EFFECT OF SEASON ON THE VARIATION OF HERBAGE AVAILABILITY AND QUALITY IN COMMUNAL PASTURE AND CROP RESIDUE YIELD IN THE SAVANNA ZONE OF NORTHERN GHANA

Konlan[1], S. P., Ayantunde[2], A. A., Addah[3], W., Dei[3], H. K. and Panyan[1], E. K.
[1]Council for Scientific and Industrial Research –
Animal Research Institute, P. O. Box TL 52 Tamale, Ghana
[2]International Livestock Research Institute,
01 BP 1496 Ouagadougou, Burkina Faso, West Africa
[3]Department of Animal Science,
University for Development Studies, P. O. Box TL1882 Tamale, Ghana

ABSTRACT
Herbage availability variation in pasture and crop residue yields were estimated as feed resources in northern Ghana. Data were collected across seasons for one year using a wooden meter square quadrat. Samples of pasture yield in 1-m^2 quadrat were taken randomly from communal grazing land and crop residues from cultivated fields at crop maturity. The data was analyzed with GenStat using ANOVA. Seasons were fixed factors with herbage yield/ha and nutritive parameters as variable factors. Results showed that quantity of herbage in the pasture across seasons varied significantly (P<0.05). The values were 3.0, 1.5, 0.5 and 2.0 tonnes DM/ha for early dry (November–January), late dry (February–April), early wet (May–July) and main wet (August–October) seasons, respectively. Highest (P<0.05) crop residue yield of 8.5 tonnes DM/ha was obtained in sorghum whereas cowpea had the lowest yield of 1.8 tonnes DM/ha. Crude protein content of commonly grazed pasture species differed (P<0.05) across seasons (75, 45, 174 and 165 g/kg DM for early dry, late dry, early wet and main wet seasons, respectively). Herbage availability in pasture during late dry season was 55% less than the amount available in early dry season; the season with highest amount of herbage. The quality was significantly lower in the late dry season indicating possible under-nutrition of animals if supplementary feeding is not done.

Keywords: *Crop residue, herbage yield, pasture, ruminant production, season*

INTRODUCTION
Increasing livestock population in Sub-Saharan Africa has triggered high feed demand among farmers especially in urban and peri-urban areas (Graefe *et al.*, 2008). The increase in feed demand coupled with a decline in pasture availability due to expansion of crop fields into grazing areas and infrastructural development leads to feed shortages especially in the dry season (Smith, 2010). The variation in feed availability in the pasture affects animal productivity as most farmers depend heavily on natural pasture. Therefore, the use of crop residue in crop-livestock system has been increasing as a backup to natural pasture (Samdup *et al.*, 2010).

In Ghana, Fleischer *et al*. (1996) estimated that about 15% of the total land area contains natural pasture and largely located in Savanna areas (Nitis 1997). According to FAO, (2006) the annual total DM yields of the pasture have been estimated as 2.0 and 2.2 tonnes DM/ha in the Coastal and Guinea Savanna ecological zones, respectively. About 80% of the forage yields are achieved within the growing season. However, not all pastures in these areas are available and accessible to animals. Variability of herbage yield in different locations in the same agro-ecological zone has been reported by others (Fleischer *et al*., 1996; Timpong-Jones *et al*., 2013). For instance, the herbage yield of South-Eastern to Western Coastal Savanna rangeland of Ghana ranged from 0.6 to 7.2 tonnes DM/ha with a mean herbage yield of 3.2 tonnes DM/ha during the peak vegetation cover (Timpong-Jones *et al.,* 2013). This variability in herbage yield in the same agro-ecological zone indicates that there is no uniformity in herbage yield in the same rangeland and this could be due to soil types and fertility levels. Fleischer *et al.* (1996) reported that herbage yield on the clayey and sandy soils of the coastal plains were 4.7 and 5.0 tonnes DM/ha, respectively. Other changes in herbage availability and quality in rangelands in Ghana have also been reported by other researchers which were attributed to seasonal changes (Annor *et al*., 2007; MoFA, 2011; FAO, 2006). However, quantitative data on the rate of herbage yield variations across seasons are inadequate especially in the Savanna zone of northern Ghana. Therefore, estimating herbage yield and quality in communal pastures during the distinct seasons of the year and crop residue yield will provide information on potential feed available for ruminant production in the various seasons. This information will be beneficial to smallholder farmers in northern Ghana who depend heavily on natural pasture and crop residues as their main sources of feed for their livestock. The objectives of this study were to estimate the variation of herbage availability and quality across seasons in the communal pasture and crop residue yield in cultivated fields

MATERIALS AND METHODS

Location of the study

The study was conducted in the three political administrative regions of northern Ghana (Northern, Upper East and Upper West regions). The data were collected from three communities in each Region. The communities covered in each region for this study were Tibali, Bontingli and Duko in Northern Region; Gia, Nyangua and Sambolgo in Upper East; and Zanko, Guo and Passe in the Upper West Region.

