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Research Article

Intercropping legumes covers with maize on soil moisture improvement in selected dry land areas of Basketo Zone, Ethiopia

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Abstract

Intercropping aims to increase land productivity by offering enough flexibility to grow two or more crops on the same plot of land at the same time. Intercropping systems' advantages are not well understood and have little experimental support. Intercropping's impact on soil moisture conservation in a moisture-stressed environment was assessed in this study. A randomized complete block design was employed in this work to create experimental plots with three replications. Five treatments were tested: lablab with maize, cowpea with maize, lablab with maize, maize only, and lablab with maize. For the investigation of soil moisture and physicochemical properties, disturbed soil samples were taken between 0 and 30 cm below the surface and composited.Each plot's yield and biomass of legume bushes and maize were measured, and the general linear model was used to examine the changes. To assess land production, the land equivalent ratio (LER) was calculated. The result showed that higher soil moisture content was reported on maize-cowpea intercrop (34.33%), followed by maize-lablab intercrop (31.20%) relative to solitary maize (26.83%) at the development stage in the first-year trial. This implies the benefit of legume bushes on soil moisture conservation, both under mono-cropped and intercropped circumstances. In this study, the highest LER values were achieved for maize intercropped with Lablab 1.44 in Angila 4 kebele, while at Angila 3 kebele, the highest LER values were obtained for maize intercropped with cowpea 1.29. Hence, conducting similar studies for more than two years on permanent field plots is vital to achieving considerable changes in soil moisture and soil physicochemical properties, as well as helping farmers make better use of cereal-legume intercropping systems to increase yields in moisture-stress areas.

Keywords: Intercropping; Legume; Land equivalent ratio; Soil moisture; Yield

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1. Introduction

The global population is expected to continue to grow, resulting in a significant increase in food, feed, and fuel demand (Ramankutty et al., 2018). Most smallholder farmers in sub-Saharan Africa often grow cereal crops such as maize (*Zea mays* L.) in a continuous monoculture to support their livelihood, even when productivity and profitability is limited (Baudron et al., 2012b). Under the current agricultural production system in sub-Saharan Africa, it might be very challenging to meet the food and nutrition requirement of the growing population, with the challenges of climate change and variability, land degradation, and infertile soils (Ngwira et al., 2012). As a result, agricultural production requires a shift towards more sustainable cropping systems to help reverse soil degradation and improve production and productivity (Esther et al., 2017).

In Ethiopia, about 90 percent of the total population depends on subsistent agriculture system. It is a leading sector as a source of income, home consumption, employment, and foreign exchange. Agricultural output is also used as an input for industries, so it can stimulate industrialization (Tariku et al., 2018). However, Ethiopia's agriculture land productivity has been decreasing in alarming rate. This can be ascribed to soil degradation and in efficient water resources utilization. Even in years of abundant rainfall, the country's is unable to produce enough grain to feed its population (Kassa, 2003). Sustainable intensification in agriculture seeks to optimize efficiency and reduce losses within crop production systems (Van Ittersum et al., 2016). Intercropping is recognized as a viable agricultural practice within semi-arid regions, with the potential to improve household food and nutrition security while minimizing the negative impacts of continuous cereal mono-cropping (Rapholo et al., 2020). Intercropping can raise aggregate yields per unit area, guarantee against crop failure particularly in arid places and promote the efficiency of land-use by complete and complementary usage of nutrients (Li et al., 2014). Studies have shown that soybean (*Glycine max* L.) intercropped with maize increased land equivalent ratio (1.25-1.46), which indicates that intercropping can increase crop yield (Xu et al., 2020). In addition, intercropping is an effective way to stabilize crop yield and reduce N input (Luce et al., 2015).

According to (FAO, 2011) to alleviate rural poverty and maintain food security, soil fertility needs to be maintained, and agricultural systems need to be modified to boost the productive capacity and stability of smallholder crop production. Greater focus is consequently being devoted to alternate means of intensification, particularly the introduction of intercropping. Cereal-legume intercrop systems are particularly beneficial in marginal sub-Saharan African landscapes, which are characterized by high levels of malnutrition, resource limitations, and rainfall variability. In this region, intercropping systems are indispensable for food and nutritional security in resources poor region (Smith, 2017). More importantly, intercropping with legumes is highly effective in conserving soil moisture, reducing soil erosion and sustaining soil fertility (Cheer et al., 2006). The use of legumes in intercropping systems can improve N-use efficiency and total biomass under reduced chemical fertilizer input (Xu et al., 2020). When intercropped with maize, cover legumes such as cowpea (Bayer et al., 2000), and lablab (Janet et al., 2014) could considerably contribute to soil moisture conservation and increased soil productivity compared to mono cropping.

