academicJournals

Vol. 8(29), pp. 3921-3929, 1 August, 2013
DOI: 10.5897/AJAR12.1044
ISSN 1991-637X ©2013 Academic Journals
http://www.academicjournals.org/AJAR

African Journal of Agricultural Research

Full Length Research Paper

The effect of integrated organic and inorganic fertilizer rates on performances of soybean and maize component crops of a soybean/maize mixture at Bako, Western Ethiopia

Abebe Zerihun[1]*, J. J. Sharma[2] and Dechasa Nigussie[2] and Kanampiu Fred[3]

[1]Bako Agricultural Research Center, P. O. Box 03, Bako West Shoa, Ethiopia.
[2]Haramaya University, P. O. Box, 138, Dire Dawa, Ethiopia.
[3]International Maize and Wheat Improvement Centre (CIMMYT), P.O. Box 1041-00621, Nairobi, Kenya.

Accepted 24 July, 2013

The experiment was conducted to determine the best compatible soybean varieties in intercropping systems and the most economically optimum integrated fertilizer rate. The factorial experiment consisted of two soybean varieties (Didessa and Boshe) treated with eight levels of combined organic and inorganic fertilizer applications in three replications. Both sole soybeans and maize under recommended fertilizer recommendation were also included for comparison purposes. The result indicated that there were significant differences in leaf area index, plant height and grain yield of maize due to integrated fertilizer application, but not in harvest index. However, statistically significant variations were observed on nodule number per plant, leaf area per plant and yield of intercropped soybeans as a result of soybean varieties and the interaction of varieties with fertilizer application. Higher nodules and leaf areas per plant were recorded in Didesa variety than Boshe. This could be due to varietal difference, integrated fertilizer application and cropping systems as well. Yield advantage obtained due to various combinations of fertilizer rates ranged from 6 to 28% over the yield of sole maize. Monetary advantage (MA) obtained due to intercropping systems ranged from the lowest Birr 1927 ha^{-1} to Birr 8446 ha^{-1} under various proportions of fertilizer applications. Application of both recommended NP and farmyard manure (FYM) resulted in the highest (Birr 8446 ha^{-1}) MA followed by recommended NP (Birr 4583 ha^{-1}). However, an integrated use of 12 t ha^{-1} FYM with 28/12N/P_2O_5 saved up to 75% cost of commercial fertilizer for both years and cost for application in the next year.

Key words: Varieties, organic and inorganic fertilizers, intercropping.

INTRODUCTION

Sustainable agriculture is successful management of resources to satisfy changing human needs while conserving natural resources. However, area of cultivable land per unit household is dwindling from time to time due to population pressure. This leads to intensive crop production per unit area of land. Intercropping is one of the intensive cropping systems which ensure sustainable utilization of limited land resources (Tesfa et al., 2001). The extent and importance of intercropping increases as farm size decreases and the smaller the farm size the more complex the combinations. In tropics, cereal/legume intercropping is commonly practiced because of yield advantages, greater yield stability and lower risks of crop failure, which are often associated with monoculture

*Corresponding author. E-mail: baatiree@gmail.com.

(Nielsen et al., 2001; Tusbio et al., 2005). In intercropping systems, legumes can provide N for intercropped cereals through N transfer (Rochester et al., 2001). The same author indicated that soybean crop is capable of supplying nitrogen for its growth and intercropped cereals through symbiotic nitrogen fixation, and hence reduces the need for expensive and environment polluting nitrogen fertilizer. Maize is a staple food crop for smallholder farmers in western Ethiopia which is suitable for intercropping with legume crops. (Aschalew et al., 1999). The same author indicated that maize is believed to be the most dependable crop to bring about food self-reliance and self-sufficiency, being the highest yielding compared to all cereal crops grown in the country.

Declining soil fertility is fundamental impediment to agricultural growth and a major reason for slow growth in food production in sub-Saharan Africa. Low soil fertility due to monoculture cereal production systems is recognized as one of the major causes for declining per capita food production. Therefore, soil fertility replenishment is increasingly viewed as one of the critical to the process of poverty alleviation (Asfaw et al., 1998). This is generally true for Ethiopian agro-ecologies, particularly for a dominant maize based mono cropping system of western Oromiya. Sustainable crop production, therefore, requires a careful management of all nutrient sources available in a farm, particularly in maize based cropping systems. These include inorganic fertilizers, organic manures and integration of legume crops in cereal based mono cropping (Wakene et al., 2007). The objective of this study was therefore; to investigate the effect of intercropping maize and soybean on nodulation and yield traits of the companion crops under combined application of FYM and NP fertilizer.

