The Impact of Harvest Frequency on Herbage Yield and Quality of Cynodon nlemfuensis

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The Impact of Harvest Frequency on Herbage Yield and Quality of C*ynodon nlemfuensis*

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Abstract

Ruminants in Ghana experience feed deficit in the dry season leading to loss of weight and condition. To curb this problem of weight loss, there is the need to raise their plain of nutrition in the critical months of the year when feed is low in quantity and quality. This can be achieved by maximising forage production through appropriate harvest management practices. This study sought to find the effect of repeated harvest on dry matter (DM) yield of *Cynodon nlemfuensis* (Cynodon) in the coastal savanna of Ghana. It was hypothesised that infrequent repeated harvest will improve DM yield and nutritive value of Cynodon. An area of 7.0 m by 5.5 m was used for a two year study (2013 and 2014). The treatments were harvest of Cynodon at 24 (T1), 12 (T2) and 6 (T3) weeks intervals. The Randomised Complete Block Design was used with four replicates per treatment. Dry matter yield and plant cell wall constituents viz. NDF, ADF and Cellulose contents decreased significantly ($P < 0.05$) in the order T3<T2<T1, indicating that DM yield and plant cell wall constituents decreased with increasing harvest frequency. Crude protein content (CP) decreased significantly ($P < 0.05$) in the order T1<T2<T3, indicating that CP content increased with increasing harvest frequency. The study has shown that repeated harvest of Cynodon provided lower DM yield of better quality, with harvest at six weeks interval exceeding the minimum CP level required for adequate intake and digestibility by ruminant livestock.

Introduction

Most tropical climates have wet season with adequate lush herbage followed by dry season with scarce forage of low quality that hamper the productivity of ruminant livestock. The crude protein (CP) contents of grasses have been found to fall to as low as 20 g/kg dry matter (DM) in the dry season (Attah-Krah & Reynolds, 1987). The scarcity of feed in the dry season also leads to trekking long distances by ruminant livestock, particularly cattle, in search for feed and water. A study by Timpong-Jones *et al.* (2014) indicated that about 18% of cattle owners in the coastal savanna plains of Ghana herd their cattle a distance of 1.5–6.4 km daily in search of feed and water in the dry season. According to Smith (1999), walking increases the maintenance requirement of ruminant livestock at the rate of 10% per 1.5 km walked. The effect of the fluctuation in feed quantity and quality on ruminant livestock production is a gain in live weight in the rainy season followed by weight loss in the dry season. Studies have shown that livestock depending solely on grass resources provided by the coastal savanna rangelands of Ghana lose about 11–15% of their live weight depending on the severity of the dry season (Otchere *et al.*, 1977). This seasonal loss of weight by ruminant livestock tends to prolong the period

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to attain maturity and market weight and sometimes death of animal could occur, causing great financial loss to livestock owners.

To curb this perennial problem of weight loss by ruminant livestock in the dry season, there is the need to raise their plain of nutrition in the critical months of the year. This can be achieved by maximising grass production in the wet season and conserve in order to provide feed of reasonable quality to livestock in the dry season. To maximise forage production, appropriate harvest management practices need to be employed. Forage harvest management is the timely cutting of forages from the field for immediate consumption by livestock or for deferred consumption as hay or silage (NRCS, 2006). Harvest management is geared toward optimising the economic yield of forage with the desired quality (NRCS, 2006). Forage harvest management takes the following parameters into consideration; the stage of forage maturity at harvest, average number of cuttings for maximum yields (cutting/ harvest intervals), residual stubble height for plant health and vigor among other parameters (NRCS, 2006). An in-depth knowledge of the effect of repeated harvests on forage yield and quality is therefore very vital in optimising forage productivity.

This study therefore sought to find out the effect of repeated harvest at different intervals on DM yield of cultivated *Cynodon nlemfuensis* (Cynodon) in the coastal savanna agro-ecological zone of Ghana. It was hypothesised that infrequent repeated sward harvest will improve the DM yield and nutritive value of cultivated Cynodon forage.

The specific objectives of this study were to: (1) investigate the effect of the frequency of sward harvest on dry matter yield of cultivated Cynodon. (2) evaluate the effect of repeated sward harvest on forage quality

Materials and methods

This study was conducted in 2013 and 2014 (May to October, 2013 and April to September, 2014) in the Western part of the Accra plains (Lat 5^0–6^0 N). This location experiences bimodal rainfall with the major season having its peak in June and the minor season having its peak in September. According to Alhassan *et al.* (1999), mean annual rainfall for the study area ranges from 600 to 1000 mm. Fig. 1 shows the amount of rainfall recorded during the study years.

