

Growth components and chemical composition of some improved dual-purpose cowpea (*Vigna unguiculata* L. Walp) varieties as influenced by manure application

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Abstract

Field experiment was conducted to determine the effect of swine manure application on the growth components and chemical composition of nine varieties of improved dual-purpose cowpea (Vigna unguiculata L. Walp). The experiment was laid out as a 2 x 9 factorial design with two levels of manure application (0kg ha^{-1} and 5kg ha^{-1}) and nine varieties of improved dual-purpose cowpea at three replicates. Agronomy parameters and dry matter yield of the cowpea were determined six weeks after sowing. Results showed that unfertilized variety IT-332 recorded highest leaf proportion (57.27) above others. Varieties IT-193 with manure (80.00 cm) and IT-297 without manure (30) recorded significantly higher (P<0.05) values for plant height and leaf number respectively. Dry matter yield of cowpea ranged significantly higher (P<0.05) from 7.20 t ha^{-1} in variety IT-817 without manure to 14.85 t ha^{-1} in variety IT-321 with manure. The average crude protein content of improved cowpea varieties ranged significantly (P < 0.05) from 97.69 g kg^{-1} dry matter in unfertilized IT-817 and IT-834 to 141.17 g kg^{-1} dry matter in fertilized IT-819. The study showed that application of swine manure into cowpea increased the dry matter yield and chemical composition which is necessary to provide sufficient feed for ruminants that can be used as a supplement during the dry season.

Keywords: Dry matter yield, cowpea varieties, nutrient contents, swine manure

Introduction

The major problem facing livestock producers in tropical areas is proper nutrition for their animals during the dry season (Murphy and Colucci, 1999). The shortage of feed for ruminants can be solved through cultivation of forage crops with better nutritional values than the existing feed resources. Deliberate cultivation of N fixing legumes has been reported to have higher concentrations of cellular protein than tropical grasses (Bjorkman *et al*., 1976). Tropical forage legumes are rich in protein, which is usually the most limiting nutrients in tropical animal diets. Forage legumes offer several advantages to tropical farming systems. Leguminous cover reduces soil erosion and runoff. This cover is able to conserve soil, improve organic matter content and compete with weeds (Humphreys 1995). Also, the legume-rhizomal symbiosis converts atmospheric nitrogen (N) to forms of N which plants can take up and cycled within the plant-animal-soil system. The legume-rhizobial symbiosis provides farmers with an inexpensive source of N whose production is environmentally "clean". One of the ways of increasing livestock production in Nigeria is to increase the area and quality of legume - based pastures (Nworg and Ajayi, 2005). Adu *et al*. (1992) reported that supplementation of feeds with forage legumes encouraged more roughage intake and digestion in sheep. A sustainable way of improving the feeding value of poor quality crop residues and pastures, especially for resource poor small holders, is through supplementation with forage legumes (Murphy and Colucci, 1999). Dual-purpose cowpea (*Vigna unguiculata* L. Walp) has the potential to function as a key integrating factor in intensifying systems through supplying protein in human diets and fodder for livestock, as well as bringing N into the farming system through biological fixation (Giller, 2001).

Plant growth and yield in all ecosystems depends on the cycling of nutrients between the plant biomass and the organic and inorganic soil stores. Sustained use of grasslands for livestock production, therefore, requires maintenance of a balance between nutrient loss through activities such as plant biomass harvest and nutrient replenishment. Many types of grassland are characterized by low productivity and can benefit from manure incorporation from different sources (Wilson *et al.,* 2010). Utilization of manure on low nutrient status of tropical soils can reduce fertilization cost associated with synthetic fertilizers (Van Wieringen *et al.,* 2005). The objective of this study was to evaluate the effects of animal manures on the agronomic performance and chemical composition of some varieties of improved dual-purpose cowpea in the Humid Savannah zone of Nigeria.

Materials and methods

Experimental site

The research was carried out at the Directorate of University Farms (DUFARMS), Federal University of Agriculture, Abeokuta (FUNAAB), Ogun State, (latitude 7° 13 49.46 N, longitude 3° 26 11.98 E above sea level) in the derived savannah area of Nigeria. Abeokuta has a bimodal rainfall pattern that typically peaks in July and September with a break of two to three weeks in August. Temperatures are fairly uniform with daytime values of 28 to 30°C during the rainy season and 30 to 34°C during the dry season with the lowest night temperature of around 24°C during the harmattan period between December and February. Relative humidity is high during the rainy season with values between 63 and 96 % as compared to dry season values of 55 to 84 %. The temperature of the soil ranges from 24.5 to 31.0°C (Source: Agrometeorology Department, FUNAAB).

