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Research Article

Determination of Optimum Level of Seeding Rate of Silver Leaf Desmodim Intercropping with Desho Grass for Dry Matter Yield and Yield-Related Components in Western Ethiopia

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Compatible production of forage grasses and legumes through intercropping is one of the best options to achieve higher biomass yield and forage quality for animal production in areas where land and other resources are scarce. This study was conducted in 2017 and 2018 with the aim of evaluating the best-match level of seeding rate of silverleaf desmodium (SLD) intercropped with desho grass (*Pennisetum pedicellatum*) in a randomized complete block design with three replications. The treatment consists of three levels of seeding rate of SLD (2, 4, and 6 kg ha^{-1}) and one pure plot of each species. The result of this study showed that the intercropping of 6 kg ha^{-1} SLD with 100% of desho's recommended plant population (50,000 plants ha^{-1}) produced the highest forage dry matter yield and maximum plant height. The total dry matter yield (TDMY) of the intercrops was also significantly varied for the tested treatments. Accordingly, 6 kg ha^{-1} of SLD intercropped with 100% recommended seed rate of desho ha^{-1} gave the highest forage TDMY, which surpasses both the grass and legume yields in monoculture. The total land equivalent ratio (LER), which shows system productivity, was also different among the treatments. About 6 kg ha^{-1} of SLD intercropped with 100% recommended seed rate of desho also produced the highest LER (1.51). Thus, in Bako and similar agro-climatic conditions, where arable land is heavily covered with food crops, desho grass intercropping with SLD can be used as one of the best strategic options for producing feeds of energy and protein sources simultaneously on the same area of land.

1. Introduction

In the tropics, livestock production is an important economic activity that produces both food and nonfood commodities [1]. The Ethiopian livestock subsector contributes 10% of the total export earnings, mainly through the export of ruminants [2]. The livestock sector is crucial to the Ethiopian economy and vital to the smallholder farming system. Currently, the productivity per animal is very low, and therefore, the contribution of the livestock sector to the overall economy is much lower than expected [3]. The ever-increasing human population has exceeded land-carrying capacity, causing environmental degradation and threatening the long-term sustainability of crop-livestock production systems. In an attempt to meet the increasing food demands of the larger human population, farmers are making more land available for the production of food crops, and grazing areas have declined as a result [4]. This shift from rangeland to crop production has multiple implications for the temporal and spatial availability and quality of forage resources.

Intensifying feed production through integrated feed production options is one of the possible strategic avenues that could be used to moderate this challenging scenario. The establishment and expansion of grass–legume mixed pastures are advantageous compared to pure stands [5]. The production of forage grasses and legumes in a compatible manner by intercropping is considered the best option for harvesting a nutritionally balanced ration for livestock feed [6]. One of the most important reasons for growing two or more plants together is to increase productivity per unit area, which is measured by the land equivalent ratio (LER), defined as the amount of land required for monocultures to achieve the same dry matter yield as their mixed crops [7]. When pure grass without legumes is grown, it generally

TABLE 1: Agro-meteorological weather data of the study site, Bako, Ethiopia, in 2017 and 2018.

	Year 2017			Year 2018		
Months	Rain fall (mm)	Min temp. (°C)	Max. temp. (°C)	Rain fall (mm)	Min temp. (°C)	Max. temp. (°C)
January	0.00	8.8	32.2	0.00	13	30.1
February	57.80	9.5	31.5	12.90	14.1	34.2
March	33.00	9.7	33.2	44.70	14	33.9
April	155.80	10	33.4	31.40	14.4	33.4
May	146.50	14.2	28.6	207.90	14.5	30.4
June	270.00	14.3	27.8	263.80	14.5	26.6
July	240.70	14.4	26.9	237.90	13.6	26.3
August	291.30	14.2	24.7	150.40	14.7	26.3
September	230.20	14.8	25.1	63.40	14	28
October	86.40	14.7	26.5	69.50	14.2	28.8
November	86.30	14.3	27.4	58.50	13.5	29.2
December	0.00	14.5	30.8	21.30	13.1	30.4

suffers yield loss due to a lack of nitrogen. Moreover, intercropping is the practice of growing two or more crops in close proximity to encourage interaction between them. A combination of grasses and legumes is generally far preferable to a pure grass mixture without legumes. Benefits include high forage yield with better quality, an increase in land use, suppression of weeds, improvement in soil fertility, and lower production costs [8].

