Effect of Cutting Stage and Turning Frequency on Nutritive Value and Digestibility of Two Tropical Forages

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Key words: cut-and-carry system, feed shortage, forage conservation, *in-vitro* digestibility, hay.

Abstract.
In Malawi, feed shortage during the dry season (June-October) is a critical factor affecting smallholder dairying. Though suitable improved forages were long introduced, important parameters that indicate forage and hay quality for dry season feeding have been less well studied. This study evaluated the effect of cutting stage and turning frequency at drying of two tropical forages on nutrient composition and digestibility. A 2^3 factorial experiment laid out in Randomized Complete Block Design was conducted in Mzuzu milk shed area. *Centrosema pubescens* and *Chloris gayana* were established on four plots (5m x 3m) each by 24 dairy farmers; two plots per forage species representing two cuts at 14 and 18 weeks. At harvest, biomass was partitioned and sun-dried as follows: first lot was turned once while the second lot was turned twice daily for four days. Forage hay samples were collected for nutrient composition analysis. All data were subjected to analysis of variance. The results showed that fibre components increased with stage of maturity while CP and digestibility declined but *Centrosema pubescens* retained quality attributes. There were no significant interactions between forage species, cutting stage and turning frequency. It is concluded that harvesting at 14 weeks produced hay with high nutritive value than at 18 weeks. Frequency of turning had no effect on nutritive value of the hay. It is recommended to promote cultivation of improved pastures for hay making to complement cut and carry system using natural pastures.

Introduction

Smallholder dairy production is an important venture in Malawi contributing substantially to household food and income security for crop-livestock farmers (Tebug et al. 2012). Generally, production is characterized by low inputs of a small herd size ranging from two to four cows. The majority of smallholder dairy farmers confine their dairy cows and practice zero-grazing throughout the year, hence require a steady supply of high-quality feeds to sustain milk production. However, feed shortage during the dry season (June-October) has been identified as a critical factor especially in the tropics and sub-tropics (Tebug et al. 2012). This problem stems from, among other reasons, high population pressure leading to less land allocated to improved pasture production which can be conserved for dry season. As a result, farmers rely on harvesting forages from natural communal grasslands. This practice is unsustainable, replete with immense challenges not least the low quality of the limited quantity of feed produced, and labour involved. The dry season feed gap is further compounded by some variations in rainfall pattern that negatively affects pasture production.

Suitable cultivated forages have long been introduced in Mzuzu milk shed area including *Panicum maximum*, *Pennisetum purpureum, Tripsacum andersonii, Chloris gayana* and *Centrosema pubescens.* These forages are still popular with farmers for their adaptability and ability to provide quality feed. Even where improved forages are adopted, quality drastically declines with maturity (Enoh et al. 2005). Further, while facilitating the curing process, excessive turning of forages during hay making affect leaf shattering especially for legume forage resulting in a decline in quality (Suttie 2000). Some forages do not withstand short cutting intervals, and so these critical points need to be studied and managed properly to enhance the nutrient profile of hays for improved utilization. Specifically, the study intended to generate information that would enable smallholder dairy farmers to know the appropriate stage to harvest and properly conserve *Centrosema pubescens* and *Chloris gayana* for dry season feeding.

Methods and Study Site

Study location. The study was conducted in the Mzuzu Milkshed Area (latitudes 11° 27ˈS-11° 36ˈS and longitudes 34°0ˈE-34°17ˈE at an elevation of 1253 m asl), with annual average precipitation of 1389 mm and temperature of 17.7°C. Soils from primary production fields belong to the sandy loams or sand textural class.

Study design, field management and hay making. A total of 24 farmers, six from each site, participated in the study. The experiment was a 2x2x2 factorial arrangement laid out in randomized complete block design

(RCBD) replicated six times. Treatments were represented by forage species, cutting stage and turning frequency with site (milk bulking group) as blocks. *Centrosema pubescens* seed were planted on two adjacent plots (5 m x 3 m) at a seeding rate of 4 kg/ha per participating farmer to represent the two forage harvesting periods (14 and 18 weeks after planting – WAP). The seeds were sown in rows spaced at 15 cm along the length of the seed bed at a depth of 2-3 cm. *Chloris gayana* was sown at a seeding rate of 2 kg per hectare on well prepared and ploughed plots (5 m x 3 m) to give two harvesting periods as described for *Centrosema pubescens*. The seed was first mixed with di-ammonium phosphate (DAP) fertilizer at a rate of 50 kg/ha and broadcasted to the seed bed to ensure uniform plant densities. Using a small tree branch the seed bed was gently raked so that the seeds were lightly covered by a thin layer of soil. Planting for both forages in all the four sites was done within the third week of January, 2015. All agronomic practices were kept the same for all the sites and weeding was done by hand. Forages were harvested at 14 and 18 WAP. For *Centrosema pubescens*, plants were cut at a height of 8 cm above ground level while *Chloris gayana* was cut at a stubble height of 15 cm using sickles. Fresh biomass from each single plot were partitioned into two and dried as follows: the first sample was turned once while the second sample was turned twice daily for four days. Forages were sun-dried in the field until curing was complete and hay was ready for stacking at the farmyard.

