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EVALUATION OF GROWTH PERFORMANCE, BIOMASS YIELD AND NUTRITIVE QUALITY OF TREE LUCERNE (C*HAMAECYTISUS PALMENSIS*) FODDER UNDER DIFFERENT HARVESTING MANAGEMENT IN LEMO DISTRICT SOUTHERN ETHIOPIA

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ABSTRACT

Tagasaste (Chamaecytisus palmensis) is an evergreen, hardy leguminous shrub that is adapted to high lands of Ethiopia. The objective of this study was to evaluate nutritive value and field growth performance of tree lucerne as influenced by different harvesting management. To conduct the present study Lemo district southern, Ethiopia were selected. From the selected district two kebeles were purposely selected to be used as research area. The fodder plants were subjected initially to two cutting heights (1m and 1.5m), and three harvesting frequencies (2, 3, 4 times per year). Tree Lucerne showed fast growth in terms of height and root collar diameter after six months. Annual biomass production was considerably greater for six months harvesting interval than for the more frequent harvests in a range of 4.185 to 8.27 t ha–1. Whereas, the two cutting heights do not show significant ($p<0.05$) differences in yield. Leaf proportion of the biomass yield consistently decreased from 63.55 to 54.52% and the stem increased from 2.38 to 16.54% as the cutting interval prolonged from three to six months, respectively. The crude protein contents for the month of June (28%) was significantly ($p<0.05$) higher than that of October (24.6%), whereas, the other months had intermediate value. There were no significant ($p<0.05$) differences in IVOMD and ME contents among the different

cutting months. The current study revealed that tree Lucerne can be a suitable protein supplement predominantly for ruminant animal in the study areas.

Keywords: Tree Lucerne, Biomass, Tagasaste, cutting frequencies, *biomass*

1. INTRODUCTION

In Ethiopia availability of feed resources is characterized by the highly seasonal fluctuations in both quantity and quality. Moreover, most of the roughages and dry forages have a crude protein (CP) content of less than 7%, which do not satisfy the requirements of rumen microorganisms (Tadesse, F. 2016). When fed alone, such feeds are unable to provide even the maintenance requirement of livestock (ILRI, 1999). Hence, the production of adequate quantities and good quality dry season forages to supplement crop residues and pasture roughages is the only way to economically overcome the dry season constraints affecting livestock production in Ethiopia (Alemayehu, 2002).

Tree lucerne is useful as a maintenance feed, during the dry period and when fed together with other feeds. Therefore, to alleviate the constraint associated with the seasonal scarcity of feed resources in the study area, there is a need to look for alternative protein sources that farmers can establish at their own farm (Tadesse, F. 2016).

Tree lucerne (*Chamaecytisus palmensis*) looks like a promising species: It is a drought tolerant, perennial, leguminous small tree (Tadesse, F. 2016, Getinet, 1998). It is a temperate, multipurpose browse legume of major importance to highland areas of Ethiopia. Tree lucerne productivity, nutritive quality, and proportions of botanical fractions are highly affected by location, cutting interval, and use of fertilization practices (Borens and Poppi, 1990).

Hence, in the present study, the potential of tree lucerne fodder for producing higher yield under different cutting management with the best quality was examined and annual performance in terms of growth, survival rate, root collar diameter, stand height, and biomass yield were studied in the Lemo district.

2. MATERIALS AND METHODS

2.1. Area Description and Study Approach

The study was conducted in Upper-Gana and Jawe kebele, Hadiya zone. This site and research kebeles are administratively located in Southern Nations, Nationalities, and Peoples' Region (SNNPR). From each kebele, 40 farmers, who showed interest in the tree lucerne research, had planted seedlings 160 seedlings per farmer during the 2015 main rainy season and these farmers were used as study respondents.

The participant farmers were grouped into three based on the field growth performance of their fodder seedlings: Group I: farmers whose tree lucerne seedling did not survive; Group II: farmers whose fodder seedling established but performed poorly and Group III: farmers whose fodder seedlings established and performed very well. Management practices of the tree lucerne seedling, including: planting niche, planting distance, fertilization, watering, weeding and fencing, applied by each of the three groups of farmers were the similar to reduce the variation among the different participant farmers plots.

