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Agronomic indices and nutritional values of plant parts of three varieties of sorghum (*Sorghum bicolor* (L.) Moench) fodder at late stages of growth

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Abstract

The study was conducted to assess the agronomic indices and nutritional values of plant parts fractions of three varieties of sorghum fodder in late stages of growth in humid tropics. The experiment was 2 x 3 factorial scheme fitted into a completely randomize design, comprising of two (2) plant fractions (stem and leaf) and three (3) varieties of sorghum (Samsorg-17, 44 and 45). Agronomic parameters (plant height, leaf length, leaf width, stem circumference, fresh leaf number and dried leaf number) were monitored from 10 – 16 weeks after planting (WAP), 16 WAP leaf and stem were sampled for proximate composition, fibre fractions, mineral profile, anti-nutritional factors and in-vitro digestibility. Results obtained showed a significant difference (P<0.05) in all the agronomic indices across the weeks of growth. Plant height was higher (P<0.05) for Sarmsorg-45 (131.25 cm) and lower (P<0.05) for Samsorg-17 (107.25 cm). There were no significant differences (P>0.05) in dry matter, crude protein (CP), ether extract, ash, neutral detergent fibre and non-fibre carbohydrate among the varieties. Leaf fraction had higher (P<0.05) contents of CP (17.53%). Stem had higher (P<0.05) values of all fibre fractions except acid detergent fibre. There was a significant (P<0.05) influence of varieties on the Ca, P, Fe, Cu and Mn. Leaf fraction had higher (P<0.05) contents of P (1.06%), K (0.37%), Na (1.75%), Cu (13.01 mg/kg) and Zn (17.53 mg/kg). Plant fractions were significantly (P<0.05) influenced by the anti-nutritional factors. Leaf fraction had higher (P<0.05) contents of phytate (0.79%), oxalate (0.60%), tannins (0.60%), trypsin inhibitor (15.98 mg/g) and dhurrin (6.97 μg/g). Post in-vitro characteristics were not significantly (P>0.05) influenced by varieties. Leaf fractions had higher (P<0.05) in-vitro organic matter digestibility (47.39%) IOMD compared to stem (39.65%). Conclusively, all the varieties of sorghum exhibited a good agronomic indices and nutritional value that characterized sorghum as a fodder in humid tropic. Farmers should be encouraged to use leaf fractions of sorghum than stem. Samsorg-17 is recommended because of height.

Keywords: Agronomic indices, Fodder, Nutritional value, Ruminant production, Sorghum

Introduction

Inability of rangelands to support livestock needs and production in particular due to population exploitation and infrastructural development has compelled the pasture agronomists to pay more attention to cultivation of forage plants. Fodder production can be one of the most economical and viable strategy of feeding ruminant animals. Fodder is an agricultural term for animal feed, and fodder trees and shrubs are those plants (shoots or sprouts, especially tender twigs and stems of woody plants with their leaves, flowers, fruits or pods) that are raised, used and managed to feed livestock. Fodder plants are plants which are grown in order to provide the nutritional needs of animals. Babayemi and Bamikole (2006) opined that fodder and shrubs are important components of ruminant diet and they have been found to play some important roles in the nutrition of grazing animals in areas where few or no alternatives are available.

Sorghums have been shown to have a great potential to provide both feed and food in the humid areas. It is therefore important to develop and evaluate more sorghum varieties suited for humid areas. Sorghum serves as a source of nourishment for ruminant livestock in many production systems due to its drought and disease resistance and high forage characteristics (Kallah *et al.,* 1999). Samsorg-17 popularly known as Short Kaura has a maturity period of 165-175 days for grains whose seed colour is yellow with a potential grain yield of 2.5-3.5 ton/ha. The agronomic and forage potential of these sorghum varieties is encouraging. For example, Munza *et al*. (2018) reported a leaf length of 66.27 cm and leaf width of 5.73 cm for Samsorg-16 at Shika, Nigeria. One of the major factors limiting the utilization of sorghum forage, especially till the flowering stage, is the production cyanogenic glycoside, i.e., dhurrin, which is toxic to the feeding livestock (Haskins *et al*., 1987). Hydrocyanic acid (HCN) toxicity due to hydrolysis of dhurrin from sorghum forage in the rumen of the cattle causes their death. Leaves and stems of all sorghum species contain dhurrin. Other plants also produce HCN, but in lesser amounts, whereas in sorghum it is produced in larger amount which is hazardous to the animal species (Kojima *et al*., 1979). This study therefore was undertaken to assess the effects of agronomic indices and nutritional value for plant fractions of three varieties of sorghum fodder in late stages of growth in humid tropics.

