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Research Article

Integration of annual forage legume with maize for better feed availability of livestock in maize dominated mixed farming system of Southern Region, Ethiopia

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Abstract

This study was conducted at Dore Befano and Meskan district of Sidma regional state and Gurage zone of south nation, nationalities, and peoples of southern Ethiopia's (SNNPR), where maize dominated. The trial was conducted to evaluate the outcome of under sowing lablab on the grain yield, Stover, and appropriate time and seeding rate of forage crop under sowing. The trial was implemented using a 3 by 3 factorial combination with two sole treatments in an RCBD with three replications. The treatments were sole Maize ($T_{1)}$ Sole forage (T_2) and Maize & Forage Simultaneous with maize sowing date full Simultaneous with maize sowing date 75%, Simultaneous with maize sowing date at 50%, Maize & Forage After 15 days of maize sowing full, after 15 days of maize sowing 75%, After 15 days of maize sowing 50%, Maize & Forage After 30 days of maize sowing full, Maize & Forage After 30 days of maize sowing 75% and Maize & Forage After 30 days of maize sowing 50% T_3 to T_{11} respectively. Under sowing of lablab with maize did not affect the grain yield of maize. Among experiments, T5 was a more appropriate seeding rate and sowing time for under sowing of lablab with maize.

Introduction

Feed shortage is one of the many problems faced by smallholder dairy farmers in developing countries. The lack of feeds is particularly arduous during the dry season when cattle are regularly allowed to graze on maize stover which is often the only accessible feed during the dry part of the year and hence it is a significant feed supply. There is a great want for smallholder dairy farmers in common lands to sustainably improve the nutritive value of maize stover and quantity as well hence, one option is the application of intercropping. Intercropping, which is the practice of concurrently growing two or more crops on the same land [1,2], may deliver many paybacks to smallholder livestock farmers. In countries like Ethiopia, planting forage crops as the sole crop for animal feed is difficult owing to a scarcity of tillable lands and labor to plant the forages. The only possibility is the use of small farmland for a combined food and feeds. Intercropping forage legumes is one way of announcing forage crops in crop-livestock schemes. The system offers the potential for increasing forages without a considerable decrease in grain yield [3,4]. These profits include increased crop yields per unit area of land, amended soil fertility by intercropping of legumes, reduced soil erosion and topsoil evaporation reduced weed invasion, and a decrease in the amount of land needed for crop production [2,5-7]. Intercropping can also support farmers to integrate different crop varieties within the same field in the same cropping season hence minimalizing jeopardies related to the failure of producing a single crop. Farmers keep multiplicity as an assurance to encounter future environmental change, and social and economic needs [8]. It is thus imperious that for an intercropping system to achieve complete sustainability, it must be under agroecological principles and approaches which are designed and managed in productive agroecosystems, socially just, environmentally sound, and economically viable [8-10]. In the same way, the application of this intercropping

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technology must follow the way of a participating method to report the social and economic needs of the local rural farming community sensitively and responsively, as well as ensuring environmental conservation. The most important methods to precisely evaluate the efficiency of intercropping in terms of land resource use and yield by associated crops are land equivalent ratio (LER) and Relative Yield (RY), respectively. Maize intercropped with legumes was more effective than sole crop maize in dry matter (DM) yield and silage quality [11]. The addition of perennial forage in maize and fallow alternation, by under-sowing, can not only lighten livestock feed insufficiency but also efficiently preserve fertility in the sub-humid western part of Ethiopia [12]. The incorporation of auspicious annual forage legumes and a maize based production system, has improved soil fertility, increased crop yields, and provided high quality feed for livestock [13-17], but reduced the yield of companion cereal crops as a result of competition for moisture and nutrients between cereals and legumes [18]. Besides this, legumes improve soil fertility by fixing nitrogen biologically [19]. The addition of leguminous plants improves livestock nutrition since maize residues tend to be high in carbohydrates but low in protein [4,20]. Lablab (Lablab purpureus L.) is one of the herbaceous forage legumes which were identified for its adaptability and good forage yield. However, there is limited information on the appropriate time for intercropping of lablab with maize. This trial was therefore designed at evaluating the outcome of under sowing on maize grain, stalk, and forage yield of maize and forage, investigate the appropriate time and seeding rate of forage crop under sowing, and evaluate the economic feasibility of the cropping system in terms of land equivalent ratio.

