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AN ASSESSMENT OF THE EFFECTS OF GREEN MANURE ON YIELD AND NUTRIENT COMPOSITION OF HAY AND SILAGE MADE FROM *Brachiaria Ruziziensis*

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ABSTRACT

This study was undertaken to assess the effects of green manure on yield and nutritive value of hay and silage made from Brachiaria ruziziensis. The experiment was conducted in two phases: The first experiment evaluated the yield, morphological characteristics and quality of hay while the second phase assessed the fermentation characteristics and quality of silage. The experimental design involved a 1x5 factorial arrangement in a split plot design and was replicated three times. Three legume species -- Centrosema poscurum, Lablab and Glycine max -- were used as sources of green manure and a positive control (Urea, Single Super Phosphate and Muriate of Potash at rate of 100, 50, 50 kg/ha, respectively) and negative control (0 k/ha). The results revealed that the dry matter yield of Brachiaria ruziziensis was significantly (P<0.05) higher when Centrosema poscurum was used as green manure while positive control recorded the highest value. The same trend was observed in terms of plant height, leaf length and leaf width. Proximate composition (CP, DM, Ash and NFE) of Brachiaria ruziziensis was significantly (P<0.05) higher while fiber fractions (NDF and ADF) reduced when Centrosema poscurum was used *compared to other sources of green manure however, statistically different with positive control. Silage fermentation characteristics revealed that high quality silage was produced. Silage proximate composition and fiber fractions of Brachiaria ruziziensis showed similar trend with hay. It was concluded that Centrosema poscurum should be used as green manure for the cultivation of Brachiaria ruziziensis in the study area.*

Keywords: *Brachiaria ruziziensis, Leguminous green manure, Hay, Silage.*

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1. INTRODUCTION

Any crop that is raised with the intention of being ploughed back into the ground while still green in order to increase soil fertility is considered a green manure crop (Oladipo et al., 2005). For sustainable agriculture it is crucial to employ legumes as green manure. Leguminous green manure, depending on the variety of legumes utilized, aids in fixing atmospheric nitrogen (Tejada et al., 2009). Leguminous green manure, in contrast to other organic fertilizers, helps to break up deep soil layers, enhance soil structure, and encourages future crops' roots to penetrate the soil (Watson et al., 2002). Leguminous green manure also promotes soil microbial activity, which determines soil quality and guarantees soil aggregate stability, hence enhancing the physical and chemical characteristics of the soil (Tejada et al., 2008; Ziblim et al., 2013).

Leguminous green manure crops, such as cowpea and soybean, can accumulate a significant amount of nitrogen (N) in as little as six (6) weeks, reaching up to 75 and 115 Kg N/ha, respectively (Adesoji et al., 2013). According to Tejada et al.

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(2008) and Shua'ib et al. (2010), the decline in soil organic matter, acidification, nutrient imbalance, and degradation of soil properties are among the issues that Nigeria, like other African nations, is facing the most. This is because most farmers add little fertilizer due to the high cost of chemical fertilizer and occasionally its unavailability, which raises the cost of production. The use of legumes as green manure to replenish and maintain the soil fertility for sustainable pasture production is therefore gaining interest across the globe. However, their benefits are only realized after decomposition and subsequent nutrient release (Mubarak et al., 2002; Igbal, 2009). Therefore, the present study was aimed at assessing the reciprocal benefit of green manure on yield and nutrient composition of hay and silage made from *Brachiaria ruziziensis*.

2. REVIEW OF LITERATURE

2.1 Green Manure

Crops used as green manure are those that are grown up to the point of blooming with the goal of harvesting the biomass and incorporating it into the soil (Wutke et al., 2009). This technique's primary goal is to enhance the physical, chemical, and biological properties of soil in order to increase crop production in a region (Wutke et al., 2009).

2.1.1 Plants used as green manure

Tropical climates support a wide range of green manure species, including members of the Fabaceae, Brassicaceae, Asteraceae, and Poaceae families.

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Table 1. Examples main species used in tropical environments, their characteristics of dry matter yield, amount of fixed nitrogen, and mineral composition of macronutrient and micronutrients

Common name	Scientific name	Dry matter	Fixed N	N	P	K	Ca	Mg	S	B	Cu	Mn	Zn
Preferred sowing in period (September to March)													
		t/ha		kg/ha	g/kg of dry matter				mg/kg of dry matter				
Sunnhep	*Crotalaria juncea*	10–17.6	150–450	11.3–44.0	0.9–3.7	5.7–33.7	3.3–23.1	2.5–8.0	1.2–2.7	15–25	5.5–14	23–179	16–44
Jack bean	*Canavalia ensiformis*	3.4–8	49–190	22.2–33.9	1.2–5.7	11.1–56.2	16.4–25.8	2.4–6.3	1.1–2.0	24–33	9–17	15.7–106	13–62
Canavalia	*Canavalia brasiliensis*	3–6.5	142–173	22.7–27.1	1.1–1.5	15.8–18.1	2.0–15.9	1.6–2.1	–	25–28	4–24	17–35	12–18
Sunflower	*Helianthus annuus*	2–12	–	10.2–18.0	1.5–2.4	24.0–27.8	15.5	6.2	–	–	18	96	31
Pigeon pea	*Cajanus cajan*	8–15.6	37–280	13.2–33.5	0.9–2.5	4.7–28.4	5.7–17.9	1.9–4.9	1.9–2.1	22–25	5–12	26–99	15–66
Labe-labe	*Dolichos lab lab*	5–11	66–180	13.6–50.0	1.3–11.5	5.3–27.7	11.6–16.5	2.7–6.6	1.1–3.5	26	5–10	48–143	16–33
Leucaena	*Leucaena leucocephala*	5.5–16	400–600	31.8–44.3	1.7–2.8	10.0–19.4	6.9–8.6	5.0–5.6	–	–	–	–	–
Velvet bean	*Mucuna aterrina*	6–13	120–210	19.7–30.8	1.1–6.1	7.8–20.5	8.7–12.8	2.7–3.5	1.2–2.8	27	15–26	133–174	10–29
Soybean	*Glycine max*	2–4	60–180	13.5–40.0	2.1–2.5	10.8–17.6	10.0–20.0	4.0–6.0	2.0–2.5	21–55	10–30	20–100	20–50
Preferred sowing period (April to August)													
White oat	*Avena sativa*	2.5–7.0	–	8.1	0.6	24.0	2.4	1.7	1.5–4.0	5–20	6	138	9
Black oat	*Avena strigosa*	2.5–11	–	7.0–16.8	1.0–4.2	10.8–30.8	2.5–3.6	1.7–2.0	–	21–22	5–7	41–102	11–22
Ryegrass	*Lollium multiflorum*	2–6	–	11.6–13.4	0.7–1.0	21.2–26.0	4.1–4.4	2.2	–	–	9	214	23
Grasspea	*Lathyrus sativus*	2–6	80	22.0–32.5	1.0–2.6	29.0–30.0	3.9–7.9	1.9–4.3	–	–	11–29	52–70	11–22

