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Effects of cutting dates on nutritive value of Napier *(Pennisetum purpureum)* grass planted sole and in association with Desmodium *(Desmodium intortum)* or Lablab *(Lablab purpureus)*

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Abstract

The experiment was conducted at Pawe Agricultural Research Center located Northwestern Ethiopia to assess the effects of days at cutting on nutrient yield and quality of Napier grass (*Pennisetum purpureum*) planted sole and in association with desmodium (*Desmodium intortum*) or lablab (*Lablab purpureus*). The experimental design was a split plot design with three cutting dates (60, 90 and 120 days from planting) as main plots and five plant associations, namely, Napier grass sole, desmodium sole, lablab sole, Napier grass / desmodium and Napier grass / lablab associations as subplots. The 15 treatments were replicated thrice.

Significant ($P<0.01$) effects of days at cutting, plant associations and their interactions was observed on crude protein yield (CPY), *in vitro* organic matter digestibility (IVOMD), content of CP, neutral detergent fiber (NDF), acid detergent fiber (ADF), acid detergent lignin (ADL), ash and hemicellulose. The CPY, NDF, ADF, ADL and hemicellulose increased significantly ($P<0.01$), whereas CP, ash and IVOMD decreased significantly ($P<0.01$) with advance in plant maturity. The CP content of all the treatments (including the factors and their interaction) was above the minimum level of 7% required for optimum rumen function. Cutting Napier grass and the legume associations at 60 and 90 days could also satisfy the minimum CP contents of 15% required for lactation and growth. Relatively high IVOMD values of 71.9, 68.0 and 63.5% were respectively obtained at 60, 90 and 120 days of cutting for the Napier grass/ lablab association. Digestible organic matter yield (DOMY) was maximum at 120 days of cutting.

It was concluded that the association of Napier grass with both legume species generally improved the nutritive value of Napier grass, however, better results were obtained for the parameters of nutritive value considered in the study when Napier grass was planted in association with lablab for all cutting days.

Key words: Associations, Desmodıum, Elephant grass, Lablab, Nutritive value

Introduction

In tropical environments, native pasture and crop residues are poor in quality and provide inadequate nutrients to grazing livestock. Nevertheless, the supply of nutrients to animals can be improved by cultivation of promising tropical forage species. Some of such forages are Napier (*Pennisetum purpureum*) grass, and legumes including desmodium and lablab species. Napier grass is native to Africa and introduced to all tropical and sub-tropical countries of the world (Bogdan 1977). It is an adaptable, vigorous, highly productive species and withstands considerable periods of drought. It rapidly recovers from stagnation of growth with the onset of rains after extended dry periods (Sollenberger et al 1990). Napier grass is palatable and could be fed fresh, as silage or directly grazed on the field (Woodard and Prine 1991; Woodard et al 1991). Fertile soils are a requirement to maintain productivity of the grass (Bogdan 1977), and it also performs well if intercropped with climbing forage legumes (Magacale et al 1998).

Like other tropical grasses, Napier grass is considered to be high in structural cell wall carbohydrates that increase rapidly with advance in maturity, whereas the contrary is true with its crude protein (CP) content and digestibility (Van Soest 1994). This implies the need for production strategies that can help improve the CP concentration and digestibility of Napier grass. One such approach is to establish it in association with legume species to make use of the yield advantage of Napier grass and the high CP content and digestibility of legume species. Moreover, optimization of productivity and nutritive value of grass /legume associations can be achieved by forage management tools such as altering the days at cutting (Steen 1992). The days at cutting of forage crops also has an influence on *in vitro* digestibility, which is a function of the chemical constituents of forages (Coward-Lord et al 1974). To this effect, the use of tropical legumes like desmodium (*Desmodium intortum*)or lablab (*L. purpureus*) which are perennial or short term perennial species in association with productive, but high cell wall fiber containing grass species such as Napier grass could be an advantage in improved supply of nutrients to livestock. This study was therefore conducted with the objectives of assessing the nutrients' content and yield of Napier grass sole and its associations with desmodium and lablab.

