REPORT VOL. 5, 2019

DISCOVERY Agriculture

ISSN 2347–3819 EISSN 2347–386X

Evaluation of Trifolium accessions for Agronomic Performance in the Mid-altitude of Benishangul-Gumuz Region, Western Ethiopia

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Article History
Received: 17 January 2019
Accepted: 06 March 2019
Published: March 2019

Citation
Mulisa Faji, Alemayehu Abebe, Habtamu Alebachewu, Kedija Ahmed, Diribi Mijena. Evaluation of Trifolium accessions for Agronomic Performance in the Mid-altitude of Benishangul-Gumuz Region, Western Ethiopia. *Discovery Agriculture*, 2019, 5, 98-104

General Note
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ABSTRACT
A study was conducted at Assosa Agricultural Research Center with the objective of to identify the superior accessions of Trifolium species based on the dry matter (DM) yield and herbage components. Five Trifolium accessions (*T. Steudenary* 9720, *T. Decorum* 9447, *T. Quantinum* 6301, *T. Tembense* 7102 and *T. Steudenary* 9712) were evaluated in randomized complete block design with three replications. The collected data were analyzed using the general linear model procedures of SAS and least significance

difference was used for mean comparisons. Combined analysis indicated that the tested accessions varied significantly ($P < 0.001$) for number of tiller (NT), number of branch per plant (NBPP), plant height at harvesting (PHH) and forage DM yield. Mean forge DM yield ranged from 1.49 to 5.11 t ha^{-1} with a mean of 3.62 t/ha. Accordingly, *T. Quantinum* 6301 accession gave the highest mean forage DM yield followed by *T. Steudenary* 9712 (3.99 t/ha) and *T. Steudenary* 9720 (3.89 t/ha) accessions, whereas the lowest obtained from accession *T. Tembense* 7102. The highest NBPP and PHH were recorded for *T. Quantinum* 6301, *T. Steudenary* 9712 and *T. Steudenary* 9720. The NBPP, HAH and leaf to stem ratio (LSR) were significantly influenced ($P < 0.001$) by year. Correlation analysis indicated that forage DM yield was positively associated with NBPP, PHH and LSR while negatively correlated with NT. It was concluded that *T. Quantinum* 6301, *T. Steudenary* 9712 and *T. Steudenary* 9720 top performing accessions and recommended for the study area.

Key words: Dry matter yield; Leaf to stem ratio; *Trifolium Quantinum;* number of branch per plant

1. INTRODUCTION

The livestock subsector is a vital constituent of Ethiopian agriculture and plays a considerable role as a strategic subsector to offset the widespread social and economic consequences of poverty (Behnke and Metaferia, 2011). Despite the fact that there exists high population and wide range of distribution, the present productivity of livestock in Ethiopia is very low. The low productivity of livestock is mainly attributed to inadequate nutrition, low genetic potential of indigenous breeds, prevalence of disease and parasites. Among the factors contributing to low productivity, low nutrition is considered to be the most important (Adugna *et al.*, 2000). Scarcity of feed constrains the livestock sector in Ethiopia, particularly in the lowlands (Mengistu *et al.*, 2010). Much of the feed is obtained from fragmented native pastures, transient pastures between cropping cycles, crop residues and aftermath grazing (Wondatir, 2010). Though indigenous pastures traditionally contributed much to livestock feed supply, current trends indicate that they are gravely overstocked and existing grazing areas are gradually shrinking due to encroachment of crop production which is induced by the need to feed the increasing human population especially in developing country (Melaku, 2004).