The three regions are located within latitude 90^0 38"S and 100^0 24" N and longitude 20^0 61" W and 00^0 84" E in the Guinea and Sudan Savanna agro - ecological zones (MoFA, 2011). The rainfall pattern is unimodal and begins in May and end in October (GMA, 2017). The annual mean amount of rainfall of the three Regions are 1200, 940 and 950 mm for the Northern, Upper East and Upper West Regions, respectively (MoFA, 2011).

A focus group discussions were conducted at the beginning of the study in each community to obtain farmers view on rainfall pattern and its effect on herbage availability. Monthly rainfall intensity was scored by farmers on a scale of 0 – 5 (0 = no rainfall and 5 = heaviest rainfall) using their last three years of farming experiences. Seasonal changes that had impact on feed resources were also identified by classifying the months into seasons.

Design of the experiment

The experiment was conducted in a randomized complete block design (RCBD). The blocking was done against regions, communities in each region were replicate plots with seasons being treatments. The data collected included herbage yield/ha in all the four seasons in a year (early dry, late dry, early wet and main wet seasons) in the communal pasture of the study communities. Estimation of crop residue yield/ha at crop maturity was also carried out. Specifically, the crop residues yield data was collected in October to November 2014. The herbage yield estimation data was collected in December, 2014 in the early dry season, and then in March 2015 (during late dry season), June (early wet season) and September (main wet season). The quadrat pasture yield estimation method was used to estimate the herbage yield (Nitis 1997). A 1–m^2 wooden quadrat was used for the data collection. Samples of forage available in the communal pasture were taken from eight quadrats thrown randomly in each communal pasture during each season. The forage in each quadrat was cut at 4 cm above ground level (Morris et al. 1999) and collected. Quadrat samples were taken within three km radius at different locations in each communal pasture within the distance covered by small ruminant during grazing. The most commonly grazed forage species in the pasture were sampled, pooled and sub-sampled for laboratory analysis to determine the composite chemical composition of the pasture in all the seasons. Also, some commonly grazed forage species were identified in the wet season. The pure samples of such forage species were taken and chemical composition determined. The residue yields of crops (maize, sorghum, rice, groundnut, cowpea and soybean) commonly cultivated in the area, whose residues are often fed to ruminants, were estimated at harvest. Three samples of each crop residue in each community were taken randomly at crop maturity in 1–m^2 quadrat. The crop residues in each quadrat were collected to ground level leaving the roots. The collected crop residue in each quadrat were sampled, pooled, sub-sampled and analyzed for their chemical composition.

Laboratory and data analysis

All samples collected were oven–dried and milled to pass through 2–mm sieve and analyzed for dry matter (DM), ash, crude protein (CP), *in vitro* organic matter digestibility (IVOMD), neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL) at the International Livestock Research Institute (ILRI) Nutrition Laboratory in Addis Ababa, Ethiopia. The laboratory analysis for DM and ash were done using AOAC (1990) approved methods. Nitrogen content was determined by the Kjedahl method and CP calculated as N x 6.25. The Van-Soest and Robertson (1985) procedure was used to determine the fibre fractions (NDF, ADF and ADL) of the samples. *In vitro* organic matter digestibility was determined using Tilley and Terry (1963) two stage *in vitro* digestion technique for forages.

The dry weight of biomass harvested was determined and yield/ha calculated using the equation given below according to t'Mannetje (1978).

$$Y = R \times 10{,}000$$

Where Y is dry herbage yield per hectare and R is dry herbage yield per square meter

The data on seasonal herbage yield (kg DM/ha) and chemical composition such as DM, CP, NDF, ADF, ADL and IVOMD were analyzed with GenStat Eleventh Edition (VSN International, 2008) using general ANOVA analytical procedure. The seasons were the fixed factors with herbage yield/ha and nutritive value parameters being variable factors. Treatment means were separated by Least Significant Differences at 0.05 level when significant differences were observed.

RESULTS

Effect of rainfall on seasonality of feed resource availability

The results of scores of farmers on monthly rainfall intensity and distribution among the regions are presented in Figure 1. The rainfall distribution pattern was similar throughout northern Ghana with little differences at the beginning and end of the rainy season. Seven months of rainfall (April to October) with peak rains in July to September and 5 months of dry period (November to March) were obtained during the focus group discussions.

