Yield and nutrient composition of fertilized maize as fodder for ruminant production

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Abstract

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Maize plant generates a lot of underutilized leaves which if properly harnessed can be cheaper source of nutrients for cattle, sheep and goat production, thereby improving the challenges of dry season feed shortages. In the study, the fodder yield and the nutritive value of fertilized maize were investigated as feedstuff for ruminant production. Six treatments comprised of maize fertilized with cattle, sheep, swine and poultry manures, NPK and the control were arranged in a randomized complete block design with five replicates in a field study in the early and late cropping seasons. Parameters on chemical composition, leaf and grain yield as well as plant height were determined. Results showed that crude protein content ranged from 10.08 ± 0.70 to $12.48 \pm 0.82\%$ with manure fertilized maize leaves having the highest ($P < 0.05$) values in both seasons. The neutral detergent and acid detergent fibre contents ranked the same statistically ($P > 0.05$) across fertilized maize with values ranging from 53.70 ± 0.81 to $59.90 \pm 0.83\%$ and 33.70 ± 0.60 to $37.32 \pm 0.63\%$, respectively. Acid detergent lignin varied ($P < 0.05$) and ranged from 5.01 ± 0.25 to $8.82 \pm 0.31\%$ across treatments. Leaf yield and yield components were also higher in manure fertilized maize compared to maize fertilized with NPK and the control. Leaf yield ranged from 883.33 to 1113.24 kg DM/ha with maize fertilized with sheep manure having the highest values in the early season. It can be concluded that animal manures have excellent potential to increase fodder yield and nutrient composition of maize plants.

Keywords: Maize crop, fodder yield, nutrient composition, livestock manure application

Introduction

Ruminants are important livestock species in Nigeria and form integral part in smallholder farming systems as they provide adequate nutrients required as food. Small ruminants in particular are useful to humans during periods of cyclical and unpredictable food shortages (Birteeb *et al.*, 2012). Despite the importance of these animals, poor nutrition especially during the dry season has been indicated as a major threat to their sustainable production (Lamidi and Ologbose, 2014). Adequate supply of fodder is however essential for development of livestock and a major way to overcome dry season fodder shortage is to source for crop residues during the cropping season and preserve for dry season

feeding.

Maize based cropping system is common, stable and very productive in Nigeria. It generates a lot of leaves which are currently underutilized as waste products during the cropping season (Abubakar, 1999), which makes them cheap sources of nutrients especially dietary energy and fermentable products for ruminant production. The application of manure has been reported to improve maize growth as manure nutrients have been found to be released more slowly and stored for a longer period, thereby ensuring a long residual effect (Namazi *et al.*, 2015).

The integration of maize crop through the abundance of these leaves with sheep production systems if well harnessed could

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constitute a new paradigm for agriculture and animal husbandry, thereby increasing fodder and meat productivity as well as reducing the risks of natural resources degradation and facilitating expansion of food production. This study therefore investigates into the fodder yield and nutritive value of manure fertilized maize in smallholder small ruminant production system.

Materials and methods

Experimental Site

The study was conducted at the Teaching and Research Farms, Federal University of Agriculture, Abeokuta, Nigeria. The location is 7.6 meters above sea level and falls within Latitude 7°15'N and Longitude 3°25'E, and situated in the derived savannah vegetation zone of south western Nigeria. It experiences approximately eight months of rainfall that is bimodal in pattern and receives a mean annual precipitation of 1037mm, with a mean annually temperature of 34.7°C and mean relative humidity of 82% (Google Earth, 2017).

Maize cultivation

One hectare of land was ploughed and harrowed and used for a field experiment in the early and late cropping seasons. Sole cropping was adopted in and arranged in a randomized complete block design with six treatments replicated six times. Maize seeds variety Downey Mildew Resistant - Early – Streak Resistant (DMR-E-SR) was planted across the slope in an ideal practice using 75cm inter-row spacing and 50cm intra-row spacing with seed rate of three seeds planted per hole and thinned to two seedling per stand at two weeks after planting. Manures from cattle, sheep, poultry and swine were sourced from the University Teaching and Research Farms and applied at the rate of 4.57t/ha for the first four treatments, respectively. The NPK (20:10:10) fertilizer was applied to the fifth

treatment which amount to 68.57kg/ha of nitrogen and 34.29kg/ha of phosphorus and potassium, respectively. The sixth treatment was the control with no manure application.

