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Effect of cutting height on nutritional characteristics of three agroforestry tree legume species and their feed supplement value on *Chloris gayana* Kunth.

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This study investigated the effect of cutting height (30 and 100 cm) on chemical composition and *in vitro* digestibility in field-grown *Acacia angustissima* (Mill.) Kuntze. (Prairie acacia), *Leucaena pallida* Britton & Rose (guaja) and *Mimosa scabrella* Bentham. (bracatinga) legumes and their value in supplementing a basal diet of *Chloris gayana* Kunth. (Rhodes grass). Cutting height did not affect major chemical composition. Crude protein (CP) was highest in *A. angustissima* and lowest in *M. scabrella*, while neutral detergent fibre (NDF) and acid detergent fibre (ADF) were highest in *M. scabrella*. Degradation parameters were greater at 100 cm cutting height. *L. pallida* showed high *in vitro* organic matter digestibility but *A. angustissima* had the highest metabolisable energy. Addition of *A. angustissima*, *L. pallida* and *M. scabrella* to the basal diet increased improved the nutritional value and increased the CP content from 8.4 to 19.8% and 18.1 and 16.1%, respectively. Cutting height of *A. angustissima*, *L. pallida* and *M. scabrella* had no effect on their nutritional value. Their other functions and benefits will determine choice of cutting height as management practice when used on farms.

Key words: Legume trees, cutting height, chemical composition, *in vitro* degradability.

INTRODUCTION

Livestock production is an important component to the livelihood of many smallholder farming systems throughout the tropics (Klapwijk et al., 2014). Demand for animal-based foods is increasing, providing good possibilities for livestock producers to improve their income. However, they will need to increase the productivity of the livestock, for example through improved nutrition and feeding. Population increases

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have decreased access to grazing lands in many countries, leading to adoption of zero grazing system based mainly on cut-and-carry grass forage. Tropical grasses mature rapidly, with productivity limited by soil infertility in particular and their lack of N leads to protein deficiency in livestock (Giller, 2001) , so they often need to be supplemented with protein feed resources. Use of commercial concentrates is not financially feasible for many smallholder farmers, who instead use forage from shrubs and tree legumes to correct dietary deficiencies in protein, energy and minerals (Al-Masri, 2007). Moreover, tree legumes are tolerant to drought, can fix nitrogen, stabilize the soil and be used in terracing, contour cultivation and strip-cropping to combat soil erosion and increase soil fertility (Dubeux et al., 2017). Tropical tree legumes have high concentrations of CP, ranging from 14 to 29% of dry matter (Simbaya, 2002). However, their use as feed supplements to ruminants can be limited by the presence of anti-nutritional factors, such as tannins and phenolic, which can limit feed intake, digestibility and reduce live weight gain, milk and other production parameters (Mlambo and Mapiye, 2015). Foliage from legume trees is reported to have both positive and negative effects on feed value parameters such as digestibility, energy, nitrogen content and voluntary intake of individual forages (Niderkorn and Baumont, 2009). According to Dal Pizzol et al. (2017), the positive effects of legumes in feed mixtures are governed by the fermentation rate of different components. This rate is dependent on the fermentability of their chemical constituents, especially proteins, sugars and cellulose (Mauricio, 1996). *Acacia angustissima*, *Leucaena pallida* and *Mimosa scabrella* are promising tree legumes that can provide protein-rich feed for ruminants, as well as fuelwood, nutrient-rich mulch, erosion control and land stabilisation (Niang et al., 1998; Gusha et al., 2013; Mutimura et al., 2015). However, information on their nutritional quality and productivity under different agro-ecological conditions and management strategies is limited (Mokoboki, 2011; Mutimura et al., 2013a). This study examined the effect of cutting height on nutritional characteristics of tree legumes grown on an acidic Ferralsols in Rwanda, and their nutritional effect when mixed with grass forage.

