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Effect of manure type and season of harvest on the forage yield, quality and macro-elements of two *Panicum maximum* varieties.

*[1]Dele, P. A., [1]Akinyemi, B. T., [2]Amole, T. A., [1]Okukenu, O. A., [1]Sangodele, O. T.,[3]Sowande. O. S., [1]Olanite, J. A., [1]Arigbede, O. M. and [1]Jolaosho, A. O.
[1.] Department of Pasture and Range Management, Federal University of Agriculture, Abeokuta
[2.] International Livestock Research Institute, Ibadan, Nigeria
[3.] Department of Animal Production and Health, Federal University of Agriculture, Abeokuta
*** Corresponding Author:** delepa@funaab.edu.ng

Target Audience: Pasture Scientist, Ruminant Nutritionist, Ruminant Farmers

Abstract

A two year study was carried out to evaluate the effect of manure type and season on forage yield, quality and macro elements of two Panicum maximum varieties. The manures used are those of cattle, swine and poultry, the two P. maximum varieties are Local and Ntchisi whereas the seasons are the rainy and dry seasons. The grass samples were harvested and yield measured from each plot, the samples harvested were used in the determination of the dry matter (DM), crude protein (CP), neutral detergent fibre (NDF), acid detergent fibre (ADF) and macro-elements (P, Ca, K, Mg and Na). The grasses harvested in the rainy season (14.55 vs 15.76 tha^{-1} for 2010 and 2011 respectively) had better yield ($P<0.05$) than those of the dry season (12.2 vs 13.32 tha^{-1} for 2010 and 2011 respectively) in both year of the study. Grasses fertilized with swine manure outweighed others in both years (16.65 vs 18.51 tha^{-1} for 2010 and 2011 respectively) and P. maximum Ntchisi was performed better than P. maximum Local. The crude protein (CP) content of grasses harvested in the rainy season (104.20 vs 110.30 g kg^{-1}DM for 2010 and 2011 respectively) was higher than those of dry season, the CP content of grasses fertilized with cattle dung was highest in the first year and grasses fertilized with swine manure had the highest CP content in the second year, though statistically similar to those fertilized with cattle dung. The neutral detergent fibre (NDF) of the grasses fertilized with poultry manure (594.01 vs 580.12 g kg^{-1}DM for 2010 and 2011 respectively) was the least ($P<0.05$) for both years and P. maximum Ntchisi had the least NDF content. The grasses harvested in the dry season in both years recorded higher ($P<0.05$) values for P (3.18 vs 3.21 g kg^{-1}DM), Ca (5.99 vs 5.82 g kg^{-1}DM) and Mg (2.23 vs 2.25 g kg^{-1}DM) concentrations for 2010 and 2011 respectively, while the grasses harvested in the rainy season had higher ($P<0.05$) values for K (8.79 vs 8.83 g kg^{-1}DM) and Na (1.63 vs 1.52 g kg^{-1}DM) concentrations for 2010 and 2011 respectively. Grasses fertilized with swine manure had the highest P concentration, Ca concentration in the first year was recorded for unfertilized grasses. Grasses fertilized with cattle dung had *the highest Mg (2.13 vs 2.18 g kg^{-1}DM) concentration in 2010 and 2011 respectively whereas the K (8.87 vs 8.61 g kg^{-1}DM) and Na (1.71 vs 1.90 g kg^{-1}DM) concentrations for 2010 and 2011 respectively were recorded for grasses fertilized with swine manure and unfertilized ones respectively. Panicum maximum Ntchisi had higher values of Ca (5.63 vs 5.49 g kg^{-1}DM), Mg (2.23 vs 2.01 g kg^{-1}DM), K (8.38 vs 7.93 g kg^{-1}DM) and Na (1.34 vs 1.29 g kg^{-1}DM) concentration for 2010 and 2011 respectively. It could be concluded that manured P. maximum varieties are a very good source of macro minerals for ruminant livestock.*

Keywords: Mineral, grasses, ruminant, Guinea grass, concentration.

Description of Problem

Guinea grass (*Panicum maximum*) is a prominent grass in the humid savannah zone of Nigeria, and highly valued for its high yields of palatable herbage. It is an important grass for hay and silage especially in the south-western part of the country. In view of its importance in the expansion of ruminant production, the grass has received reasonable research attention over the years with regards to its yield and quality (1); (2); (3); (4) and (5). (6) reported grasses as an important and only source of mineral nutrient for grazing animals. However, the variations in the mineral contents of grasses have been attributed to different factors (7); (4) and (8). (9) reported that soil fertility and plant characteristics as major influences in the mineral composition of forages. (10) recognized that season also do affect the mineral content of *P. maximum*. Seasonal variations have been found to have effect on the nutrient composition of forages especially grasses (11). For instance, dry season in Nigeria had posed serious threat to the livestock industry over the years (12). Some studies have been carried out to test effect of nitrogen fertilizer and season on the mineral content of some grasses (13); (10) and (14). This study was therefore, undertaken to determine the effect of manure and season on the macro element of *P. maximum*.

