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Supplemental Irrigation and the Herbage Yield of Sesbania Tree Legume Lines (Sesbania scopoli)

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ABSTRACT

In order to help livestock farmers choose the most promising species to raise for fodder, this research compared three different lines of native perennial Sesbania tree legumes grown with and without additional irrigation. Three Sesbania tree legume lines—S. sesban DZF-405, S. dummeri DZF-336, and S. sesban DZF-403—were used in a Randomized Complete Block Design with three replications. There was no statistically significant difference (P>0.05) between the three Sesbania tree legume lines with respect to the agronomic performances measured by vigor, height, diameter, lateral branches less than 50cm and 100cm, survival, dry matter percent, dry matter leaf-to-stem ratio, and dry matter yield in tons per hectare. In terms of dry matter yield (Mean±SEM) in tons per hectare, the two S. sesban lines of DZF-405 and DZF-403 statistically outperformed S. dummeri DZF-336 (3.29±1.07). Compared to the second harvest (3.3±0.39 and 6.59±0.78) and third harvest (4.44±0.39 and 7.82±0.78), the first and second harvests, respectively, had a significantly higher number of lateral branches smaller than 50 and 100 cm, with a p-value of less than 0.001. Nevertheless, at the first harvest, the diameter was noticeably small at 2.88±0.24 (P<0.001). There was a significant increase (P<0.001) in the dry matter yield (8.7±1.07) and the dry matter leaf-to-stem ratio (1.32±0.06) during the second harvest period. Under Wondogenet circumstances, the two S. sesban fodder lines produce quantitatively superior dry matter. The types are more prolific when watered with more water, and they may produce harvests at least three times a year. Use it to feed fresh fodder or leaf hay with ease using the cut-and-carry method. For animal feed resources, this smallholder farmer is recommended to employ the S. sesban lines of DZF-405 and DZF-403 while supplementing irrigation.

Keywords: Fodder, *Sesbania scopoli*, Irrigation, Legumes, Livestock, Performance, Sesbania, and Yield.

INTRODUCTION:

Ethiopians rely heavily on agriculture for both their subsistence and economic progress. East African nations are facing challenges with livestock production due to feed shortages and the effects of climate change. Their economies are heavily reliant on agricultural production systems that are vulnerable to these changes. When it comes to nutrition and food security, East African areas, like Ethiopia, are particularly at risk. There are a number of problems confronting the cattle business, such as rising feed costs and environmental protection concerns. Sesbania fodder was used more and more in Ethiopia to replace grass or low-quality forage with protein (Tessema & Baars, 2004).

The most important feed resources in Ethiopia, according to the CSA report from 2021, are green feed or grazing (54.54 percent) and crop residue (31.13%). Additionally, around 7.35% of the feeds came from hay, while 2.03% came from by-products. Additional feed types accounted for around 4.37%. Nevertheless, the contributions of enhanced feed resources were significantly insufficient, constituting just around 0.57 percent of the country's overall feed supplies. This highlights the need for more research into the assessment of enhanced grown fodder crops that are both environmentally friendly and productive. Using enhanced fodder for cattle feed also offers the added benefit of improving the country's livestock output in a climate-smart way and lowering greenhouse gas emissions (FAO, 2016). The development and consumption of enhanced fodder crops must be prioritized in order to increase productivity and quality. Adaptation, yield, quality, resistance/tolerance to biotic and abiotic stressors, and the introduction or collection of promising germplasm are all part of this process (Aklilu & Asheber, 2019; Hossain et al., 2019). Simple management approaches allow perennials like Sesbania to be quickly established, thrive in hardy regions, and keep producing. Their many desirable traits make them promising species for use in agricultural production systems and as multifunctional plants (Gutteridge and Shelton, 1993). Soil conservation measures and animal feed sources are both made possible by the multi-use tree species Sesbania sesban, which grows in the Ethiopian highlands. Fifty species are found in the genus Sesbania. Gillett (1963) said that the greatest variety of sesbania species was located in Africa. Although Heering et al. (1996) do not know where S. sesban originated, the plant is cultivated and spread extensively across tropical Asia and Africa. The author also mentioned that S. sesban has a lot of promise as a multi-use tree; ruminants consume its leaves and young twinges, which are rich in protein, and people can make use of the tree's large branches and stem for things like building materials and firewood. According to Heering and Gutteridge (1992) and Degefu et al. (2011), it not only helps to enhance soil fertility but also reduces erosion. The same holds true for