Source: Wutke *et al*., (2009).

Journal of Integrated Sciences
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2.1.2 Factors to take into account while selecting green manure

When selecting green manure, it is important to think about the farmer's needs. High biomass output and the ability to associate with N-fixing bacteria can be recommended to farmers that have nitrogen supply goals (Table 1).

The phytosanitary component is a crucial factor to take into account while selecting the best green manures. Some species are capable of suppressing plant diseases. For example, Crotalaria species are efficient at suppressing nematode species that may produce root knots (Wutke *et al*., 2009). Others, however, serve as both pests and hosts for various pathogen species. The cultivation of jack beans (Canavalia ensiformis) and common beans (Phaseolus vulgaris) in succession or rotation is an illustration of this issue. The whitefly (Bemisia tabaci), an insect that spreads the bean golden mosaic virus, is a host in this green manure (Calegari *et al*., 1993). Therefore, it is advised to use species from several phylogenetic groups. Additionally, it is practical to use species from several families since they have various patterns of nutrient accumulation and root architecture, allowing for the exploitation of various soil levels.

Understanding the climatic needs of the manure to be utilized is essential; for example, several types of green manure are better suited to the dry season while others are to the wet (Table 1). Due to their water needs, photoperiod, and thermoperiod, pigeon pea (Cajanus cajan) and sunnhep (Crotalaria sp.) accumulate more biomass and nutrients when planted during the wet season (Sauza *et al*., 2012).

2.1.3 Green manure management in tropical climates

Green manure plants can be employed in zero-till, minimal-till, and systems that involve harrowing and ploughing. These plants can be used as a soil cover during fallow periods, as an intercrop with perennial crops, or as part of succession or rotational farming schemes with annual crops. In general, a cut must be made and put into the soil when the plants reach the reproductive stage, when roughly 50% of the flowers are opened. Although other species may have longer cycles, they must be cut before the seeds germinate. For instance, avena strigosa needs to be cut when the milky grain stage of grain maturation is reached (Carvalho & Amabile, 2006). If these plants are cut before this point, they can regenerate, and if they are cut after this point, the grains might become viable. In tropical soil conditions, plants from the Fabaceae family with a C/N ratio of about 20 (Table 1) disintegrate quickly. Since a large portion of the nitrogen (N) is mineralized in the first 60 days, commercial crop planting in rotation or succession to this type of plant should be done a few days (less than two weeks) after the green manure is incorporated (Wutke *et al*., 2009).

2.2 Effects of Green Manure on Forage Crops

The main positive and negative effect of green manures to tropical soils are listed below (Wutke *et al*., 2009, Souza *et al*., 2012).

2.2.1 Positive effect

2.2.1.1 Chemical aspects

i. Nitrogen input to the soil because of the green manure association with nitrogen-fixing bacteria; Green manures with deep root systems allow cycling of nutrients that have been leached to deep layers.

ii. Increased cation exchange capacity (CEC) due to an increase in soil organic matter content.

iii. They add many tons of organic matter to the soil, thereby improving topsoil depth, water-holding capacity, nutrient content, friability, and texture of the soil.

iv. Green manure crops present no transportation problems, in contrast to compost and chemical fertilizers.

v. The release of organic acids allows the solubilization of more stable forms of phosphorus.

2.3.1.2 Biological aspects

vi. They favor the microflora and macroflora and fauna through carbon supply.

vii. Some species control nematodes population.

viii. They can serve for attracting insect pests and stop disease cycles.

ix. They release compounds with allelopathic effect on weeds.

x. They compete for growth resources with weeds.

2.2.1.3 Physical aspects

xi. Green manure crops can shade the soil up to eleven months out of the year, a factor extremely important in tropical climates for preservation of soil moisture and organic matter.

xii. The cover they provide for the soil protects it from wind and water erosion.

xiii. They enhance stability of aggregates and porosity by adding organic matter and growth and death of roots.

xiv. They increase water retention by cover the soil and by add organic matter.

xv. They often provide an incentive for people to abandon harmful traditional practices, such as burning crop residues or letting animals loose in the dry season to devour everything in sight.

xvi. Some green manures, when intercropped with basic grains, can control weeds, thereby eliminating costly weeding operations.

xvii. They allow natural decompression of the soil, when using species with deep root system.

xviii. They reduce the thermal soil amplitude.

