ORIGINAL ARTICLES

Evaluation of Yield and nutritive value of *Alternanthera brasiliana* at various stages of growth as a potential fodder for ruminants in the tropics

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ABSTRACT

This study evaluated the potential yield and nutritive value of *Alternenthera brasiliana* (*A.brasiliana*) at different stages of growth as fodder for ruminants in the tropics. *A.brasiliana* was established in a school plot in a completely randomized block design with three replications and were harvested at 4, 8 and 12 weeks of growth. Results revealed that dry matter (DM) yield increased significantly ($p < 0.05$) with maturity, ranging from 0.47 to 2.52 t/ha for 4 - 12 weeks respectively. The crude protein (CP) yield increased significantly from 0.03 -0.16 t/ha in 4 – 12 week-old *A.brasiliana* respectively. Result of nutrient composition revealed that DM increased significantly with age, ranging between 23.91 and 20.17 % in 12 week old stem and leaf plus stem respectively. The CP content decreased significantly from 4-12 week-old *A.brasiliana.* Highest CP (22.83 %) was obtained in 4 week-old leaf, while the lowest (8.83 %) was obtained in 12 week-old stem. The neutral detergent fibre increased significantly with maturity, recording the highest (66.81 %) in 12 week old stem and lowest (38.24 %) in 4 week old leaf. Macro and micro minerals contents differed significantly ($p<0.05$). The mineral concentration of all parts decreased with maturity. Leaf contained higher concentrations of macro and micro elements than other parts except for potassium that is highest in the stem. Anti-nutrients content was not significant, although the values obtained here are safe for animal consumption It can be concluded that *Alternenthera brasiliana* has potential as forage in animal nutrition in this region, as it contained adequate nutrients to meet the requirements of ruminants in the tropics. This research will go ahead to ensile *A.brasiliana* and feed to ruminant animals.

KEY WORDS: *Alternenthera brasiliana,* anti-nutrient and nutrient content, potential yield, ruminants, stages of growth

INTRODUCTION

Nutritional inadequacy limits the performance of ruminant animal during the dry season when the natural pasture is scarce and is deficient in nutrients and minerals (Tolera, 2007). Tree and Shrub fodder are important in providing nutrients to grazing ruminants in the tropics, where inadequate feeds are major constraints to livestock production (Aganga and Tshwenyane, 2003). Tree and shrub fodder, maintain high protein and mineral content during growth than grasses which decline rapidly with progress to maturity (Shelton, 2004). Intensification of livestock particularly ruminant production in the tropical region should not rely solely on intensive use of grains. Strategies for ruminant development should be based on the optimal utilization of local feed resources underutilized as fodder such as *Alternanthera brasiliana* to reduce feed cost as it makes up about 65% of the total production cost (Azizan and Eusof, 1996). Research results have demonstrated that it is possible to improve current ruminant production with the appropriate use of tropical feed resources such as legumes and tree fodder. Protein fodder such as *Gliricidia sepium, Calliandra calothysus* and *Luceana leucocephala* have received much attention in the tropics and in most cases, the result have been encouraging (Stewart, 1998).

Alternanthera brasiliana (L.) O. Kuntze (AB) is an important -perennial forage herb, well adapted to varying weather conditions and available throughout the year. It is native to tropical and sub-tropical regions. The common name for the species is 'JOY WEED', while the local name is 'SAJEJE'. Saawan *et al.,* (2011) reported that the species (leaf and stem) contain crude protein of 21.04 %. The nutrient content in immature *Alternanthera brasiliana* was found to be comparable to alfafa hay (Swingle *et al*., 1978) and its production was relatively high (Najid and Ismawaty, 2001). *Alternanthera brasiliana* could be grown and harvested four times in a year and with a potential annual production of about 41.0 tons DM/ha (Najid and Ismawaty, 2001). Based on the optimum forage

quality and quantity *Alternanthera brasiliana* was best harvested between 10 and 12 weeks after planting, when CP is approximately 21% (Phillip *et al*., 1999). However, the information of potential yield and chemical composition of *Alternanthera brasiliana* as fodder for ruminants in the tropics is presently insufficient.

Therefore this study was conducted to evaluate the yield and nutritive value of *Alternanthera brasiliana* at different stages of growth as feed supplement for ruminants in the tropics.