Materials and methods

Experimental site and land preparation

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° 58' – 7° 60'E and longitudes 4° 40' – 4°55'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 (Lamidi and Ogunkunle, 2016). The routine soil analysis of 0 - 15 cm depth (Udom and Lale, 2017) 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.

Three varieties of sorghum seeds (Samsorg-17, 44 and 45) were obtained from the *National Animal Production Research Institute, Shika, Ahmadu Bello University, Zaria, Kaduna State, Nigeria.* The land was cleared and beds 4m by 6 m was used for each variety of the sorghum and replicated into three.

Five (5) seeds were planted on bed at 2 cm depth at plant spacing of 15 x 85 cm using the planting dates and later thinned to two (2) plants/ stand after twelve (12) days so as to have a uniform plant population of (13,333 stands/ha). A uniform dose of 120 kg/ha NPK (20:10:10) was applied to grain sorghum seedlings at 2 and 5 weeks after sowing as first and second doses, respectively. Weeding was done manually as the need arises.

Agronomic data collection

Measurement of plant height

Measurement of the height of the sorghum was done by measuring from the base of the plant to where the last leaf on the stem emerges with the aid of a meter rule on the three varieties of sorghum fodder

Measurement of leaf length

Leaf length of the sorghum varieties was done by measuring the length of the leaf from its tip to the ligule. This was done with the aid of a 30cm meter rule on the three varieties of sorghum fodder.

Measurement of leaf width

Measurement of the leaf width of the sorghum varieties was done by measuring the length of the leaf half way and at that point measuring its width. This was done with aid of a 30cm meter rule on the three varieties of sorghum fodder.

Chemical analysis

Proximate composition

The dry matter, crude protein, ether extract and ash contents of the milled grass sample were determined according to A.O.A.C. (2000). Non-fibre carbohydrate was calculated as NFC = 100 - (CP + Ash + EE + NDF). Mineral contents such as calcium, potassium, sodium, zinc, copper, magnesium and Phosphorus were determined by AOAC (2005) methods using the Atomic Absorption Spectrophotometer.

Fibre fractions and anti-nutritional factors analysis

Neutral detergent fibre (NDF), Acid detergent fibre (ADF) and Acid detergent lignin (ADL) of the milled silage sample were determined with the procedure of Van Soest *et al.* (1991). Cellulose content was taken as the difference between ADF and ADL while hemicellulose content was also calculated as the difference between NDF and ADF. Tannin and saponin contents were determined according to the methods described by Lamidi and Ogunkunle (2015). Oxalate was according to Munro (2000) while phytate was determined as described by Prokopet and Unlenbruck (2002). Dhurrin by a method modified from Halkier and Møller (1989). Trypsin inhibitor was according to Kakade *et al.* (1974).

***In vitro* gas production procedures**

Rumen fluid was collected from three (3) West African dwarf goats by using suction tube prior to morning feeding. The method of collection was as described by Babayemi *et al*. (2006). The goats were previously fed with 40% concentrate (growers mash) and 60% *Pennisetum purpureum*. The rumen liquor was collected into thermo flask that had been pre-warmed to a temperature of 39 ^{0}C. Incubation procedure was as reported by Menke and Steingass (1988). Two hundred (200) mg of the milled samples were weighed into calibrated transparent plastic syringes with fitted silicon tube. The rumen fluid was taken to the laboratory, sieved with four layers' cheese cloth and added to the anaerobic buffer medium. Thirty (30) ml of the mixture was then added to each syringe in ratio 1:4 (v/v) respectively. The mixture was handled under continuous flushing with CO_2 and immediately dispensed using 50 ml plastic calibrated syringes. The syringe was tapped and pushed upward by the piston in order to eliminate air completely in the inoculums. The silicon tube in the syringe was then tightened by a metal clip so as to prevent escape of gas. Incubation was carried out at 39^{0}C and the volume of gas production was measured at 3, 6, 9, 12, 15, 18, 21, and 24 hours.