The rainfall pattern influenced the occurrence of two distinct seasons namely, dry and wet seasons. The focus group discussions with the farmers further indicated the existence of two sub-seasons with slight differences that have impact on quality and availability of feed in the pasture in both wet and dry seasons. The sub-seasons in the dry season were windy-dry and occurred from November to January (early dry season). The second part of the dry season per the farmers' agreement was warm-moist dry beginning from February to April (late dry season) and in the wet season the sub-seasons were early wet with little rainfall from May to July and the main wet season with frequent and

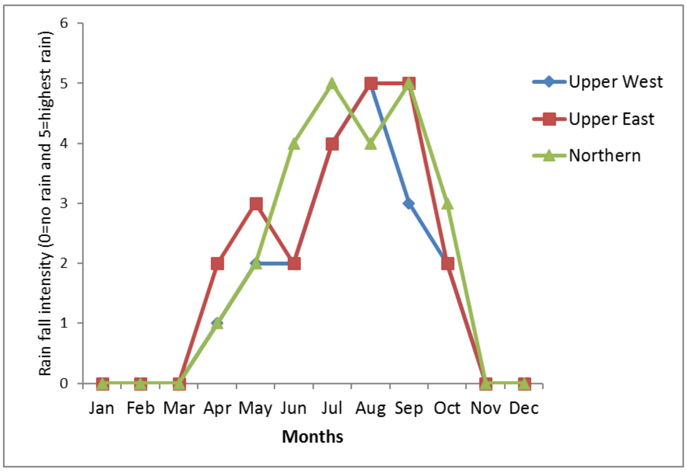

Figure 1: Annual rainfall distribution pattern

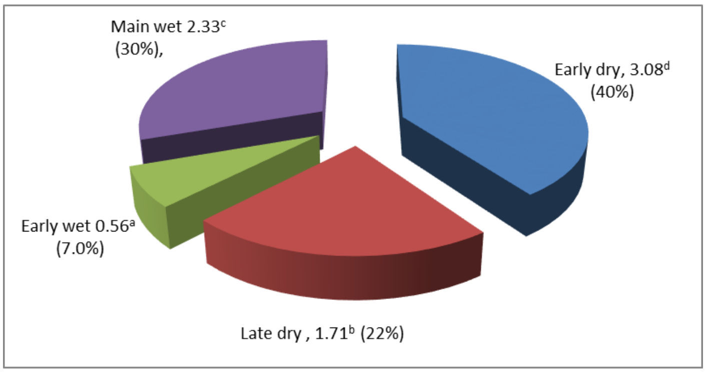

Figure 2a: Effect of season on forage yield at natural pasture (tonnes DM/ha)

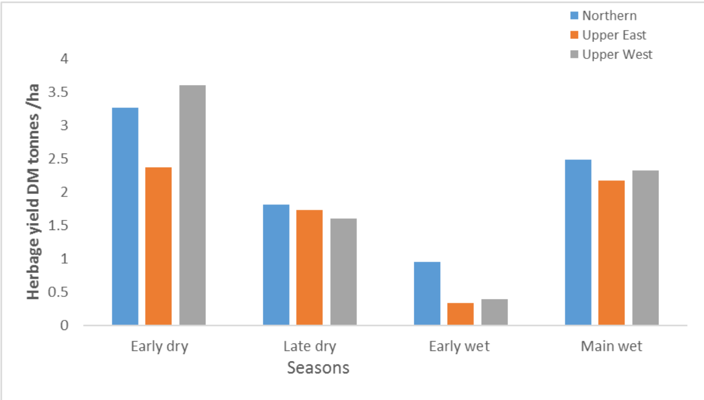

Figure 2b: Herbage yield in communal pasture among the three regions in northern Ghana (tonnes DM/ha)

heavy rainfall from August to mid-October (Konlan *et al.,* 2016).

Herbage availability in the communal pasture

The herbage yield in communal pastures differed (P<0.05) across seasons (Figure 2a). Early dry season had the highest herbage yield of 3.08 tonnes DM/ha and early wet season had the lowest yield (0.56 tonnes DM/ha). Change in season therefore significantly affected herbage available in the communal pastures in the study communities. Herbage yield also differed significantly (P<0.05) among the three regions in the study sites (Figure 2b). Upper East Region consistently had the lowest herbage yield in the pasture in all the seasons.

