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Effects of stage of growth on dry matter yield and nutrients composition of stylo (*Stylosanthes guianensis* cv. Cook) in Vom, Plateau State, Nigeria

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Abstract
An experiment was conducted in Vom, Plateau State to evaluate the effects of stage of growth on dry matter yield and nutrients composition of Cook stylo (Stylosanthes guianensis cv. Cook) in 2015 and 2016 cropping season. Four stages of growth (9, 13, 17 and 21 weeks after sowing (WAS)) which served as the treatmenmts were arranged in a Randomized Complete Block Design replicated four times. The land was divided into sixteen (16) plots of 5m x 3m each. The spacing between each block was 1m and 0.5m along the rows and columns, respectively. Growth components and dry matter (DM) yield were measured at the various stages of growth. There was no significant (P<0.05) difference between 17 and 21 WAS (83.47 and 82.95, respectively) in plant height. Leaf to stem ratio significantly (P<0.01) decreased from 9 to 21 WAS with 9 WAS having the highest value (0.94). Highest (P<0.01) dry matter yield was recorded at 17 WAS (8.02 t/ha). Crude protein (CP), ether extract (EE) and nitrogen free extract (NFE) contents decreased (P<0.01) with increased age of the plant. Crude fibre (CF) on the other hand was significantly higher (P<0.01) at 21 WAS (36.86%) than at the early stages of growth. Cook stylo (Stylosanthes guianensis) sown in early June in Vom, Plateau State should be harvested at 17 WAS when the DM yield is optimum and crude protein content is sufficient to meet the requirement of reuminant animals.

Key words: Maturity, yield, Components, dry matter, weeks after sowing

Introduction

Stylosanthes guianensis cv. Cook is one of the forage legumes well suited to the sub-humid tropical zone with a marked dry season (Heuzé, *et al*., 2015). Bogdan (1977) and Mannetje and Lones (1992) pointed out that *S. guianensis* is a tropical herbaceous perennial legume, primarily used for pasture in humid tropical regions. Mannetje and Lones (1992) further stated that over sowing of *S. guianensis* improves the quality of tropical rangeland and it can also be used as a cover crop, green manure crop and as fallow crop. The crop has been reported to be palatable to livestock when mature and can be easily established on very low fertile soils. Thang *et al.* (2010) stated that *S. guianensis* is used as a supplementary feed during dry season to improve the nutritive value of low quality crop residues. Heuzé, *et al*. (2015) reported yield of 10 - 20 t DM ha^{-1} for *S. guainensis*. Magalhaes *et al*. (2003) found that the Organic Matter Digestibility (OMD) of *S. guianensis* was in the range of 51 - 67% by goats. Dry matter and crude protein digestibilities in West Africa Dwarf sheep were reported to be 71.82 and 71.80%, repectively (Ogunbode and Akinlade, 2012).

Different locations have been found to influence the yield and quality of forage crops but the stage of growth at which a forage crop is harvested for livestock feeding is also important when the overall forage yield and quality are considered. As forage crop matures, the dry matter content increases, but digestibility of NDF, starch, sugar and crude protein contents, are all reduced (Kilcer *et al.*, 2003). Therefore, there should be a growth/maturity stage to harvest in order to obtain optimum dry matter yield and forage quality in different environments. It has become important to evaluate forage yield and quality of Stylo (*S. guianensis cv.* cook) at different stages of growth to determine the optimum stage of growth for which the forage crop could be harvested for livestock feeding either as pasture, hay or silage. The study was therefore designed to examine the effect of stages of growth on dry matter yield and nutrients composition of *S. guianensis* in Vom, Plateau State, Nigeria.