The study area has a high annual average temperature of about 26.4 ^{0}C and a relative humidity range of 60–75% (Alhassan *et al.*,1999). Soil analyses conducted during the study period indicated that the soil has characteristics of vertisols with a pH range of 5.4–5.9, organic carbon of 1.78 to 1.90%, ammonium nitrogen of 24.2–26.1 µg/g and nitrate nitrogen of 265–276 µg/g. Soil particle size consists of 53.10% sand, 15.16% silt and 31.74% clay.

An area of 7.0 m by 5.5 m representative of the pure Cynodon stand was used for the two year study in 2013 and 2014. The defoliation regimes (treatments) that were used in this study are shown in Table 1.

While T3 was to simulate grazing with short fallow periods, T2 was to estimate DM yield at the end of the major and minor rainy seasons and T1 was to estimate DM yield if sward remains undisturbed until the end of both rainy seasons.

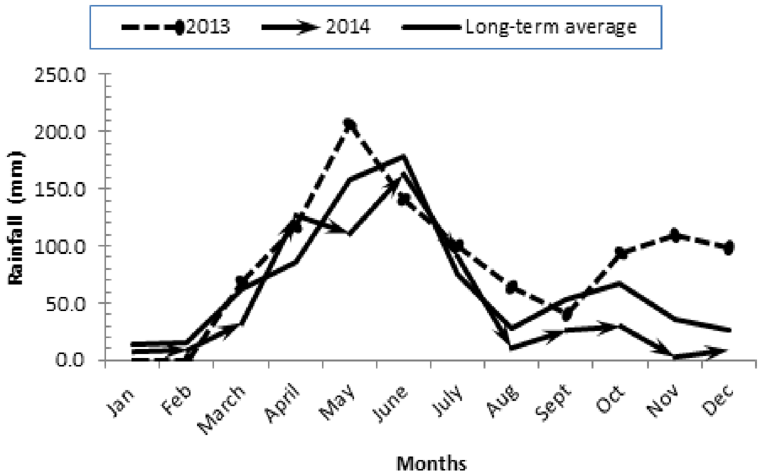

Fig. 1. Amount of rainfall for the study years and the long-term average.

TABLE 1
Treatments and their descriptions

Treatment	*Description*	*No. of times harvested*
T1	Control	Once. At 24 weeks
T2	Infrequent harvests at 12 weeks intervals	Twice. At 12 and 24 weeks
T3	Frequent sward harvest at 6 weeks intervals	Four. At 6, 12, 18 and 24 weeks

The Randomised Complete Block Design was used; this was to keep variability among plots in a block as minimal as possible (Gomez and Gomez, 1984). The plot size for each treatment was 1.0 m × 1.0 m. Spaces between blocks and treatments measured 0.5 m. These spaces were clearly weeded and served as paths for easy access to treatments as well as prevent shading of experimental plots. There were four replicates for each treatment.

Sward was harvested for all the treatments at the start of the rainy season by cutting the herbage at a height of about 7 cm from the ground using a sickle. This height was to ensure that the apical meristems were not destroyed. Regrowth makes use of sugars stored in the bottom 4 cm of the tiller (AHDC, 2010), thus 7 cm was deemed high enough not to hinder grass regrowth. Data collected at each harvest was the above ground biomass yield (ton ha^{-1}).

Harvested samples weighing between 250–500 g were taken, placed in labeled envelops and dried in a forced draught oven at 65 ^{0}C for 48 h. The dried samples were then weighed at room temperature to determine the dry weight. The procedures outlined by the Association of Official Analytical Chemists (AOAC, 1995) were used to determine CP and ash contents while the procedure by Van Soest *et al.* (1991) was used to determine the cell wall constituents; Neutral Detergent Fibre (NDF), Acid Detergent Fibre (ADF), cellulose, hemicellulose and lignin.

The data were subjected to least squares analysis using the Generalised Linear Model (GLM) Type III procedures of SAS (1999) for any differences in DM yield, CP, NDF, ADF, lignin, cellulose and total ash contents of the three treatments.

Results and Discussion

Dry matter yield

Dry matter yield decreased significantly ($P < 0.05$) in the order T3<T2<T1 (Table 2), indicating that DM yield decreased with increasing harvest frequency. It has been well established that the productivity of forage plants is influenced by management factors (Kramberger & Gselman, 2000) with cutting frequency being of major importance (Vinther, 2006). A plot of forage DM yield with time results in a sigmoid curve, with an initial period of slow growth, a rapid growth middle period and a final period of slow growth (Stubbendieck & Burzlaff, 1971). Sims *et al.* (1973) reported that the early above-ground growth is mainly made up of leaf material with the middle period having stem materials in addition while the final phase of growth accumulates DM rather slowly. All these stages of development are associated with DM accumulation, thus leading to the control treatment (T1) having a significantly higher DM yield ($P < 0.05$) than T2 and T3.

