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Full Length Research Paper

Seasonal variation in the anti-nutrient and mineral components of some forage legumes and grasses

Onyeonagu, C. C.*, Obute, P. N. and Eze, S. M.

Department of Crop Science, University of Nigeria, Nsukka, Nigeria.

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This study was conducted in Nsukka, Nigeria to evaluate the effect of season of harvest (rain and dry) on the anti-nutrient and mineral components of four herbaceous legumes (*Calapogonium mucunoides*, *Centrosema pubescens*, *Stylosanthes guyanensis* and *Pueraria phaseoloides*) and four forage grasses (*Panicum maximum*, *Pennisetum purpureum*, *Cynodon nlemfuensis* and *Andropogon gayanus*). The grasses were analyzed separately from the legumes. A 2 × 4 factorial arrangement laid out in completely randomized design (CRD) was used. Species, season and their interaction significantly (P < 0.05) influenced the anti-nutrient and mineral concentrations in the forage grasses and legumes. The alkaloid, hydrogen cyanide (HCN), oxalate, phytate, saponin, tannin, nitrogen (N), phosphorus (P) and potassium (K) contents of the grasses and legumes were significantly (P < 0.05) higher during the rainy than in the dry season. The concentrations of N, P and K varied significantly (P<0.05) among the legumes and between the grass species. *C. mucunoides* harvested during the rainy season significantly yielded higher percentage N compared with other legumes while *P. phaseoloides* harvested during the rainy season which had higher concentration of K than other legumes in any season. *P. maximum* harvested during the rainy season significantly produced higher N content compared with other grasses in any season while *P. purpureum* harvested in the rainy season significantly gave higher percentage of K and P compared with other grass species in any season.

Key words: Alkaloid, hydrogen cyanide, oxalate, saponin, tannin, minerals, grasses legumes, season.

INTRODUCTION

Livestock production in Nigeria depends on natural pastures with low yield and poor quality forage materials (Onwuka et al., 1989; Abubakar and Mohamed, 1992; Osagie, 1998; Tian et al., 1998). The supply of nutrients to animals can be improved by cultivation of promising tropical forage species (Bayble et al., 2007). The quality of any forage material depends to some extent on the presence or absence of anti-nutritional factors. The anti-nutrient components of forage materials limit the availability and utilization of nutrient in the animal body (Gohl, 1981; Tecon and Jackson, 1985; Adesogan et al., 2006). Anti-nutrient factors are those substances generated in the natural feedstuffs by the normal metabolism of species, which exert effects contrary to optimum nutrition (Aganga and Tshwenyane, 2003; Allen and Segarra, 2001).

The concentrations of anti-nutrient factors in forage species depend not only on the prevailing seasonal and environmental conditions but also on the individual plant species (Love et al., 1994; Pandey et al., 2011; Onyeonagu and Ukwueze 2012). The performance of any livestock depends on feed availability, nutrient content, feed intake, digestibility and metabolism of the feed digested (Collins et al., 1988). Anti-nutrients have been found to be antagonistic to all these factors mentioned above (Kumar and Vaitiyanathan, 1990). Seasonal variations affect forage nutrient composition and this affect the feed intake, digestibility and energy released to farm animals after its consumption (Aganga and Tshwenyane, 2004; Adesogan et al., 2006). The constraints posed by dry season on continual availability of pasture to livestock in the tropics, has been a matter of

*Corresponding author. E-mail: onyeonagu@yahoo.com.

concern in animal production. Dry season is a key factor that predisposes ruminants fed with standing hay and low protein roughages to consistent weight loss (Babayemi and Bamikole, 2006). Blakely and Blade (1994) asserts that the climate of an area affects the nutrient composition of the forage species growing in that area.

Some studies have been carried out to test the effects of cutting frequency and nitrogen fertilizer application on anti-nutrient components of grass species (Onyeonagu and Ukwueze, 2012) and the effect of source (location) of collection on the anti-nutrient components of some browse plants found in Nsukka, derived savanna of Nigeria (Agbo, 2008). There is scanty information on the effect of season of harvest on the concentrations of anti-nutrient and mineral components of forage grasses and legumes commonly found in Nigeria. This research was therefore, undertaken to determine the effect of season on the concentrations of anti-nutrient and mineral components of forage grasses and legumes found in Nsukka, derived savanna zone of Nigeria.

MATERIALS AND METHODS

The experiment was conducted on a pasture ground established in 2006 at the Teaching and Research Farm of the Department of Crop Science, Faculty of Agriculture, University of Nigeria, Nsukka (latitude 06° 52′ N and longitude 07° 24′ E and on altitude of 447.2 m above sea level). Nsukka is characterized by low land humid tropical conditions and the soil is classified as an ultisol (Asiegbu, 1989). The pasture ground was used for cutting experiment in 2006 and 2007 and was allowed to fallow before sample collections in 2008 (that is, from September to December, 2008).