Integration of grasses and legumes production through intercropping is an appropriate way to solve soil erosion and land degradation problems, because the fibrous roots of grasses can increase soil permeability and water-holding capacity [9]. Biomass production of grass–legume mixture has more excellent stability than monoculture [10] because it exhibits more even seasonal growth distribution than grass monoculture. A grass–legume mix is more adaptable to changing climatic conditions than monoculture because the deep roots of the legumes can compensate for slower grass growth during the dry season. Earlier research indicated that a mixture of grass/legume pasture consistently increased the forage yield and its quality compared to the unfertilized sole grass pasture [11]. Feed availability and seasonal distribution of grass–legume mixtures are better than sole stands. Moreover, grass–legume intercropping can reduce risk in the cropping system because each plant species may respond differently to soil, pest, and weather conditions [12]. Even in less productive agriculture, grass–legume intercropping can contribute significantly to more sustainable agriculture [13].

Desho grass is an indigenous grass of Ethiopia belonging to the family of Poaceae [14]. Morphologically, it is closer to the genus Brachiaria, with which it shares the acidic wetter areas of southern Ethiopia. Moreover, the grass has the potential to control water loss effectively and recovers rapidly after watering, even under severe drought conditions. The grass was first used in the Southern Nations Nationalities and Peoples' Regional state of Ethiopia and is now widely used in other regions of the country for soil conservation practices and animal fodder [15]. Heliso et al. [16] also confirmed that desho grass is an indigenous and perennial forage plant with different names in different countries of Africa. Desho grass is annual kyasuwa grass in Nigeria and Barrein in Mauritius. The same authors also reported that it was first identified in the country's Southern region at Chencha in 1991 and was utilized for soil conservation and animal feed. On the other hand, Heuzé et al. [17] described silverleaf desmodium (SLD) as a robust perennial herb or subshrub with trailing, nontwining stems to several meters long, radiating from a stout rootstock and ascending to about 1 m at flowering. SLD can be sown as the legume component in permanent mixed pastures for grazing. It can be made into hay or incorporated into silage to improve the protein content. Furthermore, Tesfaye et al. [18] concluded that intercropping of desho grass with other herbaceous forage legumes like vetch spps can help to overcome livestock feed shortage both in quantity and quality.

Though some research activities were undertaken on desho and SLD separately for different purposes in the study area, no piece of information was generated on the two as a mixture for livestock feed production so far. Thus, the study was aimed at evaluating the effect of different levels of seeding rates of SLD intercropping with desho on forage dry matter yield and yield-related components.

2. Materials and Methods

2.1. Description of the Study Area. The experiment was conducted during the main rainy season (June–November) in 2017 and 2018 at Bako Agricultural Research Center (BARC), (Bako, Ethiopia) (9°06′N, 37°09′E 1,650 m above mean sea level). The study area is categorized under the Woina dega (midland) agro-climatic zone with a warm humid climate [19]. The soil type is sandy clay with 2.5% organic carbon, 10 ppm accessible P, 0.22% total N, and a pH of 5.18 [20]. Table 1 presents agro-meteorological data of the study period (2017 and 2018).

2.2. Experimental Materials, Design, and Treatments. This experiment used locally adapted cultivars of desho grass and SLD as test crops. The experimental design used to conduct the study was a three-replicate randomized complete block design with treatments being sole desho, sole

Table 2: Treatment arrangement of the experiment desho grass and silverleaf desmodium (SLD) at Bako, Ethiopia in 2017 and 2018.

