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Evaluation of the Effect of Perennial Forage Legume (Desmodium uncinatum) Intercropping with Sugarcane on Forage and Major Crop Yield, and Economic Effectiveness at Wondo Genet, Sidama, Ethiopia

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Abstract
This study was initiated to evaluate the effect of intercropping perennial forage legume (Desmodium uncinatum) with sugarcane on main crop and forage yield at Wondo genet. Five treatments (Sole main crop (Sugarcane), Sole Desmodium uncinatum and three seeding rates (full recommended rate, 75 % and 50 % of full recommended rate) were used for forage legume when intercropped with Sugarcane in randomized complete block design with three replications. Millable cane height, internodes number and internodes length showed non-significant effect due to different intercropping systems while cane yield (ton/ha) and green tops yield (ton/ha) did show significant difference with different intercropping systems. Experimental results reveal that different intercropping systems had no significant impact (p=0.05) on plant height, fresh biomass yield and dry biomass yield of intercrops (Desmodium uncinatum). Partial LER of sugarcane (LERs) was maximum when sugarcane was intercropped with full seeding rate of desmodium. Maximum LER of inter crops (Desmodium) (LERd) and maximum total LER (LERt) was reported in sugarcane + full seeding rate of desmodium intercropping system (1.04 and 1.80 respectively). Lowest LERt (1.36) was recorded in Sugarcane + 75% seeding rate of desmodium intercropping system. Sugarcane yield (t/ha) in sugarcane + full seeding rate of desmodium intercropping system was higher than all other combined intercropping systems. All LERt were greater than one and *it indicates that the intercrop is more productive than the respective sole cropping.*
Keywords: Sugarcane, Intercropping, Desmodium, Land equivalent ratio, Yield
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1. Introduction

Livestock production is an important integral part of the farming system in all parts of the Ethiopia. This sector of agriculture plays a vital role in the livelihood of the country. In spite of this, the productivity of livestock is low mainly due to poor availability of adequate feed in terms of both quality and quantity. As different studies indicated sugarcane is the dominant perennial crops which is produced as an income source of the livelihood in southern part of the country. Even if the cultivable land is scarce due to increasing human population farmers are forced to allocate their limited crop land for the production of perennial crops for both household consumption and income generation. Usually, farmers in the southern part of the country do not readily adapt the cultivation of forages as they divot both land and labor to crop production mainly for major cash source perennial crops such as coffee and sugarcane. As the result animals are fed on low quality of crop residue which is not available throughout different seasons of a year. This is especially due to shortage of arable land.

Intercropping forage crops, particularly legumes could play a key role in linking crop and livestock production by increasing the amount and quality of forage grown and subsequently restoring soil fertility, without requiring any more land and cultivation. Integrating leguminous forage crops (Gryseels and Anderson, 1983: Tothill, 1986; Adugna and Said, 1992) in to the cereal cropping system could be used as an alternative strategy for optimizing the productivity of a given land use system (Adugna and Said, 1992; Mohammed-Saleem and Otsyina, 1986; Kouame *et al,* 1993). Forage legumes can enhance soil fertility, improve yields and nutritive value of harvested products and sustain food and feed production (Mohammed-saleem, 1985; Garba and Renard, 1991). The approach also optimizes the use of labor and land, and reduces the cost of inputs required for establishing improved forages. It also substantially contributes towards alleviating livestock feed. The study was initiated to evaluate the effect of intercropping perennial forage legume (*Desmodium uncinatum*) with sugarcane on main crop and forage yield.

2. Materials and Methods

2.1. Description of the study area

The experiment was conducted at Wondo Genet Agricultural Research center.which is found in Sidama Regional state, Wondo Genet woreda. It is situated about 268 km south of Addis Ababa and 14 km south east of Shashemene. Its geographical location and altitude ranges from 38° 37'13"-38° 38'20" East and 7° 5'23"-7° 5'52"

North and 1760-1920 m.a.s.l respectively (Adugna *et al.,* 2010).The area receives mean annual rain fall of 1128 mm with minimum and maximum temperature of 11 and 26 ℃, respectively (Tekalign *et al*., 2017). The adaptable perennial forage legume (*Desmodium uncinatum*) was used to be intercropped with the two major crops.

2.2. Treatment's design and plot size

The experiment was executed under on-station condition using newly established sugarcane plantation at Wondo genet Agricultural Research Center. The design was randomized complete block design with three replications. Three seeding rates (full recommended rate, 75 % and 50 % of full recommended rate) were used for forage legume when intercropped with Sugarcane. Considering a single main crop, forage legumes and three seeding rates of each set of experiment the treatments were as indicated in table 1 below.

