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Nutritive value Evaluation of Buffel grass and Silver leaf Desmodium Grown in Pure Stands and in Mixture at Different Harvesting Times in Gozamen District, East Gojjam Zone, Ethiopia.

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ABSTRACT

The current study was conducted to evaluate biomass yield and quality of Buffel grass and Silver leaf desmodium grown in pure stand and in mixture at different harvesting times in Gozamen district. The study was conducted in a 3 x3 factorial arrangement of treatments in a randomized complete block design (RCBD) with three replications. The factors were forage species (Buffel grass, Silver leaf desmodium and Buffel grass/Silver leaf desmodium mixture) and three times of harvesting (HT1, HT2, and HT3). Pure-stand legume and their mixture with grass had a higher crude protein contents compared to pure-stand grass, whereas, pure-stand grass had higher fiber fraction contents compared to pure-stand legume and their mixture with grass. Harvesting time and forage species had significant effect (P<0.05) on CP, NDF, ADF, ADL and ash. However, the interaction effect was significant on ADF and ADL. As harvesting time increase, NDF, ADF, and ADL increased, whereas, CP and ash decreased. The CP content of the grass, legume and their mixture were 15.79%, 17.49% and 20.46% respectively, which are above the minimum level 7% required for optimum rumen function and could also satisfy the minimum CP content of 15% required for lactation and growth. Generally pure legume and grass-legume mixture produced forage with higher CP and lower fiber concentrations compared to pure stand grass. Therefore, grass/legume mixture could play crucial role to alleviate feed shortage problems by increasing the quantity and quality of forage.

INTRODUCTION

The main feed resources for livestock in Ethiopia are natural pasture and crop residues, which are poor in quality and provide inadequate nutrients to grazing livestock. To improve milk and growth performance of animals, it is necessary to introduce and cultivate high-quality forages with high yielding potential (Hintsa, 2016). Among the improved forages introduced in Ethiopia, Silver leaf desmodium and Buffel grass could play an important role in providing a significant amount of quality forage both under the smallholder farmers and intensive livestock production systems.

One of the potential approaches in Ethiopia to improve livestock feed availability in terms of quantity and quality is the use of grass-legume mixtures (Diriba and Diriba, 2013). In this regard, forage quality and seasonal distribution of dry matter (DM) production of grass-legume mixed sward has been found superior compared to those of grasses or legumes grown alone (Tessema and Feleke, 2018). The role of grass-legume mixtures are an integrated forage production system ensuring quality fodder availability.

The optimization of productivity and nutritive value of grass/legume associations can be achieved by forage management tools such as date of harvesting (Taye *et al.*, 2007). It is obviously known that early harvesting to get better nutritive value reduced the dry matter yield (DMY). Thus, harvesting time should balance quality and yield (Taye *et al.,* 2007; Terefe, 2017). Nevertheless, information regarding the effect of grass-legume mixtures and time of harvesting on nutritive value of Buffel grass and Silver leaf desmodium forage species in Gozamen district is lacking. Therefore, the present study was designed with the general objectives of evaluating the effect of grass-legume mixture and time of harvesting on nutritive value of Buffel grass and Silver leaf desmodium planted in pure stand and in mixture.

MATERIAL AND METHODS

Description of the Study Area

The study was conducted at Debre Markos University; Gozamen district in 2017 rainy season. It is geographically located at $10^0$20'N37^{0}43'E/10.333^{0}N37.717^{0}E with an average altitude of 2446m above sea level. It has conducive weather condition with1380 mm average annual rainfall and 18^{0}c average annual temperature.

Experimental Layout, Design and Treatment

The study was conducted using 3×3 factorial arrangements in randomized complete block design with three replications. The factors were Sliver leaf (*Desmodium uncinatum*) in pure stand, Buffel grass (*Cenchrus ciliaris*) in pure stand and Buffel- Sliver leaf mixture and 3 harvesting times (90, 120 and 150 days) after planting. Each plot consisted of an area of 3 m x 3 m (9 m^2). Spacing between plots and between blocks had 1 m and 1.5 m respectively. Treatments were assigned to each plot randomly within a block, 5 rows had been accommodated per plot with 75 cm row spacing. The experiment was conducted on total area of 35 m x 12 m (420 m^2) which was thoroughly prepared before planting.