Treatment	Description	Desho (%)	SLD (kg ha^{-1})
T1	Sole desho	100	0
T2	Sole SLD	0	6
T3	Desho + SLD2	100	2
T4	Desho + SLD4	100	4
T5	Desho + SLD6	100	6

SLD was sown at 6 kg ha^{-1}, and desho intercropped with 2 (desho + SLD2), 4 (desho + SLD4), and 6 (desho + SLD6) kg seed ha^{-1}, respectively. The SLD was planted between rows of desho, while pure stands of grass and legumes were planted based on their respective seed rates/plant density. The root splits of desho were planted 0.5 m between rows and 0.4 m between plants which is 1 plant /0.2 m^{-2} that results in 50,000 plant population of desho ha^{-1}. SLD was sown in rows at the center of each two rows of desho. The experimental plot size was $3 \times 4\ m = 12\ m^{-2}$. The spacing between the plot and blocks (replication) was 1 and 1.5 m, respectively. Plots in each block were randomly assigned to the five treatments. Detailed experimental treatments are shown in Table 2.

2.3. Land Preparation and Planting. The experimental land was plowed and fined with tractors and finally leveled by day laborers to make the soil easier for planting. Before laying out the trial plots, the seedbeds were made fine manually. The recommended amount of fertilizer of 100 kg ha^{-1} NPS and 100 kg ha^{-1} urea has been carefully prepared; NPS was applied at planting, while urea was applied 50% at planting and the remainder at 50% at flowering. Weeds were removed by hand throughout the experimental period to avoid the regrowth of unwanted plants.

2.4. Data Collection Procedure

2.4.1. Biomass Yield Determination. Both desho and SLD were harvested by hand with a sickle, leaving a stubble height of 8 cm above the ground [21] to determine the herbage DM yields. The dry matter yield of desho was determined 120 days after planting [14], and both were harvested at the same time [22–24]. This is because of the fact that desho was considered the main crop of the intercrop while SLD is a companion crop. Five plants from the middle harvestable row of each species were randomly selected to measure the plant height using a measuring tape. The number of tillers per plant of desho was calculated as the mean of counts from five plants randomly selected from the middle rows. The leaf-to-stem ratio of desho was determined by measuring 2 kg fresh weight from the selected two middle rows, separating them into leaves and stems, and drying and weighing each component separately. Immediately after harvest, fresh subsamples of the grass and legumes of approximately 250–300 g were taken from each plot and weighed in the field using a field scale. The subsamples were oven-dried at 65°C for 72 hr, and the dry weight was recorded to calculate the component DM yield (DMY) according to Mutegi et al. [25].

$$\mathrm{DMY}\left(\frac{\mathrm{t}}{\mathrm{ha}}\right) = 10 \times \mathrm{TFW} \times \left(\frac{\mathrm{DWSs}}{\mathrm{harv.}} \times \mathrm{FWSs}\right), \tag{1}$$

where 10 = constant for conversion of yields in kg m^{-2} to ton ha^{-1} [26], TFW = total fresh weight of harvesting area (kg), DWSs = subsample dry weight (g), harv. = harvested area (m^{-2}), and FWSs = subsample fresh weight (g).

Total DMY (TDMY) was calculated as the sum of the component DMYs.

2.5. Land Equivalent Ratio. Total LER is calculated using the equation proposed by Dariush et al. [27] as follows:

$$\mathrm{LER}ab = \left(\frac{Yab}{Yaa}\right) + \left(\frac{Yba}{Ybb}\right), \tag{2}$$

where Yaa = sole crop yield of species "a," Ybb = sole crop yield of species "b," and Yab = intercrop yield of species "b" in combination with species "a." The contribution to total LER by each component species is their respective partial LER (PLER).