2.2.1.4 Economic aspect

xix. Green manure crops require absolutely no capital outlay after the initial purchase of a handful of seed. Because they require no chemical inputs, dependency on outside sources of fertilizer, nutrients, and pesticides is reduced.

xx. Green manure crops provide generous amounts of high protein fodder for animals, which can be especially valuable if it is available during the last months of the dry season (inasmuch as fodder at this time of year is the limiting factor in traditional animal raising in much of the Third World).

xxi. Some green manure crops provide human food, including various kinds of edible beans, peas, and pods.

xxii. Green manure crops can provide income, by selling firewood, food or feed (and maybe seed).

2.2.2 Negative effect

i. Inadequacy of some green manure species to the production system or the soil and weather conditions.

ii. Lack of interest from consultants and farmers in this technology, which adopt immediate postures.

iii. Sometimes, green manure involves costs with no direct financial return.

iv. Low development of breeding technologies of green manure species.

v. Some green manures can host diseases and pests that attack the commercial crop.

vi. Possibility of negative allelopathic effect of green manure residues on the commercial crop.

vii. Possibility of competition between green manure plants and the commercial crop by inadequate management of the technology in intercropping systems.

viii. Some green manures have incompatible decomposition rates with the nutrient requirements of crops.

ix. Uneven seed germination of some species of green manure.

x. Difficulty of obtaining seeds for sowing.

xi. Lack of functional decomposition models to predict nutrient release.

2.3 Factors Influencing the Decomposition of Green Manures in Tropical Environments

Green manure decomposition in the soil is a complicated process that involves the interplay of numerous variables. The nutrient content and biochemical composition of the green manure added to the soil, the nature and abundance of the existing microbial communities, soil moisture, temperature, aeration, pH, the carbon/nutrient ratios of the soil organic matter (SOM), and the presence or absence of inhibitor substances are all factors that can affect the direction and magnitude of the decomposition process (Lamparter *et al*., 2009; Poirier *et al*., 2009).

2.3.1 Biochemical composition of green manures

Green manure breakdown and microbial populations in the soil are influenced by biochemical makeup. The age of the crop used as green manure, the species employed, and the fiber and lignin contents of the green manure all have an impact on the quality of the residues (Dinesh and Dubey, 1998). N2 fixing species typically have lower C/N compared to non-legume species.

2.3.2 Soil microbial communities

The residues of green manure in the soil are actively being used by various soil organisms. According to Whalen and Sampedro (2010), the soil microbial community is diverse and exhibits an uneven distribution throughout the microenvironments and over the soil profile. A microbial succession is triggered by a change in the biochemical content of the green manure residues during the breakdown process. Simpler compounds are used as a growth substrate for a large number of microorganisms that have short life span, which are called r-strategists or copiotrophs. In the later, degradation stages occur the metabolism of more complex compounds, in which some microorganisms break components more slowly and are called k-strategists or oligotrophic (Wolf & Wegner, 2005).

2.3.3 Temperature and humidity

According to Willson and Griffin (1975), temperature and humidity have a direct impact on microbial activity, specifically the microbial enzyme complex. Temperature and humidity are factors that directly affect the microbial activity, more precisely the microbial enzyme complex (Willson & Griffin, 1975). Green manure decomposition rate correlates positively with temperature and water availability within a broad range (Stott *et al.*, 1986). The enzymatic activity increases with an increase temperature or humidity up to a plateau, from which temperature and humidity can limit decomposition. Thus, the weather strongly affects the green manure decomposition rate (Bargali *et al.*, 1993).

2.3.4 Soil Moisture

Water is necessary for all hydrolytic reactions, altering the activity of extracellular enzymes and diffusion coefficients, and moisture is crucial for the reactions that take place in soil. The decomposition rate of aerobic soil microorganisms is thought to be best at a soil water content of 60% of its total permeable area. According to Lamparter *et al.* (2009), natural cycles of soil

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wetting and drying are significant modulators of decomposition rates. The following agricultural practices, for example, can help water management reach better rates of decomposition:

i. Irrigation.

ii. Drainage furrows installation in the field to remove excess water.

iii. Maintenance of residues on the soil surface to increase water infiltration and decrease evaporation and,

iv. Synchronization of green manure incorporation with the rainy season based on historical and forecast rainfall (Whalen, 2014).

Additionally, excessive wetness might result in anaerobic conditions that slow down the decomposition of green manure. Fungi and actinomycetes do not thrive in anaerobic conditions, and only a few types of bacteria can undertake anaerobic digestion, which slows down decomposition rates.

2.3.5 Soil pH

The type, density, and activity of bacteria, fungi, and actinomycetes are directly influenced by the soil's pH, constituting another significant component in the decomposition of green manure. In comparison to more acidic soils, such as tropical soils, the rate of manure decomposition is faster in neutral pH soils. Liming acidic soils, however, encourages more rapid degradation of the leftovers.

Higher rates of decomposition are favored by the development and preservation of microbial diversity in the soil (Whalen, 2014). For this reason, some agronomic practices are advised, such as:

i. Regular application of biochemically complex green manures associated with those biochemically simple and easy decomposing, which supports the greater diversity of microbial communities in the soil

ii. Maintenance of soil cover, which promotes energy (via root exudates) for free-living and symbiotic microorganisms and produces extracellular enzymes in addition to the enzymes released by plant roots (Hogberg *et al*., 2014).