Land Preparation, Planting and Management

The land was cleared, plowed and leveled manually. The planting materials, the legume silver leaf desmodium (*Desmodium uncinatum*) was brought from Fenote Salam town, Jabi Tehinan district Agriculture Office compound and Buffel grass was obtained from Debre Markos University forage nursery site. The planting materials used for Buffel grass were root splits and that of Silver leaf desmodium were the vine cuts from the already established main plants of desmodium. Each plot has 5 rows with 75 cm space between rows. A legume was planted in the same row beside to the grass. The space between plants was 50 cm for both grass and legume.

NPS fertilize was applied at the rate of 100 kg ha^{-1}at planting. Other management practices (weeding and cultivate) were done as required.

Sample Collection and Preparation for laboratory analyses

The representative forage samples of the two species were collected and weighed in the field. Then the samples were dried in a well-ventilated room until transported to the laboratory and further dried in an oven at 105^{o}C for 24 hours. Then the samples were grounded in a Willey mill to pass through a 1 mm sieve screen for chemical analysis. The samples were then put in plastic bags pending chemical analysis.

Chemical Analysis

The DM, CP and ash contents were determined using the procedures described by the association of official analytical chemists (AOAC, 1990). The structural plant constituents such as neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) were analyzed using the method described by Van Soest *et al*. (1991). The CP yield t/ha was calculated by multiplying CP% with total dry biomass yield.

Statistical Analysis

Data analysis was subjected to analysis of variance using the General Linear Model procedure of the statistical analysis system version 9.1 (SAS, 2002). Difference among treatment means was separated using Duncan's Multiple Range Test (DMRT), when treatment effects are significant ($P < 0.05$).

The statistical model for this experiment was;

$Y_{ijk} = \mu + B_i + S_j + H_{k+} (SH)_{jK} + e_{ijk;}$

Where,

$Y_{ijk =}$ the response variable
μ = overall mean
$B_i = {}^{th}_{i}$ Bock effect
$S_{j=} {}^{th}_{j}$ factor effect (species of forages)
$H_{k = K}{}^{th}$ factor effect (Harvesting time)
$(SH)_{jk} = {}^{th}_{jk}$ interaction effect (Forage species x Harvesting time)
e_{ijk} = random error

RESULT AND DISCUSSION

Dry matter content

Forage species and harvesting time/forage species interaction had no significant effect ($p>0.05$) on DM content. However, dry matter content (%) was significantly affected ($p<0.05$) by harvesting time (Table 1). Plots harvested at HT3 (150 days) had higher dry matter content as compared to HT1 and HT2. The increment of dry matter content in the later harvesting time (HT3) could be due to decreased moisture content in the leaves as the plant get matured and lignified. The present result agrees with that reported by other studies Berhanu *et al*. (2007), Bimrew *(*2016), and Terefe (2017) who reported dry matter content of grass increased with an increase in growth and development of plants, and longer harvesting time. In the current study there was no significant difference in mean DM content among the pure grass, legume and mixtures. This result agrees with Tessema and Feleke (2018), who reported that the mean DM content of grass and legumes are comparable.

Table 1. Dry matter content as influenced by harvesting times

Forage stand	Harvesting Times			
	HT1	HT2	HT3	Mean
CC	91. 67	92.67	94.00	92. 78
DU	90. 67	92.00	93.00	91. 89
CC/DU	91.33	92.33	93.33	92. 33
Mean	91.22[c]	92.33[b]	93.44[a]	92.33
SEM	0.93			
CV	1.00			
	P- value			
HT	0.0005			
FS	0.1594			
HT x FS	0.9916			

[abc] Main factors with similar superscripts in rows are not significantly different at ($P>0.05$); CV = Coefficient of variation; CC=*Cenchrus ciliaris*; DU, =*Desmodium uncinatum*; HT1-HT3=Harvesting time1-3; SEM=Standard error of the mean. FS= Forage stand; HT x FS=Interaction effect.

