Evaluation of growth and nutritive value of *Panicum maximum* intercropped with *Centrosema pascuorum* and *Clitoria ternatea*.

Muraina, T. O[1]; Olanite, J. A[2]; Ewetola, I. A[2]; Alalade, J. A[1]; Emiola, C. B[1]; Adebisi, I. A[1]; Akanbi, K. O[1]; Ojetunde, F. A[1]; Olalekan, R. A[1] and Mustapha, S. O[2]

[1]*Department of Animal Health and Production Technology, Oyo State College of Agriculture and Technology, P. M. B. 10, Igbo-Ora, Nigeria.*
[2]*Department of Pasture and Range Management, Federal University of Agriculture, P. M. B. 2240, Abeokuta Nigeria.*

ABSTRACT

An experiment was conducted at the Pasture Unit, Teaching and Research Farm of Oyo State College of Agriculture and Technology, Igboora, Nigeria to evaluate the agronomic performance, *in vitro* gas production and post-incubative parameters of *Panicum maximum* intercropped with *Clitoria ternatea* and *Centrosema pascuorum.* The experiment was laid out in a randomized complete block design (RCBD) with three treatments and three replicates. The treatments include *Panicum maximum* intercropped with *Clitoria ternatea* (PCT), *Panicum maximum* intercropped with *Centrosema pascuorum* (PCP) and sole *Panicum maximum* (SP). Samples and measurements of the plant height (PH), tiller number, leaf length, leaf number and leaf width were taken 3, 6, 9 and 12 weeks after planting (WAP). The PH values were significantly ($P<0.05$) different. Sole *Panicum maximum* (SP) harvested at 12 WAP had highest (214.67cm) PH while the least value of 61.67cm was recorded in PCP at 6 WAP. The *in vitro* gas production of *P. maximum* as affected by the interaction between legume species and age at harvest (WAP) which were significantly ($p<0.05$) different ranged from 0.00ml/200mgDM in PCP at 8WAP and at 3hrs of incubation to 47.50ml/200mgDM in SP at 4WAP at the end of 48hours of incubation period. However, organic matter digestibility (OMD) ranged from 51.59% in SP at 4 weeks to 31.65% in PCP at 8 WAP. Intercrop of either of the two legumes (*Centrosema pascuorum* and *Clitoria ternatea*) with *Panicum maximum* improved and maintained the proximate composition, organic matter digestibility and metabolizable energy compared to the sole grass.

Keywords: Pasture, nutritive value, *Panicum maximum, Centrosema pascuorum, Clitoria ternatea*.

Corresponding author: too-muraina@hotmail.com; +2347060584797

INTRODUCTION

Nigeria is one of the four leading livestock producers in Sub-Sahara Africa. In the early 1990s, estimated livestock population in Nigeria was 14 million cattle, 23 million goats and 13 million sheep (RIM, 1990). However, these figures have since increased to 15.2 million cattle, 28 million goats and 23 million sheep (FAO, 2006). Livestock productivity is low because of poor nutrition, which is primarily derived from natural pastures and limited amounts from crop residues. Native pastures are the most widely available low cost feeds for ruminants in the tropics (Tchinda *et al*., 1993). The native pastures deteriorate rapidly as the season advance towards the dry season. One of these pastures in use is Guinea grass (*Panicum maximum)* and it is one of the most common grasses in the derived savannah region of Nigeria. Under good soil conditions, its yield and nutritional value is high (McDonald *et al*., 1988).

Time and frequency of harvesting, botanical composition, fertility of the soil and climatic conditions are the major factors that determine biomass yield and nutritive value of pastures (Yihalem *et al*., 2005; Tessema *et al*., 2010). Unfertilized grasses and those grown without legume companion had been described to be less nutritive as forage (Bamikole *et al*., 2004). In Nigeria, only arable crop farmers often use manure to grow their plants while livestock owners rarely cultivate pasture using fertilizers. The use of N-fertilizer to improve grassland is undesirable because it is uneconomical and could increase environmentally related problems (Bamikole *et al*., 2001) due to excessive release of nitrogenous compounds. The use of herbaceous or tree legumes have been reported (Ezenwa and Aken'ova, 1988; Bamikole and Ezenwa, 1999). Legumes are able to return soil fertility back by converting natural atmospheric air nitrogen and deposit it into the soil. Grasses or companion pasture species can be improved with herbaceous legumes with low cost and no residual negative effects. They are rich in protein which is usually the most limiting nutrients in tropical animal diets (Andrea and Pablo, 1999). Forage legumes can be grazed, harvested and fed fresh or stored as hay or silage (Harricharan *et al*., 1988).