Sample collection

Eight forage species comprising four grasses namely: Guinea grass (*Panicum maximum*), elephant grass (*Pennisetum purpureum*), giant star grass (*Cynodon nlemfuensis*) and Northern Gamba grass (*Andropogon gayanus*) and four legume plants namely: Calapo (*Calapogonium mucunoides*), Centro (*Centrosema pubescens*), *Cook stylo* (*Stylosanthes guyanensis*) and tropical kudzu (*Pueraria phaseoloides*) were collected on the 25th of every month from the pasture land and its surroundings. Sampling lasted for four months from September to December 2008. Samples collected in September and October were bulked together according to species and considered for rainy season collection, while November and December collections represented dry season collection. Samples were dried to constant weights in a forced air oven at 80°C and grinded using Thomas Wiley lab. Mill (Mode 4) and stored in air-tight nylon papers.

Chemical evaluation

Alkaloid content was determined using the gravimetric method as described by Harbone (1973). Hydrogen cyanide was determined using the method as described by Onwuka (2005). The oxalate, saponin, tannin, P and K were determined using the methods described by Pearson (1976). Phytate content determination was done using the method as described by Oberleas (1973). Determination of nitrogen (N %) was according to the Micro Kjeldahl distillation method as described by Pearson (1976).

Meteorological data

Meteorological data of rainfall, rain days, ambient temperature and relative humidity were collected from Meteorological Station Department of Crop Science, University of Nigeria, Nsukka.

Statistical analysis

A 4 × 2 factorial arrangement laid out in completely randomized design (CRD) with two replications was used. The grasses were analyzed separately from the legumes. All data collected were statistically analyzed using the procedure outlined by Steel and Torrie (1980) for factorial experiment in a completely randomized design (CRD) using GenStat (2009) statistical package. Separation of treatment for statistical significance was done using the Fishers' least significant difference (F-LSD) according to Obi (1986).

RESULTS

Species, season and their interaction show no significant effect on grass alkaloid content (Table 1). The hydrogen cyanide (HCN), oxalate and phytate contents of the grass species were significantly ($P < 0.05$) higher in rainy than in dry season. The concentrations of all the anti-nutrient factors varied significantly ($P < 0.05$) among the grass species. The highest HCN content was obtained in *Andropogon* g*ayanus* followed by *Cynodon nlemfuensis*, *Panicum maximum* and *Pennisetum purpureum*. The oxalate content of *Pennisetum purpureum* was significantly ($P < 0.05$) higher than those of other grasses. *Andropogon gayanus* had the lowest oxalate content, which was statistically ($P < 0.05$) similar with that from *Cynodon nlemfuensis*. The phytate concentration obtained from *Andropogon gayanus* was significantly ($P < 0.05$) higher than the values of other grass species, followed by *Cynodon nlemfuensis*, *Panicum maximum* and then *Pennisetum purpureum*. *Pennisetum purpureum* yielded significantly higher saponin content than other grasses followed by *Cynodon nlemfuensis*, *Panicum maximum* and *Andropogon gayanus*. There were significant ($P < 0.05$) season x species interaction effects on all the grass anti-nutrient factors studied. *Andropogon gayanus* harvested in the rainy season significantly produced the highest HCN, phytate and tannin contents compared with other grasses irrespective of the season. *Panicum maximum* harvested in the rains significantly gave higher oxalate content than other grasses but had similar effect with *Pennisetum purpureum* harvested at any season. The lowest concentration of saponin was obtained in *Andropogon gayanus* harvested in the rains while *Pennisetum purpureum* harvested during dry season significantly yield the highest concentration of saponin compared with other grasses irrespective of the season.

The alkaloid, phytate, saponin and tannin contents of

Table 1. Effect of species and season on anti-nutrient components (mg/100 g) of forage grasses.

Species	Alkaloid Rain	Alkaloid Dry	Alkaloid Mean	Hydrogen cyanide Rain	Hydrogen cyanide Dry	Hydrogen cyanide Mean	Oxalate Rain	Oxalate Dry	Oxalate Mean	Phytate Rain	Phytate Dry	Phytate Mean	Saponin Rain	Saponin Dry	Saponin Mean	Tannin Rain	Tannin Dry	Tannin Mean
Andropogon gayanus	3.20	2.91	3.06	2.81	1.99	2.40	3.28	3.29	3.28	22.74	8.23	15.49	0.70	0.91	0.81	0.52	0.27	0.40
Cynodon nlemfuensis	3.10	1.11	2.10	2.48	1.85	2.16	3.29	3.29	3.29	14.74	10.75	12.75	1.20	0.80	1.00	0.32	0.23	0.28
Panicum maximum	3.20	0.90	2.05	2.25	1.75	2.00	4.38	3.28	3.83	10.73	9.74	10.24	0.85	0.96	0.90	0.12	0.21	0.16
Pennisetum purpureum	2.40	2.99	2.70	1.78	1.38	1.58	4.37	4.37	4.37	9.75	8.49	9.12	0.75	1.51	1.13	0.21	0.20	0.21
Mean	2.98	1.98	2.48	2.33	1.74	2.04	3.83	3.56	3.69	14.49	9.30	11.90	0.88	1.04	0.96	0.29	0.23	0.2