Materials and methods

Location and climatic condition

The research was conducted at Pawe Agricultural Research Center, Ethiopia located at 36º 20' E longitude and 11º 12' N latitude at an elevation of 1150 meters above sea level. The annual precipitation of the study area ranges from 1338.7 to 2005.7 mm with a mean of 1603.5 mm, and the rainy season extends from May to early November. The mean annual maximum and minimum temperature of the area was 38.54 ºC and 16.36 ºC, respectively.

Experimental layout, design and treatments

The experimental design was a split plot design consisting of three cutting days (60, 90 and 120 days) from planting as main plots and five plant associations, namely, Napier grass sole, desmodium sole, lablab sole, Napier grass in association with desmodium or lablab as sub plots. The 15 treatments were replicated three times and each treatment was planted on a plot of 12 m^2. A spacing of 1 m between main plots and 1.5 m between replications were maintained.

Napier grass (acc no ILRI 14984) was vegetatively propagated through root splits at 0.5 row to row and plant to plant spacing on a well-prepared red soil in the rainy season as sole plantation. In Napier grass / legume associations, a row of Napier grass was replaced with one row of each of the legume seeds which were drilled at the rate of 18 kg / ha for lablab, and 10 kg /ha for desmodium between the two rows of Napier grass. The row spacing for pure stand of legumes was 25 cm. Fertilizer was applied as diammonium phosphate (18/46, N/P_2O_5) at the rate of 100 kg/ha before planting the forage species.

Laboratory analysis of forage samples

Forage samples were ground using a laboratory mill (Wiley mill) to pass through a 2 mm and then 1mm sieve screens sequentially for laboratory analysis. The chemical analysis for DM, ash and N were carried out by the method of AOAC (1990). The CP was determined by multiplying the N percentage by 6.25. The methods of Van Soest et al (1991) were used to analyze neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL). The modified Tilley and Terry method (Van Soest and Robertson 1985) was used for the determination of *in vitro* organic matter digestibility (IVOMD) of forage samples.

Digestible organic matter and crude protein yield

Biomass on each treatment plot was cut and weighed. Sub samples from each plot were taken and dried in a forced draught oven at 60 ºC for 72 hours until constant weight was attained. Dry matter yield (DMY) was multiplied with CP content of the feed samples to determine crude protein yield (CPY). Digestible organic matter yield (DOMY) was calculated by multiplying DMY (ton / ha) by percent organic matter (OM) and by percent IVOMD. The CPY was calculated by multiplying DMY by CP percentage

Statistical analysis

The standard model for the analysis of variance in a split plot design given below was used to analyze the data collected on nutrient yield and chemical composition of the vegetation in different treatments. The statistical software MSTAT-C was used for data analysis, and Duncan's Multiple Range Test was employed for separation of treatment means.

$Y_{ijk} = m + r_i + m_j + m_{ij} + s_k + eijk$,

Where:

m = over all mean
r_i = i^{th} replication effect
m_j = j^{th} main plot treatment effect
m_{ij} = main plot error or error (a)
s_k = k^{th} sub plot treatment effect
$(sm)_{jk}$ = interaction effect
e_{ijk} = error component for sub plot and interaction or error (b)

Results and discussion

Digestible organic matter yield

Days at cutting had a significant ($P < 0.05$) effect on DOMY. An increase in DOMY were observed as the days at cutting advanced (Table 1). This increasing trend in DOMY of the forages is due to proportional increment of DMY with advance in cutting days. Napier grass / lablab association resulted in a significantly higher ($P < 0.01$) DOMY. The DOMY of Napier grass / desmodium association was also higher than that of sole Napier grass, but was not different statistically significant ($P > 0.05$).

Table 1. Influences of days at cutting and plant associations on digestible organic matter yield (ton / ha) of Napier grass sole or in association with desmodium or lablab

Plant association	Days at cutting			
	60	90	120	Mean
Napier grass sole	4.24^{f}	6.67^{d}	15.62^{b}	8.84^{b}
Desmodium sole	1.82^{h}	2.21^{gh}	3.02^{g}	2.35^{d}
Lablab sole	1.66^{h}	2.7^{gh}	6.05^{de}	3.47^{c}
Napier grass with desmodium	4.89^{f}	7.74^{c}	15.82^{b}	9.28^{b}

Napier grass with lablab	5.16^{ef}	8.67^{c}	18.84^{a}	10.87^{a}
Mean	3.55^{c}	5.59^{b}	11.75^{a}	6.96