Across moisture stress zones, like Basketo Zone in Ethiopia, crop failure is widespread. Thus, farmers have been trying to cope with this problem by employing mulches of crop leftovers. This is additionally hard because crop leftovers are used as feed for livestock and energy for cooking. Therefore, using the advantages and opportunities of cover legumes as an intercrop in moisture stress areas could solve the problems simultaneously. Moreover, the contribution of legume to the soil nutrient balance, to improve soil moisture content through reducing evaporation and reduce soil erosion. However, the impacts of legume intercropping have not been well tested in the study of agroecological conditions. In addition, there is limited experimental evidence on the mechanisms underlying benefits of intercropping systems and belowground interactions in intercrops remain largely unstudied. Therefore, this study aimed to evaluate the effect of intercropping different legumes (Cowpea and Lablab) with maize towards soil moisture conservation and crop yield improvement in moisture-stress areas.

2. Materials and Methods

2.1 Description of the study area

The study was conducted for two consecutive years (2020 and 2021) at Basketo Special Woreda in the South Nation Nationalities and People's Regional State of Ethiopia (Figure 1). The woreda is characterized as a moisture stress area. The altitudinal location of the special Woreda ranges from 780-2200 meter above sea level. Temperature of the Special Woreda ranges from 15°C-27°C and its mean annual rainfall ranges from 1000-1400mm (Tariku et al., 2018).

The experimental plots were established in Angila-3 (6°16′125″N, 36°33′34″E) and Angila-4 (6°17′17″N, 36°33′39″E) kebeles (Figure 1).

