Research Article

Open Access Journal of
Biomedical Science
ISSN: 2690-487X

Evaluation of Biomass Yield and Quality Parameters of Sesban (*Sesbania sesban* L.) Varieties in Irrigated Lowland of Dassench District of South Omo, South-Western, Ethiopia

Denbela Hidosa*

Livestock Research Directorate, Jinka Agricultural Research Center, Ethiopia

ABSTRACT

This study was conducted to quantify biomass yield and quality parameters of five *Sesbania sesban* varieties in irrigated lowland of Dassench district. The Sermemiret Kebele from Dassench district was selected for on-farm trial. The five *Sesbania sesban* varieties such as DZ-2002, DZ-0040, DZ-0079, DZ-0073 and DZ-32 were evaluated in a randomized complete block design with three replications per variety. The biomass yield, plant height, branches per plant and quality parameters were analyzed by using GLM procedure of SAS and Least Significant Difference (LSD) was used for mean separation. Result from present study showed that higher biomass yield (17.66ton/ha) was obtained from DZ-32 variety, while the lower biomass yield (8.95ton/ha) recorded from DZ-0073 variety. However, DZ-0079 variety had higher ($p<0.05$) crude protein (268.10g/kg, DM), while DZ-32 variety had lower crude protein (186.70g/kg, DM). Based result from this study, it was concluded that DZ-32 variety was best candidate to improve biomass supply for enhanced production from livestock.

KEYWORDS: Biomass yield; Crude protein; Dassench; Fiber and Irrigation

INTRODUCTION

In Ethiopia, the livestock production has been contributing substantially to the livelihoods of the rural households, but the overall productivity from the sector is very low due to poor livestock feed supply in quantity and quality [1,2]. Similarly, in the study area livestock husbandry system is extensively based on natural-pasture, which is greatly influenced by biomass supply and nutritional dynamics of pasture-forages [3-7]. The animal fed on poor-quality diets could not realize the dietary nutrient requirement. This is making livestock take too long to attain optimum production and reproduction performances [1,5,8-10]. Thus, the identifying the adaptability potential of improved fodder species and demonstrating newly adaptable fodder species to the pastoral and agro-pastoral production niches is only the strategies to beat the existing feed shortage problem [4,5,11]. Among the improved fodder species, *Sesbania sesban* is a legume fodder species, which grown up to 8m above cutting height and supplied high-quality protein for livestock [12]. The *Sesbania* species have grown best in amount of rainfall per annum which ranged from 500-2000mm with ambient temperature which averaged from 17 °C-20 °C in loose sandy to heavy clay soils [13,14]. The biomass yield of *Sesbania* species was reported up to 20ton/ha under more favorable agro-ecologies, while the world reported average forage biomass yields are ranging from four to twelve tons from a hectare per year [15]. Sesban foliage (stems + leaves) had crude protein content above 22% and with moderate-to-low cell wall content [16]. The dry matter degradability (DMD %) of *Sesbania* species was reported up to 75%, while in live goats DMD measured from the 66-71% [17]. Moreover, it reported that cattle, sheep and goats fed to diets contained different inclusion levels of *Sesbania* leaves showed better nutrient metabolism as compared to control animals

Quick Response Code:

Address for correspondence: Denbela Hidosa, Livestock Research Directorate, Jinka Agricultural Research Center, Ethiopia

Received: December 22, 2021 **Published:** January 07, 2022

How to cite this article: Denbela H. Evaluation of Biomass Yield and Quality Parameters of Sesban (*Sesbania sesban* L.) Varieties in Irrigated Lowland of Dassench District of South Omo, South-Western, Ethiopia. 2022- 4(1) OAJBS.ID.000374. **DOI:** 10.38125/OAJBS.000374

[18-21]. In addition, reports of Wambui et al. [22] and Sampathi et al. [23] were affirmed that goats fed on leaves of *Sesbania* retained more nitrogen than goat not fed on leaves of *Sesbania*. Nevertheless, with this notable potential, different *Sesbania* varieties have not evaluated in study district under irrigated condition for biomass yield and quality parameters. Thus, present study was conducted to evaluate the biomass yield and quality parameters of *Sesbania* varieties.