MATERIALS AND METHODS

Study area and plant material

Biomass of three tree legumes (*A. angustissima, M. scabrella* and *L. pallida*) and one grass species (*C. gayana*) was produced in a field experiment at Tonga research station (29°43'E; 2°35'S; 1700 m above sea level). The site has mean annual rainfall of 1200 mm and mean annual temperature of 20°C. The soil is a Ferralsols sandy clay loam, with average pH 4.5 and exchangeable Al^{3+} content 3-4 cmol kg^{-1}. *Eucalyptus* spp. and *Eragrostis curvula* dominated the site prior to establishment of the experiment. Soil preparation was done by hoe and machete.

The experiment (3x2 factorial arrangement) was laid out in a randomised complete block design with six replicates. Trees were established with fertiliser application of 15 tonnes ha^{-1} fresh weight cattle manure and 2 tonnes ha^{-1} burnt lime to boost the starting of the seedlings. Tree seedlings were planted in four rows, with 1 m between rows and 0.5 m between plants within rows, and rooted tillers of *C. gayana* were established at 0.25 m spacing between and within rows. The trees were cut to 30 or 100 cm height. Legume samples were collected in net plots comprising the two middle rows, excluding all plants less than 3 m from the borders of plots. Regrowth of the 5^{th} cut, collected 22 months after establishment and about 5 months after the previous cut, was used for analysis of chemical composition and feed value. Leaves, petioles and succulent stems (Ø <8 mm) were collected from all trees in net plots and pooled to one sample per plot. *Chloris gayana* samples were collected at the flowering stage.

Chemical analyses

Fresh samples were divided into two parts. One part was oven-dried at 105°C for 8 h to determine dry matter (DM) content and the other was oven-dried at 60°C for 72 h and milled to pass through a 1-mm sieve. Samples of the legumes, the grass and mixed legume-grass in proportions 30% legumes and 70% grass were analysed. Total ash and crude protein (CP) (AOAC, 1990; method 942.05), calculated as 6.25 times Kjeldahl nitrogen (N) measured by method 988.05. Calcium (Ca), magnesium (Mg) and phosphorus (P) concentrations were determined by dry ash (methods 927.08, 964.04). Organic matter (OM) was calculated as the difference between DM and ash. Total polyphenols (TP) content was determined according to Anderson and Ingram (1993). Cell wall constituents (neutral detergent fibre (NDF) and acid detergent fibre (ADF) were determined according to Van Soest (1991).

In vitro gas production

In vitro gas production (GP) was measured following Menke et al. (1997). Fermentation media consisted of micro-mineral solution (A), two buffer solutions B and C prepared according to Osuji (1993) and ruminal fluid to provide microbial inoculants. Rumen contents were obtained prior to the morning feed (8:00) from two fistulated steers grazed on *Panicum maximum* and fed with *C. gayana* in their stalls. Rumen contents were collected in sealed thermos flasks. To keep the thermos flask warm, it was filled with boiled water and caped tightly until the time for collecting the rumen contents. The water was quickly replaced with rumen contents, the cap screwed tightly and delivered to the laboratory within 10 min. The rumen contents were squeezed through three layers of cheesecloth into a beaker (250 ml) to remove particles. During the squeezing, the cheesecloth and contents were tightly fitted into the beaker also to ensure minimum exposure to oxygen.

Incubation and data recording

On the day of the incubation, the buffer solutions were prepared according to Osuji (1993) and preheated to 39°C. Samples (200 mg DM basis) were weighed into airtight gas syringes (100 ml). Aliquots of the combined buffer solutions (20 ml) and rumen fluid (10 ml) were dispensed into each gas syringe using a Veterinary Drenching Gun (ROUX-REVOLVER®; Henke-Sass, Wolf GmbH). Syringes containing samples with fermentation medium or blanks with only fermentation medium were incubated at 39°C in an oven

(Model 600 Memmert). Initial gas readings were recorded before the syringes were placed into the oven, and subsequent gas production was recorded at scheduled intervals up to 96 h: 2 hinterval during the first 24 h, 4 h interval between 24 and 48 h and 6 h' interval from 48 up to 96 h of incubation.

