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Research Article

Evaluations of Improved Forage Legume Potential for Pasture Land Improvement in Low Land and Mid Land Areas of East Shewa and West Arsi Zone

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Abstract

This study aims to evaluate the improved forage legume potential for pasture land improvement in low-land and mid-land areas of East Shewa and West Arsi zone of Oromia regional state during 2021/22 planting seasons. The natural pasture grazing land was selected to establish the experiment. The experiment was undertaken with RCBD design. The ripping was done before sowing and animal manures were applied before establishment to facilitate the germination of legumes forage. The experiment has four treatments with three replications including the control. The plot size was 4 m * 3 m and the distance between the plot and block were 1m and 1.5m respectively. The sample was taken by quadrant of 1 m * 1 m, weighed, and inserted into a paper bag. The sub-sample was taken for dry matter determination and biomass estimation. Laboratory chemical analyses for some of the major parameters have been done at ATARC. The feed sample was analyzed for dry matter (DM) and crude protein (PC) using AOAC (2000) method. The statistical analysis was undertaken by ANOVA procedures with Tukey's Studentized Range (HSD) Tests to separate the mean values for each parameter at P<0.05. Analysis of variance revealed that variations of sites and treatments had showed a significant effect at (P<0.05) on dry matter yield and ADL. In addition, the site effects had showed significant effects on leaf to steam ratio, percentage of dry matter, percentage of ash and coverages. The ANOVA result showed that there was no interactions effect (P<0.05) for all parameters. In addition, the dry matter have significance difference (P<0.05) between the treatments due to different legumes integration. The integrated siratro (T4) and desmodium (T3) have higher mean value of dry matter than the other treatments. Of the total dry matter, the Desmodium have 10.88% proportion while the Siratro have about 49.57%. In general, improved forage legumes integration result indicated that as to be appropriate option for natural pasture improvement in terms of quantity and quality. Thus, of the treatments the demodium and siratro components have higher dry matter and crude protein the T3 and T4 were recommended for natural pasture improvement in terms quantity and quality for lowland and midland agroecology.

Keywords

Pasture, Legumes, Crude Protein, Adami Tulu, Forages

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1. Introduction

Livestock rearing is one of the major livelihoods [11] in Ethiopia and has significant involvement to the country's GDP [10]. However, feed shortages both in quantity and quality have constrained livestock production and productivity [10, 11]. This is due to the expansion of farmland which in turn leads to the dwindling of grazing lands [7, 8, 16]. Natural pasture and crop residues are the most popular feed resources for livestock in the country, both of which are typically scarce and of low nutritive value (low crude protein and high fibers) during the dry season [20, 3]. Though grazing lands (natural pasture) play a great role in livestock production, productivity and quality were extremely low due to several influences that include overgrazing, land degradation, soil erosion, climate change, and other factors [18, 6]. For instance, the dry matter yield of heavily grazed grasslands does not exceed 1.5 tha^{-1} in the highlands above 2,600 m or 2.5 t ha^{-1} below this altitude (Alemu, 1998; [21].), while the mean DM yields of the grass-legume mixtures ranged from 4.51 to 12.09 t ha^{-1} [14].

Grazing land improvement practices are relatively less common owing to the lack of awareness and appropriate training, lack of appropriate improvement methods, and little attention given to grazing lands by the agricultural extension system [2]. Therefore, there is a great need for the community in the study areas to sustainably improve grazing land as well as fodder quality and quantity. Thus, adding improved forage legumes and grasses to grazing lands in a mixture might be the best option to enhance natural pasture in particular and address the issue of feed scarcity in general in the study areas.

Legume pastures are the basis of pasture and animal production systems in many parts of the world and forage legumes were over sown into natural grasses to determine their potential to improve feed quality and quantity [19].

Regarding the information on natural pasture improvements in various parts of the region is not available.

Improved pastures are better in nutritive value and dry matter yield when they are compared with natural/communal grazing lands relatively. In addition, the mixture of grass and legumes forage might have high biomass and nutritive values than grass production alone. Furthermore, intercropping forage legumes with grasses presents a potential to increase productivity, herbage nutritive value, resource efficiency, plant diversity, productivity, and pasture persistence [17]. Likewise, legume inclusion in the farming systems can play a vital role in sustaining crop and livestock production, and in maintaining or improving the fertility of marginal lands [13].