MATERIALS AND METHODS

Experimental site: This study was conducted from July-December 2019 main cropping season in agro-pastoral area of the Dassench district in South Omo Zone South-western Ethiopia. The study site has laid at 5014'N latitude, 36044'E longitude and 200km from Jinka town (capital city of South Omo Zone). The area has annual temperature which a range from 25-40 °C and average rainfall varies from 350-600mm in bimodal type with erratic rainfall distribution (Figure 1). The altitude of the study area is in the range of 350-900 meters above sea level with silty alluvial soil type. The study district has comprised 1, 014, 403 cattle, 753, 568 sheep, 1, 013971 goats, 23, 412 Poultry and 17, 228 donkeys [1]; (Table 1).

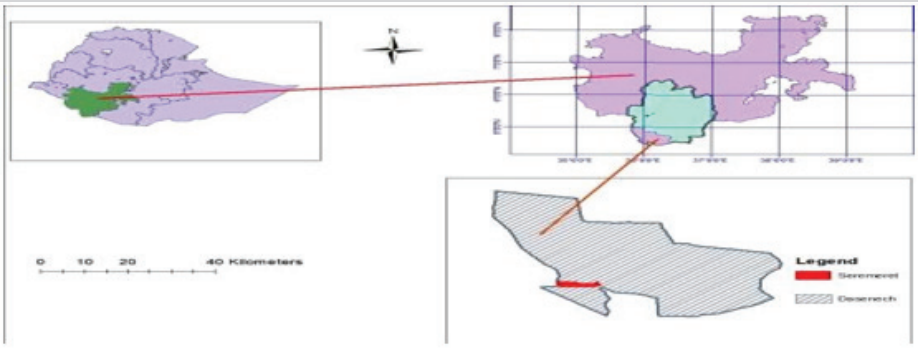

Figure 1: Map of study area.

Table 1: Soil physio-chemical chemical composition of study area, in 2019.

Soil Chemical Parameters						
PH	Nitrogen (%)	Phosphorus (mg kg^{-1})	Potassium (mg kg^{-1})	Sulfur (mg/kg^{-1})	Boron (mg kg^{-1})	OC (%)
6.03	0.08	58.9	58.9	2.41	0.16	0.9
Soil Physical Parameters						
Sand (%)	Silt (%)	Clay (%)				
44	28	28				

Keynote: OC: Organic Carbon

Agro-Pastoral Research Extension Group (APREG) Formation

The Sermemiret Kebele from the Dassench district was selected for on-farm investigation. One APREG that included about 25 agro-pastoralists (80% males and 20% females) was established with assistance of district livesock office experts based on availability and accessibility of irrigation schemes, interest and irrigation experiences of agro-pastoralists.

Experimental Treatment and Design

The five *Sesban* varieties such as DZ-2002, DZ-0040, DZ-0079, DZ-0073 and DZ-32 were collected from Debre Zeit Agricultural Research Center and transported to the experimental site. A plot area of 4x3 (12m^2) containing 4 rows which each row 1m apart and plant spaced 1m within row. The spaces between plots were 1m and the total area of experiment was 12x26m (312m^2). The experimental design used in this study was randomized completed block design comprising three replications per variety and plots in each block were randomly assigned to each variety. The furrow-irrigation was used, and all the plots were irrigated uniformly as per the intended irrigation schedule.

Site Management and Data Collection

The experimental plots were kept nearly weed-free by hand hoeing, and the data like plant height and branches per plant were measured at age of 50 percent heading (16 weeks after planting) by taking eight plants from middle of two rows per plot. The cutting height above the ground was measured from ground to the tip of the main stem of plant. The leaf biomass yields at 16 weeks, all leaf and shoots were weighed from the three harvested middle row per plot immediately in the field by using spring weight balance and five-hundred-gram composite leaves samples per plot was air dried under shade and secured for the further biomass yield and quality parameter analysis. Then the 300g of samples from the air-dried sample was taken and allotted into oven dried which set at 105 °C Temperature for 24 hours according to procedures of James et al. [24]

Biomass Yield (ton/ha) = TFW X (DWss/HA X FWss) X 10

Where TFW = total fresh weight kg/plot, DWss= dry weight of sub-sample in grams, FWss = fresh weight of sub-sample in grams, HA = Harvest plot area in square meters and 10 is a constant for conversion of yields in kg/m to t/ha. The branches per plant for each variety were calculated by counting all main branches on sampled trees and average of sampled branches were considered.

