Effect of season on the quality of forages selected by sheep in citrus plantations in Ghana

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Abstract

The study aimed at assessing the effects of season on chemical composition of forages selected by sheep grazing in a citrus plantation. Forage species growing in a sweet orange (*Citrus sinensis*) plantation were identified and sampled monthly for 2 years. Samples were bulked on monthly basis for chemical analysis. The average dry matter content of the forages increased from the rainy to the dry season but effects of season on the chemical components were inconsistent. Some species, such as *Asystasia gangetica*, had a higher crude protein concentration in the dry season, whereas for others, such as *Panicum repens*, the reverse occurred. However, average concentrations of crude protein, detergent fiber and components of fiber for all species for the rainy season were not significantly different from the dry season values. It was concluded that there were differences among forage species in their responses to changing seasons, such that grazing ruminants may select a diet to enable them to meet their nutritional requirements, provided forage biomass is adequate.

Resumen

En una plantación de naranjos (*Citrus sinensis*) se evaluaron los efectos de la época del año sobre la composición química de las plantas seleccionadas por ovejas pastando la vegetación espontánea en la plantación. Cada mes y durante 2 años se identificaron las especies consumidas y se tomaron muestras para análisis químico. El contenido promedio de materia seca de los forrajes se incrementó de la época lluviosa hacia la época seca, pero el efecto en los otros componentes químicos no fue consistente. Algunas especies, como *Asystasia gangetica*, presentaron una mayor concentración de proteína cruda durante la época seca, mientras que en otras especies, p.ej. *Panicum repens*, ocurrió lo contrario. En la época de lluvias las concentraciones promedio de proteína cruda, fibra detergente y componentes de la fibra en todas las especies no fueron significativamente diferentes de los valores de la estación seca. Se concluye que las diferencias encontradas entre las especies en sus respuestas a los cambios de estación les permiten a los animales en pastoreo seleccionar una dieta adecuada para satisfacer sus necesidades nutricionales, siempre y cuando la cantidad de la biomasa forrajera ofrecida sea adecuada.

Introduction

A major constraint to ruminant livestock production in Ghana and tropical Africa is the seasonal fluctuation in forage availability and quality due to the modal rainfall patterns. Drastic declines in forage quality have been reported for grasses, with crude protein (CP) concentrations as low as 20¬30 g/kg in the dry season being reported (Fianu et al. 1972; Crowder and Chheda 1982; Peters 1992). However, quality declines are not consistent for all forages. In Ghana, Sottie et al. (1998) observed higher CP in shrubs and trees, such as *Delonix regia, Millettia thonningii* and *Securinega virosa*, during the dry season than in the rainy season. Sarkwa et al. (2011) reported an increase in CP of *Ficus exasperata* in the dry season, whereas the opposite was observed for 7 other browse species studied. Larbi et al. (1998) also reported higher CP during the dry season in some species, such as *Ficus exasperata, Senna siamea* and *Acacia angustissima*, in southwestern Nigeria.

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It is important to evaluate the full array of species selected by sheep to have a comprehensive idea of the actual effects of season on quality of forages grazed. Many small ruminants are grazed in tree plantations and the unique environment created by the trees may influence the effects of season on the quality of forages growing in these plantations. Some studies have been conducted on forages found under oil palm in Ghana (Fianu et al. 1994), and oil palm and coconut plantations in Malaysia (Wattanachant et al. 1999; Wahab 2001) and the Philippines (Wong and Moog 2001). However, data on seasonal changes in forages under citrus are lacking. This study was therefore planned to evaluate the effects of season on forage species selected by sheep in a citrus plantation in Ghana.

Materials and Methods

Project site

The project was undertaken at the Forest and Horticultural Crop Research Centre of the University of Ghana, situated at Okumaning near Kade in the Eastern Region of Ghana. The Centre lies in the semi-deciduous forest belt (6.16º N, 0.95º W) (Google Maps). The soils at the study site occur on a catena stretching from the upper to the bottom slope. The forages covered part of the upper and middle slopes on mainly Nzima and Kokofu soil series, classified as Kandic Paleudalf and Udic Kandiudalf, respectively (Owusu-Benoah et al. 2000). An area of about 8 ha, planted with sweet orange (*Citrus sinensis*) of the Late Valencia variety, was selected for the study. No cover crops were planted under the tree crop and no fertilizer was applied to the citrus trees.