Materials and Methods

Location of the study

The experiment was carried out at the Nigerian Institute for Trypanosomiasis Research (NITR), Vom,(Lat 9° 43' 60N, Long 8° 46' 60E and 1,223m above sea level), (Ovimaps, 2014), Jos, Nigeria. Weather conditions of the study area in 2015 and 2016 cropping seasons were obtained from the Potato Programme of the National Root Crops Research Institute (NRCRI), Vom Station, Jos as shown in Table 1. The area is characterized by two major seasons (rainy and dry seasons). The rainy season starts from late-May and ends in early-October each year, while the dry season starts from late-October and ends in early-May. Peak of the rain is normally observed in the month of August each year. The climate of the area is cool with tempearature ranging from 15 - 27°C during the rainy season and 7 - 18°C during the hamattam season, while temperature range of 18 - 32°C is normally observed during the late months of dry the season (March to early-May). However, the grasses found on these highlands are shorter and the trees are fewer than at lower level (Aregheore, 2009). Soil samples of the experimental site were randomly obtained at the depth of 0-15cm at different locations with an aid of a Soil auger and its physical and chemical properties determined. Soil in this area is generally sticky when wet, impervious

Table 1: Monthly Maximum Temperature, Relative Humidity and Precipitation Distribution for 2015, 2016 and Medium-term Means (2004-2014) for Vom[a], Jos

	Max. Temp(°C)			R.H (%)			Rainfall(mm)		
Months	2015	2016	2004-2014	2015	2016	2004-2014	2015	2016	2004-2014
January	29	30	29	60	31	27	0.0	7.7	8.5
February	32	31	30	54	53	24	10.1	2.3	1.5
March	32	34	32	59	60	28	28.0	19.2	18.2
April	32	32	30	29	61	54	10.0	83.3	81.9
May	30	29	28	68	70	65	216.5	138.2	145.2
June	29	28	27	70	73	81	15.1	172.7	191.9
July	27	29	25	79	80	88	225.2	383.8	207.0
August	26	27	25	81	84	87	301.3	401.1	290.3
September	27	25	26	69	76	79	208.5	181.4	205.2
October	29	25	27	58	65	58	59.9	170.1	182.3
November	30	27	29	36	39	33	0.0	0.0	0.0
December	27	30	28	48	40	30	0.0	2.9	3.2

Source: National Root Crop Research Institute, Vom [a](Lat. 9° 44' 60N, Long. 08° 47' 60E. Alt. 1223m).

Table 2: Soil Physical and Chemical Properties of the Study Area.

Properties:	Value
Particle size (%)	
Clay	27.0
Silt	20.0
Sand	53.0
pH	5.5
Class of soil-	sandy-clay loam
Chemical properties:	
Total N(%)	0.33
Organic carbon (%)	2.91
K(mg/litre)	247.20
P(mg/litre)	7.53
Exchangeable cations (mol/kg^{-l}):	
P(mg/litre)	
Ca^{++}	14.15
Mg^{++}	0.98
CAC	16.60

to water, has low fertility and quickly becomes hard when there is no rain for 2 - 3 days and cracks easily (Aregheore, 2009). The analyses carried out on the soil is shown in Table 2. The experimental area was used in the year 2014 cropping season for Cocoa yam production.

Land preparation and experimental design

The land was ploughed and harrowed twice using tractor mounted implements. The field was levelled and all debris were removed to provide a clean seedbed. The four treatments were the stages of growth (9. 13, 17 and 21 weeks after sowing) which were arranged in a Completely Ramdomised Block Design with four replicates. The plots within each block were 5 m x 3 m (15 m^2) each. The spacing between each block was 1m and 0.5m along the rows and columns, respectively.

Pasture Establishment.

The trial was conducted when the rains were well established in the first week of June, in the 2015 and 2016 rainy seasons. The seeds were planted at seed rate of 8.82 Kg ha^{-1} which was determenined using Pure Live Seed (PLS) index by Karki (2013) as follows;

PLS Index = (% Germination x % Purity) ÷ 10,000

Kg of Seed per hectare = Recommended Seeding Rate ÷ PLS Index

Where; Kg= kilogram

PLS= Pure live seed

The seeds were scarified by immersing in hot water at 84°C for 3 minute and planted at a row spacing of 30 cm and depth of 1 cm (Crowder and Chheda, 1982). The seeds were drilled along the rows. Prior to planting, Single Superphosphate (SSP) fertiliser (18% P_2O_5) was applied at a rate of 30 kg ha^{-1} in both cropping seasons (Amodu, 2004). The plots were manually weeded three times throughout the duration of the experiment using hoes.

