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Evaluation of Reciprocal Benefits of Green Manure on Yield and Nutrient Composition of *Sorghum almum* Hay and Silage

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Abstract

The increasing cost of inorganic fertilizer and concerns for more ecological stability with sustainable soil fertility have led to a renewed interest in green manuring, which is affordable and more environmental friendly soil management practice. This experiment was undertaken to evaluate the reciprocal benefits of green manure on yield and nutritive value of Sorghum almum. The experiment was conducted in two phases. First experiment evaluated the yield, morphological characteristics and quality of hay while the second phase assessed the fermentation characteristics and quality of silage. The experiment design was 1x5 factorial arrangement in a split plot design and replicated three times. Three legume species: Centrosema poscurum, Lablab purpureum 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). Data obtained were subjected to analysis of variance (ANOVA) at P= 0.05. The results showed Significant (P<0.05) increase in values of soil pH, phosphorus, organic carbon, potassium and total nitrogen as influenced by green manure compared to Negative control. Higher significant (P<0.05) Dry matter yield among legumes was recorded when Centrosema pascourum was used to grow Sorghum almum (8.31t/ha). However, positive control recorded the highest values (9.07t/ha). The same trend was observed in terms of plant height (101.90 cm), leaf length (53.47cm) and leaf width (1.93cm). Proximate composition CP (8.75%) DM (98.13%), Ash (8.58%) and NFE (47.90%) of the grass were significantly (P<0.05) higher while fiber fractions NDF (40.42) and ADF (24.72) reduced when Centrosema pascuorum was used compared to other sources of green manure. However, positive control recorded highest proximate values with minimum fiber fractions. Silage fermentation characteristics revealed that quality silage was produced. Silage proximate composition and fiber fractions of Sorghum almum showed similar trend as hay. Conclusively, Centrosema pascourum proves to be the best source of green manure and is therefore recommended for cultivation Sorghum almum in the study area.

Keywords: *Sorghum almum,* Leguminous Green Manure, Yield, Hay, Silage.

Évaluation des avantages réciproques de l'engrais vert sur le rendement et la composition nutritionnelle du foin et de l'ensilage de *Sorghum almum*

Résumé

Le coût croissant des engrais inorganiques et les préoccupations concernant une plus grande stabilité écologique et une fertilité durable des sols ont conduit à un regain d'intérêt pour l'engrais vert, qui constitue une pratique de gestion des sols abordable et plus respectueuse de l'environnement. Cette expérience a été entreprise pour évaluer les bénéfices réciproques de l'engrais vert sur le rendement et la valeur nutritive du Sorghum almum. L'expérience s'est déroulée en deux phases. La première expérience a évalué le rendement, les caractéristiques morphologiques et la qualité du foin tandis que la deuxième phase a évalué les caractéristiques fermentaires et la qualité de l'ensilage. Le plan d'expérience était un arrangement factoriel 1x5 dans un plan en parcelles divisées et répliqué trois fois. Trois espèces de légumineuses : Centrosema poscurum, Lablab purpureum et Glycine max ont été utilisées comme sources d'engrais vert et comme témoin positif (Urée, Super Phosphate Simple et Muriate de Potasse à raison de 100, 50, 50 kg/ha, respectivement) et témoin négatif. (0k/ha). Les données obtenues ont été soumises à une analyse de variance (ANOVA) à P = 0,05. Les résultats ont montré une augmentation significative (P <0,05) des valeurs du pH du sol, du phosphore, du carbone organique, du potassium et de l'azote total sous l'influence de l'engrais vert par rapport au contrôle négatif. Un rendement en matière sèche plus élevé et significatif (P < 0,05) parmi les légumineuses a été enregistré lorsque Centrosema pascourum a été utilisé pour cultiver du Sorghum almum (8,31 t/ha). Cependant, le contrôle positif a enregistré les valeurs les plus élevées (9,07 t/ha). La même tendance a été observée en termes de hauteur des plantes (101,90 cm), de longueur des feuilles (53,47 cm) et de largeur des feuilles (1,93 cm). La composition immédiate CP (8,75 %) DM (98,13 %), cendres (8,58 %) et NFE (47,90 %) de l'herbe était significativement (P < 0,05) plus élevée tandis que les fractions de fibres NDF (40,42) et ADF (24,72) étaient réduites lorsque Centrosema pascuorum a été utilisé par rapport à d'autres sources d'engrais vert. Cependant, le contrôle positif a enregistré les valeurs immédiates les plus élevées avec des fractions de fibres minimales. Les caractéristiques de fermentation de l'ensilage ont révélé qu'un ensilage de qualité était produit. La composition immédiate de l'ensilage et les fractions de fibres du Sorghum almum ont montré une tendance similaire à celle du foin. En conclusion, Centrosema pascourum s'avère être la meilleure source d'engrais vert et est donc recommandé pour la culture du Sorghum almum dans la zone d'étude.