In Ethiopia, crop residues of cereals and pulses account for about 32% of the total feed utilized and ranked second to grazing 37% (CSA, 2015). Productivity estimates also vary, probably variation in time and ecological change, rainfall, soil type and cropping intensity (Gezu Tadesse and Moges Dereje, 2018; Kasahun Kitila and Abay Chala, 2018). Adugna (2008) reported annual production of 29.2 million tons of crop residue. However, these feed resources contain crude protein (CP) levels of below 8% and neutral detergent fiber (NDF) of above 55% which limit intake and digestibility (Seyoum and Zinash, 1995). Evidence suggests that low quality feed resource utilization could be improved by supplying deficient nutrients like nitrogen and other micronutrients to animals (Prasad *et al.*, 2001). As a result, under scenarios of intensifying crop-livestock production systems, current and future strategy in livestock feeding need to be on maximizing the use of these feeds by using, among others, various leguminous forages as supplements. The scientific basis of feeding forage legume supplements to ruminant livestock subsisting on poor quality forages has been discussed in a number of works and the efficient use of such feeds need to be a focus of attention for ensuring sustainable availability of animal source proteins for human consumption in Ethiopia as well (Diriba *et al.*, 2013). With this background, forage legume germplasm selection activities are in progress under different agro-ecologies of the country with a number of candidate genotypes at advanced level of varietal selection stages at present. Indeed in the mid-lands of Benishangul-gumuz, the problem feed shortage in terms of quality and quantity can be alleviated by growing annual forage crops such as forage legumes of clover species.

There are 240 to 300 clover species of the genus *Trifolium* distributed around the world, and clovers are ubiquitous in natural grasslands in cooler climates (Allen and Allen, 1981). Although clovers rank second in forage productivity and feeding value to *Medicago* sativa in western countries, few *Trifolium* species are cultivated due to their recent domestication (Davies and Young, 1967). Forty trifolium species are reported to be found in Sub Saharan Africa (SSA) of which 25% are endemic to Ethiopia (Akundabweni, 1984a). Two-thirds of the clover species in Ethiopia are annuals and the remainder is perennials; biennials are not found in Ethiopia (Akundabweni, 1984a; Getnet *et al.*, 2006). The Ethiopian highlands are thought to be the world's most important center of genetic diversity for clovers (Akundabweni, 1984b). Clovers grow rapidly when the growing conditions are favorable and produce a large amount of dry matter. This can be conserved as hay, which can be used to increase the quality of straw based diets and to overcome seasonal feed shortages (Akundabweni, 1984a). Some species grow naturally in valley bottoms which are not cultivated due to seasonal water logging. Thus, they can be managed to increase forage production without competing with food crops for land. Some of the African clovers are adapted to acid and low phosphorous soils. Similarly, clovers can be grown on land that would otherwise lie fallow as part of crop rotation system (Emmanuel Mavhura *et al.* 2017). Their ability to fix atmospheric nitrogen will help to improve the fertility of the soil and thus increase the yield of succeeding crop (Akundabweni, 1984a). This study was undertaken to test and identify adaptable and high yielding forage Trifolium accessions crops under mid-altitude of Benishangul-Gumuz region, western Ethiopia.

2. MATERIALS AND METHODS

Study area

The study was conducted at Assosa Agricultural Research Center which is located in Benshangul-Gumuz Regional State, Western Ethiopia. It is located10°30'N latitude and 034°20'E longitude, an altitude of 1565 meters above sea level. The pattern of rain is uni-modal with mean annual rainfall of 1275mm. The minimum temperature varies between 14°C and 20°C and the maximum temperature ranges from 25°C to 39°C. The soil type is reddish brown nitisols (Alemayehu and Woldegabriel, 2016).

Experimental treatments and design

The five accessions of Trifolium accessions (*T. Steudenary* 9720, *T. Decorum* 9447, *T. Quantinum* 6301, *T. Tembense* 7102 and *T. Steudenary* 9712) for this research experiment were collected from ILRI and Holleta Agricultural Research Center. The accessions were planted in 3 m x 4 m plot using a randomized complete block design (RCBD) with three replications at the beginning of the main rainy season. Seed will be sown by drilling and 30 cm spacing between rows and at 3 cm depth. The total experimental area was 17 m × 28 m (476 m^2) with individual plot size of 12 m^2 and spacing between plots and replications of 1.5 and 2 m, respectively. The treatments were sown according to their recommended seeding rates: 3-5 kg ha^{-1}.

Data collection

Data was collected on days to forage harvest, tillering, plant height at harvesting (PHH), number of branches per plant (NBPP) and forage dry matter (DM) yield. Number of tiller, PHH and NBPP were taken on six plants randomly selected from each plot. PHH was measured using a steel tape from the ground level to the highest leaf. For determination of biomass yield, accessions were harvested at forage harvesting stage (50% blooming stage) in laid quadrant which has 1m^2 area. Weight of the total fresh biomass yield was recorded from each plot in the field and the estimated 500 g sample was taken from each plot to the laboratory. The sample taken from each plot was weighed to know their sample fresh weight and oven dried for 72 hours at a temperature of 65 ^{0}C to determine dry matter yield.