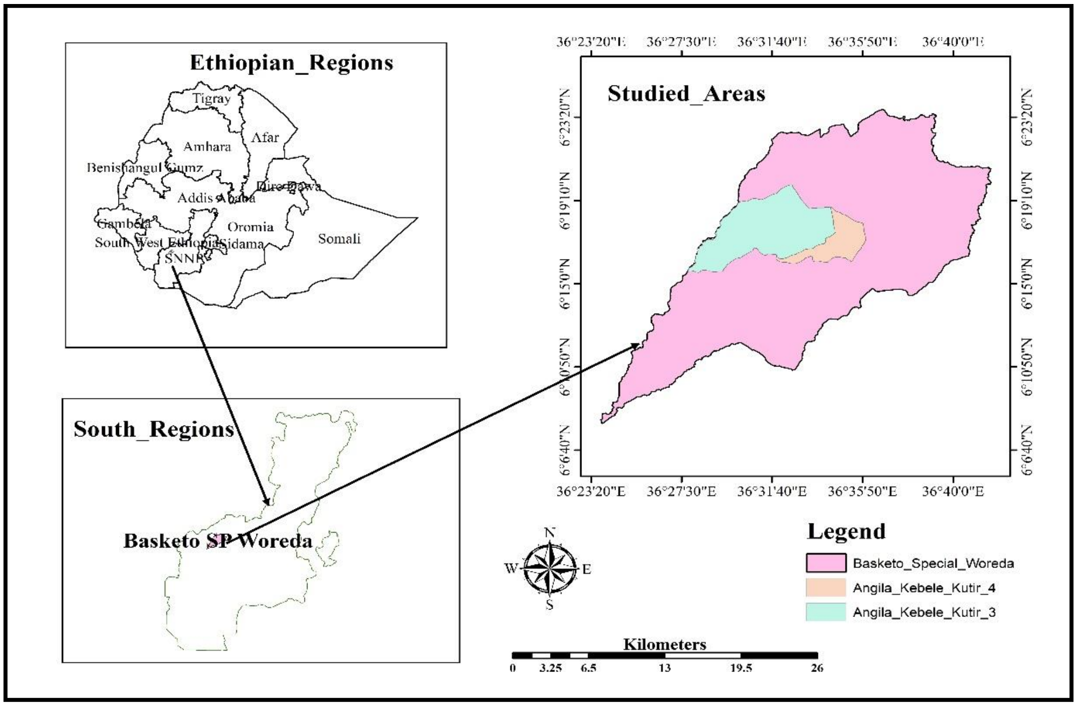

Figure 1. Location map of the study area

2.2 Research design and treatments

In order to determine how maize-legume intercropping affected soil moisture and crop output, the study was carried out at Angila 3 and Angila 4 kebeles. Each farmer's training center had three replications of each of the five treatments in the randomized complete block design (RCBD) studies. Five treatments were applied in this trial: (T1) maize alone, (T2) sole cowpea, (T3) sole lablab, (T4) maize intercropped with cowpea, and (T5) maize intercropped with lablab. The experimental field was prepared by using oxen driven local plow (Maresha). The plot size of the trial was 5m×5m (25m2) and one meter walkway between blocks and plots. Maize was planted based on the recommended spacing (80 cm and 40 cm) between rows and plants, respectively. Leguminous shrubs (Cowpea and Lablab) were sown on one row between maize with spacing of 40 cm and 30 cm between rows and plants respectively. Seed rate used was 25kg/ha for both lablab and cow pea under monocultured conditions and 75% of leguminous seed rate under intercropped conditions. 100 kg of NPSB ha-1 was applied at planting. We used a total of 75 kg of Urea twice, i.e., 50 kg was applied during planting of maize and legume crops and the remaining amount (25 kg) was applied after 35 days of planting. NPSB and Urea was used as a source of Nitrogen, Sulphur, Boron and Phosphorous. For this study, we used BH-140 maize variety. All leguminous shrubs were sown simultaneously with the maize. The treatments were maintained and repeated on the same plots and for the second season by protecting the experimental plots from livestock grazing as well as crop residues after harvesting was left on the plots in the first season. All agronomic management practices, such as weeding, pest control, etc., were performed during the trial period per the research recommendations for maize and legume crops.

2.2.1 Data collection

2.2.1.1 Soil sampling

To monitor the soil moisture status of each plot, disturbed soil samples were collected from the intra-row spacing of the intercropped plots from five sampling points at a depth of 0-30 cm at three stages at (planting, development stage and harvesting). Similarly for the non-intercropped plots, a sample was collected from the intra-row spacing from there different sampling points. Then, a composite soil sample was prepared for all plots. The weight of the wet soil sample was measured at site using digital scale and then taken to the laboratory. Then, the soil was oven-dried at 105°C for 24 hour. Finally, the gravimetric method was used to determine the soil moisture content in grams, which was then converted to a volumetric base using the following (Eq. 1).

$$SMC = \frac{\mathrm{Ww}-\mathrm{Wd}}{\mathrm{Wd}} \tag{1}$$

Where SMC, soil moisture contents %; Ww, weight of wet soil (gm); Wd, weight of dry soil (gm). In addition, at sowing time composite subsurface soil sample was collected to determine the soil physico-chemical properties of the study sites. Subsurface soil samples were, however, taken independently from each treatment-based plot at harvest time in order to analyze the soil's physico-chemical characteristics, including pH, organic carbon concentration (OC), total nitrogen concentration (TN), phosphorus and potassium availability, and exchangeable acidity.

2.2.1.2 Crop data

Grain yield and biomass of maize and legumes were determined by harvesting an area of 4m x 4m (16m2) from the total plot area of 25m2 and converted into tonnes per hectare basis. Grain yield was adjusted to 12.5% moisture level; whereas plant biomass was weighed after leaving it in open air.

2.3 Data analysis

The collected data were subjected to one way analysis of variance (ANOVA) using SAS software and least significant difference (LSD) was used to test significance of means differences at p≤0.05 levels.

For intercropped plots, land equivalent ratio (LER) was calculated to determine total production. LER was estimated using the following relationship (Eq. 2) (Willey & Osiru, 1972);

$$\mathrm{LER} = \frac{\mathrm{YMint}}{\mathrm{YMsol}} + \frac{\mathrm{YLint}}{\mathrm{YLsol}} \quad (2)$$

Where, YMint = Yield of maize under intercropping conditions; YMsol = Yield of maize under sole crop conditions; YLint = Yield of legume under intercropping conditions and YLsol = Yield of legume under sole crop condition.