Table 1. Experimental treatments

Treatment No.	Treatments
1	Sole main crop (Sugar cane)
2	Sole *Desmodium uncinatum*
3	Main crop (Sugarcane) + *Desmodium uncinatum* + Full seeding rate
4	Main crop (Sugarcane) + *Desmodium uncinatum* + 75 % Full seeding rate
5	Main crop (Sugarcane) + *Desmodium uncinatum* + 50 % Full seeding rate

2.3. Sugarcane intercropping trial

According to farmers practice, sugarcane was planted on a farm land having ridge and furrow and the sugarcane was planted in the furrow part of a farm plot. The recommended spacing of 60 cm is used between two sugarcane plantation rows on which the ridge part was left idle. Therefore, this trial mainly targets to produce the intercropped forage using this free space. The forage legume was broadcasted immediately after 10 days of main crop (sugarcane) plantation on the ridge part after disturbing the soil for better contact of seed with soil.

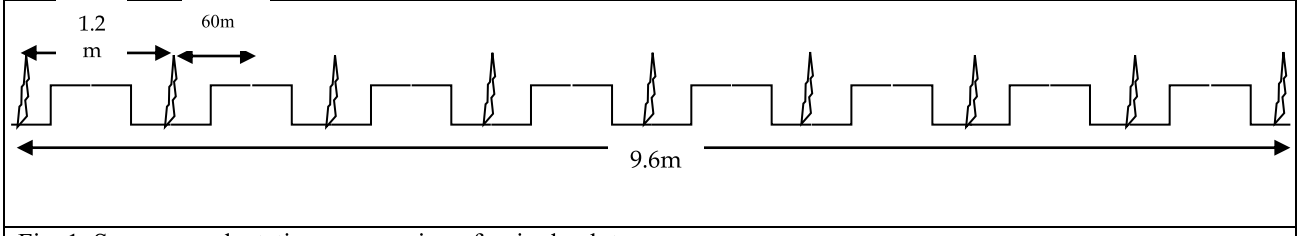

Fig. 1. Sugarcane plantation raw spacing of a single plot.

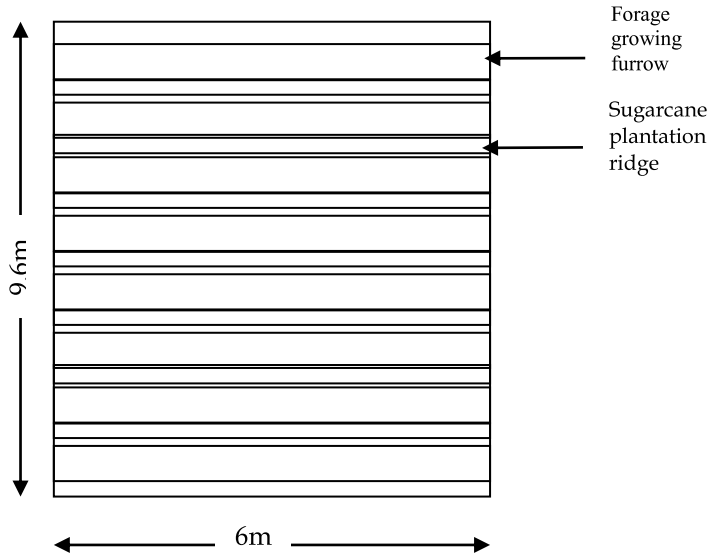

Fig. 2. Total area (57.6m^2) and planting arrangement.

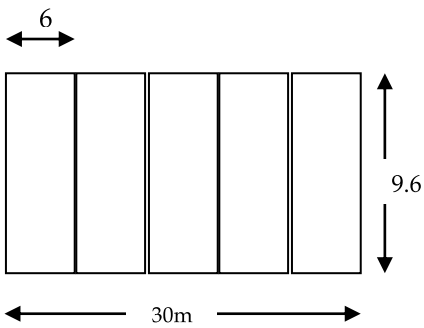

Fig.3. Total area (288m2) and orientation of a single replication.

2.4. Plot management harvesting method and measurements

Weeding and other management practices were followed similar with farmers practice during the entire period of the experiment. In the experiment the main crop was harvested using farmers harvesting stage. However, to not loss the feed quality, the forage crop will be harvested at any time when it attends 50% flowering stage and depend on the growth nature of the forage plant multiple harvests may obtained.

All yield related data were collected for main and companion crops separately as indicated in the next section.

2.4.1. Main crop (sugarcane) data

Yield related data collected from sugarcane were:

- ✓ No of nods/plant
- ✓ Average nod length (Cm) of 5 nods/plant
- ✓ Fresh biomass weight single plant with leaves and per plot
- ✓ Fresh biomass weight single plant without leaves per plot
- ✓ Fresh biomass weight of leaves per plant per plot
- ✓ DM weight of leaves per plot

2.4.2.Forage crop yield data

The major yield estimation parameters for the forage crop (*Desmodium uncinatum*) are indicated in table 2.