2.3.6 Green manure's C/N, C/P, and C/S ratios

The use of green manures has a variety of soil-conditioning benefits, but in low-fertile tropical soils, the practice's main goals are to boost the soil's cation exchange capacity (CEC) and supply nutrients for the plants. As a result, one of the first characteristics to be noticed is the nutritional levels of these plants, which are mostly N, P, and S. N, P, and S concentrations do not guarantee that they will release synchronously with plant demands throughout the decomposition process.

2.4 Chemical Fertilizer's Impact on Pasture Production

Depending on the soil's fertility, nitrogen application can increase pasture output. The yield of forages is increased by nitrogen by 50% to 60%. On more fertile soils, there may be less demand for nitrogen fertilizer because of leftover nitrogen from the previous crop. In most situations, applying more than 200–300 kg of nitrogen per hectare has reduced pasture output due to severe plant lodging (Phaikaew *et al*., 2002; Gobius *et al*.,

2001) or, in some circumstances, the toxicity of ammonium nitrate or sulphate (Paulo *et al*., 2014).

There is no ideal soil for growing grass, and all soils require some sort of amendment to produce the highest yield possible (Gbenou *et al*., 2018). Nutrients from the soil, like nitrogen, phosphorus, and potassium, are frequently used as amendments. For crops to grow and develop to their full potential, all nutrients must be present in sufficient amounts. This will impact blossom initiation and seed production. However, in reality, nitrogen is the main component that restricts grass production (Loch *et al*., 1999; Flavia *et al*., 2017; Raij, 2011). Most soils lack enough plant-available nitrogen to enable plants to produce their maximum yields.

Muhammad *et al*. (2004) reported that, compound fertilizer (NPK) was necessary for grasses in the savannah zones of Nigeria. High forage yields have been obtained with application of 100-150kg/ha for grasses and 18-30kg/ha for legumes. Muhammad *et al*., (1993) also reported that increasing the nitrogen level resulted in increased number of tillers per plant. Plant height re-growth and total forage yield. Fertilizer should be applied at planting or 2 weeks after planting. Generally speaking, applying nitrogen fertilizer to crops has an impact on the dynamics of yield component traits like an increase in tiller (Brian, 2007), an increase in the number of fertile tillers (Li & Zhao, 1993), an increase in tiller size, an increase in florets per tiller (Hare & Rolston, 1990), an increase in seed production per head, and an increase in seed yield and quality (Cook et al., 2005). Depending on the plant species and variety, nitrogen fertilizer has different effects on the components of seed output. Although nitrogen fertilizer generally increases seed yield, by contrast, it can produce no significant effect in some cases as for the case of Triticum aestivum (Brian et al., 2007) or even depletion effect by reduction of seed yield with increasing nitrogen fertilizer rates (Cookson et al., 2000; Phaikaew et al., 2002).

3. RESEARCH METHODOLOGY

3.1 Experimental location

The experiment was conducted in two phases: the first phase was carried out at the Screen house, Department of Agronomy, Faculty of Agriculture, Bayero University, Kano from April to September, 2021. The second phase was conducted at the Laboratory of Animal Science Department, Faculty of Agriculture, Bayero University, Kano, Nigeria. The farm falls within the Sudan savanna agro-ecological zone of Nigeria, it lies between latitude 11.97932° to 11.98194°N, and longitude 8.41245 ° to 8.42205°E. Kano has a tropical wet season (May to September) with an average precipitation of 690 mm per year, the bulk of which falls from June through September, and dry season (October to April) (Adamu and Aliyu, 2012). Temperature is averagely warm to hot throughout the year at about 25 ± 7°C (KNARDA, 2010).

3.2 Treatments and experimental design

Congo grass (*Brachiaria ruziziensis*) was used to evaluate the contribution of three legumes (*Lablab purpureum, Centrosema Pascourum*, and *Glycine max*) as green manure. A positive (Urea, Single super phosphate and Muriate of potash were applied at the rate of 100, 50, 50 kg/ha respectively) and negative control (where no manure was applied) was also used in the evaluation of the grass. The experiment was conducted using 15 polythene bags. The Legumes were planted as main crops which were incorporated back into the soil at vegetative stage. The compost so made was left for 2 weeks to allow for partial decomposition. Thereafter the compost was sorted for the establishment of *Brachiaria ruziziensis* and was replicated three times. The experiment was a split plot design with 1×5 factorial arrangement. The main treatments were the 3 legumes, a positive control and a negative control. The sub treatment was *Brachiaria ruziziensis*.

3.3 Soil sampling and analysis

Soil samples were collected prior to the commencement of the experiment, and after decomposition at 0-15 cm depth using a soil auger from 3 different points which was mixed. Soil samples were air dried and bulked for analysis. The soil samples were analyzed for physical and chemical properties as described by Agricultural Experimentation Station (1998), to determine pH, organic carbon, as well as concentration of nitrogen, phosphorous and potassium in the soil.

Table 2. Physical characteristics and chemical properties of the soil used in the greenhouse trial

Soil Characteristics	Analytical Results
Agro-ecological Zone	North-west
Texture	Sandy loam
pH	6.13
Organic carbon	5.4
Total N (%)	0.20
Available phosphorous (mg/kg)	0.0396
Exchangeable K (cmol/kg)	2.2667

Field study, 2021.

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3.4 Land preparation and cultural practices

Each experimental polythene bag contained 10kg of sandy loam soil. Viable seeds of the legumes (*Lablab purpureum*, *Centrosema Pascourum*, and Glycine max) were sown in April. The number of seedlings was thinned to 4 per hole after emergence. Subsequently, viable seeds of the grasses *Brachiaria ruziziensis* were sown in July, 2021. The number of seedlings was thinned to three per hole after emergence. Weed control was done by hand pulling. It was carried out regularly to ensure that the weed do not interfere with the forage grasses throughout the experimental period. Fertilizer was only applied to positive control. Prior to sowing, Nitrogenous, Phosphorous and Potassium fertilizers were applied at rate of 100, 50 and 50 kg/ha respectively in form of Urea, single Phosphate and Muriate of Potash.