Determination of the seasons

Data on monthly mean rainfall amount and number of rainy days were collected from the on-site weather station. Data for 4 years (2007–2010) were averaged and used to define the rainy and dry seasons for the study site. The rainy season is between March and November (inclusive) and the dry season from December to February (Figure 1).

Experimental animals and determination of forage species selected

An area of about 5 ha was selected within the plantation and was stocked with 30 female West African Forest type sheep. The sheep were deliberately selected with a weight range of 12–25 kg to mimic a natural flock. They were grazed between 08.30 and 14.30 h each day. After 2 weeks of grazing to acclimatize, the sheep were observed during grazing and samples of forages they selected were collected according to a direct observation method described by Hirata et al. (2008). One adult sheep (20–25 kg live weight) was randomly selected on each observation day and observed closely by a single observer for 4 h in the morning (08.30 to 12.30 h). This was done to get the complete array of species selected during the period of active grazing. Forage species eaten were recorded and sampled for subsequent identification at the Livestock and Poultry Research Centre (LIPREC) of the University of Ghana. Observations were made on 5 consecutive days at the beginning of each season. Care was taken not to interfere with the normal grazing of the animals.

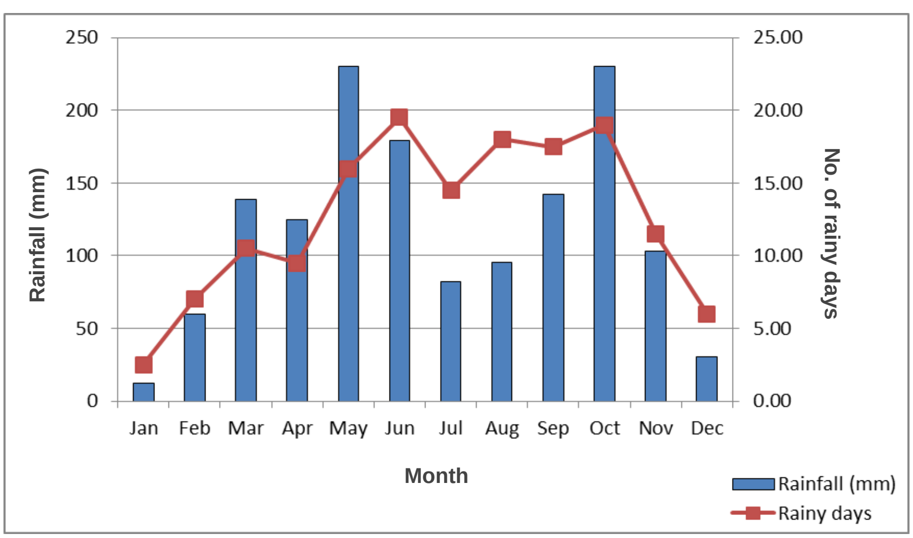

Figure 1. Mean monthly rainfall for the study period (2009 and 2010).

Forage sampling and determination of species composition

Forage sampling for the determination of species composition was done within the first three months of the rainy season (March – May) in year 1. At monthly intervals a quadrat measuring 50 cm x 50 cm was thrown 6 times at random across the field (at distances of at least 30 m apart) and forage within the quadrat harvested. Clipping was done at approximately 2 cm from ground level, and the harvested material was placed in paper bags. Each sample was weighed, separated according to species and individual species weighed. Dry matter (DM) of each species was determined by drying in a forced-draught oven at 65 ºC for 48 h. The dry weight of the total sample was calculated from the mean DM of the individual species. The contribution of each species to the total sample biomass was calculated according to the formula below:

$$A = Da/Dt$$

$$Dt = \sum(Da + ... + Dn)$$

where:
A is contribution of species A;
Da is DM (g) of species A per quadrat;
Dt is total DM (g) of forage per quadrat; and
Dn is DM (g) of the nth species per quadrat.