3. Results and Discussion

3.1 Effect of intercropping on soil physicochemical properties

Table 1 presents we analyzed and documented the baseline condition of soil physicochemical properties. We found that before experiment in experimental sites according to (Tekalign, 1991); Soil OM or OC ratings, the soil property values of %OC are between 1.5-3.0, %OM is between 2.59-5.17 which are under medium rates and total nitrogen is between 0.05 - 0.12 which are under low rates accordingly, in both the study site the availability of total nitrogen was under low rates. The surface soil pH values varied from 6.25-6.56 and rated as slightly acidic. The textural classes of the surface soils at both experimental sites were silty clay loam and loam (Table 1).

Table 1. Physicochemical properties of the soil under experimental site before the experiment (2020)

Study site	Parameters										
	pH (H_2O)	EC (ds/m)	OC (%)	OM (%)	TN (%)	C:N ratio	Av.P (ppm)	Texture			
								%Sand	%Clay	%Silt	Textural class
Angila 3	6.25	2.39	2.79	4.79	0.11	13.95	27.9	41.6	22	36.4	Loam
Angila 4	6.56	1.85	2.44	4.13	0.10	11.62	23.2	20	38.6	41.4	Silty clay loam

pH=Power of hydrogen, NT=Total Nitrogen, OC=Organic Carbon, OM=Organic matter, Av.P=Availability of Phosphorus, EC= Electrical conductivity, C:N= Carbon-to-Nitrogen ratio

The result from experimental plots showed the surface soil pH values increased at the experimental site of Angila 4 and were rated as neutral in all treatments relative to maize mono-cropping (Table 2). Soil organic matter content of surface soils were varied from 2.6-5.2% at baseline condition (i.e., prior to experimental trials) (Table 1) and rated as moderate ranges

(Berhanu, 1980). The result also showed high ranges >5.2% of organic matter in maize intercropping with lablab (6.67%) and in monocropped conditions of Cowpea (6.57%) in Angila 4 as well as monocropped conditions of Lablab (5.63%) in Angila 3 after the experiment (Table 2). Our finding is also similar to rating described by (Tekalign, 1991). Soil organic matter content can alter and improve the physical, chemical, and biological properties of soils, then helps to increase plant productivity. This is because of the intercropping of legume crop and the fast mineralization of nitrogen from the organic matter. The distribution pattern of total nitrogen across experimental sites were similar to that of soil organic matter, since soil organic matter content is a good indicator of the available nitrogen status in the soil. According to (Havlin, 1999) total nitrogen content of soils is categorized as low (<0.15%), medium (0.15-0.25%), and high (> 0.25%) which revealed that, in both study sites the availability of total nitrogen was rated as medium (Table 2) and it was also similar with (Tekalign, 1991) ratings.

Table 2. Physico-chemical properties of soil after experiment (2021)

Studied sites	Treatments	Parameters								
		pH (H_2O)	EC (ds/m)	OC (%)	OM (%)	TN (%)	C:N ratio	A.v.P (ppm)	CEC (mg/kg)	Av. K (mg/kg)
Angila 3	Maize only	6.4	0.11	2.27	3.91	0.19	11.95	20.7	86.76	7.4
	Lablab only	6.3	0.14	3.27	5.63	0.22	14.86	21.0	85.86	6.17
	Cowpea only	6.3	0.11	1.93	3.32	0.20	9.65	22.0	58.46	7.0
	Maize + Lablab	6.4	0.12	2.88	4.95	0.21	15.16	18.0	76.5	7.87
	Maize+ Cowpea	6.5	0.12	2.70	4.64	0.22	12.27	19.0	55.97	8.08
Angila 4	Maize only	6.50	0.22	2.93	5.04	0.16	16.28	28.0	86.76	7.4
	Lablab only	6.85	0.20	2.38	4.10	0.18	14.0	27.6	85.86	6.17
	Cowpea only	6.91	0.22	3.82	6.57	0.19	20.11	32.0	58.46	7.0
	Maize + Lablab	6.73	0.21	3.87	6.67	0.20	22.76	33.7	76.5	7.87
	Maize+ Cowpea	6.75	0.18	2.70	4.64	0.21	12.86	27.8	55.97	8.08

pH=Power of hydrogen, NT= Total Nitrogen, OC=Organic Carbon, OM=Organic matter, Av. P=Availability of Phosphorus, Av. K= Availability of Potassium, EC=Electrical conductivity, C:N= Carbon-to-Nitrogen ratio

