

Effect of Planting Pattern and Cutting Height on *In Vitro* Digestibility and in Sacco Degradability of Napier Grass Mixed with Silver Leaf Desmodium at Bako, Western Ethiopia

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Abstract

In vitro digestibility and in sacco dry matter (DM) degradability of Napier grass/silver leaf Desmodium mixtures were carried out using 3X2 factorial experiment arranged in randomized complete block design with three replications. The treatments were three levels of stubble cutting heights (20cm, 30cm, and 40cm) and two levels of planting patterns (same row and alternate row). For the legume component DM disappearance after 24, 48, 72 and 96 hours of incubation significantly ($p<0.05$) increased with increasing cutting heights (20cm to 40cm) during second year production season. Both factors had no significant effect on DM disappearance and most of degradability characteristics of the grass component during first year, however, *in vitro* DM digestibility was higher ($p<0.05$) for alternate than same row planting pattern and increased significantly ($p<0.01$) with increasing cutting height. During second year, alternate row planting pattern showed higher ($p<0.05$) DM disappearance after 48, 72 and 96 hours of incubation. Significant difference for DM degradation between cutting heights were observed for 72 and 96 hours of incubation. Among degradability characteristics, slowly fermentable fraction significantly increased ($p<0.05$) with increasing cutting height. The *in vitro* DM digestibility of the second season harvest of grass followed similar trend of the first harvest grass component.

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INTRODUCTION

The main sources of livestock feed in sub-Saharan African countries are natural pasture and crop residues, which are characterized by poor nutritional quality and insufficient and seasonal supply. In such situations reliable and sustainable animal production can hardly be anticipated (Lemma *et al.*, 1991). Such cases encourage the use of high yielding forage crops like Napier grass (*Pennisetum purpureum*) as it gives high yields from a small plot of land (Tarawali *et al.*, 1995). Its leafy nature, considerable plant height, high tillering, and re-growth potential makes it a highly productive fodder crop per unit area of land as compared to other grass species (Whiteman, 1980; Mwangi, 1994). Because of high cost of synthetic nitrogen fertilizers, pasture improvement based on biological nitrogen fixation will assume increasing importance

(Whiteman, 1980; Mwangi and Wambugu, 2002; Mbutia and Gachuri, 2002).

But like other tropical grasses, the issue of nutrient density and availability (digestibility) is a subject of concern in Napier grasses. Forage management practices such as cutting height and spacing affects DM yield and forage quality (ASA, 1976). Nylon bag techniques and *in vitro* DM digestibility are some of the methods available for evaluating forage quality and or digestibility (Van Soest and Robertson, 1980). Moreover, management practices such as cutting height and spacing that give a satisfactory compromise between the DM yield and digestibility of the grass and/or the mixed stand as a whole needed to be identified. Thus, the objective of this study was to

determine optimum cutting heights and appropriate planting patterns of Napier grass-silver leaf *Desmodium* mixed pasture that optimizes both *in vitro* digestibility and *in sacco* degradability of the forages.

MATERIALS AND METHODS

Description of the Study Area

The mixture of Silver leaf *Desmodium* and Napier grass was established at Bako Agricultural Research Center located in East Wellega Zone of Oromia Regional State, Western Ethiopia at an altitude of 1650 m.a.s.l. Bako is located at 9°6' N latitude and 37° 09' E longitude at a distance of 260 km west of Addis Ababa.

The area experiences a sub humid tropical climate with unimodal rainfall pattern i.e. one main rainy season. The mean minimum and maximum long-term (45 years) precipitation for the area were 13.1 mm in January and 253.8 mm in July, respectively. The major rainy season covers the months from April to October and the maximum fall occurs in July and August with mean value of 253.8 mm and 232.2 mm, respectively. The total annual rainfall in 2004 and 2005, the years when the experiment was conducted, were 1,161.0 mm and 1,258.1 mm, respectively.