Materials and methods

Description of study area

The Hawassa Zuria site (Dore Befano) district is geographically situated at 07° 1' 0.83"N latitude and 38° 22' 26"E longitude with an altitude of 1,713 m above sea level. The site is mainly characterized by a semiarid climate with a long-term average annual rainfall of 958 mm, of which 81% falls during the growing season (April to October) and an annual mean temperature of 21°C. Meskan is found at 08° 05' 33" N latitude and 38° 26' 75" E longitude with an altitude of 1,841 m above sea level. The experimental site is mostly categorized under a semiarid climate with a long-term average annual rainfall of 987 mm, of which 84% falls during the growing season (April to October) and an annual mean temperature of 20.4°C [21]. 'e soil types for the field trial were Cambisols for Hawassa Zuria and Chernozem for Meskan, according to the World Reference Base for soil classification system [22].

Experimental design and data collection

In general, the experiments were conducted in two sets of production seasons during the two years (2011-2012 E.C) production seasons of the respective locations (Awassa Zuria-Dore Befano and Meskan) using released and adopted maize variety hybrid (BH-540) and one Lablab (*Lablab purpureus* (*L.*)) used. Three under sowing times of forage; together with maize (Major crop sowing date), 15 and 30 days after the maize sowing date (DAMS) with three seeding rates (100%, 75%, and 50% of the suggested seeding rate (RSR)) of annual forage legumes were used in the trial. Accordingly, the factorial combination of three forage under sowing date (UD) and three seeding rates (SR) with sole maize and forage crops, a total of 11 treatments. These treatments were applied for each released maize variety.

The trial was implemented using a 3 by 3 factorial combination with two sole treatments in a randomized complete block design (RCBD) with three replications. The treatments were sole maize (T_1), Sole lablab (T_2), maize and forage simultaneous with maize sowing date using 100% (T_3), 75% (T_4), and 50% (T_5) seed rate (SR) of lablab, forage lablab under sown after 15 days of maize sowing using 100% (T_6), 75% (T_7), and 50% (T_8) seeding rate of lablab, and forage lablab under sown after 30 days of maize sowing using 100% (T_9), 75% (T_{10}), and 50% (T_{11}) seeding rate of lablab.Plot size was 6m x 4.8m= 28.8m² containing 7 rows of maize and 8 rows of lablab with 1m between plots and 2m between blocks space. The Maize seed and lablab forage were sown on well ploughed and prepared by oxen and on the ridge, by row with 75cm b/n row and 30cm b/n plant, 20cm for maize and lablab respectively using 25kg/ha rate of maize. DAP fertilizer was applied at the rate of 100 kg per hectare at planting and Urea 50kg/ha (one-third at sowing and the rest at knee height stage) of maize. Plant height was taken from five randomly selected plants from each plot. Among seven rows of maize plants, 4 rows of the stalk were harvested at 12cm of height above ground and among the eight rows of forage crop, the middle Five (5) rows were harvested at 12cm above ground for fresh biomass yield determination. The weight of the total fresh biomass yield was recorded from each plot in the field for both maize and lablab and the 300g sample was taken from each plot both from the maize stack and lablab to the laboratory. The sample taken from each plot was weighed to know the total sample fresh weight using sensitive table balance and oven-dried for 72 hours at a temperature of 65°c for maize stack and lablab DM yield determination. No. of cobs/plant was the count for all plants within the harvestable area of each plot. An average of 10cobs/plot will be used to record grain yield estimation.

Land Equivalent Ratio (LER)

The Land equivalent ratio (LER) for inter-cropping was calculated, using the formula:

$LER = \frac{IYSC}{YSC} + (\frac{IYD}{YD}$ [23], Where: YSC = yield of maize alone; IYSC = yield of inter-cropped maize; IYD = yield of intercropped lablab; and SYL = yield of Lablab alone.

Statistical analysis

Data on agronomic parameters and yield was analyzed by using analysis of variance by (ANOVA) procedures of SAS general linear model (GLM) [24]. The least significant difference (LSD) at a 5% significant level was used for the comparison of means.

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Results and discussion

Forage plant height

Field observations displayed that during the first month after planting lablab seed into the maize crop, lablab plants grew gradually competing with weeds between maize rows, but not with the maize. This is alike with [25]. When the maize began to braid, lablab vines started to grow more strongly and got their greatest growth a month earlier than the maize cobs were collected.

