


Research Article

Comparative Effect of Organic Fertilizer Treatments on the Herbage Production and Nutritive Value of Congo Grass (*Brachiaria Ruziziensis*) Hay

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Abstract

This study evaluated the effect of organic fertilizer treatments on the nutritional value of *Brachiaria ruziziensis* hay. Congo grass was cultivated in the field and treated with fertilizers: T1 (no fertilizer), T2 (Natsoil), T3 (Wonder fertilizer), and T4 (poultry manure) in a randomized complete block design with four replications. The fresh herbage and dry matter yields were determined. The grass was harvested at bloom stage, packed and air-dried as hay and stored for chemical analysis, volatile fatty acid content and *In Vitro* Dry Matter Digestibility (IVDMD). The fertilizer treatments had significantly higher ($p < 0.05$) values for fresh herbage yields compared to the control treatment: T3 (18.38 tons/ha), T4 (16.66 tons/ha), T2 (14.05 tons/ha), and control (10.25 tons/ha). Also, the dry matter yield obtained for T3 (6.90 tons/ha), T4 (6.19 tons/ha), T2 (5.23 tons/ha) were significantly higher than that for the control (3.85 tons/ha). The results showed that crude protein, ether extract and carbohydrate fraction were significantly higher ($p < 0.05$) in T3 (Wonder fertilizer) than in other fertilizer treatments. Furthermore, for metabolizable energy, the T3 (4.36%), T4 (4.28%) and T2 (4.16%) fertilizers were significantly higher ($p < 0.05$) than control (3.80%), while the cellulose content was significantly the highest ($p < 0.05$) in T2 (21.75%) followed by T1 (21.65%), T3 (21.19%) and T4 (21.02%). The fertilizers T3, T4, and T2 had significantly higher ($p < 0.05$) propionate, butyrate and lactate contents than T1 (control). The total volatile acid was significantly the highest ($p < 0.05$) in T3 (152.50 mmol/100ml), followed by T4 (145.00 mmol/100ml), T2 (142.80 mmol/100ml) and the lowest in control (123.40 mmol/100ml). T3 had the highest ($p < 0.05$) gas produced at 9, 12, 21 and 24, as well as NH₃-H gas and IVDMD, higher than other fertilizer treatments. Conspicuously, the Organic Matter Digestibility (OMD) was significantly higher ($p < 0.05$) in T3 (60.87%), T4 (60.06%) and T2 (60.11%) than in control T1 (56.06%). It was concluded that Congo grass treated with Natsoil, Wonder and poultry litter fertilizers had increased crude protein, metabolizable energy, volatile fatty acid as well as IVDMD. However, the wonder fertilizer treatment was outstanding.

Keywords: Organic fertilizer, Nutritive value, In vitro digestibility, Congo grass, Hay

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1. Introduction

The availability of green forage is seasonal, mostly in rainy season, when plant growth is high (Ayandiran et al., 2024). *Brachiaria ruziziensis* or Congo grass is a forage crop that is grown throughout the humid tropics with fast growth at the beginning of the wet season due to strong seedling vigour, ease of establishment, and the ability to suppress weeds (Heuze et al., 2017). *B. ruziziensis* is a tropical grass that has remarkable qualities that favour the improved ruminant production. *B. ruziziensis* has remarkable traits like excellent acceptance, a good response to fertilization, high fodder quality and nutritional content (Santos et al., 2014), quick establishment, strong growth at the start of the wet season, ability to work well in association with legumes, dense flowering, and abundant seed yield (Valle et al., 2013). Congo grass is important in many parts of the world as it gives a high yield and is economically attractive (Ecoport, 2014). However, low soil fertility and unfavourable soil physical properties are some of the major flaws of its production in Nigeria (Adekiya and Ojeniyi, 2002). Fertilizers play a critical role in enhancing crop productivity and maintaining soil fertility (Gao et al., 2022). Hence, this study evaluated the efficacy of organic fertilizer treatments on herbage production and nutritive value of Congo grass hay.

2. Materials and methods

2.1. Site information

The research was carried out at the Teaching and Research Farm of the Osun State University College of Agriculture, located in Ejigbo, Osun State, in the Southwest of Nigeria.