Factors	SE	LSD	
		0.01	0.05
Days at cutting	0.43	5.89	1.67
Plant association	0.20	0.79	0.59
Days at cutting x plant association	0.35	1.38	1.02
CV (%)	8.70		

abcdefgh main factors and interactions means with similar superscripts in columns or rows are not significantly different at (P > 0.05); CV = coefficient of variation; LSD = least significant difference; SE = standard error

Napier grass / lablab associations yielded significantly higher (P < 0.01) DOMY than Napier grass sole at cutting days of 90 and 120, and was also superior (P < 0.01) in DOMY than Napier grass / desmodium association at 120 days of cutting. On the other hand, Napier grass / desmodium association resulted in significantly higher (P < 0.01) DOMY at 90 days of cutting than Napier grass sole.

Crude protein content and yield

Days at cutting, plant associations and their interactions resulted in significant differences (P < 0.01) in CP content of the forage crops (Table 2).

Table 2. Effects of days at cutting and plant associations on crude protein content (%) of Napier grass sole or in association with desmodium or lablab

Plant association	Days at cutting			
	60	90	120	Mean
Napier sole	14.13^{d}	10.4^{f}	7.77^{g}	10.77^{cd}
Desmodium sole	19.62^{a}	17.46^{b}	15.19^{c}	17.43^{a}
Lablab sole	19.27^{a}	17.45^{b}	13.73^{d}	16.82^{ab}
Napier with desmodium	17.75^{b}	15.01^{c}	10.79^{ef}	14.52^{b}
Napier with lablab	17.25^{b}	15.11^{c}	11.73^{ef}	14.69^{b}
Mean	17.60^{w}	15.09^{x}	11.85^{y}	14.85

Factors	SE	LSD	
		0.01	0.05
Days at cutting	0.08	0.54	0.33
Plant association	0.16	0.64	0.47
Days at cutting x plant association	0.28	1.11	0.82
CV, %	3.28		

abcdefg main factors and interactions means with similar superscripts in columns or rows are not significantly different at (P > 0.05); CV = coefficient of variation; LSD = least significant difference; SE = standard error.

The CP content constantly reduced (P < 0.01) with advance in cutting days. Higher CP content was observed in plant samples cut at 60 days than either at 90 or 120 days, and cutting at 90 days also resulted in higher (P < 0.01) CP content than cutting at 120 days. Among the plant associations, sole stand of legumes resulted in the maximum CP content as compared to sole stand of Napier grass and its associations with the legumes. The higher proportion of leaf in the forage crops at the earliest cutting day might have contributed for the higher CP content, which decreased with advance in the age of the crops. Such trend in CP content was also reported by other studies (Kidunda et al 1990; Seyoum et al 1998; Tessema et al 2002), and is mainly attributable to dilution of the CP contents of the forage crops by the rapid accumulation of cell wall carbohydrates at the latter stages of growth and (Van Soest 1994).

The sole legumes and their association with Napier grass had significantly higher ($P<0.01$) CP content than Napier grass sole. Moreover, desmodium was significantly higher ($P<0.01$) in CP content than its association with Napier grass, whereas such differences were not observed between lablab and its association with Napier grass. The interaction of plant association with days at cutting indicated that association of Napier grass with either of the legumes resulted in significantly higher ($P<0.01$) CP content at all days of cutting than Napier grass sole.

The CP content of all the treatments was above the minimum level of 7% required for optimum rumen function (Van Soest 1994). Moreover, the CP content of lablab sole at 60 and 90 days of cutting, desmodiumsole at 60, 90 and 120 days of cutting and Napier grass / lablaband Napier grass / desmodium associations cut at 60 and 90 days could also satisfy the minimum CP requirement of 15% for lactation and growth (Norton 1982; McDonald et al 2002). These indicated the possibility of improving the feeding of animals in tropical regions by planting Napier grass which is reputed for its high biomass yield along with lablab or desmodium, thus enhancing the quality of nutrients supplied to animals. The Napier grasses / legume associations resulted in lower CP content at 120 days of cutting, however, under practical production settings these require less supplementation to support reasonable productivity of animals than sole Napier grass cut at 120 days of growth. The effect of days of cutting, plant associations and their interactions were significant ($P<0.01$) on CPY. The effect of days of harvesting indicated an increasing trend in CPY with extended days of harvesting (Table 3). This is due to the fact that accumulation of CP is a function of total DM and CP concentration.

