Effect of intercropping of maize and cowpea on the yield, land productivity and profitability of components crops in Bena- Tsemay Woreda, Southern Ethiopia

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ABSTRACT

Field experiment was carried out during the 2017-18 cropping season at Kako, Bena-Ttsemay woreda, South Omo zone, Southern Ethiopia to determine the effect of intercropping of maize and cowpea on the yield, land use efficiency and profitability of both crops. The experiment consisted of 4 treatments (sole maize, sole cowpea, one row maize to one row cowpea and one row maize to two-row cowpea) and laid in RCBD in four replications. Intercropping of one row maize to one row cowpea and one row maize to two-row cowpea, resulted in 55.8% and 27.9% greater land use efficiency than for either crop grown alone. The highest MAI was obtained by growing one row of maize to one row of cowpea (11563.17) followed by one row maize to two-rows of cowpea (6783.50).Based on the present finding, intercropping of one row maize and one row cowpea more economic advantage than the other crop combination or grown alone. Therefore, intercropping of one row maize to one row cowpea is an advantageous to farmers in the study area since it would provide additional crop yield with the same piece of land and more profitable related to cost benefit.

Keywords: Inter cropping, Maize, Cowpea, Yield

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Introduction

Intercropping is the growing of two or more crops simultaneously on the same field such that the period of overlap is long enough to include the vegetative stage (Lithourgidis *et al.,* 2011). Intercropping, double cropping and other mixed cropping practices that allow more efficient uses of farm resources are among the agricultural practices associated with sustainable crop production (NRC, 1993; Tolera, 2003).

Reported grain legume–cereal intercropping performance indicates some principal advantage worth considering while directing present agricultural practices in more sustainable directions like yield advantages and greater yield stability over years compared to grain legume sole cropping (Hauggaard-Nielsen, *et al.,* 2001; Jensen, 1996).

The main concept of intercropping is to get increased total productivity per unit area and time, besides equitable and judicious utilization of land resources and farming inputs including labor. One of the main reasons for higher yields in intercropping is that the component crops are able to use natural resources differently and make better overall use of natural resources than grown separately (Willey, 1979). A careful selection of crops having different growth habit can reduce the mutual competition to a considerable extent.

Sustainable intensification of maize legume systems via intercropping had multiple advantages. These include soil moisture conservation, soil nutrient enhancement, increment in soil carbon trapping, reduction of soil erosion by wind and water, and ultimately increment in crop productivity per unit of land. Cereal-legumes mixtures have been adjudged the most productive form of intercropping. Since, the cereals may benefit from the nitrogen fixed in the root nodules of the legumes the study of intercropping maize and cowpea very important. However, there is no much work has been done in the area regarding cereal legume intercropping. Thus, this study was undertaken to evaluate the benefit of inters cropping with sole cropping on yield and yield components.

Materials and Methods

Description of the study area

This experiment was conducted at Kako, Bena-Tsemay woreda South Omo Zone during 2017-18 cropping season. Kako is located about 730 km from the capital city of Addis Ababa, and 500 km from SNNPRS capital city of Hawassa, in the south eastern part of the country in South Omo zone. It lies at 036° 40.259' E longitude and 05° 38.332' N latitude at an altitude of 1205 masl. The study area has a mean annual rainfall and temperature ranging from 800-1000 mm and 18-32.1°C, respectively.

Experimental treatments and procedures

Field experiment conducted using 4 treatments and laid in randomized complete block design in 4 replications. The treatments involved sole maize, sole cowpea, one row maize to one row cowpea and one row maize to two-row cowpea.

The study used maize (variety MH 140) and cowpea (variety black eye bean). Maize planted using 80×25 cm of inter and intra row spacing and two-rows of 40 and 20 cm apart were left made between the two maize rows to plant cowpea. Seeds of cowpea placed at 10 cm intra spacing.

Observation and measurement

Plant height, cob length, grain yield and total biomass were taken from maize plant. Plant height, number of pod per plant, number of seed per pod, grain yield and total biomass were taken from cowpea plant. The collected data were subjected to ANOVA using SAS computer software (SAS Institute, 2000).

Land use efficiency was determined by calculating Land equivalent ratio (LER) using (Mead and Willey, 1980) Land equivalent ratio of maize is calculated as intercrop yield of maize/pure stand yield of maize and that of cowpea is calculated as intercrop yield of cowpea/pure stand yield of cowpea. The overall LER is simply the sum of LER of maize and LER of cowpea. The competitive value is determined by calculating the ratio of the individual LER's of the two crops.