Evaluation of Quality Parameters

For the evaluation of quality parameters, samples per variety

in three replicates were allowed to oven which set at 65 °C for 48hrs, and then ground to pass through 1mm sieve screen [25]. The crude protein (CP) and ash contents were analyzed according to the procedures of AOAC [25]. The Neutral Detergent Fiber (NDF) contents were calculated using the procedure of Van Soest et al. [26], whereas the Acid Detergent Fiber (ADF) value was analyzed using the procedures described by Van Soest & Rebert [26].

Statistical Analysis

The cutting height above the ground, number of branches per plant, forage biomass yield and quality parameters were subjected to analysis of variances (ANOVA) using the Generalized Linear Model (GLM) procedure of SAS [27]. The significant differences among the means of varieties were declared at p<0.05 and mean was separated using LSD test with following model: Yijk = μ + Si + eijk, where; yijk = all dependent variables; μ = overall mean; Si = the effect of variety; and eijk = random error.

RESULTS AND DISCUSSION

Agronomic Parameters and Biomass Yield

The agronomic parameters (cutting height above ground and branches per plant) and biomass yield of *Sesbania* varieties under irrigated lowland of Dassench district are illustrated in Table 2. The higher (p<0.05) biomass yield obtained from DZ-32 variety than DZ-2002, DZ-0040 and DZ-0073 varieties, but biomass yield of DZ-32 variety was comparable (p>0.05) to DZ-0079 variety. However, the biomass yield was not significantly (p>0.05) varied among DZ-2002, DZ-0040, DZ-0073 and DZ-0079 varieties. The plant height of tested *Sesbania sesban* varieties had not significantly (p>0.05) varied each other, but the DZ-0079 variety had taller plant height, while plant height for DZ-2002 variety was shorter. Likewise, the tested *Sesbania sesban* varieties shares similarly trend as plant height for the branches per plant, but more (p>0.05) branches per plant were recorded from the DZ-0079 variety, while fewer branch per plant was for DZ-32 variety. The result on leaf to stem ratio revealed that higher (p<0.05) leaf to stem ratio was observed for DZ-2002 variety than DZ-0073, but DZ-0073 variety had comparable leaf to stem ratio to DZ-0040, DZ-0073 and DZ-0079 varieties. The higher biomass yield for DZ-32 *Sesbania* variety from this study is due to higher varietal potential of variety. Similar to result from the present study, Megerssa & Feyisa [28] and Negasu et al. [12] were reported that different forage biomass production among the forage crops is due to variation in in genetic potential of forage crops. Likewise, also the report of Kebede et al. [29] discovered that the biomass yield variability among the forage species is due to varietal or biological potential of forage species. The variability in biomass yield is due to biological or genetic effects have been widely described for legumes species in general [30].

Table 2: Leaf biomass yield, plant height, branches per plant (BPP) and leaf to stem ratio (LTSR) of *Sesbania* varieties grown in irrigated lowland of Dassench district in 2019 planting year.

Variety	Biomass Yield (ton/ha)	Plant Height(m)	BPP	LTSR
DZ-2002	9.46[b]	2.99	54.33	1.27[a]
DZ-0040	9.34[b]	3.49	63.33	1.13[ab]
DZ-0079	11.86[ab]	3.48	64.67	1.07[ab]
DZ-0073	8.95[b]	2.89	56.67	0.98[b]
DZ-32	17.66[a]	3.18	43.33	1.06[ab]
SEM	3.43	0.99	20.23	0.14
LSD	6.19	1.81	36.807	0.26

Keynote: Means with the similar letters in across column for biomass yields, plant height, BPP and LTSR at 50% flowering age are not significant at p>0.05; SEM: Standard Error of Mean; LSD: Least Significant Difference.