A sustainable way of improving the feeding value of poor quality pastures is through supplementation with forage legumes (Andrea and Pablo, 1999). The capability to fix nitrogen into the soil and as such, enhancing the crude protein content of forage with resultant increase in yield and feed quality, make legumes an integral part of pastures (Aribisala, 2003; Sanginga and Mulongoy, 1992). The objectives of this study are to compare the growth and nutritive value of

Panicum maximum (Guinea grass) intercropped with *Centrosema pascuorum* (Centro) and *Clitoria ternatea* (Butterfly pea).

MATERIALS AND METHODS

The study was carried out at the Pasture unit of the Teaching and Research Farm, Oyo State College of Agriculture, Igbo-Ora. The area has a mean annual rainfall of 1230 mm in a bimodal distribution pattern. Mean monthly temperature ranges between 25.70 ^{0}C in July and 30.20 ^{0}C in February. The study was arranged in a randomized complete block design and it includes the following treatments: *C. pascuorum* + *P. maximum*; *C. ternatea* + *P. maximum*; and Sole *P. maximum.*

The proximate compositions of the forages were analyzed according to AOAC (2000). Neutral Detergent Fibre (NDF), Acid Detergent Fibre (ADF) and Acid Detergent Lignin (ADL) were determined using the method of Van Soest *et* a*l*., (1991). Cellulose and hemicellulose were derived by calculation from NDF, ADF and ADL as follows: Hemicellulose = NDF – ADF, Cellulose = ADF – ADL. The *in vitro* gas production was determined following the procedure of Menke and Steingass (1988). Rates and extent of gas production were determined for each substrate from the following non-linear regression equation: GV (ml/200mg DM) = b $(1 - e^{-c\,(t-lag)})$ (Ǿrskov and McDonald (1979).

Data collected were subjected to Analysis of Variance (ANOVA) and treatment means were separated using Duncan Multiple Range Test at 5% level of significance (Duncan, 1955).

RESULTS AND DISCUSSION

The interactive effect of legume intercrop and age at harvest on the growth characteristics of *P. maximum* was presented on Table 2. Sole *P. maximum* had highest plant height (214.67 cm) at 12 weeks after planting while the least value (61.67cm) was obtained at 6 weeks after planting in the intercrop of *P. maximum* with *C. pascuorum*. Leaf length values ranged from 50.67 cm in sole *P. maximum* harvested after 3 weeks after planting to 140.67cm in the intercrop of *P. maximum* with *C. ternatea* at 12 weeks after planting. Highest leaf width (4.33cm) was obtained in *P. maximum* intercrop with *C. ternatea* at 9 weeks after planting, while the least value (2.70cm) of leaf width was recorded in 3 weeks after planting in *P. maximum* intercrop with *C. pascuorum* and *P. maximum* intercrop with *C. ternatea*. However, the tiller number ranged from 3.67 in *P. maximum* intercrop with *C. ternatea* at 3 weeks after planting to 12.33 in *P. maximum* intercrop with *C. ternatea* at 12 weeks after planting. Significant higher leaf number (41.67) was obtained in *P. maximum* intercrop with *C. ternatea* at 12 weeks after planting while the least value (10.00) occurred in *P. maximum* intercrop with *C. pascuorum* at 3 weeks after planting.

Table 3 presents the proximate composition and fibre fraction of *P. maximum* as affected by legume intercrop and age at harvest. Ether extract (EE), dry matter (DM), crude protein (CP), crude fibre (CF), Neutral Detergent Fibre (NDF), Acid Detergent Fibre (ADF), Acid Detergent Lignin (ADL), Cellulose (CEL) and Hemicellulose (HEM) contents were significantly different ($p<0.05$). Maximum ash content (8.50%) was obtained in *P. maximum* intercrop with *C. pascuorum* at 4 weeks after planting while the minimum ash (7.00%) was obtained in sole *P. maximum* at 8 weeks after planting. Highest (21.00%) and least (16.50%) EE contents were obtained in *P. maximum* intercrop with *C. pascuorum* at 4 and 8 weeks after planting respectively. Highest (85.50%) DM was obtained in *P. maximum* intercrop with *C. pascuorum* at 8 weeks after planting while the least DM (79.50%) was obtained in sole *P. maximum* at 4 weeks after planting. CP of this result ranged from 5.20% in sole *P. maximum* at 8 weeks after planting to 13.43% in sole *P. maximum* at 8 weeks after planting.