Preparation of buffer

A buffered mineral solution was prepared consisting of $NaHCO_3$ + Na2HPO$_4$ + KCl + NaCl + $MgSO_4$. 7H_2O + CaCl2. 2H_2O (Makkar, 2003).

Methane determination

The volume of methane gas produced from each sample was determined by dispensing 4 ml of 40 % NaOH (40 g of NaOH in 100g of distilled water) to the sample at the end of 24 hours of incubation. The tip of 5 ml syringe containing the 4ml NaOH was introduced into the incubated syringes through the silicon tube just above the metal clip. The clip was carefully unscrewed and the reagent introduced. The NaOH was added to absorb CO_2 produced during the process of fermentation and the remaining gas was recorded as methane according to Fievez *et al.* (2005). The syringe was then turned upside down for the reading of CH_4 level.

Calculations

Hemicellulose was calculated as NDF – ADF, Cellulose was calculated as ADF – ADL, Non-fibre carbohydrates were calculated as (100 <(CP + EE + Ash + NDF).

In vitro organic matter digestibility (OMD) was estimated as;

OMD = 14.88 + 0.889 GV + 0.45 CP + 0.651 ash (Menke and Steingass, 1988).

Short-chain fatty acids (SCFA) was estimated as;

SCFA = 0.0239 GV - 0.0601 (Getachew *et al*., 2000).

Metabolizable energy (ME) was calculated as;

ME = 2.20 + 0.136 GV + 0.057 CP + 0.00029 CF (Menke and Steingass, 1988).

The Fermentation Efficiency (FE) was calculated as;

Fermentation Efficiency (FE) = Dry matter Digestibility (g/kg)/ Total Gas Volume (mL/g).

Statistical analysis

The experiment was a 2 x 3 factorial scheme (2 plant fractions i.e. Stem and leaf) and 3 varieties of sorghum i.e. Samsorg-17, 44 and 45) fitted into 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 (2002) package.

Results and discussion

Table 1 shows the effects of age and varieties on the agronomic indices of sorghum fodder at late stages of growth. There was a significant difference ($P<0.05$) in all the agronomic indices across the weeks of growth. Highest plant height (PH) was recorded at 16 weeks after planting (WAP). Least ($P<0.05$) PH was observed at 10 WAP. The leaf length (LL), leaf width (LW), stem circumference (SC), fresh leaf number (FLN) and dried leaf number (DLN). Similar ($P>0.05$) values were recorded for the agronomic indices across the varieties of sorghum. The values ranges from 107.00 – 131.25cm, 86.35 – 91.73cm, 8.00 – 22.58cm, 9.75 – 11.00 and 2.75 – 3.50 for PH, LL, LW, SC, FLN and DLN, respectively. The steady increase in the plant height and other agronomic parameters of the sorghum fodder with advancing age of growth is in line with earlier report (Lamidi and Aina, 2013). The plant height as a plant growth character 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 (Lamidi and Aina, 2013). Samsorg-17 is the shortest compared to other varieties, this in line with the report of Munza *et al*. (2019).