Material and methods

Cultivation of *Alternanthera brasiliana*

Alternanthera brasiliana Linn was planted in the Teaching and Research Farm of Tai Solarin University of Education, Ijagun, Ijebu-Ode. The location is 7°21′ N and 3° 45′ S at an altitude of between 200m and 300m above sea level. The mean temperature is 25-29 °C with an average rainfall of about 1250mm. The plant was established in plots (10 x 12 m) with seed and row spacing of 30 and 50 cm respectively. The soil was loamy fine sand and its pH was 6. *A. brasiliana* was propagated by broadcasting its seeds on a plot size of 2 by 3 m for each treatment resulting to a grass plot of size of 10 x 12 m, with a walk way of 1 m apart. Experimental plots were arranged in a randomized block design with three replicates. All plots were treated with a post emergence application of, NPK 8:8:8 fertilizer at 300kg/ha. Manual eradication of weed in experimental plots was carried out weekly. *Alternanthera brasiliana* was sampled approximately 5 cm above ground level using 1x1 m quadrant (three replicates for each sampling) on 4, 8 and 12 week old plant. Plants within the quadrant were immediately weighed to determine fresh weight. Five plants were selected randomly from each quadrant and measured for plant heights, number of leaves and later separated the leaves and stems to determine the leaf to stem ratio.

Determination of yield of dry matter

Yield of DM per unit area of leaf plus stem, leaf and stem fractions and CP yield per unit area of leaf plus stem were estimated from fresh weight, DM and CP contents of each fraction.

Chemical analysis

Proximate analysis

Leaf plus stem, leaf and stem samples from each quadrant were chopped and dried at 60 ^{0}C to constant weight to determine dry matter (DM). Dried samples were ground through a 1-mm mesh and analyzed for the contents of Crude Protein (CP), Ether Extract (EE) ash (AOAC, 2012). Neutral detergent fibre (NDF), Acid detergent fibre (ADF) (Van Soest, 1994).

Analysis of minerals

A total of nine minerals were analyzed (Ca, Na, K, Fe, Cu, Mn, Zn, Mg and Pb) using the standard mineral method of analysis according to AOAC (2007).

Quantitative determination of tannin, saponin, oxalate and phytate

Tannin contents were determined as described by Bohm and Kocipai-Abyazan (1994). The method of Peng and Kobayasli (1995) was used for saponin analysis. While Oxalate and Phytate contents were determined as described by Oke (1969) Maga (1983) respectively.

Statistical analysis

Data generated were analyzed in a Completely Randomized Design using the general linear model procedure (SAS 2012) according to the following statistical model: $Y_{ij} = \mu + A_{i} + e_{ij}$, where A is effect of age of *Alternanthera brasiliana*. The differences among means were separated using Duncan's New Multiple Range Test (Steel and Torries, 1980)

Results and discussion

Yield characteristics

Table 1 presents the yield characteristics of 4, 8 and 12 week old Alternanthera brasiliana (*A.brasiliana)*. The fresh and dry matter yield of *A.brasiliana* increased significantly ($p<0.05$) with increasing age of cutting. This result is in agreement with the value reported for kenaf plant (Chantiratikul et al., 2009). It ranged from 0.77 - 4.98 and 0.47 - 2.52 t/ha in fresh and dry matter respectively. Similar trend was observed for leaf and stem dry matter. It ranged from 0.42 - 1.11 and 0.30 - 2.03 t/ha respectively. Although the CP content of each plant part decreased with increasing maturity, the CP yield of *A.brasiliana* increased ($P<0.05$) significantly. This could be attributed to the progressive increased yield of the plant. However the CP yield (0.03 - 0.16 t/ha for 4 and 12 week old plant) of *A.brasiliana* in this study is similar to the report of Chantiratikul et al. (2009), but significantly lower than that of other researchers (Webber, 1993 and Chantiratikul et al., 2006). The leaf-stem ratio decreased significantly ($p<0.05$) with increasing maturity of *A.brasiliana*. Normally, as *A.brasiliana* advance in maturity, the lower leaves senesced and this resulted in decreasing proportion of leaves with increasing proportion of stem (Webber, 1993). Plant height and number of leaves also follow same trend. This result is consistent with the report of Chantiratikul et al. (2009). Plant height and number of leaves ranged from 31.97 - 122.27 cm and 15 - 53 respectively. The 12 week old *A.brasiliana* is leafier than 4 and 8 week old plant. Generally, the rate of plant growth is mainly dependent on plant variety,

and other agronomic factors such as season of grown, quality of soil, fertilizer, temperature and rainfall (Rowell and Han, 1999).