Mots-clés : *Sorghum almum*, Engrais vert de légumineuses, Rendement, Foin, Ensilage.

Introduction

Use of legumes green manure is an important practice for sustainable agriculture as the legumes help fix atmospheric Nitrogen, unlike other organic fertilizers, leguminous green manure through the strong roots helps to break up deep soil layers, improves soil structure and promotes roots penetration of subsequent crops (Watson *et al,* 2002). Leguminous green manure crops, apart from improving the soil fertility through their nitrogen fixing ability, they suppress weeds (Cobo *et al.,* 2002, Bohlool *et al.*, 2004), nematode and controls erosion (Tamiru, 2013). Some leguminous green manure crops have ability to accumulate high amount of N within a short period of time. In about six (6) weeks, cowpea and soybean could accumulate up to 75 and 115 Kg N / ha respectively (Adesoji *et al.,* 2013). The use of organic manures to replenish depletion in soil fertility and reduce environmental pollution which frequently occurs as a result of continuous use of chemical fertilizers is growing interest worldwide. However; their benefits are realized upon decomposition and subsequent nutrient release (Mubarak *et al.,* 2002; Igbal, 2009). Therefore, the present study was aimed at evaluating the reciprocal benefit of green manure on some soil properties, yield and nutrient composition of hay and silage made from *Sorghum almum.*

Materials and Methods

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. 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^{o} to 11.98194^{o}N, and longitude 8.41245 ^{o} to 8.42205^{o}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^{o}C (KNARDA, 2010).

Treatments and experimental design

Columbus grass (*Sorghum almum*) 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) was 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 two weeks to allow for partial decomposition. Thereafter, the compost was sorted for the establishment of *Sorghum almum* and was replicated three times. The experiment was a split plot design with 1×5 factorial arrangement. The main treatments were three legumes, a positive control and a negative control. Sub treatment was *Sorghum almum*.

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 three 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 1: 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

Land preparation and cultural practices

Each experimental polythene bag contained 10kg of sandy loam soil. Viable seeds of 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 *Sorghum almum* were sown in July. 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.

Data collection

Prior to harvest, data were recorded on 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 materials were weighed fresh using weighing scale, thereafter oven dried at 65 $^{\circ}C$ 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.

Silage preparation

Stella pomade bottles (250mL) were used as Laboratory bottles for ensiling. Samples of the harvested *Sorghum almum* 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 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 $^{\circ}C$ 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 2: Description of colour and aroma scores used in assessing silage quality of *Sorghum almum*

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).

Chemical analysis

In the first and second experiments, collected *Sorghum almum* 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).

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

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.

Result and discussion

Physical characteristics and chemical properties of the compost used to grow sorghum almum

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 three 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 C*entrosema pascourum,* was used as green manure, this could be due to smaller carbon- nitrogen (C: N) ratio, which results to faster decomposition rate and quicker release of nutrients by C*entrosema pascourum* when used as green manure. This is in line with the work of Balasubramanian and Nnadi (1980) who reported that legumes are known to have a smaller carbon- Nitrogen (C: N) ratio which enhances decomposition and are rich source of nutrients to the soil. Similar results were also reported by Adediran *et al.* (2004) and Ziblim *et al.* (2013).