2.2. Measurements and sampling procedures

The fodder plant heights at different stage of growth were measured by using measuring tape. A minimum of 12-fodder plant were randomly selected from each plot. The selected fodder seedlings were treated at 1meter, tagged and given identification numbers.

Afterwards, three harvesting interval were introduced per year after the initial harvest). Measurement of biomass yield and sampling were conducted as follows. The fresh weight of the biomass harvested from each plant were weighed and then separated in to morphological fractions (stem, edible branches and leaves) and weighed again. Samples of the leaf fractions were taken for dry matter (DM) determination and analysis of major chemical fractions.

2.3. Chemical analysis

All samples were dried in a forced draft oven at 65 °C for 72 hrs to determine DM percentage. Dried samples were ground to pass through a one mm sieve size for quality evaluation. The nitrogen (N) content was determined using the Kjeldahl method and crude protein concentration (CP) was calculated by multiplying N concentration by 6.25 (AOAC, 1995). In-vitro DOMD was determined according to the two-stage Tilley and Terry (1963) method for the different fractions and treatments. The metabolizable energy (ME) content was estimated from the IVTOMD value using the equation: ME (MJ/kg DM) =0.15*IVOMD (g/kg).

2.5. Data analysis

The household survey, data were analyzed by using descriptive statistics. The collected data from the farmer's fields were entered into SPSS statistical program (PASW statistics version 16) and analyzed with the procedure of general linear model, univariate analysis of variance. Analysis of variance (ANOVA) was carried out to test the effect of cutting height and interval on the biomass yield and botanical fractions.

3. RESULTS

3.1. Major feed resources

The predominant feed resources and their contributions are shown in **Figure 1**. According to the current observation crop residues (37%)

contributed the largest share of the feed resources, followed by local feed resources. Grazing both (private and communal grazing) and Hay contributed about 33% whereas; the contribution of concentrates and some fodder plants were rated as low in the area.

3.2. Reasons for establishing tree Lucerne in the area

Farmers are requested to indicate the main purpose of growing tree Lucerne in their farmland. About 48% of the farmers mentioned that their main reason for attracting in tree lucerne cultivation is to produce livestock feed supplement, while about 14% and 8% mentioned soil fertility function and seed production. Fencing, firewood and ornamental functions were rated low **(Figure 2)**.

3.3 Measurement and observations

3.3.1 Classifying of participant farmers based on the performance of seedlings

The farmers who have been participating in tree lucerne adaptation trial were grouped into three classes based on the level of survival and growth of the fodder seedlings. The proportion of the farmers who fell into seedlings did not survive was 18% 12% in Jawe and Upper-Gana respectively. Farmers whose seedlings performed poorly were categorized under farmer group (II) and their fodder seedlings perform poorly. Farmers who fell under group (II) categories ranged from 16.3 to 22.9% between the two sites. The last group included those farmers whose seedlings survived and performed very well, and the majority of the farmers (59-72%) fell into this category **(Figure 3)**.

3.2.2. Growth and root collar diameter at different growing stages

Figure 4 shows fodder seedlings growth measurement record at 3, 6, 9 and 12 months. The mean height reached about 54cm after 3 months of growth, 108cm after six months, 220cm after 9 months and 284cm after 12 months in Jawe Kebele. Whereas; the mean height for Gana kebele reached 52cm, 109cm 220cm and 285cm in 3, 6, 9 and 12months respectively.

The mean increase in root collar diameter under the different growth stage of tree lucerne is showed in **Table 1**. The mean root collar diameter of seedlings reached about 0.48mm, after 3months, 0.79mm, after 6months, 1.47mm, after 9months and 1.85mm after 12months. The rapid growth in RCD observed after 6months of seedlings planting out.

