EVALUATION OF FRESH BIOMASS YIELD, NUTRIENTS CONTENT AND THE GREEN MANURE POTENTIAL OF SOME FORAGE LEGUME SPECIES FOR ADOPTION INTO THE FARMING SYSTEMS IN BORNO STATE, NIGERIA

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ABSTRACT
Fresh biomass from forage legume species does offer immense benefits in farming systems if used in livestock feeding or as green manure. A pot experiment was conducted in 2013 at the screen house, faculty of Agriculture, University of Maiduguri, to evaluate the fresh biomass yield and the green manure potentials of some leguminous forage species. The experiment consisted of eight plants namely:- Mucuna pruriens black (T_1), Stylosanthesis guinensis (T_4), Cajanus cajan ICPL 332 (T_6), Centrosema pubescens (T_{10}) Mucuna pruriens white (T_{13}), Sesbania rostrata kirenowa (T_{14}), Sesbania rostrata Jere (T_{16}) and Sesbania rostrata Loskuri (T_{17}). The plants were grown in plastic pots of 3 kg topsoil and at six weeks after sowing, these were harvested, the fresh weights and NPK content were measured. The result showed that Mucuna pruriens black (T_1) and Mucuna pruriens white (T_{13}) produced the highest biomass weights of 26.33 and 20.5 grammes/pot respectively. Followed by Sesbania rostrata Jere (T_{16}) 15.8 and Sesbania rostrata Loskuri (T_{17}) 13.1 g/pot. Others produced lower biomass yields with 6.53, 5.7, 4.67 and 3.7 g/pot for Centrosema pubescens (T_{10}), Sesbania rostrata kirenowa (T_{14}), Cajanus cajan red (T_6) and Stylosanthesis guinensis (T_4) respectively. The best four biomass yielders were T_1 (26.33), T_{13} (20.5), T_{16} (15.80) and T_{17} (13.1). Based on their biomass yields, these four plants were recommended for use as livestock feed and as green manure in the farming systems of Borno State.

Key Words Agricultural biodiversity, Carbon sequestration, Forage legumes, Fresh biomass, Green manure,

INTRODUCTION

Agricultural productivity in the semi-arid environment (SAE) of Nigeria is the lowest in the world and is manifested in both animal and crop production sectors. Yields of most staple food crops were less than one ton/hectare, far below their potential yields of 2 - 4 tons/ha (FMARD, 2005; Yakubu *et al*, 2010). Likewise African livestock productivity put at meat (kg) 79 and 6.5 for cattle and sheep/goat respectively in the developed countries and 14 and 3.7 for Africa. Milk productivity was also the lowest at 360 kg/cow/lactation in Africa compared to 3,130 in the developed countries (ILCA, 1989). Further, in Nigeria average milk yield in the traditional low-input systems is 6 litres/cow/day compared to average yield of purebred Friesian cow in a commercial system is 30 litres/cow/day (FMARD, 2011). The low agricultural productivity prevailing in the SAE can be attributed to climatic, edaphic and anthropogenic factors. And it is agriculturally worthy to note that the drier climate in this agro-ecological zone has reduced agricultural biodiversity. Agricultural biodiversity refer to the variety and variability of animals, plants and microorganisms on earth that are important to food and agriculture (FAO, 2019). This phenomenon has definitely reduced both the provision of vegetative cover for the land and fodder for livestock feed.

Therefore, considering the scarcity of mineral fertilizers which are necessary to build up soil productivity, coupled with the acute shortage of forage for grazing livestock in the zone, there is need to explore the immense benefits offered by the use of "high biomass yielding and nutrient-fixing forage legumes (Skerman *et al.*,1988), which abound in northern Nigeria. Tropical forage legumes consist of a variety of herbaceous and woody plants selected from undomesticated and cultivated legume species (CIAT, 2019). Researchers at the International Centre for Agriculture in the Tropics-CIAT (2019) reported that forage species had multiple uses in the low input farming systems of the tropics. These uses include:- restoration of soil fertility of degraded agricultural land; provision of high quality livestock feed, and high potential