Materials and methods

Experimental sites

The research was a-2 year field experiment conducted at the Organic Research farm, Federal University of Agriculture, Abeokuta during 2010 and 2011 growing season and laboratory analyses were carried out at the laboratory of the Institute of Subtropical Agriculture (ISA), the Chinese Academy of Science, Changsha, Hunan Province, China. The experimental site in Nigeria lies within the savanna agro-ecological zone of South Western Nigeria (latitude: 7°N, longitude 3.5°E, average annual rainfall: 1037 mm), while that of the ISA Changsha lies on latitude 28°12'03 86" N longitude 113° 05' 00 77" E at elevation 135ft (15).

Land preparation

The land was cleared, followed by ploughing after which the land was allowed to rest for a period of two weeks before harrowing. After land preparation and before planting, soil samples were randomly collected from the plots 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 (Table 1).

Manure collection, analysis and application

Manure from three animal species namely: cattle, swine and poultry as well as control were used for the study; these were collected from the Teaching and Research Farm, Federal University of Agriculture, Abeokuta. 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 and quantities of the manures were determined based on the nitrogen content of the manure and nutrient compositions of the manures as presented in Table 2.

Sourcing of planting materials and

Table 1: Physico- chemical characteristics of the composite soil samples taken at 0-15 cm depth from the experimental site before planting in 2010.

Chemical properties	Values
pH	7.03
Total nitrogen (%)	0.11
Organic carbon (%)	1.29
C:N ratio	28.38
Available P (mg/kg)	53.87
Acidity (cmol/kg)	0.13
CEC	1.79
Exchangeable cations (cmol/kg)	
Sodium (Na)	0.80
Potassium (K)	0.20
Calcium (Ca)	2.77
Magnesium (Mg)	2.72
Particle size	
Sand (%)	77.93
Silt (%)	17.33
Clay (%)	4.73

Table 2: Nutrient composition of animal manures

Parameters	Cattle	Swine	Poultry
N (g/kg)	15.6	16.9	30.2
P (g/kg)	6.9	6.3	10.6
K (g/kg)	7.3	7.6	10.3
Ca (g/kg)	21.2	31.6	37.2
Mg (g/kg)	11.7	19.2	17.3
Na (g/kg)	1.1	1.6	2.1
Fe (mg/kg)	614.6	650.7	630.9
Zn (mg/kg)	54.8	81.2	75.4
Cu (mg/kg)	29.1	27.3	32.7
Mn (mg/kg)	321.9	260.3	217.9

planting

The Guinea grass varieties planted are *Panicum maximum* (Local) and *P. maximum* (Ntchisi). The crown splits of the *P. maximum* varieties were sourced from established plots. The grasses were planted at the spacing of 0.5 m x 0.5 m so that each plot had forty-eight stands. The plots were well labeled with the treatments indicated.

Experimental design and plot management

The study was a 2 x 4 x 2 factorial experiment in a Randomized complete block design with two grass varieties (*P. maximum* Local) and *P. maximum* Ntchisi), the three manures (Cattle, swine, poultry manures) and No manure (control), and two season (dry and rainy season), which constitute the treatments totalling sixteen (16) with four replicates. The inter-plot and intra-plot spaces were kept weed-free throughout the experimental period by hand weeding.

Forage harvesting and sampling

The grasses were harvested at 8 weeks after planting and 8 weeks after cutback for the rainy and dry seasons respectively at the stubble height of 15 cm above ground level in 2010 and in 2011, at the onset of rainy season and dry season the grasses were cut back to a stubble height of 15 cm. At harvest, yields from each plot were measured and sample obtained for the estimation of dry matter determined using a forced air drying oven until constant weights were achieved. The dried samples were ground through a 1 mm screen and milled samples packed in plastic bags for subsequent chemical analyses.

Chemical analyses

The dried samples were milled through a 1-mm screen mill and analyzed for crude protein (CP) content (990.03) according to (16) method. The neutral detergent fibre (NDF) and acid detergent fibre (ADF) contents were analyzed according to the methods described by (17).

Plant Wet Digestion Method for Mineral Content

Samples of 1.0 g were prepared for mineral analysis by the wet digestion method. The samples are placed into digestion vessels, Kjeldhal flasks, using concentrated nitric acid and 70% perchloric acid heated slowly at a low temperature.