Table 3: Chemical properties of the soil used in the greenhouse trial after decomposition

	After green manure incorporation			
Treatment	**NC**	**LL**	**GM**	**CPR**
Ph	6.13	6.58	6.49	6.41
Phosphorous (mg/kg)	0.09	0.32	0.27	0.52
Organic carbon	5.6	8	7.7	8.2
Exchangeable K (cmol/kg)	2.99	8.19	5.98	10.88
Total N (%)	0.2	0.4	0.4	0.5

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

Dry matter yield (Kg/ha) and moisture content (%) of Sorghum almum grown with different of sources green manure

Results of dry matter yield and moisture content of *Sorghum almum* 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. Dry matter yield was significantly ($P<0.05$) higher (9.07 t/ha) in positive control followed by C*entrosema pascourum, Lablab purpureum and Glysine max* (8.31, 7.60 and 6.84 t/ha, respectively). The least dry matter content was recorded when manure was not applied (negative control). Higher dry matter yield among sources of legumes was observed when C*entrosema pascourum* (8.31 t/ha) was used as green manure, which is within the range of 8 – 14 t/ha as reported by Muhammad *et al*. (2002), 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 and supports biological activity (Salahi *et al.,* 2013), Similar result was reported by Tanimu *et al*. (2007). Furthermore, the significant difference observed between positive control and green manure made from C*entrosema 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 Ball and Field (1992), who reported that increase in yield with increased nitrogen, was mainly associated with greater plant height, number of leaves and stem diameter.

Table 4: Dry matter yield (Kg/ha) and moisture content (%) of*Sorghum almum* grown with different sources of green manure

	Yield as influenced by green manure						
Treatment	**PC**	**NC**	**LL**	**GM**	**CPR**	**P value**	**SEM**
Dry Matter (t/ha)	9.07^{a}	4.11^{e}	7.60^{c}	6.00^{d}	8.31^{b}	<.0001*	0.0487
Moisture Content (%)	73.21^{a}	72.91^{a}	66.83^{b}	68.03^{b}	67.83^{b}	<.0001*	0.1212

^{a,b,c} =Means with different superscripts wi thin rows differed significantly ($P<0.05$), **PC**= Positive control **NC**= Negative control **LL**= Lablab purpureum **GM**= Glysine max **CPR**= Centrosema pascourum

Effects of different sources of green manure on the morphological characteristics of sorghum almum

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

Plant height in *Sorghum almum*, was significantly ($P<0.05$) higher (113.00 cm) in positive control followed by Centrosema *pascourum* (101.90cm), *Lablab purpureum* (92.33cm) and *Glysine max* (88.27cm). The least plant height (79.33cm) was observed in negative control. Higher plant height among sources of legumes was observed when C*entrosema pascourum* was used as green manure, 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 *Sorghum almum* during cell division to form building blocks (protein) for cell elongation, this agrees with the work of Tanimu *et al*.,(2007) who reported that legumes such as C*entrosema pascourum* has a lower C: N ratio which allows a faster release and decomposition of nutrients (N). Similar result was reported by Mensah *et al*. (2007). Furthermore, the significant difference observed between positive control and green manure made from C*entrosema pascourum* could be attributed to application of inorganic fertilizer (100 kg/ha) which contributed to a more rapid increase in plant height of the grasses, this is in agreement with the findings of Gasim (2001) who observed that the increase in plant height with nitrogen fertilizer is due to the fact that nitrogen promotes plant growth, increases the number of internodes and length of the internodes.

Also, Table 5 showed leaf area (leaf length and leaf width) among sources of green manure 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 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 El Noeman *et al.* (1990) and Gasim (2001) who reported that nitrogen fertilization increased number of leaves per plant and leaf area.