Data computation and statistical analysis

Cumulative gas volume in each syringe was calculated as the difference between the value at time (t_i) and the initial value (t_0), adjusted for control values (blanks) at the corresponding recording times. From the gas produced, organic matter digestibility (OMD) and metabolisable energy (ME) values were estimated according to Menke et al. (1979):

$$OMD\ (g/kg\ DM) = 148.8 + 8.89V_{24} + 4.5\ CP + 0.651\ Ash \quad (1)$$

$$ME\ (MJ/kg\ DM) = 2.20 + 0.136\ V_{24} + 0.057\ CP + 0.0029\ CP^2 \quad (2)$$

Where, V_{24} (mL) is the estimated gas at 24 h and CP is the crude protein.

The kinetics parameters of gas volume production were determined using combined models (Schofield et al., 1994):

$$GP = G/1+e\ [2+4c\ (lt-t)] \quad (3)$$

As described by Campos et al. (2004):

$$GP = a/1+e\ [2+4d(c-t)] + b/1 + e[2+4e(c-t)] \quad (4)$$

Where, GP is total gas volume (mL), a and b are gas volume from rapidly soluble and slowly soluble degradable fractions, respectively, d and e are degradation rate (h^{-1}) for rapidly and slowly degradable fractions, respectively, and c is bacteria colonization or lag time (h).

The time taken to produce half the gas volume ($T_{1/2}$) was estimated based on Sahoo et al. (2010):

$$T_{1/2}(h) = lt+1(2xc) \quad (5)$$

Models 3, 4 and 5 were run using PROC NLIN in SAS software 9.4 (SAS, 2012). Data on chemical composition, *in vitro* degradation, ME and kinetics parameters were subjected to two-way analysis of variance (ANOVA) using general linear model procedures in SAS software 9.4 (SAS, 2012):

$$Y_{ijk} = \mu + \alpha_i + \beta_j + \alpha\beta_{ij} + e_{ijk} \quad (6)$$

Where, Y_{ijk} is independent variable, μ is overall mean of observations, α_i is effect of species (i=1,2,3), β_j is effect of cutting height (j=1, 2), $\alpha\beta_{ij}$ is interactive effect between species and cutting height (i=1,2,3; j=1,2) and e_{ijk} is residual effect. Differences in means were statistically examined by Tukey's test at $p<0.05$.

RESULTS

Chemical composition

Most of the chemical constituents of the legumes species, *C. gayana* and mixtures of grass and legumes showed significant differences (Tables 1 and 2). The CP was highest in *A. angustissima.* The NDF and ADF were highest and TP lowest in *M. scabrella*. Mineral content was relatively similar across the legume species. *C. gayana* had the highest contents of ash, cellulose and K and the lowest CP (Tables 1 and 2). Protein level was not affected by cutting height but higher levels of NDF were found at 100 cm cutting height in *A. angustissima* and *M. scabrella* (Table 1).

In vitro gas production, fermentation kinetics and *in vitro* degradation

There were few consistent differences between the legume species. Higher gas production was observed in the legumes at 100 cm than at 30 cm cutting height, and also higher ME were observed in *A. angustissima*. Positive correlations ($P<0.05$) were observed between ME and CP (r=0.141), ash (r=0.259) and total polyphenols (r=0.040). Generally, mixing *C. gayana* with legumes increased dietary CP, P and Ca concentration compared to the pure grass (Table 2), and decreased gas production (Table 4). Increased rapidly soluble degradable fraction (a) and decreased slowly soluble degradable fraction (b) were also observed in the mixed feeds compared to the pure grass (Table 3).