Therefore, evaluating different forage legumes for their compatibility in pasture land improvement is the alternative option in the areas. Thus, this study aimed to evaluate the improved forage legumes potential and their compatibility in pasture land improvement at the study sites. To this end, this study aimed to address the following specific objectives: (1) to evaluate herbage dry matter yield and nutritional quality of selected herbaceous forage legumes over sown on natural pasture; (2) to evaluate the potential and compatibility of selected legumes in pasture land improvement practices.

2. Materials and Methods

2.1. Description of the Study Area

The study was done at Adami Tulu Agricultural Research Center (ATARC) and Dodola district of west Arsi zone of Oromia regional state, which represent lowland and midland agro-ecology respectively. ATARC is found in east Shewa zone of Oromia region and far 167 km from the capital city of the country 'Finfinnee'. It was located at 7° 45'N 38° 40'E longitude and latitude with an elevation ranging from 1500-2300 masl. It has an average annual rainfall of 760 mm and minimum and maximum temperatures of 12.8 and 27.3 ℃, respectively. The Dodola district is found in west Arsi zone of Oromia region and is located at 06° 59'N and 39° 11'E longitude and latitude, respectively, with an altitude ranging from 2362-2493 masl. The average annual rainfall of the district is 750mm with minimum and maximum temperatures of 22 and 28 ℃, respectively. In addition, the 95% of the dodola area district is highland while 5 % is midlands [15].

2.2. Experimental Procedure, Design, and Layout

Natural pasture land was selected to establish the experiment. Before sowing, ripping was done by rake, and animal manure was applied to facilitate the germination of sown forage legumes. The experiment was consisted four treatments including the control: Sole pasture land (T1), Sthylothantus (T2), Desmodium (T3), and Siratro (T4). The treatments were laid out in a randomized complete block design (RCBD) with three replications. The plot size was 4 m * 3 m and the distance between the plot and block was 1 m and 1.5 m, respectively. The experimental forage legumes were applied with the recommended seed rate and over sown while the rain began.

2.3. Data Collection

2.3.1. Forage Sampling Procedures

A 1m*1m quadrant were used to harvest the sample from each treatment at 50% flowering stage for legumes and head setting for natural grasses and cut at a height of 0.5 cm near the ground to determine the forage dry matter yield. After harvesting, the total fresh weight of the forage sample from each plot was measured immediately for biomass yield determination. The species composition were classified from samples of pasture in each experimental plot by counting (Mannetje *et al.* 1976), and weighed at field by sensitive balances. The harvested sample was sub-sampled, labeled, and inserted into a paper bag to transport to the ATARC animal feed laboratory.

2.3.2. Dry Matter Determination

The DM yield was determined by drying a representative sample in an oven at 60℃ for 72 hours for partial DM determination at ATARC.

2.4. Chemical Analysis

The dried samples were ground to pass through a 1mm sieve for chemical analyses. Ash was determined by igniting the samples in a muffle furnace at 550°C for 3 hours in ATARC. The nitrogen (N) contents were determined by Kjeldahl method (major feed has 16% N which means 100/16=6.25N) and CP is calculated as N*6.25 [4], ADF, ADL and NDF were by Van Soest and Robertson at ATARC Animal feeds Laboratory with the standard procedures [22].

2.5. Statistical Analysis

The organized data were interred into Microsoft excel and imported to SAS software version 9.1 to analysis statistically. The ANOVA procedure was computed to analysis the data and the list significance differences (LSD) test was used for mean separation. The significance difference was assigned at P<0.05.

3. Results and Discussion

Analysis of Variances

Analysis of variance revealed that variations of sites and treatments had showed a significant effect at (p<0.05) on dry matter yield and ADL. In addition, the site effects had showed significant effects on leaf to steam ratio, percentage of dry matter, percentage of ash and coverages as indicated on the following table 1. The ANOVA result showed that there is no interactions effect (p>0.05) for dry matter, leaf to steam ratio, percentage of coverage, species abundance, percentage of dry matter and Ash, and fibers parameters. The obtained result clearly indicated that the environments have significant effect on dry matter yields.