The biomass yield obtained from this study for *Sesbania* varieties were higher than reported biomass yield values which ranged from 4.64-7.91ton/ha by Wubshet et al. [31] for five *Sesbania* varieties from highland of Eastern Harerge of Ethiopia and (20ton/ha) reported from the Kenya [32]. However, the biomass yield from this study was lower than reported values of (18.91ton/ha) and (27.64ton/ha) for DZ-89 and DZ96 varieties, respectively by Negasu & Gizahun [12], but the biomass yield was comparable to biomass yield of DZ-80, DZ-104 and DZ-123 *Sesbania* varieties by same authors from Kelem Wollega, Ethiopia.

The cutting plant height above ground and braches per plant are a good description to identify the growth and adaptation performances of crops [31,33]. Similar plant height growth potential was reported from highland of Eastern Harerge, by Wubshet et al. [31] for five *Sesbania* varieties. The plant height attained from this study is in agreement to previously reported values which ranged from 2.9- 3.3m by Asmelash et al. [33], but it was lower than value attained at 10 months of harvest (4m) reported by Megerssa & Feyisa [28] and (3.65-3.87m) by Wubshet et al. [31], 3.75-4.88m by Negasu & Gizahun [12] at 24 months.

The higher braches per plant from this study than value of (26) reported by Asmelash et al. [33] from South Omo for *Sesbania* variety, but braches per plant from this study was comparable to values of (40-52) reported by Denbela et al. [7] for six pigeon pea varieties that adapted the South Omo under rain fed condition.

Leaf to stem ratio is an important factor that influences forage quality, diet selection, intake and nutrient degradability [34,35]. The significant difference observed among the *Sesbania sesban* varieties for leaf to stem ratio from this study is also related to genetic variation among the varieties. The result on leaf to stem ratio from this study is higher than leaf to stem ratio values ranged from 0.23-0.313 reported by Wubshet et al. [31] from Highland of Eastern Harerge for five *Sesbania sesban* varieties, but lower than reported values of (0.98-1.27) by Denbela et al. [7] for six pigeon pea varieties which grown in rain fed condition from Ethiopia.

Quality Parameters

The quality parameters of *Sesbania* varieties grown in irrigated lowland of Dassench district are presented in Table 3. The Sesban DZ-0040 had higher (p<0.05) ash concentration than DZ-2002, DZ-

0079 and DZ-32 varieties, but its ash concentration was similar (p>0.05) to DZ-0073 variety. The DZ-0079 variety had higher (p<0.05) crude protein concentration than DZ-32, but the CP concentration was similar (p>0.05) to DZ-0073 variety. Regarding to fibers fractions, the DZ-0040 variety had higher (p<0.05) NDF concentration than DZ-0073 variety, but NDF concentration was similar (p>0.05) among the rest varieties. However, DZ-0073 variety had lower (p<0.05) ADF concentration than DZ-0079 and DZ-32 varieties, but ADF concentration was similar to DZ-2002 and DZ-0040 varieties.

Table 3: The quality parameters of *Sesbania* varieties grown in irrigated lowland of Dassench district in 2019 planting year.

Variety	DM%	Ash (g/kg, DM)	CP (g/kg, DM)	NDF (g/kg, DM)	ADF (g/kg, DM)
DZ-2002	90	79.3[b]	204.9[c]	535.03[ab]	402.49[ab]
DZ-0040	89.67	116.9[a]	240.6[b]	557.23[a]	404.51[ab]
DZ- 0079	89.67	88.2[b]	268.1[a]	487.87[ab]	415.75[a]
DZ-0073	89.33	101.1[ab]	260.2[a]	438.87[b]	309.89[b]
DZ-32	91.33	88.5[b]	186.7[d]	520[ab]	412.56[a]
SEM	1.43	14.9	0.79	5.52	5.29
LSD	2.61	27.1	14.54	100.41	96.38

Keynote: Means with similar letters (a, b, c, d) in across column for quality parameters are not significantly differed at p>0.05 at 50% flowering stage; DM%: Dry Matter Percent; CP: Crude Protein; NDF: Neutral Detergent Fiber; ADF: Acid Detergent Fiber; SEM: Standard Error of Mean; LSD: Least Significant Difference.