After digestion, the samples are diluted to the appropriate volume with deionized water. According to UNICMP 929 atomic absorption spectroscopy cook book manual. Working standards prepared using the extracting solution. For calcium and magnesium determination, the final sample dilution and standards should contain 1% lanthanum as a releasing agent and to overcome potential interferences e.g. from phosphorus and alkali metals. Calcium (Ca) and magnesium (Mg), were determined using air/acetylene flame and D corrector of the atomic absorption spectroscopy (AAS), UNICAM 929. © Unicam Limited (Division of analytical Technology Inc.), 1991, Cambridge, UK. The concentrations of potassium (K) and sodium Na) determined by flame photometer (Corning) whereas phosphorus (P) determined spectrophotometrically at 440 ìm according to fertilizers and feeding stuffs regulations, after diluting the ash extract (1:20) and an aliquot of this reacted with ammonium vandovmolybdate reagent, to form the orange-yellow complex vanadium phosphomolybdate.

Statistical analysis

Data collected were subjected to analysis of variance using the Statistical package (18) and significant means were separated using Duncan Multiple Range Test.

Results

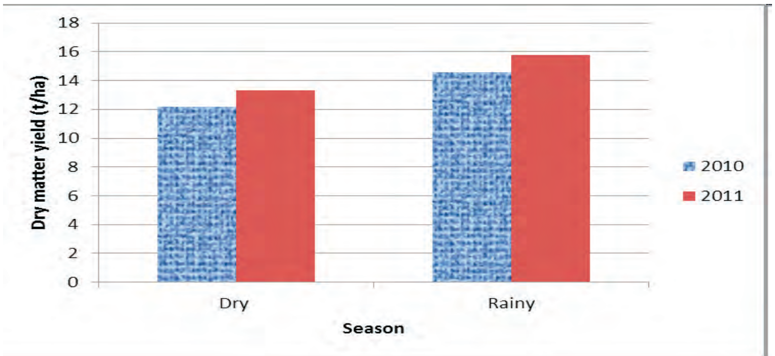
The effect of season and manure type on the dry matter of two *P. maximum* varieties is shown in Figure 1a-c. The effect of season on the yield was significantly ($P<0.05$) higher for grasses harvested in the rainy season in both years. The percentage increase in the yield of the grasses was 9.18% and 8.32% in the dry and rainy season respectively. The influence of manure was significantly highest on the yield (16 t ha^{-1} vs 18.51 t ha^{-1} for 2010 and 2011 respectively) for grasses fertilized with swine manure while the least yield (9.29 t ha^{-1}vs 8.91t ha^{-1} for 2010 and 2011 respectively) value was recorded for unfertilized grasses. The yield of the variety *P. maximum* Ntchisi was significantly ($P<0.05$) higher than the yield of *P. maximum* Local for both season as well as both years.

The CP (104.21 g kg^{-1} DM vs 110.30 g kg^{-1} DM for 2010 and 2011 respectively) content of the grasses were higher ($P<0.05$) in the rainy season than the dry season for both years (Figure 2a). The CP content of the grasses was significantly ($P<0.05$) affected by the manure type applied with the grasses fertilized with cattle dung been the highest for 2010 rainy season whereas the CP content for grasses fertilized with cattle dung and swine manure were statistically similar (Figure 2b). The CP content of *P. maximum* Ntchisi was higher for both seasons and the two years under study (Figure 2c).

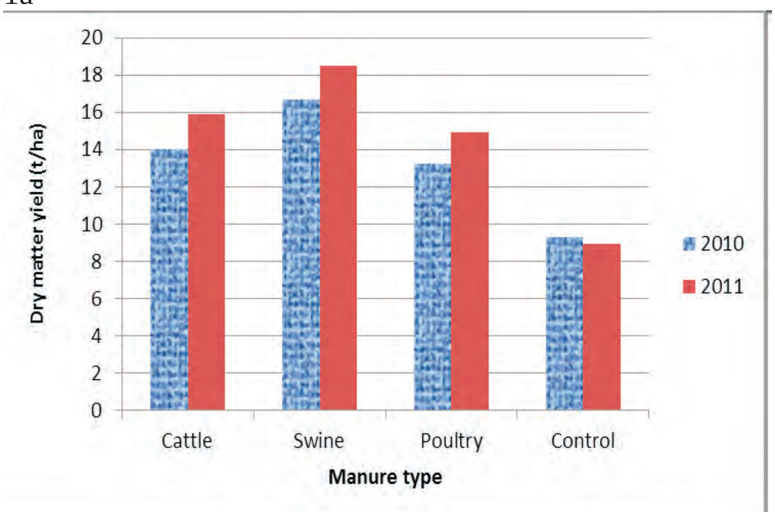
Season had no significant effect ($P>0.05$) on the NDF content of the grasses in both seasons of the two years. In the first year, manure type had no effect on the NDF content ($P>0.05$) of the grasses while in the second year, manure type had effect on the NDF content, with the unfertilized grasses have the highest NDF (610.22 gkg^{-1} DM) content. Varietal effect on the NDF for both seasons and years showed that *P. maximum* Local was significantly ($p<0.05$) higher than *P. maximum* Ntchisi (Figure 3a-c)