Change in season affected the composite chemical composition of commonly grazed forage species. The CP content differed (P<0.05) among seasons. The values obtained were 75, 45, 174 and 165 g/kg DM for early dry, late dry, early wet and main wet seasons, respectively. Details of other chemical components of the composite samples of these commonly grazed forage species are presented in Table 1. The commonly grazed forage species (Table 2) in the communal pastures were similar. Few improved species (*Andropogon gayanus, Chrysopogon zizanioides and Stylosanthes hamata)* were however found in some pastures in Northern and Upper East regions.

The chemical composition of identified individual forage species at their vegetative stage of growth during the wet season (early wet and main wet seasons) are presented in Table 2. Among the grasses, CP content differed (P<0.05) and was highest in *Rotteboellia cochinchinensis* and lowest in *Andropogon gayanus.* Also, IVOMD of the grasses was highest (P<0.05) in *Dactyloctenium aegyptium and lowest in Andropogon gayanus.* The forbs did not show significant differences (P>0.05) in all the chemical components determined.

Dactyloctenium aegyptium had the highest IVOMD (607 g/kg DM) and *Andropogon gayanus* had the lowest (258 g/kg DM). The mean CP content of legumes (130 g/kg DM) was significantly higher (P<0.05) than that of grasses CP (83 g/kg DM). Other parameters of chemical composition between legumes and grass forage species differed (Table 2). Dry matter content was, however, similar.

Residues yield and quality of commonly cultivated food crops

Commonly cultivated crops in the area whose residues are mostly used in feeding ruminants included cowpea, groundnut, soybean, maize and sorghum. The residue yield (DM/ha) of these crops is presented in Figure 3a. The highest (P<0.05) residue yield of 8.5 tonnes DM/ha was observed in sorghum whereas cowpea had the lowest residue yield of 1.8 tonnes DM/ha. The regional comparison of the various crop residue yield (Figure 3b) was not significantly different (P>0.05).

Chemical compositions of the three legume crop residues analyzed were not significantly different in most of the parameters (Table 3). The CP content was however, highest (P<0.05) in groundnut haulms compared to the CP content for cowpea haulms and soybean residues. Also, NDF content of soyabean residue was higher (P=0.05) than other two leguminous crop residues. The nutritional compositions of the two cereal crop residues analyzed were similar for all the parameters determined.

DISCUSSION

The relationship between rainfall pattern and feed availability in the pasture in this study agrees with the report that feed availability is a function of rainfall pattern (Jayasuriya, 2002). This influenced the variation of quality and availablity of herbage in the pasture as obtained in this work. Annor *et al*. (2007) stated that feed becomes more available towards the end of wet season and most accessible to ruminants after crop harvest when animals are allowed to graze freely.

The highest herbage yield observed in the early dry season and lowest during early wet season followed the forage growth pattern in the area as

Table 1: Effect of season on composite chemical composition (g/kg DM) of commonly grazed forage species in the communal pasture

Season (n=3)	Ash	CP	NDF	ADF	ADL	IVOMD
Early dry season	117.9	75.1[a]	530.6[ab]	471.8[b]	142.6[b]	399.6[a]
Late dry season	121.3	44.8[a]	443.7[a]	498.1[b]	164.4[b]	388.2[a]
Early wet season	138.3	174.0[b]	669.5[c]	368.6[a]	71.3[a]	606.7[b]
Main wet season	134.0	165.4[b]	659.9[b]	376.0[a]	87.7[a]	543.7[b]
SED	48.78	19.26	54.83	35.56	12.99	35.8
P values	0.15	0.01	0.02	0.02	0.01	0.02

Means with different superscripts in the columns are significantly different at P<0.05, CP = Crude protein, NDF = Neutral detergent fibre, ADF = Acid detergent fibre, ADL= Acid detergent fiber, IVOMD = In vitro organic matter digestibility, SED = Standard errors of differences of means

Table 2: Chemical composition (g/kg DM) of identified forage species during the wet season