2.2. Experimental layout and treatments

The Congo grass experimental field of 900 m² was divided into four blocks (each 225 m²). Each block was further divided into four plots using a randomized complete block design with four replicates. There were four fertilizer treatments comprising T1 (control-no fertilizer), T2 (Natsoil), T3 (Wonder fertilizer), and T4 (poultry manure). These fertilizers were applied by side placement method at 3 weeks after planting. Both Natsoil and Wonder fertilizers were applied at 2.4 tons/ha, while Poultry manure was applied at 7.5 ton/ha.

2.3. Fertilizer application

After 4 weeks of planting, the fertilizers, Natsoil, wonder fertilizer and poultry manure were applied separately to the treatment plots, with treatment one left as control. All fertilizers were applied using the side placement method with instructions from the producers strictly followed.

Natsoil containing 2% nitrogen was applied at the rate of 250kg per hectare (T2), Wonder fertilizer with 3.75% nitrogen was applied at the rate of 250kg per hectare (T3) while poultry manure with 2.09% nitrogen was applied at 5 tons per hectare (T4).

2.4. Determination of herbage yield

The yield of fresh herbage was calculated by randomly tossing a 1 m² quadrat. Using a weighing scale, the herbage covered by the quadrat was harvested, weighed and recorded. Each plot had three throws, and after measuring the gathered herbage after each toss, the average weight was calculated. Each plot's yield was given in tons per hectare.

2.5. Determination of dry matter yield

To determine the dry matter percentage, 100 g sample of hay from each plot was taken and oven-dried at 65°C until a consistent weight was reached. The percentage of dry matter and the fresh weight that was taken from each plot were multiplied to get the dry matter yield, which was then projected to ton/ha.

$$DM\% = \frac{\text{Fresh Weight (g)} - \text{Dry Weight (g)}}{\text{Fresh Weight (g)}} \times 100$$

2.6. Preparation of hay

The grass was harvested at the flowering stage, gathered using a rake, packed, and air-dried until a proper moisture level was achieved. The hay was then packed in the sacks and stored at room temperature for a month before the samples were taken for analysis.

2.7. Chemical analysis

The proximate content of hay samples was determined using the procedure of AOAC (2000), while fiber fractions such as acid detergent fiber, neutral detergent fiber, acid detergent lignin, hemicellulose and cellulose were analyzed using Van Soest et al. (1991) method.

2.8. Volatile fatty acids determination

Following 24-hour incubation, the decanted supernatant was centrifuged and preserved with 25% metaphosphoric acid and total volatile fatty acids (VFAs). The amounts of propionate, acetate, and butyrate were calculated following the protocol outlined by Ikyume et al. (2020).

2.9. In vitro gas production and IVDMD

The silage samples were analysed for IVDMD according to the method of Tilley and Terry (1963). Rumen contents were squeezed through four layers of cheesecloth and kept in a water bath at 39°C until incubation took place. Representative samples of the mixtures (2.5g DM) were

taken in a separate bottle having 0.05 litres rumen liquor, 0.2 litres buffer solution (Buffer solution: KCl 0.57 g/L, MgSO₄. 7H₂O 0.12 g/L, NaCl 0.47 g/L, CaCl₂ 0.04 g/L, Na₂HPO₄.12H₂O 9.30 g/L, NaHCO₃ 9.80 g/L, Cysteine 0.25 g/L (12;11) according to [Elmenofy et al. \(2012\)](#). The bottles were kept in a water bath at 39°C. The samples were run for IVDMD at 6, 9, 12, 15, 18, 21 and 24 hours of incubation.

2.10. Data analysis

The data collected were subjected to one-way analysis of variance procedure of the General Linear Model ([SAS 2008](#)). Significant means were separated using the Duncan New Multiple Range Test.

3. Result

Results showed significant variations ($p < 0.05$) in the herbage and dry matter yields of *B. ruziziensis* across the fertilizer treatments in this study ([Table 1](#)). The fertilizer treatments with significantly higher ($p < 0.05$) values for fresh herbage yields were T3 (18.38 tons), T4 (16.66 tons), T2 (14.05 tons) compared to control treatment (10.25 tons). Also, the dry matter yield obtained for T3 (6.90 tons), T4 (6.19 tons), and T2 (5.23 tons) was significantly higher than the control treatment (3.85 tons).