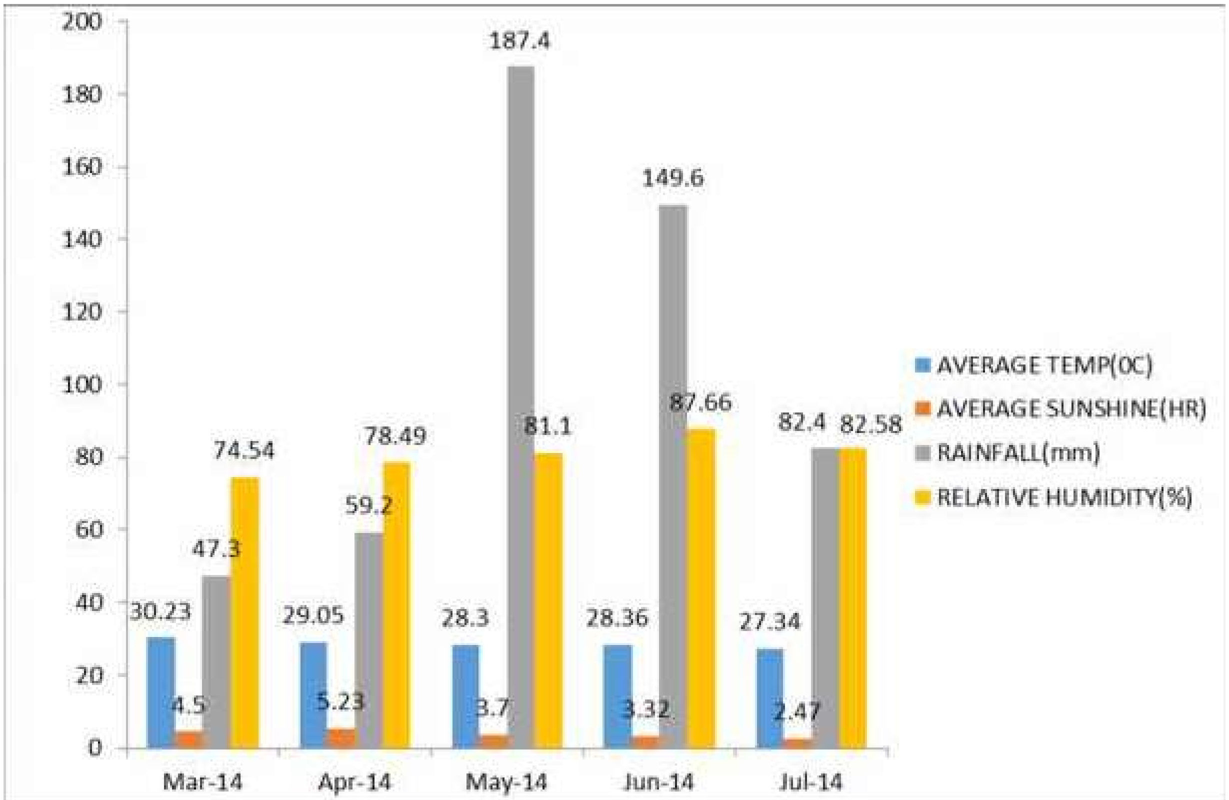

Figure 1: Monthly weather condition of the site between March and July, 2014.

Source: OYSCATECH Agro-meteorological Station

Table 1: Physico-chemical properties of the composite soil samples taken from the experimental site before planting

Chemical properties	Values
Ph	6.50
Macro-nutrients (%)	
Total Nitrogen	0.06
Organic Carbon	0.49
Available P (mg/kg)	6.08
Acidity (cmol/Kg)	0.06
CEC (cmol/Kg)	8.02
Base (%)	99.25
Exchangeable cations (cmol/kg)	
Sodium (Na)	0.77
Potassium (K)	0.48
Calcium (Ca)	5.57
Magnesium (Mg)	1.14
Micro-nutrients (mg/kg)	
Iron (Fe)	27.30
Copper (Cu)	1.50
Zinc (Zn)	6.90
Manganese (Mn)	166
Particle size (%)	
Sand	92
Silt	6.0
Clay	2.0