Chemical composition

Samples of all species of forage selected by sheep were taken between 09.00 and 11.00 h once a month for 3 months in each season for 2 years (2009 and 2010). For shrubs, samples were made up of leaves and twigs of not more than 5 mm in thickness. For grasses and forbs, samples were taken by harvesting at about 2 cm above ground level. The samples were oven-dried at 60 ˚C for 48 h to determine DM, milled through a 1.0 mm screen and bulked on monthly basis (combining the 2 years). Total N was determined by the Kjeldahl method (AOAC 1990) and CP was calculated as % N x 6.25. Neutral detergent fiber (NDF), acid detergent fiber (ADF) and their components were determined according to Goering and Van Soest (1970).

Data analysis

Data on chemical composition were subjected to analysis of variance using the General Linear Model (GLM) as in JMP-SAS (SAS Institute 2009) according to the model:

$$Y = u + S + e$$

where:
Y is the response variable such as DM, CP, NDF or ADF;
S is the effect due to season; and
e is the residual error.

Means were compared using Tukey-Kramer HSD (Honestly Significant Difference) as in JMP-SAS.

Results

Species identified

Ten species were identified under the plantation canopy, while 5 species were identified as growing only at the fringes of the tree canopy and in areas in the orchard where some trees had been felled, creating a break in the canopy (Table 1). In addition to the listed forages, sheep also consumed leaves of orange trees within their reach.

Table 1. Forage species selected by sheep in a citrus plantation in Ghana.

Species	Plant family	Forage type
Under the trees		
Asystasia gangetica	Acanthaceae	Forb
Centrosema molle (formerly: *C. pubescens*)	Leguminosae, (Papilionoideae)	Forb
Pueraria phaseoloides	Leguminosae, (Papilionoideae)	Forb
Axonopus compressus	Poaceae	Grass
Oplismenus burmanii	Poaceae	Grass
Panicum repens	Poaceae	Grass
Combretum sp.	Combretaceae	Shrub
Ficus exasperata	Moraceae	Shrub
Griffonia simplicifolia	Leguminosae, (Papilionoideae)	Shrub
Mallotus oppositifolius	Euphorbiaceae	Shrub
Only at fringes or in the open		
Ageratum conyzoides	Asteraceae	Forb
Aspilia africana	Asteraceae	Forb
Melanthera scandens	Asteraceae	Forb
Mimosa pudica	Leguminosae, (Mimosoideae)	Forb
Synedrella nodiflora	Asteraceae	Forb
Panicum maximum	Poaceae	Grass

Contribution of species to forage biomass

The species contributing most to forage biomass under the tree canopy was *Panicum repens*, which contributed

46.1% to the total forage biomass (Table 2). Although *Ficus exasperata* was identified under the tree canopy, it was not captured in the sampling due to its low frequency of occurrence.

Table 2. Mean contribution of species to available forage (n = 3).

Species	kg DM/ha/yr	%
Panicum repens	511.0	46.1
Combretum sp.	331.1	22.7
Mallotus oppositifolius	105.2	8.6
Oplismenus burmanii	93.5	8.4
Pueraria phaseoloides	46.8	4.7
Griffonia simplicifolia	36.8	2.5
Asystasia gangetica	20.2	2.3
Centrosema pubescens	22.6	1.7
Axonopus compressus	2.7	0.2
Miscellaneous species[1]	33.9	2.9
Total	1,204	100

[1]Parts of plants that could not be identified.

Chemical composition

Dry matter and CP concentrations of selected forages for the 2 seasons are presented in Table 3. Average DM % was higher in the dry season (37.4–54.3%) than in the rainy season (28.8–50%) (P<0.05). In both seasons, *Asystasia gangetica* had the lowest DM percentage. Overall average CP concentration was not affected (P>0.05) by season. However, some species, such as *Asystasia gangetica* and *Mallotus oppositifolius*, had higher CP concentrations in the dry season than in the rainy season, whereas for other species, such as *Griffonia simplicifolia* and *Panicum repens*, the reverse occurred.

Season had no significant effect (P>0.05) on the overall means for both NDF and ADF (Table 4).

Table 3. Seasonal effects on dry matter and crude protein concentrations of forage species in a citrus plantation (n = 3 per season).