In mixed crop-livestock production systems (Nigussie, 2012) in the country's medium to high altitude zones, screening of multi-purpose tree species, such as Sesbania species, showed increased fodder yield production potentials (Mengistu et al., 2002).

Moreover, it has been noted by Orwa et al. (2009) and Sabra et al. (2010) that Sesbania sesban (L.) Merr's high fodder nitrogen content makes it a valuable supplement to ruminant diets lacking in protein or a replacement for commercial protein supplements (Mekoya et al., 2009a). Orwa et al. (2009) found that the foliage often has a crude protein content of more than 25% and an in vitro dry-matter digestibility of more than 75%. Dried S. sesban leaf has a nitrogen digestibility of 96.7% and a nylon-bag dry-matter of 90.7%. Along with these benefits, the species has the ability to be a high-quality feed source because to its high phosphorus levels and low crude fiber content. According to Zerihun and Getachew (2013), S. sesban has a long-term impact on family food security, nutrition, and income. Under the Wondogenet environment, there is a lack of data on the performance of sesbania tree lineages. This study's overarching goal is to identify the most promising perennial sesbania species for use as a farmed fodder resource for animals by assessing how well they do under supplementary irrigation.

MATERIALS AND METHODS:

Description of the study area

The experiment was undertaken collaborately in Won- dogenet Agricultural Research center and Bangladesh researcher. The center is located at 07°19.1' North lati- tude, 38°30’ East longitude of 268 km to the South of Addis Ababa, capital city. The altitude of the area is 1780 meter above sea level. The area receives mean annual rain fall of 1128 mm with minimum and maxi- mum temperature of 11 and 26°c, respectively (Teka- legn *et. al.,* 2017). The texture of the top soil (0-25cm) was sandy clay loam with pH 8.84 (1:2.5 soil water suspensions) and total nitrogen of 0.18.

Treatments and design

The experiment was conducted in Randomized Com- plete Block Design of three indigenous perennial Ses- bania tree legume lines with three replications. The three treatment lines employed for the study were *S. sesban* DZF-405, *S. dummeri* DZF-336 and *S. sesban* DZF-403. Before establishment, seeds were treated with acid-scarified by soaking in concentrated sulfuric acid for 30 minutes. In order to maintained uniform plant population, seedlings were established in plastic tubes filled with fertile soil. Two seeds were sown per tube and then thinned to one plant. During the first month of establishment, sprinkler water was provided twice every day in the morning and afternoon till the required filled capacity was reached. Then water was applied only once every evening for the second month. A total of nine experimental plots each with $16m^2$ (4mx4m) areas were prepared for fodder establish- ment. Seedlings were then transplanted into dug plan- ting holes of 30cm wide and 30cm deep spaced 0.5m intra-row and 1.5m inter-row. The plot contained three rows, each consisting of 9 plants (27 plants per plot). The treatment groups were assigned randomly and independently to each experimental block. Manage- ment practices of hand-weeding, pest and disease mon- itoring or control were done uniformly.