Land preparation

The land used for the experiment was cleared, ploughed and harrowed. The climatic data of the experimental area at the time of study was in Table 1. Soil samples of the plot were randomly collected from 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 nutrient composition of the soil (Table 2). Fine seed beds of 4 x 5 m were prepared. The land was divided into three replicates. Swine manure that was used for this study was collected at the piggery section of the DUFARMS. Sub-samples of the swine manure were taken for analysis prior to application to determine the nutrient composition (Table 3).

Table 1: Meteorological data for the experimental areas from June - December 2015

Month/Year	Rainfall (mm)	Temperature (^{0}C)	Relative humidity (%)
June ‘15	164.9	26.9	79.4
July ‘15	65.6	26.6	80.9
August ‘15	29.4	26.3	79.3
September ‘15	165.1	26.5	81.3
October ‘15	159.1	27.4	81.9
November ‘15	16.6	28.6	72.5
December ‘15	0	26.1	39.7

Source: Agrometeorology Department, FUNAAB, Nigeria

Table 2: Physicochemical characteristics of the composite soil samples taken from the experimental site at 0 to 15 cm depths before sowing of cowpea in the year 2015

Parameters	Values
pH	6.75
Particle size (%)	
Sand	84.60
Silt	9.80
Clay	5.60
Exchangeable bases (cmol kg^{-1})	
Calcium	3.36
Magnesium	2.42
Potassium	0.79
Sodium	1.51
Al + H	0.06
ECEC	8.14
Base saturation %	99.26
Total N %	0.11
Total Org C %	1.27
Available phosphorus (mg kg^{-1})	30.40
Micro nutrients (mg kg^{-1})	
Manganese	263.15
Iron	21.25
Copper	0.95
Zinc	6.55

Table 3: Nutrient composition of the swine manure used for the study

Parameters	Values
pH	8.1
Exchangeable bases (%)	
Calcium (Ca)	4.76
Magnesium (Mg)	2.40
Potassium (K)	1.92
Sodium (Na)	2.07
Nitrogen (N) %	0.34
Phosphorus (P) (mg kg^{-1})	12070
Total Organic carbon	6.30
Micro – nutrients (mg kg^{-1})	
Manganese (Mn)	910
Iron (Fe)	1,432
Copper (Cu)	87
Zinc (Zn)	623

The manure was later applied by broadcasting to individual plots according to treatment in one application after air dried for two weeks. The plots were left for two weeks to rest before sowing of the cowpea varieties. Nine improved cowpea varieties (i.e. IT04K-332-1, IT07K-297-13, IT07K-298-15, IT08K-193-15, IT09K-321-1, IT09K-456, IT10K-817-1, IT10K-819-4 and IT10K-834-3; hereafter designated IT-332, IT-297, IT-298, IT-193, IT-321, IT-456, IT-817, IT-819 and IT-834 respectively) obtained from International Institute of Tropical Agriculture, Ibadan, Nigeria were used for this study. They were sown at a spacing of 0.5 x 0.5 m with two seeds per hole at the seed rate of 15 kg ha^{-1} in August 2015 into seed beds that have previously been fertilized with swine manure at 5 kg ha^{-1} while some were not fertilized. The experimental area was maintained weed-free at the early part of growth of the cowpea to reduce competition. Growth component parameters (plant height, plant length, leaf number, leaf area and ground cover) were measured and dry matter yield was estimated six weeks after sowing. Samples were harvested from the cropping field prior to flowering (6 weeks after sowing) to determine the dry matter yield with the use of 1m^2quadrat and chemical composition. Sub samples were taken, weighed and oven – dried at 65 ^{0}C to constant weight. The dry matter percentage was estimated as:

$$\text{Dry matter percentage} = \frac{\text{Weight of dry sample x 100}}{\text{Weight of fresh sample}}$$

While dry matter yield was estimated as

Dry matter yield = dry matter percentage x fresh sample from 1m^2 which afterwards was extrapolated in tonnes per hectare.

The dried samples were milled through a 1mm sieve and the proximate and mineral contents were determined according to the standard methods of AOAC (2000). Neutral detergent fibre was determined according to Van Soest *et al*. (1991).