for carbon sequestration – second only to forests. Carbon sequestration is the process of capture and storage of carbon dioxide (CO2) to mitigate dangerous climate change (Agroforestry, 2015). The use of these species in the SAE will raise the level of agricultural biodiversity. Biomass is the sum total of the plant components above and below the soil line and is an important concept which directly affects soil productivity (Kusvuran *et al.,* 2015). Rapid biomass growth from forage species might probably be a source of green manure and a vegetative cover for agricultural land against soil erosion. And provide high quality feed to improve ruminant livestock production. Green manure is a plant purposely planted to be incorporated into the soil while still green as a source of organic matter (Bashir, 2019).
The objectives of the present study were to evaluate 8 leguminous forage species for their fresh biomass yields and their NPK contents, and to identify the best four biomass yielders for use as green manure in the farming systems of Borno State.

MATERIALS AND METHODS

Seeds of the Forage Legume Species. Seeds of best-bet green manure species (Mureithi, 2016) were collected from the National Animal Production Research Institute –NAPRI Shika, Ahmadu Bello University Zaria. There was *Mucuna pruriens* black (T_1). Similar best-bet leguminous plant species were collected from the Federal University of Agriculture Makurdi, Benue State. They were *Stylosanthesis guinensis* (T_4), *Cajanus cajan* ICPL 332 (T_6), *Centrosema pubescens* (T_{10}) and *Mucuna pruriens white* Benue (T_{13}). Others collected from some fields in Local Government Areas surrounding Maiduguri (i.e. Jere and Konduga) and the Shores of Lake Chad were the undomesticated species of the well-known green manure species of *Sesbania. They were Sesbania rostrata* kirenowa *(T_{14}), Sesbania rostrata* Jere *(T_{16}) and Sesbania rostrata* Loskuri *(T_{17}). Seeds of Pearl Millet variety 9702 were obtained from Lake Chad Research Institute, Maiduguri, as the test crop.*

Experiment: A pot experiment was conducted in 2013 at the Screen house, Faculty of Agriculture, University of Maiduguri. The treatments consisted of 8 species of the forage plants. The treatments were replicated three times and arranged in a completely randomized design. Topsoil (0-20 cm) was collected from a fallow land in the University of Maiduguri Farm, air-dried and sieved through a 2-mm screen. 27 plastic buckets were perforated at the bottom with five holes for easy drainage. Three kilograms of the soil were placed in each plastic pot. Seeds that were known to exhibit dormancy, especially *S. rostrata* were soaked in boiled water for one minute and air-dried 24 hours before sowing. Four seeds were sown per pot, and seedlings were thinned down to two per pot a week after emergence. Appearances of plants at six weeks old are shown in annexes Plates 1 –3. At six weeks after sowing, the plants were harvested by cutting the shoots at soil surface level and the roots were removed separately and washed with distilled water and fresh weights measured. The plant materials were then oven-dried at 65^0C for 48 hours and kept for laboratory analysis.

Plant analysis for N, P and K contents of Forage plants

The N, P and K contents of the plant materials were determined using the single acid digestion method as described by Marr and Cresser (1983).

^{N}– the determination of nitrogen was by regular macro-kjeldahl method (%) and then titrated with 0.01N HCL acid.

^{P} – colorimetric determination of phosphorus in plant was done using vanado-molybdate(yellow) method.

^{K}– determination of potassium was done by flame photometric method.

RESULTS AND DISCUSSION

The result for fresh biomass production by the forage legume plants was presented in Table 1. *Mucuna pruriens black* and *Mucuna pruriens* Benue produced the highest biomass weights (26.33 and 20.5 g/pot respectively). Followed by 15.8 and 13.1 g/pot for Sesbania rostrata Jere and Sesbania rostrata Loskuri respectively. The lowest biomass weights of 3.7, 5.0, 5.7 and 6.53 were yielded by Stylosanthesis guinensis benue, Cajanus cajan ICPL 332, Sesbania rostrata kirenowa and Centrosema pubescens benue respectively. Kusvuran et al. (2015) defined biomass as the sum total of the plant components above and below the soil line and is an important concept, which directly affects soil productivity.