MATERIALS AND METHODS

The experiment was conducted for two consecutive years (2010-2011) at Bako Agricultural Research center (BARC). The centre is located in the Western part of Ethiopia which lies at a latitude of 9° 6' N; longitude of 37° 9' E and at an altitude of 1650 m above sea level. It has a warm humid climate with annual mean minimum and maximum air temperatures of 13.5 and 29.7°C, respectively. The area receives average annual rainfall of 1237 mm with maximum precipitation being received in the months of May to August. The soil of the experimental site was reddish-brown, Nitosol, which is acidic with a pH of 5.2-5.6. The experimental site was low in available nitrogen and phosphorus contents which could be because of mono-cropping history of the experimental site. Soybean varieties and integrated organic and inorganic fertilizers were the two main factors. Two soybean varieties (Didessa, and Boshe) were used. Didessa is a medium maturity type (135-145 days to maturity) whereas Boshe is early maturity type. Both crops are highly adaptable to areas of mid and low altitudes. Two soybean varieties (Didessa and Boshe) were combined with eight levels of combined inorganic and organic fertilizers (110/46+0, 0+16, 110/46+16, 110/46+ 4, 83/35+4, 55/23 + 8, 28/12+12 and control, in kg ha^{-1} N/P_2O_5 + t ha^{-1} FYM, respectively) in intercropping. In addition, sole maize with recommended N/P_2O_5 and FYM and sole soybean varieties with recommended N and P_2O_5 were included in the experiment. The levels of manure and inorganic fertilizers (N and P_2O_5) were based on recommendation for sole maize in the area, which are 110/46 N/ P_2O_5 kg ha^{-1} and 16 t ha^{-1} FYM for hybrid maize varieties. The experiment was a randomized complete block design (RCBD) and replicated three times.

Manure application

In year one (2010), decomposed and dried FYM (20% moisture content) was applied per treatments and incorporated in to the soil manually, three weeks before maize planting. The plot was retained permanently to repeat the experiment in 2011 to evaluate the residual nutrient availability of applied manure.

Inorganic fertilizer application

Both in 2010 and 2011 years, at planting of maize, half of the N and full dose of phosphorus was uniformly drilled into the maize rows and mixed with the soil to avoid contact of the seed with the fertilizer. The remaining half of N was applied per treatment at knee height growth stage of maize. For sole soybeans, 100 DAP kg ha^{-1} was drilled into the furrows at the time of sowing.

Planting

A maize variety "BH-543" was sown on May 26, 2010 and June 3, 2011, respectively. The hybrid variety was released by BARC which requires 1000-1200 mm annual rainfall having 148 days to physiological maturity. The potential yield of the variety is 8.5 to 11 t ha^{-1} at research station and 4.7 to 6 t ha^{-1} at on farm. The size of each plot was 3.75 × 3.00 m. intercropped soybean and maize that consisted of five maize rows of 75 cm inter row spacing 30 cm intra row spacing. Three weeks after sowing of maize (in 2010), the two soybean varieties were intercropped on 15 June, 2010 in between two rows of maize. However, in second year, soybean was planted on 28 June, 2011 after maize planting. Intercropped soybeans were spaced at 75 cm with intra row spacing of 10 cm. For sole soybean varieties, however, inter and intra row spacing was 40 × 10 cm, respectively.

Data collection: Maize

Leaf area (LA) was measured at 50% days to tasseling (90 days after planting). LA was taken from ten plants and three representative active leaves per plant. Leaf length and maximum width were measured. Area of each leaf was determined by multiplying length by maximum width and constant factor as described by Burren et al. (1974).

Biological and grain yield (t ha^{-1})

All maize stocks from each harvestable plot were cut just at the ground level and the aboveground biomass including the cobs was measured. Grain yield from each net plot was also measured and finally standard moisture contents, 12.5%. Similarly, yield of soybean from each plot was measured and the moisture content of the grain was determined using a moisture tester and adjusted to standard moisture content (10%).

Harvest index (%)

It was determined as a ratio of economic yield to biological yield.

Table 1. The effect of varieties and integrated fertilizer rate in leaf area index and plant height of maize component crop in crop mixture.

Treatment	LAI at tasseling		Pooled means	Plant height (cm)		Pooled mean
	2010	2011		2010	2011	
Soybean varieties						
Didessa	3.69	3.4	3.6	238.3	221	230
Boshe	4.07	3.4	3.7	245.1	222	233
LSD (P<0.05)	0.22	NS	NS	5.2	NS	NS
NP_2O_5 kg ha^{-1} + FYM t ha^{-1}						
110/46 +0	4.43	3.59	4.01	245.8	223	234.5
0 +16	3.49	3.16	3.32	234.4	218	226.2
110/46 +16	4.03	4.0	4.39	247.2	219	232.9
110/46 + 4	4.27	3.64	4.04	248.9	224	236.2
83/35 + 4	3.95	3.59	3.77	241.7	217	229.4
55/23 + 8	3.99	3.30	3.65	247.8	229	238.4
28/12 + 12	3.73	3.47	3.60	241.9	223	232.4
control	3.11	2.46	2.78	225.7	218	222.3
LSD(P<0.05)	0.43	0.69	0.79	10.3	NS	13.1
CV (%)	9.5	17	13	3.6	5.9	6.9
Intercropped vs. sole crop						
Inter crop maize	3.87	3.4	3.64	241.7	221	231.6
Sole maize (NP)	3.47	3.1	3.26	232.2	221	226.7
Sole maize(FYM)	3.35	2.7	3.32	235.6	218	227
LSD(P < 0.05)	NS	NS	NS	NS	NS	NS
CV (%)	14	20	16.7	4.8	5.6	5.1

LSD = Least significant difference (P< 0.05); CV = coefficient of variation; NS =not significant; sole M with NP= sole maize sown by recommended NP fertilizer; sole M with FYM= sole maize sown by recommended farm yard manure.

Soybean

Leaf area index and nodule number

Leaf area (LA) of soybeans was measured at the time of flower initiation by using leaf area meter. Nodules were collected at the time of 50% flower initiation by digging from five plants in each plot. Effective nodules from sampled plants were counted based on their colour (pink colour) and the mean value of five plants was recorded.