Species	Dry matter (%)			Crude protein (% DM)		
	Dry season	Rainy season	s.e.m.	Dry season	Rainy season	s.e.m.
Asystasia gangetica	37.4	28.8	1.85	20.6	16.9	1.63
Centrosema molle	45.4	44.1	2.56	18.7	19.0	1.15
Citrus leaves	50.2	50.0	1.18	12.8	13.0	0.27
Combretum sp.	54.3	49.2	1.44	19.9	18.2	1.02
Griffonia simplicifolia	47.3	49.6	2.12	17.9	20.1	1.46
Mallotus oppositifolius	43.3	43.4	2.30	17.1	15.6	0.80
Oplismenus burmanii	47.8	39.1	2.71	7.5	10.7	1.28
Panicum repens	46.5	38.8	1.14	8.9	10.8	0.68
Pueraria phaseoloides	43.5	34.8	2.11	18.5	17.5	0.81
Mean	46.2a[1]	42.0b		15.8a	15.5a	

[1]Means followed by different letters are significantly different (P<0.05).

Table 4. Seasonal effects on neutral detergent fiber (NDF) and acid detergent fiber (ADF) concentrations in forage species in a citrus plantation (n = 3 per season).

Species	NDF (% DM)			ADF (% DM)		
	Dry season	Rainy season	s.e.m.	Dry season	Rainy season	s.e.m.
Asystasia gangetica	41.7	43.6	0.95	31.3	33.0	1.46
Centrosema molle	55.2	60.4	0.68	33.4	36.3	2.11
Citrus leaves	45.2	46.8	1.26	27.2	31.1	2.07
Combretum sp.	68.1	67.8	0.63	38.0	45.3	2.25
Griffonia simplicifolia	55.5	57.7	1.16	32.4	35.5	1.48
Mallotus oppositifolius	44.5	45.8	1.14	22.4	27.0	1.50
Oplismenus burmanii	64.4	66.8	2.17	37.2	36.6	1.96
Panicum repens	62.6	68.3	1.73	36.2	36.4	0.70
Pueraria phaseoloides	55.9	61.1	1.53	34.2	37.6	1.34
Mean	54.8a[1]	57.5a		32.5a	35.8a	

[1]Means followed by different letters are significantly different (P<0.05).

Table 5. Seasonal changes in cellulose and hemicellulose concentrations of forages in a citrus plantation (n = 3 per season).

Species	Cellulose (% DM)			Hemicellulose (% DM)		
	Dry season	Rainy season	s.e.m.	Dry season	Rainy season	s.e.m.
Asystasia gangetica	18.6	21.5	1.43	10.5	10.6	1.22
Centrosema molle	18.2	22.9	1.53	21.8	24.1	0.52
Citrus leaves	15.7	20.9	2.17	18.0	15.7	1.34
Combretum sp.	21.8	23.7	1.42	30.2	22.5	1.71
Griffonia simplicifolia	16.7	16.8	0.96	23.1	22.2	1.32
Mallotus oppositifolius	14.2	21.3	1.68	22.2	18.8	1.88
Oplismenus burmanii	27.1	25.7	1.58	27.2	30.2	0.88
Panicum repens	24.8	26.1	0.92	26.5	31.9	1.88
Pueraria phaseoloides	23.7	25.7	1.03	21.7	23.5	0.53
Mean	20.1a[1]	23.0a		22.3a	22.2a	

[1]Means followed by different letters are significantly different (P<0.05).

For the full range of forages selected by sheep, season had no effect (P>0.05) on cellulose and hemicellulose concentrations in the forage (Table 5). However, for some species, such as *Mallotus oppositifolius*, cellulose levels were higher in the rainy season than in the dry season.

Lignin concentrations were as follows: grasses - range 3.6–17.6%, mean 7.5%; shrubs - 4.6–26.0%, mean 14.0%; and forbs - range 3.2–18.0%, mean 11.3%. Silica concentrations in forbs and shrubs were similar (P>0.05) but both were lower (P<0.05) than for grasses (Table 6).

Discussion

This study has provided useful information on the seasonal changes in nutrient concentrations in forages selected by sheep in a citrus orchard in Ghana. The data indicate that forage quality, particularly CP, would not be a limiting factor for production and that DM availability is more likely to determine how well sheep perform in these situations.

Since the period of active growth for most forage species is the rainy season, it is often assumed that CP concentrations fall and fiber levels increase as the season advances from the rainy season towards the dry season. Studies based on a few planted species have supported this idea. However, in natural pastures with diverse forage species, this may not be the case. Results of this and other studies show that different species can respond differently to changing seasons. This is important for grazing ruminants because it provides an opportunity to select forage species in such a way as to minimize variations in their nutrient intake as the seasons change. Development of mixed pastures, therefore, may be a strategy to mitigate the effects of the dry season on ruminant production.

