Biomass Yield and Hay Quality of Irrigated *Brachiaria ruziziensis* Fertilized with Goat Manure as Dry Season Forage

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ABSTRACT

Shortage of forage during the dry season has remained a major challenge for improved ruminant production in most tropical countries. For successful ruminant production, high forage yield and quality are required. This study evaluates the biomass yield and hay quality of irrigated *Brachiaria ruziziensis* as influenced by five different rates of goat manure application (0, 5, 10, 15 and 20 t/ha DM). Treatments were arranged in a randomized complete block design with five replicates. The grass was cut back to 15 cm stubble height at the commencement of the study after which two consecutive cuts were made at 45−day intervals. Samples from the treatments were stored for 3 months from which aliquots were taken monthly and analyzed. Results showed that dry matter yield of *Brachiaria ruziziensis* increased ($P < 0.05$) with increasing rates of goat manure application rates, up to 5.26 t/ha in the first harvest and to 8.16 t/ha in the second cut for plots fertilized with 20 t/ha of manure. The crude protein concentration of *Brachiaria ruziziensis* also increased ($P < 0.05$) from 7.38 to 12.90% for 0 to 20 t/ha goat manure application rates. As the length of storage of *Brachiaria ruziziensis* hay increased, dry matter and fibre fraction concentrations increased but crude protein concentration decreased ($P < 0.05$). The study concluded that increasing rate of goat manure application up to 20 t/ha enhanced the dry matter yield and crude protein concentration of *Brachiaria ruziziensis.*

Keywords: Ruminant, dry matter yield, *Brachiaria ruziziensis*, goat manure

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INTRODUCTION

Natural grasslands constitute the major feed resources of ruminants, either by grazing or as conserved forages (Tolera and Abebe, 2007). In most tropical countries, the inadequacies in feeding and nutrition during the dry season are a major limitation to successful ruminant production. The available natural pasture and crop residues after crop harvest during the dry season are usually fibrous and limited in most nutrients which are required for increased rumen microbial fermentation and improved performance of the host animal (Simbaya, 2002). Most of these animals suffer from seasonal nutritional stress, resulting in weight loss, reproductive inefficiency and even death (Yohanna *et al.,* 2015).

To improve the overall performance of ruminant animals to an economically profitable level, there is need to provide a sustainable year−round feeding program through irrigation and manure fertilization of sown pastures during the dry season. *Brachiaria ruziziensis* is a perennial tropical forage reported to have good tolerance to acidic soils and that responds well to nitrogen (Skerman and Riveros, 1990). Goat manure (GM) like any other organic manure is renewable, biodegradable, sustainable, and environmentally friendly, and widely reported to be rich in nutrients, increasing crop growth rate, yield, quality, and ability to tolerate stressful conditions (Odedina *et al*., 2011; Nweke *et al*., 2013). Most studies on utilization of animal manure have largely focused on arable crops with little plausible information on forage crops. Since ruminant performance is directly related to forage nutritive value, information is therefore needed on the effects of manure application on forage nutritive value. This experiment therefore evaluates the effect of dry season goat manure application on biomass yield and nutritive value of irrigated *Brachiaria ruziziensis* (BR).

MATERIALS AND METHODS

Experimental Site

The experiment was conducted at the Kalahari red goat unit of the Institute of Food Security, Environment Resource and Agricultural Research farms of the Federal University of Agriculture, Abeokuta, Nigeria, situated within latitude 7°18’2’’N and 7°18’30’’N; and longitude 3°22’10’’E and 3°22’41’’E, and 76 m above sea level. The climate is humid tropical, with mean annual rainfall of 1,037 mm and relative humidity of 82%.

Establishment of *Brachiaria ruziziensis*

The *Brachiaria ruziziensis* was established by planting the seeds using a drill in June 2015. The plants were undefoilated before the initial cut−back to a stubble height of 15 cm above ground level in December 2015 at the commencement of the experiment. Each plot measure 4 m by 4 m with an inter plot space of 0.5 m.