There were significant ($P < 0.05$) differences for lablab height of sole forage from 100%, 75%, and 50% established simultaneously with maize (T_2, T_3, and T_4). No significant differences in plant height among T_6, T_7, and T_8 were observed which was established 15 days after the main crop was planted. There was also no significant deferent between T_9, T_{10}, and T_{11} which is established after 30 days of main crop establishment (Tables 1,2). This result shows that sowing time does not have any effect on the height of the forage plants but the seed rate of forage has some effects on the height of the lablab crop.

Forage fresh and dry matter biomass and maize grain yield

The effects of intercropping of maize with lablab on fresh (FBY) and dry matter biomass (DBY) yield of lablab and maize grain yield (GY) at Hawasa zuria, Dore Befano and Meskan were presented in Tables 1,2 respectively. There were significant ($P < 0.05$) differences between treatment 2 and the others in both fresh and dry matter biomass yield of lablab. The maize stover dry matter yield was similar among treatments at both locations which indicated that lablab intercropping could not disturb the stover yield of maize. This result was consistent with [4]. This might be due to the later planting date which was exposed to moisture stress at the latter crop growth stage. As a result, the forage biomass yield of lablab was low for the lately under sown time. Intercropping of Lablab showed a significant effect ($P < 0.05$) on maize grain yield at Dore Befano (Table 1) but not at Meskan (Table 2). Similarly, Hassen, et al. [12] reported that for intercrops, grain yield was affected by an interaction between legume of date of planting in both years. Intercropped lablab significantly decreased ($P < 0.05$) grain yields when planted concurrently with maize, but there was no significant difference ($P > 0.05$) when planting was late.

The sole lablab is significantly different (P>0.05) or higher from 100%, 75%, and 50% sow simultaneously with maize in fresh biomass (FBY) and dry matter biomass yield (DBY) in Meskan (Table 2). Significant differences ($P < 0.05$) were also observed between the seed rate of lablab sown at 15 and 30 days after the establishment of maize and sole lablab on fresh

Table 1: Two years (2011 and 2012 E.C) mean value of yield and yield components of different maize-intercropping with lablab at Hawassa Zuria (Dore Befano).

Treatment*	Forage Parameters			Maize parameters		
	PH (cm)	FBY (t/ha)	DBY (t/ha)	GY (t/ha)	FSY (t/ha)	DSY (t/ha)
1				5.15^{ab}	4.97	4.22
2	80.8^{d}	18.02^{a}	7.70^{a}			
3	118.7^{ab}	5.31^{b}	1.22^{b}	3.41^{bc}	3.74	2.90
4	115.3^{bc}	4.12^{bc}	0.94^{b}	3.49^{bc}	3.72	3.61
5	147.1^{a}	4.84^{bc}	1.08^{b}	4.25^{abc}	4.84	3.94
6	134.5^{ab}	4.40^{bc}	0.88^{b}	4.15^{abc}	4.10	3.87
7	137.4^{ab}	4.81^{bc}	0.97^{b}	4.05^{abc}	4.25	3.63
8	139.7^{ab}	2.39^{bc}	0.46^{b}	4.38^{abc}	4.46	3.64
9	89.9^{dc}	1.86^{bc}	0.40^{b}	5.44^{a}	4.66	4.10
10	85.0^{d}	1.26^{c}	0.27^{b}	4.58^{abc}	5.52	4.24
11	86.0^{d}	2.03^{bc}	0.41^{b}	2.75^{c}	4.93	4.17
SEM	8.99	1.18	1.05	0.56	0.01	0.54

Means in the row followed by different superscripts are significantly different ($P < 0.05$); SE = standard error of the mean; t/ha = ton per hectare; PH = Plant Height; FBY = Fresh Biomass Yield; DBY = Dry Biomass Yield; GY = Grain Yield; FSY = Fresh Stem Yield; DSY = Dry Stem Yield

Table 2: Two years (2011 and 2012 E.C) mean value of yield and yield components of different maize-intercropping with lablab at Meskan Woreda.