2.6. Statistical Analysis. Pooled data were subjected to the analysis of variance procedure using the general linear model of SAS software (2002) version 9.3 [28] to evaluate the effects of year and SLD seeding rate treatments and their interaction. Replicates within a year were identified as unique and considered random significant differences among treatments, which were separated using the least significant difference test at a 5% significance level.

3. Results and Discussion

3.1. Dry Matter Yield and Yield-Related Components of Desho. Intercropping combinations had a significant variation among the treatments (Table 3). Based on the statistical analysis of the 2-year data of the current study, the highest DMY of desho in the intercropped combination was recorded for desho + SLD6. This could be attributed to the contribution of the highest level of seeding rate of the legume in adding N to the soil through N2 fixation, which in turn promotes biomass production of the grass component. This agrees with the research results of Gulwa et al. [29]. Tessema and Baars [30] also concluded that grasses in grass–legume mixtures had a higher TDMY. The maximum plant height of desho was also recorded in desho + SLD6 (Table 3). In this study, it is evident that plant height is associated with biomass yield. The highest number of tillers per plant of desho grass was obtained from a sole desho, decreasing as the SLD seeding rate increased (Table 3). This could be due to the interspecific competition between desho and SLD for growth resources. The number of tillers per plant observed in this study is lower than the result of Walie et al. [1]. The difference may be agroecology, rainfall, temperature, humidity, soil type, and the type of fertilizer applied. In the current study, varying levels of seeding rate of SLD caused no significant difference among treatments on LSR of desho grass.

Table 3: Herbage dry matter yield and yield related traits of desho grass as affected by intercropping with different levels of seeding rates of silverleaf desmodium (SLD) at Bako, Ethiopia, in 2017 and 2018.

Year	DMY (ton ha^{-1})	PLHT (cm)	Tilpp (no)	LSR
2017	14.23	40.67	49.39^{b}	1.16
2018	14.52	45.67	50.34^{a}	1.16
Treatments				
Sole desho	15.96^{a}	40.50^{b}	53.64^{a}	1.12
Desho + SLD2	12.65^{d}	39.17^{b}	49.06^{b}	1.13
Desho + SLD4	13.88^{c}	44.17^{ab}	46.96^{c}	1.11
Desho + SLD6	14.86^{b}	48.83^{a}	43.95^{d}	1.09
Mean	14.34	43.17	48.40	1.13
SE	0.224	2.231	0.571	0.015
LSD (0.05)	0.668	6.656	1.705	0.045
P value				
Year	0.47	0.06	0.002	0.07
Treatment (TRT)	0.001	0.06	0.001	0.06
Year × TRT	0.005	1.00	0.001	0.06

^{a,b,c,d}Means with different superscripts along the column are significantly different. LSD, least significant difference; DMY (ton ha^{-1}), dry matter yield tons per hectare; PLHT, plant height; Tilpp, tiller per plant; LSR, leaf to stem ratio; SLD2, SLD4, SLD6, SLD seeding rates of 2, 4, and 6 kg ha^{-1}, respectively. Values are the means of 2 years and three replicates.

Table 4: DMY and plant height of SLD intercropped with desho grass at different levels of seeding rates at Bako, Ethiopia, in 2017 and 2018.

Treatments	DMY (ton ha^{-1})	Plant height SLD (cm)
Sole SLD	4.24^{a}	101.63^{b}
Desho + SLD2	1.28^{d}	102.83^{ab}
Desho + SLD4	1.88^{c}	103.77^{ab}
Desho + SLD6	2.41^{b}	105.61^{a}
Mean	2.45	103.46
SE	0.145	1.227
LSD (0.05)	0.434	3.659
P value (0.05)	0.001	0.17

^{a,b,c,d}Means with different letters along the column are significantly different. DMY (ton ha^{-1}), dry matter yield tons per hectare; LSD, least significant difference.