Prior to manure application, soil samples were randomly collected from the plots, air−dried, sieved with a 2 mm mesh sieve and analyzed for physical and chemical properties through methods reported by Osayande *et al.* (2015). Goat manure (GM) was also collected from heaps of manure at the goat unit of the experimental site and composted, subsamples taken and analyzed. Uniformity was ensured by thorough mixing of the manure before sub sample was taken. The manure was applied once in December a day to commencement of the experiment by making a small farrow about 4−8 cm from the base of the plant then manure applied and farrow closed back. The experiment was laid out in a randomized complete block design with 5 replicates and GM was applied at 0, 5, 10, 15 and 20 t/ha DM. The plots were irrigated using a sprinkler method at a 3−day interval throughout the duration of the experiment. The experiment was conducted during the dry season and irrigation of the plots started 7 days before the commencement of the experiment.

Estimation of Fresh Biomass Yield and Dry Matter Yield (DMY)

Fresh biomass yield was estimated by harvesting the herbage materials to a stubble height of 15 cm. The plots were harvested manually using a sickle at 45−day regrowth. A 1.0 × 0.5 m^2 quadrant frame was thrown thrice in each plot and the entire sward falling inside it was clipped at height of 15 cm above ground. The remaining areas of the plot were cleared to 15 cm stubble height. The samples harvested per plot were weighed fresh to determine biomass yield, sub samples taken and oven dried at 65°C till constant weight.

Storage Test

Brachiaria ruziziensis was harvested from the established plots at 45 days of regrowth, processed by chopping to about 5 cm, air−dried and then made into bales of 5 kg in jute bags and stored for three months in a well−ventilated room. The chemical composition of stored hay was determined at monthly intervals throughout the storage period.

Chemical Analysis

Samples of *Brachiaria ruzizensis* from each harvest, hay samples, were analyzed for dry matter and crude protein using the procedure of AOAC (2005), fibre fractions were determined using the procedures of Van Soest *et al.* (1991).

Statistical Analysis

Data collected were subjected to analysis of variance using the statistical package (SAS, 2003) and significant means separated using the least significant difference (LSD).

RESULTS AND DISCUSSION

The soil characteristics and goat manure composition are shown in Table 1. The composition of goat manure (GM) observed in this study was lower in total nitrogen, organic matter, phosphorus and potassium values (total N of 4.9%, organic matter 69.2%, phosphorus of 4.1 mg/kg and potassium 1.9 cmol/kg) reported by Awodun *et al.* (2007) while the 1.37% total nitrogen reported by Odedina *et al.* (2011) was lower than the value reported in this study. The differences in nutrient concentrations of GM could be related to the nutritional management of goats. The goat manure used in this experiment were sourced from goat fed concentrate diet, grasses and crop residue and they were also managed in an semi−intensive system. Generally, the source of raw material has been reported to influence the humification process during composting (Chefetz *et al.,* 1998) and chemical composition affects the decomposition rate of all organic matter including manure (Gordillo and Cabrera, 1997).

Table 1 Physicochemical properties of soil samples and goat manure used for the experiment

Parameters	Soil	Goat manure
pH in water	8.15	8.07
Sand (%)	76.90	−
Clay (%)	17.80	−
Silt (%)	5.30	−
Total nitrogen (%)	0.14	1.55
Organic carbon (%)	0.60	13.07
Organic matter (%)	1.03	45.41
Available phosphorus ($mgkg^{-1}$)	16.10	0.22
K^+ ($cmolkg^{-1}$)	0.84	0.87
Na^+ ($cmolkg^{-1}$)	0.71	0.28
Ca^{2+} ($cmolkg^{-1}$)	3.13	1.27
Mg^{2+} ($cmolkg^{-1}$)	1.46	1.36
Exchangeable acidity ($cmolkg^{-1}$)	2.70	−

The effect of varying GM application rate on fresh biomass yield of *Brachiaria ruziziensis* over two consecutive cuts and the total yield over the period of the experiment is shown in Table 2. BR with varying application rates of GM resulted in a greater dry matter yield than the control treatment suggesting that GM probably improved soil fertility.