Experimental design

The experiment was laid out as a 2 x 9 factorial design with two levels of manure application (no manure (control) and with manure (5kg ha^{-1})) and nine varieties of improved dual-purpose cowpea at three replicates. The data obtained were analysed as a two-way analysis of variance using the Duncan multiple range test (Duncan, 1955).

Results and discussion

The physicochemical characteristics of the composite soil samples taken from 0 to 15 cm depths of the experimental site are shown in Table 2. Unlike the tropical soils, the available phosphorus of the experimental site was higher while the pH fell within 6.6-7.3 that have been categorized as very good for normal crop response (Hoskins, 1997). Legumes have been noted to contribute nitrogen to the soil through atmospheric fixation. However, there is need to apply fertilizer to the soil in order to supply phosphorus which will serve as energy-driving process for nitrogen fixation potential of the legumes (Ndakemi and Dakora, 2007). Meanwhile, there was perceived reluctance on the part of the resource-poor small-holder farmers to spend money on inorganic fertilizer which may increase the cost of production. In order to reduce the cost of production as much as possible and to avoid a decline in soil fertility, a recycling of nutrients in terms of fertilization with dung or manure have been recommended (Anele *et al*., 2011).

Table 4 shows the interaction effect of manure and varieties on the growth parameters and dry matter yield of some improved dual-purpose cowpea. Effects of manure application was significant ($P<0.05$) on the growth parameters of cowpea species. Cowpea varieties IT-193 and IT-819 with manure recorded a higher significant ($P<0.05$) increase in plant height and ground cover respectively than in other varieties. Meanwhile, leaf number was significantly highest ($P<0.05$) in IT-297 variety with no manure application. The plant height ranged from 37 cm for variety IT-193 without manure to 80.00 cm for variety IT-193 with manure. Unfertilized cowpea varieties IT-332 recorded significant ($P<0.05$) highest leaf (57.27 %) percentage above other species. Meanwhile, significant ($P<0.05$) highest dry matter yield (14.85 t ha^{-1}) was recorded for cowpea IT-321 variety with manure application. The plant height value of *V.*

unguiculata in this study was considerably higher than those reported by Taura and Fatima (2008) with values of 9.8 to 14.6 cm when cattle dung was applied to different variety of cowpea. The variation in the plant height of the cowpea varieties could be as a result of the different animal manures that were used, which might differ in nutrients uptake by plants.

The implication of highest value for plant length of unfertilized IT-298 cowpea variety is that it will encourage early soil coverage because of canopy they formed, high dry matter yield and high level of control of weed species which is usually a major problem of sown pastures in South West Nigeria (Olanite, 2003) since they are creeping species.

Research have shown that leafiness of forage species is a desirable attribute because the leaves have higher nutritive quality thereby, making them more digestible and improve animal dry matter intake (Minson, 1990, Adam, 2004). Higher number of leaves will lead to higher rate of transpiration and will also give the plant the opportunity of being able to trap enough sunlight for photosynthesis to take place leading to increase in plant height as well as dry matter yield. Higher value recorded for leaf number of unfertilized legumes above the fertilized ones, could be as a result nutrients in the soil. The experimental areas was just opened for cultivation, this makes the soil to be rich in nutrients. The leaf numbers of the cowpea varieties as observed in this study were higher than values obtained by Taura and Fatima (2008) when organic and inorganic manures were applied to some selected varieties of *V. unguiculata*. The values for number of leaves of cowpea varieties irrespective of manure application or not in this study were higher than the value of average of 13 legumes reported under rain-fed condition in Samaru (Adesoji *et al.*, 2013). The variation could be attributed to differences in variety investigated and soil nutrient composition. Larney *et al.* (2009) proposed that increased productivity is due to manure addition, self-perpetuating the amendment effect.

Many reports have shown that higher leaf proportion is a desirable attribute in forage species, as leaves have higher nutritive quality in addition to being generally more digestible, thereby eliciting higher animal intake (Olanite, *et al.*, 2006, Ojo *et al.*, 2014). Highest leaf production in variety IT-332 without manure application is an important component of yield, and it will play a vital role in increasing the green forage yield due to more assimilation of sunlight intercept on the leaf, which increases photosynthesis activity of the plant. Leaf fraction of forage was highly relished by animals and that was the most desired part during grazing. Cultivars with more leaves have been reported to be much higher in quality than cultivars that produced more stems (Beaty and Engel, 1980).

