50[b-d]	14.70	12.09
Control	*P. maximum* (Ntchisi)	95.00[abc]	8.34[bcd]	4.50[bc]	10.50	15.66
	P. maximum (Local)	95.00[abc]	8.36[bcd]	1.50[ef]	9.45	17.69
	Brachiaria decumbens	95.50[ab]	8.43[bc]	4.50[bc]	9.80	15.27
SEM		0.51	0.06	0.48	1.45	2.84

a-f: means on the same column with different superscripts are significantly different ($P < 0.05$), DM=dry matter, CP=crude protein, EE=ether extract, NFC=non fibre carbohydrate, SEM=standard error of mean

Table 2: Effect of residual animal manure on fibre composition of the three grass species during the early rainy season

TREATMENT		PARAMETERS				
MANURE TYPE	GRASS SPECIES	NDF (%)	ADF (%)	ADL (%)	CEL (%)	HEM (%)
Cattle	*P. maximum* (Ntchisi)	61.00^{ab}	46.40^{bc}	14.02^{bcd}	32.38^{c}	24.60^{ab}
	P. maximum (Local)	59.00^{ab}	45.40^{bcd}	11.58^{b-f}	33.82^{bc}	23.60^{ab}
	Brachiaria decumbens	61.00^{ab}	45.50^{bcd}	9.24^{c-f}	36.27^{bc}	25.50^{ab}
Swine	*P. maximum* (Ntchisi)	61.00^{ab}	45.40^{bcd}	11.36^{b-f}	34.04^{bc}	25.60^{ab}
	P. maximum (Local)	64.00^{a}	47.36^{b}	12.86^{b-f}	34.50^{bc}	26.64^{ab}
	Brachiaria decumbens	58.00^{b}	43.32^{cde}	10.53^{c-f}	32.79^{c}	24.68^{ab}
Small ruminant	*P. maximum* (Ntchisi)	63.00^{ab}	46.40^{bc}	14.02^{bcd}	32.38^{c}	26.60^{ab}
	P. maximum (Local)	64.00^{a}	51.35^{a}	8.55^{ef}	42.81^{a}	22.65^{b}
	Brachiaria decumbens	60.00^{ab}	41.45^{e}	14.52^{bc}	26.93^{d}	28.55^{ab}
Poultry	*P. maximum* (Ntchisi)	61.00^{ab}	47.36^{b}	11.36^{b-f}	35.81^{bc}	23.64^{ab}
	P. maximum (Local)	63.00^{ab}	46.40^{bc}	8.89^{d-f}	37.51^{b}	26.60^{ab}
	Brachiaria decumbens	61.00^{ab}	43.40^{cde}	16.59^{b}	26.81^{d}	27.60^{ab}
Control	*P. maximum* (Ntchisi)	61.00^{ab}	44.40^{b-e}	7.73^{f}	36.67^{bc}	26.60^{ab}
	P. maximum (Local)	63.00^{ab}	46.40^{bc}	13.34^{b-e}	33.06^{c}	26.60^{ab}
	Brachiaria decumbens	62.00^{ab}	42.40^{de}	22.43^{a}	19.97^{e}	29.60^{a}
SEM		1.30	0.72	1.14	1.07	1.45

a-f: means on 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, CEL=cellulose, HEM=hemicellulose

Table 3: Effect of residual animal manure on proximate composition of the three grass species during the mid-rainy season

TREATMENT		PARAMETERS				
MANURE TYPE	GRASS SPECIES	DM (%)	CP (%)	EE (%)	ASH (%)	NFC (%)
Cattle	*P. maximum* (Ntchisi)	95.00	8.46^{a-d}	4.00^{ab}	12.95	12.51
	P. maximum (Local)	95.00	8.32^{cd}	4.50^{ab}	11.90	12.29
	Brachiaria decumbens	95.50	8.32^{cd}	4.50^{ab}	11.20	11.98
Swine	*P. maximum* (Ntchisi)	95.00	8.25^{d}	2.00^{b}	11.20	16.55
	P. maximum (Local)	94.50	8.26^{d}	4.50^{ab}	9.45	14.90
	Brachiaria decumbens	95.50	8.42^{bcd}	3.50^{ab}	8.75	14.84
Small ruminant	*P. maximum* (Ntchisi)	95.50	8.30^{d}	4.00^{ab}	10.85	13.86
	P. maximum (Local)	94.00	8.41^{bcd}	5.00^{a}	8.75	12.85
	Brachiaria decumbens	95.50	8.34^{cd}	3.50^{ab}	10.15	16.01
Poultry	*P. maximum* (Ntchisi)	94.00	8.76^{a}	5.00^{a}	10.85	13.40
	P. maximum (Local)	94.00	8.47^{a-d}	2.50^{ab}	10.15	13.89
	Brachiaria decumbens	95.00	8.46^{a-d}	2.50^{ab}	10.15	14.90
Control	*P. maximum* (Ntchisi)	94.00	8.64^{abc}	3.00^{ab}	10.85	12.29
	P. maximum (Local)	93.50	8.68^{ab}	4.50^{ab}	8.75	14.07
	Brachiaria decumbens	94.50	8.38^{bcd}	3.00^{ab}	9.45	14.84
SEM		0.51	0.07	0.67	2.10	2.65