3.2 Effect of intercropping on soil moisture

Soil moisture and water availability to plants are determining factors in intercropping systems. Efficient water use leads to the use of other resources. At the development stage of the first-year study, maize cowpea intercrop had higher soil moisture content (34.33%), followed by maize lablab intercrop (31.20%), compared to solitary maize (26.83%) (Figure 2). Similarly, during the second year of the trial, the maize cowpea intercrop had greater soil moisture content (28.16%), followed by the maize lablab intercrop (25%), compared to solitary maize (19.45%) at the development stage (Figure 3). Similar study was also found by (Ayele, 2020) in Bena-Tsemay district, South Omo zone; Southern Ethiopia where intercropping of maize with cowpea had better soil moisture

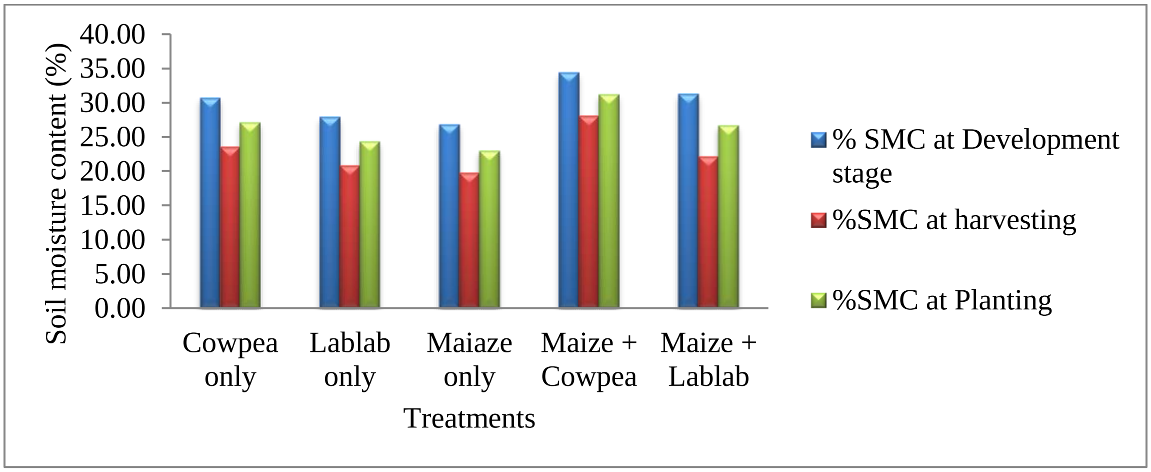

Figure 2. Effects of intercropped maize-legume covers on % soil moisture content (SMC) at first year in 2020 (Angila 4 kebele)

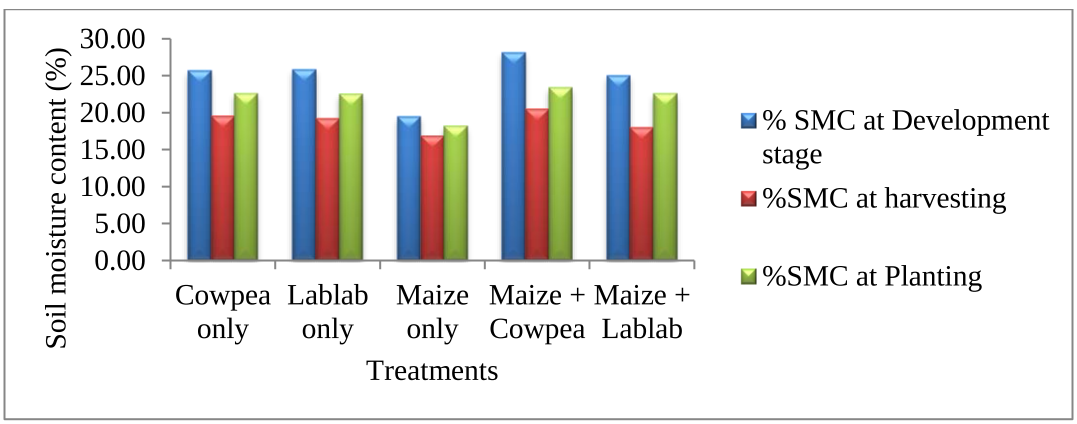

Figure 3. Effects of intercropped maize-legume covers on % soil moisture content (SMC) at second year in 2021 (Angila 4 kebele)