Nutrient composition determination. All samples were prepared by grinding using a laboratory mill to pass through a 1 mm mesh screen, packed in airtight plastic containers. Analysis for DM, ash, CP and EE were determined using methods described by Association of Official Analytical Chemists [AOAC] (2002). Fibre components, NDF and ADF, were determined using the ANKOM^{200} Fiber Analyzer (ANKOM Technology Corp., Fairport, NY). ANKOM technology method 3 using the DAISY^{II} Incubator (ANKOM Technology Corp., Fairport, NY) was used to determine i*n vitro* dry matter digestibility (IVDMD). Gross energy content was determined in an oxygen bomb calorimeter (Parr 6100 Calorimeter, Parr Instrument Company, Moline, Illinois, USA).

Statistical analyses. The data were managed and analyzed with GenStat for Windows 17th Edition. Analysis of variance (ANOVA) using the General Linear Model was used as a statistical test. Means were separated using the Pearson's protected LSD at 95% confidence level.

Results

Nutrient composition and digestibility of the cultivated forages. A summary of nutrient composition and IVDMD of the forages is presented in Table 1. Overall, *Centrosema pubescens* had significantly higher CP, 132.9 g/kg DM, than *Chloris gayana*, 76.7g/kg DM ($p<0.05$). Both fibre fractions, NDF and ADF, were higher ($p<0.05$) in *Chloris gayana*, than in *Centrosema pubescens*. Considering the IVDMD, *Centrosema pubescens* was highly digestible (624.3g/kg DM) compared to *Chloris gayana*, (436.7g/kg DM) ($p<0.05$).

Table 1: Nutrient composition and digestibility of cultivated forages (g/kg DM)

	DM	CP	NDF	ADF	GE†	EE	ASH	IVDMD
Centrosema	902.9^{b}	132.9^{a}	622.3^{b}	381.4^{b}	16.19^{a}	55.8^{b}	86.8^{a}	624.3^{a}
C. gayana	906.4^{a}	76.7^{b}	808.8^{a}	501.6^{a}	14.46^{b}	49.3^{a}	89.4^{a}	436.7^{b}
SEM	0.10	0.21	0.75	0.64	0.14	0.06	0.25	0.51

^{ab} means with different superscripts within a column are significantly different ($p<0.05$), DM=dry matter, CP=crude protein, NDF=neutral detergent fibre, ADF=acid detergent fibre, GE†=gross energy (MJ/kg DM), EE=ether extract, IVDMD=in vitro dry matter digestibility, SEM=standard error of mean

Effect of cutting stage and turning frequency during drying on nutrient composition and digestibility of improved forages. Table 2 presents data on nutrient composition and IVDMD of the forages as affected by the growing stage at cutting and the turning frequency during hay making. The analyses of variance for the 2 *x* 2 *x* 2 (forage type *x* cutting stage *x* drying method) interaction showed no significance ($p>0.05$) for all the variables. The results suggest that turning frequency during hay making did not significantly affect proximate components, gross energy and digestibility of the two forages at either of the two growth stages. However, a significant interaction was observed between forage species and cutting stage for both forages ($p<0.05$), with exception of NDF in *Centrosema pubescens* and ADF in *Chloris gayana* whose interactions were insignificant ($p>0.05$). Thus CP, EE, gross energy and IVDMD tended to drop with advanced maturity (18 WAP), but NDF concentrations in *Centrosema pubescens* were almost maintained contrasting with *Chloris gayana* whose concentration increased as harvesting was delayed.

Table 2: Nutritive value as affected by growth stage and turning frequency (g/kg DM)

F	W	M	DM	CP	NDF	ADF	GE†	EE	ASH	IVDMD
Cp	14	1	893.0^{b}	138.3^{b}	625.6^{b}	363.7^{d}	18.2^{a}	61.4^{a}	70.0^{c}	646.7^{a}
		2	883.5^{c}	151.7^{a}	629.8^{b}	369.9^{cd}	17.8^{a}	58.9^{a}	72.0^{c}	648.6^{a}
	18	1	917.1^{a}	118.6^{c}	613.7^{b}	400.2^{b}	14.4^{c}	52.2^{b}	105.2^{a}	593.2^{b}
		2	918.1^{a}	123.0^{c}	620.0^{b}	391.6^{bc}	14.3^{c}	50.7^{b}	100.1^{a}	608.8^{b}
Cg	14	1	894.1^{b}	89.5^{d}	796.6^{b}	500.2^{a}	16.4^{b}	53.0^{b}	83.4^{bc}	444.9^{c}
		2	890.7^{bc}	88.1^{d}	791.0^{b}	494.4^{a}	16.1^{b}	52.6^{b}	81.7^{bc}	458.4^{c}
	18	1	921.5^{a}	66.1^{e}	816.0^{a}	501.5^{a}	12.7^{d}	45.7^{b}	98.4^{a}	410.3^{d}
		2	919.2^{a}	62.9^{e}	831.7^{a}	510.6^{a}	12.6^{d}	45.9^{c}	94.2^{ab}	433.2^{cd}
SEM			0.19	0.42	1.50	0.90	0.28	0.13	0.50	1.02