The ADF contents were significantly ($p<0.05$) affected by season for both years, the manure effect in the first year on the ADF was significantly different with grasses fertilized with swine manure being the highest while in the second year unfertilized grasses recorded the highest ADF content. *P. maximum* Local had higher ADF content than *P. maximum* Ntchisi for both years (Figure 4a-c).

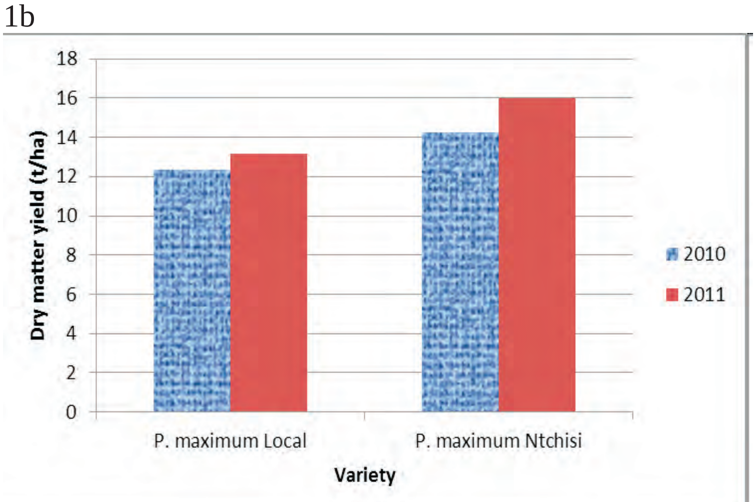
Except for varietal effect, the forage P concentrations of the grasses were significantly ($P<0.05$) affected by season and manure type for both years. The Ca (5.99 vs 5.82 g kg^{-1}DM for 2010 and 2011 respectively) concentrations were affected by season in both years with higher values recorded for the



1a

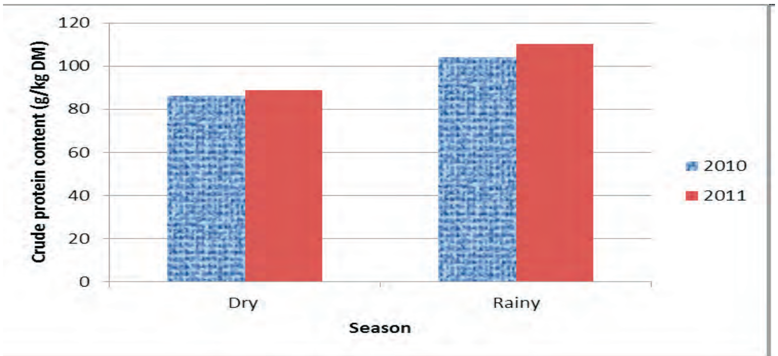


1b

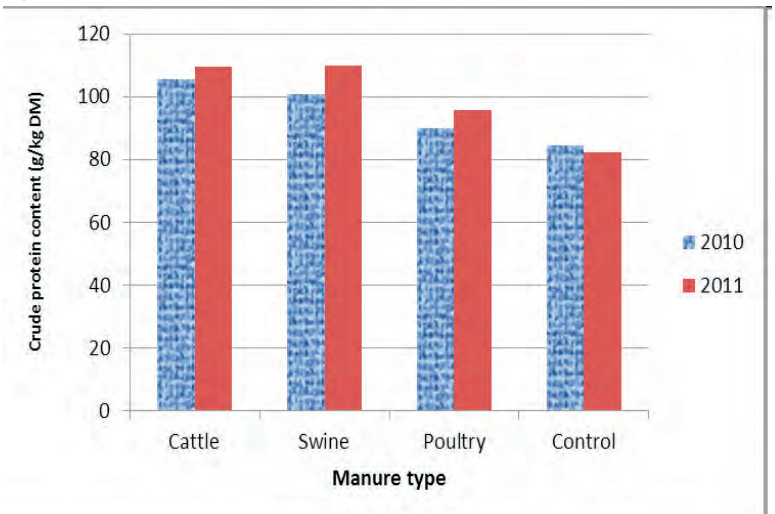


1c

Figure 1a-c: Effect of Season, Manure type and Variety on the dry matter yield of two *Panicum maximum* varieties