Statistical analysis

Analysis of variance (ANOVA) procedures of SAS general linear model (GLM) was used to compare treatment means (SAS, 2002). LSD test at 5% significance will be used for comparison of means. The Pearson correlation analysis procedure of the SAS statistical package was applied to measure the strength of linear dependence between any two measured variables. The data was analyzed using the following model:

$$Y_{ijk} = \mu + T_i + B_{k(j)} + e_{ijk}$$

Where, Yijk = measured response of treatment i in block k of location j,

μ = grand mean,

Ti = effect of treatment i,
Bk (j) = effect of block k j, and
e ijk = random error effect of treatment i in block k of location j.

3. RESULTS AND DISCUSSIONS

Number of tillers per plant

The tillering performance of the tested Trifolium accessions is presented in Table 1. The result of combined analysis revealed that number of tillers was significantly different ($P < 0.001$) among the accessions, however non-significant ($P > 0.05$) with the production years. The highest number of tillers (4.72) over years was observed for *T. Decorum* 9447. The difference in tillers produced per plant among the accessions of Trifolium could be attributed to genetic variations among the accessions. Increased tillering is probably an adaptive feature to tolerate frequent defoliation by re-establishing lost photosynthetic area and maintaining basal area (Gezahgn, *et al*, 2016). High tiller production not only indicates stable productivity (Mukhtar, 2006) but also is linked to better persistence after periods of unfavorable environmental conditions (Assuero and Tognetti, 2010) and in agreement to the finding of this authors, in this study lower forage DM yield was observed for *T. Decorum* 9447. The number of tillering observed in this experiment (2.90) was in line with the value (2.98) that reported by Verena and Brigitta (2002) for *Trifolium pallescens* in Australia.

Table 1 Mean number of tillers of five Trifolium accessions tested over years at Assosa

Accessions	Year			Combined Over Years
	2016	2017	2018	
Trifolium Steudenary 9720	2.00	3.22^{a}	2.25^{bc}	2.49^{bc}
Trifolium Decorum 9447	3.67	4.17^{a}	6.33^{a}	4.72^{a}
Trifolium Quantinum 6301	2.33	2.94^{a}	1.67^{c}	2.31^{c}
Trifolium Tembense 7102	2.67	3.11^{a}	3.83^{b}	3.20^{b}
Trifolium Steudenary 9712	1.67	1.67^{b}	2.00^{bc}	1.78^{c}
Mean	2.47	3.02	3.22	2.9
SEM	0.24	0.25	0.52	0.21
P-Value	0.0517	0.0210	0.004	0.0001

Number of Branches per plant at Forage Harvesting

The mean number of branches per plant of tested Trifolium accessions presented in Tabe 2. The number of branches per plant of tested Trifolium accessions was significantly affected by accession (P < 0.001) and year (P < 0.01). The result of combined analysis indicated that higher mean number of branch per plant was observed for *Trifolium Steudenary* 9712 accession and followed by *Trifolium Steudenary* 9720 and *Trifolium Quantinum* 6301 accessions. The mean number of branch per plant in this experiment (9.44) was higher than that the values reported by Akundabweni (1984b) (4.13) for *T. tembense* in Ethiopia.

Table 2 Mean number of branches per plant of five Trifolium accessions tested over years at Assosa

Accessions	Year			Combined Over Years
	2016	2017	2018	
Trifolium Steudenary 9720	11.67^{a}	10.00^{a}	10.92^{a}	10.86^{ab}
Trifolium Decorum 9447	8.67^{b}	7.39^{b}	7.67^{b}	7.91^{c}
Trifolium Quantinum 6301	13.00^{a}	7.78^{b}	9.67^{ab}	10.15^{b}
Trifolium Tembense 7102	8.33^{b}	5.22^{c}	7.33^{b}	6.96^{c}
Trifolium Steudenary 9712	13.00^{a}	10.06^{a}	10.92^{a}	11.32^{a}
Mean	10.93^{a}	8.09^{c}	9.30^{b}	9.44
SEM	0.61	0.52	0.52	0.36
P-Value	0.0025	0.0009	0.0232	0.0001