Table 3. Effects of days at cutting and plant associations on crude protein yield (tons / ha) of Napier grass sole or in association with desmodium or lablab

Plant association	Days at cutting			
	60	**90**	**120**	**Mean**
Napier sole	0.98^{efg}	1.19^{def}	2.22^{c}	1.46^{b}
Desmodium sole	0.57^{h}	0.70^{gh}	0.83^{fgh}	0.7^{d}
Lablab sole	0.52^{h}	0.81^{fgh}	1.55^{d}	0.96^{c}
Napier with desmodium	1.37^{de}	1.94^{c}	3.15^{b}	2.15^{a}
Napier with lablab	1.31^{de}	2.01^{c}	3.74^{a}	2.35^{a}
Mean	0.95^{b}	1.33^{b}	2.99^{a}	1.53

Factors	**SE**	**LSD**	
		0.01	**0.05**
Days at cutting	0.01	0.66	0.40
Plant association	0.05	0.21	0.16
Days at cutting x plant association	0.09	0.37	0.27
CV, %	10.52		

abcdefgh main factors and interactions means with similar superscripts in columns or rows are not significantly different at ($P > 0.05$); CV = coefficient of variation; LSD = least significant difference; SE = standard error

Overall, Napier grass associations with both the legumes resulted in higher ($P < 0.01$) CPY than either Napier grass or the legumes. However, the CPY was similar for Napier grass and its associations with the legumes at 60 days of cutting. Generally, the results indicated the complementarity of Napier grass and the legume species in increasing herbage DMY and CP content, respectively, which together contributed towards improved nutritional qualities of the Napier grass / legume mixtures. This result is in line with the findings of Gebrehiwot et al (1996) who reported improved CP content in grass legume mixed forage.

Cell wall constituents

The effect of days of harvesting on NDF content was significant (P<0.01), and increased with advance in days at cutting (Table 4). This is in agreement with other results (Seyoum et al 1998; Tessema et al 2002; Adane 2003).

Table 4. Effects of days at cutting and plant associations on neutral detergent fibre (%)
of Napier grass sole or in association with desmodium or lablab

Plant association	Days at cutting			
	60	90	120	Mean
Napier grass sole	68.3^{b}	71.7^{b}	73.6^{a}	71.2^{a}
Desmodium sole	47^{h}	50.9^{g}	55.7^{f}	51.2^{d}
Lablab sole	45.8^{h}	47.9^{h}	51.1^{g}	48.2^{e}
Napier grass with desmodium	60.1^{e}	64.8^{c}	68.5^{b}	64.5^{b}
Napier grass with lablab	54.1^{f}	58.7^{e}	62.4^{d}	58.4^{c}
Mean	55^{c}	58.8^{b}	62.2^{a}	58.7

Factors	SE	LSD	
		0.01	0.05
Days at cutting	0.16	1.07	0.65
Plant association	0.29	1.16	0.85
Days at cutting x plant association	0.51	2.00	1.48
CV, %	1.49		

abcdefgh main factors and interactions means with similar superscripts in columns or rows are not significantly different at (P > 0.05); CV = coefficient of variation; LSD = least significant difference; SE = standard error

Napier grass sole contained higher (P< 0.01) NDF than in association with both legume species for all the cutting days. Napier grass / desmodium association contained significantly (P< 0.01) higher NDF as compared to Napier grass / lablab association for all dates of cutting. Roughage diets with NDF content of 45-65 and below 45% were generally considered as medium and high quality feeds, respectively (Singh and Oosting 1992). Thus, the NDF contents of lablab sole, desmodium sole, Napier grass / lablab, and Napier grass / desmodium associations could be considered within the medium quality range, except for Napier grass / desmodium association cut at 120 days of growth. The lower (P< 0.01) NDF content in Napier grass / legume associations as compared to Napier grass sole indicated improvement in nutritive value, since decrease in NDF content has been associated with increase in digestibility and hence feed intake (Van Soest 1994; McDonald et al 2002).