2a



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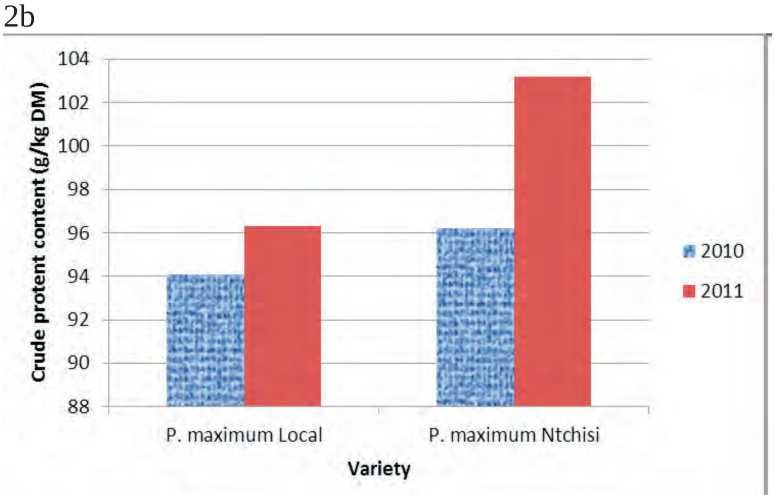
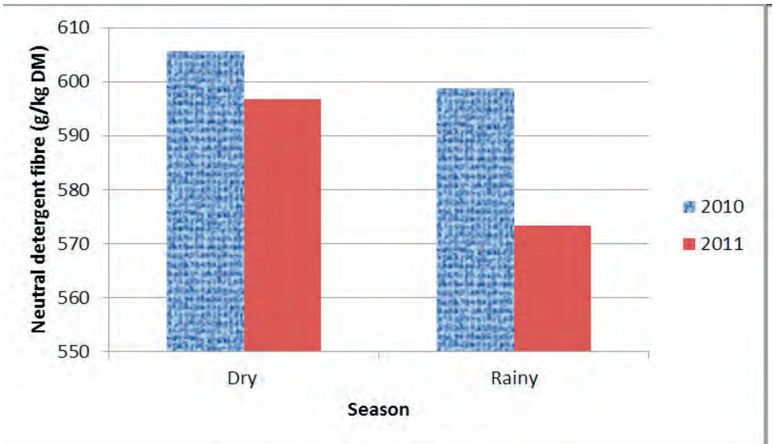
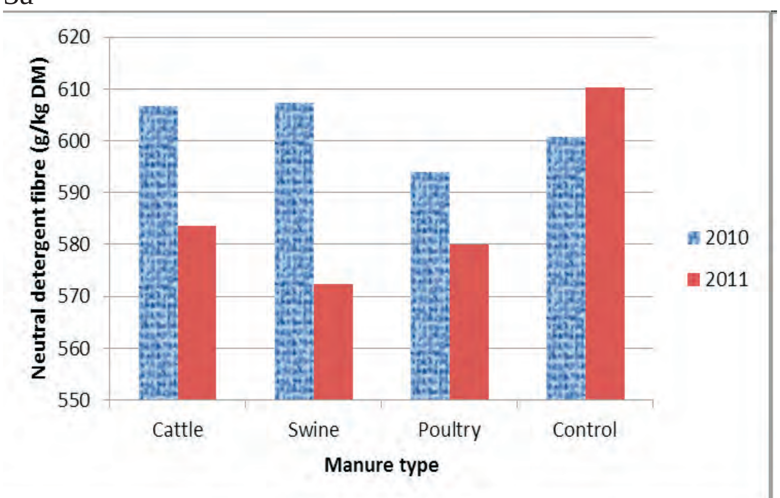


2c

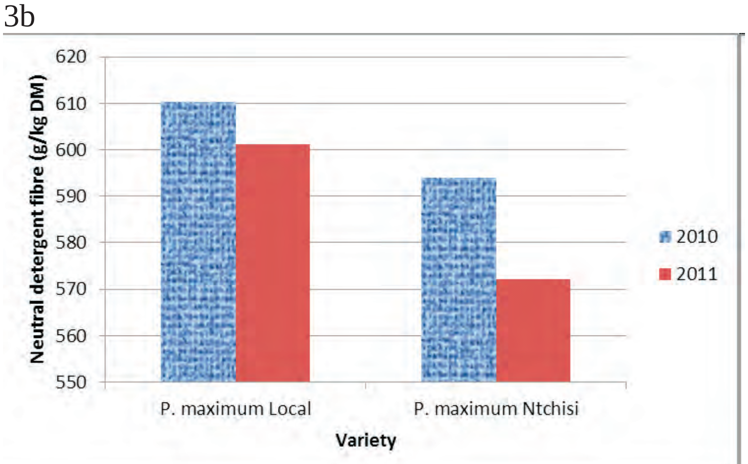
Figure 2a-c: Effect of Season, Manure type and Variety on the crude protein content of two *Panicum maximum* varieties