Table 2 Effect of varying goat manure application rate on fresh biomass and dry matter yield (t/ha) of *Brachiaria ruziziensis* over two consecutive cuttings

Goat manure (t/ha DM) application rates	Cut 1		Cut 2		Total	Yield
	FBY	DMY	FBY	DMY	FBY	DMY
Control (0)	5.02^{c}	1.88^{c}	6.89^{b}	2.47^{c}	11.91^{d}	4.35^{d}
5	6.98^{bc}	2.84^{bc}	10.78^{b}	3.78^{bc}	17.76^{c}	6.63^{c}
10	8.67^{b}	3.43^{b}	10.44^{b}	3.56^{bc}	19.11^{c}	6.99^{c}
15	8.22^{b}	3.45^{b}	18.33^{a}	6.34^{ab}	26.55^{b}	9.79^{b}
20	10.22^{a}	5.26^{a}	22.22^{a}	8.16^{a}	32.44^{a}	13.41^{a}
C.V. (%)	13.80	20.67	16.25	30.45	8.50	13.95
LSD (P<0.05)	2.06	1.27	4.06	2.69	2.40	2.09
SEM	0.65	0.33	1.59	0.64	2.12	0.87

Note: ^{a,b,c,d} Means within a column having different superscripts were significantly different ($P < 0.05$) CV. Coefficient of variation; LSD, Least significant difference, SEM, Standard error of means; FBY, Fresh Biomass Yield ; DMY – Dry matter yield

The increase in BR fresh weight with an increasing rate of GM application for both cuts agrees with the finding of Maleko *et al.* (2015) that biomass yield of *Brachiaria ruziziensis* increased significantly from 9.31 to 13.70 t/ha with cow manure application rate from 0 to 15 t/ha DM. Similar results were obtained by Ahmed *et al.* (2012) and Batista *et al.* (2014) on the influence of farmyard manure and nitrogen on the production characteristics of *Panicum maximum/Stylosanthes guianensis* and *Brachiaria ruziziensis*, respectively. The increase in biomass yield with increased manure application can be attributed to increased availability of nutrients as a result of a large amount of GM added to the soil with slow nutrient release from the manure, particularly nitrogen (Amanullah *et al.,* 2010). Higher soil microbial activities have been found to release nutrients from the farmyard manure as well as soil for better plant growth. Nitrogen is reported to plays a major role in leaf growth via its involvement in cell division and as a primary component of enzymes for all the living systems and processes (Duru *et al.,* 1997).

The effect of varying GM application rate on the dry matter yield (DMY) of BR over two consecutive cuttings shows variation ($P < 0.05$) at both harvests. The highest DMY of 5.26 and 8.16 t/ha were recorded for the first and second cuts, respectively, while the least DMY recorded for first and second cut were 1.88 and 2.47 t/ha, respectively.

The dry matter (DM) yield for first and second harvest, respectively in this study was greater than the yield reported by Panchaban *et al.* (2005) for BR subjected to organic and inorganic fertilizers. Higher yield of 17.6 tDM/ha per year at 800 kg N/ha per year application was observed in Malaysian sandy loam soil (Skerman and Rivero 1990) while Naveh and Anderson (1967) reported 21.5 DM t/ha in Tanzania when fertilizer mixture of (1 cwt./ac. double superphosphate (42% P_2O_2), 10 cwt./ac. Lime (56% CaO, 5% MgO), ½ cwt./ac. Muriate of potash (60% K_2O) 10 Ib./ac. Manganese sulphate, 10 Ib./ac. copper sulphate 10 Ib./ac. Zinc sulphate 10 Ib./ac. Borax and 1 Ib./ac. Molybdenum trioxide) was applied. The observed variations might be due to time period of data collection, height of stubble after cut, season variation, type and rate of fertilizer/manure applied.

The nutrient composition of *Brachiaria ruziziensis* as influenced by different goat manure application rates in two consecutive cuts is presented in Table 3. DM contents were not influenced (P > 0.05) by GM application rates in both cuts. This result is similar to the reports of Olanite *et al*. (2014) on proximate composition of three grass species subjected to animal manure during the mid−rainy season.