Crude protein content

The analysis of variance showed highly significant ($P<0.001$) differences in CP content as a result of harvesting time, and forage species differences while, their interaction did not make significant differences ($p>0.05$) on CP content (Table 2). The highest CP content (20.51) was recorded at HT1 while, the least (15.13) was recorded at HT3. The CP content recorded at HT1 was significantly higher than HT2 and HT3 while, HT3 significantly lower than HT1 and HT2. This result indicated that CP content in samples harvested during the experiment period significantly decreased ($P < 0.01$) as the age of plants advanced. This might be due to the dilution of the CP content by an increase in structural carbohydrate content of forage materials harvested at late maturity. Higher content of CP in young herbage is associated with higher proportions of vegetative grass tillers than after prolonged growth (Steinshamn *et al*., 2016). This result confirms the report of Bimrew (2016), Terefe (2017), Genet *et al*. (2017) and Tessema and Feleke (2018) who reported decreasing trend of CP content as plants become matured. The CP content of the sole Silver leaf desmodium (SD) was higher compared to pure grass (BG) and buffel grass-Silver leaf desmodium mixture (BG/SD). In addition to this, higher CP was recorded at the mixture (BG/SD) compared to pure grass (BG). The result of the current result denoted that CP content decreases as day of harvesting increase and increase in grass-legume mixture than in pure grass.

The mean CP content of the legume was much higher than that of the grass component due to legume fix

atmospheric nitrogen, therefore, have a higher protein and feed value than associating grass. The CP content of the legume reduced in the mixture due to the dilution effect of the grass incorporation. The present study is in line with that noted by Tessema and Baars (2006), Taye *et al.* (2007), Amole *et al*. (2015), Tessema and Feleke (2018) who stated that CP content of legume was higher than that of grass. The decrease in CP content as the grass gets matured was also due to an increase in the proportion of stem, which has lower CP content than the leaf fraction (Van Soest, 1982).

According to Kazemi *et al.* (2012) quality standards, legume, grass and grass- legume mixtures containing greater than 19% CP are rated as having prime standard and those with CP values lower than 8% are considered to be of inferior quality. The mean CP content of Silver leaf desmodium in the present study (20.46%) is comparable to the indicated critical value but the pure grass (15.79%) and the mixture (17.92%) are remarkably lower. In addition to this, it is apparent that the legume component had CP levels greater than 15%, a level which is usually required to support lactation and growth (Nsahlai *et al.,* 1996), suggesting the apparent role of legume integrations in improving overall nutritional quality of mixed stand herbage.

Total ash

Ash was highly affected ($p<0.001$) by harvesting time and similarly, significantly affected ($p<0.05$) by forages species. Though their interaction did not cause significant differences ($P> 0.05$) (Table 2). The highest mean ash content (12.71%) was recorded at HT1, while the lowest (9.89%) was recorded at HT3. Similarly, intermediate ash content (11.74%) was obtained at 120 days as compared to the extreme harvesting days. The results obtained also showed a linear decrease in ash content with a corresponding increase in days of harvesting ($P<0.001$).

The decreasing trend of total ash as harvesting time increase might be due to decline in the total ash content of forages which brings about earlier dilution and translocation of different minerals associated with the vegetative portion of the leaf at later time of maturity. The decreasing of ash contents proves beneficial for feeding animals due to reduction of silica that disturbs the digestibility of feeds. This result in line with Berhanu *et al.* (2007) and Terefe (2017) who reported decreased trend of total ash content as age of plant advanced. The total ash content also significantly affected ($p<0.05$) by forage species. Consequently, ash content of pure grass was significantly ($P<0.05$) higher compared to pure legume (DU) but, was not significant ($p>0.05$) compared to the mixture (CC/DU). Sudesh *et al*. (2006) reported higher ash content in grasses than legumes. They suggested that this is due to more silica in grasses than in legumes.