Table 6. Seasonal changes in lignin and silica concentrations in forages in a citrus plantation (n = 3 per season).

Species	Lignin (% DM)			Silica (% DM)		
	Dry season	Rainy season	s.e.m.	Dry season	Rainy season	s.e.m.
Asystasia gangetica	9.2	11.2	1.04	0.5	0.9	0.43
Centrosema molle	11.8	12.5	0.90	1.6	1.0	0.20
Citrus leaves	9.2	9.8	0.86	0.1	2.4	0.98
Combretum sp.	14.7	17.2	1.04	1.6	3.6	1.15
Griffonia simplicifolia	14.2	18.2	1.62	0.4	0.6	0.23
Mallotus oppositifolius	6.8	6.5	0.35	0.3	0.9	0.23
Oplismenus burmanii	10.0	8.3	0.49	4.7	4.8	0.38
Panicum repens	8.9	7.3	0.57	2.1	3.3	0.27
Pueraria phaseoloides	9.8	11.6	0.92	0.8	1.3	0.62
Mean	10.5a[1]	11.0a		1.4a	2.1a	

[1]Means for each parameter followed by different letters are significantly different (P<0.05).

Differences in response to season by different forage species have been reported in the literature. Although several studies have indicated a decline in forage CP concentrations in the dry season (Fianu et al. 1972; Crowder and Chheda 1982; Peters 1992), others have reported an increase in CP during the dry season for some species (Larbi et al. 1998; Sottie et al. 1998; Sarkwa et al. 2011). In a study involving 7 grasses, Evitayani et al. (2004a) observed similar CP concentrations in 4 species in both dry and rainy seasons.

Although shade has been reported to have a negative effect on forage CP levels (Johnson et al. 2002), the average CP concentrations for forages under citrus trees of 15.5% and 15.8% for the dry and rainy seasons, respectively, were still high compared with the maintenance requirement of 6–7% CP for ruminants (Smith 1992). As animals can actively select for leaf, the CP concentrations in the diet selected would certainly be higher than these mean values for whole plant samples.

The higher NDF levels in grasses (*Oplismenus burmanii* and *Panicum repens*) during the dry season than in the rainy season were similar to earlier reports (Khan et al. 1999; Evitayani et al. 2004a; Waterman et al. 2007). However, for broad-leaved plants, responses varied. Work by Sottie et al. (1998) indicated no seasonal effect on the NDF levels of some browses in the Accra plains, while Larbi et al. (1998) and Sarkwa et al. (2011) observed decreases in both NDF and ADF concentrations in browse species in the dry season.

Similar seasonal changes in forage DM content to those observed in this study have also been reported in the literature. Sottie et al. (1998) reported DM increases averaging about 32% in selected forages as the season changed from the major rainy season to the dry season in the coastal savannah area of Ghana. The lower variation in DM content of forages in the current study may be due to the shorter dry season in the study area and the effect of high humidity resulting from a combination of the higher rainfall and the tree crop canopy. The higher variation in DM content of grasses than browses is in consonance with a report by Peters et al. (1997) that the effect of season on DM content of shrubs is less drastic than the effect on grasses.

The overall absence of an effect of season on forage lignin concentration agrees with the observations of Adejumo (1992). This lack of a significant overall effect of season is due to variation in the response by individual species, as reported by Evitayani et al. (2004b) and Sottie et al. (1998). The concentrations of silica, which is known to be an anti-nutritional factor and a digestibility depressant (Smith and Urquhart 1975), were also not affected by season. The wide range of values for lignin concentration in forages in this study (6.5–18.2%) is probably due to the diversity in the forage species in the study area, but the range is lower than the range of values (6–35%) reported in the literature (Khanal and Subba 2001; Kumar and Sharma 2003; Ogunbosoye and Babayemi 2010).

Conclusions

The range of species selected by sheep in this citrus plantation and the overall lack of change in nutrient concentrations in the forage throughout the year should present a situation where low quality of forage would not be a limiting factor to production. Considering that ruminants are selective in feeding, it may be expected that they would select forages in such a way as to minimize variation in nutrient intake during the dry season provided forage availability is adequate.

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