There were no significant differences ($p > 0.05$) in the dry matter, crude fiber, ash, Neutral detergent fiber (NDF), Acid detergent fiber (ADF), Acid detergent lignin (ADL) Acid detergent fiber (ADF) and hemicellulose across the

fertilizer treatments ([Table 2](#)). However, the crude protein, ether extract, and carbohydrate fraction were significantly higher ($p < 0.05$) in the hay of *B. ruziziensis* fertilized with Wonder fertilizer (T3) than in other fertilizer treatments. Furthermore, the metabolizable energy of the hay of *B. ruziziensis* fertilized with Wonder fertilizer (4.36%), poultry manure T4 (4.28%) and Natsoil, T2 (4.16%) were significantly higher ($p < 0.05$) than control T1 (3.80%). While the cellulose content was significantly the highest ($p < 0.05$) in the hay of *B. ruziziensis* fertilized with Natsoil (21.75%) followed by control (21.65%), Wonder fertilizer T3 (21.19%) and poultry manure T4 (21.02%) ([Table 2](#)).

There were significant differences ($p < 0.05$) between the control and the treatments for all the evaluated parameters except valeric and lactic acid ([Table 3](#)). The range of values recorded for propionic acid was (8.05-13.00 mmol/100ml), acetic acid (22.85-30.65 mmol/100ml), butyric acid (4.50-7.00 mmol/100ml), valeric acid (1.06-2.30 mmol/100ml), lactic acid (2.20-4.60 mmol/100ml), and total volatile fatty acid (123.40-152.50 mmol) ([Table 3](#)).

The results obtained for hay of *B. ruziziensis* fertilized with Wonder fertilizer (T3) had the highest values ($p < 0.05$) for propionic acid, butyric acid, valeric acid and lactic acid, followed by poultry manure (T4) and Natsoil (T2), while the lowest values were recorded for control, except in acetic acids, where it showed superiority to other treatments ([Table 3](#)).

Table 1. Yields of *Brachiaria ruziziensis* grass fertilized with organic fertilizers

Parameters (tons)	T1	T2	T3	T4	SEM
Fresh herbage yield	10.25 ^d	14.05 ^c	18.38 ^a	16.66 ^b	0.82
Dried herbage yield	3.85 ^d	5.23 ^c	6.90 ^a	6.19 ^b	0.30

a,b,c,d: Means in the same row with different superscripts are significantly different ($p < 0.05$)

T1 = Control (No fertilizer), T2 = Natsoil fertilizer, T3 = Wonder fertilizer and T4 = Poultry manure

Table 2. Chemical Composition and fiber fractions of *Brachiaria ruziziensis* hay

Parameters (%)	T1	T2	T3	T4	SEM
Dry matter	92.66	92.82	92.76	92.85	0.06
Crude protein	7.54 ^b	7.70 ^b	8.52 ^a	7.90 ^b	0.09
Crude fiber	27.88	27.57	26.12	26.67	0.51
Ash	8.25	9.95	10.02	9.87	0.24
Ether extract	2.62 ^b	2.62 ^b	3.07 ^a	2.77 ^b	0.06
Carbohydrate fraction	51.02 ^b	52.00 ^{ab}	55.10 ^a	52.82 ^{ab}	0.62
Metabolizable energy	3.80 ^b	4.16 ^a	4.36 ^a	4.28 ^a	0.06
Neutral detergent fiber	67.50	65.87	65.57	65.87	0.25
Acid detergent fiber	33.32	33.27	32.21	32.42	0.25
Acid detergent lignin	11.67	11.52	11.02	11.40	0.18
Hemicellulose	34.23	32.55	33.36	33.45	0.20
Cellulose	21.65 ^{ab}	21.75 ^a	21.19 ^c	21.02 ^c	0.13

a, b, c: Means in the same row with different superscripts are significantly different ($p < 0.05$)

T1 = Control T2= Natsoil fertilizer T3= Wonder fertilizer T4= Poultry manure

Table 3. Effects of fertilizer types on volatile fatty acids of *Brachiaria ruziziensis* hay