Stem fractions of forage are usually fibrous, low in nutrient density and digestibility and are thus poorly utilized by animals (Ndlovu, 1991; Minson, 1983). The stem proportion of unfertilized IT-817 cowpea variety with highest value of 62.73 % may therefore not be preferred to other varieties that have lower stem materials, especially at a similar growth stage if there is a choice.

The highest dry matter yield of the cowpea in this study was higher than the highest yield that was reported by Anele *et al.* (2011) with value of 8755kg ha^{-1} for improved cowpea variety during wet season. Cowpea varieties values in this study were higher than the values of 1.4 to 7.07 t ha^{-1} reported for lablab (Amodu *et al.,* 2004). However, values of cowpea species

Table 4: Effect of manure application on the growth parameters and dry matter yield of some improved dual-purpose cowpea (Vigna unguiculata L. Walp) varieties

Cowpea	Manure	Plant height (cm)	Plant length (cm)	Leaf number	Leaf area	Ground cover (cm)	Leaf (%)	Stem (%)	Dry matter yield (t ha^{-1})
IT-332	Manure	65.00b	90.00e	28.00ab	63.85	70.00b	46.60f	39.45hi	8.15h
	No manure	65.00b	75.00f	27.00abc	45.85	80.00a	57.27a	41.27gh	10.15e
IT-297	Manure	60.00bc	135.00b	26.00abc	53.25	60.00c	49.06e	41.18gh	9.25fg
	No manure	65.00b	120.00d	30.00a	39.85	70.00b	54.28b	35.24j	13.30c
IT-298	Manure	60.00bc	90.00e	18.00e	45.10	66.00bc	55.25ab	33.63j	9.45fg
	No manure	38.00f	160.00a	23.00bcde	51.85	70.00b	46.04f	48.89e	11.75d
IT-193	Manure	80.00a	125.00cd	27.00abc	36.85	70.00b	38.74h	59.73b	9.05g
	No manure	37.00f	120.00d	20.00de	36.40	60.00c	40.76h	54.85c	7.50i
IT-321	Manure	62.00b	155.00a	24.00bcd	55.85	65.00bc	44.95fg	50.07e	14.85a
	No manure	55.00cd	95.00e	25.00abcd	58.48	60.00c	53.50bc	42.86g	9.80ef
IT-456	Manure	55.00cd	95.00e	23.00bcde	59.10	60.00c	54.63b	38.91i	11.90d
	No manure	48.00e	125.00cd	20.00de	49.35	65.00bc	54.00b	41.73g	10.25e
IT-817	Manure	50.00de	45.00g	22.00cde	45.85	70.00b	50.83de	34.72j	9.30fg
	No manure	60.00bc	75.00f	18.00e	45.10	60.00c	36.66i	62.73a	7.20i
IT-819	Manure	50.00de	95.00e	23.00bcde	58.23	80.00a	43.10g	52.06d	10.20e
	No manure	45.00e	90.00e	28.00ab	36.85	65.00bc	50.58de	49.42e	11.30d
IT-834	Manure	60.00bc	124.00cd	25.00abcd	36.85	65.00bc	35.71i	60.55b	11.80d
	No manure	45.00e	130.00bc	23.00bcde	75.85	50.00d	51.69cd	45.18f	10.50e
	SEM	1.06	1.43	2.00	19.41	1.10	1.15	0.41	0.19
	P-value	<0.0001	<0.0001	0.0104	0.9009	<0.0001	0.0376	<0.0001	<0.0001

abcdefg: Means on same columns with different superscript are significantly ($P<0.05$) different
SEM= Standard error of mean difference

from this study were similar to the values reported by Karachi (1983) that total green DM yields ranged from 2000 to 12000 kg ha^{-1} for *Lablab purpureus ecotypes.* The variations could be as a result of differences in species used, soil nutrients status, as well as application of manure into the soil which enhanced the plant growth. There was similarity in this study and in the findings of Abebe *et al.* (2004) that dry matter yield of *Vigna unguiculata* increased as rate of manure application increased. Ahmed (1997) also reported similar trend as rate of manure was increased in common vetch plant. Dry matter yield of cowpea varieties in this study were higher than 1.48 t ha^{-1} reported by Muir (2002) when the yield of different herbaceous legumes and browse plants were compared. The highest value recorded for the IT-321 cowpea variety with manure application agrees with the findings of Campbell *et al.* (1986) and Cremenscu *et al.* (1985) who reported that organic manures increases crop yield.