The higher crude protein concentration for the DZ-0079 variety is likely to be fast hereditary-potential to accumulate the high nitrogen contents from the soil. Similarly, the investigation was reported by Cheema et al. [36] which revealed that variation in crude protein concentration for fodder species was related to genotypic variation in accumulation of protein in the leaves during growth periods. The result on crude protein concentration obtained from present finding for all *Sesbania* varieties was higher than reported value of (154g/kg, DM) by Asmelash et al. [33], but crude protein concentration from this study was comparable to reported values of (228g/kg, DM) and (236.5g/kg, DM) by Debela et al. [37] and Uday et al. [10], respectively for DZ-0040 variety. In the study district, the crude protein from the rangeland especially from the sward's is cannot provide adequate protein level to meet the requirement of the ruminant animal [38].

Therefore, the result from this study indicated that all *Sesbania* varieties had crude protein content above the minimum critical level of crude protein (80g/kg, DM) which required for normal function of rumen microorganisms [39,40]. This is suggested that there is possibility of using all varieties as protein supplements to low-quality diet in the agro-pastoral and pastoral areas by planting superior variety (candidate). The result on fiber fractions (NDF and ADF) from present study were higher than values stated by different scholars. Accordingly, values of NDF (238g/kg, DM) and ADF (202g/kg, DM) by Debela et al. [37], NDF (189g/kg, DM) and ADF (153.5g/kg, DM) by Asmelash et al. [33] and (368-373g/kg, DM) and (146.4-171.7g/ kg, DM) for NDF and ADF, respectively for six *Sesbania* varieties [31]. The higher fibers contents from this study than previously reported values might be due to varietal differences and environmental factors. The soluble carbohydrate contents in neutral detergent do not depend only on species, but also on their responses to the environmental factors [40,41].

CONCLUSION

The DZ-32 variety gave higher biomass yield, while DZ-0073 variety gave lower biomass yield. The DZ-0079 variety had higher crude protein, while DZ-32 had lower crude protein concentration. Based result from this study, it was concluded that DZ-32 variety as superior candidate to adapt in tested agro-ecologies than other varieties for supply of higher dry matter yield.

ACKNOWLEDGEMENT

The author extremely thankful the Regional Pastoral Livelihood Resilience Project (RPLRP) Coordination Office at Hawassa for fully fund for this research activity. The author was also grateful to acknowledge Dassench district Livestock and Fisheries Development Office, Kebele Developmental Agents and Agro-pastoralists for fully participation in this study and made result from this study to be fruitful.

CONFLICT OF INTERESTS

Author declared that there no conflict of interests for this article and I revised and approved this manuscript for publication.

REFERENCES

1. Central Statistical Agency (CSA) (2018) Agricultural sample survey, Report on livestock and livestock characteristics (Private peasant holdings). In: Volume II, Statistical Bulletin, Addis Ababa, Ethiopia, pp. 100.
2. Tahir MB, Wossen AM, Mersso BT (2018) Evaluation of livestock feed balance under mixed crop-livestock production system in the central highlands of Ethiopia. Agriculture & Food Security 7(8): 19-25.
3. Terefe E, Dessie T, Haile A, Mulatu W, Mwai O (2015) On-farm phenotypic characterization of Mursi cattle in its production environment in South Omo Zone, Southwest Ethiopia. Anim Genet Resource 57(3): 15-24.
4. Denbela H, Yidinachachew T, Ayele F (2017) Assessment on feed resource, feed production constraints and opportunities in salamago woreda in South Omo Zone, in South-Western Ethiopia. Academic Journal of Nutrition 6(3): 34-42.
5. Hidosa D, Tesfaye Y (2018) Assessment study on livestock feed resource, feed availability and production constraints in Malle woreda in South Omo Zone. J Fisheries Livest Prod 6(2): 269.
6. Demerew G, Sandip B, Mestawet T (2019) Husbandry and breeding practices of Malle Cattle reared in Malle District South Omo Zone of Southwest Ethiopia. J Anim Vet Adv 18(12): 323-338.
7. Denbela H, Shanachew H, Joseph O (2020) Goat feed inventory and feed balance in Hamer and Bena-Tsemay woreda of South Omo Zone, Southwestern Ethiopia. Acta Scientific Veterinary Sciences 2(6): 28-43.
8. Shapiro BI, Gebru G, Desta S, Negassa A, Nigussie K, et al. (2015) Ethiopia livestock master plan. In: International Livestock Research Institute (ILRI), ILRI Project Report, Nairobi, Kenya.