Table 5: Effects of different green manures on the morphological characteristics of *Sorghum almum*

Treatment	Morphology as influenced by green manure						
(cm)	PC	NC	LL	GM	CPR	P value	SEM
Plant height	113.00^{a}	79.13^{c}	92.33^{b}	88.27^{b}	101.90^{ab}	0.0058*	2.9183
Leaf length	69.20^{a}	51.43^{b}	57.90^{b}	53.47^{b}	60.46^{ab}	0.0001*	1.1904
Leaf width	2.55^{a}	1.57^{b}	1.70^{b}	1.67^{b}	1.93^{b}	<.0001*	0.0412

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

Chemical composition (%) and fiber fractions of hay made from Sorghum almum grown with different sources of green manure

Results of chemical composition (%) of *Sorghum almum* grown with different sources of green manures were shown on Table 5. 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 *Sorghum almum* . Percentage crude protein was significantly (p<0.05) higher (11.95%) when inorganic fertilizer was applied (Positive Control) followed using C*entrosema pascourum* (8.75%), *Lablab purpureum* (8.54%), and *Glysine max* (7.38%), respectively. Least percentage (4.75%) crude protein was recorded when no green manure was incorporated. The result on Table 6 portrays a linear increase among different sources of green manure in term of percentage CP of hay made from *Sorghum almum*. The percentage of crude protein when C*entrosema pascourum* and *Lablab purpureum* were used as green manure was within the range of 8-10 as reported in a study by Muhammad *et al*. (2005). Higher percentages (%) of CP were recorded when C*entrosema 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 (Oliveira *et al.,* 2010). However, the significant difference observed between positive control and green manure made from C*entrosema pascourum* could be attributed to application of high rate of inorganic fertilizer, this is in agreement with Tripathi *et al.* (1999) reported that application of nitrogen gave a significant additional increase in CP content in forage oats. The CP concentrations among sources of green manure and positive control of hay was above the minimum 7% requirement for rumen microbial fermentation except for Negative control (Van Soest, 1994).

Neutral detergent fiber value (50.53%) was significantly higher (p<0.05) when no green manure as incorporated in the soil (Negative control), followed by the use of *Glysine max* (45.63%), *Lablab purpureum* (43.80%), and *Centrosema pascourum* (40.42%) respectively. Least percentage (30.37%) of Neutral detergent fiber was observed when inorganic fertilizer was applied (Positive Control). The same trend was observed in ADF, this indicates that increase in CP leads to reduction in both NDF and ADF. The values of ADF and NDF reported in this study were lower than 40.0-44.0 % ADF and 61.2-75.3 % NDF in *Sorghum almum* as reported by Kallah *et al.* (1999). These values were also lower than earlier reports of Muhammad *et al*. (2005) and Olanite *et al*. (2010) except for Negative control. The downward trend observed in the values for fiber fractions (ADF and NDF) among different sources of green manure and inorganic fertilizer (positive control) could be attributed to low Water Soluble Carbohydrate content in grasses, 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 Neto (2017). This is supported by the work of Delevatti *et al.,* (2019) who studied the effects of nitrogen application rates on yield, forage quality and animal performance in tropical pasture and reported that diminishing of fiber fractions (ADF and NDF) with the increased nitrogen concentration was due to an increase in crude protein and other soluble contents.

Table 6: Chemical composition (%) and fiber fractions of hay made from *Sorghum almum* grown with different sources of green manure

