Greener Journal of Agricultural Sciences
Vol. 9(4), pp. 396-404, 2019
ISSN: 2276-7770

DOI Link: https://doi.org/10.15580/GJAS.2019.4.090319167
https://gjournals.org/GJAS

Evaluation of Agronomic performance and Biomass Yield 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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ARTICLE INFO

Article No.: *090319167*
Type: *Research*
DOI: *10.15580/GJAS.2019.4.090319167*

Submitted: *03/09/2019*
Accepted: *23/09/2019*
Published: *01/11/2019*

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Keywords: *Buffelgrass; Forage yield; grass-legume mixture; Silver leaf desmodium*

ABSTRACT

The objectives of this study were evaluating the effect of grass-legume mixture and time of harvesting on the agronomic performance and biomass yield of Buffel grass and Silver leaf desmodium planted in pure stand and in mixture. The study was conducted in a 3 x3 factorial arrangement of treatments in a randomized complete block design (RCBD) with three replications. The first factor was forage species (Buffelgrass, Silver leaf desmodium and Buffelgrass/Silver leaf desmodium mixture) and three times of harvesting (HT1, HT2, and HT3). Plant height, number of branches per plant of the legume, leaf length and leaf area of the grass were significantly affected (p<0.05) by harvesting time. Number of tillers per plant, basal circumference and number of leaves per plant of the grass were significantly affected by harvesting time and forage species, and the interaction effect was significant (p>0.05) on the basal circumference of the grass. DM yield of Buffelgrass was significantly affected by harvesting times. The highest DM yield in Buffelgrass was recorded in the later harvesting time (HT3) compared to HT1 and HT2. The highest DMY in Buffelgrass (3.0 t /ha) was recorded at Buffelgrass planted with desmodium compared to (2.79 t /ha) at the sole Buffel grass. In Silver leaf desmodium, the highest DMY (2.64 t/ha) was recorded at the third harvesting time (HT3) while the least (1.95 t/ha) was recorded at the first harvesting time. The total DMY recorded at grass/legume mixture was higher compared to the grass and forage legume grown in pure-stand. Harvesting time, forage species and their interaction showed significant (p<0.001) effect on CPY. Generally, agronomic performance and dry matter yields of grass and legume monocultures, as well as the mixture, were generally low at the early days of harvesting compared to later days of harvesting.

1. INTRODUCTION

The main feed resources for livestock in Ethiopia are natural pasture and crop residues, which comprise about 54.59% and 31.60% of the total feeds, respectively (CSA, 2017). However, the role of grazing as sources of feed is diminishing due to continuous expansion of cropping into grazing lands (Habtamu, 2018). As a result, crop residues are increasingly becoming the major sources of feed for livestock (Malede and Takele, 2014). The high proportion of crop residues of livestock feeds in the country is unable to support high level of animal productivity (Alan *et al.,* 2012).

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 Buffelgrass could play an important role in providing a significant amount of forage yield both under the smallholder farmers and intensive livestock production systems.

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). Nevertheless, information regarding the effect of grass-legume mixtures and time of harvesting on biomass yield 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 the agronomic performance and biomass yield 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’N$37^0$43’E/10.333^0N37.717^0E with an average altitude of 2446m above sea level. It has conducive weather condition with1380 mm average annual rainfall and 18^0c 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- Silver 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 Buffelgrass was obtained from Debre Markos University forage nursery site. The planting materials used for Buffelgrass 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. Legume was planted in the same row beside to the grass. The space between plants was 50 cm for both grass and legume. NPS fertilizer was applied at the rate of 100 kg ha^{-1}at planting. Other management practices (weeding and cultivate) were done as required.

Data Collection

Agronomic data were recorded for each parameter at each time of harvest with the first forage sample taken at the 90^{th} days after planting (HT1) and continued every 30 days interval with the second and the third dates being at the 120 (HT2) and 150 days (HT3) after planting. The samples were taken from the middle rows from each plot leaving one border row from each side.