Forage species Grass	Ash	CP	NDF	ADF	ADL	IVOMD
Andropogon gayanus	708.3	53.1[a]	798.9	492.5	78.2	224.4[a]
Axonopus compresus	106.9	78.6[ab]	626.8	389.3	73.9	338.0[ab]
Dactyloctenium aegyptium	99.0	94.8[bc]	586.7	351.7	73.5	607.7[d]
Digitaria ciliaris	148.4	60.6[a]	702.2	454.0	70.8	432.1[bcd]
Digitaria horizontalis	105.5	94.2[bc]	742.9	459.7	82.9	530.2[cd]
Eleusine indicia (L) Gaertn	114.1	89.9[bc]	722.6	448.5	70.6	474.4[bcd]
Pennisetum pedicellatum	121.7	52.3[a]	765.0	502.1	76.8	406.8[bc]
R. cochinchinensis	74.2	109.3[c]	678.3	405.6	95.6	442.4[bcd]
SED	24.34	12.45	682.43	59.51	10.35	85.68
P values	0.100	0.001	0.098	0.23	0.32	0.01
Legumes/forbs						
A. hispidum	153.8	109.9	499.9	403.3	108.7	513.0
Amaranthus spinosus	203.2	121.0	515.8	364.5	98.0	428.8
Boerhavia difusa	139.8	181.4	408.8	335.9	96.7	632.2
Sida acuta	106.9	107.9	644.7	423.3	70.4	549.1
SED	60.21	49.46	112.75	91.03	23.76	11.15
P values	0.49	0.45	0.29	0.78	0.47	0.39
Forage class						
Grass	105.0	82.6	702.9	437.8	77.8	432.1
Legumes	150.7	130.1	517.4	381.7	93.5	530.8
SED	17.71	16.37	37.90	31.67	7.13	41.99
P values	0.02	0.01	0.01	0.09	0.04	0.03

Means with different superscripts in the columns are significantly different at P<0.05 within the grass or forage species. n= 3 for each forage specie, CP = Crude protein, NDF = Neutral detergent Fibre, ADF = Acid detergent fibre, ADL= Acid detergent fiber, IVOMD = In vitro organic matter digestibility, R= Rotteboellia, A = Acanthospermum SED = Standard errors of differences of means reported by FAO (2006). Ayantunde *et al*. (1999) also observed 50% decline in herbage dry matter yield during the late dry season in the rangeland of Sahel region in Niger. Most forage species (annual grasses and forbs) in northern Ghana attain their highest vegetative growth and maturity at the end of the wet season which is in October (GMA, 2017). They also attain their highest foliage growth in early dry season with low moisture due to maturity (FAO, 2006). This account for the highest herbage yield observed during early dry season. The lowest forage yield in the late dry season could be attributable to fodder depletion due to grazing, bush burning and other human uses of the dry fodder in the communal pasture (Karbo and Agyare, 2002). Similar observations were made by Ayantunde et al. (1999) in Niger and other workers in northern Ghana (FAO, 2006; Annor *et al.*, 2007; MoFA, 2011). The values obtained were however lower than the reported herbage yield of 5.0 tonnes DM/ha in the coastal Savanna zone

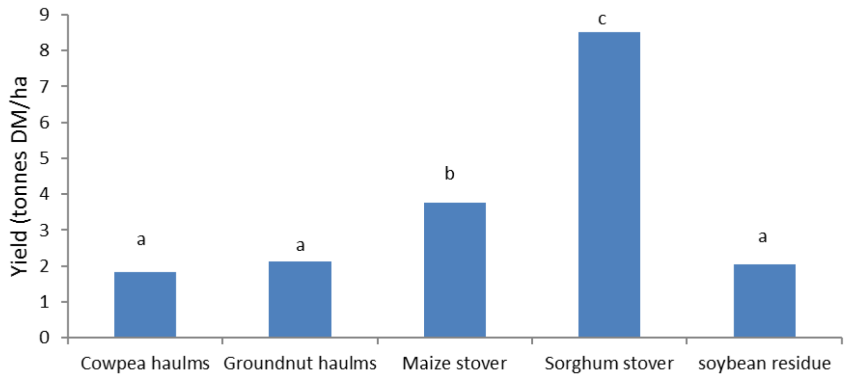

Figure 3a: Residue yield of commonly cultivated food crops (showing significant differences)

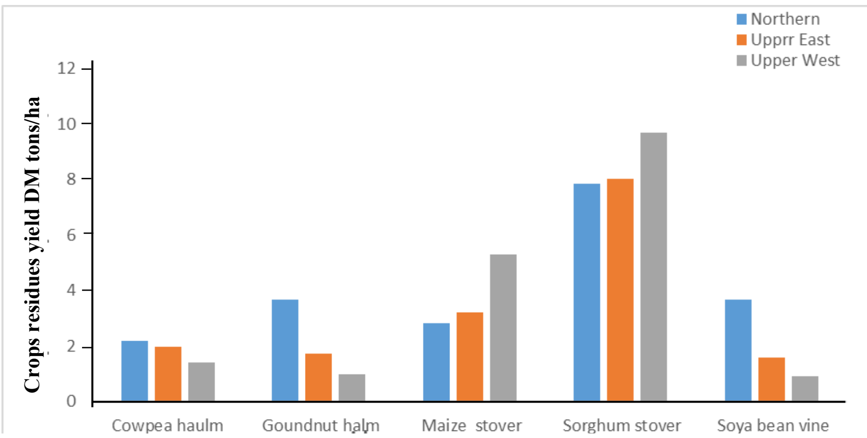

Figure 3b: Residue yield of crops often used as feed in the three Regions in Northern Ghana