3.3.3. Effect of cutting management on biomass yield of tree lucerne

Table 2 shows the dry matter biomass yield of tree Lucerne fodder when cut at different heights (1m and 1.5m) and frequencies (two to four times per year). Biomass yield and height of tree lucerne consistently and significantly increased (*P* <0.05) as cutting interval was prolonged from three to six months. Total DM production was substantially greater for the prolonged cutting interval (6month) than for the more frequent cutting. Linear regression analysis test pointed that there was a significant correlation ($P<0.001$, $r = 0.70$) between harvesting frequency and dry matter production of tree Lucerne fodder.

3.3.4. Botanical fractions of tree lucerne as affected by cutting height and interval

The effects of cutting frequency on the leaf, edible branches and stem proportion of fodder plant are presented in **Figure 5**. The leaf proportions consistently and significantly ($P<0.05$) decreased from 64.22% to 54.51% while the stem increased from 2.41% to 1854% as the harvesting interval increased from 3months to 6 months. All the leaf, edible branch and stem proportions showed significant ($P < 0.05$) differences among the different cutting intervals.

Figure 5 Average dry matter proportion (%) of Tree lucrene biomass yield separated into leaf, edible branch and stem at different harvesting intervals.

The chemical compositions and digestibility for tree lucerne harvested at the different months are presented in **Table 3**. The crude protein contents for the month of June was significantly ($p<0.05$) higher than that of October. The ash content for the months of July and October were significantly higher than the remaining months.

The highest Neutral Detergent Fiber (NDF) and Acid Detergent Fiber (ADF) contents were reported in July. The ADL contents for the months of July, October and April were higher than that of May. There were no significant ($p<0.05$) differences in In-vitro True Organic Matter Digestibility (IVOMD) and Metabolizable Energy (ME) contents among the different harvesting months. The hemicellulose (HC) and cellulose content for fodder plant harvested under the different months showed significant ($p<0.05$) differences.