Table 2: Interactive effects of legumes and age at harvest on the agronomic performance of *P. maximum*

Effect of Legume	Age at harvest	PH(cm)	LL(cm)	LW(cm)	TN	LN
SP	3	72.57[f]	50.67[d]	2.77[c]	5.67[ab]	14.67[b]
PCP	3	69.03[f]	51.0[d]	2.70[c]	3.67[b]	10.00[b]
PCT	3	71.17[f]	52.33[d]	2.70[c]	5.33[ab]	12.33[b]
SP	6	108.27[de]	64.67[cd]	3.27[bc]	9.67[ab]	28.33[ab]
PCP	6	61.67[f]	69.33[bcd]	3.27[bc]	7.00[ab]	19.00[b]
PCT	6	93.33[ef]	69.50[bcd]	3.37[abc]	8.00[ab]	27.00[ab]
SP	9	172.33[b]	90.67[ab]	3.33[abc]	8.67[ab]	28.33[ab]
PCP	9	135.67[de]	91.33[ab]	3.67[ab]	10.67[ab]	29.00[ab]
PCT	9	150.00[bc]	102.67[a]	4.33[a]	9.00[ab]	28.67[ab]
SP	12	214.67[a]	83.67[abc]	4.00[ab]	4.33[ab]	18.67[b]
PCP	12	181.00[ab]	98.67[a]	4.00[ab]	8.33[ab]	28.33[ab]
PCT	12	176.67[b]	104.67[a]	3.93[a]	12.33[a]	41.67[a]
SEM		9.01	3.77	0.12	0.71	2.17

[a, b, c……f]: Means in same column with different superscripts are significantly ($p<0.05$) different

SEM = Standard Error of Mean; SP: Sole Panicum; PCP: *P. maximum* x *C. pascuorum*; PCT: *P. maximum* x *C. ternatea*; 3, 6, 9 and 12 WAP: 3, 6, 9 and 12 weeks after planting

Table 3: Interactive effects of Legumes and age at harvest on the proximate composition and fibre fractions of *P. maximum*

Effect of legume	Age at harvest (weeks)	DM	EE	CP	CF	ASH	NDF	ADF	ADL	HEM	CEL
SP	4	79.50^{b}	20.50^{ab}	13.43^{a}	74.00^{abc}	7.50	68.00^{b}	39.00^{c}	8.00^{ab}	29.00^{b}	31.00^{c}
SP	8	84.00^{ab}	18.50^{abc}	5.20^{e}	73.00^{bc}	7.00	76.00^{a}	43.00^{b}	40.00^{ab}	33.00^{a}	33.00^{bc}
PCP	4	80.50^{b}	21.00^{a}	12.03^{c}	76.00^{ab}	7.50	70.00^{b}	37.00^{c}	4.00^{c}	33.00^{a}	33.00^{bc}
PCP	8	85.50^{a}	16.50^{c}	6.40^{d}	78.00^{a}	7.00	78.00^{a}	43.00^{b}	8.00^{ab}	33.00^{a}	35.00^{ac}
PCT	4	82.00^{ab}	17.50^{bc}	12.47^{b}	71.00^{c}	8.50	70.00^{b}	38.00^{cd}	6.00^{bc}	32.00^{a}	32.00^{c}
PCT	8	84.00^{ab}	17.50^{bc}	6.40^{d}	71.00^{c}	8.50	69.00^{b}	46.00^{a}	10.00^{a}	23.00^{c}	36.00^{a}
SEM		0.70	0.51	0.82	0.80	0.30	0.83	0.80	0.57	0.90	0.47

$^{a, b, c, d}$: Means in same column with different superscripts are significantly ($p<0.05$) different
SEM = Standard Error of Mean; SP: Sole Panicum; PCP: *P. maximum* x *C. pascuorum*; PCT: *P. maximum* x *C. ternatea*; 4, 8, 9 and 12 weeks after planting: 4, 8 weeks after planting; DM: Dry matter; EE: Ether extract; CP: Crude protein; CF: Crude fibre; NDF: Neutral detergent fibre; ADF: Acid detergent fibre; ADL: Acid detergent lignin; HEM: Hemicellulose; CEL: Cellulose

Figure 2: Sequential *in vitro* gas production of *P. maximum* as affected by legume species and age at harvest.

