International Journal of Research Studies in Agricultural Sciences (IJRSAS)
Volume 3, Issue 4, 2017, PP 26-30
ISSN 2454-6224
http://dx.doi.org/10.20431/2454-6224.0304004
www.arcjournals.org

Evaluation of Forage Legumes under Sown with Maize on Dry Matter, Maize Grain Yield and Other Agronomic Parameters in the Highlands of Bale

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Abstract: *The experiment was undertaken at Agarfa and Gasera sites of the Bale highland with the objectives to evaluate forage yield performance of some forage legumes undersown with maize and to assess their effect on grain yield of maize. Accordingly, four types of forage legumes Vecia dacycarpa, Trifolium quartinanium, Melilotus alba and Hunter river were tested in randomized complete block design with four replications. The two sites combined analysis revealed that the dry matter yield recorded were significantly ($p<0.05$) differ among the tested treatments. The highest (3.0t/ha) forage dry matter yield was recorded from vetch-maize treatment whereas the least forage dry matter yield (0.71 t/ha) was harvested from trifolium-maize treatment. The two sites combined result also showed that there were a significant ($p<0.05$) differences in maize grain yield among the tested treatments. However, there was no significant ($p> 0.05$) differences among the tested treatments in grain yield at Agarfa site. The highest grain yield (39.2quintal/ha) was harvested from sole maize treatment followed by trifolium-maize treatment (33.6quintal/ha). The lowest (28.7 quintal/ha) yield was produced by alfalfa-maize treatment. However, there was no significant ($p>0.05$) grain yield differences among the control (sole maize) and trifolium-maize treatments. The two sites mean grain yield result indicated that 26.7%, 24.4%, 22.4%, and 14.2% of yield reduction were calculated due to Hunter river, Vecia dacycarpa, Melilotus alba and Trifolium quartinanium under sown with maize respectively. The reason for maize yield reduction could be due to the competition of the forage legumes for nutrient. The choice of the right time of sowing forage legume under the maize plant could be also the factors for the yield reduction recorded in this study. Hence, the right time of under sowing of forage legume to the cereal and the right choices of both food and forage crop is critical to have a good forage production without affecting the grain yield of the main crop. For this particular experiment, there is the possibility to minimize the grain yield reduction by adjusting the time of under sowing of forage legumes to the maize forage crops. Hence it needs further study on the time of under sown forage crops and selecting the best compatible forage legume that can produce higher forage production as the expense of minimum grain yield reduction.*

Keywords: *Forage legumes, maize under sowing, Bale highland.*

1. Introduction

Ethiopia is known for its large and diverse livestock resource endowments. Livestock is primarily kept on smallholdings where it provides draught power for crop production, manure for soil fertility and fuel, and serves as a source of family diet and source of cash income (from sale of livestock and livestock products). However; the advantage we fetch from the resource is insignificant and not compromised with the livestock potential (Asfaw *et al*., 2011).

Shortage of feeds in terms of quantity and quality are the major constraint to livestock production and productivity especially during the dry season (Ahmed *et al*., 2010). Feed supply from natural pasture and crop residues are low in quantity and quality and fluctuates following seasonal dynamics of rainfall (Solomon *et al*., 2008). This has resulted in significant decrease in milk production, loss of body weight, reduced draught power, increased susceptibility to diseases, reduced reproductive performance and retarded growth rate and high mortalities of young animals (Alemayehu 1997). Similarly, the availability of feed resources in quantity and quality is considered as a major problem in the highlands of Bale zone of Ethiopia (Solomon *et al*., 2009).

Maize is one of the important food crop to smallholder farmers of the Bale highlands. Farmers are growing it because of its dual advantages' one of which is feeding value of its stalk and/or leaves.

Integration of food and feed production is one of the approaches to solve inadequate feed supply. Forage legumes which are compatible with food crops will improve soil fertility, crop yield and herbage quality and make the system more sustainable (Lithourgidis *et al.*, 2006, Saidi *et al.*, 2010). Therefore, integrating forage crops particularly the leguminous ones in to cereal based cropping systems is one of the strategic options to overcome feed shortage and soil fertility problems that farmers are currently facing. Several improved forage legumes such *Vecia dasycarpa, Trifolium quartinanium, Melilotu alba, Melilotu altisumus and Alfalfa (Hunter river)* have been tested and selected for the highlands of Bale. But their compatibility with other cereals has not been exhaustively studied. Therefore, this study was initiated with the objectives to evaluate forage yield performance of some forage legumes and to assess their effect on grain yield of highland maize crop.

2. Material and Methods

The experiment was undertaken at Agarfa and Gasera sites of the Bale highland. The two sites are characterized by mixed crop/livestock farming system. The soil type in Agarfa area is dark-brown to dark reddish where as in Gasera it is dark black clay vertisol (Bekele *et al* 1997). Bimodal and erotic rainfall pattern is common in the area.