The mean minimum, mean maximum and average air temperatures of the area recorded for 45 years were 13.3, 27.9 and 20.7 °C, respectively. During the experimental years, 2004 and 2005, the mean minimum, maximum and average monthly air temperatures were, 13.2, 28.7 and 21.0 °C, respectively for the former and 13.5, 29.7 and 21.4 °C for the latter year (unpublished metrological data of Bako Agricultural Research Center). The major farming system of the area is a mixed crop-livestock production system.

Experimental Design and Treatments

A 3X2 factorial combination arranged in randomized complete block design (RCBD) with three replicates was used in the experiment. The treatments were two levels of planting patterns (same row and alternate row) and three levels of stubble cutting height (20, 30 and 40 above ground).

Forage Management

Napier grass stem cutting and seeds of silver leaf *Desmodium* were used for establishment of the mixed pasture, which were managed under rain-fed system. Starter fertilizers of 1:1 ratio DAP to Urea 200 kg/ha of each were applied during the establishment year (Chadhokar, 1978) whereas no fertilizer was applied in the second year. The grass with accession number ILRI-14389 was cut into

pieces constituting three nodes, where two of the nodes were put in well-prepared soil whereas the remaining third node was left above the ground (Skerman and Riveros, 1989). The distance between the plants within a row was 0.5 m whereas the distance between rows was 0.75 m (Khan, 2002). The grass component was intercropped with the legume silver leaf *Desmodium* simultaneously at two different planting patterns. Weeds were controlled by hand pulling especially for the sole silver leaf *Desmodium* but no weeding was performed in all mixed stand plots because of high dominance of the pasture against weeds. The experiment was executed for two consecutive cropping seasons, 2004 and 2005. *In vitro* DM digestibility (IVDMD) and *in sacco* degradability were used to evaluate the nutritive value of the two mixed pasture species grown together.

During harvesting, forage samples were cut manually using sickles. Both the grass and the legume were cut at different heights (0.20, 0.30 and 0.40 m) above the ground when the upper plant height reached 90-120cm height ranges (IIRR, 1998; Tessema *et al.*, 2002). Two forage harvests were taken within two cropping seasons as the prolonged dry seasons retarded its growth rates and thereby the frequency of harvesting. The fresh weight (300 g) of the forage biomass was taken in the field. After chopping the samples were sun dried during the first harvest and then transferred to a known weight paper bags and dried in a forced draft oven at a temperature of 60 °C for 48 hours and reweighed to determine the partial DM content. The dried samples were ground to pass 1-mm for use in chemical analysis and IVDMD but the 2-mm sieve sizes to be used for determination of *in sacco* DM degradability of the forages.

In Sacco DM Degradability

Dry matter degradation of the feeds was determined by incubating about 2.5 g of the dry samples, ground to pass through 2 mm sieve, in nylon bags (pore size 40 µm) in three rumen fistulated mature rams of the local sheep from Adilo, southern Ethiopia. During the experiment the animals were fed 450 g *Desmodium intortum* (cv. green leaf) hay, 450-g *Cynodon dactylon* dominated native pasture hay and 100 g concentrate composed of equal proportion of ground maize and wheat bran. All bags were consistently incubated 1 h after the sheep were offered feed and withdrawn after 4, 8, 16, 24, 48, 72 and 96 h of incubation. Immediately after being withdrawn from the rumen, the bags were rinsed with cold water and washed in domestic washing machine for 30 minutes (first for 15-min, then for 10-min and lastly for 5-min) until the rinsing water become clear. The bags were dried in forced draft oven to constant weight at 60°C for 48 h

and weighed after cooling in a desiccator. Washing losses were determined by soaking two bags per sample in warm tap water (~39 °C) for 1 h followed by washing and drying as before.