Table 1: Yeild Production characteristics of different parts of *A. brasiliana harvested at different time*

	Alternanthera brasilianan (week after planting)			
Parameters	4	8	12	SEM
Fresh yield (t/ha)	0.77^{c}	2.72^{b}	4.98^{a}	0.34
DM yield (t/ha)	0.47^{a}	0.91^{b}	2.52^{a}	0.17
Leaf DM yield (t/ha)	0.42	0.57	1.11	0.17
Stem DM yield (t/ha)	0.30^{c}	0.81^{b}	2.03^{a}	0.01
Protein DM yield (t/ha)	0.03^{c}	0.09^{b}	0.16^{a}	0.0001
Plant height (cm)	31.97^{c}	65.42^{b}	122.27^{a}	0.06
Number of leaves	15.00^{c}	24.00^{b}	53.00^{a}	1.0
Leaf-stem ratio	2.21^{a}	1.31^{b}	0.81^{c}	0.01

^{a,b,c} =means on the same row with different super script differed significantly ($p<0.05$)

Chemical composition

The chemical composition of the morphological parts (leaf plus stem; leaf and stem) of *A.brasiliana* as affected by stages of growth is shown in Table 2. The crude protein (CP) content of the morphological parts decreased significantly ($p<0.05$) with increasing age of cutting, the highest CP content was obtained in the leaf (21.53 - 25.53% for 12 and 4 week old plant respectively) while the lowest was obtained in the stem (8.83 - 11.35% for 12 and 4 week old plant respectively). This result is in agreement with results found in previous studies for *A.brasiliana* (Mako *et al*., 2015). This result is also within the CP range (6.4 to 33.3% reported for leaves of shrub species (Kokten *et al*., 2012), however, this result is higher than the CP content (13.93 - 19.37% for 12 and 6 week old) reported for Kenaf plant (Chantiratikul *et al*., 2009). The reduced CP content of the stem as the plant matures was mainly due to rapid accumulation of fibrous content (Wong and Vijasegaran, 2001). Maturity has large influence on the CP content of forage and its reduction with advancing maturity may be attributed to two factors namely: (i) fodder mature increases proportionally in the stem (ii) CP content fall in all fractions with advancing maturity (Minson, 1990).

The ash content of all plant parts decreased with increasing maturity, this is in agreement with reports of Mupangwa *et al*. (2006). The highest range (10.31 - 12.88%) was observed in the leaf for 12 and 4 week old plant respectively, while the lowest range (4.40 - 7.27%) was recorded for 12 and 4 week old stem respectively. These ranges are in agreement with the values reported elsewhere for tropical legumes (Mupangwa *et al*., 2006).

The NDF and ADF contents of morphological parts increased with advancing maturity. The obtained fibrous content in this study were higher than those in the foregoing studies (Chantiratikul *et al*., 2009 and Kokten *et al*., 2012). In those studies, NDF was reported to be between 41.99 and 48.74 % while ADF ranged between 27.20 and 30.57 % for 4 and 12 weeks old plant respectively. On the average over the stages of growth, the highest NDF and ADF (66.81 and 49.94 %) were obtained in the stem at 12 weeks old, while the lowest (38.24 and 20.36 %) was recorded for leaf at 4 weeks old.

The macro and micro mineral contents of different morphological fractions of *A.brasiliana*, as well as whole plant harvested at three stages of growth are presented in table 3. This result revealed that, the effect of maturity influenced the macro and micro mineral content of morphological fractions and whole plant significantly ($p<0.05$). The performance and health status of grazing animals is dependent on the adequacy and availability of essential minerals from forages. It was observed that the leaf contained higher concentrations of macro-elements than the stem and leaf plus stem, except for potassium, this report is in agreement with the findings of Halgerson *et al*. (2004) and Markovic *et al*. (2009) who reported that concentrations of most minerals are greater in the leaves than in stems, but who also found potassium concentrations to be greater in stems than in leaves. It was also observed that, the contents of the minerals decreased with increasing maturity, with the highest value occurring in the early stage of cutting (Markovic *et al*., 2009). Generally, there is rapid uptake of mineral during early growth and gradual dilution as the plant matures. However, calcium on the contrary increased with maturity. This could be attributed to the fact that calcium is needed for proper growth and functioning of root tips and meristems, thus increasing mechanical strength of the plant and the amount of cellular material which is composed principally of this element (Markovic *et al*., 2009). The value of calcium was highest (0.279%) in the 12 week old leaf, while it was lowest (0.208%) in the 4 week old stem.