Treatment	**Hay chemical composition as influenced by green manure**						
(%)	**PC**	**NC**	**LL**	**GM**	**CPR**	**P value**	**SEM**
Dry matter	98.58^{a}	94.53^{d}	97.99^{c}	97.92^{c}	98.13^{b}	<.0001*	0.0098
Ash	9.19^{a}	6.45^{b}	8.23^{ab}	8.10^{ab}	8.58^{a}	0.0081*	0.1807
Ether extract	7.83^{a}	6.09^{e}	6.89^{ab}	6.30^{ab}	7.17^{ab}	0.0437*	0.1627
Crude fibre	23.34^{e}	40.83^{a}	29.11^{c}	33.85^{b}	25.73^{d}	<.0001*	0.1517
Crude protein	11.95^{a}	4.75^{e}	8.54^{c}	7.38^{d}	8.75^{b}	<.0001*	0.0126
Nitrogen free extract	50.27^{a}	34.40^{e}	45.22^{c}	42.29^{d}	47.90^{b}	<.0001*	0.3728
Neutral detergent fiber	30.37^{c}	50.53^{a}	43.80^{b}	45.63^{ab}	40.42^{b}	<.0001*	0.5176
Acid detergent fiber	21.50^{d}	40.33^{a}	26.98^{bc}	27.87^{b}	24.72^{c}	<.0001*	0.2633

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

Silage characteristics of Sorghum almum grown with different sources of green manure

Results of colour, aroma, temperature and pH characteristics of Sorghum *almum* grown with different leguminous manures are presented in 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 C*entrosema 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 Sorghum *almum* ranges from 31.86-32.50 ^{0}C and 4.66-5.96 respectively which indicates that satisfactory silage was made.

Table 7: Silage characteristics of Sorghum *almum* grown with different green manures

Parameter	Silage characteristics as influenced by green manure						
	PC	**NC**	**LL**	**GM**	**CPR**	**P value**	**SEM**
Colour	Yellowish green	Light brown	Pale yellow	Pale yellow	Yellowish green	<.0001*	0.0667
Aroma	Very sweet	Pleasant	Sweet	Sweet	Sweet	<.0001*	0.0667
Temperature (°C)	32.5	31.86	32.33	31.96	32.33	0.0085*	0.0481
pH	4.66	5.96	4.8	4.8	4.66	<.0001*	0.0163

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

Chemical composition (%) and fiber fractions of silage made from Sorghum almum grown with different sources of green manures

Results of chemical composition (%) of ensiled *Sorghum almum* 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 (9.92%) when inorganic fertilizer was applied (Positive Control) followed by the use of C*entrosema pascourum* (6.54%), *Lablab purpureum* (6.17%) and *Glysine max* (5.78%) respectively. Least percentage (3.15%) of crude protein was obtained when no green manure was incorporated into the soil (Negative control). The result on Table 8 revealed that CP concentrations among all sources of green manure of silage made from *Sorghum almum* were below the 7% recommendation except for Positive control which gave higher values above the 7% requirement. Higher percentages (%) of CP were recorded when C*entrosema pascourum* was used as green manure; this could be attributable to increase in the synthesis of amino acids and proteins (Bennett *et al.,* 2008). However, the significant difference observed between positive control and green manure made from C*entrosema pascourum* could be attributed to application of high rate of inorganic fertilizer, this is in line with Ibrahim (2021) who reported that application of higher rate of nitrogen fertlizer increases the CP content in rye grass.

Neutral detergent fiber value (59.80%) was significantly higher ($p<0.05$) when no green manure as incorporated in the soil (Negative control), followed by the use of *Glysine max* (53.45%), *Lablab purpureum* (52.18%), and C*entrosema pascourum* (46.75%) respectively. Least percentage (41.93%) of Neutral detergent fiber was observed when inorganic fertilizer was applied (Positive Control). Forages with a high NDF content are considered to be lower in quality, and forage intake is generally low (Baba *at, 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 Bennett *et al.* (2008); Dupas *et al.* (2010); Oliveira *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); Viana *et al.* (2011) and Dupas *et al.* (2016).