a-d: means on the same column with different superscripts are significantly different ($P< 0.05$), DM=dry matter, CP=crude protein, EE=ether extract, NFC=non fibre carbohydrate, SEM=standard error of mean

Table 4: Effect of residual animal manure on fibre composition of the three grass species during the mid-rainy season

TREATMENT		PARAMETERS				
MANURE TYPE	GRASS SPECIES	NDF (%)	ADF (%)	ADL (%)	CEL (%)	HEM (%)
Cattle	*P. maximum* (Ntchisi)	62.00	48.40^{ab}	$10.87^{b\text{-}e}$	$37.53^{a\text{-}e}$	23.60^{bc}
	P. maximum (Local)	63.00	50.35^{a}	8.35^{de}	42.00^{a}	22.65^{c}
	Brachiaria decumbens	64.00	46.40^{bc}	14.29^{abc}	32.11^{efg}	27.60^{ab}
Swine	*P. maximum* (Ntchisi)	62.00	45.40^{bc}	6.62^{e}	38.78^{abc}	26.60^{abc}
	P. maximum (Local)	65.00	46.40^{bc}	8.51^{de}	$37.89^{a\text{-}d}$	28.60^{a}
	Brachiaria decumbens	62.00	45.36^{bc}	7.14^{e}	$38.22^{a\text{-}d}$	26.60^{abc}
Small ruminant	*P. maximum* (Ntchisi)	63.00	46.40^{bc}	6.82^{e}	39.58^{ab}	26.60^{abc}
	P. maximum (Local)	65.00	46.40^{bc}	$13.44^{a\text{-}d}$	$32.96^{d\text{-}f}$	28.60^{a}
	Brachiaria decumbens	62.00	46.35^{bc}	15.51^{ab}	30.84^{fg}	25.65^{abc}
Poultry	*P. maximum* (Ntchisi)	62.00	46.36^{bc}	9.61^{cde}	$36.75^{a\text{-}e}$	25.64^{abc}
	P. maximum (Local)	65.00	47.40^{abc}	13.96^{abc}	$33.44^{c\text{-}f}$	27.60^{ab}
	Brachiaria decumbens	64.00	44.36^{c}	16.45^{a}	27.91^{g}	29.64^{a}
Control	*P. maximum* (Ntchisi)	65.00	45.40^{bc}	9.11^{cde}	$36.2^{9b\text{-}f}$	29.60^{a}
	P. maximum (Local)	64.00	44.40^{c}	$11.58^{a\text{-}e}$	$32.82^{d\text{-}g}$	29.60^{a}
	Brachiaria decumbens	65.00	47.40^{abc}	$10.87^{b\text{-}e}$	$36.53^{a\text{-}e}$	27.60^{ab}
SEM		0.95	0.73	1.13	1.16	1.15

a-g: means on 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, CEL=cellulose, HEM=hemicelluloses

Table 5: Effect of residual animal manure and species on *in vitro* dry matter digestibility and post incubation kinetics of the three grass during the early rainy season