Table 3 Dry matter, crude protein and fibre fraction composition (%) of *Brachiaria ruziziensis* at two consecutive cuts using different goat manure application rates

Goat manure rate (t/ha DM)	DM		CP		NDF		ADF		ADL	
	Cut 1	Cut 2	Cut 1	Cut 2	Cut 1	Cut 2	Cut 1	Cut 2	Cut 1	Cut 2
Control	37.2	35.9	7.59[c]	7.38[c]	61.0	59.3	32.6[ab]	27.5[a]	13.7	10.9[b]
5	40.9	35.2	8.10[bc]	10.3[b]	60.8	59.2	33.7[a]	28.3[a]	13.3	11.4[ab]
10	39.5	34.1	8.17[bc]	11.6[a]	60.4	59.0	32.3[ab]	26.9[ab]	13.0	10.8[b]
15	41.8	34.5	8.69[b]	12.1[a]	60.5	58.2	32.6[ab]	27.6[a]	13.1	10.6[b]
20	42.7	35.9	9.28[a]	12.9[a]	59.0	58.1	31.8[b]	26.0[b]	12.7	11.7[a]
SEM	0.96	0.73	0.17	0.54	0.68	0.25	0.24	0.26	0.17	0.13

Note: [a,b,c] Means within a column having different superscripts were significantly different (P < 0.05)
DM = Dry Matter; CP = Crude Protein; NDF = Neutral detergent fibre; ADF = Acid detergent fibre; ADL = Acid detergent lignin

The crude protein (CP) concentration in both cuts was influenced by GM application rates. The average CP concentration of 7.59 to 12.9% across both cuts is greater than minimum CP levels for ruminant intake. The critical level of protein in forage to facilitate adequate rumen fermentation is approximately 7% (Minson, 1982), although many classes of livestock require much greater concentrations to achieve target production. Concentrations below 7% limit animal production due to low voluntary intake, lower rate of digestibility and negative nitrogen balance.

The greatest CP concentrations were observed for BR fertilized with 20 t/ha DM goat manure, an indication of the more positive effect of increasing GM rate on the grasses at both cuts. This corroborates the finding of Panchaban *et al*. (2005) that the higher rate of chicken manure application of 3.75 t/ha and 312kg/ha chemical fertilizer (N: P: K 15:15:15) yielded the highest CP concentration for *Brachiaria ruziziensis* against other treatment in the experiment conducted to test the effect of organic and inorganic fertilizers on the yield and quality of ruzi grass (BR) grown on saline sandy soils of the Northeast, Thailand. This was attributed to quicker release of nutrients, in the form of nitrogen and phosphorous for plant uptake.

No differences in the neutral detergent fibre (NDF) concentration in both cuts supports the findings of Rogers *et al.* (1996) who reported no effect of increased fertilization on the NDF concentration in forage plants.

The acid detergent fibre (ADF) concentration was influenced (*P* < 0.05) by GM application rates and is in agreement with separate experiments of Cox *et al.* (1998) and Cox and Cherney (2001) of a negative linear relationship between ADF concentration and increased rate of fertilizer application.

The effect of 3 months length of storage on some BR nutrients is depicted in Figures 1 to 4. DM increased with an increase in the month of storage with slight ($P < 0.05$) differences observed in the second and third month. The range of DM values in this study were similar to those suggested for hay by Rotz *et al.* (1991), who also noted that moisture less than 10% could indicate brittleness or excessive leaf loss, while high moisture greater than 14 to 18% indicates a risk for mold growth and other micro biotic activity. The crude protein (CP) concentration of BR decreased with the length of storage. This corroborates earlier reports in the reduction of CP concentration of the leaves as storage length increases (Fasae *et al.,* 2009).