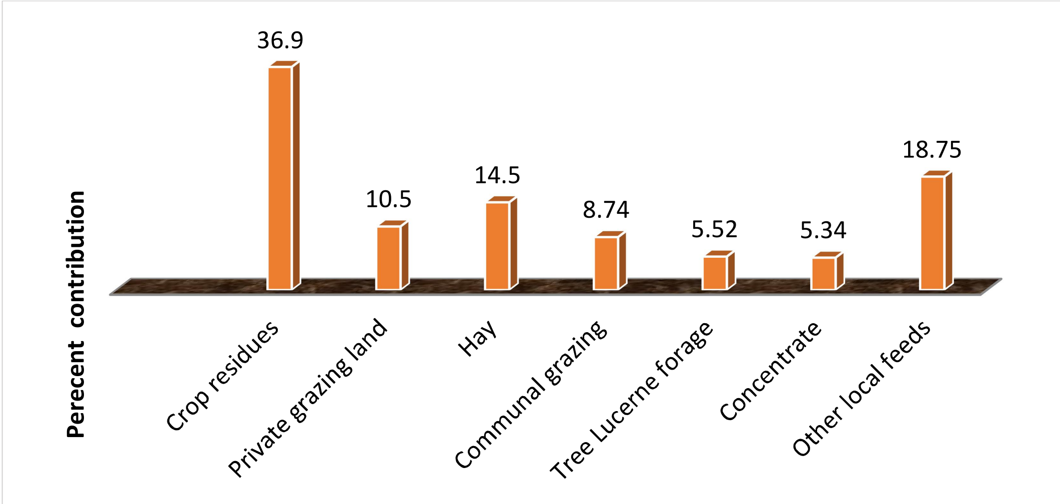

Figure 1: The contribution of different feed resources in the study area

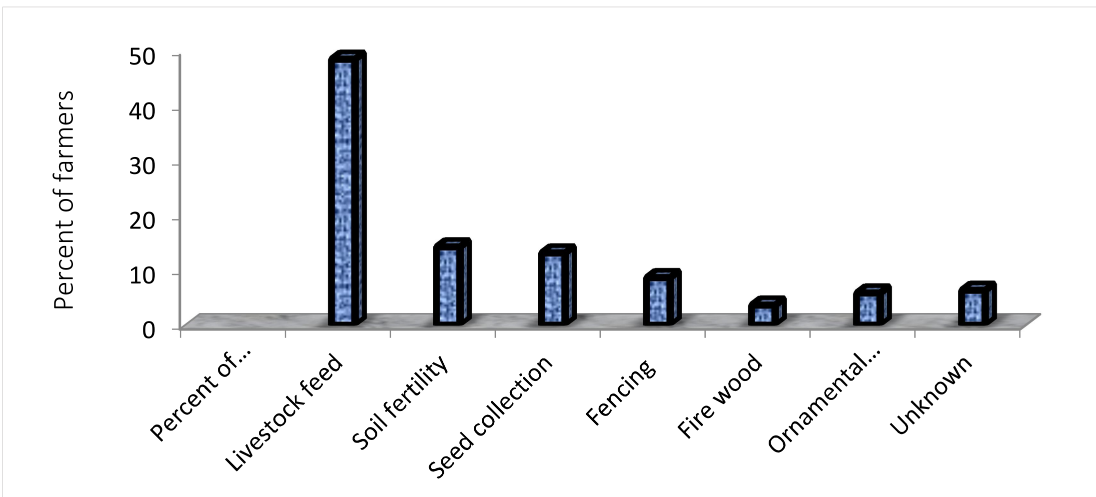

Figure 2: Purpose of establishing tree lucerne (N=80)

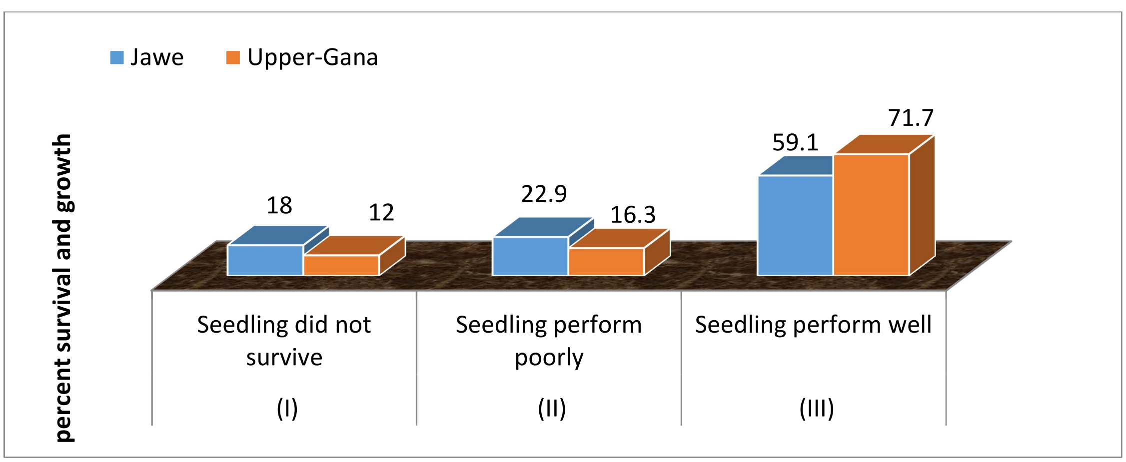

Figure 3: Shows survival and growth performance of tree Lucerne seedlings across households