Chemical weed control was carried out using primextra, applied pre-emergence a day after sowing using a knapsack sprayer, and supplemented with hoe weeding at four weeks after planting.

Data collection

Leaf yield of maize was taken at harvest by harvesting the leaves from the soil level with exception of the flag leaf. Plant height was measured by randomly selecting ten (10) plants at maturity per treatment from the inner rows and their heights in centimeters were measured using a meter rule from the soil level to the flag leaf. For the determination of the grain yield, dried maize cobs were harvested from the net plot; they were shelled, winnowed and weighed.

Chemical analysis

Samples of soil and the manure types were analyzed using the recommended procedures described (IITA, 1979 and Anderson and Ingram, 1998) for soil pH; organic carbon; total nitrogen, electrical conductivity and ammonium concentration (for the manure only); available P (using Bray-1 method), exchangeable basic cations; exchangeable acidity and effective cation exchange capacity. Available moisture content as well as physical properties were determined on the soil.

The dry matter, crude protein, ether extract and ash contents of the maize leaf samples were determined (AOAC, 2000). Fibre fraction namely neutral detergent fibre, acid detergent fibre and acid detergent lignin were determined with the procedure of Van Soest *et al.* (1991).

Statistical analysis

Data were subjected to analysis of variance using statistical package SAS (1999).

Significant means were separated using Duncan's Multiple Range Test in the same package.

Results and discussion

The chemical composition of manures and the soil used in this study are presented in Table 1. The various manure types used were generally high in the major nutrients and had properties consistent with those manures reported in earlier studies from other farms in Nigeria (Adeniyi *et al.*,

2011; Waniyo *et al.*, 2013). High calcium content across manure types could probably be responsible for the relatively high pH. Studies have shown that high calcium carbonate in organic manure treatments is believed to increase buffering, thereby increasing the soil pH (Eghbal, 1999). The range of soil electrical conductivity (EC) is an indication of the availability of nutrients in the soil. The higher the EC, the more the cations that are being held in the soil that is beneficial to plants (CUCE, 2007).

Table 1: Chemical analysis of manure types and soil samples

Parameters	Animal sources of manure				Parameters	Soil
	Cattle	Sheep	Poultry	Swine		
% Moisture	31.79	28.09	29.24	30.07	pH	7.09
Ph	8.51	8.32	8.17	8.67	% Sand	95.33
% Total Nitrogen	3.13	3.42	3.41	3.12	% Silt	1.26
% Organic Carbon	22.09	29.09	26.23	23.84	% Clay	3.41
% Organic matter	38.09	50.16	48.67	41.10	% Total Nitrogen	0.34
NH ₄ -N (mg/kg)	3390.5	3927.5	3915.0	3383.5	% Organic Carbon	1.11
NO ₃ -N (mg/kg)	371.0	480.5	465.0	367.0	% Organic Matter	1.92
% Total Phosphorus	1.41	1.81	1.79	1.42	Calcium (Cmol/kg)	2.76
% Calcium	2.47	2.85	2.82	2.48	Magnesium (Cmol/kg)	0.97
% Magnesium	0.35	0.43	0.41	0.36	Sodium (Cmol/kg)	0.35
% Potassium	2.65	2.88	2.86	2.66	Potassium (Cmol/kg)	1.29
% Sodium	0.91	0.98	0.96	0.92	Exch Acidity(Cmol/kg)	0.45
% Sulphur	0.31	0.357	0.35	0.32	Elec. conductivity (Cmol/kg)	1.24
Copper (mg/kg)	305.0	346.5	337.0	313.5	Av.. Phosphorus (mg/kg)	5.13
Iron (mg/kg)	1888.0	1970.0	1959.0	1892.0	Manganese (mg/kg)	5.44
Zinc (mg/kg)	220.0	275.5	269.5	229.5	Copper (mg/kg)	0.26
Manganese (mg/kg)	239.0	269.0	260.5	246.0	Zinc (mg/kg)	1.52