Plant height five plants of the grass and legumes species were randomly selected, and the heights of each plant were measured from ground level up to the tip of the leaf of the main stem. Leaf length (LL) was measured from ligules to leaf apex, using a ruler from five randomly selected plants Tiller number was recorded from 5 randomly selected plants by direct counting the tillers and the average value was taken. Five plants of the legume species were selected randomly from each plot and the number of branches per plant was counted and then the average was recorded. Leaf number for grass species (Buffel grass) was recorded from 5 randomly selected plants by counting the total number of leaves on each plant and the average of recorded. The basal circumference is the circumference of a collection of tillers per plant and was measured using meter around the base of Buffelgrass. Five plants were selected randomly from the middle rows and the leaf area was measured and calculated using the following formula. Leaf area = Leaf length x Leaf width x 0.75 (Sticker *et al.,* 1961).

DM yield fresh yield of samples from the middle rows excluding border rows were harvested 5 cm above ground level from each plot and then weighed in kg. A fresh sample was put into a plastic bag and the fresh weight was taken in the field using a top loading field balance. Then, samples of 150 fresh matters (FW) were weighed out. The fresh samples were then partially air-dried under shed so as to estimate dry matter (DM) fodder yield. The dry matter yield was calculated after drying the samples in a forced drying oven for 72 h at 65^0C and prepared for chemical analysis. The DM yield was calculated as:

DMY Kg ha-1 = (10 x TFW x SSDW) / (HA x SSFW) (James, K. 2008).

Where:

10 = constant for conversion of yields in kg/m^2 to tone/ ha;
TFW = total fresh weight (kg);
SSDW = sub-sample dry weight (g);
HA = harvest area (m^2), and
SSFW = sub-sample fresh weight (g).

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;

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

Where,

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

RESULT AND DISCUSSION

Plant height

Height of Buffel grass and Silver leaf desmodium was highly affected by harvesting time (P<0.001); but not affected (p>0.05) by forage species and their interaction effect (Table 1). The highest mean plant height (53.40 cm) in grass was recorded at HT1 (150 days after planting); while, the shortest height (30.83 cm) was recorded for HT1 (90 days after planting). Likewise, the highest plant height in legume (67.38 cm) was recorded at the later harvesting time, nevertheless, the shortest plant height (30.50 cm) was recorded at early harvesting time (HT1) (Table 1). The increase in plant height might be due to the massive root development and efficient nutrient uptake allowing the plants to continue increasing in height.

Number of branches per plant for legume

Forage species and their interaction effect with harvesting time had no significant effect (p>0.05) on the number of branches per plant (Table 1). However, harvesting time showed a significant effect (p<0.05) on the number of branches per plant. The number of branches per plant significantly increased (P < 0.05) with increasing harvesting times. Plants harvested at HT3 (150 days) had significantly higher (P < 0.05) number of branches per plant compared to legume harvested at 90 and 120 days after planting. Plant harvested at HT1 (90 days) produced lower (P < 0.05) the number of branches per plant compared to HT2 (120 days) and HT3 (150 days).

The current result justified that, the number of branches per plant increase as the time of harvesting increased. The increase in the number of branches per plant as harvesting time increase might be due to the encouragement of commencing supplementary buds to regenerate new branches. In line with the present finding Berhanu *et al.* (2007) reported an increasing number of branches per plant as the day on harvesting increase in vetch.

Leaf length for grass

Leaf length did not show significant difference (p>0.05) for species and interaction (Table 1). However, leaf length was significantly affected (p<0.05) by harvesting time. In this regard, higher leaf length (36.88 cm) was recorded at HT3 (150 days); while the least leaf length (29.57 cm) was recorded at HT1 (90 days). This indicated that leaf length increase as harvesting time increase. The difference in leaf length between early and late harvesting might be due to the differences between physiological growth conditions of the plant. The present study in line with the result of Terefe (2017) who noted that leaf length of forage increased when harvested at a later stage of development.

Leaf area

The results from the analysis of variance revealed that forage species and the interaction effect had no significant difference (P>0.05) on the leaf area. However, the leaf area increased significantly (p<0.05) across the harvesting days (Table 1). Leaf area increased as harvesting time increased and the highest *(*50.16 cm) mean leaf area was recorded at HT3 whereas; the least (31.65 cm) was recorded at HT1. The increase in the number of leaves per plant as harvesting time increase may be responsible for increasing the leaf area. Malaghi (2005) and Haileslassie (2014) reported the same result to the current study which is leaf area increase as plant harvesting time increases.