9. Gelayenew B, Nurfeta A, Assefa G, Asebe G (2016) Assessment of livestock feed resources in the farming systems of mixed and shifting cultivation, Gambella Regional State, Southwestern Ethiopia. Global Journal of Science Frontier Research (D) 16(5).

10. Uday K, Narasimha M, Chandrapal S, Mahadevappa D, Gouri YB, et al. (2017) Biomass yield and chemical composition of *Sesbania grandiflora* and *Moringa oleifera*. International Journal of Science, Environment and Technology 6(6): 3264-3269.

11. Denbela H, Sintayehu K, Berako B (2020) Evaluation of Pigeon pea (*Cajanus cajan*) for dry matter yield and chemical composition on station of Jinka Agricultural Research Center, South Omo, South-Western Ethiopia. American-Eurasian J Agric & Environ Sci 20(3): 129-136.

12. Negasu G, Gizahu W (2019) Adaptation study of improved fodder tree (*Sesbania Sesban* (L.) Merril) at Haro Sabu, Kelem Wollega, Oromia, Ethiopia. International Journal of Research - Granthaalayah 7(8): 212-219.

13. Food and Agricultural Organization (FAO) (2010) Grassland Index. A searchable catalogue of grass and forage legumes. Rome, Italy.

14. Cook B, Brown B, Donnelly SD, Eagles JL, Franco DA, et al. (2005) Tropical forages: An interactive selection tool. CSIRO, DPI&F (Qld), CIAT and ILRI, Brisbane, Australia.

15. Heering JH, Gutteridge RC (1992) *Sesbania sesban* (L.) Merrill. Record from Proseabase. In: Mannetje L, Jones RM (Eds.), PROSEA (Plant Resources of South-East Asia) Foundation, Bogor, Indonesia.

16. Kaitho RJ, Umunna NN, Nsahlai IV, Tamminga S, Bruchem J (1998) Effect of feeding graded levels of *Leucaena leucocephala*, *Leucaena pallida*, *Sesbania sesban* and *Chamaecytisus palmensis* supplements to teff straw given to Ethiopian highland sheep. Anim Feed Sci Technology 72(3-4): 355-366.

17. Gutteridge RC, Shelton HM (1991) Evaluation of *Sesbania sesban* - A new forage shrub species for tropical and subtropical Australia. Final Technical Report, Meat Research Corporation, Canberra, Australia, pp. 12.

18. Tessema Z, Baars RMT (2004) Chemical composition, *in vitro* dry matter digestibility and ruminal degradation of Napier grass (*Pennisetum purpureum* (L.) Schumach.) Mixed with different levels of *Sesbania sesban* (L.) Merr. Anim Feed Sci Technol 117(1-2): 29-41.

19. Melaku S, Peters KJ, Tegegne A (2004) Feed intake, live weight gain and reproductive performance of Menz ewes supplemented with *Lablab purpureus*, graded levels of *Leucaena pallida* and *Sesbania sesban*. Livest Prod Sci 87(2-3): 131-142.

20. Manaye T, Tolera A, Zewdu T (2009) Feed intake, digestibility and body weight gain of sheep fed Napier grass mixed with different levels of *Sesbania sesban*. Livest Sci 122 (1): 24-29.

21. Mekoya A, Oosting SJ, Fernandez-Rivera S, Tamminga S, Tegegne A, et al. (2009) Effect of supplementation of *Sesbania sesban* on post-weaning growth performance and sexual development of Menz sheep (Ethiopia). Livest Sci 121(1): 108-116.