	Alkaloid	Hydrogen cyanide	Oxalate	Phytate	Saponin	Tannin
F-LSD $_{0.05}$ for comparing 2 species means (S)	-	0.16	0.018	0.013	0.017	0.012
F-LSD $_{0.05}$ for comparing 2 season means (W)	-	0.011	0.013	0.009	0.012	0.008
F-LSD $_{0.05}$ for comparing 2 S x W means	-	0.022	0.025	0.018	0.024	0.017

-, Not significant at 0.05 probability level.

legumes harvested in the rains were significantly (P < 0.05) higher than those harvested in the dry season (Table 2). The concentrations of HCN and oxalate were significantly higher among the legumes harvested in the dry than in the rainy season. *C. mucunoides* and *C. pubescens* had statistically (P < 0.05) similar alkaloid content that was significantly (P < 0.05) higher than the value from *Pueraria phaseoloides* or *Stylosanthes guyanensis* which did not differ with each other. *Pueraria phaseoloides* significantly produced higher HCN content than *Centrosema pubescens* or *Stylosanthes guyanensis,* but was similar to *Calapogonium mucunoids*. *Stylosanthes guyanensis* and *C. mucunoides* were statistically (P < 0.05) similar in their oxalate concentrations, which were significantly higher than those of the other legumes. *Pueraria phaseoloides* yielded significantly the lowest oxalate content compared with other legumes. The highest phytate content was obtained in *Centrosema pubescens* followed by *Pueraria phaseoloides*, *C. mucunoides* and then *Stylosanthes guyanensis*. The saponin concentration in *Stylosanthes guyanensis* was significantly (P < 0.05) higher than the values recorded for other legumes followed by *Calapogonum mucunoides*, *Centrosema pubescens* and *Pueraria phaseoloides*. *Pueraria phaseoloides* significantly yielded the highest tannin content compared with other legumes followed by *Stylosanthes guyanensis*, *Calapogonium mucunoides* and then *Centrosema pubescens*.

Season × species interaction show significant (P < 0.05) effect on all the legume anti-nutrient contents studied. *C. mucunoides* and *Centrosema pubescens* collected during the rainy season had alkaloid contents that were significantly higher than those of other legume species collected at any season. *Pueraria phaseoloides* harvested in rainy season gave significantly the lowest HCN contents compared with other legumes at any section but had the highest HCN value when harvested in the dry season. *Centrosema pubenscens* harvested in the rains significantly produced the lowest oxalate content compared with other legumes harvested at any season. *Centrosema pubescens* obtained during the rainy season significantly produced the highest phytate content among the legumes while *Stylosanthes guyanensis* harvested during the same season had the lowest phytate content. The saponin content of *Stylosanthes guyanensis* collected during the rainy season was significantly (P < 0.05) higher than those of other legumes irrespective of the season. *Pueraria phaseoloides* harvested during the rainy season had saponin content that was significantly lower than those of other legumes harvested at any season. The tannin content of *Pueraria phaseolides* was significantly (P < 0.05) higher in the rainy season harvests than the values obtained in other legumes irrespective of the season except *Stylosanthes guyanensis* harvested in the rainy season.

The legumes harvested during the rainy season significantly (P < 0.05) had higher concentrations of potassium and nitrogen compared with the dry season harvests (Table 3). The % K obtained

Table 2. Effect of species and season on anti-nutrient components (mg/100 g) of forage legumes.

Species	Season																	
	Rain	Dry	Mean	Rain	Dry	Mean	Rain	Dry	Mean	Rain	Dry	Mean	Rain	Dry	Mean	Rain	Dry	Mean
	Alkaloid			Hydrogen cyanide			Oxalate			Phytate			Saponin			Tannin		
Calapogonium mucunoides	3.40	3.10	3.25	2.85	2.57	2.71	3.28	4.37	3.82	10.74	12.25	11.49	1.41	1.29	1.35	0.30	0.28	0.29
Centrosema pubenscence	3.40	3.10	3.25	2.26	2.27	2.26	2.19	5.01	3.60	20.75	17.75	17.50	1.75	0.84	1.30	0.12	0.13	0.13
Pueraria phaseoloides	2.60	2.41	2.50	1.97	3.74	2.85	3.29	3.28	3.29	19.25	15.75	17.50	0.70	0.81	0.75	0.55	0.46	0.50
Stylosanthes guyanensis	2.20	2.40	2.30	253	1.98	2.26	3.28	4.38	3.83	9.75	9.99	9.87	10.51	0.84	5.68	0.45	0.27	0.36
Mean	2.90	2.75	2.83	2.40	2.64	2.52	3.01	4.26	3.63	15.12	13.93	14.53	3.59	0.94	2.27	0.36	0.28	0.32

	Alkaloid	Hydrogen cyanide	Oxalate	Phytate	Saponin	Tannin
F-LSD $_{0.05}$ for comparing 2 species means (S)	0.018	0.015	0.012	0.015	0.013	0.012
F-LSD $_{0.05}$ for comparing 2 season means (W)	0.013	0.011	0.009	0.011	0.009	0.008
F-LSD $_{0.05}$ for comparing 2 S x W means	0.026	0.021	0.018	0.021	0.018	0.017

Table 3. Effect of species and season of harvest on the mineral contents (%) of four forage legumes.