Yield Measurements
Yield components

Five (5) plants in the middle of a row in each plot were tagged and used in determining the yield components (plant height, number of leaves per plant and number of branches per plant) at 5, 9, 13, 17 and 21 weeks after sowing (WAS). The height of the tagged plants were measured from the ground level to the flag leaf with the aid of a graduated metre rule. The number of leaves and branches of the tagged plants were counted for each forage legume. Five plants within a row in each plot were harvested to determine leaf-to- stem ratio at the various weeks after sowing by seperating the leaves of the harvested plants from the stem. Petiole was weighed as a component of the stem. The leaves and stem were weighed immediately in the field after seperation, oven-dried at a temperature of 65°C for 48 hours and weighed again. Thereafter, the leaf dry weight was divided by the stem dry weight to determine leaf-to-stem ratio.

Forage yield

Plants within 0.5 m^2 quadrant placed in the middle rows of the plots were cut at 5 cm above the ground level with a sickle to determine the forage yield at different cutting frequencies and stages of growth. Three cutting frequencies were employed. The first cut (primary growth) was carried out at 9WAS while the second (re-growth from the first cut) was carried out at 5 weeks after first cut and and the third cut (re-growth from second cut) was also carried out at 5 weeks after second cut. Forage yield was determined at the following stages of vegetative growth (9, 13, 17 and 21WAS) using 0.5 m^2 quadrant. The legumes were cut at 5 cm above the ground level. The cut forages were immediately weighed to determine fresh weight after which they were oven-dried at a temperature of 65°C for 48 hrs to determine their forage dry matter yields. Forage dry matter yields were calculated using the formula of Teagasc (2009).

Forage dry matter yield (kg DM ha^{-1}) = Fresh weight (kg) x Oven dried weight (DM%) x 40,000

There are 40,000 quadrant ($0.5m^{-2}$) per hectare

Chemical Analyses of Samples

Dried forage samples of the legumes were ground with a Thomas Willey Laboratory Mill-Model 4 to pass through 1-mm sieve. Proximate analysis was carried out using the method of AOAC (1990), while detergent fibre analysis was carried out according to the method described by Van Soest *et al.* (1991). Mineral composition (Ca, P, Mg, K and Na) of the samples were determined using the Atomic Absorption Spectrophotometer (AOAC, 1990)..

Statistical Analyses

All data generated were subjected to analysis of variance (ANOVA). The general linear model of SAS (2001) statistical software was used for the analyses and means were seperated using the Tukey test.

Statistical model

$Y_{ijkl} = \mu + A_i + B_j + A_k \times B_j + e_{iik}$

Where; μ= population mean

A_i = i^{th} effect of stages of growth

B_j = jth effect of year

$A_i \times B_j$ = Interaction of statges of growth and year

e_{ijk}= Random error

Results

Table 3 shows the yield components and dry matter yield of *S. guianensis* at different stages of growth. There was no significant (P<0.05) difference between 17 and 21 WAS in plant height. But the two stages of growth were significantly (P<0.01) different compared to the early stages of growth (9 and 13 WAS). Similarly, the difference between 17 and 21 WAS were not significant in number of leaves per plant, but, the two stages of growth were significantly (P<0.01) higher compared with the early stages of growth. Leaf to stem ratio was however, significantly (P<0.01) higher at 9 WAS (0.94) compared to the other stages of growth. The result showed that leaf to stem ratio decreased from 9 to 21WAS. Highest dry matter yield was recorded at 17 WAS (8.02 t/ha). The yield components were significantly (P<0.01) higher in 2015 cropping season compared to 2016. Consequently, the dry matter obtained was higher (P<0.01) in 2015 than 2016. The stage of growth and year interaction on yield components and dry matter was significant (P<0.01).