The average crude protein (CP) content of improved cowpea varieties ranged significantly ($p < 0.05$) from 97.69 g kg^{-1} DM in unfertilized IT-817 and IT-834 varieties to 141.17 g kg^{-1} DM in fertilized IT-819 variety (Table 5). Cowpea variety IT-193 with swine manure had the highest NDF content (670.00 g kg^{-1}) while the least value of 530.00 g kg^{-1} DM was recorded for variety IT-321 without manure.

The CP values of cowpea without manure (97.69-114.19 g kg^{-1}) were higher than the critical level of 7 g kg^{-1} DM which have been reported to be necessary for voluntary intake in ruminants (Nori *et al*., 2009) while CP content of cowpea varieties with manure (133.43-141.17 g kg^{-1}) were above the range of 110–130 g CP kg^{-1} DM, which is adequate for maintenance and growth of beef cattle (NRC 1996). The highest CP content in cowpea with manure could have been due to higher rate of manure mineralisation which the legumes were able to uptake for better quality. Cowpea with manure recorded greater fibre concentrations than the unfertilized cowpea. The NDF values of improved cowpea varieties recorded in this study were below the 65% (except in IT-193 with higher value of 670.00 g kg^{-1}) suggested as the level at which intake of tropical feeds by ruminants would be limited (Eastridge, 2006). Ruminants will require adequate fibre in their diets so as to aid rumen microorganisms to perform optimally. This is necessary to lead to the production of volatile fatty acid (Trevaskis *et al*. 2001; Lamidi and Ogunkunle, 2016) which in turn facilitates microbial protein synthesis (Lamidi and Aina, 2013).

Calcium and phosphorus make up to 70% of the total mineral elements in the body and have vital functions in almost all tissues in the body and must be available to livestock in proper quantities and ratio (Anele *et al*., 2011). Calcium is a mineral that perform vital functions such as blood clotting, transmission of nerve impulse, muscle contractions and cardiac regulation (NRC, 2001). The values recorded for Ca in the present study ranged from 6.39 g kg^{-1} in variety IT-321 with manure to 10.11 g kg^{-1} in variety IT-456 g kg^{-1} DM without manure and it is above the critical level of 3 g kg^{-1} DM recommended for ruminant needs in the warm wet climates (McDowell *et al*., 1993). Higher P contents of cowpea varieties fertilized may be due to the fact that the foliage may have been fortified by animal manure application. The range of P in this study falls within the normal requirements reported for growing cattle (1.1-4.8g/kg) (Begum *et al*., 2001).

Table 5: Effect of manure application on the chemical composition of some improved dual-purpose cowpea (Vigna unguiculata L. Walp) varieties