DM degradation data was fitted to the exponential equation $p = a + b(1 - e^{-ct})$ where p is DM degradation (%) at time t (Ørscov and McDonald, 1979; McDonald, 1981) using the Neway Excel Programme (Chen, 1995). Since the washing loss (A) was higher than the estimated rapidly soluble fraction (a), the lag time was estimated by fitting the model $p = A$ for $t \leq t_0$, $p = a + b(1 - e^{-ct})$ for $t > t_0$ and the degradation characteristics of the forage mixtures were defined as $A = \text{washing loss (rapidly soluble fraction)}$; $B = (a + b) - A$, which is the insoluble but fermentable part; $c = \text{the fractional rate constant at which } B \text{ will be degraded and the lag phase (L)} = 1 / \log_e[b / (a + b - A)]$. The effective DM degradability of the forage species was calculated at rumen outflow rate of 0.05 h^{-1} .

Statistical Analysis

Analysis of variance was carried out on the *in vitro* DM digestibility and *in sacco* DM degradability data using the General Linear Model Procedure of the Statistical Analysis System (SAS) computer software (SAS, 2003). Mean comparison was done using the least significance difference (LSD).

RESULTS AND DISCUSSION

In this result and discussion part, each of the legume and grass components were separately treated even though they were grown together as a mixed pasture. This was happened for three main reasons: first if the mixed components (Napier grass and Silver leaf Desmodium) were mown together and analyzed together, the nutritive value obtained during first year inevitably varies from what is expected in the second year due to dynamic agronomic progress of the two components and hence the recommendation may not, later on, apply for Napier Desmodium mixed pasture grown elsewhere. Secondly, if the herbage are cut together and analyzed together, it brings difficulty to separately calculate the amount of nitrogen fixed by

the legume and supplied to the grass through its root in mixed stand since it can be confused with the nitrogen coming from the leaves of the legume to the total mixture. Thirdly, the different nutrients contained in separate components (Napier and Silverleaf Desmodium) are more constant than the composition of their mixture (depends on the relative proportion of the components) and is more important in feedlot ration formulation

The Legume Component

Effect of Planting Patterns and Cutting Heights on Nylon Bag DM Degradability of Silver Leaf Desmodium during First Year Harvest

Effect of planting patterns and cutting heights on *in sacco* DM degradability of silver leaf Desmodium is given in Table 1. Non-significantly higher DM degradation was noted for alternate row than same row planting patterns in all incubation periods. However, more visible differences occurred between times of incubation than planting strips. Cutting height also non-significantly influenced DM degradability throughout the incubation periods. Increase in cutting height from 20 to 40 cm resulted in consistent increase of DM degradability for all incubation times with the exception of 4 hours of incubation in which no clear trend was noted.

The DM degradability characteristics were not significantly affected ($p > 0.05$) both by planting pattern and by cutting height. However, the degradation rate and the effective degradability tended to be higher, while the lag was lower in alternate row planting than same row planting approach. Similarly, the degradation rate and effective degradability tended to increase while the lag time tended to decrease with increased cutting stubble height. Alternate row planted legume resulted in relatively higher *in vitro* DM digestibility than same row and increased cutting height resulted in increased ($p > 0.05$) digestibility. Figures 1 and 2 below for both first and second year harvests of Silver leaf Desmodium indicated that further and significant ($p < 0.05$) DM degradation did not occur after 70 hours of incubation.

Table 1: Effect of planting patterns and cutting heights on *in sacco* DM degradability of silver leaf Desmodium at first harvest.

Degradability characteristics	Planting patterns			Cutting heights			
	Within row	Alternate row	SE	20 cm	30cm	40 cm	SEM
<i>In vitro</i> DM digestibility							
72h <i>in sacco</i> degradability:	52.3	54.2	1.9	49.7	52.3	55.2	2.3
Washing loss (A)	23.3	23.5	0.00	23.1	23.2	23.8	0.00
Slowly fermentable fraction (B)	45.3	46.3	1.20	44.6	46.0	46.7	1.5
Potential degradability (PD)	69.6	68.8	1.2	68.5	69.3	69.9	1.5
Degradation rate (c)	0.04	0.05	0.01	0.04	0.04	0.05	0.001
Lag time	1.4	1.0	0.47	1.9	0.98	0.70	0.58
Effective degradability (ED)	42.2	44.6	1.4	41.5	43.5	45.2	1.7