Table 3: Effect of Stages of Growth on Yield Components and Dry Matter Yield of *Stylosanthes guianensis* in Vom, Plateua State.

	Plant Height (cm)	Branches number/plt	Leaves number/plt	Leaf to stem ratio	Dry matter yield (t/ha)
Stages of growth (SG) –Weeks after sowing					
9	27.86^c	2.88^c	16.62^c	0.94^a	0.94^b
13	44.82^b	15.75^b	39.25^b	0.52^b	3.37^b
17	83.47^a	24.50^a	103.37^a	0.33^c	8.02^a
21	82.95^a	29.50^a	105.50^a	0.21^d	6.54^a
SEM	5.97	2.53	7.50	0.05	1.18
LOS	**	**	**	**	**
Year (Y)					
2015	73.61^a	24.43^a	85.56^a	0.64^a	7.87^a
2016	45.93^b	12.24^b	46.81^b	0.35^b	1.57^b
SEM	6.57	2.66	10.23	0,02	0.75
LOS	**	**	**	**	**
SG X Y	0.001	0.001	0.001	0.001	0.001

^{abcd} means with different superscript within columns deferred significantly (P<0.01) SEM = standard error of mean, LOS = level of significance, plt= plant height, SG X Y = stage of growth and year interaction.

The effect of stages of growth on proximate and detergent fibre composition is shown Table 4. Crude protein (CP), ether extract and ash contents were significantly (P<0.01) lowered with increased plant age. On the other hand, crude fibre, nitrogen free extract, neutral detergent fibre and acide detergent fibre were significantly (P<0.01) higher at later stages of growth.

The effect of stages of growth on mineral composition is presented in Table 5. Calcium content differ significantly (P<0.01) between the stages of growth. It was higher at 9 WAS (12 g/kg) compared to the value 9.80 g/kg recorded at 21 WAS. Phosphorus content showed higher (P<0.01) value at 9WAS (3.51 g/kg) compared to the latter stages of growth. Similarly, the results of Magnesium and Potassium contents were significantly (P<0.01) lower at 21 WAS with the values 17.03 and 0.28 g/kg compared to the early stages of growth.

Table4: Effect of Different Stages of Growth on Proximate and Detergent Fibre Composition *Stylosanathes guianensis* (average over 2015 and 2016).

	Stages of growth					
Parameters **(%)**	9 WAS	13 WAS	17 WAS	21 WAS	SEM	LOS
Crude protein	18.98[a]	17.68[b]	16.22[c]	14.37[d]	0.18	**
Crude fibre	29.42[d]	32.60[c]	33.59[b]	36.86[a]	0.13	**
Ether extract	2.76[a]	2.10[b]	1.44[c]	1.03[d]	0.04	**
Ash	9.80[a]	8.02[b]	7.70[c]	7.13[d]	0.06	**
Nitrogen free extract	33.55[d]	34.20[c]	35.68[b]	36.82[a]	0.19	**
Neutral detergent fibre	40.29[d]	43.41[c]	46.85[b]	49.44[a]	0.32	**
Acid detergent fibre	30.42[d]	33.95[c]	36.12[b]	39.42[a]	0.30	**

[abcd]Means with different superscripts within a row are significantly different, SEM= standard error of mean, WAS= Weeks after sowing, **highly significant (P<0.01)

Table 5: Effect of Different Gtages of growth on Mineral Composition of *Stylosanathes guianensis* (average over 2015 and 2016).

	Stages of growth					
Parameters ($g\ kg^{-1}$)	9 WAS	13 WAS	17 WAS	21 WAS	SEM	LOS
Calcium	12.16[a]	11.83[b]	10.15[c]	9.80[d]	0.03	**
Phosphorus	3.51[a]	3.17[b]	2.75[c]	2.39[d]	0.07	**
Magnesium	3.39[a]	3.07[b]	2.16[c]	1.54[d]	0.10	**
Potassium	19.54[a]	18.27[b]	17.78[c]	17.03[d]	0.04	**
Sodium	0.74[a]	0.53[b]	0.44[c]	0.28[d]	0.02	**

[abcd]Means with different superscripts within a row are significantly different, WAS= Weeks after sowing, SEM= standard error of mean, LOS= Level of significance at 1%.