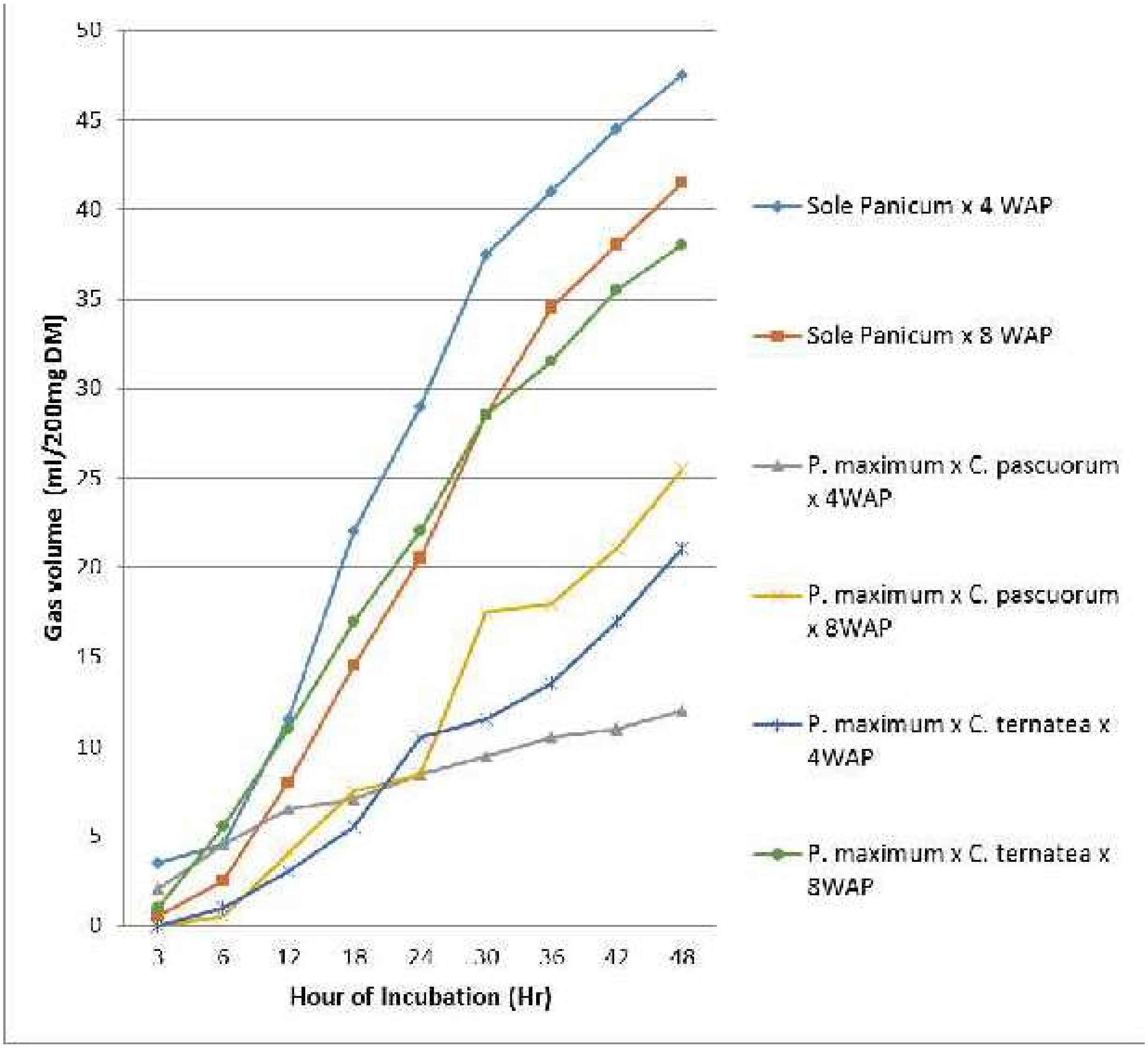

Table 4: Interactive effects of legume species and age at harvest on the post incubation parameters of *P. maximum*