Species	Season								
	Rain	Dry	Mean	Rain	Dry	Mean	Rain	Dry	Mean
	% Potassium			% Nitrogen			% Phosphorus		
Calapogonium mucunoides	0.99	0.78	0.88	3.78	2.52	3.15	0.53	0.31	0.42
Centrosema pubescens	1.09	0.85	0.97	3.61	3.51	3.56	0.31	0.69	0.50
Stylosanthes guyanensis	1.06	0.74	0.90	3.77	2.94	3.35	0.42	0.95	0.68
Pueraria phaseoloides	1.31	0.99	1.15	2.13	2.40	2.26	0.47	0.21	0.34
Mean	1.07	0.88	0.97	3.33	2.81	3.07	0.40	0.46	0.43

	% K	% N	% P
$LSD_{(0.05)}$ for comparing 2 season means (S)	0.003	0.036	0.003
$LSD_{(0.05)}$ for comparing 2 species means (P)	0.004	0.056	0.005
$LSD_{(0.05)}$ for comparing 2 S × P means	0.006	0.080	0.008

from *Pueraria phaseoloides* was significantly higher than the values from other legumes. *Calapogonium mucunoides* had the lowest % K compared with other legumes. *Pueraria phaseoloides* harvested during the rainy season gave the highest concentration of potassium compared with other legumes in any season. Among the legumes, *Centrosema pubescens* significantly gave the highest nitrogen content followed by *Stylosanthes guyanensis, Calapogonuim mucunoides* and *Pueraria phaseoloides*. The highest % N was obtained in *Calapogonium mucunoides* harvested during the rainy season while *Pueraria phaseoloides* harves ted during the rainy season gave the lowest % N

Table 4. Effect of species and season of harvest on the mineral contents (%) of four forage grasses.

Species	Season								
	Rain	Dry	Mean	Rain	Dry	Mean	Rain	Dry	Mean
	% Potassium			% Nitrogen			% Phosphorus		
Andropogon gayanus	0.89	0.53	0.71	2.80	1.11	1.96	0.05	0.53	0.29
Cynodon nlemfuensis	0.89	0.46	0.67	2.52	1.26	1.89	0.37	0.25	0.31
Panicum maximum	0.85	0.42	0.63	3.07	2.66	2.86	0.27	0.53	0.40
Pennisetum purpureum	1.49	0.92	1.21	2.67	1.54	2.10	1.38	0.81	1.09
Mean	1.05	0.66	0.85	2.52	1.46	2.00	0.56	0.50	0.53

	% K	% N	% P
$LSD_{(0.05)}$ for comparing 2 season means (S)	0.003	0.007	0.009
$LSD_{(0.05)}$ for comparing 2 species means (P)	0.005	0.011	0.015
$LSD_{(0.05)}$ for comparing 2 S × P means	0.007	0.015	0.021

Table 5. Meteorological data for Nsukka in 2008.

Month	September	October	November	December
Total annual rainfall (mm)	218.72	198.63	8.38	10.93
Rain days	19	11	2	2
Max. Air temp. (°C)	31.02	29.87	31.10	31.52
Min. Air temp. (°C)	25.12	20.87	22.00	21.58
Relative humidity (%)	78.21	76.35	74.80	72.94

value compared with other legume species. *Stylosanthes guyanensis* harvested during the dry season significantly produced the highest phosphorus concentration compared with other legumes.

Among the grasses, the rainy season harvests significantly ($P < 0.05$) had higher concentrations of potassium, nitrogen and phosphorus than dry season harvests (Table 4). *Pennisetum purpureum* significantly had the highest % K compared with other grasses. *Cynodon nlemfuensis* produced similar % K with *Panicum maximum* or *Andropogon gayanus. Pennisetum purpureum* harvested during the rainy season significantly ($P < 0.05$) gave the highest % K compared with other grasses in any season. *Panicum maximum* had significantly the highest % N compared with other grasses. *Panicum maximum* harvested during the rainy season significantly gave the highest concentration of N compared with other grasses in any season. *Pennisetum purpureum* significantly gave the highest percentage of phosphorus compared with other grasses.

Rainfall was more frequent and highest in September compared with October, November and December (Table 5). The maximum air temperature was high in the months of September, November and December. The relative humidity was relatively higher in September and October followed by November and December.

DISCUSSION

The significant effect of season on the anti-nutrient concentrations of the forage grasses and legumes observed in this study is in conformity with the report by Frutos et al. (2004). Earlier reports also illustrate the effects of environmental and seasonal factors as well as of phenological development on the concentration of anti-nutrients in forage species (Jones et al., 2010; Pandey et al., 2011; and Onyeonagu and Ukwueze, 2012). According to Frutos et al. (2004), seasonal variation clearly correlates with phenological stages of plants. Dung (2012) reported that alkaloid content of plant species was higher in the young-growing leaf material but decreased in concentration in the more mature leaf. Pandey et al. (2011) also reported a decreasing trend in the hydrogen cyanide (HCN) content of green sorghum fodder with advancement in age of the plant. The results of the present study agreed with those reports. The concentrations of alkaloid, HCN and most other anti-nutrients in this study were shown to be higher during the rainy season than in the dry season in both grass and legume species.