Plant height at Forage Harvesting

The mean plant height at harvesting for the tested Trifolium accessions indicated in Table 3. The result of combined analysis showed that plant height at harvesting (PHH) was significantly different (P < 0.001) among accessions and production years. Among the tested Trifolium accessions the highest PHH value was recorded for *T. Quantinum* 6301 and *T. Steudenary* 9720 and followed by *Trifolium Steudenary* 9712, while *T. Tembense* 7102 gave the lowest PHH value. The PHH was highest (P < 0.001) for the first and third year of production than second year of production. The difference in PHH among the accessions of Trifolium could be attributed to genetic variations among the accessions and their interactions to the environment. PHH performance also varies with production years due to variation in distribution and amount of rainfall. Tadesse *et al* (2013) reported that most species of Trifolium have their own niche when grow naturally. In agreement to the finding of this study, Getinet *et al* (2006) also reported that *T. tembense* usually grows very well on waterlogged areas while *T. rueppellianum* and *T. quartinianum* dominate drained pasture and arable land borders. Chatter, (1984) also reported that *T. tembense* prefers wet soils and seems unable to perform well on soils with good drainage. The overall mean (48.42 cm) for plant height at forage harvesting of the five Trifolium accessions in the present study was higher and lower than the overall mean value (32 cm) and (64.79 cm) reported by Tadesse *et al.* (2013) and Marijana *et al.*

(2013) for tested Trifolium accessions (T. *quartinianum, T. decorum, T. tembense, T. rueppellianum* and *T. Steudenary*) and red clover (*Trifolium pratense*) respectively.

Table 3 Mean plant height (cm) of five Trifolium accessions tested over years at Assosa

Accessions	Year			Combined Over Years
	2016	2017	2018	
Trifolium Steudenary 9720	69.11[a]	45.67[ab]	63.42[ab]	59.40[a]
Trifolium Decorum 9447	54.67[ab]	34.72[b]	37.50[c]	42.30[b]
Trifolium Quantinum 6301	63.11[a]	49.89[a]	85.02[a]	66.01[a]
Trifolium Tembense 7102	26.22[c]	20.33[c]	35.04[c]	27.20[c]
Trifolium Steudenary 9712	46.11[b]	38.72[ab]	56.67[bc]	47.17[b]
Mean	51.84[a]	37.87[b]	55.53[a]	48.42
SEM	4.45	3.04	6.25	2.92
P-Value	0.0012	0.0058	0.0112	0.0001

Leaf to stem ratio at forage harvesting

The leaf to stem ratio at forage harvesting of tested Trifolium accessions presented in Table 4. Leaf to stem ratio of tested Trifolium accessions showed non-significant ($P < 0.05$) variation in combined and each year analysis except in 2018. In 2018, high leaf to stem ratio value was recorded for Trifolium Decorum 9447 accession and followed by *Trifolium Steudenary* 9720 and *Trifolium Steudenary* 9712 accessions. In this study the highest leaf to stem ratio is obtained from high tillering accessions of Trifolium when compared to low tillering accessions and this might be due the function of the longer periods of physiological growth with increase defoliation frequency stimulating leaf growth at the expense of stem production. Moreover, leaf to stem ratio difference in during 2018 might be due to differences occurred due to variations among the tested genotypes. Leaf to stem ratio was varies ($p < 0.01$) with production years and this might be due to variation in distribution and amount of rainfall. The overall mean (0.35) for leaf to stem ratio of the five Trifolium accessions in the present study was lower than the overall mean value (0.87) reported by Marijana *et al.* (2013) for tested red clover (*Trifolium pratense*)

Table 4 Mean leaf to stem ratio of five Trifolium accessions tested over years at Assosa

Accessions	Year			Combined Over Years
	2016	2017	2018	
Trifolium Steudenary 9720	0.20	0.17	0.52[b]	0.30
Trifolium Decorum 9447	0.22	0.29	0.73[a]	0.41
Trifolium Quantinum 6301	0.30	0.34	0.43[b]	0.36
Trifolium Tembense 7102	0.30	0.33	0.45[b]	0.36
Trifolium Steudenary 9712	0.23	0.33	0.47[b]	0.34
Mean	0.25[b]	0.29[b]	0.52[a]	0.35
SEM	0.30	0.03	0.36	0.06
P-Value	0.1163	0.3997	0.0436	0.7069