3a

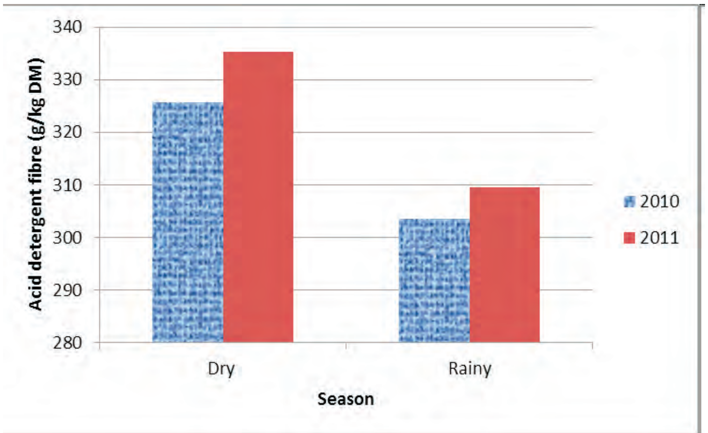


3b

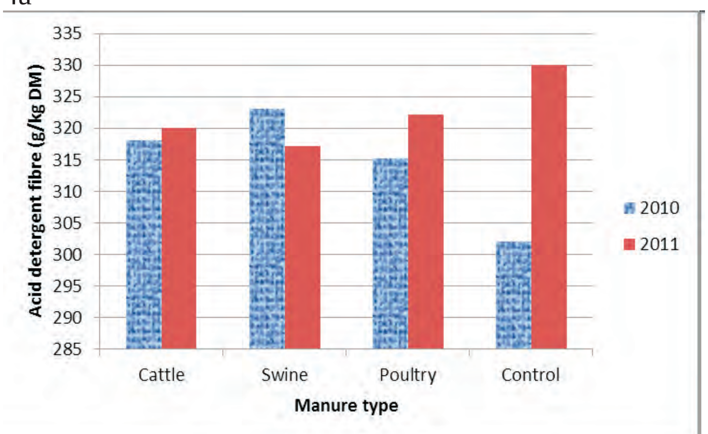


3c

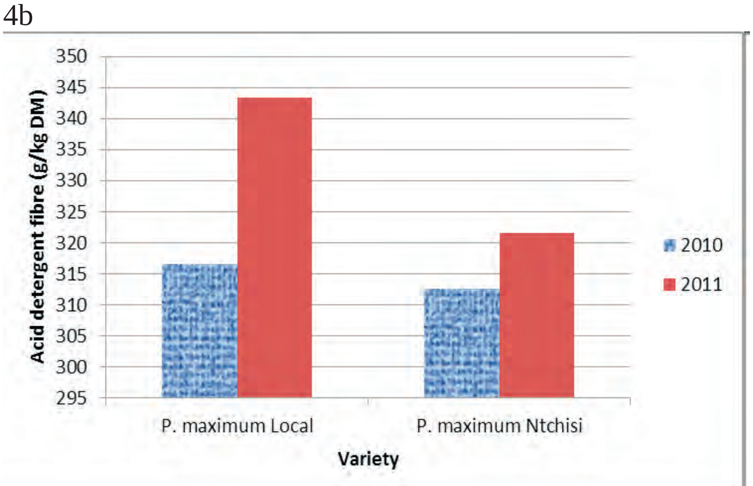
Figure 3a-c: Effect of Season, Manure type and Variety on the Neutral detergent fibre of two *Panicum maximum* varieties



4a



4b



4c

Figure 4a-c: Effect of Season, Manure type and Variety on the Acid detergent fibre of two *Panicum maximum* varieties

Table 3: Effect of season and manure type on the macro minerals contents (g kg^{-1}DM) of two *P. maximum* varieties