The local variety of maize and four types of forage legumes *Vecia dacycarpa*, *Trifolium quartinanium, Melilotus alba* and Alfalfa (*Hunter river*) were used for the experiment. The design used for the experiment was randomized complete block design with four replications. Each plot measured 4.1m by 4.25m. The spacing between plots and replications were 1 and 1.25m respectively. Maize was planted in rows with the 75 cm distance between rows and 30 cm within rows. Forage legumes were planted at 37.5cm distances from the maize rows simultaneously with maize crop. Seed rate of 40 kg/ha was used for maize, 30kg/ha for vetch and 15kg/ha for other legumes were used. The treatments received fertilizer rate of 41/46 N/P_2O_2 kg /ha. Grain yield, forage dry matter and other relevant agronomic data were collected and analyzed using SAS and significant mean differences were separated using the LSD procedure.

3. Results and Discussions

Mean Dry Matter Yield and Agronomic Performance of Forage Legumes

The dry matter yield performance of under sown forage legumes is presented in table 1. The yield recorded were significantly ($p<0.05$) differ among the treatments at all the two sites. The highest (3.4t/ha) and (2.6t/ha) forage dry matter yield were recorded from vetch-maize treatment at Agarfa and Gasera respectively. The least yield harvested were from trifolium-maize treatment at both sites. The dry matter yield performance of undersown forage legumes were better at Agarfa as compared to Gasera site except for trifolium-maize treatment. The main reasons for yield variability could be due to moisture and soil fertility differences across the sites. The combined mean analysis of the two site also indicate that the highest dry matter yield (3.0t/ha) was recorded from vecth-maize treatment. The forage dry matter yield obtained in this study were lower as compared to the other findings (Merga Abera, 2012) probably due to the soil moisture and fertility differences.

There were a significant ($p<0.05$) variation in forage plot cover and plant height among the tested forage treatments. The highest plot cover was recorded for vetch-maize treatment at Agarfa site while at Gasera alfalfa-maize treatment have the highest value. The combined mean of the two sites showed that vetch-maize and alfalfa-maize undersown treatments recorded the highest plot cover. The least value was recorded for trifolium-maize treatment. The highest plant height, 205.6cm and 140.4cm were produced for melilotus-maize treatment respectively at Agarfa and Gasera sites. Vetch-maize treatment recorded the second highest plant height while the least was recorded for alfalfa-maize at Agarfa and trifolium-maize at Gasera site. The better plant height might have contributed for better dry matter yield of the forage. The study conducted by Dhumale and Mishra (1979) also shown that fresh herbage yields were positively correlated with plant height.

Table 1. *Mean plot cover, plant height and dry matter yield of forage legumes under-sown with maize at Agarfa and Gasera districts of Bale highland.*

Treatments	Plot cover (%)			Plant height (cm)			Dry matter yield (t/ha)		
	Agarfa	Gasera	Mean	Agarfa	Gasera	Mean	Agarfa	Gasera	Mean
Vetch-maize	91.8^a	79.2^b	85.5^a	194.4^a	88. 6^b	141.5^b	3.4^a	2.6^a	3.0^a
Trifolium-	71.8^c	36.0^c	53.9^c	146.9^b	45.2^d	96.1^c	0.2^d	1.2^c	0.71^d

maize									
Melilots-maize	73.2[c]	78.0[b]	75.6[b]	205.6[a]	140.4[a]	173.0[a]	2.9[b]	1.3[bc]	2.1[b]
Alfalfa-maize	80.6[b]	89.4[a]	85.0[a]	101.2[c]	70.5[c]	85.85[d]	1.9[c]	1.5[b]	1.7[c]
Sole maize	-	-	-	-	-	-	-	-	-
Mean	79.4	70.6	75.0	162.1	86.2	124.1	2.1	1.63	1.9
LSD	2.6	3.3	1.4	12.2	5.6	8.4	0.2	0.7	0.3
CV	11.8	16.5	18.3	13.2	11.6	17.7	12.6	21.8	23.5

LSD=Least Significance Difference, CV= Coefficient of Variation, Figures with the same letters in columns are not significantly different (P>0.05).

Mean Plant Height, Stover Dry Matter and Grain Yield of Maize

The grain yield of maize intercropped with forage legumes at Agarfa and Gasera are presented in the table 2. The analysis of the result showed that there was no significant (p> 0.05) differences among the tested treatments in grain yield at Agarfa. This indicated that the undersown forage legumes did not significantly affected the grain yield harvested at this site. However, at Gasera the tested forage legumes were significantly (p<0.05) affected grain yield as compared to sole maize yield (control). At the Gasera site the highest grain yield was recorded for the control while the lowest grain yield was recorded for vetch-maize treatment. The combined analysis of the two sites also indicated that the tested treatments had a significant (p<0.05) difference on grain yield. However, there was no significant (p>0.05) different among the control (sole maize) and trifolium-maize treatment. The highest grain yield (39.2quintal/ha) was harvested from sole maize treatment followed by trifolium-maize treatment (33.6quintal/ha). The lowest (28.7 quintal/ha) was produced by alfalfa-maize treatment. Hence, yield reduction of 26.7%, 24.4%, 22.4%, and 14.2% were calculated due to alfalfa, vetch, melilotus and trifolium undersown with maize respectively. Even though the undersown forage legumes produces additional feed sources for livestock, the depression of cereal grain yield which the forge legumes undersown should be minimal possibly not more than 15% for it to be acceptable to the farmers (Nnadil and Haque, 1986). The reason for yield reduction could be the competition of the forage legumes for nutrient and the insufficient moisture availability during the trial period. Moreover, the choice of the right time of sowing forage legume under the maize plant could be the main factors for the maize grain yield reduction.