Effect of Legume	Age at harvest (weeks after planting)	B (ml/200 mgDM)	c (ml/hr)	Lag (hr)	SCFA (µmol)	OMD (%)	ME (MJ/kg)
SP	4	84.69[a]	0.24[a]	1.88[b]	0.63[a]	51.59[a]	6.33[a]
SP	8	83.17[a]	0.01[a]	4.06[a]	0.40[b]	28.33[ab]	5.11[b]
PCP	4	15.67[c]	0.04[b]	5.52[a]	0.14[c]	32.73[c]	3.55[c]
PCP	8	83.17[a]	0.02[b]	5.40[a]	0.19[c]	31.65[c]	3.74[c]
PCT	4	54.33[b]	0.02[b]	4.93[a]	0.13[c]	33.14[c]	3.44[c]
PCT	8	65.56[b]	0.02[b]	2.37[b]	0.14[b]	42.85[b]	5.31[b]
SEM		6.09	0.03	0.38	0.05	1.78	0.27

[a, b, c]: Means in same column with different superscripts are significantly ($p<0.05$) different
SEM= Standard Error of Mean; SP: Sole Panicum; PCP: *P. maximum* x *C. pascuorum*; PCT: *P. maximum* x *C. ternatea*; 4 WAP: 4 weeks after planting; 8WAP: 8 weeks after planting.

Maximum (13.43%) and minimum (5.20%) CP contents were obtained in sole *P. maximum* at 4 and 8 weeks after planting respectively. The ash content represents the inorganic (mineral matter) content in a feed. Its value is mainly in the contents of phosphorus, calcium, or potassium and large amounts of silica (Bogdan, 1977). The values of ash obtained for *P. maximum* falls within the range of 3 – 12% (Gillespie, 1998) and 8 – 12% (Bogdan, 1977). The maximum

CP of this study was very high compared with those reported for sole *P. maximum* and mixtures of *P. maximum* with *S. guianensis* or *A. histrix* (Ajayi, *et al*., 2007). The crude protein contents of *P. maximum* as affected by the intercrop of *C. pascuorum* or *C. ternatea* were within the acceptable range for ruminant performance (NRC, 1981), and were within the critical CP level of 7 % recommended by ARC (1980) and 8 % suggested by Norton (1994) for ruminal function. Highest (78.00%) CF was obtained in *P. maximum* intercrop with *C. pascuorum* at 8 weeks after planting while the least value (71.00%) was obtained in *P. maximum* intercrop with *C. ternatea* at 4 weeks after planting. The fibre contents (NDF, ADF, Lignin, cellulose and hemicellulose) have implication on the digestibility of plants. The neutral detergent fibre (NDF), which is a measure of the forage cell wall contents, is the chemical component of the feed that determines its rate of digestion (Odedire and Babayemi, 2008). NDF is inversely related to the plants' digestibility (McDonald *et al*., 1995; Gillespie, 1998). Highest (78.00%) NDF of this study was obtained in *P. maximum* intercrop with *C. pascuorum* at 8 weeks after planting while lowest value (68.00%) was obtained in sole *P. maximum* at 4 weeks after planting.

The roughage diets with NDF content of 45-65% and below 45% were generally considered as medium and high quality feeds, respectively (Singh and Oosting, 1992). Thus, the NDF contents of *P. maximum* in this study could be considered to be extremely fibrous and low in quality at 8 weeks after planting, since decrease in NDF content has been associated with increase in digestibility and hence feed intake (Van Soest, 1994; McDonald *et al*., 2002). Maximum (46.00%) ADF content was obtained in *P. maximum* intercrop with *C. ternatea* at 8 weeks after planting while least value (37.00%) was obtained in *P. maximum* intercrop with *C. pascuorum* at 4 weeks after planting. The digestibility of forage in the rumen is related to the proportion and extent of lignification (Van Soest, 1994). Highest (10.00%) ADL of this study was obtained in sole *P. maximum* and *P. maximum* intercrop with *C. ternatea* at 8 weeks after planting while the least value (4.00%) was obtained in *P. maximum* intercrop with *C. pascuorum* at 4 weeks after planting. Lignin content of a plant is the most indigestible component of the fibre fractions (Gillespie, 1998) and its amount will also influence the plant's digestibility. As such, the lower lignin content (4.0 %) of *P. maximum* as intercropped with *C. pascuorum* and harvested at weeks after planting of this study may likely predispose *P. maximum* intercrop with *C. pascuorum* at 4 weeks after planting to better digestibility by grazing animals than other treatments. Digestibility has been reported to be synonymous to *in vitro* gas production (Fievez *et al*., 2005) such that the higher the gas production the higher the digestibility of forage.