^{abcde} means with different superscripts within a column are significantly different ($p<0.05$), DM=dry matter, CP=crude protein, NDF=neutral detergent fibre, ADF=acid detergent fibre, GE†=gross energy (MJ/kg DM), EE=ether extract, IVDMD=*in vitro* dry matter digestibility, F=Forage species, W=cutting stage (weeks), M= turning protocol, Cp.=*Centrosema pubescens*, Cg=*Chloris gayana*, SEM= standard error of mean.

Discussion

The nutrient composition values reported provide background information vital in diet formulation for dairy cattle. *Centrosema pubescens* ranked highly in terms of CP, energy, digestibility and low fibre concentration compared to *Chloris gayana*. These differences can be explained by inherent characteristics of each species related to physiology and the ability to extract and accumulate nutrients from the soil and/or the capacity of a leguminous plant to fix atmospheric nitrogen. Dzowela (1990) reported slightly comparable values, with variations attributed to growing conditions, management during hay making which lead to differences in leaf: stem ratio, which has a major effect on differences in CP and fibre especially among legume forages. For both forages, the levels of CP in the hay exceeded the minimum of 75 g/kg DM suggested as necessary for optimum rumen function (van Soest 1994). CP levels in *Centrosema pubescens* also fall within the 100-180 g/kg DM range described by Moran (2009) to support lactation requirements of dairy cattle. The results confirm the potential of the two forage hays to improve the diets of dairy cattle during critical months. *Centrosema pubescens* was highly digestible attributed to high concentrations of readily degradable fractions such as CP as compared to high fibre fractions in *Chloris gayana*.

In respect of the growth stage at harvest, as plants develop physiologically from vegetative to reproductive phases, there is an increased stem fraction compared to the leaf fraction. Stem elongation is accompanied by an accumulation of hemi-cellulose, cellulose and lignin, which provide strength to the plant. This accumulation dilutes the readily degradable cell contents such as CP and crude fat thereby reducing the overall quality of forage hays harvested at 18 WAP. For *Centrosema pubescens*, the NDF concentration at 18 WAP tended to be lower than at 14 WAP, supporting earlier reports that improved legumes do not accumulate more cell wall components as is apparent in tropical grasses. Assessing the adequacy of the *Chloris gayana* hay, the CP content at 18 WAP was lower than recommended for a healthy rumen function (van Soest 1994) so too the IVDMD value. Stage of maturity is the most important of all the factors affecting hay quality (Enoh et al. 2005) and the one in which the greatest progress can be made. Therefore, harvesting forages at 14 WAP optimizes nutrient composition and offer quality hay that would support animal nutritional needs during the critical period.

No significant variations were observed between the two drying methods in this study. This finding is inconsistent with previous studies (Suttie 2000) which described losses in hay quality owing to poor weather conditions, mechanical influences and respiration, allied with the effects of turning and raking hay, which led to leaf shattering and decreased quality in terms of biomass and nutrients such as protein. Findings in this study are attributed to good conditions at harvest time such as no rainfall and excessive dew in the morning, which facilitated even drying and prevented leaf shattering. In addition, since only small quantities of forage were dried out in loose swathes, this facilitated even drying of leaves and stems preventing shattering (Kiesselbach and Anderson 1931). In contrast, when curing heavy yields of forages in deep swathes, moisture loss from stems is slower than from leaves and in the lower parts of the swathe, the leaves are brittle, crumbling and shattering easily.

In conclusion, the study demonstrated that *Centrosema pubescens* harvested at 14 weeks after planting and conserved by sun drying had a higher nutritive value compared to the week 18 harvest to cover the dry season feed deficit. Frequency of turning during drying had no effect on nutrient composition of the hay in this study. Thus, dairy farmers can make hay from the evaluated forages using either method. The legume/grass mixture combines quantity and quality attributes. The policy implication of these findings is to promote cultivation of improved pastures for hay making to complement the cut and carry system with natural pastures, which decline in nutritive value in dry season. Improved pastures will in turn ensure good feed flow and adequate nutrition for dairy animals.

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