RESULTS AND DISCUSSION

Maize

Leaf area index and plant height

There was significant (P<0.01) differences across the years in LAI due to the effect of integrated fertilizer applications of the maize intercrop at time of tasseling, but there was no significant difference due to interaction effect of varieties by fertilizer application (Table 1). The result of pooled means indicated that the highest LAI was recorded when consecutive recommended 110/46 kg ha^{-1} and 16 t ha^{-1} FYM (in 2010) was applied to the system. This result with the support of other findings indicated that there was positive effect of residual nutrients on growth parameters of the following crops (Ayoola and Makinde, 2008). However, there was a decreasing trend from year one to year two, which might be due to decreasing nitrogen availability from applied FYM. The lowest LAI was recorded at zero fertilizer application in each year, which is in agreement with findings of Faisalabad et al. (2010).

A significant variation was observed in year one due to varieties and integrated fertilizer application while it was significantly unaffected in year two. But the pooled mean result indicated that the highest plant height was recorded when successive application of 83/35 N/P_2O_5 kg ha^{-1} with 4 t ha^{-1} in year 2010 were applied to the permanent plot while the lowest was obtained from unfertilized plot (Table 1). Associated soybean varieties did not significantly affect leaf area index and plant height of the maize in contrast with its sole crops both under recommended organic and inorganic fertilizer rates. However, higher leaf area index was attained in intercropped maize than the soles, indicating that the soybean varieties might have contributed available nitrogen through biological nitrogen fixation (Tamado and

Table 2. The effect of varieties and integrated fertilizer application on biomass, grain and harvest index of associated maize in intercropping system.

Treatment	Biomass (t ha^{-1})		Pooled mean	Grain yield (t ha^{-1})		Pooled mean	Harvest index (%)		Pooled mean
	2010	2011		2010	2011		2010	2011	
Varieties									
Didessa	22.41	20	21.2	9.11	9.1	9.1	41	46	43
Boshe	22.80	19.4	21.1	9.57	9.0	9.3	42	47	44
LSD (P<0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
NP_2O_5 kg ha^{-1} + FYM t ha^{-1}									
110/46 + 0	22.52	20.2	21.3	9.52	9.6	9.6	43	47	45
0 +16	24.20	19.5	21.9	10.0	8.7	9.4	42	44	43
110/46 + 16	25.80	20.9	23.4	10.5	9.9	10.2	42	48	45
110/46 + 4	22.45	18.7	20.6	9.47	9.3	9.4	42	50	46
83/35 + 4	22.21	21.4	21.8	8.97	9.3	9.1	40	44	42
55/23 + 8	23.13	19.4	21.3	9.74	9.3	9.5	42	49	45
28/12 + 12	23.85	20.5	22.2	9.86	9.3	9.6	42	45	43
Control	16.69	17.2	16.9	6.88	7.2	7.0	40	43	41
LSD(P<0.05)	1.26	NS	1.92	1.14	NS	2.1	NS	NS	NS
CV (%)	9.6	12.5	11.1	10.4	17.7	14.1	11.1	16.5	13
Intercropped vs. Sole crop									
Intercrop M	22.6	19.74	21.2	9.5	9.1	9.21	41.5	44	44
SM (NP)	21	19.4	20.2	9.4	9.1	9.23	44.7	46	46
SM(FYM)	23.7	18.6	21.2	10.4	8.33	9.36	44.3	47	44
LSD(P < 0.05)	NS	NS	NS	NS	NS	NS	2.7	NS	NS
CV (%)	9.1	13	14	13.4	18	16.1	5.4	17	12

SM = Sole maize; IM = intercrop maize; LSD = least significant difference (P< 0.05); CV = coefficient of Variation; NS = Not significant; sole M with NP = sole maize sown by recommended NP fertilizer; sole M with FYM= sole maize sown by recommended farm yard manure.

Eshetu, 2000). Similar to leaf area index, plant height of intercropped maize was not significantly affected by cropping system.

Biological and economic yield

The result also revealed that both biomass and grain yield of maize were significantly varied in 2010 as the result of integrated fertilizer application. In year 2011, however, it showed no significant different was observed across fertilizer treatments (Table 2). This similarly confirmed with other authors that the residual nutrient availability from the preceding FYM application which ranged from 4-16 t ha^{-1} of the recommended manure might significantly increase both biomass and grain yield (Getachew, 2009). The residual nutrient definitely save up to 100% cost of inorganic fertilizer in both years and cost of manure application in second year (2011), as observed from sole application of FYM. The pooled mean also indicated that both biological and economic yield obtained from permanent plots, which were applied by 4-16 t ha^{-1} FYM in 2010 with consecutive application of 28/12-110/46 kg ha^{-1} in each year, were not statistically different except in unfertilized plot (Table 2). This response indicated that repeated application rates of organic manure in every year did not significantly increase yield and yield components of the main crops though there is a gradual increase in nutrient availability from organic manure that would ensure supply of the crop requirements (Achieng et al., 2010). The lowest grain yield, however, was recorded from untreated plot. Moreover associated soybeans did not significantly increase yield of maize.