The concentrations of anti-nutrients varied significantly among the forage species as reported by Bamikole et al. (2004). Similarly, Baloyi et al. (2001) reported significant differences ($P < 0.05$) between some tropical forage legumes (*Vigna unguiculata L.*) Walp (cowpea), *Desmodium uncianatum* (silver leaf desmondium), *Stylosanthes guyanensis* and *stylosanthes scabra* (Fitzroy) and natural pasture (veld) hay in the condensed tannins. Ologhobo (2012) reported significant differences in the tannin content of 25 forage legumes collected from different locations in Nigeria, and noted that such differences could be genetical or due to cultural practices and soil composition. The mean values of alkaloids reported in this study for grasses (2.48 mg/100 g) and legumes (2.83 mg/100 g) were below the alkaloid content (6.32 mg/100 g) reported for Mexican sunflower (*Tithonia diversifolia*) (Ekeocha and Fakolade, 2012) and 55.65 mg/100 g reported for *Talinum Triangulare* in Nigeria (Aja et al., 2010). The mean values of alkaloid reported for grasses and legumes in this study were found to be very low compared with the 10 g ergot/kg above which, lameness occurred in cattle consuming alkaloid-rich forage materials (Scientific Panel on contaminants in food chain, 2005).

The mean HCN contents obtained in this study for grasses (2.52 mg/100 g) and legumes (2.04 mg/100 g) were found to be low compared with the values Okoli et al. (2003) reported for browse plants, which ranges from 1.52 mg/g (*Vernonia amygdalina*) to 6.40 mg/g (*palisota hirsute*). The HCN levels reported in this study are below the lethal dose of HCN for cattle and sheep as reported (Kumar, 2011) to be 2.0 to 4.0 mg per kg body weight. Excess cyanide ion in forage materials were reported (Sulc and Barker, 2012) to inhibit hemoglobin activity and interfered with oxygen transfer. The ruminant animal dies of asphyxiation. Prussic acid (HCN) acts rapidly, frequently killing animals in minutes. The symptoms were reported (Sulc and Barker, 2012) to include; excess salivation, difficult breathing, staggering, convulsions and collapse and ruminants were also shown to be more susceptible than horses or swine because cud chewing and rumen bacteria help the release of cyanide.

The levels of oxalate obtained in the present work for grasses (3.28 to 4.37 mg/100 g) and legumes (2.19 to 3.29 mg/100 g) were low compared with the range of oxalate (0.54 to 0.82%) reported (Ologhobo, 2012) for forage legumes in Nigeria. The levels of oxalate were also lower compared with the range (0.23 to 0.71g/100 g Dm) reported for five species of ficus in Nigeria (Bamikole et al., 2004). Oxalates affect calcium (Ca) and magnesium (Mg) metabolism (Onwuka, 1983; 1996; Hang et al., 2011). Dietary oxalate has been known to complex with Ca, Mg and Fe leading to the formation of insoluble oxalate salts and result in oxalate stone (Wardlow and Kessel, 2002). The oxalate content of the grasses and legumes obtained in this study are unlikely to pose health problems to animals consuming the forage species as reported by Ogunka-Nnoka and Mepba (2008). The values of phytate in the forage grasses and legumes were too low to be of any nutritional concern when compared with the range (8.0 to 9.9 g/kg dry matter) reported in cereals (Ravindran et al., 1994). Phytate plays a significant role in decreasing the bioavailability of multivalent cations such as Ca^{2+}, Mg^{2+}, Zn^{2+}, Fe^{2+} and Fe^{3+} (Reddy and Salunkhe, 1995) by forming insoluble metal complexes and rendering them unavailable to man and animals.

The levels of saponin obtained in this study for grasses (0.81 to 1.13 mg/100 g) and legumes (0.75 to 5.68 mg/100 g) were low compared with the range (0.015 to 0.093 g/100 g DM) reported for some species of ficus in Nigeria (Bamikole et al., 2004). The levels of saponin reported in this present work are low and pose no threat to ruminant nutrition as reported by Lu and Jorgensen (1987). Kumar (2011) reported that saponins from different plant species have varied biological effects probably due to structural differences in their sapogenin fractions. Saponins are characterized by a bitter taste and foaming properties. Erythrocytes lyse in sapoinin solution and so these compounds are toxic when injected intravenously (Kumar, 2011). Mean tannin content for grasses (0.26 mg/100 g) and legumes (0.32 mg/100 g) were low compared with the value (5.05 ± 0.75% in the range 0.00 to 10.72%) reported for some forage legumes in Nigeria (Ologhobo, 2012). The level of tannin which adversely affects digestibility in sheep and cattle is between 2 and 5% (Mcleod, 1974). Goats were shown to have a threshold capacity of about 9% dietary tannin (Nasitis and Malachek, 1981). All the forage grasses and legumes analyzed in this study contained tannin at levels tolerable to cattle, sheep and goats.