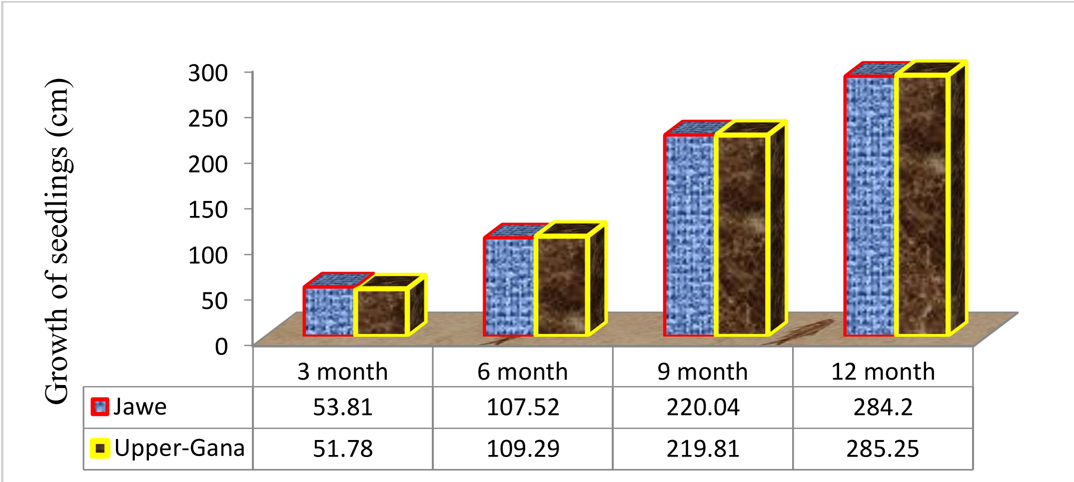

Figure 4: Growth of tree lucerne seedlings at different stages of growth

Table 1: Mean root collar diameter (RCD) of fodder seedlings

Kebeles/sites	Root collar diameter (mm)				Overall mean	SEM
	3 month	6 month	9 month	12 month		
Jawe	0.46[d]	0.79[c]	1.45[b]	1.84[a]	1.135	0.033
Upper-Gana	0.49[d]	0.78	1.48[b]	1.85[a]	1.150	0.033
Overall mean	0.475	0.785	1.465	1.845		
SEM	0.040	0.041	0.041	0.041		
P-value	RCD			0.000		
	Sites/kebele			0.117		
	RCD * Sites			0.693		

Values followed by the same letters within the same rows are not significantly different at ($p<0.05$)

Table 2: Annual biomass yield of tree lucerne as affected by cutting height and interval

Cutting height (m)		Cutting interval (month)			Overall	
		3	4	6	mean	SEM
1meter		3.19[c]	6.38[b]	7.65[a]	5.74	1.01
1.5meter		5.18[c]	7.67[b]	8.89 [a]	7.25	0.991
Overall mean		4.185 [c]	7.025[b]	8.27 [a]		
SEM		0.65	1.22	0.82		
P- value	Cutting height			NS		
	Cutting interval			***		
	Height * interval			NS		

Different superscripts within rows denote significant difference ($P < 0.05$)