DISCUSSION

The crude protein content was high in all legume species in the present study and it was not affected by cutting height. The CP content in *A. angustissima* and *L. pallida* was higher than reported by Adbulrazak et al. (2000) for different *Acacia* spp. and by Mutimura et al. (2013b) for *L. pallida.* The CP content in *M. scabrella* was lower than that reported by Niang et al. (1996), although they do not mention cutting height. According to Kazemi et al. (2012), legumes, grasses and legume-grass mixtures with CP concentration >19% (DM basis) are classified as prime quality and those with CP <8% as inferior quality. In all cases, the CP content of *A. angustissima, L. pallida* and *M. scabrella* at both cutting heights made them eligible as a protein source in poor-quality basal diets. The fibre content in the legumes was high compared with literature values, for example for NDF in *A. angustissima* (Abdulrazak et al., 2000; Hove et al., 2001; Rubanza et al., 2005). The NDF content in *L. pallida* was similar to that reported by Mutimura et al. (2013b), but lower than that reported by Diriba et al. (2013). The high NDF content in our findings was a result of mature leaves developed during the long (~5 months) and dry period (June-October) since the previous cut. Similarly, Elseed et al. (2002) observed increased NDF concentration in different *Acacia* spp. harvested late in the dry season, compared with early in the dry season, in Sudan. Buxton (1996) concluded that increased temperature lowers forage quality, irrespective of morphological stage. An increase in NDF and/or ADF may therefore decrease the digestibility of fodder tree foliage when ingested mature in

Table 1. Chemical composition (g/kg DM) of *Acacia angustissima* (Aa), *Leucaena pallida* (Lp) and *Mimosa scabrella* (Ms) cut at 30 or 100 cm height (H).

H (cm)	Species	DM	Ash	OM	CP	NDF	ADF	CF	Cellulose.	TP	P	Ca	Mg	K
30	Aa	910^{b}	53^{a}	857^{b}	261^{a}	638^{c}	539^{b}	180^{c}	133^{b}	13^{a}	2.7^{a}	8.3^{a}	3.7^{a}	11.2^{b}
	Lp	909^{b}	58^{a}	851^{bc}	255^{ab}	620^{c}	519^{b}	168^{c}	111^{b}	13^{a}	2.5^{a}	9.8^{a}	4.1^{a}	13.3^{a}
	Ms	922^{a}	37^{c}	885^{a}	196^{c}	725^{b}	688^{a}	306^{b}	268^{a}	9^{b}	1.6^{b}	6.7^{b}	4.3^{a}	8.0^{c}
100	Aa	911^{b}	48^{b}	863^{b}	284^{a}	731^{b}	598^{b}	192^{c}	132^{b}	13^{a}	2.7^{a}	7.7^{b}	4.0^{a}	12.2^{b}
	Lp	911^{b}	48^{b}	863^{b}	245^{b}	566^{c}	480^{b}	140^{c}	113^{b}	14^{a}	2.7^{a}	7.5^{b}	4.4^{a}	14.2^{a}
	Ms	925^{a}	50^{a}	875^{a}	182^{c}	846^{a}	723^{a}	362^{a}	282^{a}	12^{ab}	3^{a}	9.7^{a}	4.1^{a}	10.7^{b}
	SEM	0.2	0.3	0.4	0.9	3.2	2.9	1.4	0.9	0.1	0.02	0.1	0.1	0.1
p -value	Species	<.0001	0.0011	<.001	<.0001	<.0001	<.0001	<0001	<.0001	<.0001	0.0627	0.0006	0.8345	<.0001
	Height	0.3737	0.2026	0.5994	0.0632	0.0012	0.097	0.0146	0.4343	0.0496	0.0015	0.0089	0.9464	0.0076
	Species×height	0.6145	0.0033	0.0417	0.0400	0.6369	0.6608	0.1082	0.3731	0.1108	0.0007	0.0001	0.5467	0.1785

SEM, Standard error of mean. [a, b, c:] Values within columns with different letters differ significantly (p<0.05); DM, dry matter; OM, organic matter; CP, crude protein; NDF, neutral detergent fibre; ADF, acid detergent fibre; CF, crude fibre; TP, total polyphenols; Aa, *Acacia angustissima*; Lp, *Leucaena pallida*; Ms, *Mimosa scabrella*.