The effect of length of storage on neutral detergent fibre and acid detergent fibre (Figures 3 and 4) shows an increased from initial to final points across all treatments. A similar finding was observed by Shewmaker (2015) and was attributed to the fact that respiration reduces forage quality by removing some of the most digestible nutrients, causing an increase in proportions of the fibre fractions in the hay

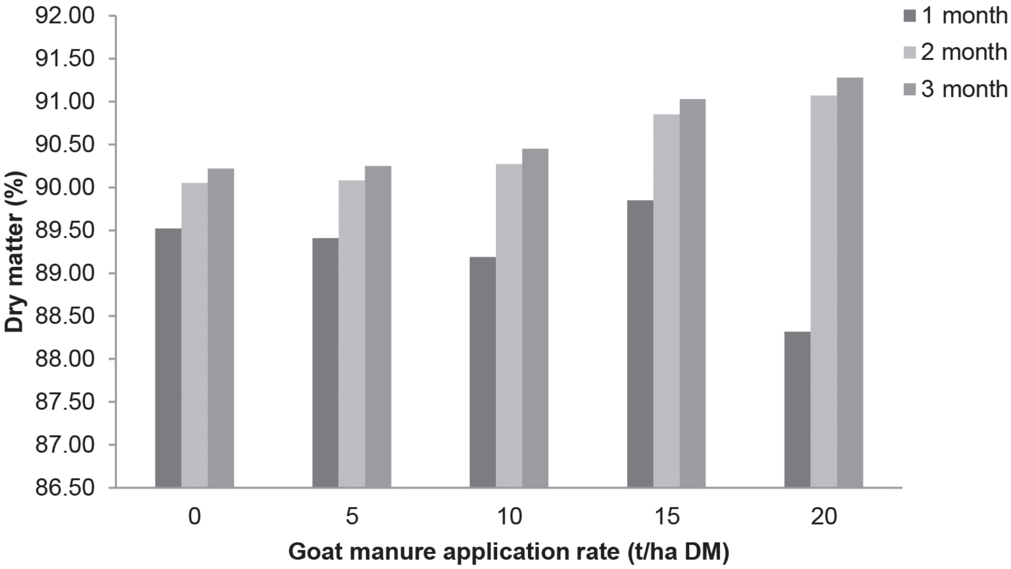

Figure 1 Effect of length of storage on the Dry matter concentration of Brachiaria ruziziensis fertilized at different goat manure application rates

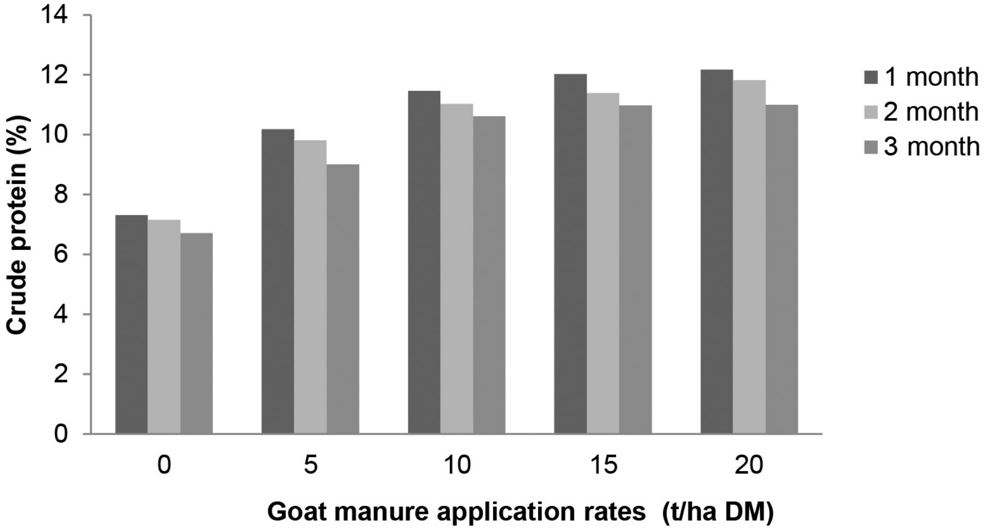

Figure 2 Effect of length of storage on the crude protein concentration of *Brachiaria ruziziensis* fertilized at different goat manure application rates