Table 1. Mean value of plant height, number of branch per plant, leaf length and leaf area as influenced by harvesting times

Harvesting time	Parameters				
	PH for BG	PH for SD	NBPP	LL	LA
90	30.83[c]	30.50[c]	10.27[c]	29.57[c]	31.65[c]
120	38.97[b]	55.8[b]	19.33[b]	32.65[b]	38.59[b]
150	53.40[a]	66.17[a]	27.00[a]	36.88[a]	50.16[a]
p-value	<0.0001	<0.0001	0.0001	0.0004	<.0001
SEM	2.89	30.73	4.07	2.04	2.59
CV	7.05	16.45	21.57	6.17	6.45

[abcd] Mean values within columns and row followed by a different letter are significantly different at (P<0.05) .Where, LL= leaf length, LA= leaf area, PH =plant height, NBPP = number of branch per plant, HT1-HT3=Harvesting Times 1-3, BG= Buffel grass and SD= Silver leaf desmodium; MSE= standard error of Mean; SPP=Forage species; CV=Coefficient of variation; HT x SPP=Interaction effect.

Number of tillers per plant for grass

Harvesting time (p<0.001) and forage species (p<0.05) had a significant effect on the number of tillers per plant. However, their interaction had no significant (P > 0.05) effect on the number of tillers per plant (Table 2). The highest mean tillers number per plant (62.32) was recorded at HT3 while the least (17.87) recorded at HT1. The increase in the tiller number might be due to longer days of maturity and the associated continuous increment in the photosynthetic rate of the grass. The increment of the number of tiller per plant as days of harvesting increased in the current study was in agreement with the report of Berhanu *et al*. (2007) and Terefe (2017).

There was a significant difference (P < 0.01) in tillers count due to variation in forage species. Buffelgrass planted with Silver leaf desmodium (BG/SD) had higher (p<0.05) tiller count compared to the sole Buffelgrass (BG). This indicated that the tiller number increased in mixtures compared to pure stands. Increased tiller number per plant in the grass-grown with legume is due to the nitrogen fixation of the root nodule of legume which is not only favored the legumes but also the companion grass to increase tiller number per plant. In consistent with the current result Stephano (2016) in hybrid Napier grasses stated that desmodium integration with the grass was found increase tiller number per plant of the grass.

Table 2. NTPP and NLPP as influenced by harvesting time and forage species

Harvesting time	parameters	
	NTPP	NLPP
90	17.87[c]	75.57[c]
120	173.43[b]	173.43[b]
150	62.32[a]	310.17[a]
P-value	<0.0001	<0.0001
SEM	5.15	30.73
CV	12.80	16.45
Forage species		
BG	36.82[a]	167.53[b]
BG/SD	43.70[b]	205.24[a]
P-value	0.0178	0.0264

[abc]Means within rows and columns indicated by different letters show a significant difference at (p<0.05). Where BG= Buffelgrass and SD= Silver leaf desmodium; NTPP= number of tillers per plant; NBPP=number of tillers per plant; HT1-HT3=Harvesting Times 1-3; SPP=Forage species, CV=Coefficient of variation; SEM= Standard error of the mean; HT x SPP=interaction effect.

Number of leaves per plant for the grass

Harvesting time and forage stand had significant effect ($p<0.05$) on the number of leaves per plant. However, the effect of their interaction had no significant effect ($p>0.05$) on the number of leaves/ plant (Table 2). Accordingly, later harvested plant (HT3) showed higher ($p<0.05$) number of leaves per plant compared to harvesting at HT1 and HT2. Plots harvested at the shortest time of harvesting (HT1) was significantly lower ($p<0.05$) than the intermediate (HT2) and late harvesting days (HT3). The higher number of leaves in the later harvesting time might be due to the increment of plant height, tillers number and a number of nodes that produce comparable numbers of leaves. An increase in the number of nodes is followed by production of an equal number of leaves in grass cut at maturity as compared to harvesting of younger plants (ILRI, 2013). The current finding confirms to the finding of Mehiret (2008) and Terefe (2017).

A significant difference in the number of leaves per plant ($P < 0.05$) was noted due to forage stand. The highest number of leaves per plant was recorded at the grass planted with desmodium (CC/DU); while, the least mean was recorded at the pure grass (CC). The higher number of leaves per plant at the grass planted with legume might be due to the effect of legume which initiates development of new tillers by fixing soil nitrogen which in turn favors the development of a number of leaves per plant. The higher number of leaves per plant at the grass planted with legume in the current result in line with Muhammad (2010).