LER= Yab/ Yaa + Yba/ Ybb

Where,

Yab = Intercrop yield of crop "a" Yba = Intercrop yield of crop "b" Yaa = Pure stand crop yield of "a" Ybb = Pure stand crop yield of "b"

LER= 1: no advantage of intercrop
LER<1: intercropping reduce total yield
LER>1: intercropping increase total yield thus beneficial

Finally, the monetary advantage index (MAI) was calculated since none of the above competition indices provides any information on the economic advantage of the intercropping system. The calculation of MAI was as follows:

MAI = (value of combined intercrops) (LER-1) /LER

Results and Discussion

Effect of intercropped cowpea with maize on plant height, cob length, grain yield and total biomass of maize

There was no significant effect of intercropping on plant height and cob length of maize plant (Table 1). Maize yield was significantly influenced by cropping system. The highest grain yield (4228.67 kg ha^{-1}) was obtained by sole cropping system. This could be attributed to high plant density and lack of competition for resources such as light, nutrients and water. Among the intercrops, the grain yield of maize is higher when intercropped with the ratio of one row maize to two-row cowpea 3577.67 kg ha^{-1} followed by one row maize to one row cowpea 3271.00 kg ha^{-1} (Table 1). Factors that affect competition in intercropping systems were not determined in the present study. However, differences in the depth of roots, lateral root spread and root densities are some of the factors that affect competition between the component crops in an intercropping system for nutrients (Eskandari and Ghanbari, 2009). Previous studies reported yield reduction in cowpea and maize in maize-cowpea intercrops (Willey and Osiru, 1972) due lower plant densities.

Maize total biomass was significantly influenced by cropping system. The highest total biomass was obtained from sole cropping (17.39 t ha^{-1}). The total biomass of maize is higher when intercropped with the ratio of one row maize to two-row cowpea (16.17 t ha^{-1}) followed by one row maize to one row cowpea (14.35 t ha^{-1}) (Table 1).

Table 1. Effect of intercropped cowpea with maize on yield and yield components of maize.

Treatments	PH (cm)	CL (cm)	GY (Kg ha^{-1})	TBM (t ha^{-1})
Sole maize	217.80	17.60	4228.67[a]	17.39[a]
1Maize: 1Cowpea	216.27	17.42	3271.00[c]	14.35[b]
1Maize: 2Cowpea	217.18	17.00	3577.67[b]	16.17[a]
LSD 5%	NS	NS	283.29	1.39
CV (%)	16.94	36.30	19.20	14.50

Mean values within column followed the same letters are not significantly different (P < 0.05).
PH=Plant height, CL=Cob length, GY=Grain yield and TBM=Total biomass.

Effect of intercropped cowpea with maize on plant height, number of pod per plant, number of seed per pod, grain yield and total biomass of cowpea

There was no significant effect of intercropping on plant height, number of pod per plant and number of seed per plant of cowpea plant (Table 2).

Cowpea yield was significantly influenced by cropping system. The highest grain yield (1317.13 kg ha^{-1}) was obtained by sole cropping system. The grain yield of cowpea is higher when intercropped with the ratio of one row maize to one row cowpea 1033.77 kg ha^{-1} followed by one row maize to two-row cowpea 568.63 kg ha^{-1} (Table 2). This is consistent with the findings of Alhaji (2008) he observed reduction in cowpea yield due to high maize density in the intercropping system.

Chemeda (1997) reported higher grain yield under sole cowpea compared to intercropping. Competition for water, nutrients and shading are probably the two factors that reduced cowpea yield under high numbers of maize plants in Intercrop (Lesoing and Francis, 1999).

Cowpea total biomass was significantly influenced by cropping system. The highest total biomass (5.51 t ha^{-1}) was obtained by sole cropping system. The total biomass of cowpea is higher when intercropped with the ratio of one row maize to one row cowpea (3.50 t ha^{-1}) followed by one row maize to two-row cowpea (2.33 t ha^{-1}) (Table 2).

Table 2. Effect of intercropped cowpea with maize on yield and yield components of cowpea.

Treatments	PH(cm)	NPPP	NSPP	GY (Kg ha^{-1})	TBM (t ha^{-1})
Sole cowpea	48.26	32	10.67	1317.13[a]	5.501[a]
1Maize: 1Cowpea	49.13	30	10.00	1033.77[a]	3.50[b]
1Maize: 2Cowpea	48.83	30	9.66	568.63[b]	2.33[c]
LSD 5%	NS	NS	NS	295.78	0.31
CV (%)	19.30	11.90	6.90	9.98	14.50

Mean values within column followed the same letters are not significantly different (P < 0.05).
PH=Plant height, NPPP=Number of pod per plant, NSPP=Number of seed per plant, GY=Grain yield and TBM=Total biomass.

Land Equivalent Ratio (LER) and Monetary Advantage Index (MAI) of intercropped maize with cowpea

The land equivalent ratio (LER) was greater when maize intercropped with cowpea. The highest LER was obtained by growing one row maize to one row cowpea (1.558) followed by one row maize to two-row cowpea (1.279) (Table 3).

The highest MAI was obtained by growing one row maize and one row cowpea (11563.17) followed by one row maize and two-row cowpea (6783.50). Intercropping of one row maize and one row cowpea more economic advantage (32285.70 Ebirr) than the other crop combination or grown alone (Table 3).

Table 3. Land Equivalent Ratio (LER) Monetary Advantage Index (MAI) of intercropped maize with cowpea.