3.5 Data collection

Prior to harvest, data were recorded on the following parameters: Plant height, Leaf length, and Leaf width.

i. Plant height (cm): this was measured with the use of a measuring tape from the base of the plant to the tip of the youngest leaf (flay leaf).

ii. Leaf area (cm^2): This was determined by measuring the height (h) and the width (w) of the leaves of sampled plants using meter rule multiplied by a constant 0.75 (hxwx0.75).

Harvesting was carried out 90 days after sowing. Grasses were cut with the aid of knife or sickle at 5cm stubble height. The cut

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materials were weighed fresh using weighing scale, thereafter oven dried at 65 ^{0}C for 72 hours. The materials were reweighed and yield on dry matter basis was determined and expressed in t/ha. The dried samples were milled using hammer mill to pass through 2 mm sieve, stored in plastic containers and used for chemical analysis.

3.6 Silage preparation

Stella pomade bottles (250ml) were used as Laboratory bottles for ensiling. Samples of the harvested *Brachiaria ruziziensis* were chopped into 2-3cm length, tucked inside the laboratory silos and compressed to remove entrap oxygen to facilitate anaerobic fermentation. The bottles were closed tightly with the aid of grease which was applied at the mouth of the bottles to ensure air tightness (anaerobic condition).

Thereafter, the resulted silage was scored for color and aroma by three (3) independent trained scorers on a scale of 1-4 after 21 days fermentation period. Silage temperature was measured using mercury glass thermometer, while digital pH meter was used to determine the pH of the silage as described by (Muhammad *et al*, 2009; Babayomi and Igbekoyi, 2008). The samples were oven-dried at 65 ^{0}C for 72 hours. The dried samples were milled with hammer mill to pass through 2 mm sieve, and stored in plastic containers for use in chemical analysis.

Table 3. Description of colour and aroma scores used in assessing silage quality of Brachiaria ruziziensis

RATING	COLOUR	AROMA
1	Dark or deep brown	Putrid or rancid
2	Light brown	Pleasant
3	Pale yellow	Sweet
4	Yellowish green	Very sweet

Source: Muhammad *et al*, (2009).

3.7 Chemical analysis

In the first and second experiments, collected *Brachiaria ruziziensis* samples were oven dried at 65°C for 72 hours and ground. The sample was sieved using a 2mm sieve, the finely ground samples was subjected to proximate analysis. Analysis of crude protein was carried out using Kjeldhal method while percentage nitrogen was determined and multiplied by a factor of 6.25. Other proximate constituents (DM, CF, EE, NFE and Ash) were determined according to procedure described by AOAC, (1999). Fiber fractions (ADF and NDF) were determined according to the procedure of Van Soest *et al.* (1999).

The silage, after scoring, was oven-dried at 60°C for 48 hours and ground for proximate analysis. The dried *Brachiaria ruziziensis* sample was made to pass through 2mm sieve and stored in plastic containers for proximate analysis as described earlier.

3.8 Statistical analysis

Data obtained was subjected to analysis of variance using general linear model of JMP (2015). The difference between means was separated using Tukey HSD at 5% probability.

4. RESULT AND DISCUSSION

4.1 Physical characteristics and chemical properties of the compost used to grow *Brachiaria ruziziensis*

The incorporation of green manure changed the soil chemical properties when compared to soil without green manure i.e. Negative control (Table 3), where the incorporation of green manure increased the content of available P, Organic matter, exchangeable K, and Total nitrogen. Comparing the 3 legumes used as green manure, soil chemical properties differed according to the legume species used (Table 3).

Soil pH did not differ between legumes used as all treatments were slightly acidic. However, available P, Organic carbon, exchangeable K and total Nitrogen contents were higher when *Centrosema pascourum*, was used as green manure, this could be due to smaller carbon- Nitrogen (C: N) ratio resulting to faster decomposition rate, and quicker release of nutrients by *Centrosema pascourum* when used as green manure, this collaborated with the work of Giller and Wilson (1991) who reported that legumes are known to have a smaller carbon- Nitrogen (C: N) ratio which enhances decomposition. Similar result was also reported by Adediran *et al*. (2004).

Table 3. Physical Characteristics and Chemical Properties of the Soil Used in the Greenhouse Trial after Decomposition

Treatment	Ph	phosphorous (mg/kg)	Organic carbon	Exchangeable K (cmol/kg)	Total N (%)
NC	6.23	0.12	5.90	3.02	0.20
LL	6.58	0.32	8.10	8.34	0.70
GM	6.77	0.27	7.80	6.07	0.40
CPR	6.74	0.93	8.50	10.89	1.00

PC= Positive control NC= Negative control LL= *Lablab purpureum* GM= *Glysine max* CPR= Centrosema *pascourum*.

4.2 Dry Matter Yield (Kg/Ha) and Moisture Content (%) of *Brachiaria ruziziensis* Grown with Different of Sources Green Manure

Results of dry matter yield and moisture content of *Brachiaria ruziziensis* grown with different green manure sources of green manure are shown on Table 4. The results revealed that significant ($P<0.05$) differences were observed among sources of green manure in terms of dry matter yield and moisture content. Dry matter yield was significantly ($P<0.05$) higher (11.99 t/ha) in Positive control followed by *Centrosema pascourum* (9.12 t/ha), *Lablab purpureum* (7.58 t/ha), and *Glysine max* (6.56 t/ha). However, negative control recorded the least dry matter yield (4.68 t/ha).

