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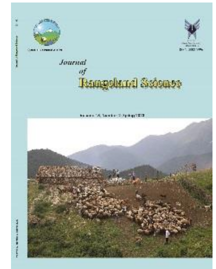

Research and Full Length Article:

Forage Yield and Quality of *Desmodium dichotomum* Accessions in Eastern Amhara, Ethiopia

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Abstract. *Bouffordia dichotoma* (Willd.) Ohashi *et al.* [syn. *Desmodium dichotomum* (Willd.) DC], family Fabaceae, is recognized by farmers (locally called *Chimero*) in Eastern Amhara Region, Ethiopia as a valuable livestock feed. This forage is growing as spontaneous intercrop with sorghum or maize crop. It is an herbaceous self-regenerating legume growing in a wild state. Short-listed accessions were undergoing for preliminary variety trial. In order to determine forage yield and quality of *Desmodium dichotomum*, a field experiment was carried out using Randomized Complete Block Design (RCBD) with three replications in year 2020. Plots were harvested to determine Dry Matter (DM) yield and leaf to stem weight ratio. Forage samples from each replicates were harvested and grounded using Wiley Mill, to pass through a 1 mm screen. The ground tissue was then analyzed for moisture, Crude Protein (CP), Crude Fiber (CF), crude fat, total ash and mineral concentrations. The highest mean DM yield was recorded for accession no. 37708 (10.78 ton/ha) followed by accession 37709 (7.7 ton/ha) while the lowest was 2.84 ton/ha (accession 2003). The highest CP concentration occurred in accessions no. 37708 and 37709 (23.9%), followed by accession no. 37702 (23.3%), while the lowest value of CP was recorded for accession no. 37715 (20.5%). A considerable concentration of mineral element was observed among the tested accessions. According to the results accession no. 37708, 37709 and 37705 can be considered as a good source of forage.

Key Words: Biomass, Chimero, Nutrient, Forage quality

Introduction

Despite the high livestock population and favorable environmental conditions for livestock production, the current livestock production and productivity is far below expectations in Ethiopia (Negassa *et al*., 2011). Among the constraints of livestock production in Ethiopia, poor nutrition is the major constraint limiting livestock performance (Belete *et al*., 2012). In Ethiopia, ruminant feeds are obtained mainly from native pastures; however, currently they are steadily shrinking because of land use change to dry land farming (Getnet *et al*., 2016) and crop residues characterized by low crude protein content but high cell wall and cell wall constituents (Seyoum *et al.*, 2007).

Concentrate feed supplementation is one strategy, which can increase digestibility, nutrient supply and intake (Preston and Leng, 1987). However, industrial by products are not yet effectively utilized for animal feed production due to low availability and high cost. Therefore, it has become imperative to improve the nutrition of livestock through improving the quality of available feed resources like native pastures and alongside this develop new forage crop varieties both from local and exotic introductions. Locally collected grass and legume species have shown high potential as cultivated forage crops as evidenced from nationally released forage varieties (NVRC, 2017).

Even though some efforts have been made in screening and evaluation of forage/grass local collections, the majority of the research activities and recommended forage species have been based on exotic species (Getnet, 2012). Hence, exploring of indigenous forage species which is already adapted to the local environment and covering large geographical area of the country is crucial to introduce in the existing farming system. From a recent survey, *Bouffordia dichotoma* (Willd.) Ohashi *et al.* (2018) [syn. *Desmodium dichotomum* (Willd.) DC], family Fabaceae, is recognized by farmers (locally called Chimero) in several districts of eastern Amhara (Ethiopia) as a valuable livestock feed (Hunegnaw, 2020). According to Hunegnaw (2020) this forage was growing as spontaneous intercrop with sorghum or maize crop. This plant is native in this region and growing in a wild state. It is an herbaceous self-regenerating legume. The DM yield and quality traits were studied under sorghum crop at natural wild state (Hunegnaw, 2020). However, there is no information on DM yield and quality traits of *Desmodium dichotomum* in its pure stand under experimental field conditions. Therefore, the proposal was initiated with the objective to determine the DM yield, major quality traits and mineral concentration of *Desmodium dichotomum* under experimental plots.

