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Growth indices, dry matter yield and nutritive value of *Centrosema pascuorum* at four different cutting regimes in humid tropics

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***Targeted audience**: Ruminant Nutritionist, Extension officers, Ruminant farmers*

Abstract

A study was conducted on growth indices, dry matter yield (DMY) and nutritive value of Centrosema pascuorum at four different cutting regimes of growth i.e. 8, 10, 12 and 14 weeks after sowing (WAS). Experimental design was a complete randomized design with three replicates on 4m by 12m bed. Results showed significant ($P<0.05$) increase in the number of leaves (16.70 – 55.67), leaf length (7.63 – 11.34 cm), leaf width (1.00 – 1.68cm) and plant height (49.34 – 108.40cm) from 8 to 14 WAS. Higher significant ($P<0.05$) DMY was recorded in 12 WAS (7.47t/ha) and 14 WAS (7.80t/ha). There was a significant ($P<0.05$) difference in crude protein, crude fibre, neutral detergent fibre, acid detergent fibre, non-fibre carbohydrate, ash, calcium and phosphorus. Significant ($P<0.05$) values were recorded for dry matter intake, dry matter digestibility and relative feed value across the cutting regimes. Significant difference ($P<0.05$) was also observed for the methane (CH_4) gas production (18.00 – 21.33 ml) and methane reduction percentage (87.88 – 91.67%). Similar ($P>0.05$) contents were observed for 24 hours' gas production, in vitro dry matter digestibility, in vitro organic matter digestibility, short chain fatty acid and metabolizable energy across the different cutting regimes. Conclusively, growth pattern and DMY of Centrosema pascuorum across the different cutting regimes 8 – 14 WAS consistently increased, coupled with nutritive parameters and post in vitro characteristics. Centrosema pascuorum could be best harvested at 12 and 14 WAS for its effective and efficient utilization for livestock production especially ruminants.

***Key words**: Centrosema-pascuorum; Cutting-regime; Dry-matter-yield; Growth-indices; Nutritive-value*

Description of Problem

Livestock production occupies a major part in the economic and social activities of Nigerians. Pasture is an important resource for livestock production. Its establishment and improvement has been recommended for better performance of ruminant animals in the production of milk, meat hide and skin and other livestock (such as rabbit, pig etc.) for their products (meat, fur, pork and lard) **(1)**. The increasing shortage in forage for ruminant feeding, coupled with the inefficiency of crop residues to meet the nutrient requirements of ruminant during off season, and the need to ensure that feed is always available to the animals has become a serious challenge in ruminant nutrition and farmers who are at receiving end.

In recent years, the use of forage legumes in livestock production systems for ruminants in the tropics as alternative to oil seed cakes has increased. Forage legumes and fodder trees provide high quality proteins as well as digestible cell wall carbohydrates. **(2)**. Feeding of forage legumes has been found easily adoptable, but farmers do not pay particular attention to the planting of pure forage legume stands, rather greater emphasis is on the cultivation of other crops (**3**).

Increments in fodder production can be achieved by expansion of land areas under natural pastures or by increasing yields per unit land area. With the present trend of competitive land use, increasing forage production through expansion of land area of natural pasture is hardly feasible as a result of the demographic changes **(4)**. In emerging shift in animal management systems towards confinement because of pressure on land, a strategic forage harvesting and management system suitable for confined ruminant livestock and which will guarantee a regular supply of high-quality forages to these livestock is required **(5)**.

The stage of growth seems to be the most important factor affecting the nutritive value of the forage. Nutrients composition alone cannot be use to adjudge the nutritional potential or value of a particular feed ingredient (**6**). The *in vitro* degradability method is a laboratory estimation of assessing the potential nutritive value of the feed. It is also a method that is reproducible and parameters obtained correlate well with *in vivo* trials (**7**). Meanwhile, this study intends to assess the growth indices, dry matter yield and nutritive value of *Centrosema pascuorum* at four different cutting regimes in humid tropics.