Table 1. *Mean squares of combined analysis of variance (ANOVA) for the effects of treatments and location on dry matter yield and other physical and quality parameters of different legumes tested in different locations.*

Sources of variation	DF	Mean squares			
		DMY	LSR	Coverage	SAB
Location (Loc)	1	11978.5***	155.45***	29800.35***	213.19^{ns}
Treatment (Trt)	3	557.40*	2.12^{ns}	179.27^{ns}	94.44^{ns}
Trt x Loc	3	65.40^{ns}	4.26^{ns}	62.34^{ns}	27.63^{ns}
Error	16	2.87	1.59	59.26	129.16
Residuals		0.87	0.87	0.94	0.22

*Note: DM=dry matter, CP=Crude protein, ADF=Acid detergent fiber, ADL=Acid detergent lignin, NDF=Nitrogen Detergent fiber.

Table 2. *Mean squares of combined analysis of variance (ANOVA) for the effects of treatments and location on dry matter percentage and other quality parameters of different legumes tested in different locations.*

Sources of variation	DF	Nutritional parameters					
		Mean squares					
		DM%	Ash%	CP	ADF	ADL	NDF
Location (Loc)	1	3.08**	15.68**	1.55^{ns}	73.5^{ns}	35.04***	4.17^{ns}
Treatment (Trt)	3	0.12^{ns}	0.03^{ns}	6.07**	571.1***	53.8***	49.08**
Trt x Loc	3	0.12^{ns}	0.41^{ns}	1.02^{ns}	35.61	38.49^{ns}	4.17^{ns}
Error	16	0.21	1.62	2.76	21.63	0.62	4.17

Sources of variation	DF	Nutritional parameters Mean squares					
		DM%	Ash%	CP	ADF	ADL	NDF
Residuals		0.54	0.40	0.34	0.85	0.97	0.71

*CP=Crude protein, ADF=Acid detergent fiber, ADL=Acid detergent lignin, NDF=Nitrogen Detergent fiber.

Table 3. *Combined analysis for DMY, coverage, and leaf to stem ratio, dry matter percentage and other quality parameter of natural pasture improvements tested from 2021/22 year at dodola and ATARC sites.*

No	Treatments	Parameters									
		DMY	LSR	Coverage	SAB	DM%	Ash%	CP	ADF	NDF	ADL
1	Sole pasture land	7.40^{b}	3.61^{b}	93.95	7.49	89.58	9.20	7.80^{b}	25.88^{b}	61.42^{b}	19.02^{a}
2	Sthylothantus	7.16^{b}	4.73^{a}	91.48	11.15	89.37	9.22	8.61^{ab}	22.74^{b}	61.00^{bc}	7.00^{d}
3	Desmodium	8.83^{ab}	5.23^{a}	96.82	5.33	89.32	9.28	10.18^{a}	32.00^{a}	58.58^{c}	9.08^{c}
4	Siratro	12.55^{a}	4.39^{a}	90.80	11.30	89.27	9.37	8.48^{ab}	8.94^{c}	65.48^{a}	12.03^{b}
Overall mean		9.00	4.54	93.26	9.56	89.38	9.27	8.76	22.39	61.62	16.78
CV		18.87	27.77	8.25	11.83	0.51	13.74	18.95	20.77	3.31	2.84
P-Value		<.0001	<.0001	ns	ns	ns	ns	0.0021	0.0001	0.0021	<.0001

*Means with the same letter are not significantly different, CV=Coefficient variation, DM=dry matter, CP=Crude protein, ADF=Acid detergent fiber, ADL=Acid detergent lignin, NDF=Nitrogen Detergent fiber.