Parameters (mmol/100ml)	T1	T2	T3	T4	SEM	P value
Propionic acid	8.05 ^c	11.57 ^b	13.00 ^a	11.90 ^b	0.22	<.0001
Acetic acid	30.65 ^a	25.70 ^c	22.85 ^d	26.50 ^b	0.23	<.0001
Butyric acid	4.50 ^d	5.70 ^c	7.00 ^a	6.00 ^b	0.21	<.0001
Valeric acid	1.06	1.70	2.30	1.75	0.21	<.0001
Lactic acid	2.20 ^c	3.80 ^{ab}	4.60 ^a	4.00 ^{ab}	0.29	<.0001
Total volatile fatty acid	123.40 ^d	142.80 ^c	152.50 ^a	145.00 ^b	6.33	<.0001

a,b,c: Means in the same row with different superscripts are significantly different ($p < 0.05$)

T1 = Control, T2 = Natsoil Fertilizer, T3 = Wonder Fertilizer, T4 = Poultry Manure

Table 4. Gas production and digestibility of *Brachiaria ruziziensis* hay

Hours of incubation	T1	T2	T3	T4	SEM
3	1.00	1.37	1.75	1.50	0.15
6	2.00	2.70	3.23	2.87	0.27
9	2.75 ^b	4.00 ^{ab}	5.20 ^a	4.50 ^{ab}	0.40
12	2.75 ^b	4.00 ^{ab}	5.20 ^a	4.50 ^{ab}	0.40
15	4.75	5.50	7.62	6.50	0.45
18	6.37	6.87	8.50	8.00	0.35
21	7.65 ^d	9.37 ^c	10.12 ^a	9.75 ^b	0.36
24	7.95 ^d	10.57 ^c	12.00 ^a	11.42 ^b	0.50
Nutritive values					
Total volume of gas (ml)	7.95	10.57	12.00	11.42	0.50
Methane (ml)	2.26	2.81	3.60	3.25	0.27
CO ₂ (ml)	5.69	7.76	8.40	8.17	0.50
NH ₃ -N	11.00 ^c	12.80 ^b	15.60 ^a	12.75 ^{bc}	0.01
Organic matter digestibility (%)	53.66 ^b	60.00 ^a	60.87 ^a	60.06 ^a	0.93
<i>In vitro</i> dry matter digestibility (%)	56.06 ^c	56.06 ^c	60.11 ^a	58.92 ^b	0.44
Short chain fatty acid (μmol)	0.13	0.19	0.22	0.21	0.00

a,b,c: Means in the same row with different superscripts are significantly different ($p < 0.05$)

T1 = Control T2= Natsoil Fertilizer T3= Wonder Fertilizer T4= Poultry Manure

There were no significant differences ($p > 0.05$) among the means of gas produced at 3, 6, 15, 18 hours, as well as total volume of gas (TVG), methane, CO₂ and short-chain fatty acid across the fertilizer treatments (Table 4).

Notwithstanding, hay of *B. ruziziensis* fertilized with Wonder fertilizer had produced significantly the highest ($p < 0.05$) gas production at 9, 12, 21 and 24 as well as NH₃-H gas and IVDMD as compared to those for other fertilizer treatments. Conspicuously, the OMD values were significantly higher ($p < 0.05$) in the hay of *B. ruziziensis* fertilized with Wonder fertilizer (60.87%), followed by poultry manure (60.06%) and Natsoil fertilizer (60.11%), than the control (56.06%) (Table 4).

4. Discussion

High-yield species are more favoured because they produce a quantity adequate for immediate feeding and preservation. It has been clearly and repeatedly reported that yields can be improved by the application of fertilizer. The notably varied yields observed between the control and treatments and among the treatments in this study were due to the availability of nutrients caused by the application of organic fertilizers to the treatments. The

results obtained in this study were in agreement with other various reports (Islam et al., 2020 and John et al., 2021) in which the application of fertilizers brought about an increase in fresh and dry matter yield. The difference observed among the treatments might be due to the ability of the organic fertilizers to release the nutrients, especially substantial amounts of nitrogen after mineralization (Ewetola et al., 2021). Qamar et al. (2020) reported that the application of fertilizer resulted in the increased tiller density, plant height, number of leaves, and other leaf parameters such as leaf width, leaf length and stem-leaf ratio, which in consequence improved the fresh and herbage yield of the grass. The recorded dry yield in this study (3.85- 6.90 tons/ha) is similar to the values (3.07- 6.24 tons/ha) obtained from the study of Ojo and Ojeniyi (2018) in which swine manure was used at a dosage of 0-15 tons/ha to fertilize *B. ruziziensis*. On the contrary, the recorded dry matter yield for this study was less than the values obtained by (Yakubu et al., 2024), where various green manures were used to fertilize *B. ruziziensis*. The difference obtained from this study might be due to available nutrients in the soil promoted by a faster fixation of atmospheric nitrogen by the root nodules of the legume and also, a more enhanced mineralization of soil organic