As expected, the trend in ADF content due to days at cutting was similar with NDF content and significantly increased (P < 0.01) with advance in maturity (Table 5) which confirmed the results of similar studies (Zinash et al 1995; Seyoum et al 1998).

Table 5. Effects of days at cutting and plant associations on acid

detergent fibre (%) of Napier grass sole or in association with desmodium or lablab

Plant association	Days at cutting			
	60	**90**	**120**	**Mean**
Napier grass sole	42.1^{c}	43.1^{d}	44.1^{c}	43.1^{b}
Desmodium sole	36.2^{i}	38.3^{g}	42.2^{e}	38.9^{c}
Lablab sole	37^{h}	38.6^{g}	40.4^{f}	38.7^{c}
Napier grass with desmodium	40.8^{f}	44.5^{c}	47.2^{a}	44.2^{a}
Napier grass with lablab	40.4^{f}	43.1^{d}	45.4^{b}	43^{b}
Mean	39.3^{c}	41.5^{b}	43.8^{a}	41.6

Factors	SE	LSD	
		0.01	**0.05**
Days at cutting	0.07	0.43	0.26
Plant association	0.07	0.29	0.12
Days at cutting x plant association	0.13	0.49	0.21
CV, %	0.52		

abcdefgh main factors and interactions means with similar superscripts in columns or rows are not significantly different at (P > 0.05); CV = coefficient of variation; LSD = least significant difference; SE = standard error

Contrary to the content of NDF, Napier grass / desmodium association resulted in significantly higher (P < 0.01) ADF content as compared to Napier grass sole overall, and at the latter days of cutting. Therefore, association of Napier grass with desmodium or lablab could be of an advantage in reducing ADF content of forage only when it is accompanied with early utilization of the biomass by cutting it at no more than 60 days of growth.

Significantly (P<0.01) increasing trend in ADL content was recorded as the days of cutting advanced (Table 6), which was in conformity with other reports (Kidunda et al 1990; Tessema et al 2002; McDonald et al 2002) that showed ADL content to increase with the advance in harvesting days of forage crops.

Table 6. Effects of days at cutting and plant associations on acid detergent lignin (%) of Napier grass sole or in association with desmodium or lablab

Plant association	Days at cutting			
	60	**90**	**120**	**Mean**
Napier grass sole	4.6^{f}	5.5^{f}	6.3^{d}	4.9^{d}
Desmodium sole	6.9^{de}	8.3^{bc}	9.6^{a}	8.3^{a}
Lablab sole	6.3^{e}	7.1^{de}	10.1^{a}	7.8^{ab}
Napier grass with desmodium	4.9^{f}	7.6^{cd}	10.1^{a}	7.5^{b}
Napier grass with lablab	4.9^{f}	6.3^{e}	8.5^{b}	6.6^{c}
Mean	5.5^{c}	6.9^{b}	8.6^{a}	7.02

Factors	SE	LSD	
		0.01	**0.05**
Days at cutting	0.08	0.53	0.32
Plant association	0.12	0.47	0.35
Days at cutting x plant association	0.21	0.82	0.61
CV, %	5.11		

abcdefgh main factors and interactions means with similar superscripts in columns or rows are not significantly different at (P > 0.05); CV = coefficient of variation; LSD = least significant difference; SE = standard error

Significant increase (P < 0.01) in ADL content was observed in the last cutting day compared to the first two cutting days of Napier grass and lablab, which indicated rapid lignification to occur late in development in the two species. The ADL content was higher (P<0.01) in the legumes compared to Napier grass and this also caused an increase (P<0.01) in ADL content in the association of Napier grass with the legumes at 90 and 120 days of cutting. This result was as expected due to higher content of ADL in tropical legumes than in tropical grass species (Van Soest 1994). The interaction between plant and days at cutting was significant (P<0.01) in ADL content. At 90 and 120 days of plant age, association of Napier with either of the legumes produced significantly (P <0.01) higher ADL content as compared to Napier grass sole.

In vitro organic matter digestibility

Decreasing trends in IVOMD (P < 0.01) were observed with the advance in the days of harvesting (Table 7) which is in agreement with similar studies (Tessema et al 2002; Daniel 1994). Aschalew (1992) also indicated low IVOMD in late cut tropical grasses.