The combined mean result showed that the different physical parameter and nutritive values of natural pasture evaluated have significance differences (P<0.05) as indicated in the above table 2. In addition, the dry matter has a significant difference (P<0.05) among the treatments. The integrated siratro (T4) and desmodium (T3) have higher mean value of dry matter than the other treatments. Of the total dry matter indicated in the above table 1, the Desmodium have 10.88% proportion while the Siratro have about 49.57%. This might be due to the higher plot coverage and high species abundances of T4 (Siratro) than the others. However, the leaf to steam ratio have highly significant variation (P<0.05) between the treatments. The integrated legumes forage have higher than natural pasture (control) treatments. This might be due to grazing land management, fertilizer application, over-sowing of legumes, optimum harvesting stage, feed conservation and utilization are important practices to improve the productivity of natural pasture and used to maintain the nutritive values of the pastures over seasons [1]. The natural pasture dry matter yield is 4.4tha^{-1} and 5.5 CP [20] especially low in during the dry season. The integration of improved forage incurs the quantity of natural pasture and this results in line with [23] and the high proportion of legumes integration increases the feed quality and quantity to improve the productivity of natural pasture [1].

The percentage of dry matter and Ash components have no significance differences at (P>0.05) between the treatments. Also, there is no significance effect of legume integration on species abundance and percentage of coverages. If a pasture mainly composes of unproductive native grasses, there may be a benefit of introducing improved grass species and varieties (Tesfaye A *et.al*, 2017; [23]. Over sowing is the simplest forage development strategies and can be undertaken at very low cost into common grazing lands, native pastures and degraded areas without any cultivation or other inputs [5]. They improve the seasonal distribution of forage dry matter by boosting summer production [23].

The statistical analysis showed that the significance differences (P<0.05) of improved forage integration to pasture lands on chemical composition (crude protein and fibers (ADF, ADL and NDF)) between the treatments. The Desmodium (T3) and siratro (T4) integrated have higher crude protein than the other treatments. This refers that the integration of improved forages enhanced the feed quality and [23] stated as integration of improved forages improve protein levels and overall digestibility of the forage. Similar result was also reported by [9]. In addition, legumes provide high-quality feed for grazing animals because, forage legumes are high in protein and are highly digestible while grasses tend to be less productive (Melissa *et al.*, 2020). Similar result was stated that in mid-altitudes the perennial *Desmodium uncinatum* has shown superior establishment with Rhodes grass (*Chloris gayana*) and Siratro (*Macroptilium atropurpureum)* [1]. In addition, livestock fed on fodder from grass/legume mixed pastures may benefit more than those fed on natural pastures alone [12]. Also the integration of improved forage have increased the yield of natural pasture [23].

4. Conclusion and Recommendation

Analysis of variance revealed that variations of sites and treatments had showed a significant effect at ($P<0.05$) on dry matter yield and ADL. In addition, the site effects had showed significant effects on leaf to steam ratio, percentage of dry matter, percentage of ash and coverages. The ANOVA result showed that there no interactions effect ($P<0.05$) for all parameters. In addition, the result of the study states that the integration of improved legumes forage mixture to natural pastures showed the significance differences ($P<0.05$) of dry matter and crude protein with different treatments. The treatment 3 (Desmodium) and T4 (siratro) have higher dry matter and crude protein than the other treatments. In addition, due integrations improved forage legumes to improve natural pasture land there is significance difference ($P<0.05$) between the treatments. In general, improved forage legumes integration result indicated that as to be appropriate option for natural pasture improvement in terms of quantity and quality. Thus, of the treatments the demodium and siratro components have higher dry matter and crude protein the T3 and T4 were recommended for natural pasture improvement in terms quantity and quality for lowland and midland agroecology.

Abbreviations

ATARC	Adami Tulu Agricultural Research Center
ADF	Acid Detergent Fiber
ADL	Acid Detergent Lignin
AOAC	Association of Official Analytical Chemist
CP	Crude Protein
DM	Dry Matte
NDF	Nitrogen Detergent Fiber
RCBD	Randomized Complete Block Design
T	Treatments

Author Contributions

Meseret Tilahun: Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Project administration, Supervision, Writing – original draft, Writing – review & editing

Yadeta Nigatu: Conceptualization, Formal Analysis, Methodology, Project administration, Supervision, Writing – review & editing

Dawit Abate: Data curation, Formal Analysis, Supervision

Lalisa Diriba: Conceptualization, Data curation, Methodology, Supervision

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Conflicts of Interest

The authors declare no conflict of interest.

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