Table 8: Chemical composition (%) of ensiled *Sorghum almum* grown with different sources of green manure

Treatment	Silage chemical composition as influenced by green manure						
(%)	PC	NC	LL	GM	CPR	P value	SEM
Dry matter	96.76^{a}	91.55^{d}	94.45^{b}	93.52^{b}	94.56^{b}	$<.0001^{*}$	0.0765
Ash	11.33^{a}	6.67^{d}	9.46^{c}	9.29^{c}	9.95^{b}	$<.0001^{*}$	0.0208
Ether extract	7.74^{a}	6.11^{e}	6.56^{c}	6.37^{d}	7.07^{b}	$<.0001^{*}$	0.0064
Crude fibre	25.41^{e}	47.56^{a}	35.12^{c}	37.42^{b}	32.10^{d}	$<.0001^{*}$	0.0071
Crude protein	9.92^{a}	3.15^{e}	6.17^{c}	5.78^{d}	6.54^{b}	$<.0001^{*}$	0.0074
Nitrogen free extract	42.36^{a}	28.04^{e}	37.14^{c}	34.67^{d}	38.89^{b}	$<.0001^{*}$	0.1124
Neutral detergent fiber	41.93^{c}	59.80^{a}	52.18^{b}	53.45^{b}	46.75^{bc}	$<.0001^{*}$	0.6654
Acid detergent fiber	29.78^{d}	56.01^{a}	36.97^{c}	43.65^{b}	36.22^{c}	$<.0001^{*}$	0.1170

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

Conclusion

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

References

O. A. C 1999. Association of Official Analytical Chemists, Official Methods of Analysis (18th edition) Washington D.C, USA Pp69-88.

Adamu, G. K and Aliyu, 2012. Determination of the influence of Texture and Ogarnic Matter and Soil Water Holding Capacity in and Around Tomas Irrigation SchameDanbatta Local government Kano State. *Research Journal of*

*Enviromental and Earth Sciences 4(12) : 1038-1044,*ISSN: 2041-0942 Maxwell Scientific Organization

Adediran J. A, Akande M. O, Oluwatoyinbo F. I 2004. Effect of mucuna intercropped with maize on soil fertility and yield of maize. *Ghana J. Agric. Sci*. 37:15-22.

Adesoji, A. G, I. U. Abubakar and D. A. Labe 2013. Contributions of Short Duration Legume Fallow to maize (*Zea mays L.*) Varieties Under Different Nitrogen Levels in a Semi – Arid Environment

AES 1998. Agricultural Experimental Station of North Central Region of America.

Baba, M., Nasiru, A., Kabiru, A., Erakpotobor, M. and Umar, G. A. 2018. Effects of Additives and Their Levels of Inclusion on Nutritive Value of Silage Made From Elephant Grass (*Pennesetum purpureum*). *Nigerian Journal of Animal Production*, 45(2): 352-362

Babayemi, O. J., Ekokotu, O. A and U. A lyang 2009. Evaluation of ensiled Cassava peels together with *Albizia Samam* pods in: B.I Umoh, A.B.I Udedibie, LP Solomon, O.L Obasi, B.I Okon and E.J Udoh (eds). Animal Agriculture and Global Food challenges. Proceedings of the 34th annual conference of the NSAP held at University of Uyo, Uyo, Akwa Ibom State, Nigeria: 544 - 546.

Balasubramanian, V. and L. A. Nnadi, 1980. Crop residue management and soil conservation in savanna areas. In: FAO Soil Bulletin No. 43, Rome, pp: 15.

Ball, P. R., and Field, T. R. O. 1982. Responses to Nitrogen as Affected by Pasture Characteristics, Season and Grazing Management In P.B. Lynch (Ed.), *Nitrogen Fertilizers in New Zealand Agriculture*. New Zealand Institute of Agricultural Science: Ray Richards Publisher.

Benett, C. G. S., Buzetti, S., Silva, K. S., Bergamaschine, A. F., and Fabricio, J. A. 2008. Yield and Bromatologic Composition of Marandu Grass as Function of Sources and Doses of Nitrogen. Cienc Agrotec. 32(5):1629-1636.

Bohlool, B. B; J. K. Ladha, D. P. Garrity and George, T. 2004. Biological nitrogen fixation for sustainable agriculture: A Perspective Plant. Soil. 141 (1 – 2): 1 – 11.