The effect of varieties and plant fractions on proximate composition of sorghum fodder at late stage of growth is shown in Table 2. There was no significant different ($P>0.05$) in DM, CP, EE, ash, NDF and NFE among the varieties. Samsorg-45 was significantly higher ($P<0.05$) in CF compared to Sarmsorg-17 and Samsorg-45. The NFE was significantly higher ($P<0.05$) in Samsorg-17 (59.71%) followed by Samsorg-44 (48.49%) and Samsorg-45 had least 40.71%. There was a significant difference ($P<0.05$) on the CP, CF, ash, NDF and NFE among the plant fractions of the sorghum fodder. Leaf fraction had higher ($P<0.05$) contents of CP (17.53%), and ash (10.69%) while stem fraction had higher ($P<0.05$) contents of CF (35.42%),

Table 1: Effects of age and varieties on the agronomic indices of three varieties of sorghum at late stages of growth

		Agronomic indices				
Age (wk.)	PH (cm)	LL(cm)	LW (cm)	SC (cm)	FLN	DLN
10	92.17^{c}	92.47^{a}	9.07^{b}	9.00^{b}	12.00^{a}	1.67^{c}
12	111.27^{b}	88.67^{b}	8.70^{b}	7.27^{b}	11.00^{b}	4.67^{a}
14	128.00^{b}	89.47^{b}	8.53^{b}	7.83^{b}	11.00^{b}	4.67^{a}
16	148.33^{a}	86.00^{c}	23.50^{a}	29.67^{a}	7.33^{c}	2.67^{b}
SEM	23.03	5.62	6.78	10.04	1.01	0.87
P-value	0.00	0.00	0.00	0.00	0.00	0.00
LOS	**	**	**	**	**	**
Varieties						
Samsorg-17	107.00^{c}	89.38	9.63	9.75	11.00	2.75
Samsorg-44	125.63^{b}	91.73	9.55	8.00	10.25	3.50
Samsorg-45	131.25^{a}	86.35	8.18	22.58	9.75	2.75
SEM	22.81	5.38	6.27	9.14	1.24	0.76
P-value	0.00	0.78	0.41	0.50	0.78	0.73
LOS	**	NS	NS	NS	NS	NS

$^{a, b, c}$ Means on the same column with different superscripts differ significantly (P<0.05)
PH=Plant height; LL=Leaf length: LW= leaf width; SC= Stem circumference; FLN= Fresh leaf number; DLN= Dried leaf number; SEM= Standard error of mean; LOS= Level of significant; NS= Not significant; **= Significantly different.

Table 2: Effect of varieties and plant fractions on proximate composition of sorghum fodder at late stage of growth

		Parameters					
Varieties	DM	CP	EE	CF	Ash	NDF	NFE
Samsorg-17	88.09	12.16	2.76	27.91^{b}	7.09	66.50	59.71^{a}
Samsorg-44	88.38	12.24	2.96	27.51^{b}	8.48	67.84	48.49^{b}
Samsorg-45	88.11	12.58	3.01	36.43^{a}	7.28	68.63	40.71^{c}
SEM	0.46	0.54	0.53	0.47	0.55	0.47	0.29
P-value	0.88	0.84	0.94	0.00	0.19	0.02	0.00
LOS	NS	NS	NS	**	NS	NS	**
Plant fractions							
Leaf	88.61	17.53^{a}	3.71	25.72^{b}	10.69^{a}	60.45^{b}	48.74^{b}
Stem	87.77	7.12^{b}	2.11	35.42^{a}	4.60^{b}	74.86^{a}	50.75^{a}
SEM	0.38	0.44	0.43	0.38	0.45	0.38	0.24
P-value	0.14	0.00	0.23	0.00	0.00	0.00	0.00
LOS	NS	**	NS	**	**	**	**

$^{a, b, c}$ Means on the same column with different superscripts differ significantly (P< 0.05)
DM=Dry matter; CP= Crude protein; EE= Ether extract: NDF= Neutral detergent fibre; NFC= Non-fibre carbohydrate; SEM= Standard error of mean; LOS= Level of significant; NS= Not significant; **= significantly different.

NDF (74.86%) and NFC (50.75%). The DM for the varieties of sorghum fodder (88.09 – 88.38%) and plant fractions (87.77 – 88.61%) recorded in this study can be compared favorably with other forage and feedstuff reported by Lamidi and Ogunkunle (2015) to feed goat in South-west, Nigeria. The CP value for sorghum varieties (12.16 – 12.58%) and plant fractions (7.14 – 17.53%) recorded in this study contains the required CP for microbial fermentation. McDonald *et al.* (1995) suggested threshold of about 7 to 8% CP to guarantee sufficient utilization of feed.