Harvest index

The result also indicated that harvest indices (HI) did not considerably vary across the treatments in each year (Table 2). However, there was an increasing trend across fertilizer treatment from year one to year two. This indicated that there is lower translocation of the nutrient to economic yield under sufficient nutrient availability than biological yield. In other words, higher nutrient availability might enhance the vegetative growth of the crops that

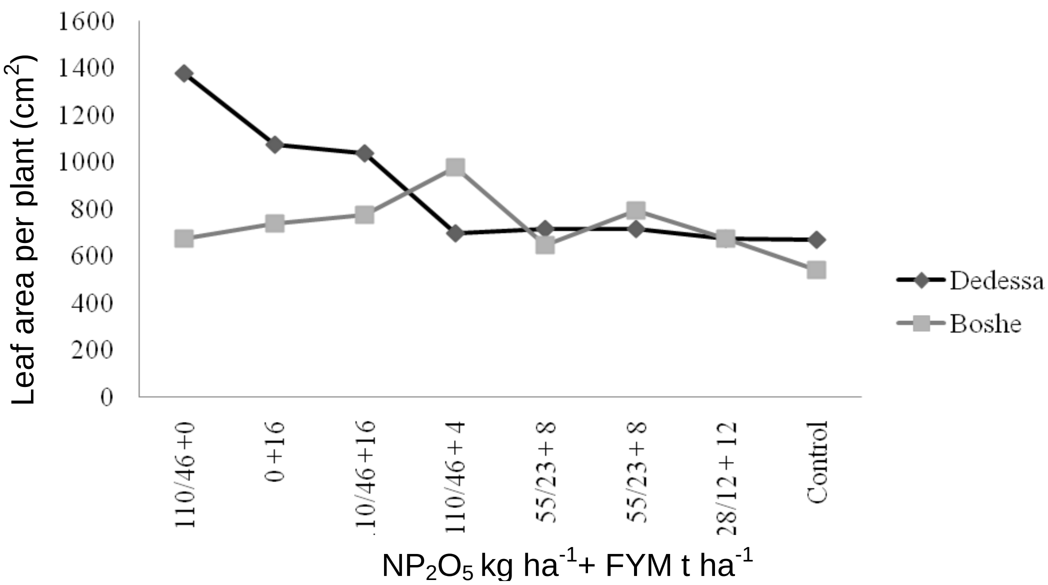

Figure 1. The effect of varieties and integrated fertilizer application on leaf area per plant (pooled mean) of associated soybean in intercropping (LSD at P<0.05=226).

may reduce the economic yield. Associated soybean varieties did not considerably affect the harvest index of the main crop.

Means of two year data revealed that the effect of cropping systems due to associated soybean varieties did not significantly vary on yield and yield traits (biomass yield, grain yield and harvest index) of the intercropped maize as compared with soles, which was treated under recommended organic and inorganic fertilizer application (Table 2). This result may indicate that maize is the main dominant crops that significantly compete with the associated soybean varieties. However, significant reduction in harvest index for intercropped maize was recorded as compared to the sole crops.

Soybeans

Leaf area per plant

The result of analysis of variance revealed that significant variations were observed across the years due to the effect of varieties and integrated fertilizer application (Figure 1). The two ways interaction of varieties by fertilizer application was also significantly affected in leaf area per plant of the companion crops. A significant higher leaf area per plant was recorded in 2010 year as compared to the second year. This variation was probably caused by variation imposed by time of planting of the companion crops after maize planting. Didessa variety generally produced higher leaf area than Boshe one across various fertilizer rates. This result is in agreement with other finding (Maheshbabu et al., 2008) that the higher leaf area was observed when higher proportions of inorganic fertilizer rates were applied to the treatment, which might be because of higher availability of nitrogen. Untreated plots showed the lowest leaf area for both Didessa and Boshe varieties. The effect of cropping systems due to associated main crops was significantly reduced in leaf area per plant of the companion crops (Figure 2). The significant variations across the years were also observed, which might be the result of variation in cropping season. The mean of two years indicated that about 83 and 68% reduction in leaf area per plant of Didessa and Boshe varieties were recorded when compared with their respective sole crops (Figure 2). This reduction might be due to the maize shading effect which adversely affected light interception that result in reduced growth and expansion of associated soybean in intercropping and the same result was also reported by Demisew (2002). A part from this, sole Didessa variety had significantly higher leaf area per plant as compared to the sole Boshe (Figure 2).

Effective nodule number per plant

Nodule number per plant was significantly affected by both varieties and integrated fertilizer application across the years (Figure 3). Higher number of nodules was recorded in 2011 than in the first year. This higher number of nodules might be because of improved soil chemical properties caused by the residual effects of applied organic manure (Marschner, 1995). Didessa variety had significantly higher number of nodules when compared with Boshe. The difference in nodulation might be probably due to differential compatibility with effective indigenous *rhizobium* in the soil of the experimental field.