Cobo, J. G; E.Barrios, DCL. Kass and Thomas, R. J. 2002. Nitrogen Mineralization and Crop Uptake from Surface – applied leaves of green manure species on a tropical volcanic – ash soil. *Biological Fertility of Soil*. 36: 87-92

Delevatti, L. M., Cardoso, A. S. and Baebero, R. P. 2019. Effects of Nitrogen Application Rates on Yield Forage Quality and Animal Performance in Tropical Pasture. Science Rep. 9,7596

Dupas, E., Buzetti, S., Sarto, A. L., Hernandez, F. B. T., and Bergamaschine, A. F., 2010. Dry Matter Yield and Nutritive Value of Marandu Grass Under Nitrogen Fertilization and Irrigation in Cerrado in Sao Poulo. *Brazilian Journal of Animal Science*, 39: 2598-2603.

El Noeman, A. A., El-Halem, K. A., El-Zeiny, H. A. 1990. Response of Maize (Zea mays L.) to Irrigation Intervals Under Different Levels of Nitrogen Fertilization. *Egyptian Journal of Agronomy*, 15 (1–2) pp. 147-158

Gasim, S. H. 2001. Effect of Nitrogen, Phosphorus and Seed Rate on Growth, Yield and Quality of Forage

Maize (*Zea mays L.*). M.Sc. Thesis, Faculty of Agriculture, University of Khartoum.

Ibrahim, S. U. 2019. Influence Of Nitrogen And Spacing On Yield And Nutritive Value Of Hay and Silage Of Perennial Ryegrass Grown During Harmattan Season In Kano. M,Sc. Thesis, Faculty of Agriculture, Bayero University Kano.

Iqbal, S. M. 2009. Effect of crop residue qualities on decomposition rates, soil phosphorus dynamics and plant phosphorus uptake (Thesis Ph.D, University of Adelaide, School of Earth and Environmental Sciences).

Kallah, M. S., Muhammad, I. R ., Baba, M.,and Lawal., R 1999. The effect of Maturity on the composition of Hay and Silage made from Columbus grass (*Sorghum almum*).Tropical Grasslands.33:46-50

Kano Agricultural and Rural Development Authority (KNARDA), 2010. Metrological Station Reports. Temperature Record Book and Management Unit, 12:13

Keraf, F. K., Y. Nulik, and M. L. Mullik, 2015. [The effects of nitrogen fertilization and plant's age on the quality and production of kume grass (Sorghum plumosum var. timorense)]. J. Anim. Husbandry Indonesia, 17: 123-130.

Mensah, J. K., Akomeah , P. A. and Eifediyi , E. K. 2007. Soil fertility regeneration of impoverished Ultisol of Edo State using *Gliricidia sepium* Jacq Walp. *Journal of Agronomy*.6:593-59.

Mubarak, A. R., Rosenani, A. B., Anuar, A. R., & Zauyah, S. 2002. Decomposition and nutrient release of maize stover and groundnut haulms under tropical field conditions of Malaysia. *Community Soil Science and Plant Analysis, 33(3)*, 609-622. https://doi.org/10.1081/CSS-120002767

Muhammad I. R., Abdullahi B., Mohammed A. K., Tanko R. J., Kallah M. S and Alawa J. P 2005. Influence of irrigation intervals on dry matter yield, concentration of crude protein, calcium and phosphorus in Lablab purpureus and Sorghum almum fodder in the Sudan Savannah zone of Nigeria. *Nigerian Journal of Animal Production*, 32, 280–286.