Table 1. Fresh Biomass Yield and NPK Contents of 6 weeks old Leguminous Forage Plants in pot experiment, 2013.

Plant	Biomass yield g/pot	Macronutrients content (%) in plants			
		% N	% P	% K	Combined NPK(%)
Mucuna pruriens black(T_1)	$26,33^{a}$	3.85	0.07	3.08	7.0
Stylosanthesis guinensis Benue(T_4)	3.70^{f}	4.57	0.09	3.08	7.74
Cajanus cajan, red ICPL 332(T_6)	4.67^{ef}	4.48	0.09	3.69	8.26
Centrosema pubescens, Benue(T_{10})	6.53^{ef}	3.16	0.09	3.77	7.02
Mucuna pruriens, Benue(T_{13})	20.47^{b}	3.81	0.09	3.22	7.12
Sesbania rostrata, Kirenowa(T_{14})	5.70^{ed}	3.50	0.09	4.56	8.15
Sesbania rostrata, Jere(T_{16})	15.80^{c}	4.37	0.09	3.74	8.20
Sesbania rostrata, Loskuri(T_{17})	13.07^{cd}	3.22	0.09	3.36	6.67
Pearl Millet var. 9702(T_{19})	10.0	1.75	0.10	4.48	6.33
S. E.	1.692	0.551	0.013	0.564	-

The legume species after 6 weeks of growth produced satisfactory and variable biomass weights. Similar result trends were observed by FAO (2011) where these type of plants produced variable fresh biomass. Mullen (--) reported result where Mucuna and Lablab produced higher biomass weights than Soybean and Cowpea forages. The average biomass weight for all the plants in the experiment was a high 12 g/pot. As depicted in Fig 1, four of the plants in the experiment (T_1, T_{13}, T_{16} and T_{17}) yielded above average biomass weights.

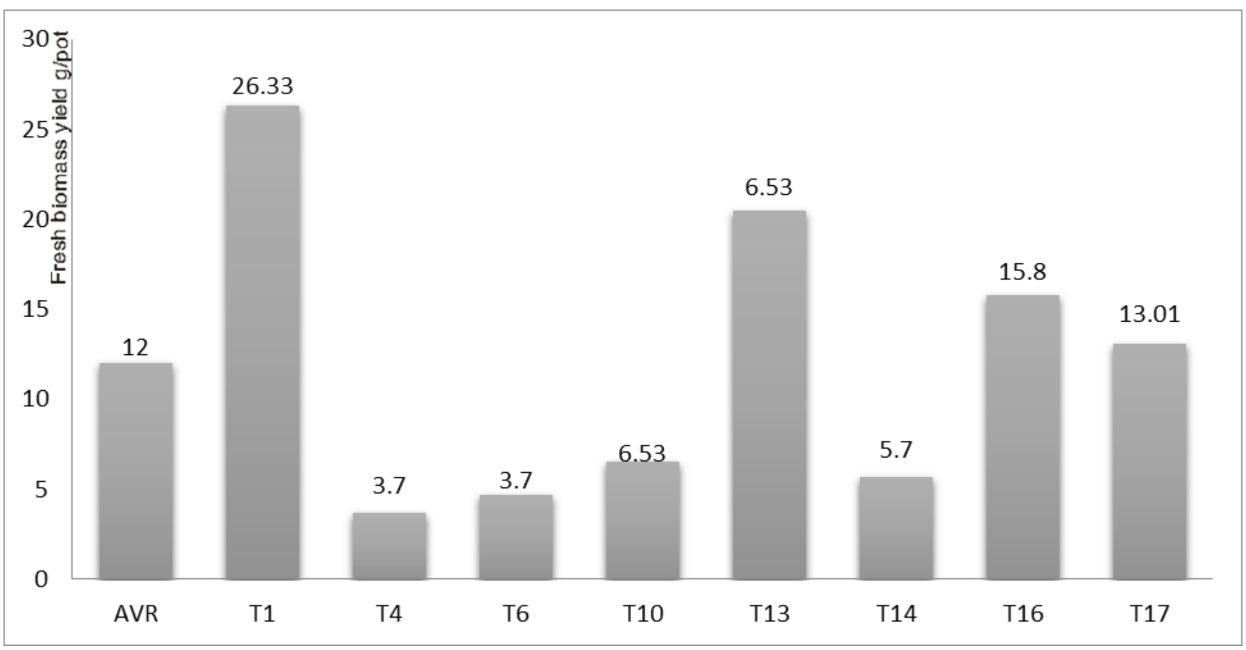

Fig. 1 Comparison of species' biomass weights (for key to T_1 to T_{17} See Table 1)