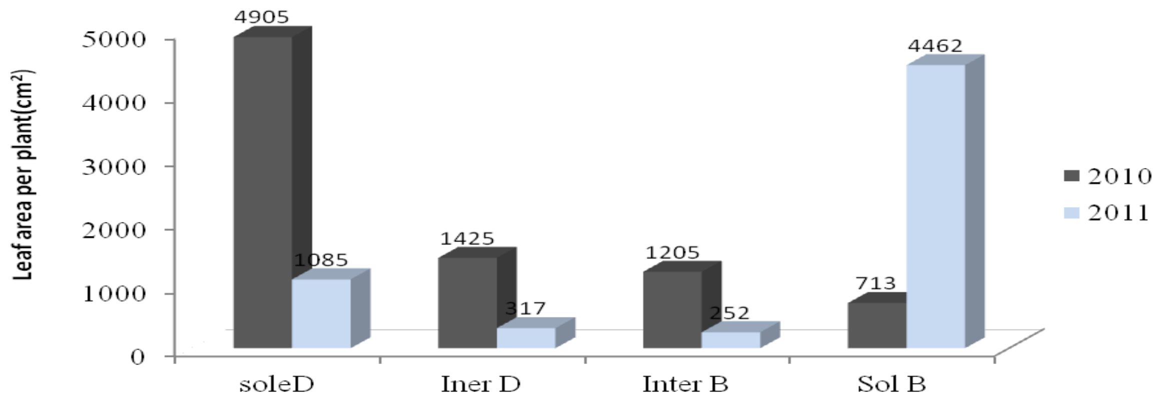

Figure 2. The effect of cropping systems on leaf area per plant of associated soybean varieties. Sole D= sole Didessa;Inter D= intercropped Didessa;Sol B= sole Boshe;inter B= intercropped Boshe.

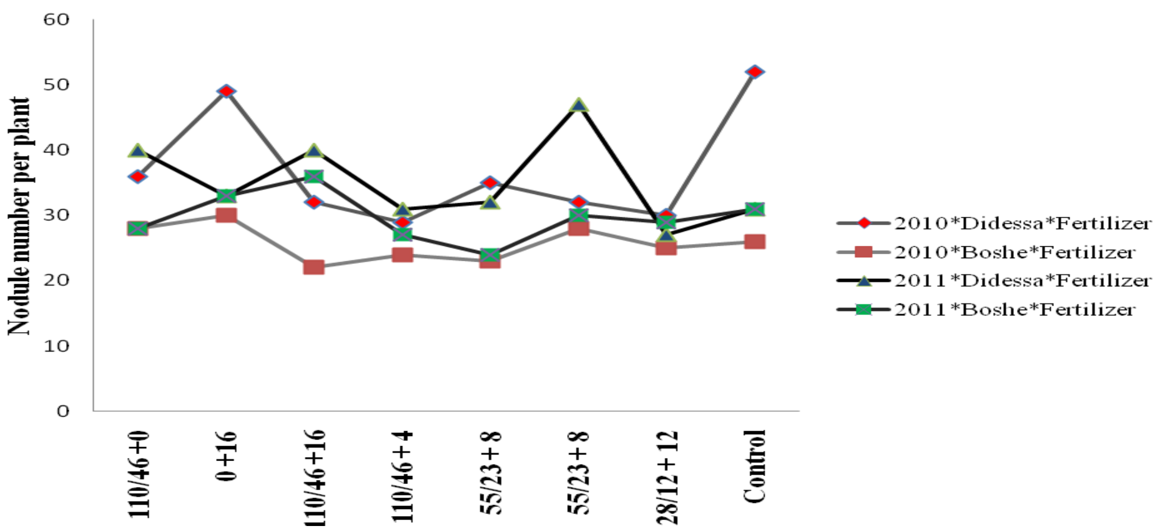

Figure 3. The effect of varieties and integrated fertilizer application on nodule number per plant soybean intercrops (LSD at P<0.05=12.4).

The highest nodule number 52 and 49 were recorded in 2010 from unfertilized plot and recommended application of FYM (2010), respectively (Figure 3).

Cropping systems caused a significant (P<0.05) reduction of nodule number when compared with the respective sole crops (Figure 4). A reduction in 39% for intercropped Didessa vareity and 22% for Boshe vareity were attained as compared with their respective sole crops (Figure 4). This result in agreement with other finding might possibly be the shading effects of maize that significantly reduced light interception potential of the associated soybeans and reduced the photosynthetic assimilate (Ghosh et al., 2006). Reduced assimilate might be resulted in limited food supply for associated *rhizobium* bacteria, and consequently their atmospheric fixation capacity were diminished (Tisdale et al., 1999). Moreover, Sole Didessa variety produced significantly higher number of nodules per plant as compared to sole Boshe variety (Figure 4).

Grain yield

The result of analysis revealed that significant higher grain yield per hectare was obtained from each variety in year one as compared to year two for both associated companion crops (Figure 5). This might be caused by the variation in time of planting after maize planting, 20 days and 25 days after maize planting in 2010 and 2011, respectively (Addo-Quaye et al., 2011). Associated Didessa variety significantly produced higher grain yield than Boshe variety (Figure 5). This result with other finding might indicate that medium or late maturity types of soybeans considerably compete on common resources