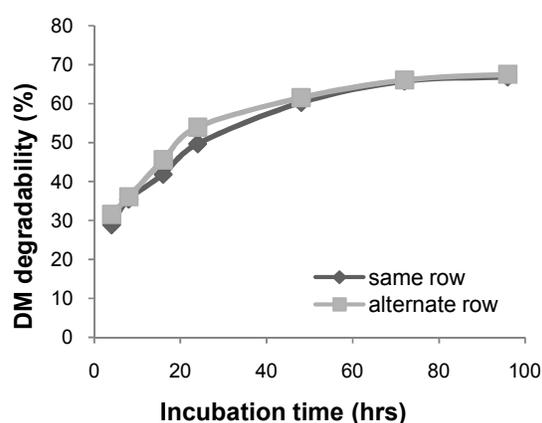


Figure 1: Effect of planting patterns on silver leaf *Desmodium rumen* degradability (1st harvest).

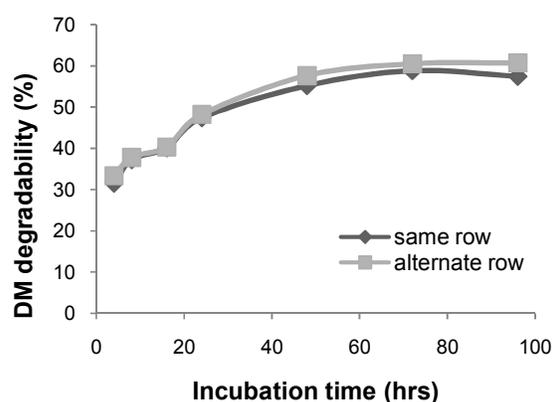


Figure 2: Effect of planting patterns on silver leaf *Desmodium rumen* degradability (2nd harvest).

Effect of Planting Patterns and Cutting Heights on Nylon Bag Dm Degradability of Silver Leaf *Desmodium* during Second Harvest

Effect of planting patterns and cutting heights on nylon bag DM degradability of silver leaf *Desmodium* harvested during second year is indicated in Table 2. There is no significant difference between planting strips for all time of incubation and degradability characteristics. However, relatively better DM degradability is noted in alternate than same row for incubation periods. Though not significantly differed ($p < 0.05$), the same row planting patterns gave higher values of degradability characteristics except for degradation rate and effective degradability. The former had equal values in both patterns of planting while the latter was higher in alternate than same row strips.

The DM disappearance from the nylon bag after 24 hours of incubation was significantly higher ($p < 0.05$) at a cutting height of 40 cm than the two lower cutting heights (Figure 3 and 4). Similarly, the DM disappearance after 48 and 72 hours of incubation and the PD were significantly higher ($p < 0.05$) at cutting height of 40 and 30 cm than at 20 cm cutting height. The DM disappearance after 96 hours of incubation, the slowly degradable fraction and the effective degradability were significantly higher ($p < 0.05$) at a cutting height of 40 cm. Figures 3 and 4 below indicates the diagrammatic presentation of the effects of stubble cutting heights on DM degradability of the legume during both first and second year harvests.

Table 2: Effect of planting patterns and cutting heights on nylon bag DM degradability of silver leaf *Desmodium* of second harvest.

Degradability characteristics	Planting patterns			Cutting heights			SEM
	Within row	Alternate row	SE	20 cm	30 cm	40 cm	
<i>In vitro</i> DM digestibility	52.5	55.1	2.1	49.9	51.2	55.3	2.5
72 h in sacco degradability:							
Washing loss (A)	21.2	22.4	0.0	21.2	21.5	22.7	0.00
Slowly fermentable fraction (B)	38.8	41.8	1.4	36.4 ^b	41.6 ^{ab}	42.9 ^a	1.7
Potential degradability (PD)	61.2	62.9	1.4	57.9 ^b	64.1 ^a	64.4 ^a	1.7
Degradation rate (c)	0.04	0.04	0.04	0.03	0.04	0.04	0.005
Lag time	0.28	0.00	0.20	0.00	0.00	0.42	0.24
Effective degradability (ED)	41.9	41.9	0.98	40.1 ^b	41.3 ^{ab}	44.3 ^a	1.2