In a situation where human activities remove crop residues from the farm, there is high tendency of land degradation as the removal of vegetative cover exposes it to erosion. Scavenging livestock also overgraze the scanty vegetation cover on the land, causing further degradation. The fresh herbage from forage plants might probably be an environmentally friendly source of soil organic matter as well as a high quality animal feed. Murphy and Colucci (1999) reported that forage legumes offer several advantages to tropical farming systems. First, forage/green manure plants cover reduces soil erosion and improve soil organic matter content. Second, N fixing tropical forage legumes are rich in protein, which is the most limiting nutrients in tropical animal diets. Sullivan (2003) also concurred that fresh biomass from forages is the source of organic matter and animal feed. The contribution of organic matter to the soil from a green manure is comparable to the addition of 20 to 29 tons/hectare of farmyard manure (Sullivan, 2003). In animal husbandry; especially dairy and milk production, fresh and sufficient herbage is an indispensable feeding resource. Many of the conventional feeds in the tropics for ruminants are poor quality roughages typified by low protein and high fibre; leading to poor reproductive performance. Including herbaceous legumes in these feeding regimes helps rectify the problem associated with low protein and high fibre diets (Murphy and Colucci, 1999). Several studies reported by Murphy and Colucci (1999) indicated that forage legumes supplement to poor regular ruminant diets resulted in high weight gains and high level of milk production in cattle and sheep. Capstaff and Miller (2018) emphasized that the most important criteria or trait to assess the performance of any forage crop is rapid biomass production, which depends on the species grown. The ranking of the species performance in this parameter was as follows: Mucuna pruriens black>Mucuna pruriens benue>Sesbania rostrata Jere>Sesbania rostrata Loskuri>Centrosema pubescens benue>Sesbania rosrata kirenowa>Cajanus cajan ICPL 332>Stylosanthesis guianensis benue.

The result for macronutrients content of the forage plants were also presented in table 1. It showed that Cajanus cajan red accumulated the highest NPK content (8.26%), and the result was at par with that of Sesbania rostrata Jere(8.20%), Sesbania rostrata kirenowa (8.15 %) and Stylosanthesis guinensis benue(7.74 %). The result also showed that Mucuna pruriens benue, Centrosema pubescens benue, Mucuna pruriens black and Sesbania rostrata Loskuri contained comparatively lower but substantial % NPK of 7.12, 7.02, 7.0 and 6.67 respectively. Adesoji et al. (2014) reported lower result (4.39 – 5.31 % NPK) in green manure plants in Samaru Zaria than the present study, with Mucuna pruriens containing the lowest % NPK. The average NPK percent for the plants in the experiment was (7.5%), while average NPK analysis of farmyard manure (TNAU, 2016) was a meagre 1.15 % (0.6% N, 0.09% P and 0.46% K).