Materials and method

Experimental site, land preparation and planting

The study was carried out at the Teaching and Research Farm, University of Port Harcourt, Rivers State, Nigeria. Port Harcourt is a coastal city located in the Niger Delta region of Nigeria within latitudes 6^o 58' – 7^o 60'E and longitudes 4^o 40' – 4^o55'N. The monthly rainfall in Port Harcourt follows a sequence of increase from March to October before decreasing in the dry season months of November to February (**8** and **9**). The routine soil analysis of 0 - 15 cm depth (**10**) showed that it had pH (H_2O) 4.5, total nitrogen (g kg^{-1}) 0.94, organic carbon (g kg^{-1}) 16.94, exchangeable K (cmol kg^{-1}) 0.24, Mg^{2+} (cmol kg-1), Ca^{2+}(cmol kg^{-1}) 6.1, sand (g kg^{-1}) 710, silt (gkg^{-1})152, clay (g kg^{-1}) 138. The land was cleared and prepared into seed beds of 4m by 12 m and, later divided into four equal parts. Seeds of *Centrosema pascuorum* used for the experiment were obtained from the National Animal Production Research Institute, Shika, Ahmadu Bello University, Zaria, Kaduna State. The seeds were planted as described by Hassan *et al.* (**11**).

Agronomic practices and data collection

Plots were weeded manually using hand hoes as at when due. Ten randomly tagged plants at middle of each plot were used in recording the plant height (cm) this was done by measuring from the base of the plant to where the last leaf on the stem emerges with the aid of a tape rule, leaf length and width with ruler and the numbers of leaves were counted, also dry matter yield were determined according to Ojo *et al*. (**12**) at four different cutting regimes (8, 10, 12 and 14 weeks after sowing).

Chemical analysis

The proximate composition of the milled samples was determined according to AOAC (**13**) while neutral detergent fibre (NDF) was determined according to Van Soest *et al.* **(14**). Non-fibre carbohydrate was calculated as NFC = 100 – (CP + Ash + EE +NDF). Calcium and phosphorus were determined by AOAC (**13**) methods using the Atomic Absorption Spectrophotometer.

Nutritive parameters

Nutritive parameters such as Dry matter intake (DMI), Digestible dry matter (DDM) and Relative feed value (RFV) were calculated as follows: DMI = (120 ÷ NDF% dry matter basis), DDM = 88.9 - (0.779 x ADF% dry matter basis), RFV = (DDM% x DMI% x 0.775) (**15, 16**).

In vitro digestibility trial

The *in vitro* trial was carried out at the laboratory of Department of Animal Science, University of Benin, Benin City, Edo State, Nigeria. The modified *in vitro* fermentation procedure of Navarro-Villa *et al*. (**17**) was adopted as described by Bamikole *at al*. (**18**). A phosphate – bicarbonate buffer (**19**) used (g/L) were: 1.98 $Na_2HPO4.12H_2O$, 1.302 KH_2PO_4, 0.105 $MgCl_2.6H_2O$, 1.407 NH_4HCO_3, 5.418 NaOH. Rumen fluid was obtained from three fistulated goats before morning feeding into a thermos flask and taken to the laboratory where it was strained through four layer of Cheesecloth under continuous flushing with CO_2. Inoculum for incubation was prepared using ratio of rumen fluid to buffer of 1:2. 190 mg of substrate (mixture of equal proportion ground maize, Guinea grass and *Centrosema* molle) was weighed with 10 mg of the test material (experimental treatments) into nylon bags, sealed and incubated using 30ml of inoculum in 100 Ml graduated syringes at 30^oC for 24hrs. Syringes containing only the substrate (i.e. without the experimental treatments) and those containing only the inoculum (i.e. without sample) represent the control and blank respectively. Gas production (i.e. accumulated gas in the head space of each fermentation syringe) was read 3 hourlies for 24 hours to know the volume of gas produced. At the end of incubation, 4mLof 10M NaOH was introduced into the headspace of the syringes for methane determination. The bags with the residue were removed from the syringes, rinsed thoroughly with water and dried at 100^0C for 24 h, and then to constant weight to determine *in vitro* dry matter disappearance (IDMD).