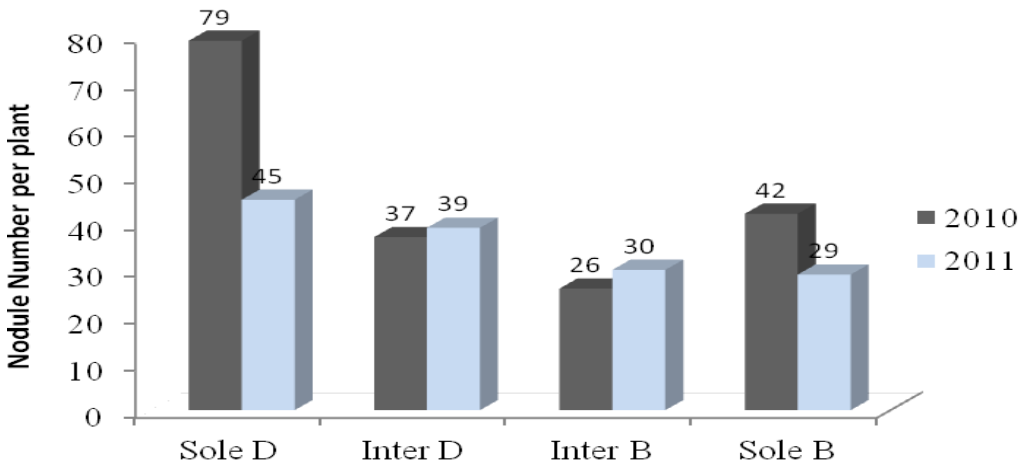

Figure 4. The effect of cropping systems on nodule number per plant of intercropped soybean varieties. Sole D= sole Didessa; Inter D= intercropped Didessa; Sole B= Sole Boshe;Inter= Intercropped Boshe.

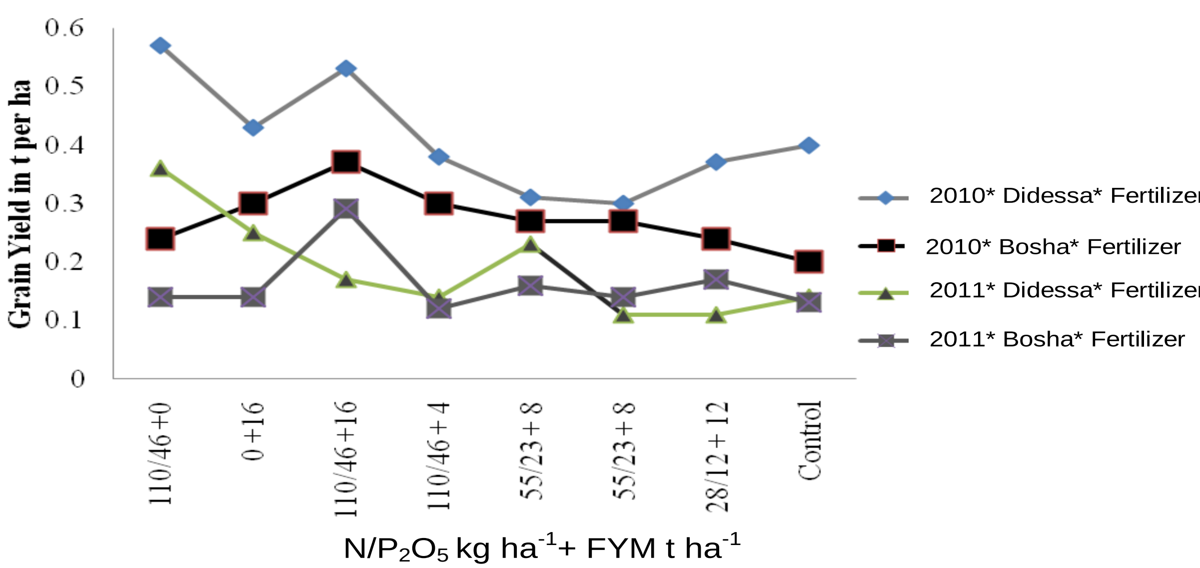

Figure 5. The effect of varieties and integrated fertilizer application on grain year of soybean intercrops (LSD at P<0.05=0.043).

or it might have escaped the period of more competition exerted, as the maize crop was approaching to maturity than the early types (Otieno et al., 2009). The highest grain yield was recorded for both associated crops when recommended NP_2O_5 (110/46 kg ha^{-1}) and FYM (16 t ha^{-1}) were applied while the lowest was obtained from untreated plot (Figure 5). However, a significant more grain yield of Didessa variety was obtained from unfertilized plot as compared to Boshe. Similar results with this finding indicated that the fixation capacity of the associated soybean under limited nutrient might be enhanced and utilized by the legumes so that the competitive ability of intercropped Didessa variety is very high than Boshe even though maize is also competing for the same common resources (Muoneke et al., 2007).

The effect of cropping systems considerably influenced grain yield of intercropped soybean varieties when compared with their respective sole crops (Figure 6). A significant reduction in grain yield was observed as compared with the sole ones although population variations are another factor. The reduction of LAI, nodule number and other parameters caused by shading effect might contribute to reduction in grain yield (Figures 2 and 4). The study indicated that shading effect of the maize drastically reduced the light transmission that may significantly reduce photosynthetic assimilates (Ghosh et