Table 2. Effect of mixing *Acacia angustissima* (Aa), *Leucaena pallida* (Lp) and *Mimosa scabrella* (Ms) cut at 30 or 100 cm height with baseline *Chloris gayana* (Cg) on feed composition (g/kg DM).

H (cm)	Feed	DM	Ash	OM	CP	NDF	ADF	CF	Cellulose	TP	P	Ca	Mg	K
30	AaCg	921^{c}	77.5^{a}	851^{a}	191^{a}	703^{ab}	594^{ab}	162^{b}	141^{b}	12.7^{a}	1.9^{a}	7.5^{b}	3.6a	15.9^{bc}
	LpCg	921^{c}	74.6^{a}	855^{a}	182^{ab}	666^{b}	570^{b}	147^{b}	125^{b}	12.5^{ab}	2.0^{a}	9.1^{a}	4^{a}	18.6^{b}
	MsCg	930^{b}	56.7^{b}	863^{a}	161^{c}	725^{a}	658^{a}	306^{a}	276^{a}	9.6^{b}	1.5^{b}	6.4^{bc}	4.1^{a}	13.8^{c}
100	AaCg	918^{c}	77.2^{a}	852^{a}	198^{a}	738^{a}	646^{a}	217^{b}	141^{b}	13^{a}	2.0^{a}	7.3^{b}	3.9^{a}	17.2^{b}
	LpCg	920^{c}	77^{a}	857^{a}	179^{b}	670^{b}	564^{b}	189^{b}	124^{b}	14.3^{a}	2.1^{a}	7.1^{b}	4.4^{a}	17.7^{b}
	MsCg	929^{b}	70^{a}	865^{a}	139^{d}	785^{a}	697^{a}	341^{a}	288^{a}	11^{b}	2.3^{a}	8.8^{a}	4^{a}	16.4^{b}
	Cg	938^{a}	86.4^{a}	852^{a}	84^{e}	772^{a}	652^{a}	332^{a}	294^{a}	9.6^{b}	1.3^{b}	6.4^{bc}	3.1^{a}	22.4^{a}
Significance	SEM	2.0	5.8	3.9	5.6	24.6	23.5	13.8	6.8	0.5	0.2	0.4	0.3	0.8
	P-value	<0.0001	0.0408	0.0937	<0.0001	0.0058	0.0016	<0.0001	<0.001	<0.0001	0.0005	<0.0001	0.0895	<0.0001

SEM, Standard error of means. [a, b, c, d, e:] Values within columns with different letters differ significantly (p<0.05). DM, dry matter; OM, organic matter; CP, crude protein; NDF, neutral detergent fibre; ADF, acid detergent fibre, CF, crude fibre; TP, total polyphenols; AaCg, *A. angustissima* +*C. gayana*; LpCg, *L. pallida* +*C. gayana*; MsCg, *M. scabrella* +*C. gayana*.

Table 3. *In vitro* degradability and kinetics parameters of *Acacia angustissima* (Aa), *Leucaena pallida* (L.p) and *Mimosa scabrella* (Ms) cut at 30 or 100 cm height (H).