Basal circumference for the grass

Basal circumference of the grass showed highly significant variation ($p<0.001$) on harvesting time and significantly affected ($p< 0.05$) by forage species and the interaction effect (Table 3). The highest mean basal circumference (54.27 cm) was recorded at buffelgrass planted with Silver leaf desmodium (BG/SD) at HT3 (150 days) while, the least (16.60 cm) followed by (15.93 cm) were recorded at HT1 when Buffelgrass planted with desmodium (BG/SD) and at pure grass (BG) respectively. On the other hand, HT1 (90 days) and HT2 (120 days) forage species did not show the statistical difference; whereas; at HT3 (150 days) the grass planted with desmodium (BG/SD) showed a higher value than pure grass (BG). This could be attributed to the longer physiological growth of the plants during late harvest, which might have an increased number of tillers per plant which favors increasing basal circumference of the plant. The results of the present study are inconsistent with the report of Butt *et al*. (1992) and Mushtaque *et al*. (2010). According to Butt *et al*. (1992) and Mushtaque *et al*. (2009) basal circumference of Buffel grass and *Panicum antidotal* increased with rising of the clipping stage. They attributed it to the longest vegetative growth period with advancing plant maturity.

In the current study, the highest mean basal circumference was recorded for Buffel grass planted with Silver leaf desmodium harvested at 150 days after planting might be due to the increment of root nodulation of desmodium in the late harvesting which enhances higher tiller production and causes for basal circumference increment.

Table 3. Basal circumference as influenced by harvesting stage, forage species and their interaction

Harvesting times	Basal circumference		
	BG	BG / SD	Mean
90	15.93^{d}	16.60^{d}	16.27^{c}
120	30.47^{c}	32.07^{c}	31.27^{b}
150	47.67^{b}	54.27^{a}	50.97^{a}
Mean	31.36^{b}	34.31^{a}	32.83
SEM = 1.03			
CV = 3.13			
P- value			
HT	<.0001		
SPP	0.0001		
HT*SPP	0.0001		

^{abcd}Mean values within columns and row followed by a different letter are significantly different at ($P<0.05$). Where, HT1-HT3=Harvesting Times 1-3, BG= Buffelgrass and SD= Silver leaf desmodium; MSE= standard error of Mean; SPP=Forage species; CV=Coefficient of variation; HT x SPP=Interaction effect.

Dry matter yield

The dry matter yield (DMY) of the grass was highly affected ($p<0.001$) by harvesting times and significantly affected ($p<0.05$) by the forage species; while, the interaction effect of harvesting times and forage species was not significant ($p>0.05$) (Table 4). Plots harvested at the third harvesting time (HT3) had significantly ($p<0.05$) higher DMY compared to HT1 and HT2. Significantly ($p<0.05$) lowest DMY was recorded at HT1 compared to HT2 and HT3. Likewise, harvesting time showed a highly significant effect ($p<0.001$) on DMY of the legume. Dry matter yield recorded at 150 days (HT3) was significantly higher compared to at 90 days (HT1) and 120 days (HT3 (Table 6). On the other hand, significantly least dry matter yield was recorded at 90 days (HT1) compared to 120 days (HT2) and 150 days (HT3). The increasing trend of dry matter yield in both species could due to the development of additional tiller in the grass, branches in legume, leaf formation, leaf elongation, stem development and vegetative growth of the plant. Van Soest (1994) claimed that at late harvesting, DMY increased due to the cumulative effect of plant growth and environmental factors influencing the distribution of energy and nutrients derived from photosynthesis.

The same result was reported by Tessema and Feleke (2018) which is biomass yield increase as advance matur ity stages of the plant. Dry matter yield of the grass planted with desmodium (BG/SD) was significantly higher than pure grass (BG). This is due to the associative effect where the grass had benefitted from the fixed N by the legume. This result also similar to Tessema and Baars (2006), Diriba and Diriba (2013) and Tessema and Feleke (2018) who reported that grass planted with the legume had higher dry matter yield than at the pure stand grass.