Calculation for post incubation parameters

Organic matter digestibility (OMD) was estimated as: OMD = 14.88 + 0.889 GV + 0.45 CP + 0.651 ash (**20**); Short-chain fatty acids (SCFA) were estimated as: SCFA = 0.0239 GV − 0.0601 (**21**); Metabolizable energy (ME) was calculated as: ME = 2.20 + 0.136 GV + 0.057 CP + 0.00029 CF (**20**).

Statistical Analysis

The study was conducted using a completely randomize design (CRD). All data obtained were subjected to the analysis of variance (ANOVA). Means were separated using Duncan's Multiple Range Test SAS (**22**) package.

Results and Discussion

Table 1 shows the average weather condition of the experimental station during the experimental period. The temperature decreases towards the end of the experiment, its ranges from 30^0C in June to 33^0C in March. The rainfall and the days of the rainfall increases towards the end of the experiment the value was 136 mm – 288 mm and 9 days – 17 days respectively. Sunshine hour was 3.4 hours (June) to 4.5 hours (May)

Table 1: Average weather condition of the experimental station (March – June 2018)

	Months			
Parameters	March	April	May	June
Temperature (^0C) max	33	32	31	30
Temperature (^0C) min	23	23	23	23
Rainfall (mm)	136	188	235	288
Rainfall (days)	9	12	14	17
Sunshine (hours)	3.7	4.4	4.5	3.4

Growth indices and dry matter yield (t/ha) of *Centrosema pascuorum* at four different cutting regimes in humid tropics was depicted in Table 2. There was a significant (P<0.05) difference in the number of leaves (NOL), leaf length (LLN), leaf width (LLW), plant height

(PLH) and dry matter yield (DMY) across the cutting regimes. The values ranges from 16.70 – 55.67, 7.63 – 11.34 cm, 1.00 – 1.68 cm, 49.34 – 108.40cm and 4.60 – 7.80 t/ha for NOL, LLN, LLW, PLH and DMY, respectively. The NOL, LLN, LLW and PLH significantly (P<0.05) increases from 8 to 14 WAS. The DMY was significantly (P<0.05) higher in 12 (7.47 t/ha) and 14 (7.80 t/ha) WAS, least DMY (4.60t/ha.) was recorded at 8 WAS.

Table 2: Growth indices and dry matter yield (t/ha) of *Centrosema pascuorum* at four different cutting regimes in humid tropics

		Stages of growth(weeks)				
Parameters	8	10	12	14	SEM	LOS
No of leaves	16.70^{d}	25.60^{c}	37.00^{b}	55.67^{a}	6.84	**
Leaf length (cm)	7.63^{d}	8.40^{c}	9.93^{b}	11.34^{a}	1.23	**
Leaf width (cm)	1.00^{c}	1.33^{b}	1.67^{a}	1.68^{a}	0.21	**
Plant height (cm)	49.34^{d}	71.87^{c}	84.20^{b}	108.40^{a}	1.26	**
Dry matter yield (t/ha)	4.60^{c}	6.60^{b}	7.47^{a}	7.80^{a}	0.39	**

$^{a, b, c, d}$ means with different subscripts on a row are significantly differently (P<0.05); SEM= standard error of mean, LOS= level of significance, **significant (P<0.05)

Table 3 shows the chemical composition of *Centrosema pascuorum* at four different cutting regimes in humid tropics. Similar (P>0.05) content of dry matter (DM) and ether extract (EE) were recorded across the stages of growth. There was a significant difference (P<0.05) in the crude protein (CP), crude fibre (CF), neutral detergent fibre (NDF), acid detergent fibre (ADF), non-fibre carbohydrate (NFC), ash, calcium (Ca) and phosphorus (P). The values of the ranges from 8.98 – 15.69%, 14.44 – 37.25%, 67.88 – 73.85%, 46.89 – 57.54%, 4.04 – 8.21%, 7.67 – 9.88%, 0.12 – 0.14% and 0.26 – 0.29% for CP, CF, NDF, ADF, NFC, ash, Ca and P, respectively.