Discussion

Yield Components and Dry Matter Yield

The plant height at 17 WAS (83.48 cm) was lower than 135cm reported by Kiyothong *et al.* (2005) in Indonesia. The height of the plant obtained in this study was similar to the result reported by Njarui and Wandera (2004) in Kenya. Leaf to stem ratio was lower than 1.5 obtained by Nworgu and Ajayi (2005) at Ibadan, Nigeria. The decrease in leaf to stem ratio from 5 - 21 WAS observed in this study agreed with the observations of Ball *et al.* (2001) and Ramírez *et al.* (2008) who reported that leaf to stem ratio decrease as plant matured. The DM yield at 17 WAS obtained in this study was lower than a range of 10 - 20 t DM ha^{-1} recorded by Cook *et al.* (2005), but higher than 7.73, 4.2, 5.27 and t DM ha^{-1} reported by Akinola (1981), Kiyothong *et al.* (2005) and Hare *et al*. (2007) in Nigeria, Australia, Indonesia, respectively. Higher values of yield components and dry matter yield obtained in the 2016 compared to 2015 cropping season could be attributed to a well distributed rainfall pattern in the month of June (172.7mm), which probably enhanced uniform field germination and plant establishment compared to 15.1mm in the same month in the 2015 cropping season as shown in Table 1. Low values of dry mater yield recorded in the 2016 cropping season may also be due infection probably caused by *Anthracnose* or leaf blight observed on the plant in that year.

Forage Quality

The CP, NDF and ADF contents obtained in this study were similar to the result reported by Valarini and Possenti (2006), while the ash (6.8%) and EE (4.7%) for this study than what they obtained. Ajayi and Babayemi (2008) at Ibadan, Nigeria reported similar CP and ash, higher NDF (50.66%), but lower ADF (28.52%), EE (8.88%) and NFE (25.54%) contents compared to the result obtained in this study. The decrease in CP, EE, ash and increase in CF, NDF and ADF from 9 to 21 WAS agrees with the observations of McDonald *et al*. (1998) and Marković *et al*. (2008) and that as plants growth advances, there is a greater accumulation of cellulose and lignin in the stem. This in turn leads to lowering of the CP content of the plant (Newman *et al*., 2006). The means for P (1.7 g kg^{-1}), K(13.7 g kg^{-1}) and Na (1.10 g kg^{-1}) reported by Adjolohoun *et al*. (2008) in Republic of Benin were lower than those obtained in this study. The values for Ca, P and Na in this study are similar to those reported by Nworgu and Ajayi (2005). However, the value for Mg (9.10 g kg^{-1}) observed by them was higher than the result obtained in this study. The decrease in P, Mg and K with advancing growth and maturity stage agreed the report of Kellems and Church (2002) and Schlegel *et al*. (2016), but decrease in Ca and Na was in contrast to their observations. McDonald *et al*. (1998) also reported decrease in mineral elements as plants matures. A decrease in Na content with advancing growth in other legumes such as *Lablab purpurens* has also been reported (Hassan *et al*., 2014). This is because, leaf to stem ratio is higher at early stage of growth of a forage crop than at later stages of growth. The changing proportion of leaf to stem ratio accounts for overall nutritive value within and between cultivars (Humphreys, 1999).

Conclusion and Recommendation

It is therefore, concluded that stage of growth has influence on *S. guianensis* DM yield and nutrient composition. Cook stylo (*Stylosanthes guainensis* cv. Cook) grown in early June in Vom, Jos Plateau should be harvested at 17 WAS when the DM yield is at optimun and crude protein content is sufficient to meet the requirements of ruminant animals.

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