The higher concentrations of the mineral components of the grasses and legumes during the rainy season compared with dry season may be attributed to the availability of the essential nutrient elements in the soil, ability of the forages to utilize the favorable climatic and edaphic growth conditions necessary for the production of high-quality forage as well as ideal maturity stage obtainable during rainy than dry season. Moisture required for nutrient availability and uptake was more available in the rainy season (September and October) than in dry season (October and December) as shown in Table 5. This finding supports the results of Buxton (1996) and George (2005) that shortage of nutrients or unavailability of most nutrients elements is encountered more in dry season, when forages are exposed to extreme climatic conditions and that mineral contents of forage species are influenced by climatic and soil factors on which plants grow. They further stated that changes in grass and legume herbage composition, which occur in dry season imposes a lot of stress on the animal as the chemical compositions of forages are much connected with and affect feed intake, digestibility and energy available for use by the animals.

The observed variation in the concentrations of minerals among species was earlier reported by Zafar et al. (2007). These authors attributed the variation in mineral concentrations to differences in nutrient uptake among forage species. They also noted that when the supply of nutrients is marginal, it is useful to select forages capable of extracting and supplying the required amount of the nutrients for the grazing ruminants. The significant species × season interaction effects on mineral concentrations observed in this study agreed with the report by Guillard and Allinson (1988).

The ranges of phosphorus in the herbaceous legumes and forage grasses were 0.34 to 0.68 and 0.29 to 1.09%, respectively. These values were higher compared to the NRC recommendation of 0.15% for phosphorus (NRC, 1985). The 0.88 to 1.15 and 0.63 to 1.21% ranges of potassium values in the legumes and grasses, respectively, were also higher than the NRC 0.80% recommendation for potassium (NRC, 1985).

Conclusion

Data analysis show that anti-nutrient and mineral concentrations varied significantly among the forage grass and the legume species. Seasonal variation shows significant effect on most of the anti-nutrients studied. Significant species × season interaction effect on anti-nutrients was observed. The concentrations of most anti-nutrients were higher in the rainy than in the dry season. The grass and legume species studied have anti-nutrient concentrations that are below the critical levels and therefore are not deleterious to ruminant animals. The concentrations of the minerals were significantly affected by plant species, season and species × season interaction effects. The forage species harvested during rainy season had higher concentrations of minerals than those harvested in dry season.

REFERENCES

Abubakar MM, Mohamed A (1992). Utilization of slaughterhouse byproducts for sustainable livestock production in Nigeria, In: Ojo JAT (ed). Mobilizing finance for Natural resources conservation in Nigeria. National resources conservation council, Abuja pp. 13-20.

Adesogan AT, Sollenbenger LE, Moore JE (2006). Feeding value and Anti nutritive Factors of Forage tree legume. J. Agron.7:174-179.

Aganga AA, Tshwenyane A (2003). Feeding values and anti-nutritive factors or forage tree legumes. Pak. J. Nutr. 2(3):170-177. In: Agbo CC (2008). Effect of season and location on nutritional and Anti-nutritional factors of some forage browse plants in Nsukka Derived Savanna Zone. A B. Agric project submitted to Department of Crop Science, Faculty of Agriculture, University of Nigeria, Nsukka 54 pp.

Aganga AA, Tshwenyane S (2004). Potentials of Guinea Grass (*Panicum maximum*) as Forage Crop in Livestock Production Animal Science, and Production, Botswana College of Agriculture, Gamborone. Pak. J. Nutr. 3(1):1.

Agbo CC (2008). Effect of season and location on nutrientional and Anti-nutritional factors of some forage Browse plants in Nsukka Derived Savanna Zone. B. Agric project submitted to the Dept. of Crop Science. University of Nigeria, Nsukka, 65 p.

Aja PM, Okaka ANC, Onu PN, Ibiam U, Urako AJ (2010). Phytochemical Composition of *Talinum Triangulare* (water leaf) leaves. Pak. J. Nutr. 9(6):527-530.

Allen VG, segarra E (2001). Anti-quality components in forage: Overview, significant and economic impact. J. Range Manag. 54: 409-412. http://www.caf.wvu.edu/Nforage/quality-factors /anti-bullentin.pdf. retrieved on 20/12/11.

Asiegbu JE (1989). Response of onion to lime and fertilizer N in a tropical ultisol. Trop. Agric. (Trinidad) (2) 66:161-166.

Babayemi OJ, Bamikole MA (2006). Supplementary value of *Tephrosia bracteolata*, *Tephrosia candida*, *Leucaena leucocephala* and Gliricidia, septum hay for West African dwarf goats kept on range. J. Cent. Eur. Agric. 2:323-328.

Baloyi JJ, Ngongoni NT, Topps JH, Acamovic T, Hamudikwanda H (2001). Condensed tannin and saponin content of *Vigna unguiculata* (L.) Walp, *Desmondium uncinatum, Stylosanthes guianensis* and *Stylosanthes scabra* grown in Zimbabwe. Trop. Anim. Health Product. 33:57-66.