		DM	CP	Ash	EE	NFC	NDF	Ca	P
Cowpea	**Manure**								
IT-332	Manure	975.00^{a}	136.51^{a}	65.00^{ab}	115.00^{abc}	53.49^{gh}	630.00^{cde}	7.33^{n}	2.28^{e}
	No manure	970.00^{ab}	113.14^{b}	65.00^{ab}	115.00^{abc}	76.86^{defg}	630.00^{cde}	9.11^{i}	2.33^{de}
IT-297	Manure	960.00^{ab}	138.58^{a}	70.00^{ab}	125.00^{ab}	86.42^{def}	580.00^{gh}	6.89^{q}	2.10^{ef}
	No manure	900.00^{d}	114.19^{b}	70.00^{ab}	125.00^{ab}	120.81^{c}	570.00^{h}	9.01^{j}	2.17^{ef}
IT-298	Manure	965.00^{ab}	135.49^{a}	75.00^{a}	105.00^{cde}	94.51^{cd}	590.00^{gh}	6.71^{s}	2.67^{bc}
	No manure	985.00^{a}	99.55^{c}	65.00^{ab}	110.00^{bcd}	175.45^{b}	550.00^{i}	8.69^{l}	2.10^{ef}
IT-193	Manure	980.00^{a}	140.58^{a}	55.00^{b}	115.00^{abc}	19.42^{i}	670.00^{a}	7.34^{n}	2.83^{abc}
	No manure	960.00^{ab}	99.73^{c}	65.00^{ab}	90.00^{ef}	165.27^{b}	580.00^{gh}	9.84^{e}	1.65^{hi}
IT-321	Manure	945.00^{bc}	133.43^{a}	65.00^{ab}	125.00^{ab}	86.57^{def}	590.00^{gh}	6.39^{u}	2.60^{cd}
	No manure	965.00^{ab}	101.61^{c}	55.00^{b}	85.00^{f}	228.39^{a}	530.00^{j}	9.18^{h}	1.60^{i}
IT-456	Manure	965.00^{ab}	135.49^{a}	60.00^{ab}	120.00^{abc}	64.51^{defgh}	620.00^{de}	8.78^{k}	2.60^{cd}
	No manure	980.00^{a}	100.07^{c}	60.00^{ab}	95.00^{def}	164.93^{b}	580.00^{gh}	10.11^{c}	2.10^{ef}
IT-817	Manure	965.00^{ab}	137.87^{a}	70.00^{ab}	105.00^{cde}	57.13^{efgh}	630.00^{cde}	7.83^{m}	3.00^{a}
	No manure	980.00^{a}	97.69^{c}	65.00^{ab}	90.00^{ef}	212.31^{a}	535.00^{ij}	9.89^{d}	1.90^{fgh}
IT-819	Manure	960.00^{ab}	141.17^{a}	60.00^{ab}	130.00^{a}	88.84^{de}	580.00^{gh}	6.66^{t}	2.75^{abc}
	No manure	925.00^{c}	100.88^{c}	65.00^{ab}	130.00^{a}	79.12^{defg}	625.00^{de}	9.44^{f}	1.80^{ghi}
IT-834	Manure	970.00^{ab}	137.22^{a}	70.00^{ab}	105.00^{cde}	37.78^{hi}	650.00^{bc}	7.28^{o}	2.93^{ab}
	No manure	980.00^{a}	97.69^{c}	60.00^{ab}	115.00^{abc}	87.31^{def}	640.00^{cd}	10.44^{a}	1.98^{fg}
	SEM	3.30	2.52	1.29	2.16	8.14	4.81	0.18	0.06
	P-value	<0.0001	<0.0001	0.5267	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

abcdefghi: Means on same columns with different superscript are significantly ($P<0.05$) different
SEM= Standard error of mean difference
DM= Dry matter, CP= Crude protein, EE= Ether extract, NFC = Non fibre carbohydrate, NDF = Neutral Detergent Fibre, Ca= Calcium, P= Phosphorus

Conclusion

From this study it can be concluded that application of swine manure into improved dual-purpose cowpea varieties increased the dry matter yield as well as their chemical composition which is necessary to provide sufficient feed for ruminants that can be used as supplement during the dry season. The cowpea varieties investigated can be used as forage legumes which can improve animal performance and productivity.

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References

Abebe, G., Butros, H. and Abdul-Rahman, M. A. 2004. Nutrient availability as affected by manure application to cowpea (*Vigna unguiculata* L. Walp.) on calacarious soils. *Journal of Agriculture and social sciences.1813-2235/2005:1-6.* http://www.ijabjass.org.

Adam, M. Y. 2004. ***Effect of Seed Rate and Nitrogen on Growth and Yield of Teff Grass (Eragrostis teff zucc.) Trotter*. M.Sc. Thesis. Faculty of Agriculture, University of Khartoum, Sudan.**

Adesoji, A. G., Abubakar, I. U., Tanimu, B., and Labe, D. A. 2013. Influence of Incorporated Short Duration Legume Fallow and Nitrogen on Maize, *American-Eurasian Journal of Agricultural & Environmental Science, 13*(1), 58-67.

Adu, I. F., Fajemisin, B. A. and Adamu, A. M. 1992. The utilization of sorghum stover fed to sheep as influenced by urea and graded levels of lablab supplementation. In: Small Ruminant Research and Development in Africa. Proceedings of the 1st Biennial Conference of the African Small Ruminant Research Network, ILRAD, Nairobi, Kenya, 10 - 14 December, 1990. ILCA Nairobi, Kenya. Rey B, Lebbie S H B and Reynold R (editors) 367 - 374.

Ahmed, A. M. 1997. Comparative study of two forage legumes species for their performance as influenced by different levels of organic manure at Al-Muwagar. M. Sc. Thesis, University of Jordan, Amman-Jordan.

Amodu, J. T., Kallah, M. S., Adeyinka, I. A. and Lakpini, C. A. M. 2004. Response of lablab varieties to farmyard manure in the northern quinea savanna of Nigeria. In: Sustaining livestock production under changing economic fortunes. Proceedings of the 29th Annual Conference of the Nigerian Society for Animal Production held in Sokoto, 21- 25 March, 2004. Pp 293 - 297.