H (cm)	Feed	GP (mL/200 g)	a (g/kg DM)	b (g/kg DM)	c (%/h)	$t_{1/2}$ (h)	IVOMD (g/kg DM)	ME (MJ/kg DM)
30	Aa	14^{b}	-2.4^{a}	16.4^{a}	0.026^{a}	27.4^{a}	327^{a}	7^{b}
	Lp	15.1^{ab}	-7.4^{a}	22.5^{a}	0.026^{a}	21.0^{a}	342^{a}	7^{b}
	Ms	14.7^{b}	6.6^{a}	8.1^{a}	0.049^{a}	25.6^{a}	322^{a}	6^{b}
100	Aa	19^{a}	8.7^{a}	10.2^{a}	0.039^{a}	23.4^{a}	299^{a}	8^{a}
	Lp	16.7^{a}	4.2^{a}	12.5^{a}	0.020^{a}	31.1^{a}	349^{a}	7^{b}
	Ms	21.3^{a}	8.4^{a}	13^{a}	0.024^{a}	28.6^{a}	296^{a}	6^{b}
P-value	SEM	1.7	8.1	7.9	0.01	3.9	14.1	0.3
	Species	0.4319	0.5397	0.6793	0.2922	0.9084	0.0288	0.0006
	Height	0.0031	0.2271	0.5635	0.4319	0.3484	0.1842	0.0422
	Species × height	0.03119	0.7914	0.6255	0.1166	0.2145	0.3696	0.0497

SEM, Standard error of means. $^{a, b, c, d, e:}$ Values within columns with different letters differ significantly ($p<0.05$). Gp, gas production (mL/200 g); a (g/kg DM), rapidly degradable portion; b (g/kg DM), slowly degradable portion; c (%/h), degradation rate; $t_{1/2}$ (hour), time needed to produce half of all gas produced; IVOMD (g/kg DM), *In vitro* organic matter degradability; ME (MJ/kg DM), metabolisable energy; Aa, *Acacia angustissima*; Lp, *Leucaena pallida*; Ms, *Mimosa scabrella*.

Table 4. Effect of mixing *Acacia angustissima* (Aa), *Leucaena pallida* (Lp) and *Mimosa scabrella* (Ms) cut at 30 or 100 cm height with baseline *Chloris gayana* (Cg) on kinetics and *in vitro* degradability.

H (cm)	Feed	GP (mL/200 g)	a (g/kg DM)	b (g/kg DM)	c (%/h)	$t_{1/2}$ (h)	IVOMD (g/kg DM)	ME (MJ/kg DM)
30	AaCg	22.3^{c}	3.0^{a}	19.3^{b}	0.019^{a}	44.9^{a}	401^{a}	5^{b}
	LpCg	24.8^{bc}	10.4^{a}	14.4^{b}	0.022^{a}	24.1^{b}	357^{b}	5^{b}
	MsCg	20.7^{c}	-18.1^{a}	38.8^{b}	0.019^{a}	37.6^{a}	354^{b}	6^{a}
100	AaCg	33.6^{b}	105.3^{a}	-71.7^{b}	0.014^{b}	47.2^{a}	339^{b}	6^{a}
	LpCg	31.4^{b}	68.1^{a}	-36.6^{b}	0.016^{ab}	41.6^{a}	356^{b}	6^{a}
	MsCg	28.7^{b}	2.51^{a}	26.2^{b}	0.018^{ab}	44.1^{a}	291^{c}	5^{b}
	Cg	40.8^{a}	-771.8^{b}	812.7^{a}	0.015^{ab}	39.3^{a}	329^{b}	5^{b}
Significance	SEM	2.0	192.5	192.1	0.002	3.9	15.4	0.2
	P-value	<0.0001	0.039	0.034	0.022	0.0032	0.0013	<0.0001

SEM, Standard error of mean. $^{a, b, c:}$ Values within columns with different letters differ significantly ($p<0.05$); Gp, gas production; a (g/kg DM), rapidly degradable portion; b (g/kg DM), slowly degradable portion (g/kg DM); c(%/h), degradation rate; $t_{1/2}$ (h), time needed to produce half of all gas produced; IVOMD (g/kg DM), *in vitro* organic matter degradability; ME (MJ/kg DM), metabolisable energy; AaCg, *A. angustissima +C. gayana*; LpCg, *L. pallida +C. gayana*; MsCg, *M. scabrella +C.gayana.*

the dry season. The fibre content could perhaps be lowered by harvesting fodder tree leaves at shorter intervals or in the wet season and preserving them for use in the dry season. However, some studies report high variability in NDF content (20-80%) in subtropical forages (Jung and Allen, 1995; Harper and McNell, 2015). Although legumes species have higher CP than grass, their higher NDF and ADF content could limit their potential as a supplement to low-quality feeds, by limiting feed intake through physical fill effects and by reducing the digestibility (McDonald et al., 2011). This effect would be more pronounced for *A. angustissima* and *M. scabrella* cut at 100 cm, since they had the highest NDF content.