Material and Methods

Description of the study area

The experiment was conducted at the nursery site of Habru woreda agriculture office (Ethiopia) in 2020. The study site is located at 581.5 km away from Addis Ababa (capital city of Ethiopia) in the north east direction at an altitude of 1429 m above sea level and geographical coordinates of 11ºº34’ 00’’ N and 39 º43’ 20’’ E. The average annual rainfall of the study area was 945 mm and the mean maximum and minimum temperatures were 32 and 13^{o}C, respectively (HWoARD, 2010).

Plant Materials and Field Experimental

The eight accessions evaluated were selected from previous screening conducted at the same nursery site on the bases of their forage yield potentials (Hunegnaw and Tewodros, 2022). Short-listed accessions from previous screening experiment were undergone for preliminary variety trial. Field trial or experiment was carried using RCBD (Randomized Completely Block Design) with three replications. Plot size was 2×2m with 1m inter-plot and inter-block space. The seed of the *Desmodium dichotomum* accessions (37699, 37702, 37705, 37708, 37709, 37713, 37715 and 37721) were sown on well-prepared seedbed in rows spaced 20 cm apart using a seed rate of 2 kg/ha. Four interior rows were used for herbage production determination and four exterior rows for seed production and leaf to stem ratio determination. A basal application of NPS fertilizer was applied at a rate of 100 kg/ha. Plots were hand-weeded.

DM yield and yield components

Samples were collected to determine Dry yield, leaf proportion, stem proportion, leaf to stem ratio and plant height at 50% flowering stage. Plots were harvested and yields were determined using field weighing balance. Three interior rows were clipped at 5cm above the ground level to determine the DM yield and quality traits. From each replicates samples of 300 g were taken and dried in an oven at 65°C for 72 hours to a constant dry weight. The leaf and stem yield was determined by harvesting a central section of two adjacent middle rows. The harvested biomass separating in to leaf and stem and packed into paper bag followed by partitioning the harvested biomass in to leaf and stem fractions, and drying the fractions at 65°C for 72 hours for determination of partial DM yield (AOAC, 1990). Finally the recorded DM yield data on the plot was changed to yield per hectare. For plant height determination, mean height of 10 randomly selected plants were recorded for each plot. Susceptible to diseases were measured in 1 to 4 scale (1 = resistant, 2 = moderately resistant, 3 = moderately susceptible and 4 = susceptible)

Quality Traits Evaluation

The harvested forage samples from each replicates were grinded in a Wiley Mill, to pass through a 1 mm screen. This grinded tissue was analyzed for moisture, crude protein, crude fiber, crude fat, total ash, Calcium, Magnesium, Sodium, Potassium, Iron, Copper, Manganese, Zinc and Cobalt at Bless Agri Food Laboratory Service PLC, Addis Ababa (Ethiopia) and determined using the method of AOAC 999.10 (AOAC, 1990).

Statistical analysis

The collected data were analysis of variance (ANOVA) procedures of R- software (R core team version 3.6.1, 2019). Least significance difference (LSD) at 5% significance level was used for comparison of means.

Results and Discussion

DM yield and yield components

The results for dry matter (DM) yield, plant height and leaf to stem ratio of the eight

Desmodium dichotomum accessions are shown in Table 1. DM yield varied significantly (P<0.01) and ranged among accessions from 2.84 to 10.78 ton/ha. The highest mean DM yield was for accession no. 37708 (10.78 ton/ha) followed by accession no. 37709 (7.7 ton/ha).

Table 1. Means of Yield performances of *Desmodium dichotomum* accessions

Accessions	DM Yield (t/h)	plant height(cm)	leaf to stem ratio	50% flowering date
37699	7.21^{a}	76.1^{a}	1.267^{ab}	73^{a}
37702	7.45^{b}	73.2^{ab}	1.18^{b}	73^{a}
37705	5.52^{c}	68.9^{b}	1.24^{ab}	73^{a}
37708	10.78^{a}	71.0^{ab}	1.56^{a}	73^{a}
37709	7.70^{b}	69.7^{b}	1.17^{b}	73^{a}
37713	4.25^{d}	42.6_{c}	1.22_{b}	73_{a}
37715	3.16^{e}	33.6^{d}	0.95^{b}	98^{a}
37721	2.64^{e}	29.9^{d}	1.17^{b}	98^{a}
Mean	6.09	58.12	1.22	79.25
Standard error	0.17	1.37	0.07	1.28
P-level	**	**	**	NS

*significant at P=0.05; ** significant at P≤0.01; NS, not significant;
Means of columns followed by same superscript letters are not significantly different.