Table 3: Chemical composition (g/kg DM) of crop residues at harvest period

Crop residues (n=3) Legumes	Ash	CP	NDF	ADF	ADL	IVOMD
Cowpea haulms	71.6	91.4[a]	568.7	716.8	101.2	525.9
Groundnut haulms	96.1	114.1[b]	526.9	655.2	97.9	549.1
Soybean residues	94.4	94.8[a]	600.9	712.4	114.3	506.7
SED	14.93	6.96	28.63	39.87	8.06	26.60
P Values	1.21	0.01	0.05	0.25	0.12	0.30
Cereals						
Maize stover	71.8	52.4	547.3	837.7	60.7	655.7
Sorghum stover	65.8	38.9	526.6	800.1	55.9	685.5
SED	6.99	7.95	19.99	23.88	7.04	28.46
P Values	0.41	0.11	0.32	0.14	0.50	0.31

of Ghana (Fleischer *et al.,* 1996) but fell within a herbage yield range of 0.6 to 7.2 tonnes DM/ha in the South-Eastern to South-Western Coastal Savanna (Timpong-Jones *et al.,* 2013). The lower values reported in this study could be attributable to the differences in the agro-ecological zones and soil types as these factors affect forage yield (Duku *et al.,* 2010). MoFA (2011) reported that there is a shorter duration of dry season in the Coastal Savanna that influences higher forage yield than in the Guinea Savanna zone. The values were however, similar to the annual forage yield of 2.0 tonnes DM/ha obtained by FAO (2006) in the Guinea Savanna agro-ecological zone of Ghana. The lowest herbage yield in the pasture obtained in Upper East Region in all the seasons could be attributed to higher land use pressure leaving only marginal lands in communities as grazing land. Overgrazing, due to larger number of animals per unit area in Upper East Region may also contribute to this low herbage yield.

The declining quality of herbage in the pasture from early wet season to late dry season as indicated by the chemical composition of commonly grazed forage species was a result of forage maturity and lignin accumulation. This was also reported by others in a similar study (Ayantunde *et al.,* 1999: FAO, 2006). The significant variability in nutritive quality of herbage in the communal pasture across seasons is triggered by precipitation and temperature variation across seasons as stated by Smith (2010). Antwi *et al.* (2010) reported that high variation in ambient temperature and moisture levels affected the quality of standing hay in the dry season. The CP content of commonly grazed forage species in the pasture (50 – 80 g/kg DM and 160 – 170 g/kg DM for dry and wet seasons) in this study were higher than 20 – 40 g/kg DM and 80 – 120 g/kg DM for dry and wet seasons reported by FAO (2006) in Ghana. The differences could be attributed to sampling techniques and location of sample collection as observed by Singh *et al.* (2011).

The seasonal variations of standing herbage yield in the communal pasture is in consonance with the observation of Ayantunde *et al.* (1999) in their study of rangeland herbage yield in Niger. This has implications on feed accessibility to animals as stated by Karbo and Agyare (2002). The comparatively high yield of herbage in the pasture during the main wet and early dry seasons suggests favourable conditions for higher productive performance of ruminant during these seasons. This confirmed the report of other studies (Karbo and Agyare, 2002; Smith, 2010) on the effect of seasons on herbage availability. Combell *et al.* (2003) emphasized that deficiency of feed in quantity and quality negatively affect the productive and reproductive performance of grazing livestock. The lower quantity and quality of herbage in the pasture during the late dry season implies grazing animals will need supplementary feeding to maintain their potential production performance or lose weight if they are not supplemented.