TREATMENT		PARAMETERS						
MANURE TYPE	GRASS SPECIES	b (ml/200/mgDM)	c (ml/hr)	Lag	IVDMD (%)	OMD (%)	SCFAs (µmol/gDM)	ME (MJ/kg)
Cattle	*P. maximum* (Ntchisi)	4.64[ab]	1.05[ab]	0.98	91.00[abc]	32.30[abc]	0.24[ab]	3.83[ab]
	P. maximum (Local)	3.31[b]	0.41[b]	-11.79	94.00[a]	32.46[abc]	0.19[b]	3.84[ab]
	Brachiaria decumbens	3.57[b]	0.66[ab]	-3.72	93.00[ab]	32.27[abc]	0.26[ab]	3.78[abc]
Swine	*P. maximum* (Ntchisi)	6.49[ab]	0.72[ab]	-5.41	84.00[cd]	27.91[d]	0.01[c]	3.10[d]
	P. maximum (Local)	4.60[ab]	0.31[b]	-8.88	83.50[cd]	30.84[a-d]	0.30[ab]	3.72[abc]
	Brachiaria decumbens	9.05[ab]	0.60[ab]	1.53	88.00[a-d]	28.87[cd]	0.27[ab]	3.37[cd]
Small ruminant	*P. maximum* (Ntchisi)	4.64[ab]	0.87[ab]	1.06	80.50[d]	31.00[a-d]	0.29[ab]	3.46[bcd]
	P. maximum (Local)	4.54[ab]	2.80[a]	2.54	87.00[a-d]	30.57[a-d]	0.18[b]	3.56[a-d]
	Brachiaria decumbens	6.29[ab]	0.33[b]	2.98	86.50[a-d]	32.01[abc]	0.37[ab]	3.66[abc]
Poultry	*P. maximum* (Ntchisi)	6.20[ab]	0.32[b]	1.60	85.00[bcd]	32.07[abc]	0.36[ab]	3.82[ab]
	P. maximum (Local)	4.64[ab]	0.95[ab]	1.02	80.00[d]	30.10[bcd]	0.30[ab]	3.58[abc]
	Brachiaria decumbens	5.28[a]	0.66[ab]	1.49	87.00[a-d]	34.21[ab]	0.33[ab]	3.63[abc]
Control	*P. maximum* (Ntchisi)	10.38[a]	0.00[b]	-41.28	85.00[bcd]	38.36[a]	0.33[ab]	4.71[a]
	P. maximum (Local)	7.63[ab]	0.37[b]	-2.38	89.00[abc]	33.60[ab]	0.30[ab]	4.03[ab]
	Brachiaria decumbens	4.75[ab]	0.06[b]	-4.35	83.50[cd]	34.83[ab]	0.41[a]	4.24[a]
SEM		1.36	0.37	3.20	2.08	4.06	0.04	0.50

a-d: means on the same column with different superscripts are significantly different ($P < 0.05$), SEM=standard error of mean

Table 6: Effects of residual animal manure on *in vitro* gas production (ml/200mgDM) of three grasses during the early rainy season

TREATMENT		GAS VOLUME PRODUCTION (ml/200gmDM)								
MANURE TYPE	GRASS SPECIES	3HRS	6HRS	9HRS	12HRS	24HRS	36HRS	48HRS	60HRS	72HRS
Cattle	*P. maximum* (Ntchisi)	5.50^{abc}	6.00^{bcd}	6.75^{ab}	7.50^{bc}	12.50^{ab}	19.00^{abc}	24.00^{abc}	28.75^{abc}	31.50^{abc}
	P. maximum (Local)	8.00^{ab}	8.00^{abc}	8.00^{ab}	8.50^{abc}	10.50^{b}	13.00^{cd}	15.50^{cd}	17.50^{cd}	18.00^{cd}
	Brachiaria decumbens	5.50^{abc}	6.00^{bcd}	7.00^{ab}	7.75^{bc}	13.50^{ab}	20.25^{abc}	25.50^{abc}	29.00^{abc}	30.75^{abc}
Swine	*P. maximum* (Ntchisi)	2.50^{bc}	3.00^{bcd}	3.00^{b}	3.00^{c}	3.00^{c}	7.50^{d}	10.50^{d}	13.00^{d}	15.00^{d}
	P. maximum (Local)	5.50^{abc}	6.50^{a-d}	7.00^{ab}	7.50^{bc}	15.00^{ab}	21.00^{abc}	27.00^{abc}	31.50^{abc}	33.50^{abc}
	Brachiaria decumbens	1.50^{bc}	2.00^{cd}	2.50^{b}	4.00^{c}	14.00^{ab}	22.00^{abc}	29.50^{ab}	32.00^{abc}	34.50^{ab}
Small ruminant	*P. maximum* (Ntchisi)	0.00^{c}	0.50^{d}	2.50^{b}	5.50^{bc}	14.50^{ab}	22.50^{abc}	27.75^{abc}	31.00^{abc}	33.00^{abc}
	P. maximum (Local)	0.00^{c}	3.50^{bcd}	5.00^{b}	6.50^{bc}	10.00^{b}	15.00^{bcd}	18.50^{bcd}	21.00^{bcd}	22.50^{bcd}
	Brachiaria decumbens	1.50^{bc}	1.50^{cd}	4.50^{b}	7.00^{bc}	18.00^{ab}	26.50^{a}	31.75^{ab}	35.00^{ab}	36.00^{ab}
Poultry	*P. maximum* (Ntchisi)	2.00^{bc}	3.75^{bcd}	4.50^{b}	7.75^{bc}	17.00^{ab}	26.00^{a}	33.50^{a}	37.50^{a}	41.50^{a}
	P. maximum (Local)	2.25^{bc}	4.25^{bcd}	5.50^{b}	6.50^{bc}	15.00^{ab}	21.00^{abc}	28.00^{abc}	29.50^{abc}	32.50^{abc}
	Brachiaria decumbens	1.50^{bc}	3.50^{bcd}	4.50^{b}	6.75^{bc}	16.00^{ab}	25.50^{ab}	30.00^{ab}	32.00^{abc}	33.00^{abc}
Control	*P. maximum* (Ntchisi)	12.00^{a}	12.80^{a}	13.25^{a}	14.50^{a}	16.50^{ab}	19.50^{abc}	22.00^{a-d}	25.25^{a-d}	27.00^{a-d}
	P. maximum (Local)	6.75^{abc}	7.00^{a-d}	8.00^{ab}	9.90^{ab}	15.00^{ab}	22.00^{abc}	29.45^{ab}	32.50^{ab}	35.00^{ab}
	Brachiaria decumbens	8.00^{ab}	8.50^{ab}	8.50^{ab}	11.00^{ab}	19.50^{a}	28.00^{a}	35.00^{a}	37.50^{a}	41.00^{a}
SEM		1.52	1.49	1.46	1.55	1.77	2.45	3.27	3.35	3.63