Anele, U. Y., Südekum, K.-H., Arigbede, O. M., Welp, G., Oni, A. O., Olanite, J. A. and Ojo, V. O. A. 2011. Agronomic performance and nutritive quality of some commercial and improved dual purpose cowpea (*Vigna unguiculata* L. Walp) varieties on marginal land in southwest Nigeria. *Grassland Science* 57**:** 211 - 218.

AOAC, 2000. *Official Methods of Analysis*. 16th edn. Association of Official Analytical Chemists, Arlington, VA, USA.

Beaty, E. R. and Engel, J. L. 1980. Forage quality measurements and forage research-A review, critique and interpretation. *Journal of Range Management.* 33 (1): 49-54.

Begum, S. M. M., Rahman, M. J., Abedin, M., Islam, M. R. *and* Uddin, M. 2001. Effects of nitrogen supplied from manure and fertilizer on the growth, yield and nutrient uptake of rice. *Journal of Biological Science* **18**,708-710.

Bjorkman, O., Boynton, J. and Berry, J. 1976. Comparisons of the heat stability of photosynthesis, chloroplast membrane reactions, photosynthetic enzymes, and soluble proteins in leaves of heat adapted and cold adapted C4 species. Carnegie Institution of Washington Yearbook 75:400-407.

Campbell, C. A., Schnitzer, M. J., Stewart, W. B., Biederbeck, V. O. and Sells, F. 1986. Effect of manure and fertilizer on properties of a black chernozem in southern Saskachevan. *Canadian journal of soil science 66(40): 601-614*

Cremenescus, G., Ceausu, C., Povarna, F., Lancu, D., Mihailescu, M. and Popescu, C. 1985. Fertilizer application with manure on wheat and maize on acid soils. *Analele institutului de cercetari, pentru cereal si plantae Technic Fundulea.* 53:155-171.

Duncan, D. B. 1955. Multiple Range and Multiple F-Test *Biometrics*. 11:1-42

Eastridge, M. L. 2006. Major Advances in Applied Dairy Cattle Nutrition. *Journal of Dairy Science* 89 (4): 1311-1323.

Giller, K. E. 2001. Nitrogen fixation in the Tropical Systems. 2nd Edition CABI: Wallingford, UK. pp. 150-300.

Hoskins, B. R. 1997. Soil testing handbook for professionals in agriculture, horticulture, nutrient and residuals management (Third edition). Pg. 119

Humphreys, L. R. 1995. Diversity of Productivity of Tropical Legumes. In: Tropical Legumes in Animal Nutrition; D'Mello, J.P.F. and C. Devendra (eds). CAB International, Wallingford, UK. pp 1-21.

Karachi, M. 1983. Yield and quality of *Lablab purpureus* ecotype in high altitude semi-arid lands in Kenya. FAO. The epidemiology, diagnosis and control of helminth parasites of ruminants.

Lamidi, A. A. and Aina, A. B. J. 2013. Presowing treatment, agronomic parameters and nutritive potential of *Tephrosia bracteolata* (Guill. Et Perr.) at four different stages of growth. *African Journal of Livestock Extension,* 11: 31-36.

Lamidi, A. A. and T. Ogunkunle. 2016. Nutritional potential of poultry dropping meal as feed resources for ruminant production in Niger Delta, Nigeria. *Global Agricultural Science & Technology*, 1:1-11.

Larney, F. J., Janzen, H. H., Olson, B. M. and Olson, A. F. 2009. Erosion-productivity-soil amendment relationships for wheat over 16 years. *Soil Tillage Res.* 103: 73-83.

McDowell, L.R., Conrad, J.H. and Humbry, F.G. 1993. Minerals for grazing ruminants in tropical regions. Bulletin: The US Agency for Literature Development and Caribbean Basin Adversary

Group (CBAG) USA.

Minson, D. J. 1983. Effects of chemical and physical composition of herbage eaten upon intake. In: Nutritional Limits to animal Production from Pastures, J.B. Hacker (Ed.) CAB, Farnham Royal, UK p 169 – 182.

Minson, D. T. 1990. Chemical composition and nutritive value of tropical grasses. *In*: P.J. Skerman and F. Riveros (Eds.). *Tropical Grasses*, Food and Agricultural Organisation of the United Nations, Rome. *FAO Plant Production and Protection Serie*s No. 23. pp 163 – 180.