Therefore, the experimental treatments would provide adequate nitrogen requirement by rumen micro-organism to maximally digest the main components of dietary fiber leading to the production of volatile fatty acid (Trevaskis *et al*., 2001; Lamidi, 2009) which in turn facilitates microbial protein synthesis (Lamidi and Aina. 20013). The NFE is an indicator of carbohydrate content of feedstuff or ingredient that is soluble or easily digested and available for animal. It implies that the soluble carbohydrate could support the production of volatile fatty acids in the rumen during fermentation (Blummel *et al*., 1997). The higher contents of the nutrients concentrated in leaf fractions of the sorghum fodder was supported by Hamilton *et al.* (1970) and Lamidi and Aina (2013) who reported that green leaf content of a pasture can support high milk, meat and wool production. The higher NDF value obtained for varieties and plant fractions of sorghum fodder in this study is an indication that it will be a useful feeding stuff as good energy source in ruminant animal production as NDF is preferred measure for ruminant feeds and dietary balancing programs (Van Soest *et al*., 1991).

Table 3 shows the effect of varieties and plant fractions on fibre fractions of sorghum fodder. There were no significant effects of sorghum varieties on acid detergent fiber, hemicellulose and cellulose. Acid detergent fiber was significantly (P<0.05) influenced. Samsorg-45 had higher (P<0.05) (48.90%) content of ADF followed by Samsorg-44 (47.87%), least was recorded in Samsorg-17 (46.57%). The acid detergent fiber, acid detergent lignin, hemicellulose and cellulose were significantly influenced in the fractions of sorghum. Stem had higher (P<0.05) contents of all fibre fractions except ADF. The level of ADF is an indicator of digestibility. The higher the ADF, the less digestible the feed and less energy it contains (Mc Donald *et al*., 1991). Shroeder (2004) states that as the ADF content increases, forage digestibility decreases. Ball *et al*. (2007) classified forages with ADF values greater than 43.00 – 45.00% as low quality forages. Based on this the ADF recorded in this study, especially on stem fractions of the sorghum (52.96%) indicated that stem of the sorghum fodder at late stages of growth is of low quality and should be fortified with other feedstuffs so as to improve its nutritional value.

Table 3: Effect of varieties and plant fractions on fibre fractions of sorghum fodder

	Parameters			
Varieties	ADF	ADL	HEM	CEL
Samsorg-17	46.57[c]	20.97	20.18	25.65
Samsorg-44	47.87[b]	21.53	19.97	26.34
Samsorg-45	48.90[a]	22.15	19.73	27.89
SEM	0.48	0.49	0.49	1.00
P-value	0.02	0.27	0.82	0.30
LOS	**	NS	NS	NS
Plant fractions				
Leaf	42.60[a]	19.73[b]	17.86[b]	23.63[b]
Stem	52.96[b]	23.36[a]	22.06[a]	29.62[a]
SEM	0.39	0.40	0.41	0.82
P-value	0.00	0.00	0.00	0.00
LOS	**	**	**	**

[a, b, c] Means on the same column with different superscripts differ significantly (P<0.05)

ADF=Acid detergent fiber; ADL= Acid detergent lignin; HEM=Hemicellulose; CEL= Cellulose; SEM= Standard error of mean; LOS= Level of significant; NS= Not significant; **= significantly different

Effect of varieties and plant fractions on minerals profile of sorghum fodder is shown in Table 4. There was a significant (P<0.05) influence of varieties on the Ca, P, Fe, Cu and Mn. Similar (P>0.05) contents of K, Na, Mg and Zn was recorded for sorghum varieties. There was significant effect (P<0.05) of plant fractions on the mineral profile. Leaf fraction of the sorghum had higher (P<0.05) contents of P (1.06%), K (0.37%), Na (1.75%), Cu (13.01 mg/kg) and Zn (17.53 mg/kg). Calcium (3.50%), Mg (1.23%) and Fe (25.72 mg/kg).