a-d: means on the same column with different superscripts are significantly different ($P < 0.05$), SEM=standard error of mean, HRS=hours of incubation

Table 7: Effect of residual animal manure on *in vitro* dry matter digestibility and post incubation kinetics of the three grasses during the mid-rainy season

TREATMENT MANURE TYPE	GRASS SPECIES	PARAMETERS b (ml/200mgDM)	c (ml/hr)	Lag	IVDMD (%)	OMD (%)	SCFAs (µmol/gDM)	ME(MJ/kg)
Cattle	*P. maximum* (Ntchisi)	6.76	2.29^{a}	-0.11	88.50^{abc}	38.67^{ab}	0.21^{c-f}	4.50^{ab}
	P. maximum (Local)	4.64	0.94^{b}	1.03	91.00^{a}	35.26^{abc}	0.18^{c-f}	4.09^{a-d}
	Brachiaria decumbens	7.18	0.31^{b}	-3.89	81.50^{bcd}	39.25^{a}	0.30^{a-e}	4.77^{a}
Swine	*P. maximum* (Ntchisi)	5.99	0.66^{b}	-113.62	82.50^{a-d}	34.33^{abc}	0.17^{d-f}	3.97^{bcd}
	P. maximum (Local)	5.20	0.64^{b}	-1.30	87.50^{a-d}	32.75^{bc}	0.16^{ef}	3.95^{cd}
	Brachiaria decumbens	8.05	0.07^{b}	-1.36	90.50^{ab}	37.70^{ab}	0.30^{a-e}	4.76^{ab}
Small ruminant	*P. maximum* (Ntchisi)	6.27	0.59^{b}	2.12	78.50^{d}	38.57^{ab}	0.29^{a-e}	4.69^{ab}
	P. maximum (Local)	4.64	0.89^{b}	1.05	87.00^{a-d}	36.81^{ab}	0.27^{a-e}	4.66^{ab}
	Brachiaria decumbens	5.67	0.32^{b}	2.46	83.50^{a-d}	41.69^{a}	0.38^{ab}	5.23^{a}
Poultry	*P. maximum* (Ntchisi)	5.74	0.56^{b}	1.56	80.00^{cd}	36.11^{abc}	0.21^{c-f}	4.34^{abc}
	P. maximum (Local)	5.26	0.62^{b}	0.87	85.00^{a-d}	34.63^{abc}	0.19^{c-f}	4.13^{a-d}
	Brachiaria decumbens	6.02	0.07^{b}	1.34	84.50^{a-d}	43.07^{a}	0.42^{a}	5.42^{a}
Control	*P. maximum* (Ntchisi)	6.78	0.31^{b}	-74.98	86.00^{a-d}	32.05^{c}	0.11^{f}	3.67^{d}
	P. maximum (Local)	6.31	0.35^{b}	1.89	84.00^{a-d}	39.37^{ab}	0.34^{abc}	5.03^{a}
	Brachiaria decumbens	6.45	0.34^{b}	1.72	85.00^{a-d}	38.58^{ab}	0.31^{a-d}	4.81^{a}
SEM		0.91	0.29	2.32	1.92	3.98	0.03	0.45

a-f: means on the same column with different superscripts are significantly different ($P< 0.05$), IVDMD=*in vitro* dry matter digestibility, OMD=organic matter digestibility, SCFAs=short chain fatty acids, ME=metabolizable energy, SEM=standard error of mean