DM yield is one of the main determinant factors for forage quality (Kambashi *et al*., 2014). An important reason why different forage materials show great variations in this parameter is genetic diversity. The study showed that DM yields differed significantly between the accessions tested, which suggests that there are genetic differences between the accessions. The DM yield varied significantly (P<0.01) and ranged among accessions from 2.64 ton/ha (accessions no. 37721) to 10.78 ton/ha (accession no. 37708) and with average value of (6.09 ton/ha) (Table 1). According to Hunegnaw (2020), the average yield of *Desmodium dichotomum* assessed under sorghum crop was 4.4 ton/ha with a range of 4.1 to 4.8 ton/ha at 3–4-months of age. Our result is higher than Hunegnaw (2020) since the study was conducted under experimental plot unlike Hunegnaw (2020) which was sown naturally under sorghum crop. Other possible factors contributing might be variation in agronomic practices such as timely weeding, fertilizer and land preparation.

The finding is similar with the report of Mengistu *et al.*, (2017) who indicated silverleaf Desmodium (*Desmodium uncinatum*) generally gives 4–7 DM yield tons/ha. However, the finding of this study is higher than the result of Cook (2005) who reported that the DM yield of *Desmodium uncinatum* ranged from 3 to 7 ton/ha. The result is also higher than the findings of Ndikumana and Leeuw (1996) who found DM yield of *Desmodium intortum* in Nyankpala (Ghana) was 0.45 tons/ha. In addition, the result is higher than the findings of Ndikumana and Leeuw (1996) who reported that the DM yields of *Desmodium intortum* in Pokoase (Ghana) was 2.12 tons/ha. Moreover, the study is higher than the findings of Asmare *et al.*, (2018) who revealed that the DM yield of *Desmodium intortum* planted under sorghum in push pull technology in Artuma Fursi district of Ethiopia (2.43 ton/ha). On the other hand, the result is lower than the report of Younge *et al.,* (1964) who indicated that the DM yield of *Desmodium intortum* was ranged from 8.97 to 11.2 tons/ha.

Plant height varied significantly (P<0.001) between accessions, being longest for accession no. 37699 (76.1 cm) followed by accession no. 37708 (71 cm), while the shortest accession was accession no. 37721 (29.9 cm) with mean value of 58.12 cm (Table 1). The plant height in self-sown (naturally grown) under sorghum condition (64.21cm) was higher than the height under an experimental field condition (Hunegnaw, 2020).

Higher leaf to stem ratio were recorded for accessions no. 37721 (1.56), no. 37699 (1.27) and no. 37705 (1.24) with a mean value of 1.22. The value was higher than the report of Adjolohoun *et al.,* (2008) who indicated the leaf:stem ratio for herbaceous legumes was 0.87–1.10 and for browse legumes was 0.35–0.49. High leaf to stem ratio implies their superiority over other accessions in terms of nutritive quality, given that leaf is generally of higher nutritive value than stem (Islam *et al.*, 2003).

Quality Traits

The Crude protein (CP), crude fat, crude fiber (CF) and total ash of the *Desmodium dichotomum* accessions are presented in Table 2. The mean yields of CP (21.96%), CF (22.01%), crude fat (2.3%) and total ash (11.85%) varied significantly (P<0.01) among the tested accessions ranging from 20.5-23.9%, 21-22.8%, 2.01-2.62% and 10.7-13%, respectively. The CP, crude fat and CF are usually used as important indicators of the nutritive value of forages (Lauriault and Kirksey, 2004). Similarly, nutrient composition is one of the main determinant factors to indicate for the feeding value of forage crops (Kambashi *et al*., 2014).

Table 2. Quality traits of *Desmodium dichotomum* accessions

Accessions	Crude protein (%)	Crude fiber (%)	Crude Fat (%)	Total ash (%)
37699	21.3[c]	22.8[d]	2.01[c]	10.7[f]
37702	23.3[b]	21.1[ab]	2.35[b]	11.1[ab]
37705	20.7[d]	22.4[d]	2.48 [bc]	11.6[bc]
37708	23.9[a]	21.6[c]	2.39 [bc]	12.3[de]
37709	23.9[a]	21.0[a]	2.62[a]	12.9[ef]
37713	21.2[c]	21.1[bc]	2.04[c]	11.8[cd]
37715	20.5[d]	23.5[e]	2.47 [bc]	11.4[bc]
37721	20.9[ab]	22.6[d]	2.07[c]	13.0[a]
Mean	21.96	22.01	2.30	11.85
Standard error	0.05	0.1	0.1	0.12
P-level	**	**	**	**