The application of different manure types on maize significantly ($P < 0.05$) affected the dry matter, crude protein and ether extract of leaves (Table 2) with manure fertilized maize having higher ($P < 0.05$) values compared to the other treatments. This corroborates earlier reports that application of organic manure improved the soil physical and microbial contents and also enhanced nutrient quality of manured fertilized forages as a major feed of grazing animals (Sodeinde *et al.* 2009; Ojo *et al.*, 2015). Dry matter (DM) content of maize leaves ranged from 90.83 to 93.32% across

the season with maize leaves from plants fertilized with poultry manure recording the highest and the least observed in maize leaves from plants fertilized with swine manure. Crude protein (CP) values across season ranged from 10.08% in unfertilized maize leaves to 12.48% in maize leaves fertilized with sheep manure. Despite these variations, the forage generally contained adequate amounts of the protein to meet ruminant requirements. The CP contents of maize leaves in this study is below the critical limit which intake of forages by ruminants and rumen microbial activity

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would be adversely affected (Van Soest, 1994) and these values are above the CP range of 6.5–8.0% prescribed for optimum performance of tropical ruminant animals (Minson, 1981). The leaves are therefore adequate for meeting the protein requirement of growing ruminant animals

to generate a high level of ammonia in the rumen from degradable protein to ensure an efficient digestion process (Ørskov, 1995). The higher CP content recorded for the maize fertilized with sheep manure might be attributed to high nitrogen content in the manure (Muyekho *et al.*, 2000).

Table 2: Proximate composition (%) of maize leaves fertilized with different manure types

Treatment	Dry-matter		Crude protein		Ash		Ether extract	
	Early	Late	Early	Late	Early	Late	Early	Late
Cattle MFM	91.08 ^a	92.77 ^b	11.51 ^c	10.75 ^a	5.50	5.25	11.50 ^a	11.45 ^a
Sheep MFM	91.59 ^a	91.22 ^b	12.48 ^a	11.98 ^a	6.01	5.65	10.50 ^b	10.45 ^b
Poultry MFM	91.72 ^a	93.32 ^a	11.32 ^c	10.88 ^b	5.50	6.01	10.59 ^b	11.50 ^a
Swine MFM	90.83 ^b	90.22 ^b	12.03 ^{ab}	10.78 ^b	5.60	6.05	10.50 ^{ab}	10.35 ^b
NPK	90.92 ^{ab}	92.65 ^{ab}	11.90 ^b	10.56 ^{bc}	5.48	4.70	11.00 ^b	10.45 ^b
Unfertilized M	91.32 ^a	90.87 ^b	10.17 ^d	10.08 ^c	5.41	5.65	10.45 ^b	10.00 ^b
Mean	91.24	91.84	11.57	10.83	5.58	5.55	10.75	10.70
SEM	0.68	0.72	0.78	0.81	0.13	0.11	0.25	0.33

^{a, b, c, d} Means along the same column with different superscripts are significant ($p < 0.05$).

MFM – Manure Fertilized maize

The application of animal manures types had little effect on fibre fractions of maize leaves (Table 3). Values recorded for fibre fractions across treatments were similar to those earlier reported by Fasae *et al.* (2009). Variations ($P < 0.05$) were not observed in neutral detergent fibre and acid detergent fibre of maize leaves with appreciable differences ($P < 0.05$) observed in acid detergent lignin. Acid detergent lignin (ADL) content ranked the same among fertilized maize while the NPK fertilized maize recorded the highest ($P < 0.05$) ADL content. The high ADL observed in leaves of NPK fertilized maize leaves when compared to the control is consistent with the findings of Holubek *et al.* (1999) that

observed that non-fertilized semi-natural grassland contained lower lignin content compared to the same fertilized grassland. Wolf and Boberfeld (2003) also noted that the value of ADL increased with increasing amounts of nitrogen fertilizer application on the plant. The NDF recorded is below 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 (Muia, 2000). The moderate fibre levels of the maize 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.