Bamikole MA, Ikhatua UJ, Arigbede OM, Babayemi OJ, Etela I (2004). An evaluation of the acceptability as forage of some nutritive and antinutritive components and of the dry matter determination profiles of five species of ficus. Trop. Anim. Health Product. 36:157-167.

Bayble T, Melaku S, Prasad NK (2007). Effects of cutting dates on nutritive value of Napier (*Pennisetum purpureum*) grass planted sole and in association with Desmodium (*Desmodium intortum*) or lablab (*Lablab purpureus*). http://www./rrd19/1/bayb19011.htm. Retrieved on March 15th, 2012.

Blackely A, Blade AL (1994). An evaluation of Kentucky Bluegrass J. Agron. 37:259-267.

Buxton DR (1996). Quality related characteristics of forages as influenced by plant environment and agronomic factors. Anim. Feed Sci. Technol. 59:37-49.

Collins M (1988). Composition and fibre digestion in morphological components of an alfalfa-timothy sward. Anim. Feed Sci. Tech. 19:135-143. http://www.smallstock.info/infor/feed/forage.htm. Retrieved on the 20/12/2011.

Dung W (2012). Capital Press Research. A West Coast Agriculture's home page for news and agribusiness marketplace. Htt;://www.capitalpress.com/print/dwarn-column-050412.

Ekocha AH, Fakolade P (2012). Studies on the physiochemical and mineral profile of lactating West African dwarf ewe fed mexicam sunflower leaf meal based diet. J. Rec. Adv. Agric. 1(4):146-156.

Frutos P, Hervas G, Giraldez FJ, Mantecon AR (2004). Review. Tannins and ruminant nutrition. Span. J. Agric. Res. 2(2):191-202.

Genstat (2009). Genstat Release 7.22 DE, Discovery. Third Edition, Lawes, Agricultural Turst Rothamsted Experimental Station.

George MF, Lin CH, Lerch RN, Garrett HE (2005). Incorporating forage grasses in riparian buffers for bioremediation of atrazine isoxaflutole and nitrate in Missouri. Agroforestry Syst. 63:87-95.

Gohl B (1981). Tropical Feeds. FAO Animal Production Health Series 12. P. 529. In: Phytonutreints in Citurs Peel Meal and Nutritional implication for livestock production by Olurenic, O.I.A., Ngi, J. and Andrew, I.A. www.Irrd.org/Irrd 19/7/olur 19089.htm retrieved 12/03/2012.

Guillard K, Allinson DW (1988). Seasonal variation in chemical composition of forage Brassicas. 1. Mineral concentrations and uptake. Agron. J. 81(6):876-881.

Guillard K, Allinson DW (1988). Seasonal variation in chemical composition of forage Brassicas. 1. Mineral concentrations and uptake. Agron. J. 81(6):876-881.

Hang DT, Binh LV, Preston TR, Savage GP (2011). Oxalate content of different taro cultivars grown in Central Viet Nam and the effect of simple processing methods on the oxalate concentration of the processed forages. Livest. Res. Rural Dev. 23(6):387-391.

Harbone JB (1973). Phytochemical Methods. A guide to modern techniques of plant analysis. Chapman and Hall, New York. pp. 267-270.

Have M, Gragen EF, Tatspong P, Lunpha A, Soengkham M, Wongpichet K (2004). Inter-row planting legumes to improve the crude-protein concentration in paspalum atratum. Trop. Grasslands J. 38(3):167-177.

Jones P.D, Rude B, Muir JP, Demarais S, Strickland BK, Edwards S (2010). Condensed tannins effect on White-tailed deer forage digestibility in Mississippi. J. Wildl. Manag. 74(4):707-713.

Kumar R (2011). Anti-nutritional factors. The potential risks of toxicity and methods to alleviate them. www.irrd.org/Ag/AGA/AGAP/FRG/A4pp102/102-145. Retrieved on 23/01/2012.

Kumar R, Vaithiyanathan S (1990). Occurrence, nutritional significance and effect on animal productivity of tannins in tree leaves. Anim. Feed Sci. Technol. 30:21-38.

Love SL, Herman TJ, Thompsonjohns A, Baker TP (1994). Effect and interaction of crop management factors on the glycoalkaloid concentration of potato tubers. Potato Res. 37(1):77-85.

Lu CD, Jorgensen NA (1987). Alfalfa saponins affect site and extent of nutrient digestion in ruminants. J. Nutr. 117:919-927.

Mcleod MN (1974). Plant tannins: their role in forage quality. Nutrition Abstract Review, 44:803-815. In: Okoli IC, Anunobi MO, Obua BE, Enemuo V (2003). Studies on selected browses of Southeastern Nigeria with particular reference to their proximate and some endogenous anti-nutritional constituents. http://www.irrd.org/irrd15/9/0ko1159.htm. Retrieved on 23/06/2012.

Mecha I, Adegbola TA (1980). Chemical composition of south eastern Nigeria forage eaten by goats. International symposium, ILCA. Addis, Ababa Ethiopia.