The observed highest sorghum residue yield compared to all other crops was due to the high vegetative growth attributes of the sorghum plant compared to the other crop plants covered in this study. This is in consonance with the findings of Ayamga et al. (2015) in their study of total annual crop residue production in the Lawra-Nandom district of the Upper West Region. Ayamga *et al.* (2015) found that the sorghum crop generates the highest amount of residue among cereals and contributes up to 59% of the total annual crop residues produced in that area. Kombiok *et al.* (2005) also reported highest vegetative growth of sorghum crop among cereal in Northern Ghana in terms of height and consequently produces highest residue. Unfortunately, the sorghum stover is less used in feeding animals due to its low nutritive quality and other competing domestic uses such as fuel, roofing material and in the weaving industry (Karbo and Agyare 2002). The intake of sorghum stover by ruminants is also reported to be low due to high lignin content (Singh *et al.,* 2011). The crop residue yields obtained were higher than reported values (13, 6, 2.3, and 5 tonnes DM/ha for maize, groundnut, soybeans and cowpea respectively) by Singh *et al.* (2011) in a review of grain and residue yield of crops in the arid agro-ecological zone of West Africa in crop-livestock integrated system productivity. The values however, fell below the range of 10 – 16, 11 – 17, 3 – 6 and 1 – 5 tonnes DM/ha for maize, sorghum, groundnut and soybean residue yield respectively as reported by Reddy *et al.* (2003). The differences could be attributable to varietal, rainfall patterns, inputs used, agronomic practices and soil fertility (Reddy *et al.,* 2003; Kombiok *et al.,* 2005). If more effort is put on treatment of sorghum for use as feed there will be an increased utilization and consequently would positively affect feed resources available for feeding ruminants.

The similarity of the chemical composition of legume crop residues may be due to the similarity of soil types and rainfall pattern of the area. Onwuka *et al.,* (1997) reported similar findings in Nigeria. The CP values (91.4 and 114.1 g/kg DM for cowpea and groundnut haulms, respectively) obtained in this study were lower than the 180 g/kg DM CP content for both residues reported by Onwuka *et al.* (1997) but close to 100, 120, and 30 g/kg DM CP content for cowpea, groundnut and maize residues respectively, reported by Opoku, (2011) in the same Savanna agro-ecological zone of Northern Ghana. The slight differences could be due to varietal differences, soil and agronomic practices (Reddy *et al.,* 2003). Amole and Ayantunde (2016) reported lower ADF content of 390 to 490 g/kg DM and higher IVOMD of 600 to 610 g/kg DM for cowpea and groundnut haulms in the arid agro-ecological zone of Niger compared to the current observations. The difference in the fiber content and digestibility may be attributed to the difference in the time of residues collection after harvest. Early collected residue has been reported to contain low lignin and fibre, and had high digestibility compared to late collected crop residues (Singh *et al.,* 2011).

CONCLUSION

The quantity and quality of herbage in pasture varied significantly across seasons. The yield was highest during early dry season and about 55% lower in the late dry to early wet season. More cereal crop residues were generated than legume residues in the smallholder farming system. Sorghum residue was found to be highest among the cereals whereas groundnut residue dominated the legumes. The nutritive quality of standing pasture in the communal grazing lands was highest during early wet season and lowest during late dry season. Farmers could supplement grazing animals strategically during the late dry season for sustainable productivity to reduced cost.

REFERENCES

Amole, T.A. and Ayantunde, A. A. (2016). Assessment of existing and potential feed resources for improving livestock productivity in Niger. International Journal of Agricultural Research, 11: 40–55.

Annor S.Y., Djang-Fordjour, K.T. and Gyamfi K. A. (2007). Is growth rate more important than survival and reproduction in sheep farming in Ghana? Journal of Science and Technology, 27: 23–31.

Antwi, C., Osafo, E.L.K., Fisher, D. S., Yacout, H.M., Hassan, A.A., and Adu-Dapaah, H. (2010). Storage practices and their effects on nutrient and haulm availability of four dual-purpose cultivars of cowpea (*Vigna unguiculata* L. WalP) haulm. Ghanaian Journal of Animal Science, 5: 32–40.

AOAC. (1990). Official Methods of Analysis. 15th edn. Association of Official Analytical Chemists, Washington, D. C.

Ayamga E.A., Kemausuor, F. and Addo A. (2015). Technical analysis of crop residue biomass energy in agricultural region of Ghana. Resources, Conservation and Recycling, 96: 51–60.

Ayantunde, A.A., Hienaux, P., Fernandes-Rivera S., van Kealen H. and Udo H.M.J. (1999). Selective grazing by cattle on spatially and seasonally heterogeneous rangeland in Sahel. Journal of Arid Environment, 42: 261–279.

Campbell, J. R., Kenealy, M.D. and Campbell, K.L. (2003). Animal Science: the Biology, Care and Production of Domestic Animals. McGraw Hill, pp. 224–232.

Duku, S., Akke, J.Z. and Howard, P. (2010). Small ruminant feed systems: perceptions and practices in the transitional zone of Ghana. Journal of Ethno-biology and Ethnomedicine, 6 (11). http://www.ethnobiomed.com/content/ 6/1/11

FAO. (2006). Food and Agriculture Organization country pasture / forage resource profile report, pp.16–25. http//www.fao.org/ag/agp/AGP/doc/pasture/forage/htm.