** significant at P≤0.01;
Columns with same superscript letters are not significantly different

The mean CP value was 21.96% with the highest CP concentration of 23.9% occurred in accessions no. 37708 and no. 37709, followed by accession no. 37702 (23.3%), while the lowest was recorded for accession no. 37715 (20.5%). Our findings were similar to findings of Hunegnaw (2020) who reported the CP content of *D. dichotomum* self-grown under sorghum was 22%. The CP value was higher than the content of *Stylosanthes scabr*a (12.24%) as reported by Musco *et al.,* (2016). All the accessions had CP values of above 15%, a level suggests for a protein source supplements to be considered optimal to support lactation and growth in dairy cattle (Nsahlai *et al*., 1996). The result showed that *Desmodium dichotomum* produces more protein per hectare; therefore, it could be widely used as a supplement for ruminant animals.

The mean value of total ash concentration of the accessions was 11.85% ranging from 10.7% to 13%. The total ash value was higher than the content of *Cajanus cajan* (5.86%). The mean crude fat value of *Desmodium dichotomum* was 2.3% and higher than the content of *Stylosanthes hamata* (1.88%) as reported by Musco *et al.,* (2016).

The mean value of CF (22.01%) of the study was lower than the content of *Desmodium uncinatum* (32%) according to the report of Heuzé *et al.,* (2015). The value is also lower than the CF of *Desmodium intortum* (30.6%) as reported by Heuzé *et al*., (2017).

Mineral concentration

The mineral concentrations of *Desmodium dichotomum* accessions are presented in Table 3. The mean values of each mineral concentration of the accessions for Ca, Mg, Na, K, Fe, Cu, Mn, Zn and Co were 12.97 g/kg, 3.83 g/kg, 0.53 g/kg, 24.68 g/kg, 0.68 g/kg, 0.017 g/kg, 0.517 g/kg, 0.18 g/kg and 0.013 g/kg, respectively.

Table 3. Mineral concentrations of *Desmodium dichotomum* accessions

Accessions	Ca g/kg	Mg g/kg	K g/kg	Na g/kg	Fe g/kg	Cu g/kg	Mn g/kg	Zn g/kg	Co g/kg
37699	13.57^{b}	3.90^{d}	25.15^{c}	0.045^{d}	0.57^{d}	0.0013^{c}	0.0493^{ab}	0.017^{bc}	0.0007^{b}
37702	12.19^{d}	3.98^{cd}	24.64^{c}	0.11^{a}	0.65^{c}	0.0015^{ab}	0.0488^{ab}	0.019^{bcd}	0.0009^{b}
37705	14.41^{a}	4.11^{de}	23.90^{c}	0.031e	0.45^{e}	0.0021^{b}	0.0493^{ab}	0.017^{bc}	0.0006^{b}
37708	14.57^{a}	4.31^{a}	26.70^{b}	0.056^{c}	0.66^{c}	0.0012^{c}	0.0518^{bc}	0.016^{b}	0.0009^{b}
37709	13.57^{b}	4.03^{cd}	29.92^{a}	0.063^{b}	0.72^{b}	0.0031^{a}	0.0602^{a}	0.022^{a}	0.0011^{b}
37713	11.60^{e}	3.61^{d}	27.51^{b}	0.018^{f}	0.88^{a}	0.0023^{a}	0.057^{cd}	0.021^{cd}	0.0012^{b}
37715	11.24^{f}	3.23^{e}	19.56^{d}	0.062^{de}	0.85^{a}	0.0013^{c}	0.0429^{d}	0.012^{d}	0.0026^{a}
37721	12.66^{c}	3.50^{d}	20.12^{d}	0.036^{e}	0.65^{c}	0.0012^{c}	0.0541^{bcd}	0.017^{bc}	0.0022^{a}
Mean	12.97	3.83	24.68	0.053	0.68	0.0017	0.0517	0.018	0.0013
SE	0.0646	0.0431	0.0314	0.0012	0.0107	0.0002	0.0014	0.0008	0.0001
P-level	**	**	**	**	**	**	**	**	*

Note: SE, standard error; *significant at P=0.05; ** significant at P≤0.01.
Columns with same superscript letters are not significantly different.