3.2. Dry Matter Yield and Plant Height of SLD. The DMY of SLD was affected by intercropping of desho with different levels of seeding rates of SLD (Table 4). While the highest overall DMY of SLD was produced by sole SLD, the highest and the lowest DMY of intercropped SLD were obtained from desho + SLD6 and desho + SLD2, respectively. This study revealed that the DMY of SLD increased as the level of seeding rate increased. The result is consistent with the work of Anteneh [31]. The plant height of SLD varied significantly with the levels of seeding rate. Plant height of SLD intercropped with Desho was higher compared to the sole crop. This indicates that the intercropped legumes make movement toward sunlight, which is crucial for photosynthesis. The present result disagrees with the report of Ojo et al. [32], who noted that the plant height of *Panicum maximum* intercropped with *Lablab purpureus* was not significantly different from the sole at 14 weeks after planting. The difference between the results could be attributed to such factors as the type of soil, legumes, and grass considered, date of harvesting, and other management conditions.

Table 5: Total dry matter yield partial and total land equivalent ratios of desho/desmodium intercropping as affected by different levels of seeding rate of desmodium.

Treatments	TDMY (ton ha^{-1})	PLER of desho	PLER of SLD	LER
Desho + SLD2	13.93^{c}	0.79^{c}	0.31^{c}	1.10^{c}
Desho + SLD4	15.76^{b}	0.87^{b}	0.45^{b}	1.32^{b}
Desho + SLD6	17.27^{a}	0.93^{a}	0.58^{a}	1.51^{a}
Mean	13.43	0.87	0.45	1.31
SE	0.351	0.016	0.029	0.038
LSD (0.05)	1.029	0.049	0.092	0.117
P-value	0.0001	0.0002	0.0001	0.0001

^{a,b,c}Means with different superscripts along the column are significantly different. TDMY, total dry matter yield; PLER, partial land equivalent ratio; LER, total land equivalent ratio; LSD, least significant difference.

3.3. TDMY and Land Equivalent Ratio of Desho/SLD Intercropping. The TDMY of desho grass/SLD intercrop with different levels of seeding rate of SLD varied significantly among the tested treatments (Table 5). Accordingly, the highest and the lowest TDMY were obtained from desho + SLD6 and desho + SLD2, respectively. In this study, the TDMY produced in Desho + SLD6 was greater than pure desho by 1.31 ton ha^{-1}. This is among the many advantages of intercropping grasses and legumes in biomass production. The higher TDMY of desho + SLD mixtures in comparison with monocrops agrees with the report of a previous study on other grasses [33]. Different levels of seeding rate of SLD intercropped with desho grass showed significant variation among the treatments. Moreover, all intercropped treatment combinations had an LER greater than 1.0. The highest LER was observed in desho + SLD6. This result is in agreement with the finding of Abate and Husen [34], in which all values of LER of vetch + maize were greater than 1.0.

The LERs of 1.51, 1.32, and 1.10 for forage dry matter yield were attained by desho + SLD6, desho + SLD4, and desho + SLD2 intercropping combinations, respectively, indicates that the area planted to monocultures would need to be 51% and 32% and 10% greater, respectively, than the area planted to the intercrop for the two species to produce the same combined TDMY.

4. Conclusion

Intercropping grass and legumes is one of the best strategic feed production methods to increase livestock production and productivity, reduce livelihood risks, and optimize the use of limited resources. Based on the 2-year data analysis of the current study, it is possible to achieve a higher feed dry matter yield through intercropping than through monocropping by growing SLD with desho. Thus, by mixed cultivation of 6 kg ha^{-1} SLD with desho, the optimal feed dry matter yield of desho and desmodium can be produced in a compatible and efficient use of resources in order to alleviate the existing feed problem and thereby improve the livelihood of small farmers in Ethiopia.

Data Availability

All data supporting the conclusions of this study are included in this article.

Disclosure

The experiment was done by a regional research institute.

Conflicts of Interest

The author declares that there is no conflicts of interest.

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