The sequential *in vitro* gas production of *Panicum maximum* as affected by legume species and age at harvest was presented on Table 2. Volume of gas produced after 24 hours of incubation of sole *P. maximum* was higher than those reported for the same grass by Ajayi and Babayemi (2008). Post incubation parameters of *P. maximum* as affected by legumes and age at harvest were significantly ($P<0.05$) different (Table 4). Highest OMD (51.59%) recorded in sole *P. maximum* at 4 weeks after planting was higher than the value (41.52%) reported for *Panicum* in stylo intercrop (Ajayi and Babayemi, 2008). SCFA contents ranged from 0.05µmol in *P. maximum* intercrop with *C. ternatea* at 4 weeks after planting to 0.63µmol in sole *P. maximum* at 4 weeks after planting. SCFA has obtained for sole *P. maximum* in this study was higher than 0.40% of *P. maximum* when intercropped with lablab (Ajayi and Babayemi, 2008). ME had highest value (6.33MJ/kg) in sole *P. maximum* at 4 weeks after planting while the least value (3.44MJ/kg) was obtained in *P. maximum* intercrop with *C. ternatea* at 4 weeks after planting. ME values of this study were within the range reported by Ajayi and Babayemi (2008) for sole *P. maximum* and Panicum-legume intercrops. The interaction effect of legume and age at harvest were significant ($P<0.05$) for the gas production kinetics. The insoluble but degradable fraction ranged between 15.67ml/200mg DM in *P. maximum* intercrop with *C. ternatea* and 84.69ml/200mg DM in sole *P. maximum* at 4 weeks after planting. The value for fractional rate of gas production ranged from 0.0lml/hour to 0.24ml/hour both in sole *P. maximum* at 8 weeks after planting. However, the lag time was higher (5.52 hours) and lower (1.88 hour) after 4 weeks after planting in *P. maximum* intercrop with *C. pascuorum* and in sole *P. maximum* respectively.

CONCLUSIONS

Although the Sole Panicum grew higher than others, *P. maximum* in *Clitoria* intercrop grew appreciably over the period of study. Efficient rumen fermentation can be achieved when *P. maximum* are fed at tender age (around four weeks old). Intercrop of Butterfly pea or Centro with *Panicum maximum* improved and maintained the proximate composition, organic matter digestibility and metabolizable energy compared to the sole grass. The reduction in the methane produced during gas fermentation for the sole grass is an indication of its usage as energy feed. The legumes were high in methane and so require energy supplement in order to sustain livestock production.

REFERENCES

Andrea M.M. and Pablo, E.C. (1999). A tropical forage solution to poor quality ruminant diets: A review of *Lablab purpureus*. Livestock Research for Rural Development (http://www.lrrd.org/lrrd11/2/colu112.htm)

Ajayi, F.T., Babayemi, O.J and Taiwo, A.A. (2007). Effects of *Stylosanthes guianensis* and *Aeschynomene histrix* on the yield, proximate composition and *in-situ* dry matter and crude protein degradation of *Panicum maximum* (Ntchisi). Livestock Research for Rural Development. 19 (3).

ARC (1980). The nutrient requirement of ruminant livestock. CAB Farnham Royal, U.K.

Aribisala, O.S. (2003). Agronomic evaluation of smallholder forage production schemes in Ibadan area, Oyo state, Nigeria. PhD Thesis, University of Ibadan

AOAC, (2000).Official Methods of Analysis, 17th ed. Association of Official Analytical Chemists. Washington, DC.

Bamikole, M.A. and Ezenwa, I. (1999). Performance of rabbits on guinea grass and verano-stylo hays in the dry season and the effect on concentrate supplementation. Animal Feed Science and Technology 69: 69-74

Bamikole, M.A., Ezenwa, I.A., Akinsoyinu, A.O., Arigbede, M.O. and Babayemi, O.J. (2001). Performance of West African Dwarf goats fed Guinea grass-verano stylo mixture, N-fertilized and unfertilized guinea grass. Small Ruminant Research*,* 39, 145-152

Bamikole, M.A., Akinsoyinu, A.O., Ezenwa, I., Babayemi, O.J., Akinlade, J. and Adewumi, M.K. (2004). Effect of six - weekly harvests on yield, chemical composition and dry matter degradability of *Panicum maximum* and *Stylosanthes hamata* in Nigeria. Grass and Forage Science, 59, 357-363

Bogdan, A.V. (1977). Tropical Pasture and Fodder Plants. Longman Inc., New

York. pp. 397-402.