Means with different letters in a row, considered separately for planting pattern and cutting height, are significantly different

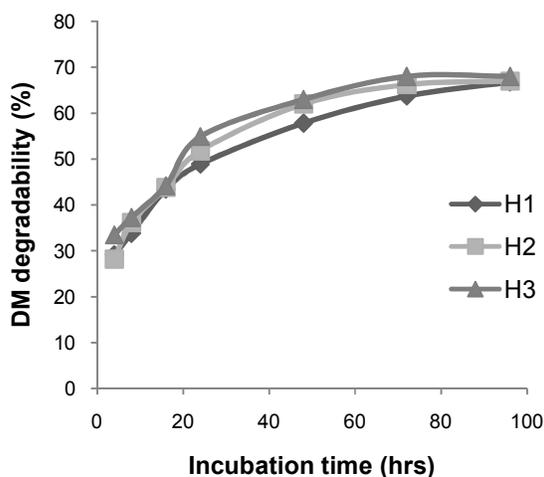


Figure 3: Effect of cutting stubble height on silver leaf Desmodium rumen degradability (1st harvest).

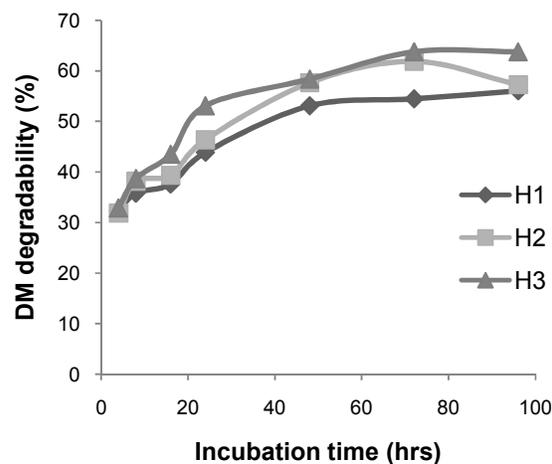


Figure 4: Effect of cutting stubble height on silver leaf Desmodium rumen degradability (second harvest).

Grass Component

Effect of cutting height and planting patterns on nylon bag DM degradability of the grass component during first harvest

The effect of planting patterns and cutting heights on nylon bag DM degradability after 4, 8, 16, 24, 48, 72 and 96 hours of incubation and degradability characteristics of the mixed component Napier grass is shown in Figure 5 and 6. The statistical analysis showed that there was no significant difference between the alternate and same row planting patterns for all time of degradation considered. However, except for 72 and 96 hours of degradation, the grass planted in alternate row planting strip tended to show higher degradability than those in the same row with the legume. This may be due to better performance and nodulation of the legume and more supply of N to the grass in alternate row than within the same rows (Sujatha *et al.*, 1986). The cutting height also resulted in non-significant difference in forage Napier degradability at all times of incubation. Increase in cutting height tended to increase the degradation of the Napier grass at 8, 16, 24, 48, 72, and 96 hours of rumen incubation.

On the other hand, washing loss, slowly fermentable fraction, potential degradability, lag time and effective degradability were not significantly different unlike the rate of degradation of gradually fermentable fraction (c) with planting systems. Except for lag phase and effective degradability, all the other degradability characteristics were better in alternate pattern than the same row with silver leaf Desmodium. Decrease in stubble cutting height tended to decrease ($p>0.05$) the rapidly soluble fraction (A), degradation rate (c), potential degradability (PD) and effective degradability (ED). The gradually fermentable fraction followed the opposite trend whereas there was no consistent trend observed for lag phase. *In vitro* DM digestibility was significantly ($p<0.05$) higher for alternate row planted Napier than same row. Increased cutting height from 20cm to 40cm significantly ($p<0.01$) increased DM digestibility. Generally, successful degradation results were obtained for both same and alternate row planted grass at both first and second year harvests (Figure 5 and 6).