Nastis AS, Malachek JC (1981). Digestion and utilization of nutrients in Oak browse by goats. J. Anim. Sci. 52:283-288. In: Ologhobo, A.D.(2012). Mineral and antinutritional contents of forage legumes consumed by goats in Nigeria. www.fao.or/wairdocs/ILRI/x548913/x5489b0o.htm.

NRC (1985). Nutrients requirements of beef cattle (17th edition) National Academy Press, Washington D.C. USA.

Oberelea SD (1973). Phytate in Toxicants occurring naturally in foods, Stong F (ed) National Academy of Sciences, Washington D.C. pp. 363-371.

Obi IU (1986). Statistical Methods for Detecting Differences between Treatment Means. SNAAP Press Limited, Enugu, Nigeria. 45 p.

Ogunka-Nnoka CU, Mepba HD (2008). Proximate composition and antinutrient contents of some common species in Nigeria. Open Food Sci. J. 2:62-67.

Okoli IC, Anunobi MO, Obua BE, Enemuo V (2003). Studies on selected browses of Southeastern Nigeria with particular reference to their proximate and some endogenous anti-nutritional constituents. http://www.irrd.org/irrd15/9/0ko1159.htm. Retrieved on 23/06/2012.

Ologhobo AD (2012). Mineral and antinutritional contents of forage legumes consumed by goats in Nigeria www.fao.or/wairdocs/ILRI/x548913/ x5489b0o.htm. Retrieved 14/08/12.

Onwuka CF (1983). Nutritional evaluation of some Nigeria browse plants in humid tropics. Ph.D. Thesis. University of Ibadan, Nigeria 275 p.

Onwuka CFI (1996). Plant phytates, oxalates and their effects on nutrient utilization by goats. Nig. J. Anim. Prod. 23(1):53-60.

Onwuka CFI, Akinsoyinu AO, Tewe OO (1989). Feed value of some Nigerian browse plants: chemical composition and "*in vitro*" digestibility of leaves. East Afr. Agric. For. J. 54(3):157-163.

Onwuka GI (2005). Food analysis and instrumentation theory and practice. Naphthali Prints Lagos, Nigeria. pp. 142-143.

Onyeonagu CC, Ukwueze CC (2012). Anti-nutrient components of guinea grass (*Panicum maximum*) under different nitrogen fertilizer application rates and cutting management. Afr. J. Biotechnol. 11(9):2236-2240.

Osagie AU (1998). Anti-nutritional factors. In; Osagie, E.U. and Eka, O.U. (Eds). Nutritional quality of plant foods. Post-Harvest Research unit, University of Benin City. pp. 221-224.

Pandey RK, Kumar D, Jadhav KM (2011). Assessment of determinants for reducing HCN content in sorghum used for ruminant in Gujarat, India. http://www.irrd.org/Irrd23/3/pand2306.htm.

Pearson D (1976). The Chemical Analysis of Food. Churchill Livingstone. Edinburgh London and New York p. 525.

Pearson DA (1976). The Chemical Analysis of Foods (7th Ed). Churchill Livingstone. Edinburgh London and New York 525 p.

Peter KJ (1988). Chemical composition of some forage grasses. Changes with plant Maturity. Agron. J. 46:361-369.

Ravindra V, Ravindra G, Sivakakagan R (1994). Total and phytic phosphorus content of various foods and feed stuffs of plant origin. Food Chem. 50:133-136 In: Ogunka-Nnoka C.U and Mepba H.D. (2008). Proximate composition and antinutrient contents of some common species in Nigeria. Open Food Sci. J. 2:62-67.

Reddy NR, Salunkhe DK (1995). Effect of Fermentation on Phytate Phosporus and mineral content of black gram and rice blends. J. Food Sci.45:1709- 1715 In: Ogunka-Nnoka C.U and Mepba H.D. (2008). Proximate composition and antinutrient contents of some common species in Nigeria. Open Food Sci. J. 2:62-67.

Steel GD, Torrie JH (1980). Principles and procedures of statistics: A Biometric Approach. 2nd Ed. McGraw-Hill Book Company, Inc. New York 633 pp.

Sulc RM, Barker DJ (2012). Hydrogen Cyanide. Ohio Agronomy Guide, 14th edition. Bulletin 472 – 05. http//www.ohioline.osu.edu /b472/0008.html retrieved 14/08/12.

Tian G., Hauser, S., Koutika, L.S., Ishida, F. and Chianu, J.N. (2000). Presasia cover crop fallow systems benefits and applicability. Minneapolis, USA, 5-9 Nov. pp 137-155. Agric. Sci. 3:4-6.

Wardlow, G.M. and Kessel, M.W. (2002). Perspectives in nutrition 5th ed. Mcgraw. Hill Companies Inc. New York, 469-779 In: Ogunka-Nnoka, (U., and Mepba, H.I). (2008). Proximate composition and antinutrient contents of some common species in Nigeria. Open Food Sci. J. 2:62-67

Zafar IK, Muhammad A, Kafeel A, Irfan M, Muhammad D (2007). Evaluation of micro minerals composition of different grasses in relation to livestock requirements. Pak. J. Bot. 39(3):719-728.