Muir, J. P. 2002. Hand-picked forage yield and quality and seed production from annual and short-lived perennial warm season legumes fertilized with composed manure. *Crop Sci.*, 42: 897-904.

Murphy, A. M. and Colucci, P. E. 1999. A tropical forage solution to poor quality ruminant diets: a review of *Lablab purpureus*. *Liv. Res. Rur. Dev*. 11(2).

Ndakidemi, P. A. and Dakora, F. D. 2007. Yield components of nodulated cowpea (*Vigna unguiculata* (L.) Walp) and maize (Zea mays) plants grown with exogenous phosphorus in different cropping systems. *Aust. J. Exp. Agric*. **47:** 587-590.

Ndlovu, L. R. 1991. Complementary of forages in ruminant digestion: Theoretical considerations. In: The complementarily of Feed Resources for Animal production in Africa, J. E. S. Stares, A. N. SAID and J. A. Abdullah (eds.). Proceedings of the Joint Feed Resources Network Workshop, Gaborone, Botswana 4-8 March 1991. Pp 17-23.

Nori, H., Sani, S, A. and Tuen, A. A. 2009. Chemical and physical properties of Sarawak (East Malaysia) rice straws. *Livestock Research for Rural Development. Volume* 21*, Article no.*122*.*

NRC. 1996. *Nutrient Requirements of Beef Cattle*, 7th edn. National Academy of Science, Washington, DC, USA.

NRC. 2001. Nutrient requirements of dairy cattle, 7 rev. ed. Washington, D.C.

Nworgu, F. C. and Ajayi, F. T. 2005. Biomass, dry matter yield, proximate and mineral composition of forage legumes grown as early dry season feeds. *Livestock Research for Rural Development, Volume 17, Article #121***.** Retrieved July 22, 2016, from http://www.lrrd.org/lrrd17/11/nwor17121.htm

Ojo, V. O. A., Dele, P. A., Yusuff, R. B., Olanite, J. A., Jolaosho, A. O., Arigbede, O. M., Adeoye, S. A., Amole, T. A. and Hassan O. A. 2014. Biomass yield and nutritive quality of four varieties of *Pennisetum purpureum* as influenced by three cutting intervals in the humid zone of Nigeria. *Nigerian Journal of Animal Production* 41: (2) 165-173.

Olanite, J. A. 2003. *Evaluation of selected grasslegume mixtures as feed for weaner calves under traditional cattle management in Ibadan, Nigeria.* PhD, Thesis, Department of Agronomy, University of Ibadan, Nigeria. 223pp.

Olanite, J. A., Arigbede, O. M., Jolaosho, O. A., Onifade, O. S. and Alabi, B. O. 2006. Effect of cutting intervals on the dry matter yield and nutritive quality of two varieties of *Panicum maximum* in the humid zone of Nigeria. *ASSETS Series A* 6 (1): 171-180.

Taura, D. W. and Fatima, M. S. 2008. Effects of organic and inorganic fertilizers on the vegetative and reproductive parts of some selected varieties of cowpea. In: *African Journal of General Agriculture, Vol. 4, No. 2, June 30, 2008. Pp 80 – 86.*

Trevaskis, L. M., Fulkerson, W. J. and Gooden, J. M. 2001. Provision of Certain Carbohydrate based Supplement to Pasture fed Sheep, As Well as Time of Harvesting of The Pasture, Influences pH, Ammonia Concentration and Microbial Protein Synthesis in The Rumen. ***Australia Journal Experimental Agriculture,*** 41: 21-27.

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. http://jds.fass.org/cgi/reprint/74/10/3583.pdf

Van Wieringen, L. M., Harrison, J. H., Nennich, T., Davidson, D. L., Morgan, L., Chen, S., Bueler, M. and Hoisington, F. 2005. Manure management effects on grass production, nutritive content, and soil nitrogen for a grass silage-based dairy farm. *Journal of Environmental Quality* **34**:164–173.

Wilson, C., Undi, M., Tenuta, M., Wittenberg, K. M., Flaten, D., Krause, D. O., Entz, M. H., Holley, R. and Ominski, K. H. 2010. Pasture productivity, cattle productivity and metabolic status following fertilization of a grassland with LHM: a three-year study. *Canadian Journal of Animal Science* 90:233–243.

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