	P		Ca		Mg		K		Na	
	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011
Season										
Dry	2.75^{b}	2.81^{b}	5.99^{a}	5.82^{a}	2.23^{a}	2.25^{a}	6.77^{b}	6.52^{b}	0.69^{b}	0.84^{b}
Rainy	3.18^{a}	3.21^{a}	4.61^{b}	5.02^{b}	1.83^{b}	1.73^{b}	8.79^{a}	8.83^{a}	1.63^{a}	1.52^{a}
SEM	0.17	0.12	0.29	0.20	0.09	0.14	0.40	0.38	0.09	0.05
Manure type										
Cattle	2.86^{b}	3.25^{b}	5.02	5.20^{b}	2.13^{a}	2.18^{a}	8.12^{ab}	8.18^{ab}	1.07^{b}	1.11^{b}
Swine	3.69^{a}	3.83^{a}	5.36	5.76^{a}	2.07^{a}	1.98^{ab}	8.87^{a}	8.61^{a}	0.94^{b}	0.90^{c}
Poultry	3.00^{ab}	3.08^{b}	5.26	5.78^{a}	1.88^{b}	1.78^{b}	7.69^{b}	7.23^{b}	0.93^{b}	0.85^{c}
Control	2.30^{b}	1.90^{c}	5.55	4.94^{b}	2.04^{a}	2.03^{ab}	6.42^{c}	6.73^{c}	1.71^{a}	1.90^{a}
SEM	0.22	0.17	0.44	0.25	0.13	0.09	0.58	0.41	0.14	0.11
Variety										
P. maximum Local	2.99	2.93	4.96^{b}	5.34	1.84^{b}	1.99	7.67^{b}	7.41^{b}	0.98^{b}	1.08
P. maximum Ntchisi	2.93	3.10	5.63^{a}	5.49	2.23^{a}	2.01	8.38^{a}	7.93^{a}	1.34^{a}	1.29
SEM	0.17	0.18	0.30	0.22	0.09	0.03	0.41	0.45	0.12	0.09

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

Table 4: Correlation coefficients between the macro element content, yield, CP, NDF and ADF in two *P. maximum* varieties

	CP	NDF	ADF	YIELD	P	Ca	Mg	K	Na
CP	-	-0.07	0.24*	-0.19	0.28**	0.04	-0.16	0.13	0.22*
NDF		-	0.36**	0.17	-0.12	-0.18	-0.04	-0.06	-0.01
ADF			-	0.10	0.04	-0.29**	-0.20*	0.19	0.09
YIELD				-	0.20*	-0.12	0.15	0.32***	-0.20*
P					-	0.24**	0.02	-0.14	-0.18
Ca						-	0.67***	-0.58***	-0.00
Mg							-	-0.34***	0.05
K								-	0.01
Na									-

*P≤0.05; **P≤0.01; ***P≤0.001

grasses harvested in the dry season, whereas the effect of manure type and variety on Ca concentration were only significant (P<0.05) in the second and first year respectively. Mg concentrations of the grasses were significantly influenced in both years except for varietal (P>0.05) effect in the second year of the study. This same trend was recorded for Na concentrations of the grasses. The K concentrations of the two grasses were significantly affected by season and manure type (Table 3).

The relationship between the yield, CP, NDF, ADF and macro mineral contents of the two *P. maximum* varieties is presented in Table 4. The CP content was negatively correlated with NDF, yield and Mg, and also positively related with the ADF (P<0.05) content. The NDF content is positively related with the ADF (P<0.01) content and negatively related with all the macro mineral content. The NDF content is positively related with the dry matter yield. The ADF content was negatively related with Ca (P<0.01) content and Mg (P<0.05) content, while the yield was also negatively related with the Ca and Na content of the grasses. The P content was positively related with the Ca (P<0.01) content and negatively related with the K and Na content. The Ca content was positively related with the M (P<0.001) content, whereas negatively related to K (P<0.001) content and the Mg was negatively related to the K (P<0.001) content.

Discussion

The variation in the dry matter yield as reported in this study with the yield in the rainy season been higher than the yield in the dry season is in line with the findings of (19), (20) and (21)**.** This could be attributed to reduced moisture and nutrient availability at the dry periods of the year (22). The highest dry matter yield recorded for swine manure fertilized grasses might be as a result of the high rate of mineralization that the manure was noted for in the year of application of the manure (23) in terms of nitrogen which is known to promote plant productivity in terms of yield (24). The *P. maximum* (Ntchisi) dry matter yield was higher than that of *P. maximum* (Local). This is consistent with the findings of (25), (4) and (5). The increase in the yield of both *P. maximum* varieties across the two years is in line with the report of (26), which might be as a result of increase in the number of tillers.