22. Wambui CC, Abdulrazak SA, Noordin Q (2006) The effect of supplementing urea treated maize stover with Tithonia, *Calliandra* and *Sesbania* to growing goats. Livest Res Rural Dev 18(5): 64-72.

23. Sampathi L, Reddy KJ, Naidu MM (1999) Nutritional evaluation of *Sesbania sesban* hay in the ration of sheep. Indian J Anim Nutr 16(1): 53-55.

24. James KM, Daniel NM, Louis VV, James BK (2008) Combining Napier grass with leguminous shrubs in contour hedgerows controls soil erosion without competing with crops. Agroforestry Systems 74(8): 37-49.

25. Association of Official Analytical Chemists (1990) Official methods of analysis (15th edn). Association of Official Analytical Chemists Arlington, USA.

26. Van Soest PJ, Robertson JB, Lewis BA (1991) Methods of dietary fiber, neutral detergent fiber, and non-starch polysaccharides in relation to animal nutrition. J Dairy Sci 74(10): 3583-3592.

27. Statistical Analysis System (2002) SAS/STAT guide for personal computers. SAS Institute Inc. (9th edn), Cary, NC, USA.

28. Megerssa E, Feyisa G (2016) *Sesbania sesban*, a fodder species potential to rehabilitate wetland vegetation in Lake Ziway, Ethiopia. International Journal of Fisheries and Aquatic Studies 4(3): 298-301.

29. Kebede G, Getnet A, Fekede F, Alemayehu M, Muluneh M, et al. (2017) Determination of appropriate seeding rate for oats/vetch mixtures grown under different drainage conditions of vertisols in the central highlands of Ethiopia. Journal of Agricultural and Crop Research 5(5): 85-95.

30. Elfeel AA, Elmagboul AH (2016) Effect of planting density on *Leucaena leucocephala* forage and Woody stems production under arid dry climate. International Journal of Environmental & Agriculture Research 2(3): 7-10.

31. Wubshet T, Tolera F, Worku B, Melese F (2021) Performance evaluation of improved forage trees (*Sesbania sesban*) cultivars for animal feed and nutritional quality in highlands of East Hararghe Zone, Oromia, Ethiopia. Food Science and Quality Management 106: 7-11.

32. Wambugu C, Franzel S, Cordero J, Stewart J (2006) Fodder shrubs for dairy farmers in East Africa: making extension decisions and putting them into practice. World Agroforestry Centre and Oxford Forestry Institute, Nairobi, Kenya.

33. Asmelash T, Alemayehu H, Getahun Y, Shimelis T (2020) Evaluation of multi-functional fodder tree and shrub species in mid-altitudes of South Omo Zone, Southern Ethiopia. Journal of Horticulture and Forestry 12(1): 27-34.

34. Forbes TDA, Coleman SW (1993) Forage intake and ingestive behavior of cattle grazing old world bluestems. Agron J 85(6): 808-816.

35. Smart AJ, Schacht W, Moser LE (2001) Predicting leaf/stem ratio and nutritive value in grazed and nongrazed big bluestem. Agronomy & Horticulture -Faculty Publications Vol. 36.

36. Cheema UB, Sultan JI, Javaid A, Akhtar P, Shahid M (2011) Chemical composition, mineral profile and in situ digestion kinetics of fodder leaves of four native trees. Pakistan Journal of Botany 43(1): 397-404.

37. Debela E, Tolera A, Eik LO, Salte R (2011) Nutritive value of morphological fractions of *Sesbania sesban* and *Desmodium intortum*. Tropical Subtropical Agro ecosystems 14(3): 793-805.

38. NRC (National Research Council) (2001) Nutrient requirements of dairy cattle. (7th rev edn), National Academy Sciences, Washington DC, USA.

39. Jamala GY, Tarimbuka IL, Moris D, Mahai S (2013) The scope and potentials of fodder trees and shrubs in agroforestry. Journal of Agriculture and Veterinary Science 5(4): 11-17.

40. Van Soest PJ (1994) Nutritional Ecology of the Ruminant. In: Comstock Publishing Associates, Cornell University Press, Ithaca, USA.

41. Eco crop (2010) Ecocrop database. Food and Agricultural Organization, Italy.