Table 3: Effect of planting patterns & cutting heights on nylon bag DM degradability of Napier grass during 1st year.

Degradability characteristics	Planting patterns			Cutting heights			SEM
	Within row	Alternate row	SE	20 cm	30 cm	40 cm	
<i>In vitro</i> DM digestibility	53.4 ^b	61.5 ^a	0.42	55.1 ^c	57.1 ^b	60.4 ^a	0.52
72 h in sacco degradability:							
Washing loss (A)	22.5	23.0	0.00	21.9	22.1	24.3	0.00
Slowly fermentable fraction (B)	49.9	52.9	1.8	47.9	51.7	54.6	2.2
Potential degradability (PD)	72.4	75.9	1.8	72.3	73.8	76.5	2.2
Degradation rate (c)	0.02 ^b	0.03 ^a	0.02	0.03	0.03	0.03	0.002
Lag time	2.0	1.5	0.32	2.2	1.3	1.7	0.39
Effective degradability (ED)	39.9	38.7	0.51	39.0	39.2	39.6	0.62

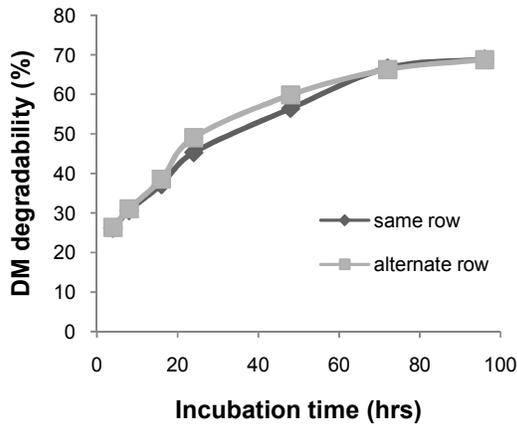


Figure 5: Effect of planting patterns on Napier grass rumen degradability (1st harvest).

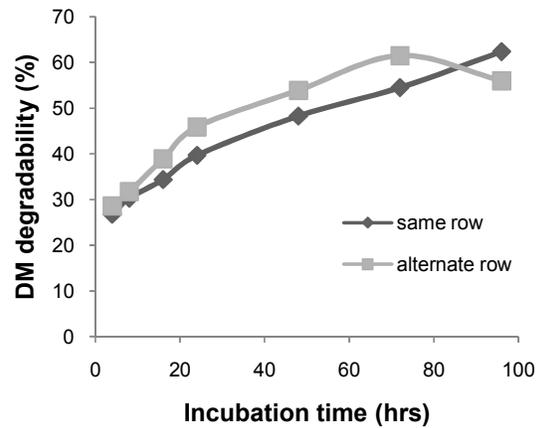


Figure 6: Effect of planting patterns on Napier grass rumen degradability (2nd harvest).

Effect of cutting height and planting patterns on nylon bag DM degradability of Napier grass mixed components during second harvest

The effect of planting patterns and cutting heights on *in sacco* DM degradability after 4, 8, 16, 24, 48, 72, and 96 hours of incubation and degradability characteristics of the mixed component Napier grass was indicated in Figures 7 and 8. There was no significant difference between the alternate and same row planting patterns for 4, 8, 16, and 24 hours of incubation. However, for 48, and 72 hours of degradation, the grass planted in alternate row planting strips had significantly higher ($p < 0.05$) degradability than those in the same row with the legume while the contrary was true at 96 hours of incubation. The degradability of Napier grass tended to increase with increasing cutting height and this is in agreement with the reports of Redfearn *et al* (1999), and Reeves and Kellaway (1996). At 72 and 96 hours of degradation, an

increase in cutting height significantly ($p < 0.01$) increased DM degradability.