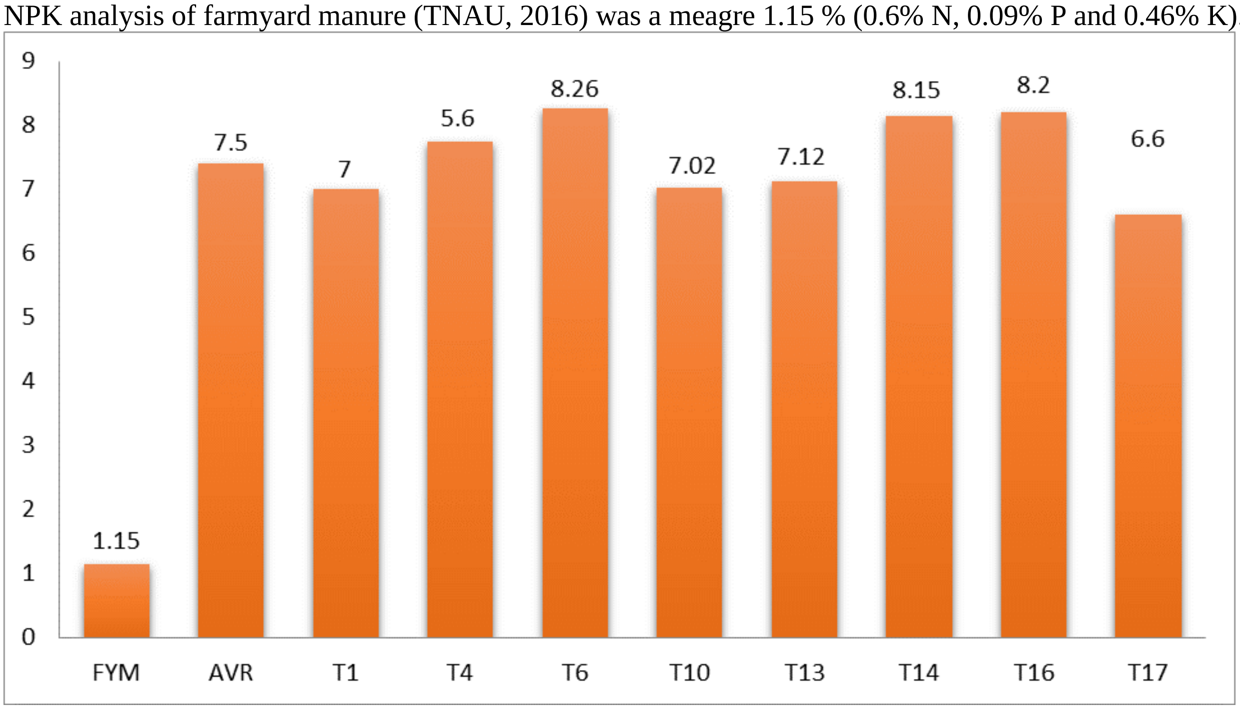

Fig. 2 Comparison of species (%) NPK with FYM (key to T_1 to T_{17} See Table 2)

Depicted in Fig. 2, four of the forage plants had above average NPK contents. It might be deduced from fig. 2 the average NPK content of legume plants in the experiment (7.5 %) was 552 % higher than the NPK analysis of Farmyard Manure- FYM (1.15 %). These plants might probably enrich the soil when used as green manure. Sullivan (2003) reported that N, P, K, Ca, Mg, S and other essential nutrients are accumulated by forage legumes when used as green manure during a growing season. These forage legumes, with the high nutrients concentration in their tissue will probably also provide high quality livestock feed with consequent improvement in dairy cattle and milk production. CIAT (2019) reported that the diverse tropical forage grasses and legumes, by providing a valuable source of livestock feed, can help farmers improve meat and milk production and raise incomes. Recent study by CIAT (2019) showed that adoption of forage legume feeding by farmers raised milk yield by 40% in Africa and reduced the time it takes cattle to mature from 4 years to 20 months in the Brazilian livestock sector.

CONCLUSION

In the experiment, the forage legume plants richest in NPK content in their tissue were Cajanus cajan ICPL332 (8.26 %), Sesbania rostrata Jere (8.20 %), Sesbania rostrata kirenowa (8.15 %), Stylosanthesis guinensis Benue (7.74 %) and Mucuna pruriens benue (7.12 %). While the best biomass yields (the most important criterion in green manure/forage legume selection) were recorded in *Mucuna pruriens* black, *Mucuna pruriens* benue, *Sesbania rosrata* Jere and *Sesbania rosrata* Loskuri. Recommendation these four best biomass yielders were recommended for adoption into the farming systems of Borno State. They can provide essential nutrients to livestock and contribute in enriching the soil if used as green manure.

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