Table 7. Influences of days at cutting and plant associations on *in vitro* organic matter digestibility (%) of Napier grass sole or in association with desmodium or lablab

Plant association	Days at cutting			
	60	90	120	Mean
Napier grass sole	66.4^{cd}	62.5^{ef}	58.5^{gh}	62.5^{b}
Desmodium sole	70.8^{ab}	61.6^{ef}	57.4^{h}	63.3^{b}
Lablab sole	68.2^{bc}	63^{e}	60.3^{fg}	64^{b}
Napier grass with desmodium	69.8^{ab}	64^{ed}	55.9^{h}	63.2^{b}
Napier grass with lablab	71.9^{a}	68^{bc}	63.5^{e}	67.8^{a}
Mean	69.4^{a}	63.9^{b}	59.1^{c}	64.1

Factors	SE	LSD	
		0.01	0.05
Days at cutting	0.16	1.08	0.65
Plant association	0.38	1.52	1.12
Days at cutting x plant association	0.66	2.63	1.94
CV (%)	1.79		

abcdefgh main factors and interactions means with similar superscripts in columns or rows are not significantly different at (P > 0.05); CV = coefficient of variation; LSD = least significant difference; SE = standard error

The steady decline IVOMD with maturity for tropical grasses has generally been attributed to an increase in structural cell wall components and decline in leaf to stem ratio (Kabuga and Darko 1993). The effect of intercropping on IVOMD was also significant (P < 0.01). The IVOMD of Napier grass / lablab association was higher (P < 0.01) for all days of cutting compared to Napier grass sole, and at 60 and 90 days of cutting compared to Napier grass / desmodium association.

Although IVOMD of Napier grass / desmodiumassociation was higher (P < 0.01) than in Napier grass sole at 60 days of cutting, it had lower IVOMD than Napier grass sole at 120 day of cutting. This could be associated with the rapid lignification occurring in desmodium at the latter date of cutting (Table 5). The results suggested improved digestibility of forages from Napier grass / lablab association as compared to Napier grass /desmodium association. The increase in digestibility may also result in increased feed intake as digestibility and feed intake were found to be positively correlated (Van Soest 1994). The IVOMD obtained at the 60 days of cutting for all treatments and at 90 days of cutting for Napier grass / lablab association could be considered to be of high nutritive value since their IVOMD were above the minimum value of 65% reported by Moore and Mott (1973) to qualify forages to be of high nutritive value. The forages from treatments below this level of IVOMD content may result in reduced feed intake due to lower digestibility.

Correlation analysis

The CP and IVDMD were positively correlated ($P < 0.01$), whereas their correlation with the cell wall fractions as well as DOMY and CPY were negative (Table 8).

Table 8. Correlation between nutrients content and yield of Napier grass sole or in association with desmodium or lablab

	DOMY	CPY	CP	NDF	ADF	ADL	IVDMD
DOMY	1						
CPY	0.96**	1					
CP	-0.79**	-0.67**	1				
NDF	0.66**	0.56*	-0.85**	1			
ADF	0.83**	0.83**	-0.83**	0.85**	1		
ADL	- 0.26	0.33	-0.19	-0.17	0.22	1	
IVDMD	-0.43	-0.36	0.67**	-0.39	-0.53*	-0.72**	1

**= $P < 0.05$; ** = $P < 0.01$; DMY= dry matter yield; DOMY=digestible organic matter yield; CPY = crude protein yield; IVOMD = in vitro organic matter digestibility.*

On the other hand, DOMY and CPY were positively correlated with cell wall fibers, which could be related to the increased content of cell wall fractions and DMY with advance in days at cutting.

Conclusions

- Prolonged days of cutting increased CPY, NDF, ADF and ADL contents and decreased CP and IVOMD contents in Napier grass and its associations with desmodium and lablab.
- The associations of Napier grass with desmodium or lablab resulted in increased CP and IVOMD and decreased cell wall fiber contents, thus improving the nutritive value of the forages arising thereof compared to Napier grass sole.
- It was concluded that the association of Napier grass with lablab is a better option to develop the grass / legume mixture, since it outperformed Napier grass / desmodium association in terms of nutritive value parameters considered in the current study for all cutting days.

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