Neutral detergent fiber

Forage stand had highly significant effect on NDF ($p<0.001$); likewise, harvesting time had a significant effect ($p<0.05$) on NDF content; yet their interaction effect did not make significant effect ($p>0.05$) (Table 2). The NDF content was increase as harvesting time increase and the highest mean NDF content (54.46%) was recorded at the later harvesting time (HT3), however, least (46.38%) was recorded at the shortest harvesting time (HT1). NDF content of the intermediate harvesting time (HT2) was significantly higher compared to early harvested plant (HT1) whereas significantly lower than lately harvesting (HT3). These results indicated that the NDF content increased with increased days of harvesting from 90 days to 150 days. This might be due to an increase in fiber content as accompanied with decrease in CP content associated with an increase in the proportion of lignified structural tissue at later stage of growth (Van Soest, 1982; McDonald *et al*., 2002) and environmental factors of temperature and water stress may also affect the cell content and leading to accumulation of less carbohydrate (Whiteman, 1980). The current result elaborates the reports of Taye *et al.* (2007), Bimrew (2016), Genet *et al.* (2017) and Terefe (2017) who reported increased NDF content with advanced age of pasture. In forage stand the highest NDF was recorded at sole grass (CC) compared to the mixture (CC/DU) and sole legume (DU). On the other hand, NDF content of sole *Desmodium uncinatum* (DU) was significantly lower compared to the mixture (CC/DU). Higher NDF value in pure grass and in grass-legume mixture as compared to the pure legume was also reported by Amole *et al.* (2015) and Tessema and Feleke (2018). Feeds containing NDF values of less than 45% are classified as high, those with values ranging from 45% to 65% as a medium, and those with values higher than 65% as having low quality (Singh and Oosting, 1992). Thus in the current study the NDF content of pure legume considered as high quality and pure grass as well as the mixture could be considered in medium standard.

Table 2. Crude protein, ash and NDF as influenced by forage species and harvesting times

Harvesting time	Parameter		
	CP	ash	NDF
90	20.51[a]	12.13[a]	46.38[c]
120	18.11[b]	11.35[b]	50.39[b]
150	15.13[c]	11.75[c]	54.46[a]
p- value	<0.0001	<0.0001	0.0002
SEM	0.56	0.60	3.16
CV	3.12	5.08	6.27
Forage stand			
BG	15.79[c]	12.38[a]	63.96[a]
SD	20.46[a]	11.10[b]	45.77[c]
BG/SD	17.49[b]	11.86[a]	53.633[b]
P-value	<.0001	0.0013	<.0001

[abc] main factors with similar superscripts in columns or rows are not significantly different at (P > 0.05); CV = Coefficient of variation; HT x SPP=Interaction effect; SPP = Forage species; SEM = Standard error of the mean; BG=Buffel grass; SD=Silver leaf desmodium, HT1-HT3=Harvesting Times 1-3.

Acid Detergent Fiber

Harvesting time and species mixture as well as their interaction showed significantly higher (P<0.001) difference on ADF content (Table 3). The highest mean ADF was recorded at BGxHT3 while, the least was recorded at SD xHT1. The result obtained showed a linear increase in ADF content with a corresponding increase in time of harvesting, but grass-legume mixture decreases the ADF content of the grass.

Table 3. Acid detergent fiber (%) as Influenced by harvesting times, forage species and their interaction

Forage Species	Harvesting Times			
	HT1	HT2	HT3	Mean
BG	41.25[h]	43.78[c]	46.22[a]	43.75[a]
SD	36.48[g]	38.66[g]	40.23[f]	38.46[c]
BG/SD	38.64[g]	41.99[d]	45.83[b]	42.15[b]
Mean	38.79[c]	41.48[b]	44.09[a]	41.45
SEM	0.17			
CV	0.42			
	P value			
HT	<.0001			
SPP	<.0001			
HT x SPP	<.0001			

[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; HT x SPP=Interaction effect; SPP = Forage species; SEM = Standard error of the mean; BG=Buffel grass; SD=Silver leaf desmodium, HT1-HT3=Harvesting Times 1-3.

The increase in ADF content as plants become mature could be due to the close association of ADF with the decrease leaf-to-stem ratio and an increase in cell well lignifications with advanced age of harvesting (Berhanu *et al.,* 2007; Taye *et al.,* 2007*).* Bimrew (2016) and Genet *et al.* (2017) in Desho and Terefe (2017) in Rhodes grass respectively reported the same result, in which ADF content increase as plants became mature. As plants mature, photosynthetic products are more rapidly converted to structural components, thus having the effect of decreasing protein and soluble carbohydrate and increasing the structural cell wall components (Ammar *et al*., 2004). Pure grass had significantly higher (P<0.05) ADF content than the mixture and pure stand of legume in all days of harvesting which corroborates with the report of Taye *et al*. (2007), Tessema and Feleke (2018). Therefore, grass-legume mixture could be of an advantage in reducing the ADF content of forage.