Table 3: Chemical composition (%DM) of *Centrosema pascuorum* at four different cutting regimes in humid

	Stages of growth (weeks)					
Parameters	8	10	12	14	SEM	LOS
Dry matter	87.66	88.07	89.66	90.79	0.61	NS
Crude protein	8.98^{c}	9.78^{c}	11.39^{b}	15.69^{a}	0.81	**
Ether extract	2.78	2.87	3.26	3.43	0.13	NS
Crude fibre	14.44^{d}	31.17^{c}	34.57^{b}	37.25^{a}	2.32	**
Neutral detergent fibre	72.36^{a}	71.82^{a}	73.85^{a}	67.88^{b}	0.72	**
Acid detergent fibre	54.49^{a}	57.54^{a}	56.31^{a}	46.89^{b}	1.08	**
Non-fibre carbohydrate	8.21^{a}	7.38^{b}	4.73^{c}	4.04^{d}	0.96	**
Ash	7.67^{b}	8.15^{b}	9.88^{a}	8.27^{b}	0.27	**
Calcium	0.13^{b}	0.13^{b}	0.14^{a}	0.12^{c}	0.00	**
Phosphorus	0.27^{b}	0.28^{b}	0.29^{c}	0.26^{c}	0.01	**

$^{a, b, c, d}$ means with different subscripts on a row are significantly differently (P<0.05) SEM=standard error of mean; LOS=level of significant, **significant (P<0.05), NS= not significant (P>0.05)

Table 4 indicates the dry matter intake, dry matter digestibility and relative feed value of *Centrosema pascuorum* at four different cutting regimes in humid tropics. There was a significant difference (P<0.05) in the dry matter intake (DMI) of *C. pascuorum* across the four different cutting regimes. Higher (P<0.05) DMI was recorded at 14 WAS, while similar (>0.05) DMI was recorded at 8, 10 and 12 WAS. Higher (P<0.05) digestible dry matter (DDM) (52.37) was recorded at 14 WAS followed by 12 WAS (47.04), 10 WAS (46.95) and 8 WAS (46.45). Relative feed value (RFV) was significantly (P<0.05) higher (71.47) at 14 WAS, while similar RFV was observed for 8, 10 and 12 WAS.

Table 4: Dry matter intake, dry matter digestibility and relative feed value of *Centrosema pascuorum* at four different cutting regimes in humid tropics

	Stages of growth (weeks)					
Parameters	8	10	12	14	SEM	LOS
Dry matter intake	1.66^{b}	1.67^{b}	1.67^{b}	1.79^{a}	0.14	**
Dry matter digestibility	46.45^{d}	46.95^{c}	47.04^{b}	52.37^{a}	0.73	**
Relative feed value	59.50^{b}	60.80^{b}	60.90^{b}	71.47^{a}	1.46	**

$^{a, b, c. d}$ means with different subscripts on a row are significantly differently (P<0.05) SEM=standard error of mean; LOS=level of significant, **significant (P<0.05), NS= not significant (P>0.05)

Table 5 shows the post *in vitro* fermentation characteristics of *Centrosema pascuorum* at four different cutting regimes in humid tropics. Significant difference was observed for methane (CH_4) production and CH_4 reduction percentage across the cutting regimes, the values rages from 18.00 – 21.33 ml and 87.88 – 91.67%, respectively for CH_4 production and CH_4 reduction percentage. Similar contents were observed for 24 hours' gas production, dry matter digestibility (DMD), organic matter digestibility (OMD), short chain fatty acid (SCFA) and metabolizable energy (ME).