The reduction in DM yield with increasing harvest frequency obtained in this study is also because, with repeated harvests, the leaf component of the sward outweighs the stem components, thus reducing whole plant DM yield (Ayala Torales *et al*., 2000). Humphrey (2005) also indicated that, lenient removal of grass shoot may still reduce net photosynthetic rate and cause unrecognised reductions in the movement of assimilate to the roots and thus reduce root growth. Additionally, Mealor (2010) reported that beyond 40% leaf volume removal, root growth by grass species begin to decline, and if root system is disturbed, aboveground production also suffers. Cutting grasses between the third leaf and the reproductive stages can lead to beneficial responses but cutting late in the seasonal development of the plant reduces the plants ability to recover (Manske *et al.*, 2001). This is because, the growing point of grasses moves from the stem bases (with time) upward during the stem elongation phase, and as they are harvested, growth in that tiller stops and it eventually dies. New growth is initiated from dormant basal buds, thus considerably slowing down the regrowth process. The reduction in DM yield with repeated harvests obtained in this study could be due to Cynodon sward's lack of regrowth vigor and persistence under frequent defoliation regime without the use of fertiliser and irrigation. This was consistent with the low survival rate of *Fescue spp* harvested at short intervals reported by McLean and Wikeem (1985).

TABLE 2

Effect of treatments on dry matter yield (ton ha^{-1})

Treatment	*Least squares mean ± s.e*
T1	$10.53^{a} \pm 0.35$
T2	$4.88^{b} \pm 0.24$
T3	$2.12^{c} \pm 0.14$

Least squares means with different superscripts differ significantly ($P < 0.05$)

T1- Control; T2- Infrequent harvest at 12 weeks intervals; T3- Frequent sward harvest at 6 weeks intervals.

Nutritive quality

Crude protein and ash contents. Crude protein content decreased significantly ($P < 0.05$) in the order T1<T2<T3 (Table 3), indicating that CP content increased with increasing harvest frequency. This is consistent with the findings of Namihira *et al.* (2005) who worked on the effect of cutting intervals on mean CP content of *Cynodon nlemfuensis*. They reported that nitrogen content for harvests at 4 weeks interval (16.0 g/kg DM N or 100.0 g/kg DM CP) was higher than at 6 weeks interval (13.0 g/kg DM N or 80.0 g/kg DM CP) and at 8 weeks interval (12.0 g/kg DM N or 75.0 g/kg DM CP). Similarly, Brown and Kalmbacher (1998) working on the same species reported CP content of 106.0 g/kg DM for harvests at 5 weeks intervals and 44.0 g/kg DM for harvests at 10 weeks intervals. Thus in all cases, CP content reduced with longer harvest or cutting intervals.

Increasing the number of cuts increased CP content because sward turns to be relatively leafy (Ayala Torales *et al.*, 2000) with a higher leaf: stem ratio (Boval *et al.*, 2002) and also because of the relatively rapid intake of minerals by grasses that takes place at early growth stages (Butler & Bailey, 1973). Frequent harvests generally caused retrogression in grass development (back to its early growth stages). This stage is characterised by high nutrient absorption for leaf development.

As plants age with longer cutting intervals, the proportion of senescent leaves with low nitrogen content and other structural components (with lower nitrogen content) outstrip that of the leaves with higher nitrogen content (Larbi, 1982; Overman & Scholtz, 2003), thus, causing CP content to decline. Additionally, perennial grasses transport excess nitrogen from the shoot system to storage organs with advancing age, making grasses frequently harvested higher in CP content than those with longer cutting intervals (Henzell, 1971).

Norton (1994) reported that forages containing less than 13.0 g/kg DM N (or 80.0 g/kg DM CP) cannot provide the minimum ammonia levels required by ruminant livestock. Minson (1981) also indicated that the CP level below which DM intake declines is 70.0 g/kg DM. The conclusion that can be drawn from these reports is that, frequent harvest of Cynodon (T3) with the least squares mean CP of 84.6 g/Kg DM is the preferred management practice for improved livestock production.

The ash content was not significantly different ($P > 0.05$) among treatments (Table 3). Apart from CP and ash contents, another important measure of forage quality is the plant cell wall constituents (Minson, 1990).