Total dry matter yield was highly affected ($p<0.001$) by harvesting time and forage species. Similarly, the interaction effect of the two variables was significant ($p<0.05$) on total dry matter yield. The highest total dry matter yield was recorded at (BG/SD) x HT3 while, the least was recorded at the legume component (SD) x HT1. The grass-legume mixture had a higher mean total DM yield of pasture compared to the pure-stand grass and forage legume (Table 6). Total DM yield production increased as the pasture harvesting period increases. This might be due to the fact that all the grass and forage legume species as pure-stand and in the mixture grew well and vigor's from the time of establishment to later stage because grass and legume usually produce more tillers and branches respectively that could contribute to the higher total DM yield for the grass-legume mixed pastures. Similar results were reported Amole *et al* (2015), Tessema and Feleke (2018).

Generally, dry matter yields of grass and legume monocultures as well as the mixture were generally low at the early days of harvesting compared to later days of harvesting. This may be attributed to the fact that both grass and legume were in the process of establishment. The capacity for tiller development had not been fully attained in the case of grass and the legume was slow in the establishment.

Table 4. Dry matter yield (tons / ha) as influenced by harvesting time, forage species and their interaction

Forage Species	Harvesting Time											
	Grass				Legume				Total DMY(tons / ha)			
	HT1	HT2	HT3	Mean	HT1	HT2	HT3	Mean	HT1	HT2	HT3	Mean
BG	2.33	2.80	3.26	2.79^{b}	-	-	-	-	2.33^{f}	2.80^{e}	3.26^{d}	2.79^{b}
BG + SD	2.48	2.83	3.68	3.00^{a}	1.99	2.17	2.59	2.25	4.47^{c}	5.01^{b}	6.27^{a}	5.25^{a}
SD	-	-	-	-	1.92	2.36	2.68	2.32	1.92^{g}	2.36^{f}	2.68^{e}	2.32^{c}
Mean	2.41^{c}	2.81^{b}	3.47^{a}	1.40	1.95^{c}	2.26^{b}	2.64^{a}	2.28	2.91^{c}	3.39^{b}	4.07^{a}	3.46
SEM	0.17				0.08				0.15			
CV	5.78				3.62				4.51			
P-value												
SPP = 0.0268					*SPP* = 0.098				*SPP* = <.0001			
HT = <.0001					HT = <.0001				HT = <.0001			
SPP x HT= 0.1706					*SPP x HT* = 0.06				*SPP x HT*= 0.0001			

[abcdef] Mean values within columns and rows followed by a different letter are significantly different at (P<0.05). Where, HT1-HT3=Harvesting Times 1-3, BG= Buffel grass; SD= Silver leaf desmodium; SEM=Standard error of the mean; SPP=Forage species; CV=Coefficient of variation; HT x SPP=Interaction effect

CONCLUSION

The analysis of variance showed that plant height of grass and legume, number of branches per plant of the legume, leaf length and leaf area of grass were significantly affected ($P<0.05$) by harvesting times but not ($p>0.05$) by forage stand and the interaction effect. The number of tillers, number of leaves per plant, and basal circumference of the grass were significantly affected ($p<0.05$) by harvesting times and forage stand while, except basal circumference ($P<0.05$), their interaction had no significance difference ($P>0.05$).DM yield of *Cenchrus ciliaris* was significantly affected by harvesting times. The highest DM yield in *Cenchrus ciliaris* was recorded in the later harvesting time (HT3) compared to HT1 and HT2. The highest dry matter yield in *Cenchrus ciliaris* (3.0 t /ha) was recorded at *Cenchrus ciliaris* planted with desmodium compared to (2.79 t /ha) the sole *Cenchrus ciliaris*. In *Desmodium uncinatum* the highest dry matter yield (2.64 t/ha) was recorded at the third harvesting time (HT3) while the least (1.95 t/ha) was recorded at the first harvesting time (HT1). But there was no significant difference ($p>0.05$) between the desmodium planted with *Cenchrus ciliaris* and pure desmodium in dry matter yield.

Therefore, grass/legume mixture could play crucial role to alleviate feed shortage problems by increasing the quantity and quality of forage. How ever 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.

ACKNOWLEDGMENT

My sincere thanks go to Ministry of Education and Ministry of Agriculture of Ethiopia for giving me the opportunity and full financial support to pursue my MSc study at Debre Markos University, College of Agriculture and Natural resource.

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Cite this Article: Demlew, M; Alemu, B; Awuk, A (2019). Evaluation of Agronomic performance and Biomass Yield 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. *Greener Journal of Agricultural Sciences* 9(4): 396-404, **https://doi.org/10.15580/GJAS.2019.4.090319167**
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