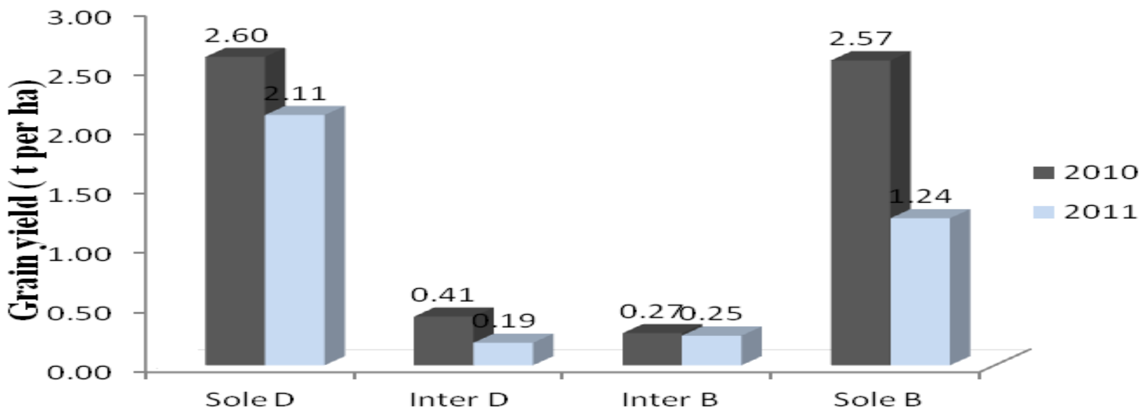

Figure 6. The effect of cropping systems on grain yield of intercropped soybean varieties. Sole D= sole Didessa; Inter D= Intercropped Didessa variety; Sole B= sole Boshe;Inter B= intercropped Boshe variety.

Table 3. Yield and Monetary advantage over sole maize monoculture as affected by integrated fertilizer application.

Treatments	Total land equivalent ratio			Monetary advantage (Eth birr ha^{-1})		
	2010	2011	Mean	2010	2011	Mean
Fertilizers						
110/46 +0	1.32	1.18	1.15	4419	4746	4583
0 + 16	1.17	1.04	1.10	5435	1148	3292
110/46 +16	1.25	1.32	1.28	7579	9314	8446
110/46 + 4	1.13	1.08	1.10	4467	2418	3442
83/35 + 4	1.02	1.10	1.06	687	3188	1937
55/23 + 8	1.12	1.08	1.10	3559	2418	2988
28/12 + 12	1.12	1.08	1.10	3906	2529	3218
Control	0.87	0.85	0.86	-3785	-4760	-4272

al., 2004).

Land equivalent ratio and monetary advantage

The result of pooled means evidently signified that yield advantage obtained due to various combinations of fertilizer rates ranged from 6 to 28% over the yield of sole maize obtained under recommended inorganic fertilizer. Mean of two years indicated that the highest LER (1.28) followed by 1.15 were recorded when 16 t ha^{-1} FYM in 2010 and consecutive application of 110/46 N/P_2O_5 kg ha^{-1} in both years were applied to the systems, respectively meaning that 28 and 15% greater area would be required under sole maize to produce the same yield as that of combined yield under intercropping system. The result with support of other finding (Demisew, 2002; Tolera et al., 2005), however, revealed the lowest LER (0.86) was without fertilizer uses to intercrops, validating that limited soil fertility significantly reduces the productivity of intercropping systems (Table 3). This result indicates that about 14% more area of land was required to produce the same amount of yield obtained from maize monoculture sown with the recommended NP rate.

The result of pooled means also indicated MA of intercropping ranged from the lowest Birr 1927 ha^{-1} to Birr 8446 ha^{-1} under various proportions of fertilizer applications. Application of both recommended 110/46 N/P_2O_5 kg ha^{-1} and 16 t ha^{-1} FYM resulted in the highest (Birr 8446 ha^{-1}) MA followed by recommended NP (Birr 4583 ha^{-1}). This attribute indicates that integrated fertilizer application with various proportions of NP with FYM significantly increased MA over the control. However, there was no gain in monetary advantage without fertilizer application. It was noted that due to total LER was less than one, negative value of MA was obtained in case of unfertilized intercrops. The negative value indicates a loss of Birr 4272 ha^{-1} from unfertilized intercrops as compared to the gross benefit obtained from maize monoculture sown with recommended NP.

Conclusion

Higher plant height and leaf area index was recorded under different rate of integrated fertilizer application when compared with the control. The result also revealed that higher leaf area index was attained in intercropped maize than the soles though not significant from each other. Similar to leaf area index, plant height of intercropped maize was not significantly affected by cropping system. Significant variation was also observed on yield of maize due to fertilizer rates. Application of recommended manure resulted in maximum number of effective nodules which did not significantly vary with the control. The effect of cropping system was significantly reduced in leaf area per plant of the companion crops (Figure 2). Significant variations across the years were also observed. The mean of two years indicated that about 83 and 68% reduction in leaf area per plant of Didessa and Boshe varieties were recorded when compared with their respective sole crops. From economic point of view, intercropping of maize with Didessa variety under application of 16 tha^{-1} organic manure resulted in the highest monetary advantage. However, an integrated use of 12 t ha^{-1} FYM with 28/12 NP_2O_5 kg ha^{-1} saved up to 75% cost of commercial fertilizer and even cost of manure application for following years. Alternatively, integrated use of 55/23 N/P_2O_5 kg ha^{-1} with 8 t ha^{-1} FYM also revealed better economic advantage with some additional yield from soybean (Didessa variety) without affecting yield of the maize.

ACKNOWLEDGMENTS

The author is grateful to Oromiya Agricultural Research Institute, Ethiopia, for sponsoring the study. His particular appreciation goes to Mr Terefe Daba and other field assistants who thoroughly collect all necessary data.