Table 2: Chemical composition of different parts of A.*brasiliana harvested on different dates*

Parameters	*Alternanthera brasiliana* (week after planting)			
	4	8	12	SEM
Leaf plus stem				
Dry matter (%)	21.67[c]	22.03[b]	22.40[a]	0.02
Crude protein(%)	22.83[a]	20.28[b]	19.34[c]	0.05
Ether extract(%)	5.51[a]	5.20[b]	4.78[c]	0.01
Total Ash(%)	12.39[a]	11.77[b]	9.84[c]	0.01
Neutral detergent fibre	38.24[c]	39.13[b]	42.07[a]	0.01
Acid detergent fibre	20.36[c]	23.36[b]	25.71[a]	0.01
Leaf				
Dry matter	20.17[c]	20.48[b]	20.88[a]	0.02
Crude protein	25.53[a]	22.43[b]	21.53[c]	0.03
Ether extract	5.76[a]	5.40[b]	4.94[c]	0.01
Ash	12.88[a]	10.95[b]	10.31[c]	0.01
Neutral detergent fibre	55.73[c]	60.27[b]	63.70[a]	0.02
Acid detergent fibre	40.17[c]	42.95[b]	47.91[a]	0.01
Stem				
Dry matter	23.27[c]	23.64[b]	23.91[a]	0.02
Crude protein	11.35[a]	9.43[b]	8.83[c]	0.06
Ether extract	2.90[a]	2.29[b]	2.14[c]	0.01
Ash	7.27[a]	4.61[b]	4.40[c]	0.01
Neutral detergent fibre	60.77[c]	62.09[b]	66.81[a]	0.01
Acid detergent fibre	43.04[c]	46.71[b]	49.94[a]	0.02

[a, b,c] =means on the same row with different super script differed significantly ($p<0.05$)

The present investigation has revealed that concentration of microelements changed in both morphological fractions, as well as in whole plant with plant maturation. The considerable decline in the iron concentration of *A.brasiliana* stem with increasing forage maturity and the consistently high iron concentration of leaf are in agreement with earlier study (Kidambi, 1990). The value of iron was lowest in the stem, it ranged between 159.65 and 174.85 ppm in 12 and 4 week old *A.brasiliana* stem respectively, while the value was highest in the leaf ranging between 234.50 and 268.45 ppm in 12 and 4 week old *A.brasiliana* leaf respectively. At each stage of cutting, the leaf contained higher concentration of zinc which ranged between 39.40 and 53.65% in 12 and 4 week old AB leaf respectively. The major minerals needed by ruminants include phosphorus, potassium, magnesium, sodium and calcium, small amount of these minerals are needed to ensure that the animals remain strong, healthy and produce optimally. According to NRC (2000), growing and finishing cattle will require 0.31% calcium, 0.10% magnesium, 0.21 phosphorus, 0.60% potassium, 0.06 – 0.08 sodium, the mineral content obtained here are within the range reported by NRC (2000) for growing and finishing stage. A dry or gestating cow will require 0.18% calcium, 0.12% magnesium, 0.16% phosphorus, 0.60% potassium, and 0.06-0.08% sodium. The maximum tolerable level for magnesium, potassium and sulphur are 0.40, 3.0 and 0.40 % respectively (NRC, 2000). The micro mineral requirement for lactating Cow are: copper- 10.00, iodine-0.05, iron- 50.0, manganese 20.0 zinc-30.0 ppm (NRC, 2000). The values obtained here for micro minerals meet the requirements of lactating cattle. It was observed that values obtained for all macro and micro minerals are within the recommended range for proper functioning of organs of ruminants in the tropics (NRC, 2002).

The result of anti-nutritional contents in the leaf, stem and leaf plus stem of AB at different stages of growth is shown in Table 4. No significant variations were observed for all the anti-nutritional factors investigated. Tannin varied from 0.062 % in 12 week old leaf plus stem to 0.083 % in 4 week old leaf plus stem; 0.054 % in 12 week old leaf and 0.070 % in 4 week old leaf; 0.022 % in 12 week old stem and 0.043 % in 4 week old stem. A range of 0.432 % to 0.458 %; 0.411 % to 0.443 % and 0.475% to 0.570% was obtained for saponin content in 12 and 4 week old leaf pus stem, leaf and stem of *A.brasiliana* respectively. It was observed that the leaf plus stem recorded the highest value of all anti nutrients tested both in 4 and 12 week old plant except for saponin that was highest in the stem. Same trend was observed for oxalate and phytate.