Despite the lack of significant variation ($p > 0.05$) observed among all the degradability characteristics for planting patterns, the alternate row planted grass achieved higher values except the lag time. The washing loss (A) increased when the cutting height increased whereas the insoluble, but gradually fermentable fraction (B) significantly ($p < 0.05$) increased with increase in cutting height. The lower cutting height (20cm) had medium PD values with the highest for the 30cm cutting height. The rate of degradation (c) showed a decreasing trend with direct relation with the cutting height in similar manner as ED. However, the lag time for 30cm cutting height was the highest followed by equal values of 20 and 40 cm. The *in vitro* DM digestibility of the second harvest grass component for planting strips and cutting height followed similar trend of the 1st harvest.

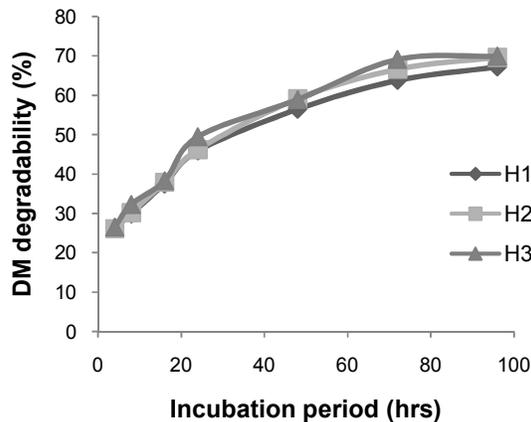


Figure 7: Effect of cutting stubble height on Napier grass rumen degradability (1st harvest).

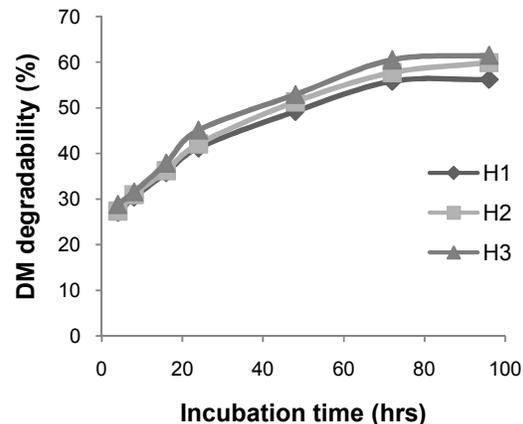


Figure 8: Effect of cutting stubble height on Napier grass rumen degradability (2nd harvest).

Table 4: Effect of planting patterns and cutting heights on nylon bag DM degradability of Napier grass during second year

Degradability characteristics	Planting patterns			Cutting heights			
	Within row	Alternate row	SE	20 cm	30 cm	40 cm	SEM
<i>In vitro</i> DM digestibility	54.4 ^b	62.3 ^a	0.44	56.0 ^c	58.1 ^b	60.8 ^a	0.54
72h <i>In sacco</i> degradability:							
Washing loss (A)	19.7	20.7	0.00	19.5	19.8	21.4	0.00
Slowly fermentable fraction (B)	43.5	45.8	2.3	37.8 ^b	45.6 ^{ab}	50.6 ^a	2.83
Potential degradability (PD)	63.2	66.5	2.3	59.2 ^b	65.1 ^{ab}	70.4 ^a	2.8
Degradation rate (c)	0.04	0.03	0.01	0.02	0.03	0.032	0.004
Lag time	0.03	0.00	0.02	0.00	0.05	0.00	0.03
Effective degradability (ED)	35.3	39.1	0.68	36.4	37.5	37.6	0.83

Means with different letters in a row, considered separately for planting pattern and cutting height, are significantly different

CONCLUSION

In the present study *in vitro* DM digestibility was higher for alternate row planting patterns than same row for both grass and legume and highest for 40cm grass stubble cutting height. For *In situ* rumen degradability of the grass component 72 hours of incubation was found to be optimum period. Planting Napier grass and Silver leaf Desmodium in alternate rows pattern and cutting at 40cm stubble heights given higher slowly fermentable fraction, potential degradability and effective degradability of the dry matter for both components in both seasons. Further study is necessary to see the effect of the two mixtures on animal performance.

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