Table 3: Fibre fractions composition (%) of maize leaves fertilized with different manure types

Treatment	Neutral detergent fibre		Acid detergent Fibre		Acid detergent lignin		Hemicellulose		Cellulose	
	Early	Late	Early	Late	Early	Late	Early	Late	Early	Late
Cattle MFM	57.10	56.90	36.30	36.00	6.09 ^b	7.00 ^b	20.80	20.90	30.21	29.00
Sheep MFM	54.21	57.20	34.11	33.70	6.11 ^b	5.01 ^c	20.10	23.50	28.00	28.69
Poultry MFM	58.32	53.70	35.34	34.60	7.21 ^b	5.90 ^c	22.98	19.10	28.13	28.70
Swine MFM	56.44	59.90	35.78	35.08	7.18 ^b	7.05 ^{ab}	20.66	24.82	28.60	28.03
NPK	55.49	55.00	35.91	34.95	8.82 ^a	7.90 ^a	19.58	20.05	27.09	27.05
Unfertilized M	55.97	55.71	37.12	36.96	7.97 ^{ab}	7.60 ^a	18.85	18.75	29.15	29.36
Mean	56.26	56.40	35.76	35.22	7.23	6.74	20.50	21.19	28.53	28.47
SEM	0.82	0.84	0.61	0.65	0.28	0.30	0.42	0.41	0.52	0.49

^{a, b, c, d} Means along the same column with different superscripts are significant ($p < 0.05$).

MFM – Manure Fertilized maize

Manure application was observed to significantly influence the fresh leaf yield of maize (Figure 1). Maize growth and yield characteristics were better with the use of animal manure compared to the control and NPK fertilizer treatments. Manure has been widely used as organic fertilizer and it has significant effect on the soil fertility by adding both major and essential nutrients as well as soil organic matter which improve moisture and nutrient retention. This has been found to increase soil quality and crop yield while reducing pollution and increasing farmer profits (Carmo *et al.*, 2016). The range of 883.33 to 1,113.24kg DM/ha obtained for

leaf yield of maize plants in both season across the treatments were comparable with values reported by Fasae and Elemo (2009). Higher leaf yield of 1500kg DM/ha was reported by Abate and Abate (1994). The increase in the fodder yield of the maize as affected by manure types in this study might be due to the release of essential plant nutrient and the supply of necessary nutrient lacking in the soil as well as increase accumulation of organic matter through the promotion of the activities of living organisms in the soil; thereby improving the forage nutritive value in term of crude protein and energy contents (Muyekho *et al.* 2000; Alalade *et al.*, 2013).

Table 1: Effect of different manure types on leaf yield of maize

The highest leaf yield recorded for maize fertilized with sheep manure might be as a result of the high rate of mineralization in the manure as sheep manure have been reported to contain high amount of primary macro nutrients and other essential nutrients for plants (Dekisissa *et al.*, 2008), which could have increased the soil cation exchange capacity thereby absorbing more cations such as calcium, magnesium and potassium than sodium (Jalali and Ranjber, 2009). Moreover, the leaf production efficiency of maize in the early season was higher than that of late season and the variation observed could be attributed to poor weather conditions which have been attributed to be a major problem limiting

maize production during the late season (Onuk *et al.*, 2010).

The overall growth parameters of maize under different manure types recorded higher values for the traits measured. Figures 2 and 3 depict that manure application increased ($P < 0.05$) plant height and grain yield of maize with higher values observed during the early cropping season. This is in line with reports that application of manure to pasture during establishment assisted quick establishment, increased forage yield, numbers of tillers and promoted plant height significantly over the control at all the stage of forage cuttings (Qamar Bilal *et al.*, 2000; Alalade *et al.*, 2013).

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The increased production of grain yield from the application of manure in the study could be due to enhanced soil fertility that in turn had enhanced nutrient provision, for optimum plant growth thereby increasing yield components and hence the grain yield (Ali, 2011). The increased grain yield with manure application in maize was also reported by Farhad *et al.* (2009).

Conclusion

The study showed that leaf yield and nutritional composition of maize fertilized with sheep manure produced the best quality forage. This could facilitate expansion of food production; and simultaneously safeguard the environment with prudent and efficient use of natural resources, thereby providing all year-round feed resulting into ruminant productivity, especially in small-holder farming systems in Nigeria.

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