Table 5: Post i*n vitro* fermentation characteristics of *Centrosema pascuorum* at four different cutting regimes in humid tropics

	Stages of growth (weeks)					
Parameters	8	10	12	14	SEM	LOS
24h gas production (ml/200mgDM)	0.54	0.62	0.68	0.58	0.03	NS
Methane (ml)	18.00^{ab}	21.33^{a}	19.33^{ab}	14.67^{b}	1.04	**
Methane reduction (%)	89.77^{ab}	87.88^{b}	89.02^{ab}	91.64^{a}	0.59	**
Dry matter digestibility (%)	62.97	54.63	44.47	53.73	3.41	NS
Organic matter digestibility (%)	55.45	56.04	51.35	49.00	1.32	NS
Short chain fatty acid (µM)	0.74	0.75	0.63	0.56	0.36	NS
Metabolizable energy (MJ/kgDM)	7.95	8.04	7.31	6.95	0.20	NS

$^{a, b}$ means with different subscripts on a row are significantly differently (P<0.05); SEM=standard error of mean; LOS=level of significant; **significant (P<0.05), NS= not significant (P>0.05)

Weather and climate data play a significant role in agricultural activities. The average weather condition observed during the experimental period was favorable, the rainfall was increasing throughout the experimental period, the weather was conducive for effective and efficient establishment of pasture especially forage legume and other agronomic practices.

The growth pattern of the *Centrosema pascuorum* was consistent throughout the experimental period (14 WAS), this is similar to the report of Mbahi *et al*. (**23**; **24**) that legumes exhibits slow growth at early stages and increases with time in the season. The higher growth pattern recorded at advance stage of growth (14 WAS) of *C. pascuorum* in this study might be attributed to the increase in the rainfall during the advance stage of the experiment because similar studies with other fodder crops (**25**; **26**; **27**) recorded a significant growth, more so, the crops were not planted in mixture with other forages which reduces competition for nutrients and sunlight.

Plant height as a plant growth indicator is very important and has a direct effect on other agronomic parameters and dry matter yield. Higher leaf number must have resulted from increasing photosynthetic activities of the plants as the plants mature in age, since higher leaf number is desirable for photosynthesis activities of the plants and well as livestock production (**28**). The higher the plant height, leaf number, leaf length and leaf breath the higher the herbage yield, the more feed materials available for livestock production.

The dry matter yield recorded across the cutting regimes in this study were within the range (4.80 – 8.94t/ha) catalogued by Hassan *et al*. (**11)** for irrigated and phosphorous fertilized *Centrosema pascuorum*.

The observed linear increase in dry matter yield with increasing cutting regimes i.e. 4.60, 6.60, 7.47 and 7.80 t/h for 8, 10, 12 and 14 WAS, respectively in this study corroborate earlier report that extended harvesting time of tropical forages encourages high dry matter yield (**29**). Meanwhile, the higher dry matter yield recorded at latter cutting regime (i.e. 12 and 14 WAS) could be attributed to the fact that as the forage plants increase in age. Higher dry matter yield is desirable in forage production since it will provide sufficient quantity of feeds for animals.

Crude protein (CP) contents recorded across the cutting regimes for *C. pascuorum* in this study (8.98 – 15.69%) were a little bit above the critical lower limit (7% CP) which forage intake by ruminants and rumen microbial activity could be negatively affected (**30** and **31)**. The CP content recorded for this study was above the 7 to 8 % CP suggested as threshold for sufficient utilization of feed by (**32**). Therefore, *Centrosema pascuorum* would provide the adequate nitrogen requirement for the rumen microorganisms to maximally digest the main components of dietary fibre leading to the production of volatile fatty acids (**33**; **9**) which in turn facilitate microbial protein synthesis (**28**) irrespective of cutting regimes. The consistent increase of CF across the cutting regimes is in line with the findings of (**34**) who reported plant maturity has been associated with the structural build-up of fibre constituents in plants.