Total polyphenol content was not affected by cutting height in the three legumes, but was much lower than values reported by Abdulrazak et al. (2000) and Rubanza et al. (2005) for *A. angustissima* grown in Kenya and Tanzania, respectively, and for *L. pallida* grown in Rwanda (Mutimura et al., 2013b). The low total polyphenol content in this study may be explained by a combination of proportion of stem and leaves in the samples and seasonal fluctuations. Parissi et al. (2018) found higher total polyphenol content in leaves than stems and lower content in autumn than spring for different browse species. However, our values were similar to those found by Rubanza et al. (2006) and Mokoboki (2011) for *Acacia* spp. and by Salem et al. (2013) for browse tree species. Moreover, differences in analytical procedures can lead to large differences in total polyphenol concentration (Makkar, 2003). The low levels found can be beneficial, by improving utilisation of the high CP content. Calcium, P and K content were affected by cutting height and were within the range found in most tropical legumes (Abdulrazak et al., 2000; Rubanza et al., 2006). The Ca and P concentrations did not meet ruminant requirements (11 g Ca/kg DM and 7.7g P/kg DM) (NRC, 2001). Thus, when using *A. angustissima, M. scabrella* and *L. pallida* to supplement forage grasses, minerals supplementation would be needed.

The lower IVOMD was expected due to the high cell wall content in the legumes. The values were low compared with those reported in some studies (Abdulrazak et al., 2000; Hove et al., 2001; Diriba et al., 2013) for *A. angustissima*, *L. pallida* and different browse legume species, but in line with values reported in others (Datt et al., 2008; Mutimura et al., 2013b). The combined effect of high cell wall, high crude fibre and relatively low ME content resulted in the low degradability observed in these fodder legumes. This corroborates findings that cell wall content constitutes a set of limits potential feed intake by physical fill effect and by reducing the digestibility (Elseed et al., 2002; McDonald et al., 2011). Buxton (1996) found a negative relationship between NDF and potential forage intake and between ADF and forage digestibility. Datt et al. (2008) found negative effects of crude fibre and cell composition on *in vitro* digestibility and ME, probably because lignin depresses digestibility.

Mixing *A. angustissima, L. pallida* and *M. scabrella* with a basal diet of grass increased dietary CP from an initial 8.4 to 19.8%, 18.1% and 16.1%, respectively. It also increased the IVOMD of the diet compared with legumes alone. Mauricio (1996) suggest that the main chemical components involved in fermentation are proteins, carbohydrates and cellulose. All the feed mixtures, irrespective of cutting height, had CP >130 g/kg DM, that is more than required to allow multiplication of rumen microorganisms (Dal Pizzol et al., 2017). Therefore, all three legume species can be used to improve low-quality forage, while cutting management can be driven by other potential benefits, such as reforestation, boundary demarcation, soil fertility and land conservation, fuelwood production and competition.

Conclusion

The chemical composition, *in vitro* degradability characteristics and gas production of *A. angustissima, M. scabrella* and *L. pallida* showed that these tree legumes can be good feeds for livestock and their inclusion can improve nutritional quality of a grass-based diet. Cutting height (30 or 100 cm) had no major effect on the nutritional value of *A. angustissima*, *L. pallida* and *M. scabrella*. Therefore, farmers do not have to consider cutting height when planning to use these species as supplement feeds. Other functions of the trees such as hedging, fertiliser, fuelwood production, etc. should be determined based on the choice of the cutting height applied at on-farm level.

CONFLICT OF INTERESTS

The authors declare that they have no conflict of interest.

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