The difference in the CP of the grasses as affected by season recorded in this study is similar to earlier findings of (27). The decline in the CP contents of the grasses in the dry season might be as a result of increased temperature in the season, a factor that is known to promote more rapid metabolic activity, which decreases the pool size of metabolites in the cellular content as well as soil moisture deficit. This has the effect of decreasing nitrate, protein and soluble carbohydrates (28). The crude protein (CP) content of the grasses in this study as affected by the different manures applied fell within the range of 8.2–11.28 % reported by (29) for *P. purpureum* when farmyard manure was applied. The CP content of the grasses affected by the manures is above the critical limit below which intake of forages by ruminants and rumen microbial activity would be adversely affected (30) and these values are above the minimum range of 65–80 g/kg prescribed for optimum performance of tropical ruminant animals (31). The grasses are therefore adequate for meeting the protein requirement of growing calves to generate a high level of ammonia in the rumen from degradable protein to ensure an efficient digestion process (32). The higher CP content recorded for the grasses fertilized with cattle and swine manure might be attributed to high carbon content in the manure (33) as they are known to have high carbon:nitrogen ratio suggesting that manure mineralization takes place at different rates between different animal species. The increase in the CP content of the grasses from 2010 to 2011 might be as a result of increase leaf nitrogen which does result from tiller multiplication (26). The higher CP content in the rainy season might be as a result of high precipitation which might increase vegetative growth

The values of the NDF and ADF of the grasses as influenced by the animal manures is lower than that reported by (4) for the two varieties of Panicum which was fertilized with inorganic nitrogen fertilizer. The varietal effect of the grasses as recorded in this study on the NDF and ADF is lower to those reported by (34). The NDF recorded is within the range of 600-650 g/kg suggested as the critical limit above which efficiency of utilization of tropical forages by ruminants would be impaired (35, 36). The moderate fibre levels of the grasses in this study will be of help in facilitating the colonization of ingesta by rumen microorganism which in turn might induce higher fermentation rates, hence improving digestibility, intake and animal performance (49). The reduction in the NDF content of the grasses could be as a result of better plant growth which is in line with the report of (26) whereas higher NDF content in the dry season might be as a result of moisture stress and high temperature which does lead to high stem/leaf ratio (37), thereby increasing lignification.

Minerals are required by both plants and animals in critical and balance amount, the excess and deficiency both reduces the efficiency of vegetation and dependant livestock production. According to (38), the presence of mineral elements in animal feed is vital for the metabolic processes of the animals. The results obtained for P in this study for the grasses to which different manures were applied were slightly higher than those reported by (39) for *P. maximum* (Local) that was fertilized with different animal manures. This might be due to different factors such as the soil fertility as well as the feed offered the animals that produced the manure used for fertilizing the grasses. The Phosphorus contents of the grasses fell within the recommended (1-4.8 g/kg) requirements for different classes of ruminant animals as stated by (40; 41). The higher content of P in the rainy season is in line with the report of (42), which attributed decreased in Phosphorus content in the dry season to the dryness of the soil because Phosphorus in the soil is not made available to the root of the plant for uptake. The roots cannot absorb the Phosphorus in the solid form, but it is able to absorb in the liquid form. This renders plant incapable to accumulate Phosphorus in the dry season. This agrees with (43), that, Phosphorus is found less in quantity in dry soils.

The increase in the calcium level in the grasses in the water stress period (dry season) could be that the plant accumulated the Calcium to deal with all injuries which happen as a result of the water stress. This is in conformity with (44), who said that the possible mechanism to minimize detrimental effect of drought in crop plants is that; the Calcium level in the plant be improved. The values recorded for Ca content of the grasses as influenced by the manure type in the first year of the study are in consonance with the report of (45) in which the Ca content of zero manured Barley had higher concentration. This might be as a result of salinity associated with manure application (46), also chelating properties of manure could be responsible in which elements such as calcium are bond into a chelate with the soil colloids and are release gradually and this is one of the importance of manure as they are known for binding up mineral elements against being washed away during erosion. The decrease in the Ca value in the second year for unfertilized grasses could be as a result of washing away of soil nutrient in the first year unlike the fertilized that form chelate with soil nutrients, thereby reducing washing away of soil nutrient. The Ca concentration in this study fell between the ranged of requirement of different ruminant animals in terms of Ca concentration (1.8 to 8.2 g/kg) as reported by (40; 41).

The Mg concentrations of the grasses under study are within the range of 1-2 g/kg for the requirement of ruminants (40; 41). It also fell within the range (1.4 – 2.8 g/kg) reported by (47) for *P. maximum*. The K concentration of grasses under study fell within the range (6-8 g/kg) considered to be adequate to meet with the requirement of ruminant animals. The higher concentration recorded for the rainy season is in line with the report of (42). The Na concentration in this study as influenced by the manure type fell within the recommended requirement as stated by (48) for lactating cows. The varietal difference in the concentration of Na is in line with report of (8) that *P. maximum* Ntchisi had higher concentration of Na than *P. maximum* Local.

Conclusion and Application

It could be concluded from the results of this study that the two *Panicum* varieties are good source of macro minerals for ruminant livestock if properly managed and manure is a very rich source of plant nutrients. It could be used in feed formulation to address mineral deficiency. It could be used to predict the mineral content of soil and uptake for more years.

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