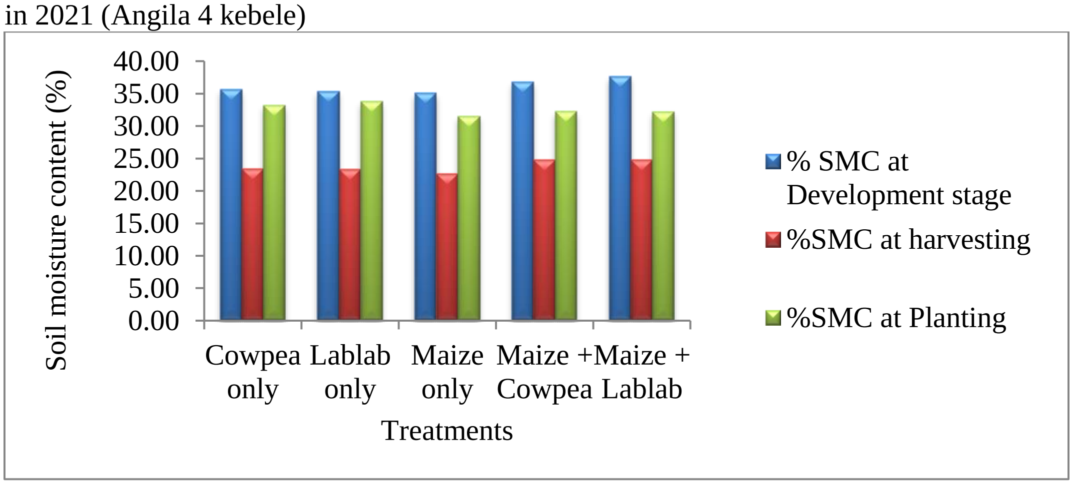

Figure 4. Soil moisture contents (SMC in %) at different growth stage at Angila 3 kebele for one year trial in 2021

contents during active crop development stage. Soil moisture content in the soil was lower in the sole crop of maize this may be due to high evaporation potential, whereas in maize intercrop with cowpea and lablab was high due to low evaporation potential in both growth stages and trial years. The study result also corresponds with a study by (Bayer et al., 2000); when intercropping maize with cowpea and intercropping maize with lablab (Janet et al., 2014) could significantly contribute to soil moisture conservation and increased soil productivity compared to sole maize cropping.The soil moisture content did not differ significantly at planting and harvesting stages in Angila 3 Kebede ($P <0.05$). However, better result was obtained by maize-lablab intercropped conditions (37.6%) followed by maize-cowpea intercrop (36.8%) at the development stage (Figure 4). The present result was supported by a study of (Sagar et al., 2020) revealed the combination of maize-cowpea intercropping can assure greater light interception and check evaporation loss of soil moisture than a pure stand of maize. A study conducted by (Bagegnehu et al., 2021) at Misrak Azerinet woreda, southern Ethiopia also revealed that, intercropping maize with legumes have comparable soil moisture content at development stage. Soil moisture and water availability to plants are determining factors in intercropping systems, and efficient water use leads to the use of other resources. Scientific investigations have shown that the maize-legume combination registered greater water use efficiency than that of sole crops, and under water stress conditions, it could be one of the best options (Sagar et al., 2020).