Mineral elements play special roles in the proper functioning of the rumen microorganisms especially those which digest plant cellulose, utilization of energy, protein and metabolism among other functions (McDowell *et al*., 1993). The values observed for Ca, Mg, K, Na and P were within the values reported by Adewumi *et al.* (2019). The phosphorus content was within the range (0.4-0.9g/day) required for growing goats (Fjell *et al*., 1991). The calcium concentration within varieties and the plant fractions was higher than the daily requirement for goats (0.5-1.1g/ca/day) reported by (Ishiaku *et al*., 2016).

Table 4: Effect of varieties and plant fractions on minerals profile of sorghum fodder

Varieties	Ca(%)	P(%)	K(%)	Na(%)	Mg%	Fem g/kg	Cu(mg/Kg)	Mn(mg/kg)	Zn(mg/kg)
17	2.78[b]	0.61[c]	0.28	1.22	1.18	27.79[b]	2.76[c]	7.09[c]	12.16
44	2.75[b]	0.85[a]	0.29	1.24	1.18	27.51[b]	9.75[b]	8.49[a]	12.24
45	3.60[a]	0.73[b]	0.30	1.25	1.19	36.43[a]	10.18[a]	7.28[b]	12.58
SEM	0.01	0.07	0.03	0.04	0.09	0.13	0.60	0.18	0.19
P-value	0.00	0.00	0.41	0.12	0.85	0.00	0.00	0.00	0.32
LOS	**	**	NS	NS	NS	**	**	**	NS
Fractions									
Leaf	2.60[b]	1.06[a]	0.37[a]	1.75[a]	1.03[b]	25.72[b]	13.01[a]	10.63[a]	17.53
Stem	3.50[a]	0.46[b]	0.21[b]	0.71[b]	1.23[a]	35.42[a]	2.11[b]	4.59[b]	7.12
SEM	0.01	0.04	0.01	0.01	0.03	0.10	0.05	0.15	0.16
P-value	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LOS	**	**	**	**	**	**	**	**	**

[a, b, c] Means on the same column with different superscripts differ significantly (P<0.05)

17= Samsorg-17; 44=Samsorg-44; 45= Samsorg-45; SEM= Standard error of mean; LOS= Level of significant; NS= Not significant; **= Significantly different

Table 5 shows the effect of varieties and plant fractions on anti-nutritional factors of sorghum fodder. The varieties did not affect (P>0.05) the anti-nutritional factors. The plant fractions were significantly (P<0.05) influenced the anti-nutritional factors. Leaf fraction had higher (P<0.05) contents of phytate (0.79%), oxalate (0.60%), tannins (0.60%), trypsin inhibitor (15.98 mg/g) and dhurrin (6.97 µg/g). Stem had higher (P<0.05) contents of saponins (0.72%).

Diagayete and Hugg (1981) reported that, sheep and cattle can tolerate 2 – 5% dietary tannin while Nastis and Malecheck (1981) reported that goats can tolerate about 9% tannin in their diets. The saponins value recorded in this study were ranged for varieties (0.61 – 0.64%) and plant fractions (0.54 – 0.72%), feedstuff containing saponins had been shown to be defaunating agent (Teferedegne, 2000) and capable of reducing methane production (Babayemi *et al*., 2004). Alalade *et al*. (2019) reported that saponin have effect on erythrocyte haemolysis, reduction of blood and liver cholesterol, depression of growth rate, bloat (ruminant) inhibition of smooth muscle activity, enzyme inhibition and reduction in nutrient absorption. Saponin have been reported to alter cell wall permeability and therefore to produce some toxic effect when ingested (Belmar *et al*., 1999).