Muhammad I. R., Kallah, M. S., Otchere, E. O., Alawa, J. P., Tanko, R. J., & Olurunjo, S. A. S., 2002. Effect of Nitrogen fertilization on yield and nutritive value of Columbus grass forage fractions in guinea savannah zone of Nigeria. *Journal Agriculture and Environment*. 3 (2): 209-223

Muhammad, I. R. Abdu, M I. Iyeghe-Erakpotobor,G.T. and Sulaiman, K. A. 2009. Ensiling Quality of Gamba Fortified with Tropical Legumes and Its Preference by Rabbits. *Research Journal of Applied Science*, 4 (1): 20-25

Muhammad, I. R. Kallah, M. S., and R. J. Tanko. 1999. Guide to Sorghum almum production and utilization. NAPRI Bulletin. No.2. (June 1994). 45-51

Neto, A. B., Dos Reis, R. H. P., Da Silva Cabral, L., De Abreu, J. G., De Paula Sousa, D., Pedreira, B. C., Mombach, M. A., Balbinot, E., De Carvakho, P., Da Silva Carvalho, A. P. 2017. Fermentation characteristics of different purposes sorghum silage. *Semina:Ciencias Agrarias* 38 (4): 2607–2618

Olanite, J. A., Anele., Arigbede, U. Y., Jolaosho., A. O and Onifade., O. S. 2010. Effect of plant spacing and nitrogen fertilizer levels on the growth, dry-matter yield and nutritive quality of Columbus grass (Sorghum almum stapf) in Southwest Nigeria. *The Journal of the British Grassland Society. The Official Journal of the European Grassland Federation. Grass and Grass and Forage Science*, 65, 369–375.

Oliveira, D. A., Bonfim-Silva, E. M., Silveira, C. P. and Monteiro, F. A. 2010. Nutritional Value of the Signal Grass in the First Year of Recovery Following Nitrogen and Sulphur Applications. *Brazilian Journal of Animal Science*, 39(4): 716-726.

Salahin, N., Alam, Md. K., Islam, Md. M., Naher, L., & Majid, N. M. 2013. Effects of green manure crops and tillage practice on maize and rice yields and soil properties. *Australian Journal of Crop Science*, *7*(12), 1901-1911.

Silveira, M. L., Vendramini, J. M. B., Sellers, B., Monteiro, F. A., Artur, A. G., and Dupas, E. 2013. Bahiagrass Response and N Loss from Selected N Fertilizer Sources. *Grass Forage Science*. 70(1):154-160.

Tamiru, H. 2013. Effect of stage at termination of legume green manure on soil organic Carbon, yield and economic performance of subsequent maize crop.

Tanimu, J., Iwuafor, E. N. O., Odunze A.C. and Tian G. 2007. **Effect of Incorporation of Leguminous Cover Crops on Yield and Yield Components of Maize.** World Journal of Agricultural Sciences 3 (2): 243-249, 2007 ISSN 1817-3047

Tripathi S. N., Singh, R. B., Mather, B. and Gill, A. S. 1979. Effect of Nitrogen and Phosphate Levels on Yield and Quality of Oats *Indian Journal of Agronomy*: 24: 250-254 pp.

Van soest, P. J, Robertson, J. B and Lewis, B. A 1999. Methods for directory neutral detergent fibre and nonstarch polysaccharides in relation to animal nutrition *.J. dairy Sci., 74:3583-3597*.

Van Soest, P. J. 1994. Nutritional Ecology of the Ruminant. Second ed. Cornell University, Ithaca, NewYork, USA

Viana, M. C. M., Freier F. M., Ferreira, J. J., Macedo, G .R. A., Cantarutti, R. B. and Mascrenhas, M. T. H. 2011. Nitrogen Fertilization on Yield and Chemical Composition of Signal Grass Under Rotational Grazing. *Brazilian Journal of Animal Science*, 40(7): 1497-1503

Watson C. A., Atkinson D., Gosling P., Jackson L. R., Rayns F. W. 2002. Managing soil fertility in organic farming systems, Soil Use Manage. 18, 239–247.

Ziblim I. A, Paul G. S, Timothy K. A 2013. Assessing soil amendment potentials of *Mucuna pruriens* and *Crotalaria juncea* when used as fallow crops. *J. Soil Sci. Environ. Manage*. 4:28-34.

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