Ezenwa, I and Aken'ova, M.E. (1988). Performance of mixtures of selected grasses and adapted herbaceous legumes in southwest Nigeria. Tropical Grasslands 32, 131-138

FAO. 2006. FAOSTAT Data. FAO. Rome, Italy.

Fievez, V., Babayemi, O.J and Demeyer D. (2005). Estimation of direct and indirect gas production in syringes: a tool to estimate short chain fatty acid production requiring minimal laboratory facilities. Animal Feed Science and Technology 123-124: 197-210

Gillespie, J.R. (1998). Animal Science. Delmar publishers, International Thompson Publishing Company, 1204 pp

Harricharan, H.J., Morris, J and Devers, C. (1988). Mineral content of some tropical forage legumes. Tropical Agriculture (Trinidad) 65 (2): 132-136

McDonald, P., Edwards, R.A. and Greenhalgh, J.F.D. (1988). Animal Nutrition (4th edition). Longman Publisher. Pp 200-250

McDonald, P., Edwards, R.A., Greenhalgh, J.F.D. and Morgan, C.A. (2002). Animal nutrition, 6th eds. Harlow: Prentice Hall.

Menke, K.H and Steingass, H. (1988). Estimation of the energetic feed value obtained from chemical analysis and in vitro gas production using rumen fluid. Animal Research and Development.28:7-55.

Norton, B.W. and Poppi, D.P. (1995). Composition and nutritional attributes of pasture legumes. In: J P F D'Mello and C Devendra (editors). Tropical legumes in Animal nutrition (CAB International) Wallingford, UK, 23-46

NRC. 1981. Nutrient Requirements for goats: Angora, Dairy and Meat goat in temperate and tropical countries. National Research Council. National Academy of Science press, Washington DC

Odedire, J.A and Babayemi, O.J. (2007). Preliminary study on *Tephrosia candida* as forage alternative to *Leucaena leucocephala* for ruminant nutrition in Southwest Nigeria. Livestock Research for Rural Development 19 (9) http://www.lrrd.org/lrrd19/9/oded19128.htm

Odedire, J.A and Babayemi, O.J. (2008). Comparative studies on the yield and chemical composition of *Panicum maximum* and *Andropogon gayanus* as influenced by *Tephrosia candida* and *Leucaena leucocephala*. Livestock Research for Rural Development 19 (9). http://www.lrrd.org/lrrd19/9/oded19128.htm

Singh, G.P. and Oosting, S.J. (1992). A model for describing the energy value of straws. Indian dairyman XLI: 322-327.

Resource Inventory and Management (RIM). (1990). Livestock resource survey.

Sanginga, N. and Mulongoy, K. (1992). Increasing biological nitrogen fixation and its contribution to the nitrogen cycle in alley cropping systems. In: Kang B T, Osiname O A and Larbi A (editors), Alley Farming Research and Development. Proceedings of an international conference on Alley farming held at Ibadan, Nigeria, 14 – 18 September 1992

Tchinda, B., Wegard, D. and Njwe. R.M. (1993). Rumen degradation of elephant grass supplemented with graded levels of perennial peanut by West African dwarf sheep. In: Lebbie S H B, Rey B and Irungu E K (Editors). Small Ruminant Research and Development in Africa. Proceedings of the second biennial conference of the African small ruminants research network AICC, Arusha, Tanzania, 7-11, December 1992. ILCA/CTA. ILCA. Addis Ababa, Ethiopia pp 187-190 http://www.fao.org/Wairdocs/ILRI/x5472B/x5472b11.htm

Tessema, Z. (2005). Identification of indigenous pasture and the effect of time of harvesting and nitrogen fertilizer in the north western Ethiopian highlands. Tropical Science. 45, 73–77.

Van Soest, P.J., Robertson, J.B. and Lewis, B.A. (1991). Methods for dietary fibre, neutral detergent fibre and non-starch polysaccharides in relation to animal nutrition. Journal of Dairy Science 74(10): 3583-3597.

Van Soest, P.J. (1994). Nutritional Ecology of the Ruminant, Comstock Publishing Associates. A division of Cornell University Press, Ithaca and London.

Yihalem, D., Berhan, T. and Solomon, M. (2005). Effect of harvesting date on composition and yield of natural pasture in northwestern Ethiopia. Tropical Science. 45, 19–22.