TABLE 3

Effect of treatments on Plant Crude Protein and Ash contents (g/kg DM)

Treatment	*Least squares mean ± s.e crude protein*
T1	$33.2^{a} \pm 5.5$
T2	$55.2^{b} \pm 3.6$
T3	$84.6^{c} \pm 2.1$
	Total ash
T1	$66.2^{a} \pm 5.4$
T2	$76.4^{a} \pm 3.8$
T3	$70.1^{a} \pm 2.2$

Least squares means with different superscripts differ significantly at $P < 0.05$

T1- Control; T2- Infrequent harvest at 12 weeks intervals; T3- Frequent sward harvest at 6 weeks intervals.

Plant Cell Wall Constituents

The plant cell wall constituents viz. NDF, ADF and Cellulose contents decreased significantly ($P < 0.05$) in the order T3<T2<T1 (Table 4). This indicates that NDF, ADF and Cellulose contents decreased with increasing harvest frequency. There was however an inconsistent relation between lignin content and frequency of harvest.

The NDF gives an estimate of the total structural carbohydrates present in forages (ADF and hemicellulose). The increase in plant cell wall constituents with longer regrowth interval recorded in this study is in harmony with other reports (Sanderson *et al*., 1999; Mahr *et al*., 2005). This trend is obvious because an increase in cutting interval leads to plant maturity, and a mature sward has more fibre content (Wilson *et al*., 1991; Blade *et al*., 1993), lower leaf: stem ratio (Boval *et al*., 2002) and a high proportion of senescent leaves in harvested samples (Ayala- Torales *et al*., 2000). Leaf senescence occurs with age because the lower and older leaves become shaded by the younger and higher leaves, leaving them with inadequate supply of sunshine, thus causing them to senesce (Larbi, 1982). Additionally, there is more formation of structural carbohydrates to enable the stem carry the inflorescence as the plant ages (Putman *et al*., 2000).

Plant cell wall fractions control the rates of digestion and intake of DM by ruminant livestock (McCammon-Feldman, 1980). Meissner *et al.* (1991) reported that the safe upper limit of NDF to guarantee adequate intake of forages is 600 g/kg DM. This upper limit indicates that, the NDF range of 768.4 (T3) to 845.5 g/kg DM (T1) recorded for Cynodon in this study was high and could hinder voluntary intake.

Apart from Lignin content, there were significant differences ($p < 0.05$) in DM yield, Ash, CP, NDF, ADF and Cellulose contents between the two years of study (2013 and 2014) (Table 5). This is attributable to the total amount of rainfall (Fig. 1) in the year as well as rainfall frequency. Cynodon yield and quality harvested after a dry spell is expected to be lower than that preceded by a frequent occurrence of rainfall.

TABLE 4

Effect of treatments on Plant cell wall constituents (g/kg DM)

Treatment	*Least Squares Mean ± s.e*
	Neutral detergent fibre
T1	845.5[a] ± 11.1
T2	805.0[b] ±7.9
T3	768.4[c] ±1.4
Acid detergent fibre	
T1	515.9[a] ± 8.8
T2	461.3[b] ± 6.2
T3	419.2[c] ± 3.6
Cellulose	
T1	372.0[a] ± 12.9
T2	335.0[b] ± 9.1
T3	300.3[c] ± 5.3
Lignin	
T1	86.7[a] ± 6.7
T2	68.2[b] ± 4.7
T3	75.7[ab] ± 2.7

Least squares means with different superscripts differ significantly at $P < 0.05$; T1- Control; T2- Infrequent harvest at 12 weeks intervals; T3- Frequent sward harvest at 6 weeks intervals.

TABLE 5

Effect of year of study on least squares mean of sward dry matter yield and quality (Dry matter basis)

Parameter	*Year 2013*	*Year 2014*	*s.e*
Dry matter yield (t/ha)	6.15[a]	5.53[b]	± 0.2
CP (g/kg)	46.8[a]	68.6[b]	± 2.8
NDF (g/kg)	815.7[a]	797.0[b]	± 6.2
ADF(g/kg)	473.2[a]	457.7[b]	± 4.9
Lignin (g/kg)	74.6[a]	79.1[a]	± 3.7
Cellulose (g/kg)	354.5[a]	317.0[b]	± 7.3
Total ash (g/kg)	92.5[a]	49.1[b]	± 3.1

Least squares means in the same row with different superscripts differ significantly ($P < 0.05$)

CP- Crude protein; NDF-Neutral detergent fibre; ADF- Acid detergent fibre

Conclusion

The study has shown that repeated harvest of *Cynodon nlemfuensis* provides forage of lower DM yield because with repeated harvests, the leaf component of the sward outweighs the stem components, thus reducing whole plant DM yield. However, with repeated harvest, *Cynodon nlemfuensis* provides forage of better quality with harvest at six weeks intervals exceeding the minimum CP level required for adequate intake and digestibility by ruminant livestock.

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