Data collection

The collected data were stand vigor, plant height, late- ral branches less than 50cm and 100cm, diameter, sur- vival per plot, herbage yield, dry matter contents and leaf-to-stem ratio. Plant height, lateral branches less than 50cm and 100cm, and diameter were taken from average of three representative plants per plot from the middle of the rows. Plant height was measured using a graduated steel tape from the ground to the tip of plant. After one season of establishment, the fodder legumes were harvested at a fixed cutting height (0.75 m) that was established as appropriate for Sesbania (Mengistu *et al.,* 2002; Orwa *et al.,* 2009). Similarly lateral bran- ches less than 50cm and 100cm height from the ground level were also counted accordingly. The stand vigor was taken by observational scores of zero to ten (100% vigor).

Estimation of Biomass and Dry Matter Yield

Biomass yield of the various perennial Sesbania tree legume fodder lines were harvested at proper stage. Weight of the total fresh biomass yield was measured using spring balance from each plot in the field. Sampled leaf and stem were separated and weighed to determined leaf-to-stem ratio. Subsamples of each 200g of leaf and stem were taken by sensitive balance and sent to the laboratory. Upon arrival at laboratory it was oven dried for 72 hours at temperature of 65°c. The oven dried samples were weighed to determine the total dry matter yield. Then the result was converted in to dry matter ton per hectare for comparison (Aklilu & Alemayehu, 2007; Ali *et al*., 2022).

Survival or reaction to diseases and pests

To determine the survival of the species and reaction to disease and pest tolerance, damaged or died plants were taken by counting the total number of Sesbania trees survived per plot.

Data Analysis

The collected data were analyzed using General Linear Model procedure of Statistical Analysis System (SAS, 2002- version 9.0). Least significant difference (LSD) test was employed for variables whose F-values de- clared a significant difference ($P<0.05$). The statistical model for data analysis was -

$$\mathbf{Y_{ijk} = \mu + t_i + b_j + e_{ijk},}$$

Where,

Y_{ijk} is the response variable under examination

μ is the overall mean

t_i is the treatment effect of sesbania tree legume fodders

b_j is the block effect/ random effect of experimental plots (j =3; 1, 2, 3) and

e_{ijk} is the random error associated with the observation ij.

RESULTS AND DISCUSSION:

Performance of the three perennial Sesbania tree legume lines

The agronomic performances of vigor, height, lateral branches less than 50cm and 100cm, diameter, sur- vival, dry matter ratio, dry matter leaf-to-stem ratio and dry matter yield in ton per hectare were not vary statistically ($P>0.05$) between three perennial Sesbania tree legume lines (**Table 1**). However, the two *S. sesban* lines (DZF-405 and DZF-403) were numeri- cally yield higher dry matter in ton per hectare of

6.23±1.1 and 6.24±1.1, respectively than *S. dummeri* (3.26±1.1 ton ha^{-1}). The dry matter yield in ton per hectare of this study was found in line with the report of Orwa *et al.* (2009), who reported yield ranged from 4 to 12 ton ha^{-1} dry matter per year, depending on location. However Ngasa & Gizahu, (2019) was found a higher average dry matter yield in tone per hectare of five *S. sesban (L.) Merril* species (17.27) than the pre- sent study (5.25±1.1). Even though *S. dumerri* yield lower dry matter, it has better leafy branches than the other two *S. sesban* species (Uddin *et al*., 2023).

Table 1: Performance of three perennial Sesbania lines (Mean±SEM).

Sesbania lines	Vigor (%)	Height (m)	LB<50cm	LB<100cm	Diameter	Survival/Plot	DMR	DMLSR	DMYTPH
S. sesban DZF-405	74.4±0.5	2.8±0.4	4.8±0.6	9.6±0.8	4.2±0.2	23.0±1.3	35.9±1.9	1.03±0.1	6.23±1.1
S. dummeri DZF-336	73.3±0.5	2.9±0.4	6.1±0.6	11.5±0.8	3.8±0.2	20.8±1.3	38.0±1.9	1.17±0.1	3.29±1.1
S. sesban DZF-403	74.4±0.5	2.8±0.4	5.0±0.6	9.8±0.8	3.6±0.2	24.8±1.3	35.5±1.9	1.0±0.1	6.24±1.1
Over all Mean	74.07±0.5	2.8±0.4	5.3±0.6	10.4±0.8	3.9±0.2	22.9±1.3	36.5±1.9	1.07±0.1	5.25±1.1
CV%	19.4	45.6	33.3	22	16.8	16.1	15.4	17	56.9
Sig	ns	ns	Ns	ns	ns	ns	ns	ns	ns