Fleischer, J.E., Allotey, J.A. and Heathcote, I. (1996). Biomass productivity and carrying capacity of the natural grassland on the Accra Plains of Ghana. Ghanaian Journal of Agricultural Science, 29: 107–114.

Genstat, (2008). General Statistics. Eleventh Edition VSN International Ltd., Rothamsted Experimental Station.

GMA, (2017). Ghana Meteorological Agency rainfall seasonal forecast www.meteo. gov. gh/ website/Index.php?option=com

Graefe, S., Schlecht, E. and Buerkert, A. (2008). Opportunities and challenges of urban and peri-urban agriculture in Niamey, Niger. Outlook of Agriculture, 37: 47–56.

Jayasuriya, M.C.N. (2002). Principles of ration formulation for ruminants: Development and field evaluation of animal feed supplementation packages. Proceedings of the final review meeting of IAEA Technical Co -operation Regional Project, Cairo, Egypt, November 2000, pp. 009–014.

Karbo, N. and Agyare, W.A. (2002). Improving livestock systems in the dry savannas of West and Central Africa. In: Tarawali G, Hiernaux P. (Eds). Crop-Livestock Systems in the Dry Savannas of West and Central Africa, pp. 22–27.

Konlan, S.P., Ayantunde, A.A., Addah, W., Dei, H.K. and Avornyo, F.K. (2016). Evaluation of Feed Resource Availability for Ruminant Production in Northern Ghana. International Journal of Livestock Research, 6(6): 39-59.

Kombiok, J.M., Safo, E.Y. and Quansah, C. (2005). Yield and nitrogen fixation of cowpea as affected by tillage and cropping system in the Northern Savanna Zone of Ghana. West African Journal of Applied Ecology, 7: 095–108.

MoFA. (2011). Ministry of Food and Agriculture; Statistics – Research and Information Directorate Report of Agriculture in Ghana. Facts and Figures Accra, Ghana, pp. 17–20.

Morris, C.D., Derry, J.F. and Hardy, M.B. (1999). Effect of cattle and sheep grazing on the structure of highland Souveld sward in South Africa. Tropical Grassland. 33:111–121

Nitis, I.M. (1997). Silvipastoral systems in the tropical context; In: *Proceedings of the XVIII* International Grassland Congress, Manitoba, Saskatchewan, Canada, 3: 9–17.

Onwuka, C.F.I., Adetiloye, P.O. and Afolami, C.A. (1997). Households' waste and crop residue uses in small ruminant feeding in Nigeria. Small Ruminant Research, 24: 233 –237.

Opoku, A. (2011). Sustainability of crop residues and manure management in smallholder cereal-legume-livestock systems in the Savannas of West Africa. Ph.D thesis, Department of Crop and Soil Sciences, Faculty of Agriculture, Kwame Nkrumah University of Science and Technology, Kumasi, pp. 48 –51

Reddy, B.V.S., Reddy, P., Bidinger, F. and Blümmel, M. (2003). Crop management factors influencing yield and quality of crop residues, Field Crops Research, 84: 57–77.

Samdup, T., Udo, H.M.J., Eilers, C.H.A.M., Ibrahim, M. N. M. and Van der Zijpp, A. J. (2010). Crossbreeding and intensification of smallholder crop–cattle farming systems in Bhutan. Livestock Science, 132: 126–134.

Singh, B.B., Musa, A., Ajeigbe, H.A. and Tarawali, S. A. (2011). Effect of feeding crop residues of different cereals and legumes on weight gain of Yankassa rams. International Journal of Livestock Production, 2: 017–023.

Smith, T. (2010). Some tools to combat dry season nutritional stress in ruminants under African conditions, University of Reading, Reading, UK. pp, 145–152.

Tilley, J.M.A., and Terry, R.A. (1996). A two stage technique for *in vitro* digestion of forage crops. Journal of British Grassland Society, 18, 104–107.

Timpong-Jones, E.C, Mutanga, O., Adogla-Bessa T., Attua E.M. and Adiku, S.G.K. (2013). Herbage yield and grazing capacity estimation in tropical coastal Savanna rangeland using spatial statistics. West African Journal of Applied Ecology, 2: 37–45.

t'Mannetje, L. (1978). Measurement of grassland vegetation and animal production. Bulletin 52 CAB (Commonwealth Agricultural Bureaux), Farnham Royal, England, UK, pp. 260–263.

Van-Soest, P.J. and Robertson, J.B. (1985). Analysis of Forage and Fibrous Foods: a Laboratory Manual for Animal Science. Cornell University, Ithaca, New York, USA, pp. 057–106.