nitrogen during legume residues decomposition which in turn, increases the soil organic matter, which in consequence, enhances soil Cation Exchange Capacity (CEC), improves soil aggregation; hence, and supports biological activity (Tanimu et al., 2007). In another similar study, Shuaibu et al. (2018) investigated the effects of varying levels of organic fertilizer (Goat manure) on the yields of *B. ruziziensis* and reported 5.02 to 10.22 tons/ha (fresh herbage yield) and 1.88 to 5.26 tons/ha (dry matter yield), lower than values obtained in this study. The highest yields recorded for the plot fertilized with Wonder fertilizer (T3) could be attributed to the ability of the fertilizer to supply more nutrients to the plants so more of it could have been absorbed by the *B. ruziziensis*, which in consequence, enhances their growth and other yield parameters that culminate to the yields.

The CP values of the present study compared well with 7.35% were reported by Ribeiro et al. (2014) for *Andropogon gayanus* hay. The CP values recorded for all treatments in this study were above 7% recommended for small ruminants (NRC, 2007). Therefore, feeding these hays to animals will result in the improved performance of the animals. The differences observed in this study could be due to available soil nutrients provided by organic fertilizers (Yakubu et al., 2024). The Metabolizable energy obtained in the present study was lower than that reported by Ewetola et al. (2021). Ewetola et al. (2020) reported that cellulose content of *Panicum maximum* was influenced by fertilizer types, as also evident in this study. The values of volatile fatty acids obtained in this study were less than those obtained by Ribeiro et al. (2014) for *Andropogon gayanus* hay. The difference observed in various volatile fatty acids could stem from various reasons such as the fiber content of the grass (Belete and Abubeker, 2014), the stage of maturity at harvesting, the population and types of rumen microbes and feed types. High NDF and ADF favour the formation of acetic acid, therefore resulting in more methane being produced. The digestibility of cellulose-containing feedstuffs causes the production of acetic acids by the cellulolytic microbes and this is accompanied by the formation of hydrogen gas that binds with carbon dioxide to produce methane. A large proportion of propionic acid depicts the presence of highly soluble carbohydrates (Ribeiro et al., 2014). As the grass matures, the crude protein content decreases and crude fiber increases. The increased fiber level reduces soluble carbohydrates thereby favour the increased structural carbohydrate content. The fermentation of structural carbohydrates results in the formation of acetic acid. The population and types of microbes influence the formation of volatile fatty acids. Cellulose-rich feedstuffs stimulate the activities of

the cellulotic microbes in the rumen resulting in the formation of acetic acid while grain-based feeds stimulate amylolytic microbes' activity leading to the formation of propionic acids (Wang et al., 2020). The present study showed that hay of *B. ruziziensis* fertilized with Wonder fertilizer could provide more energy than other treatments due to its higher total volatile fatty acid value than other treatments. The results obtained in the present study after 24 hours of incubation were in agreement with those reported by Richard (2022). It is widely established that feedstuffs that have higher gas production and IVDMD tend to produce more CH₄ during incubation (Ademola and Patience, 2023). The values of IVDMD obtained in this study were comparable with (56.0%) reported by Ribeiro et al. (2014) for *Andropogon gayanus* hay and Arroquy et al. (2014) for *Brachiaria brizantha* (56.9%).

5. Conclusion

It was concluded that though hay of *Brachiaria ruziziensis* was treated with Natsiol, Wonder and poultry litter fertilizers had superior crude protein, metabolizable energy, and in vitro gas production and digestibility. However, the hay of *B. ruziziensis* fertilized with Wonder fertilizer was outstanding.

Authors Contribution

All the authors have participated sufficiently in the intellectual content, conception and design of this work or the analysis and interpretation of the data (when applicable), as well as the writing of the manuscript.

Availability of data and materials

The data that support the findings of this study are available from the corresponding author, upon reasonable request.

Conflict of interests

The author states that there is no conflict of interest.

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