Sig= Significant level, ns= Non-significant, CV= Coefficient of Variation, S=Sesbania, SEM= Standard Error of Mean, m= Meter, LB=Lateral Branch, DMR= Dry Matter Ratio, DMLSR= Dry Matter Leaf-to-Stem Ratio, DMYTPH= Dry Matter Yield in Ton Per Hectare.

The dry matter leaf-to-stem ratio were comparable to the result reported by Denbela, (2022) who found 1.13, 1.07, and 1.06 for *Sesbania sesban L*. species of DZ- 0040, DZ-0079 and DZ-32, respectively under supple- mental irrigation condition. However the author repor- ted a higher dry matter leaf-to-stem ratio of 1.27 for DZ-2002 perennial Sesbania species than the present study 1.17±0.1. Concurrently Wubshet *et al.* (2021) reported higher dry matter leaf- to-stem ratio values (0.23-0.313) of five *S. sesban* varieties at Highland of Eastern Harerghe. The variation in dry matter yield in ton per hectare as well as its leaf-to-stem ratio might be associated with the genetic materials of perennial Sesbania species, soil types and environmental condi- tions. Likewise, the performance variation contributed due to biological or genetic effects (Megersa & Feyisa, 2016; Elfeel & Elmagboul, 2016; Kebede *et al.,* 2017; Negasu & Gizahu*,* 2019; Sharmin *et al*., 2021).

Performance of three Sesbania tree legumes lines during different harvest periods

Harvesting cycle performance of perennial Sesbania tree legume lines were indicated in **Table 2**.

The result revealed that higher dry matter yield in ton per hectare (P<0.001) were found during the second harvest (8.7±1.1) than the first (2.19±1.1) and third (4.88±1.1) harvests. Consecutively the dry matter leaf- to-stem ratio were also obtained higher (P<0.001) during the second harvest (1.32±0.1) than the first (0.95±0.1) and third (0.93±0.1) harvests. This might be associated with growing habit of the trees which in- creased productivity at the second harvest and then tend to declined. Regarding to the lateral branches rec- orded at less than 50cm and 100cm, were higher (P< 0.001) during the first harvest (8.2±0.6 and 16.7±0.8) than second (3.3±0.4 and 6.6±0.8) and third (4.4±0.4 and 7.8±0.8) harvests, respectively. This shows that the three sesbania tree legume lines were developed more branches at early stage of maturity than the late stages. But, the diameter was found lower (P<0.001) at the first harvest period (2.9±0.2) than second (4.1±0.2) and third (4.7±0.2) periods. The higher diameter obtained at older age might be due to maturity of the tree legumes.

Table 2: Performance of three Sesbania lines during three harvesting periods (±SEM).

Harvest	Vigor (%)	Height (m)	LB<50cm	LB<100cm	Diameter	Survival/Plot	DMR	DMLSR	DMYTPH
1st	80.0±0.5a	2.3±0.4	8.2±0.6a	16.7±0.8a	2.9±0.2b	26.8±1.3a	38.4±1.9	0.95±0.1b	2.19±1.1b
2nd	83.3±0.5a	2.9±0.4	3.3±0.4b	6.6±0.8b	4.1±0.2a	27.2±1.3a	37.6±1.9	1.32±0.1a	8.7±1.1a
3rd	58.9±0.5b	3.2±0.4	4.4±0.4b	7.8±0.8b	4.7±0.2a	14.6±1.3b	33.6±1.9	0.93±0.1b	4.88±1.1b
Mean	74.1±0.5	2.82±0.4	5.3±0.4	10.4±0.8	3.9±0.4	22.9±1.3	36.5±1.9	1.07±0.1	5.25±1.1
CV%	19.4	45.6	31.6	22	16.8	16.1	15.4	17	56.9
Sig	**	Ns	***	***	***	***	ns	***	***