The recorded higher dry matter yield among sources of legumes used as green manure to grow *Brachiaria ruziziensis* was observed when C*entrosema pascourum* (9.12 t/ha) was used as green manure could be due to a faster fixation of atmospheric Nitrogen by the root nodules of the legume as well as more enhanced mineralization of soil organic N during legume residues decomposition adding to the soil Organic matter, which in turn enhances soil Cation Exchange Capacity (CEC), improves soil aggregation; hence, and supports biological activity (Taminu *et al*., 2007). This agrees with the findings of Singh and Shivay (2014).

Furthermore, the significant difference observed between positive control and green manure made from *Centrosema pascourum* could be attributed to application of high rate of inorganic fertilizer which contributed to greater dry matter yield of the grasses, this is in agreement with the findings of Santos *et al.* (2004) who reported that response in biomass increase under nitrogen fertilization is attributed to plants growth acceleration which includes more tillering, more leaf production and more dry mass accumulation.

Table 4. Dry Matter Yield (kg/ha) and Moisture Content (%) of Brachiaria ruziziensis grown with different sources of green manure

Treatments	Dry Matter (t/ha)	Moisture Content (%)
PC	11.99^{a}	62.77^{c}
NC	4.68^{e}	67.71^{abc}
LL	7.58^{c}	69.39^{ab}
GM	6.56^{d}	65.20^{bc}
CPR	9.12^{b}	71.25^{a}
P value	<.0001	0.0020
SEM	0.0636	0.4892

^{a,b,c} =Means within the same column with different superscripts are significantly different (P<0.05), PC= Positive control NC= Negative control LL= *Lablab purpureum* GM= *Glysine max* CPR= Centrosema *pascourum*

Journal of Integrated Sciences
Special Issue, February 2024
ISSN: 2806-4801

4.3 Effects of Different Sources of Green Manure on the Morphological Characteristics of *Brachiaria ruziziensis*

Results on the effects of different sources of green manure on the morphological characteristics of *Brachiaria ruziziensis* are shown on Table 5. The results revealed that significant (P<0.05) differences were observed among sources of green manure.

Plant height was significantly (P<0.05) higher (84.49cm) in positive control compared to *Centrosema pascourum* (64.00cm), *Lablab purpureum* (59.19cm), *Glysine max* (54.28cm) and negative control (49.60cm). The recorded higher plant height among sources of green manure used to grow *Brachiaria ruziziensis* was observed when *Centrosema pascourum* was used as green manure, this could be due to lower C: N ratio leading to early mineralization and fast release of nutrients such as Nitrogen than the other legumes, these Nitrogen fixed were probably used by Brachiaria *ruziziensis* during cell division to form building blocks (protein) for cell elongation. This agrees with the work of Ndukwe *et al*., (2011) who reported that a legume such as Centrosema pascourum when used as green manure fixes nitrogen biologically below the ground. Similar result was reported by Liman *et al*., (2018).

Furthermore, the significant difference observed between positive control and green manure made from *Centrosema pascourum* could be attributed to application of inorganic fertilizer which contributed to a more rapid increase in plant height of the grasses, this is in agreement with the findings of Ibrahim (2019) who observed that the increase in plant height with nitrogen fertilizer is due to the fact that nitrogen promotes progressive increase in plant height, increases the number of internodes and length of the internodes..

Leaf area (Leaf length and leaf width) among sources of green manure (Table 5) was higher when C*entrosema pascourum* was used as green manure, this could be due to more rapid cell multiplication within plant leaves resulting to larger leaf blades as a result of The higher nitrogen content which serves to enhance the process of formation of the leaves of plants, this corresponds with the work of keraf *et al* (2015), according to them, plants need nitrogen for growth especially during the vegetative growth. Furthermore, the higher leaf area observed in positive control could be attributed to application of high rate of inorganic fertilizer which contributed to a larger leaf area; this is supported by the work of Tessema *et al.* (2010) who had earlier reported that improvement of grasslands could be achieved through the application of fertilizer.

Table 5. Effects of Different Green manures on the morphological characteristics of Brachiaria ruziziensis and Brachiaria ruziziensis

Treatments	Plant height (cm)	Leaf Length (cm)	Leaf Width (cm)
PC	84.49a	34.32^{a}	1.81^{a}
NC	49.60b	21.87^{c}	1.09^{b}
LL	59.19b	26.99^{b}	1.18^{b}
GM	54.28b	24.06^{bc}	1.14^{b}
CPR	64.00b	27.99^{b}	1.20^{b}
P value	0.0016*	<.0001*	<.0001*
SEM	2.6877	0.5643	0.0402

^{a,b,c} =Means within the same column with different superscripts are significantly different (P<0.05), PC= Positive control NC=

Negative control LL= *Lablab purpureum* GM= *Glysine max* CPR= Centrosema *pascourum*

4.4 Chemical Composition (%) and Fiber Fractions of Hay Made from *Brachiaria ruziziensis* grown with different Sources of green manure

Results of chemical composition (%) of *Brachiaria ruziziensis* grown with different sources of green manures were shown on Table 6. The results revealed that significant ($p<0.05$) differences were observed among sources of green manure used in terms of proximate composition (Dry matter (DM), Ash, ether extract (EE), crude fiber (CF), crude protein (CP), nitrogen free extract (NFE)) and fiber fractions (Neutral detergent fiber (NDF) and acid detergent fiber (ADF)) content of *Brachiaria ruziziensis*.