Treatments	Grain yield (Kg ha^{-1})		LER	MAI	Value ha^{-1} (Eth. Birr)
	Maize	Cowpea			
Sole maize	4228.67	-	-	-	31715.03
Sole cowpea	-	1317.13	-	-	9878.47
1Maize: 1Cowpea	3271.00	1033.77	1.558	11563.17	32285.70
1Maize: 2Cowpea	3577.67	568.63	1.279	6783.50	31097.20

Intercropping of one row maize to one row cowpea and one row maize to two-row cowpea, reduces maize yield by 957.67 and 651 kg ha^{-1}, respectively. However, intercropping of one row maize to one row cowpea and one row maize to two-row cowpea, resulted in 55.8 and 27.9% greater land use efficiency than for either crop grown alone (Table 3). Therefore, this showed that land utilization efficiency for maize- cowpea intercropping was more advantageous than for sole cropping. A LER greater than 1.0 has been reported with bean maize intercropping (Saban *et al.*, 2007).

Conclusion and Recommendation

Based on the present finding, land use efficiency improved by 55.8% when intercropping of one row maize to one row cowpea and intercropping of one row maize to two-row cowpea was by 27.9%, which indicated that when intercropped, the productivity was higher than the sole. The highest MAI was obtained by growing one row maize to one row cowpea (11563.17) followed by one row maize to two-row cowpea (6783.50). Intercropping of one row maize and one row cowpea more economic advantage (32285.70

Ebirr) than the other crop combination or grown alone. Therefore, intercropping of one row maize to one row cowpea is important to farmers since it would provide additional crop yield with the same piece of land and more profitable related to cost benefit. Obtaining additional food grain is an attractive option for the farmers having land shortage to plant maize and cowpea separately. Thus, the benefit of obtaining additional legume grain would have positive advantage on food security and land use efficiency.

References

Alhaji, I.H. 2008. Yield performance of some varieties under sole and intercropping with maize at Bauchi, Nigeria. *African Res. Rev.* 2(3): 278-291.
https://doi.org/10.4314/afrrev.v2i3.41073

Chemeda, F. 1997. Effects of planting pattern, relative planting date and intra-row spacing on a haricot bean/maize intercrop. *African Crop Sci. J.* 5(1): 15-22.
https://doi.org/10.4314/acsj.v5i1.27866

Eskandari, H. and Ghanbari, A. 2009. Intercropping of Maize (*Zea mays*) and Cowpea (*Vigna sinensis*) as whole-crop forage: effect of different planting pattern on total dry matter production and maize forage quality. *Not. Bot. Hort. Agrobot. Cluj* 37(2): 152-155.

Hauggaard-Nielsen, H., Ambus, P. and Jensen, E.S. 2001. Interspecific competition, N use and interference with weeds in pea–barley intercropping. *Field Crops Res.* 70: 101–109.
https://doi.org/10.1016/S0378-4290(01)00126-5

Jensen, E.S. 1996. Grain yield, symbiotic N2 fixation and interspecific competition for inorganic N in pea–barley intercrops. *Plant and Soil.* 182: 25–38.
https://doi.org/10.1007/BF00010992

Lesoing, W.G. and Francis, C.A. 1999. Strip intercropping effects on yield and yield components of corn, grain sorghum, and soybean. *Agron. J.* 91(5): 807–813.
https://doi.org/10.2134/agronj1999.915807x

Lithourgidis, A.S., Dordas, C.A., Damalas, C.A. and Vlachostergios, D.N. 2011. Annual Intercrops: an alternative pathway for sustainable agriculture. *Australian J. Crop Sci.* 5(4): 396-41.

Mead, R. and Willey, R.W. 1980. The concept of land equivalent ratio and advantages in intercropping. *Expl. Agric.* 16: 217-228.
https://doi.org/10.1017/S0014479700010978

NRC. 1993. Sustainable agriculture and the environment in the humid tropics. National Research Committee, National Academy Press. Washington D.C. 702p.

Saban, Y. Mehmt, A. and Mustafa, E. 2007. Identification of advantages of maize–legume intercropping over solitary cropping through competition indices in the East Mediterranean Region. *Turk. J. Agric.* 32: 111- 119.

SAS Institute. 2000. SAS Users guide, Statistics version 8.2. ed. SAS. Inst,. Cary.NC., USA.

Tolera, A. 2003. Effects nitrogen, phosphorus farmyard manure and population of climbing bean on the performance of maize (*Zea mays* L.)/ climbing bean (*Phaseolus vulgaris* L.) intercropping system in Alfisols of Bako. MSc Thesis, School of Graduate Studies of Alemaya University, Dire Dawa, Ehtiopia. 75p.

Willey, R.W. 1979. Intercropping-Its importance and research needs. Part I competition and yield advantages. *Field Crop Abstr.* 32 : 1-10.

Willey, R.W. and Osiru, D.S.O. 1972. Studies on mixtures of maize and beans with particular reference to plant population. *J. Agric. Sci.* 79(3): 517–529.
https://doi.org/10.1017/S0021859600025909