Treatment*	Forage Parameters			Maize parameters		
	PH (cm)	FBY (t/ha)	DBY (t/ha)	GY (t/ha)	FSY (t/ha)	DSY (t/ha)
1				8.76	11.58	8.86
2	205.67^{cde}	60.28a	7.12^{a}			
3	292.93^{a}	15.82b	1.8^{b}	8.06	11.18	6.84
4	251.67^{abc}	10.43b	1.06bcd	7.75	10.95	6.6
5	284.9^{ab}	14.45b	1.44^{bc}	8.05	10.23	7.94
6	217.0^{cde}	4.43c	0.76^{cd}	8.5	13.74	10.78
7	213.88^{cde}	3.45c	0.71^{cd}	8.13	11.07	7.22
8	229.17^{cde}	3.8c	0.61^{d}	8.69	11.84	8.02
9	172.20^{def}	2.63c	0.5^{d}	7.92	9.72	7.09
10	138.8^{f}	2.48c	0.39^{d}	10.26	10.78	8.05
11	156.13^{f}	2.65c	0.33^{d}	9.7	13.39	9.3
SEM	19.71	1.99	0.25	0.85	1.65	1.38

Means in the row followed by different superscripts are significantly different (P < 0.05); SE = standard error of the mean; t/ha = ton per hectare; PH = Plant Height; FBY = Fresh Biomass Yield; DBY = Dry Biomass Yield; GY = Grain Yield; FSY = Fresh Stem Yield; DSY = Dry Stem Yield

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and dry biomass yield of lablab. But has no significant effects on maize grain yield at Meskan and is similar to Kabirizi, et al. (2007) who stated that, intercropping maize with lablab (24% proportion of lablab in the intercrop) improved (P > 0.05) maize stover dry matter and grain yield by about 5 and 7 percent, respectively compared with the single cropping. Moreover, total forage dry matter, grain yields and cob size were about 32%, 7%, and 6% higher (P < 0.05) in intercrops than in maize alone, respectively.

Land Equivalent Ratio (LER) values

The result of two years shows that all treatments were a better inland equivalent ratio (LER) except T_5 and T_7 whose LER was less than 1 at Meskan. This means if LER is less than 1 it is not economically feasible (Table 3). In the case of Dore Befano T_4, T_8 and T_{11} show that their LER was less than 1 which is not economically feasible, but other treatments show their LER was more than 1 (Table 3).

Means in the row followed by different superscripts are significantly different (*P* < 0.05); SE = standard error of the mean; LER = Land Equivalent Ratio;

Conclusions and recommendations

This study showed the beneficial effects of intercropping maize with annual forage legume (lablab) on forage dry matter and maize grain yield. At Mesken experimental site the maximum LER of 1.23 for a component of intercropped maize fodder verified that those smallholder farmers, who faced land shortage, would require 23% less land to produce the same amount of dry matter fodder yield through the usage of Maize + Lablab intercropping after 30 days at 75% seeding rate. of At Hawassa Zuria (Dore Befano) district (experimental site), the maximum LER of 1.20 for a component of intercropped maize fodder verified that 20% less land is required to produce the same amount of dry matter fodder yield through the usage of Maize + Lablab intercropping after 30 days at full seeding rate.

Hence, those combinations of lablab-maize integration with better LER is recommended as appropriate intercropping date for Dore Befano and Meskan district and other areas with similar agro-ecologies.

Table 3: Two years (2011 and 2012 E.C) land equivalent ratio (LER) values of a different maize-intercropping system for both location (Hawassa Zuraia-Dore Befano and Mesken) Woreda's.

Treatment*	Relative yield mean values of two years at Mesken Woreda			Relative yield means value of two years at Hawassa Zuria Woreda		
	Maize	Lablab	LER	Maize	Lablab	LER
3	0.93	0.27^{a}	1.2	0.76^{ab}	0.3^{a}	1.05
4	0.87	0.15^{bc}	1.04	0.74^{ab}	0.23^{ab}	0.96
5	0.95	0.21^{c}	0.99	0.9^{ab}	0.28^{ab}	1.18
6	0.98	0.11^{c}	1.09	0.85^{ab}	0.2^{ab}	1.05
7	0.89	0.09^{c}	0.98	0.81^{ab}	0.2^{ab}	1.01
8	1.02	0.09^{c}	1.1	0.86^{ab}	0.11^{ab}	0.97
9	0.95	0.07^{c}	1.02	1.09^{a}	0.11^{ab}	1.20
10	1.18	0.06^{c}	1.23	0.93^{a}	0.07^{b}	1.00
11	1.11	0.05^{c}	1.15	0.51^{b}	0.09^{ab}	0.59
SEM	0.11	0.03	0.13	0.12	0.07	0.09

Means in the row followed by different superscripts are significantly different (P < 0.05); SE = standard error of the mean; LER = Land Equivalent Ratio;

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