3.3 Effect of intercropping on yield and yield components of maize

The analysis showed that there was a significant difference in grain yield of sole maize and intercropped conditions of maize with lablab and cowpea in the growing season of 2021 at Angila 4 kebele, as well as between sole maize and intercropped condition of maize with lablab at Angila 3 kebele (Table 3). A study by Sagar et al. (2020) noted that higher yield in maize-cowpea intercropping combination than in pure stand. The study also indicated that the plant height of maize was not significantly different ($P<0.05$) in both cropping seasons and sites, and other studies also reported similar results (Ayele, 2020 & Arun, 2016). In the study conducted in Bena-Tsemay Woreda, Southern Ethiopia by Biruk et al. (2021) reported as there is no significant effect of intercropping on plant height and cob length of maize plant. Similarly, in terms of maize biomass, the study also revealed that there was a significant difference ($P \leq 0.05$)

in both trial sites in the year 2021 between sole maize and intercropped condition of maize with lablab and cowpea.

However, there was no significant difference in biomass among cropping systems in the first year trial ($P \leq 0.05$) in Angila 4 kebele, which was inconsistent with the study by (Ayele, 2020). The study showed that higher value in grain yield and biomass was recorded under sole cropping. Non-significant effects in all growth parameters and maximum values were observed in sole cropping system over that of intercropped in the study by (Nigussie & Daba, 2022).

Table 3. Grain yield and biomass of Maize under legume shrub

	Angila 4 (1st year/2020)			Angila 4 (2nd year/2021)			Angela 3 (1st year/2021)		
	Ph(m)	Bm(t/ha)	Gy(t/ha)	Ph(m)	Bm(t/ha)	Gy(t/ha)	Ph(m)	Bm(t/ha)	Gy(t/ha)
Maize + Lablab	2.31	13.8	7.2	2.24	26.13^{b}	3.67^{b}	2.40	25.63^{b}	3.40^{b}
Maize + Cowpea	2.23	11.8	5.5	2.23	27.90^{b}	3.97^{b}	2.33	26.23^{b}	4.30^{ab}
Maize only	2.16	16.14	7.35	2.15	35.53^{a}	5.07^{a}	2.28	33.27^{a}	5.27^{a}
LSD (0.05)	ns	ns	ns	Ns	5.5	0.66	ns	6.4	1.7
CV (%)	5.7	15.5	14	5.1	8.1	6.7	6.5	9.9	17.8

Ph=Plant height, BM= Biomass, Gy= Grain yield, ns=not significant. Mean values with different letters within the column are statistically different at $P \leq 0.05$.

3.4 Effect of intercropping on yield and yield components of legumes

The analysis showed that there were significant differences in biomass and grain yield of legumes in both cropping systems (i.e., monocropped and intercropped) in both growing seasons and trial sites ($P \leq 0.05$). In monoculture, the yield of legumes was higher, whereas the lowest yield was obtained when legumes were intercropped with maize (Table 4). As reported by (Chemeda, 1997) higher grain yield was recorded under sole cowpea compared to intercropping. Competition for water, nutrients and shading are maybe the factors that reduced cowpea yield under high numbers of maize plants in intercrop (Lesoing & Francis, 1999).

In terms of biomass as shown in (Table 4) there were significant difference between sole cowpea and intercropping cowpea with maize in both growing season and trial sites. Biruk et al. (2021) also reported that total biomass of cowpea was significantly influenced by cropping

Table 4. Grain yield and biomass of cowpea and lablab

Treatments	Angila 4 (1st year/2020)		Angila 4 (2nd year/2021)		Angela 3 (1st year/2021)	
	Bm/ton/ha	Gy/ton/ha	Bm/ton/ha	Gy/ton/ha	Bm/ton/ha	Gy/ton/ha
Cowpea + Maize	28^{b}	0.14^{b}	16.70^{b}	0.18^{b}	17.0^{b}	0.45^{b}
Cowpea only	41.45^{a}	1.06^{a}	26.28^{a}	0.53^{a}	25.33^{a}	0.96^{a}
LSD (%)	10.5	0.8	6.8	0.12	7.5	0.4
CV (%)	8	37	9	9.8	10.2	17.6
Lablab + Maize	4.2^{b}	1.46^{b}	30.53	1.10	22.07	0.50^{b}
Lablab only	5.77^{a}	2.5^{a}	38.4	1.53	33.37	0.93^{a}
LSD (0.05)	0.95	0.5	Ns	ns	ns	0.37
CV (%)	5.43	7.42	10.7	13.5	13.4	15

Ph= Plant height, Bm=Biomass, Gy= Grain yield; ns=not significant. Mean values with different letters within the column are statistically different at $P \leq 0.05$.

system. A study result by (Baudron et al., 2012b) described that, total biomass of (maize + cowpea) intercrops was higher than in sole maize or cowpea stands and biomass production and is seen as a benefit of intercropping in mixed crop-livestock systems, which are characterized by competing uses of crop residues mainly for livestock feed and for maintaining soil organic matter. Hauggaard et al. (2001) also reported that legume-cereal intercropping performance indicates yield advantages and greater yield stability as compared to legume sole cropping.