The macro minerals are important structural components of bone and other tissues and serve as important constituents of body fluids. The trace minerals are present in body tissues in very low concentrations and often serve as components of metallo enzymes and enzyme cofactors or as components of hormones of the endocrine system (Engle *et al*., 2001). Livestock normally obtain most of their minerals from feeds and forages (Neville 2010). Leguminous species are generally much richer in macro-elements whether temperate or tropical region.

The mean concentration Ca (12.97g/kg) of *Desmodium dichotomum* of this study is similar with the report of Minson (1990) who reported mean Ca concentrations of 14.2 and 10.1 g kg^{-1} in temperate and tropical legumes, respectively. However, the value is higher than Ca concentrations of *Desmodium intortum* (8.9 g/kg) and *Desmodium unicinatum* (8.5 g/kg) as reported by Heuzé *et al.,* (2017) and Heuzé *et al.,* (2015), respectively. On the other hand, the value is higher than *Desmodium dichotomum* (6 g/kg) which was self-grown under sorghum crop (Hunegnaw, 2020).The mean concentration of K (24.68 g/kg) of the accessions in this study is higher than K concentration of *Colocynthis citrullus* which was 13.86 g/kg at flowering stage in Sudan (Ezzat *et al*., 2018). The study was higher than the report of Minson (1990) who indicated that many tropical legumes are exceedingly low in Na, with half containing less than 4 g/ kg. However, the value was higher than K concentrations of *Desmodium intortum* (9.4 g/kg) and *Desmodium unicinatum* (17.3 g/kg) as reported by Heuzé *et al.,* (2017 and Heuzé *et al.,* (2015), respectively. On the other hand, the value was higher than *Desmodium dichotomum* (14.7 g/kg) which was self-grown under sorghum crop (Hunegnaw, 2020).

The mean concentration of Na (0.053 g/kg) of this study was lower than Na concentration of *Colocynthis citrullus* which was 2.12 g/kg at flowering stage in Sudan (Ezzat *et al*., 2018). However, the value was higher than Na concentrations of *Desmodium unicinatum* (0.4 g/kg) as reported by Heuzé *et al.,* (2015). The concentration Mg (3.83 g/kg) in this study is lower than the Mg concentration of *Colocynthis citrullus* according to the report of Ezzat *et al.,* (2018) who indicated its concentration 4.34 g/kg. However, the value is higher than Mg concentrations of *Desmodium intortum* (2.2 g/kg) and *Desmodium unicinatum* (2.5 g/kg) as reported by Heuzé *et al.,* (2017) and Heuzé *et al.,* (2015), respectively. The concentration of Fe (0.68 g/kg) of this study is lower than the Fe concentration of *Desmodium intortum* (2.64 g/kg) as reported by Etana *et al.,* (2011). The concentration Cu (0.017 g/kg) of the study is lower than the Cu concentration of *Desmodium intortum* (0.179 g/kg) as reported by Etana *et al.,* (2011).

The concentration of Mn (0.0517 g/kg) of the study was lower than the Mn concentration of *Desmodium intortum* (0.0914 g/kg) as reported by Etana *et al.,* (2011). However, the value is in line with reported of Hunegnaw (2020) who indicated that the Mn content of *Desmodium dichotomum* for self-grown under sorghum crop was 0.0449 g/kg.The mean concentration of Zn (0.018 g/kg) of the study is lower than the Zn concentration of *Desmodium intortum* (0.25 g/kg) as reported by Etana *et al.,* (2011). The mean concentration of Co in the study area was 0.0013 g/kg. The concentration of Co in the forage plant is much lower than the Co concentration of *Desmodium intortum* (1.207 g/kg) as reported by Etana *et al.,* (2011) and the legume forage crop, *C. cajan* (0.36 g/kg) (Adjolohoun *et al*., 2008).

Conclusion

Based on this study eight *Desmodium dichotomum* accessions were evaluated. Accession no. 37708 was the best accession among all tested accessions in terms of forage quality and measured indices. According to the results the selected accessions are suitable for feeding the livestock in eastern Amhara and areas with similar climate. Despite the promising biomass yield and nutritional quality in accessions no. 37708 and 37709 at this preliminary variety trial, further trial at different locations and agro ecological study will also help to select and confirm the more promising accessions. Finally, evaluation, e.g. feeding trials should be conducted to test palatability, acceptability and performance of different ruminant livestock species.

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