Acid detergent lignin

Harvesting times, forage species and their interaction showed highly significant difference (P<0.001) on ADL content (Table 13).

Table 4. Acid detergent lignin (%) as Influenced by harvesting times, plant species and their interaction effect.

FORAGE STAND	Harvesting Times			
	HT1	HT2	HT3	Mean
BG	5.76^{g}	6.54^{ef}	7.48^{cd}	6.60^{c}
SD	6.59^{ef}	8.05^{c}	10.77^{a}	8.47^{a}
BG/SD	6.14^{fg}	6.95^{de}	9.26^{b}	7.45^{b}
Mean	6.16^{c}	7.18^{b}	9.17 ^{a}	7.51
SEM	0.40			
CV	5.38			
P- Value				
HT	<.0001			
FS	<.0001			
HTxFS	0.0011			

^{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; HT x SPP=Interaction effect; SPP = Forage species; SEM = Standard error of the mean; BG=Buffel grass; SD=Silver leaf desmodium, HT1-HT3=Harvesting Times 1-3.

The highest mean ADL (10.77%) was recorded at pure Silver leaf desmodium at the later harvesting time (SDxHT3) while, the least were recorded (5.76%) followed by (6.14%) at first harvesting time (HT1) at pure grass (BG) and at the mixture (BG/SD) respectively. ADL content of grass/legume mixture (BG/SD) was higher than pure grass (BG) at the later harvesting time (HT3) but not significant at the early (HT1) and intermediate harvesting time (HT2). On the other hand, pure stand legume (SD) was significantly higher than the mixture (BG/SD) at the intermediate harvesting (HT2) and at later (HT3) harvesting time, but, not at the early harvesting (HT1). The current result revealed that the ADL content increase as harvesting time increase. This might be due to the fact that as the plants grow longer, there is a greater need for structural tissue by increased proportion of stem that has higher structural carbohydrates and lignin and the upper leaves produced by older plants appear to be of more lignified than earlier produced leaves and highly resistant to chemical and enzymatic degradation and are not appreciably broken down by the micro flora in the ruminant digestive tract (Ranjhan, 1993).

The present result is similar to the findings of Taye *et al.* (2007) and Terfe (2017) who stated that lignin content increased as days of harvesting became longer. Pure legume had higher ADL content than pure grass .This result was as expected due to higher content of ADL in tropical legumes than in tropical grass species (Van Soest, 1994). Elgersma and Søegaard (2018) also reported that lignin is spatially located differently in legumes than in grasses and legumes have a higher ADL content than grasses.

CONCLUSION

Harvesting times and forage stand had shown significant difference (p<0.05) on crude protein content, total ash content, NDF content, ADF content and ADL content whereas, the interaction effect was significant only on ADF and ADL content. The dry matter content was affected significantly (p<0.05) by harvesting time, but not by forage stand and the interaction effect. As harvesting time increase, Crude protein content and ash content decrease while, dry matter content, NDF, ADF and ADL increase. Crude protein content and ADL significantly higher at legume and at the mixture, whereas, ash, NDF and ADF were significantly higher at pure grass and in the mixture compared to pure legume. The highest (20.46%) was obtained in pure stand legume while, the least (15.79%) was obtained in pure stand grass. The intermediate CP content (17.49%) was recorded at the mixture. The CP content of all the treatments was above the minimum level of 7% required for optimum rumen function and could also satisfy the minimum CP contents of 15% required for lactation and growth.

Generally pure-stand legume and their mixture with grass had higher crude protein content than pure-stand grass; whereas pure-stand grass had higher fiber fraction content compared to pure stand legumes and their mixture. Therefore, grass/legume mixture could play crucial role to alleviate feed shortage problems by increasing the quantity and quality of forage. However, further studies should be done to study its effects on the feed intake and animal productivity in terms of milk yield, meat production and body weight gain. Since *Cenchrus ciliaris* and *Desmodium uncinatum* are perennial grass and legume, further studies should also be conducted for their performance in successive years and different agro ecological condition.

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