[ab]Means bearing different superscripts along the column differ significantly, Sig= Significant level, **. ***=Significant at 0.01 and 0.001 level, ns= Non-significant, CV= Coefficient of Variation, SEM= Standard Error of Mean, LB=Lateral Branch, DMR= Dry Matter Ratio, DMLSR= Dry Matter Leaf-to-Stem Ratio, DMYTPH= Dry Matter Yield in Ton Per Hectare.

Average dry matter content of three Sesbania tree legume lines

The average dry matter percent of perennial sesbania species tree legume lines across harvesting periods were indicated in **Fig. 1**. Even though, the result reve- aled that no variations (P>0.05) in dry matter percent values among the lines, the two lines of *Sesbania ses-ban* DZF-405 and DZF-403 were numerically reco- rded higher dry matter contents of 37.3% and 38.4% during the second harvest periods, respectively. How- ever, *Sesbania dummeri* DZF-336 line was found better dry matter percent (43.6%) during the first har- vest period (Shahen *et al.*, 2019).

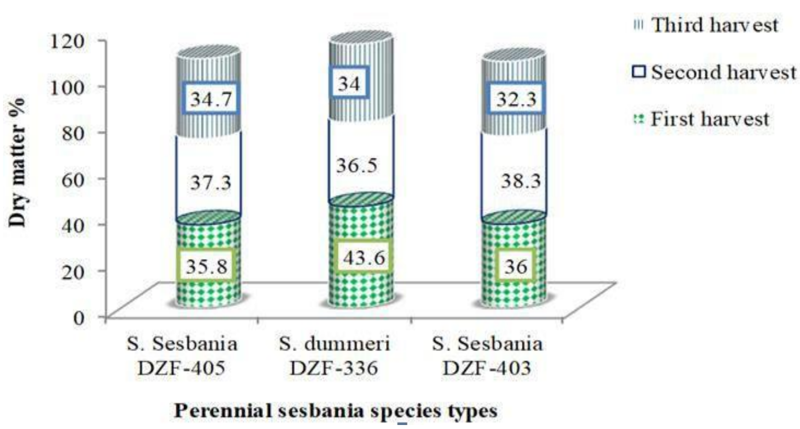

Fig. 1: Average dry matter percent of three Sesbania lines

Average dry matter yield of three Sesbania line over harvesting periods

The average dry matter yield in ton per hectare of the three Sesbania tree legume lines across various harves- ting periods were found highest during the second harvest period (**Fig. 2**). During this harvest period 9.95, 5.41 and 10.72 ton per hectare of dry matter yield were obtained by *Sesbania sesban* DZF-405, *Sesbania dummeri* DZF-336 and *Sesbania sesban* DZF-403, respectively.

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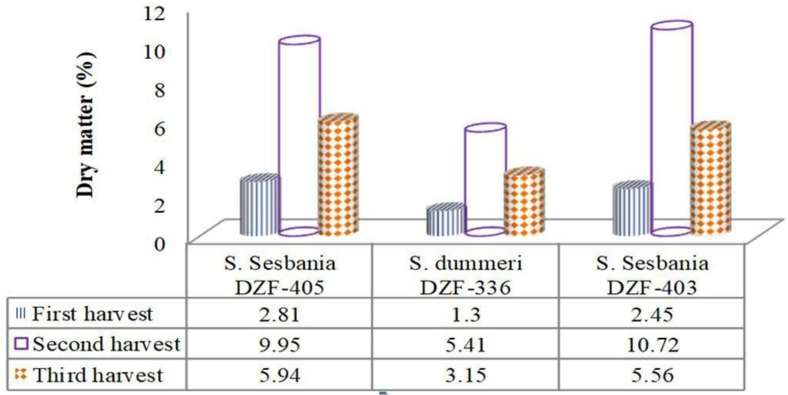

Fig. 2: Average dry matter yield in ton per hectare of three Sesbania lines.