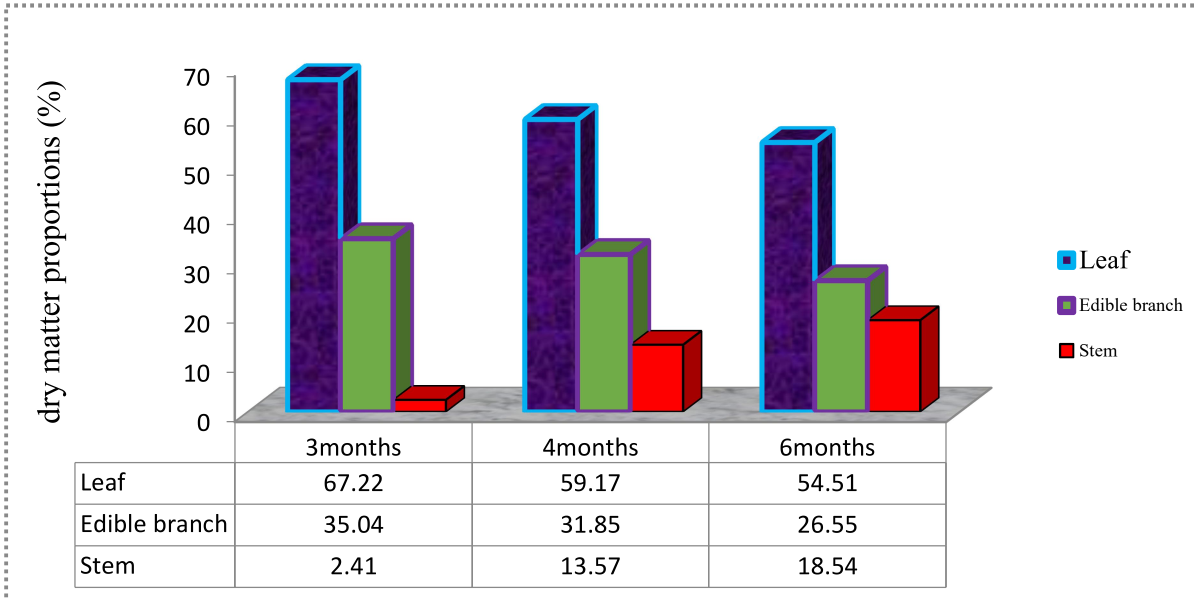

Figure 5: Average dry matter proportions (%) of Tree lucrene biomass yield

Table 3: Chemical composition and digestibility of tree Lucerne leave fractions harvested at different months of 2015G.C

Cutting month	Digestibility and chemical compositions of tree Lucerne leaf fraction (%,ME(MJ/Kg)								
	Ash	CP	NDF	ADF	ADL	ME	IVOMD	Cellulose	HC
April	5.01 ± 0.1^{b}	25.24 ± 0.6^{ab}	50.10 ± 0.7^{b}	25.42 ± 1.1^{bc}	11.70 ± 0.7^{ab}	8.29 ± 0.1	59.91 ± 0.8	14.87 ± 0.5^{b}	23.66 ± 0.6^{ab}
May	4.98 ± 0.2^{b}	25.85 ± 1.8^{ab}	47.84 ± 1.3^{b}	23.66 ± 1.2^{bc}	8.02 ± 0.6^{c}	8.42 ± 0.1	62.21 ± 0.8	14.63 ± 0.7^{b}	26.09 ± 0.8^{a}
June	5.02 ± 0.3^{b}	28.12 ± 2.3^{a}	48.21 ± 0.9^{b}	24.63 ± 1.2^{bc}	8.96 ± 0.8^{bc}	8.51 ± 0.1	62.08 ± 0.9	13.95 ± 0.5^{b}	25.6 ± 1.1^{a}
July	6.44 ± 0.2^{a}	27.81 ± 0.4^{ab}	57.43 ± 1.8^{a}	35.40 ± 1.2^{a}	15.01 ± 0.8^{a}	8.11 ± 0.1	60.07 ± 0.6	20.89 ± 1.3^{a}	22.01 ± 0.6^{bc}
October	6.34 ± 0.1^{a}	24.59 ± 0.8^{b}	49.23 ± 0.9^{b}	28.75 ± 0.8^{b}	13.91 ± 0.5^{a}	8.31 ± 0.1	59.74 ± 0.6	15.01 ± 0.4^{b}	20.57 ± 0.3^{b}
overall	5.56	26.32	50.56	27.57	11.52	8.33	60.80	15.87	23.59
P-value months	0.000	0.037	0.000	0.000	0.000	0.168	0.113	0.000	0.000

Values followed by the same letters within each column are not significantly different at ($p<0.05$) level according to Duncan Significant Difference (DSD) test. Values are expressed as mean ± standard error, CP= crude protein; NDF= neutral detergent fiber; ADF= acid detergent fiber; ADL= acid detergent lignin; NS= non-significant; SD= standard deviation; IVOMD= True Invitro Organic Matter digestibility percent; Hemicellulose = NDF - ADF; cellulose= ADF-ADL

4. DISCUSSION

4.1. Major feed resources and purpose of tree lucerne establishment in the area

According to the current observation crop residues added the largest share of the feed resources, followed by local feed resources. The current study agreed with work reported by Shiferaw *et al*.; (2018). Who reported crop residues, natural pasture, hay and browsed trees, industrial by-products, improved forages and Attela (local breweries by product) contributes the largest share of livestock feed.

According to the participant farmers, tree lucerne is adopted and established in the area for multi- purpose uses like livestock feed, soil fertility, seed productions and others. This observation agrees with the work of Getinet, (1998). According to this author multi-purpose trees (MPFTs) uses as forage and fuel-wood but farmers also value it for shelter, bee forage, nitrogen fixation, and soil conservation purposes.