Table 5: Effect of varieties and plant fractions on anti-nutritional factors of sorghum fodder

Varieties	Phytate	Oxalate	Tannins	Saponins	Trypsin inhibitor (mg/g)	Dhurrin
17	0.50	0.32	0.03	0.64	8.20	4.44
44	0.53	0.35	0.03	0.61	8.48	4.45
45	0.54	0.38	0.04	0.63	8.91	4.55
SEM	0.08	0.06	0.01	0.08	0.65	0.71
P-value	0.94	0.81	0.48	0.98	074	0.99
LOS	NS	NS	NS	NS	NS	NS
Plant fractions						
Leaf	0.79[a]	0.60[a]	0.06[a]	0.54[b]	15.98[a]	6.97[a]
Stem	0.25[b]	0.10[b]	0.00[b]	0.72[a]	1.07[b]	1.98[b]
SEM	0.07	0.51	0.00	0.07	0.53	0.58
P-value	0.00	0.00	0.00	0.00	0.00	0.00
LOS	**	**	**	**	**	**

[a, b] Means on the same column with different superscripts differ significantly ($P<0.05$)

17= Samsorg-17; 44= Samsorg-44; 45= Samsorg-45; SEM= Standard error of mean; LOS= Level of significant; NS= Not significant; **= significantly different

Effect of varieties and plant fractions on 24 hours' gas production and post *in vitro* digestibility characteristics of sorghum fodder in humid tropics shown in Table 6. There were no significant effects for varieties of sorghum and plant fractions on the 24 hr. gas production, methane production, methane/gas production ratio, in-vitro dry matter digestibility, fermentation efficiency, methane reduction, short chain fatty acid and metabolizable energy. The *in-vitro* organic matter digestibility was significantly influenced by the plant fractions. Leaf fractions had higher ($P<0.05$) (47.39%) IOMD compared to stem (39.65%).

The similar gas production value recorded across the varieties of sorghum and the fractions (leaf and stem) can be attributed to its high content of degradable carbohydrates which is supported by Akinyemi *et al*. (2019). Gas produced in *in-vitro* fermentation reflects the extent of feed fermentation and digestibility (Akinyemi *et al*., 2019). The estimation of the Metabolizable energy (ME) values is valuable for purposes of ration formulation and to set economic value of feed for other purposes (Akinyemi *et al*., 2019). It is also a good index for measuring the quality of feeds particularly forages.

Table 6: Effect of varieties and plant fractions on 24 hours' gas production and post *in vitro* digestibility characteristics of sorghum fodder

Varieties	24hr GP	CH_4	CH_4GV	IDMD	FE	CH_4red	SCFA	ME	OMD
Samsorg-17	19.50	15.50	0.80	68.92	3.56	82.97	0.41	5.55	42.12
Samsorg-44	22.33	16.67	0.73	74.07	3.53	81.68	0.47	5.94	45.56
Samsorg-45	20.00	14.67	0.73	68.57	3.49	83.89	0.42	5.65	42.88
SEM	2.09	1.99	0.04	4.31	0.27	2.19	0.05	0.29	1.84
P-value	0.61	0.78	0.49	0.61	0.98	0.78	0.60	0.61	0.41
LOS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Fractions									
Leaf	20.11	15.00	0.73	67.20	3.51	83.51	0.42	5.94	47.39[a]
Stem	21.11	16.22	6.77	73.83	3.53	82.17	0.44	5.49	39.65[b]
SEM	2.05	1.63	0.04	3.52	0.22	1.79	0.04	0.23	1.50
P-value	0.69	0.61	0.44	0.20	0.95	0.61	0.69	0.19	0.00
LOS	NS	NS	NS	NS	NS	NS	NS	NS	**

[a, b] Means on the same column with different superscripts differ significantly ($P<0.05$

24hr GP=24 hr. gas production; CH4= Methane production; CH4GV= Methane/gas production; IDMD= *In-vitro* dry matter digestibility; FE= Fermentation efficiency; CH4red= Methane reduction; SCFA= Short chain fatty acid; ME= Metabolizable energy; IOMD= *In-vitro* organic matter digestibility; SEM= Standard error of mean; SEM= Standard error of mean; LOS= Level of significant; NS= Not significant; **= significantly different

Conclusion

Conclusively, all the varieties of sorghum exhibited a good agronomic indices and nutritional value that characterized sorghum as a fodder plant in humid tropic. Farmers should use leaf fractions of sorghum than the stem. Samsorg-17 is recommended because of height.

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