In contrast, *S. dummeri* DZF-336 was produced the lowest amount of dry matter yields in ton ha^{-1} across all harvesting cycles than both *S. sesban* DZF-405 and DZF-403 tree legume lines. The result revealed that all of the Sesbania tree legume lines dry matter yields were increased during the second harvest period and then tends to decline at the third harvest. This situation might be related with the growth nature of the tree legumes as well as environmental condition of the area.

Average leaf-to-stem ratio of Sesbania tree legume lines

The average dry matter base leaf-to-stem ratio of the perennial Sesbania tree legume lines were showed in **Fig. 3**. During the second harvest period *Sesbania sesban* DZF-405, *Sesbania dummeri* DZF-336 and *Sesbania sesban* DZF-403 lines were recorded the highest leaf-to-stem ratios of 1.43, 1.41 and 1.13, respectively.

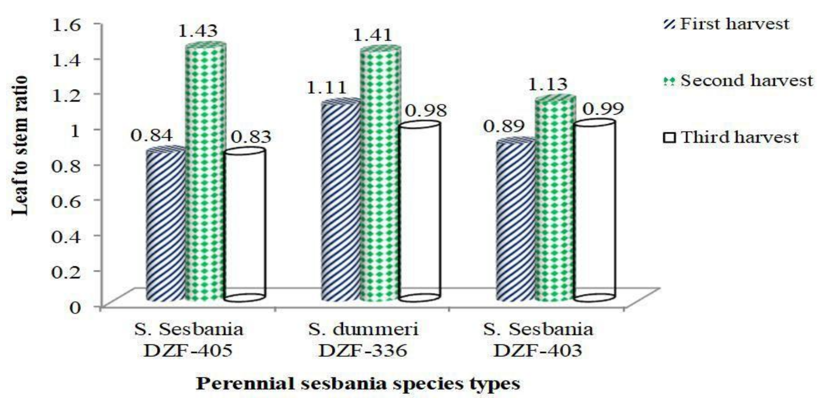

Fig. 3: Average dry matter leaf-to-stem ration of three Sesbania tree lines.

However the first and third harvest leaf-to-stem ratios of each perennial Sesbania tree legumes fodder were found comparable. Relatively, the leaf parts of the fod- der are more palatable and nutritious than the stem ones. So the higher the leaf-to-stem ratio beats the bet- ter advantage of fodder productivity and quality. The result showed that the two *Sesbania sesban* (DZF-405 and DZF-403) fodder tree legume lines were better in fodder productivity and qualities at second harvest.

CONCLUSION:

A lack of both high-quality and sufficient feed is one of the biggest problems in livestock production. The agronomic performances, dry matter contents, dry matter leaf-to-stem ratios, and dry matter yield in ton per hectare of the three perennial Sesbania fodder tree legume lines were not found to vary statistically. S. sesban DZF-405 and S. sesban DZF-403 had the best dry matter yield in tons per hectare, nevertheless. However, when comparing the dry matter leaf-to-stem ratio of the three species of Sesbania, Sesbania dummeri DZF-336 produces the best results. The second harvest season of the fodder legumes also yielded a greater dry matter yield per hectare and a leaf-to-stem ratio of dry matter that was statistically significant. With the help of additional irrigation, many types may provide more than one harvest—at least three times a year. Fresh fodder or leaf hay are two ways to use it in a cut-and-carry feeding method. Consequently, in Wondogenet conditions, small holder farmers are ideally advised to employ S. sesban DZF-403 tree legume fodders and S. sesban DZF-405 as supplementary irrigation.

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