Table 8: Effect of residual animal manure on *in vitro* gas production (ml/200mgDM) of three grasses during the mid-rainy season

TREATMENT		GAS VOLUME PRODUCTION (ml/200gmDM)								
MANURE TYPE	GRASS SPECIES	3HRS	6HRS	9HRS	12HRS	24HRS	36HRS	48HRS	60HRS	72HRS
Cattle	*P. maximum* (Ntchisi)	6.50^{a}	7.00^{a}	8.00^{a}	9.00^{a}	13.00^{b-f}	17.50^{bc}	20.00^{cd}	22.50^{c}	23.50^{cd}
	P. maximum (Local)	3.00^{a-d}	3.50^{a-d}	4.50^{bc}	5.00^{a-d}	10.00^{d-f}	16.50^{bc}	22.00^{bcd}	24.50^{b-f}	27.50^{a-d}
	Brachiaria decumbens	6.00^{ab}	6.50^{ab}	8.00^{a}	8.75^{a}	15.00^{a-e}	22.75^{ab}	29.00^{abc}	32.25^{abc}	34.25^{ab}
Swine	*P. maximum* (Ntchisi)	5.00^{abc}	5.75^{abc}	6.25^{ab}	7.00^{abc}	9.50^{d-f}	12.50^{c}	15.00^{d}	17.45^{de}	18.50^{cd}
	P. maximum (Local)	3.00^{a-d}	4.00^{a-d}	5.00^{abc}	5.00^{bcd}	9.00^{e-f}	17.50^{bc}	24.00^{a-d}	26.50^{a-d}	30.00^{abc}
	Brachiaria decumbens	4.00^{a-d}	5.25^{abc}	6.00^{ab}	7.00^{abc}	15.00^{a-e}	22.50^{ab}	28.00^{abc}	32.50^{abc}	35.00^{ab}
Small ruminant	*P. maximum* (Ntchisi)	0.00^{d}	1.00^{d}	3.50^{bc}	5.00^{bcd}	14.50^{a-e}	24.00^{ab}	32.00^{abc}	37.00^{a}	38.00^{a}
	P. maximum (Local)	0.25^{d}	2.00^{cd}	4.00^{bc}	5.00^{bcd}	14.00^{a-e}	22.00^{ab}	27.90^{abc}	31.50^{abc}	35.00^{ab}
	Brachiaria decumbens	0.50^{d}	3.00^{bcd}	5.00^{abc}	7.00^{abc}	18.50^{ab}	25.00^{ab}	33.00^{ab}	35.00^{abc}	40.00^{a}
Poultry	*P. maximum* (Ntchisi)	2.00^{bcd}	2.50^{cd}	2.50^{c}	4.00^{bcd}	11.50^{c-f}	19.00^{bc}	25.00^{a-d}	29.50^{a-d}	32.50^{ab}
	P. maximum (Local)	1.50^{cd}	3.00^{bcd}	3.50^{bc}	3.50^{cd}	10.50^{c-f}	16.50^{bc}	20.25^{cd}	24.00^{b-e}	26.00^{a-d}
	Brachiaria decumbens	2.50^{a-d}	5.50^{abc}	6.50^{ab}	9.00^{a}	20.00^{a}	29.00^{a}	35.00^{a}	39.00^{a}	40.00^{a}
Control	*P. maximum* (Ntchisi)	1.00^{cd}	2.00^{cd}	2.50^{c}	3.00^{d}	7.00^{f}	10.50^{c}	13.00^{d}	13.00^{e}	14.75^{d}
	P. maximum (Local)	2.25^{bcd}	4.00^{a-d}	5.50^{abc}	7.50^{ab}	16.50^{abc}	25.50^{ab}	32.50^{abc}	36.00^{abc}	38.00^{a}
	Brachiaria decumbens	2.50^{a-d}	3.75^{a-d}	5.50^{abc}	6.75^{abc}	15.50^{a-d}	23.75^{ab}	29.25^{abc}	34.00^{abc}	37.50^{a}
SEM		0.90	0.86	0.91	0.87	1.44	2.37	3.20	3.32	3.31

a-f: means on the same column with different superscripts are significantly different ($P< 0.05$), HRS=hours of incubation, SEM=standard error of mean