The strover yield obtained from the two sites were significantly (p<0.05) affected by the undersown forage legumes (table 2). The highest yield (20.9t/ha) and (29.7 t/ha) were harvested from alfalfa-maize at Agarfa and Gasera sites respectively. While the lowest stover dry matter yield (14.1t/ha) and (24.4 t/ha) were obtained from sole maize (control) treatment at Agarfa and Gasera sites respectively. Similarly, the combined mean analysis of the two sites shows the maximum stover yield of (25.4t/ha) was harvested from alfalfa-maize treatment. While the lowest stover yield value (19.3 t/ha) was for sole maize treatment. The stover yield from the mean analysis of the two sites indicated that 31.1% more stover yields was harvested due to alfalfa undersowing in maize. The higher stover yield obtained as compared to sole maize treatment could be due to soil fertility improvement as the result of forage legume undersowing.

The highest maize plant height 185.4 and 287.4 cm were produced for sole maize treatment at Agarfa and Gasera sites respectively. While the shortest plant height were recorded for vetch-maize at the two sites. The highest plant height recorded for the sole maize treatments could be due to better accesses for nutrients and light utilization as compared to the undersowing treatments. The combined analysis also showed that the highest plant height of maize (236.4 cm) was for sole maize. While the least value was vetch-maize treatment.

Table 2. *Mean plant height, stover dry matter and grain yield of maize intercropped with forage legumes at Agarfa and Gasera districts of Bale highland*

Treatments	Plant height (cm)			Stover DM yield (t/ha)			Grain yield (Quintal/ha)		
	Agarfa	Gasera	Mean	Agarfa	Gasera	Mean	Agarfa	Gasera	Mean
Vetch-maize	169.0[c]	274.9[b]	221.9[c]	14.2[c]	25.8[bc]	20.0[c]	26.8	32.3[b]	29.6[b]
Trifolium-maize	177.8[b]	284.4[a]	231.1[b]	17.7[b]	27.5[ab]	22.6[b]	31.8	35.4[b]	33.6[ab]
Melilots-maize	174.6[bc]	284.7[a]	229.6[b]	15.5[bc]	25.9[bc]	20.7[c]	27.4	33.4[b]	30.4[b]

Alfalfa-maize	176.3^{bc}	282.6^{a}	229.4^{b}	20.9^{a}	29.7^{a}	25.4^{a}	24.4	33.1^{b}	28.7^{b}
Sole maize	185.4^{a}	287.4^{a}	236.4^{a}	14.1^{c}	24.4^{c}	19.3^{c}	35.5	42.9^{a}	39.2^{a}
Mean	176.6	282.8	229.7	16.5	26.7	21.6	29.2	35.4	32.3
LSD	7.5	6.7	6.3	2.5	2.8	1.8	NS	6.2	6.7
CV	6.0	3.5	5.3	14.6	10.1	11.9	17.4	15.3	16.4

LSD=Least Significance Difference, CV= Coefficient of Variation, Figures with the same letters in columns are not significantly different (P>0.05).

4. Conclusions and Recommendations

It is well understood that intercropping forage legumes with maize and other cereals do have advantages such as cost reduction due to fertilizer, enhances forage production from both component species and ensures the availability of quality residue for grazing after grain harvest. From the study, most of the tested forage legumes have resulted in yield reduction of maize grain. Even though the forage dry matter yield obtained could be additional advantage for solving feed shortage problem of smallholder farmers, it was obtained as the expense of significant maize grain reduction. However, it is possible to produce additional forage legumes without significantly affecting the maize grain yield by undersowing trifolium in maize crop. The mean grain yield analysis from the two sites shows that 26.7%, 24.4%, 22.4%, and 14.2% were calculated due to alfalfa, vetch, melilotus and trifolium undersown with maize respectively. The reason for maize yield reduction could be the competition of the forage legumes for nutrient. Moreover, the choice of the right time of sowing forage legume under the maize plant could be the main factors for the yield reduction recorded in this experiment. Hence, the right time of undersowing of forage legume to the cereal and the right choices of both food and forage crop is critical to have a good forage production without affecting the grain yield of the crop. Therefore in this particular study, there is the possibility to minimize the grain yield reduction by adjusting the time of undersowing of forage legumes to the maize forage crops. Hence it needs further study on the time of undersown forage crops and selecting the best compatible forage legume that can produce higher forage production as the expense of minimum grain yield reduction.

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