Table 3: Mineral content of different parts of A.*brasiliana harvested on different dates*

	Alternanthera brasiliana (weeks after planting)			
	4	8	12	SEM
Minerals				
Leaf plus stem				
Calcium (%)	0.249[b]	0.251[b]	0.265[a]	0.0001
Phosphorus (%)	0.400[a]	0.380[b]	0.380[b]	0.001
Potassium (%)	0.840[a]	0.830[b]	0.790[c]	0.001
Sodium (%)	0.174[a]	0.165[b]	0.154[c]	0.001
Magnesium (%)	0.371[a]	0.351[b]	0.340[c]	0.002
Iron (ppm)	252.45[a]	241.35[b]	213.55[c]	0.11
Manganese (ppm)	17.00[a]	15.20[b]	15.00[b]	0.15
Zinc (ppm)	51.50[a]	42.45[b]	37.65[c]	0.10
Copper (ppm)	8.00[a]	6.70[b]	6.70[b]	0.15
Leaf				
Calcium (%)	0.270[b]	0.271[b]	0.279[a]	0.001
Phosphorus (%)	0.430[a]	0.410[b]	0.390[c]	0.001
Potassium (%)	0.581[a]	0.470[b]	0.454[c]	0.002
Sodium (%)	0.184[a]	0.172[b]	0.172[b]	0.0001
Magnesium (%)	0.380[a]	0.380[a]	0.360[b]	0.001
Iron (ppm)	268.45[a]	255.75[b]	234.50[c]	0.12
Manganese (ppm)	18.05[a]	16.20	16.10[b]	0.18
Zinc (ppm)	53.65[a]	39.40[b]	39.40[b]	0.08
Copper (ppm)	9.050[a]	7.55[b]	7.55[b]	0.13
Stem				
Calcium (%)	0.208[c]	0.219[b]	0.238[a]	0.002
Phosphorus (%)	0.291[a]	0.267[b]	0.255[c]	0.001
Potassium (%)	0.980[a]	0.850[b]	0.800[c]	0.001
Sodium (%)	0.161[a]	0.136[b]	0.128[c]	0.001
Magnesium (%)	0.285[a]	0.240[b]	0.226[c]	0.001
Iron (ppm)	174.85[a]	161.35[b]	159.65[c]	0.134
Manganese (ppm)	12.55[a]	9.55[b]	8.85[c]	0.134
Zinc (ppm)	32.95[a]	23.60[b]	22.55[c]	0.126
Copper (ppm)	5.45[a]	3.70[b]	3.40[c]	0.084

[a,b,c] =means on the same row with different super script differed significantly (p<0.0

Table 4: Anti-nutrient content of leaf plus stem, leaf and stem of 4.8 and 12 week old *A.brasiliana*

	Alternanthera brasiliana (week-old)			
Anti-nutrients	4	8	12	SEM
Leaf plus stem				
Tannin	0.083	0.075	0.062	0.0001
Saponin	0.458	0.440	0.432	0.0001
Oxalate	0.181	0.162	0.160	0.0001
Phytate	0.310	0.294	0.287	
Leaf				
Tannin	0.070	0.060	0.054	0.0001
Saponin	0.443	0.423	0.411	0.0001
Oxalate	0.174	0.154	0.145	0.0001
Phytate	0.299	0.289	0.278	0.0001
Stem				
Tannin	0.043	0.034	0.022	0.0001
Saponin	0.570	0.494	0.475	0.0001
Oxalate	0.148	0.129	0.117	0.0001
Phytate	0.281	0.250	0.233	0.0001

The level of tannin in this study is lower than the range of 6 - 10% considered to depress feed intake and growth (Min *et al.,* 2003), but within the range of 0.41 and 0.81 mg/g DM reported by Njidda *et al*., (2008) for semi-arid browse plants. Diets containing 2 to 3% tannin for ruminants have been shown to have beneficial effects because they reduce the protein degradation in the rumen by forming a protein-tannin complex (Njidda *et al*., 2009) thereby increasing the amount of by-pass protein that will be available in the small intestine for the animals (Barry and McNabb, 1999). The presence of tannin in this plant is an added advantage. Forages containing saponin have been shown to be defaunating agents (Teferegene, 2000) and capable of reducing methane production which is energy loss to the animals and also contribute to the destruction of ozone layer (Johnson and Johnson, 1995). The level of saponin obtained in this study may not pose any problem to the animals. Oxalate and phytate content in this study are within tolerable limit. Oxalate and phytate hinders absorption of minerals especially calcium, phosphorus, magnesium, zinc, iron and molybdenum (Haenlein, 1987).

CONCLUSION

The result of the yield characteristics, chemical composition, anti- nutritional factors and mineral content of *A. brasiliana* harvested at different stages of growth strongly indicates that *Alternanthera brasiliana* has very bright future as source of cheap protein and mineral supplements for animals especially during the dry season in the tropics. The plant is rich in nutrients and thus extremely nutritious feed for animals

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