Percentage crude protein was significantly ($p<0.05$) higher (12.11%) when inorganic fertilizer was applied (Positive Control) followed by the use of *Centrosema pascourum* (8.95%), *Lablab purpureum* (8.48%), and *Glysine max* (8.15%) respectively. Least percentage (4.14%) crude protein was recorded when no green manure was incorporated into the soil.

The result on Table 6 portrays a linear increase among different sources of green manure in term of percentage CP of hay made from *Brachiaria ruziziensis*. Higher percentages (%) of CP were recorded when *Centrosema pascourum* was used as green manure; this could be attributable to higher fixation of atmospheric nitrogen and increase in the synthesis of amino acids and proteins (Silveira *et al.*, 2013). However, the significant difference observed between positive control and green manure made from *Centrosema pascourum* could be attributed to application of high rate of inorganic fertilizer, this is in agreement with Ibrahim *et al* (2019) reported that increase in levels of nitrogen gave a significant increase in CP content in forage of Rye grass. The CP concentrations among all sources of green manure and positive control of hay was above the minimum 7% requirement for rumen microbial fermentation (Van Soest, 1994) except for Negative control.

Neutral detergent fiber value (44.80%) was significantly higher ($p<0.05$) when no green manure was used (Negative control) followed by when *Glysine max* (38.45%), *Lablab purpureum* (32.29%) and *Centrosema pascourum* (30.13%) were used respectively as green manure. Least percentage (20.28%) of Neutral detergent fiber was obtained in positive control. However, no significant difference ($P<0.05$) was observed between *Lablab purpureum* and *Centrosema pascourum*. Similarly, Percentage Acid detergent fiber (37.72%) was significantly higher ($P<0.05$) when no green manure was used (Negative control) followed by when *Glysine max* (23.32%), *Lablab purpureum* (21.77%) and *Centrosema pascourum* (20.55%) respectively were used as green manure. Least percentage (13.25%) of Acid detergent fiber was obtained in positive control. However, no significant difference ($P<0.05$) was observed between *Lablab purpureum* and *Centrosema pascourum.*

The downward trend observed in the values for fiber fractions (ADF and NDF) among different sources of green manure and inorganic fertilizer (positive control) was an indication that an increase in CP leads to reduction in both NDF and ADF, this

Journal of Integrated Sciences
Special Issue, February 2024
ISSN: 2806-4801

could be attributed to low Water Soluble Carbohydrate content in grass, which are characterized by low content of non-structural carbohydrates that remain in plant parts in the form of soluble sugars and higher nitrogen fertilization diluting the content of the cell wall, this is in accordance with the finding of Dupas *et al.*, (2016). This is supported by the work of Silveira *et al.* (2013) who studied the effects of nitrogen application rates on yield, forage quality reported that diminishing of fiber fractions (ADF and NDF) and increasing the dry matter yield (DMY) with the increased nitrogen concentration was due to an increase in crude protein and other soluble contents, which accumulated in the cell and cause dilution of the cell wall.

Table 6. Chemical Composition (%) and Fiber Fractions of Hay Made from Brachiaria ruziziensis grown with different Sources of green manure

Treatments (%)	DM	Ash	EE	CF	CP	NFE	NDF	ADI
PC	95.55[a]	7.53[a]	6.14[a]	12.77[e]	12.11[a]	59.00[a]	20.28[d]	13.2
NC	92.47[d]	5.04[e]	4.57[c]	38.89[a]	4.14[e]	39.83[d]	44.80[a]	37.7
LL	95.49[b]	7.06[c]	5.69[ab]	19.39[c]	8.48[c]	54.87[b]	32.29[c]	21.77
GM	94.45[c]	6.96[d]	5.33[b]	22.83[b]	8.15[d]	51.17[c]	38.45[b]	23.3
CPR	95.52[b]	7.14[b]	5.97[ab]	16.44[d]	8.95[b]	57.02[ab]	30.13[c]	20.5
P value	<.0001*	<.0001*	<.0001*	<.0001*	<.0001*	<.0001*	<.0001*	<.000
SEM	0.0088	0.0055	0.0649	0.2294	0.0099	02248	0.4321	0.25

[a,b,c] =Means within the same column with different superscripts are significantly different (P<0.05), PC= Positive control NC= Negative control LL= *Lablab purpureum* GM= *Glysine max* CPR= Centrosema *pascourum*

Journal of Integrated Sciences
Special Issue, February 2024
ISSN: 2806-4801

4.5 Silage Characteristics of *Brachiaria ruziziensis* grown with different sources of green Manure

Results of Colour, Aroma, Temperature and pH characteristics of *Brachiaria ruziziensis* grown with different leguminous manures are presented on Table 7. The result revealed a yellowish green with a very sweet aroma when inorganic fertilizer was applied (Positive control). When legumes are used, a yellowish green colour with a sweet aroma was observed when *Centrosema pascourum* was used as green manure, a pale yellow with a sweet aroma was observed when *Lablab purpureum* and *Glysine max* were used as green manures. When no green manure was incorporated (Negative control), the ensiled grasses were light brown in colour with a pleasant aroma. The temperature and pH values of ensiled Brachiaria ruziziensis ranges from 31.93-32.53 ^{0}C and 4.70-5.80 respectively which indicates that satisfactory silage was made.