4.2. Measurement and Observations

4.2.1. Growth and root collar diameter at different growing stages of fodder

During the first three months after planting out, tree lucerne stressed resulting in slow performance (growth and survival). Hence, closer work is reported by Chamshama *et al*. (1984) who noted after transplanting in the field the fodder seedlings of *Senna Singueana* suffered shock resulting in slow height growth and loss of leaves, which are essential for photosynthesis.

4.2.2. Effect of cutting height and interval on biomass yield of tree Lucerne

The current observation revealed that cutting heights could not affect the biomass yield of tree lucerne. The current observation in accordance with the work reported by Buakeeree (2006) who noted that the dry matter yield of hedge lucerne shrub is not affected substantially by harvesting height. According to Battad (1993) cutting height significantly affect dry matter yield of hedge lucerne. The biomass yield increases as cutting interval increased from three months to six months Getinet, (1998).

4.2.3. Effect of cutting height and interval on leaf, edible branch and stem fractions

The cutting intervals on botanical fractions showed significant differences. This observation is in line with finding noted by Tadesse F. (2016) who reported that the leaf fraction decreased as harvesting interval increased from 3month to 6months. The current study reported a significant difference for the edible branch fraction among the different cutting frequencies. This observation is disagreed with the work resulted by Getinet (1998) who reported similar result for edible proportions. However; the current observation on stem proportions is in conformity with this report.

4.3 Chemical Composition and digestibility of tree Lucerne

The ash contents of tree lucerne leaf fractions in the current study is nearly similar with the accounted value of (5.5%) for tree Lucerne by Tadesse F. (2016) whereas, the current finding reported slightly higher contents as compared to the work revealed by Pande (1990) who reported the ash content for tree lucerne (5.18%).

The current observation presents higher crude protein content from the leaf of tree Lucerne as compared with the values reported by Getinet, (1998). The crude protein content attains its peak value in June. Hence the quality of tree Lucerne fodder plant reaches its optimum point in June.

In the present study the mean NDF content of tree lucerne leaf fractions is higher than the value reported by Bonsi *et al* ., (1995) and Kashay *et al*., (1997). Van Soest (1965) noted that feeds with NDF values above 55% limit appetite and digestibility. Thus the NDF contents reported in current observation can be categorized as a high quality feeds. Forage legumes with a respective NDF and ADF values falling within a range of 40 – 46% and 31 – 40% are rated as having a first grade quality standard Kazemi *et al*. (2012).

The mean ADL in the current observation is comparatively higher than the work reported by Solomon *et al*. (2004), Pande (1990) whereas, the ADL contents reported at the current study is nearly in line with the contents reported by Bornens and Poppi, (1990); Bonsi *et al*., (1995) who reported that the ADL content for tree lucerne ranges between (6.4% - 7.7%).

IVOMD value obtained in this study is comparatively lower than the value reported by Douglas *et al* . (1996). Thus the present study has agreed work noted by Owen and Jayasuriya, (1989) who reported that the mean IVOMD contents were higher than the threshold value of 50% required for feeds to be considered as having acceptable digestibility and also higher than values reported earlier for other herbaceous fodder plants and browses legume species by (Seyoum *et al* . 1996).

5. SUMMARY AND CONCLUSION

The study was conducted in the highlands of two kebele located in the southern region of Lemo district. The two cutting heights under the present investigation did not significantly differ in biomass yield. However, Cutting interval significantly affects the biomass yield of tree lucerne. The highest biomass yield was recorded from the six-month harvesting frequency, whereas, the lowest yield was found from the frequently harvested fodder.

Tree lucerne has a reasonable amount of CP, high IVOMD, and ME which suggested that tree lucerne is good alternative fodder for livestock.

Whereas, cellulose and hemicellulose components in leaf fraction were lower. Moreover, the higher CP and lower fiber value in the leaf fraction are indicative of a good protein source for poultry or other mono-gastric animals. Therefore, the present results on the yield and nutrient contents in tree lucerne leaf suggest that it could be a suitable protein supplement for ruminant livestock in the study areas. Generally, if tree lucerne is established in abundance, it could help small and medium-scale farmers to overcome the shortages of quality feeds leading to a reduction in the livestock production cost.

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