3.5 Effect of intercropping on land use efficiency

Land equivalent ratio is the most common index adopted in intercropping to measure land productivity. It is often used as an indicator of the effectiveness of intercropping (Seran & Brintha, 2009b). Any value greater than 1.0 represents that a yield advantage for intercropping. In this trial, as shown in (Table 5), the highest LER values were obtained for maize intercropped with Lablab 1.44 in the second trial year at Angila 4 kebele inturn, indicating that 44% more area would be required by sole cropping system to equal the yield of the intercropping pattern. While, in Angila 3 kebele there is highest LER values or yield advantages were obtained for maize intercropped with cowpea 1.29 (Table 6) which indicats that, 29% more area would be required by sole cropping system to equal the yield of the intercropping pattern. Therefore, this showed that land was effectively utilized under maize-legume intercropping and is more advantageous than for sole cropping. A LER greater than 1.0 has been reported with bean-maize intercropping by (Saban et al., 2007). A study by Biruk et al., 2021 showed that, LER was greater when maize intercropped with cowpea. Mashingaidze (2004) also revealed that, land was effectively utilized under intercropping and yield was improved.

Table 5. Land equivalent ratio (LER) of intercropping of maize with legume crops at Angila 4 kebele

	Yield (ton/ha) first year				Yield (ton/ha) second year			
Treatments	Maize	Lablab	Cowpea	LER	Maize	Lablab	Cowpea	LER
Maize + Lablab	7.2	1.46	-	1.55	3.67	1.10	-	1.44
Maize + Cowpea	5.5	-	0.14	0.88	3.97	-	0.18	1.12
Maize only	7.35	-	-		5.07	-	-	
Cowpea only	-	-	1.06		-	-	0.53	
Lablab only	-	2.5	-		-	1.53	-	

Consistently (Amede & Nigatu, 2001) received the LER value of 1.5. Similarly (Stoltz & Nadeau, 2014) showed that intercropping commonly leads to a higher protein content compared to monocropped maize and higher yield on a LER >1 basis compared with maize monocropped. Intercropping can increase aggregate yields per unit input, insure against crop failure particularly in dry regions and enhance the efficiency of land-use by complete and complementary utilization of nutrients (Li et al., 2014). Esther et al. (2017) who have conducted both on-station and on-farm study revealed that, the total yield was higher in the intercrops than the sole crops of either maize or cowpea and most intercrop treatments had LER > 1 pointing to the greater land use efficiency of the maize-cowpea intercrop system compared to sole cropping.

Table 6. Land equivalent ratio (LER) of intercropping of maize with legume crops at Angila 3 kebele

	Yield (ton/ha) first year			
Treatments	Maize	Lablab	Cowpea	LER
Maize + Lablab	3.40	0.50	-	1.18
Maize + Cowpea	4.30	-	0.45	1.29
Maize only	5.27	-	-	
Cowpea only	-	-	0.96	
Lablab only	-	0.93	-	

4. Conclusion

It is concluded that intercropping cereals with legumes significantly enhances soil moisture content compared to growing cereals alone. The highest Land Equivalent Ratio (LER) values were observed in maize intercropped with cowpea and Lablab at both trial sites. This suggests that intercropping not only helps to retain nutrients in the field but also improves the availability of soil moisture. Farmers are encouraged to practice intercropping to improve soil moisture, specifically by intercropping maize with Lablab and cowpea rather than relying solely on a pure stand of maize. For regions similar to Angila 4, it is recommended that farmers who intercrop maize choose Lablab. Conversely, in areas like Angila 3, farmers should opt to intercrop maize with cowpea. To enhance the productivity of these intercropping systems, further studies should be conducted while considering other production factors.

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Conflict of Interest

We declare no potential conflict of interests.

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