Table 2. The major yield estimation parameters for the forage crop (*Desmodium uncinatum*)

Data Type	Method of collection
✓ Forage yield (Fresh bases)	The Forage will be harvested at 12cm of height above ground from harvestable rows of a plot and total fresh weight (kg) was recorded
✓ Forage yield (DM bases)	Sample of 400-500gm from fresh Forage harvest was taken and dried in forced draught oven at 65° C to constant weight and used for the determination of DM yield
✓ Forage yield (Q)/ha	The obtained DM Forage yield (kg) from each plot was converted into (ton)

2.5. Statistical analysis

Differences among means were tested using analysis of variance (ANOVA) procedures of SAS general linear model (GLM) (SAS, 2002). Least significance difference (LSD) at 5% significance level was used for comparison of means.

3. Results and Discussion

Millable cane height, internodes number and internodes length showed non-significant effect due to different intercropping systems while cane yield (ton/ha) and green tops yield (t/ha) did show significant difference with different intercropping systems (Table 3). Sugarcane yield (ton/ha) in sugarcane alone was significantly higher ($P<0.05$) than all other intercropping system except sugarcane + full seeding rate of desmodium intercropping system. That is planting of sugarcane alone resulted in significantly higher cane yield (178.3 t/ha) followed by cane intercropped with Sugarcane + full seeding rate of desmodium intercropping system (129.6 t/ha). This could be due to more competition of sugarcane with companion crops with nutrients and moisture.

Table 3. Effect of intercropping on yield attributing characters of sugarcane

Treatments	Millable cane height (cm)	Internodes number	Internode's length (cm)	Cane yield (t/ha)	Green tops yield (t/ha)
Sugarcane alone	224.87	15.8	14.47	178.30^{a}	11.46^{a}
Sugarcane + full seeding rate of desmodium	218.40	17.53	13.23	129.58^{ab}	7.96^{b}
Sugarcane + 75% seeding rate of desmodium	191.40	16.67	14.52	102.14^{b}	6.92^{b}
Sugarcane + 50% seeding rate of desmodium	193.27	17.67	12.49	112.09^{b}	7.55^{b}
LSD (5%)	36.16	1.89	2.67	50.16	3.17
Significance	NS	NS	NS	*	*

Means followed by a common superscript letter with in a column are not significantly different from each other at $P<0.05$.

Experimental results reveal that different intercropping systems had no significant impact ($p=0.05$) on plant height, fresh biomass yield and dry biomass yield of intercrops (*Desmodium uncinatum*) (Table 4).

Table 4. Effect of intercropping on yield attributing characters of Silverleaf desmodium (*Desmodium uncinatum*)

Treatments	Plant height (cm)	Fresh biomass yield (t/ha)	Dry biomass yield (t/ha)
Desmodium alone	208.65	35.31	8.68
Sugarcane + Full seeding rate of desmodium	239.84	33.86	6.82
Sugarcane + 75% seeding rate of desmodium	223.00	25.71	6.06
Sugarcane + 50% seeding rate of desmodium	223.99	26.05	5.52
LSD (5%)	29.61	19.98	5.27
Significance	NS	NS	NS

3.1. Land equivalent ratio (LER)

Partial land equivalent ratio of sugarcane and desmodium and total land equivalent ratio were indicated in table 5. Partial LER of sugarcane (LERs) was maximum when sugarcane was intercropped with full seeding rate of desmodium. Maximum LER of inter crops (Desmodium) (LERd) and maximum total LER (LERt) was reported in Sugarcane + full seeding rate of desmodium intercropping system (1.04 and 1.80 respectively). Lowest LERt (1.36) was recorded in Sugarcane + 75% seeding rate of desmodium intercropping system. Total land equivalent ratio (LERt) ranged from 1.36 to 1.8, hence, 36 to 80% more land should be used in sole cropping in order to obtain the same yield of intercropping, which indicates the advantage of the intercrops over single cropping in terms of the use of environmental resources for plant growth (Dhima et al., 2006). In all intercropping system, total land equivalent ratio was greater than one indicating a yield advantage over sole crops.

Table 5. Land equivalent ratio in different intercropping systems

Treatments	Land Equivalent ratio (LER)		
	LERs	LERd	LERt
Sugarcane + Full seeding rate of desmodium	0.76	1.04	1.80
Sugarcane + 75% seeding rate of desmodium	0.59	0.77	1.36
Sugarcane + 50% seeding rate of desmodium	0.64	0.78	1.41
LSD (5%)	0.28	0.64	0.64
Significance	NS	NS	NS

LERs: Land Equivalent Ratio $_{Sugar,}$ LERd: Land Equivalent Ratio $_{Desmodium,}$ LERt: Land Equivalent Ratio $_{Total.}$
Means followed by a common superscript letter with in a column are not significantly different from each other at $P<0.05$

Conclusion

Sugarcane yield (t/ha) in sugarcane + full seeding rate of desmodium intercropping system was higher than all other combined intercropping systems. All LERt were greater than one and it indicates that the intercrop is more productive than the respective sole cropping.

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