Ash content is generally taken to be a measure of the mineral content of the original food (**35**). The higher level of ash content inherent in the forages is an indication that the forage is rich in minerals which are essential in the formation and function of bloods and bones (**36**). The ash content recorded across the stages of growth for *Centrosema pascuorum* in this study was within the ash content catalogued by (**37**) for common feedstuff used for small ruminant production in South-West, Nigeria. The range of Ca content (0.12 – 0.140%) in the *Centrosema pascuorum* across the cutting regimes was a little bit lower than the recommended range (0.20 - 0.26g/100g) for maintenance of growing and lactating sheep (**38**). The P content (0.26 – 0.29%) was within the recommended range (0.15-0.48g/100g) required by ruminants (**39**).

The higher value recorded for DMI, DDM and RFV for *Centrosema pascuorum* at late cutting regime, can be view within the context of ADF and NDF level. Meanwhile, higher levels of NDF and lignin have been reported to have negative effect on dry matter intake and dry matter digestibility (**40**). Though, higher NDF recorded at early stages of growth 8, 10 and 12 WAS (72.63, 71.82 and 73.85%) even 67.88% for 14 WAS were higher than 60% which is considered safe for acceptable intakes of forage in ruminants (**41**).

The gas production is a nutritionally wasteful product (**42**) but provides a useful basis from which metabolizable energy (ME), organic matter digestibility (OMD) and short chain fatty acid (SCFA) may be predicted (**43**). Similar gas production across the four different cutting regimes is an indication that irrespective of the cutting regime, *Centrosema pascuorum* will provide adequate ammonia for rumen micro flora, stimulating microbial growth and increasing rate of breakdown of the forage. Increase in the amount of protein available to microorganism is positively related to gas production according to the reports of (**44**) who asserted that gas production is positively related to microbial protein synthesis.

The ME values (6.95 – 8.04 MJ/kg/DM) recorded in this study across the four different stages of growth revealed that the metabolizable energy of *Centrosema pascuorum* were within the recommended ME values for an average diet (6 – 13 MJ/kg/DM) (**45**), hence can fulfill the energy requirements for WAD sheep and goats when utilized.

The SCFAs or volatile fatty acids such as acetic, propionic, butyric, isobutyric, valeric, isovaleric, 2-methylbutyric, hexanoic and heptanoic acids have been reported as a major source of energy as well as a building block for milk synthesis (**46**). The higher preponderance of SCFA in the *Centrosema pascuorum* at four different cutting regimes probably showed an increased proportion of acetate and butyrate but may mean a decrease in propionate production (**47**).

Conclusion and Applications

1. The pattern of growth and dry matter yield of *Centrosema pascuorum* across the four different cutting regimes in humid tropics was consistently increased, the dry matter yield was higher and similar at 12 and 14 weeks after sowing. Higher dry matter yield is desirable in forage production since it will guarantee sufficient quantity of feeds for sustainable animal production especially ruminant.
2. Crude protein and crude fibre contents was higher at 14 weeks after sowing, but also have appreciable contents of the nutrients at 12 weeks after sowing. Therefore, *Centrosema pascuorum* could be best harvested at 12 or 14 weeks after sowing for effective utilization for livestock production.
3. Post *in vitro* fermentation characteristics exhibited across 8, 10, 12, 14 weeks after sowing indicated that *Centrosema pascuorum* will provide nutrients for effective performance of the rumen microbes which will in turn transform to animal products.
4. Meanwhile, the *Centrosema pascuorum* at four different cutting regimes exhibited the nutritional qualities that qualified it to be a feed resources for ruminant production depending on the choice of the farmer.

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