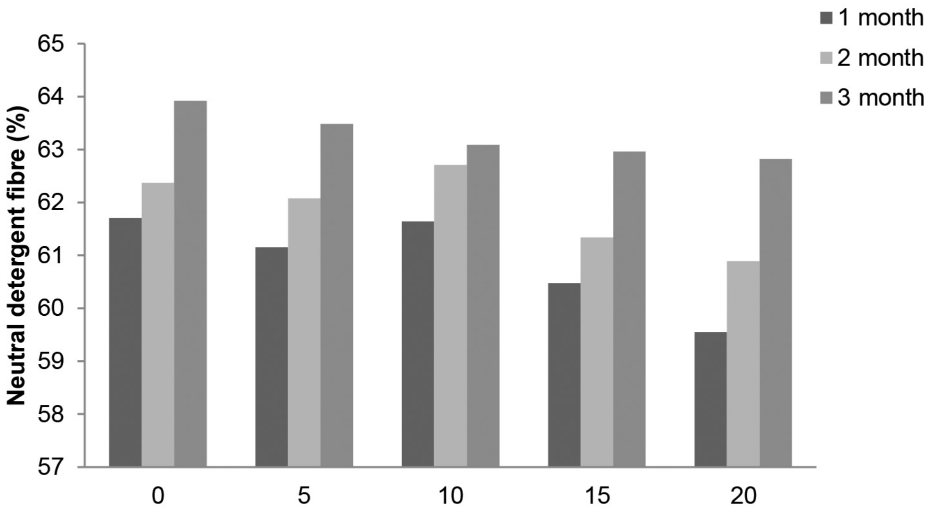

Figure 3 Effect of length of storage on the neutral detergent fibre concentration of *Brachiaria ruziziensis* fertilized with different goat application rates

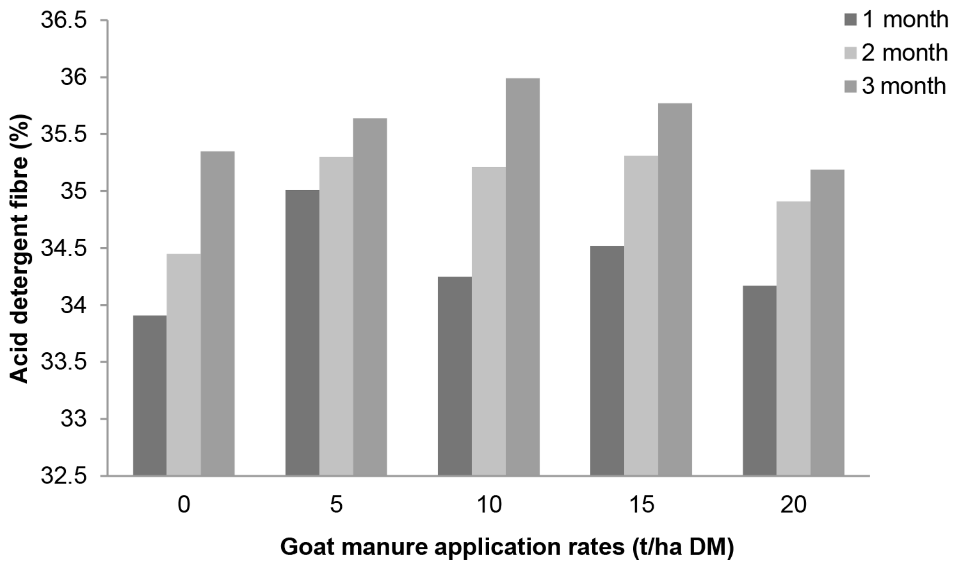

Figure 4 Effect of length of storage on the acid detergent fibre concentration of *Brachiaria ruziziensis* fertilized with different goat manure application rates

CONCLUSION

Goat manure application plots produced superior growth and nutrient concentrations in *Brachiaria ruziziensis* forage compared with the control, with *Brachiaria ruziziensis* fertilized with 20 t/ha DM goat manure producing the greatest dry matter yield and nutritive value, with higher crude protein and lower fibre fraction concentrations. This could therefore support the benefits of the goat manure as an alternative means to chemical fertilizers in improving forage production for ruminants during the dry season.

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