Table 7. Silage Characteristics of Brachiaria ruziziensis grown with different green manures

Treatments	Colour	Aroma	Temperature (°C)	pH
PC	Yellowish green	Very sweet	32.53	4.70
NC	Light brown	Pleasant	32.00	5.80
LL	Pale yellow	Sweet	32.00	4.96
GM	Pale yellow	Sweet	31.93	4.90
CPR	Yellowish green	Sweet	32.00	4.87
P value	<.0001*	0.0054*	0.0004*	<.0001*
SEM	0.0667	0.1156	0.0298	0.0221

PC= Positive control NC= Negative control LL= *Lablab purpureum* GM= *Glysine max* CPR= Centrosema *pascourum.*

4.6 Chemical Composition (%) and Fiber Fractions of Silage Made from *Brachiaria ruziziensis* grown with different sources of green manures

Results of chemical composition (%) of ensiled *Brachiaria ruziziensis* grown with different sources of green manure are shown on Table 8. The result revealed that significant ($p<0.05$) differences were observed among green manure in terms of dry matter (DM), Ash, ether extract (EE), crude fiber (CF), crude protein (CP), nitrogen free extract (NFE), neutral detergent fiber (NDF) and acid detergent fiber (ADF).

Percentage crude protein was significantly ($p<0.05$) higher (10.73%) when inorganic fertilizer was applied (Positive Control) followed by the use of *Centrosema pascourum* (7.01%), *Lablab purpureum* (6.44%), and *Glysine max* (6.16%) respectively. Least percentage (3.57%) crude protein was recorded when no green manure was incorporated. The result on Table 8 revealed that CP concentrations among sources of green manure of silage made from *Brachiaria ruziziensis* were below the 7% recommendation which could negatively affect rumen microbial activity (Van Soest 1994; Norton 2003) except for Positive control and *Centrosema pascourum* which gave values above the 7% requirement. The Higher percentages (%) of CP recorded when *Centrosema pascourum* was used as green manure could be attributable to an increase in the synthesis of amino acids and proteins (Traviskis *et al* 2001; Bennett *et al.*, 2008). However, the significant difference observed between positive control and green manure made from *Centrosema pascourum* could be attributed to application of high rate of inorganic fertilizer, this is in line with Ibrahim (2019) who reported that

Journal of Integrated Sciences
Special Issue, February 2024
ISSN: 2806-4801

application of higher rate of nitrogen fertilizer increases the CP content in rye grass. Neutral detergent fiber percentage (58.57%) was significantly higher ($p<0.05$) when no green manure was used (Negative control) followed by when *Lablab purpureum* (47.05%) *Glysine max* (45.48%), and *Centrosema pascourum* (41.58%) respectively were used as green manure. Least percentage (32.01%) of Neutral detergent fiber was obtained in positive control. Forages with a high NDF content are considered to be lower in quality, and forage intake is generally low (Baba *et al*., 2018). Similar trend as NDF was observed in Percentage ADF, as lignin content increases, digestibility of cellulose decreases thereby lowering the amount of energy potentially available to the animal. This coincides with the works of Dupas *et al.* (2010) and Silveira *et al.* (2013) reported that besides increasing the dry matter yield (DMY), nitrogen supply decreases NDF concentration in forage crops. Similar results were reported by Van Soest, (1994) and Dupas *et al*., (2016).

Table 8. Chemical Composition (%) of ensiled Brachiaria ruziziensis grown with different sources of green manure

Treatments	%DM	% Ash	%EE	%CF	%CP	%NFE	% NDF	%ADF
PC	94.79^{a}	9.49^{a}	6.09^{a}	24.03^{e}	10.73^{a}	44.45^{a}	32.01^{e}	22.88^{e}
NC	90.88^{d}	6.81^{e}	4.86^{e}	46.27^{a}	3.04^{e}	29.89^{e}	58.57^{a}	48.45^{a}
LL	94.20^{b}	8.81^{c}	5.62^{c}	35.25^{c}	6.44^{c}	38.09^{c}	47.05^{b}	37.35^{c}
GM	93.84^{c}	7.95^{d}	5.29^{d}	39.01^{b}	6.16^{d}	35.44^{d}	45.48^{c}	38.35^{b}
CPR	94.65^{a}	9.06^{b}	5.85^{b}	32.00^{d}	7.01^{b}	40.77^{b}	41.58^{d}	35.49^{d}

Journal of Integrated Sciences
Special Issue, February 2024
ISSN: 2806-4801

P value	<.0001*	<.0001*	<.0001*	<.0001*	<.0001*	<.0001*	<.0001*	<.0001*
SEM	0.0139	0.0129	0.0068	0.0953	0.0123	0.1052	0.0142	0.0062

[a,b,c] =Means within the same column with different superscripts are significantly different (P<0.05), PC= Positive control NC= Negative control LL= *Lablab purpureum* GM= *Glysine max* CPR= Centrosema *pascourum*.

5. CONCLUSION AND RECOMMENDATIONS

The results of this study indicated that green manure had profound effects on hay and silage made from *Brachiaria ruziziensis*. Dry matter yield (DMY) which is one of the most important determinant for improved livestock production was considerably higher when *Centrosema pascourum* was used as green manure, quality parameters such as crude protein (CP), Ash and nitrogen free extract (NFE) appeared to be greater when *Centrosema pascourum* was used as green manure, in addition to reduced fiber fraction (ADF and NDF) in hay made from *Brachiaria ruziziensis*. This scenario is similarly repeated in silage made from *Brachiaria ruziziensis*. It can thus be concluded that *Brachiaria ruziziensis* should be cultivated using *Centrosema pascourum* as green manure.

Based on the results and findings of this study, the following are recommended;

1. *Centrosema pascourum* is recommended as a source of green manure for the cultivation of *Brachiaria ruziziensis* for hay and silage in the study area.

2. Feeding trial should be conducted to evaluate the impacts of the treatments on animal productivity.

3. The role of extension agents in demonstrating the benefits of green manure in soil nutrient improvement and occasional workshops will improve awareness and make this system an attractive alternative for farmers in Nigeria.

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