REFERENCES

Achieng JO, Ouma G, Odhiambo G, Muyekho F (2010). Effect of farmyard manure and inorganic fertilizers on maize production on Alfisols and Ultisols in Kakamega, western Kenya. Agric. Biol. J. North Am. 1(5):740-744.

Addo-Quaye AA, Darkwa AA, Ocloo GK (.2011). Yield and productivity of component crops in a maize-soybean intercropping system as affected by time of planting and spatial arrangement. ARPN J. Agric. Biol. Sci. 6(9):50-57.

Asfaw B, Heluf G, Yohannes U (1998). Effect of tied ridges on grain yield response of Maize (*Zea mays L.)* to application of crop residue and residual NP on two soil types at Alemaya, Ethiopia. South Afr. J. Plant Soil. 15:123-129.

Aschalew G, Legesse W, Gemechu K, Wende A, Benti T, Pexley K, Mosisa W (1999). Strategy for quality maize breeding and dissemination in Ethiopia. Maize Production Technology. pp. 42-46.

Burren L, Mock JJ, Anderson IC (1974). Morphological and physiological traits in maize associated with tolerance to high plant density. Crop Sci. 14:426-429.

Ayoola OT, Makinde EA (2008). Performance of green maize and soil nutrient changes with fortified cow dung. *African Journal of Plant Science,* 2 (3):19-22. Available online at http://www.academicjournals.org/AJPS

Demisew M (2002). Effect of planting density of haricot bean and nitrogen fertilization on productivity of maize and haricot bean additive intercrop systems. M.Sc. Thesis. Alemaya Uinversity, Alemaya, P. 105

Faisalabad S, Alireza V, Hossein AF (2010). Effects of planting density and pattern on physiological growth indices in maize (*Zea mays* L.) under nitrogenous fertilizer application. J. Agric. Exten. Rural Develop. 2(3):40-47

Getachew A (2009). Ameliorating effects of organic and inorganic fertilizers on crop productivity and soil properties on reddish- brown soils.Proceeding of the 10th Conference of the Ethiopian Society of Soil Science. 25-27 March 2009, held at EIAR, Addis Ababa, Ethiopia. pp. 127-150.

Ghosh PK, Ramesh P, Bandyopadhyay KK, Tripathi AK, Hati KM, Misra AK, Acharya CL (2004). Comparative effectiveness of cattle manure, poultry manure, phosphocompost and fertilizer-NPK on three cropping systems in vertisols of semi-arid tropics. I. Crop yields and system performance. Bioresour. Technol. 95:77–83

Ghosh PK, Manna MC, Bandyopadhyay, KK, Ajay AK, Tripathi RH. Wanjari KM, Hati AK, Misra CL, Acharya A, Subba R (2006). Inter specific Interaction and Nutrient Use in Soybean/Sorghum Intercropping System. Bioresour. Technol. 98:25–30.

Maheshbabu HM, Ravi H, Biradar P, NK, Babalad HB (2008). Effect of organic manures on plant growth, seed yield and quality of soybean. Karnataka J. Agric. Sci. 21(2):219-22.

Marschner H (1995). Mineral nutrition of higher plants. London, Academic Press, London. P. 889.

Muoneke CO, Ogwuche MAO, Kalu BA (2007). Effect of maize planting density on the performance of maize/soybean intercropping system in a guinea savannah agro ecosystem. Afr. J. Agric. Res. 2(12):667-677

Nielsen H, Ambus B, Jensen ES (2001). Evaluating pea and Barley cultivars for complementarities in intercropping at different levels of soil N availability. Exp. Agric.14:112-118

Otieno PE, Muthomi JW, Cheminingwa GN, Nderitu JH (2009). Effect of rhizobia inoculation, farm yard manure and nitrogen fertilizer on nodulation and yield of food grain legumes. J. Biol. Sci. 9:326-332.

Rochester JJ, Peaples MB, Hullugare RN, Gualt, RR, Constable GA (2001). Using legumes to enhance N fertility and improve soil conditions in cotton cropping systems. Field Crop Res. 70(1):27-41.

Tamado T, Eshetu M (2000). Evaluation of Sorghum, Maize and Common Bean cropping Systems in East Hararge, Ethiopia. Ethiopian J. Agric. Sci. 17:33-45.

Tesfa B, Tolessa D, Setegn G, Tamado T, Negash G, Tenaw W (2001). Development of Appropriate Cropping Systems for Various Maize Producing Regions of Ethiopia**.** Second National Maize Workshop of Ethiopia. 12-16 November, 2001. Addis Ababa.

Tolera A, Tamado T, Pant LM (2005). Grain yield and LER of maize-climbing bean intercropping as affected by inorganic, organic fertilizer and population density in Western Oromia, Ethiopia. Asian J. Plant Sci. 4(5):458-465.

Tisdale SL, Havlin JL, Beaton DB, Werner LN (1999). Soil fertility and fertilizers. An introduction to nutrient management. 6th ed. Prentice Hall New Jersey.

Tusbio M, Walker S, Ogindio, HO (2005). A simulation model a cereal-legume intercropping for semi- arid regions. Model applications. Field Crop Res. 93:23-33.

Wakene N, Fite G, Abdena D, Birhanu D (2007). Integrated use of organic and inorganic fertilizers for maize production. In utilization diversity in land use systems: Sustainable and organic approaches to meet human needs. Conference Tropentag, 2007, October 9-12, 2007, Witzenhousen, Kassel, Germany.