Forage Dry Matter (DM) Yield

The forage dry matter yield of tested Trifolium accessions indicated in Table 5. Forage dry matter (DM) yield of Trifolium accessions showed significant ($P < 0.01$) variation in combined and each year analysis. However, *Trifolium Quantinum* 6301 accession gave the highest mean DM yield followed by *Trifolium Steudenary* 9712 and *Trifolium Steudenary* 9720. On the other hand, accession *Trifolium Tembense* 7102 gave the lowest DM yield. The variations in mean number of branch per plant and plant height might be the causes of difference in DM yield. Moreover, DM yield differences occurred due to variations among the tested genotypes. In contrast to the present study, Tadesse *et al* (2013) reported that *Trifolium tembense* produced better yield (4.0 t ha^{-1}) followed by *T. quartinianum* (2.8 t ha^{-1}) in the highland of Holota. The difference in forage DM yield among reports could be attributed to the stage of maturity at the time of harvesting, management and effect of agro-ecologies. The overall mean (3.62 t ha^{-1}) for forge DM yield of the five Trifolium accessions in the present study was higher than the overall mean value (2.5 t ha^{-1}) reported by Tadesse *et al.* (2013) for tested Trifolium accessions (T. *quartinianum, T. decorum, T. tembense, T. rueppellianum* and *T. Steudenary*).

Table 5 Forage dry matter yield (t ha^{-1}) of five Trifolium accessions tested over years at Assosa

Accessions	Year			Combined Over Years
	2016	2017	2018	
Trifolium Steudenary 9720	4.76^{a}	2.88^{cd}	3.94^{ab}	3.86^{b}
Trifolium Decorum 9447	4.08^{ab}	5.56^{a}	1.30^{bc}	3.64^{b}
Trifolium Quantinum 6301	4.69^{a}	5.36^{ab}	5.29^{a}	5.11^{a}
Trifolium Tembense 7102	2.15^{c}	1.91^{d}	0.41^{c}	1.49^{c}
Trifolium Steudenary 9712	3.58^{b}	3.85^{bc}	4.53^{ab}	3.99^{ab}
Mean	3.85	3.91	3.09	3.62
SEM	0.28	0.43	0.63	0.27
P-Value	0.0011	0.0024	0.0465	0.0001

Correlations of agro-morphological traits

The linear correlation coefficients between observed agro-morphological characters are shown in Table 6. The result of this study indicated that, all the agro-morphological traits were positively associated with forage DM yeild except number of tillers. The result of this study revealed that the number of tillering negatively associated with forage DM yield and this might be due to high tiller production not only indicates stable productivity (Mukhtar, 2006) but also is linked to better persistence after periods of unfavorable environmental conditions (Assuero and Tognetti, 2010).

Table 6 Correlation of the biomass related parameters

	DM Yield	Height at Harvesting	Leaf Height	Leaf to Stem Ratio	Number of Branch/Plant
Height at Harvest	0.6015				
Leaf Height	0.5966	0.7812			
Leaf to Stem Ratio	0.0670	0.1254	-0.2954		
No of Branch/Plant	0.3397	0.5684	0.4042	0.1941	
Number of Tiller	-0.3836	-0.3726	-0.3522	-0.0621	-0.5155

4. CONCLUSION

In conclusion, Trifolium accessions respond differently for agronomic performance to mid-altitude of Benishangul-gumuz environmental conditions. Measured agronomic traits such as number of tiller, number of branch per plant, plant height at harvesting and forage DM yield showed variations among the tested Trifolium accessions. The result revealed that *T. Quantinum* 6301, *T. Steudenary* 9712 and *T. Steudenary* 9720 accessions gave the highest number of tiller, number of branch per plant, plant height at harvesting and forage dry matter yield and we recommend these accessions for mid-altitude of Benishangul-gumuz and in similar agro-ecology and soil type.

Acknowledgement

The field research was fully financed by Ethiopian Institute of Agricultural Research (EIAR). The authors would like to thank Assosa Agricultural Research Center for facilitating the field research works.

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