Performances of Different Varieties and Population of Soybean (Glycine max L.) under Intercropping Systems with Maize (Zea mays L.)

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Abstract
The field experiment was carried out at Haro Sabu Agriculture Research Center, during 2013 with the objectives of determining the effect of varieties and population density of soybean intercropped with maize on phenological and growth parameters of the component crops. The experiment was laid out in RCBD with three replication in factorial combination of three soybean varieties (Boshe, Ethio Yugoslavia and Didesa) and three soybean plant populations (25%, 50% and 75%) along with respective sole crop of soybean varieties and maize BHQPY-545. Plant population of soybean had significant ($P<0.05$) effect on LAI of maize. The highest LAI (3.61) was obtained from 50% soybean population. The LA, LAI and number of primary branches of soybean component showed significant difference due to plant population. The highest LA per plant (3392.60 cm^2) and number of primary branches (6.22) were obtained in soybean population of 25%. However, the highest LAI (4.96) was obtained from 75% soybean population. Plant height, number of effective nodules per plant, number of primary branches, of soybean were significantly ($P<0.01$) affected by soybean varieties. The highest plant height (123.89cm) was obtained from Ethio Yugoslavia. The highest number of primary branches per plant was obtained from variety Boshe (7.33). The Highest number of effective nodules (30.33) was recorded for variety Didesa. Cropping system showed highly significant ($P<0.01$) effects on number of effective nodules per plant and significant ($P<0.05$) effect on leaf area index. The result revealed that cropping system had a significant effect on LAI and number of effective nodules per plant where higher LAI (6.18) and effective nodules per plant (46.44) were recorded from sole cropped soybean variety than the intercropping system.
Keywords: *Glycine max,* intercropping, plant populations, sole cropping*, Zea mays*

INTRODUCTION

Mineral fertilizers improve soil fertility and result in increased yields but are expensive and often beyond the reach of resource-poor farmers resulting in the chronic food insecurity in Africa (World Bank, 1996). Small holder farmers of developing countries cannot afford to apply recommended rates of fertilizer N to cereals such as maize, which has a high demand for the nutrient when grown in low fertility soils (Dorward and Chirwa, 2011). Excessive use of N fertilizers cause problems of acidification and the over-use of N and P fertilizers cause water pollution in the form of eutrophication (Brady and Weil, 2008).

Therefore, solutions to smallholder farmers' soil fertility problems may be found in the strategic combination of organic resources, particularly from nitrogen-fixing legumes, with small amounts of mineral fertilizers (Palm *et al.,* 1997). Legumes have unusual advantage in obtaining nitrogen through biological nitrogen fixation (BNF) process by participating in a symbiotic relationship with *Rhizobia spp.* The ability of legumes to fix atmospheric nitrogen in their nodulated roots and plant residues left after harvesting represent a valuable source of organic N (Hayat, 2005).

Intercropping is the agricultural practice of cultivating two or more crops in the same space at the same time. The most common advantage of intercropping is the production of greater yield on a given piece of land by making more efficient use of the available growth resources using a mixture of crops of different rooting ability, canopy structure, height, and nutrient requirements based on the complementary utilization of growth resources by the component crops (Lithourgidis *et al.,* 2011)

Many researchers have stressed the need of identification of suitable genotypes in intercropping that best cultivar for monocropping might not be most suitable for mixed cropping due to change in microclimate within crop mixture (O'Leary and Smith, 2004). Adeniyan and Ayoola (2006) reported that maturity time and growth habit of component crops were important determinants of productivity in maize soybean intercrops. Late maturing soybean varieties are able to fix more nitrogen than early and medium maturity varieties, great nitrogen concentration to any cropping system is expressed through their roots, litter and harvest residues. Ogoke *et al.* (2003) reported that a positive nitrogen balance by soybean crop was obtained due to the effect of increased crop duration and nitrogen application.

The overall mixture densities and the relative proportion of component crops are important in determining yields and production efficiencies of cereal-legume intercrop systems (Lakhani, 1976). Ofiri and strern (1987) indicated in a maize/bean intercropping that increasing maize density from 1800 to 5500 plants/ha, reduced leaf area index by 24% and seed yield by 70% in the component bean. Tamado (1994) reported that 50%

sorghum and 100% groundnut associate gave the highest relative pod yield of groundnut component as compared the highest proportions. The intercrops of maize and bean in 100% of the sole maize population (44,444 plants/ha) and 50% of the sole bean population (125,000 plants/ha) give high yield (Tamado and Eshetu, 2000). Planting intercropped soybean at 333,000 plants/ha with millet gave significantly higher seed yield than planting at 400,000 plants/ha, which, in turn, had greater seed yield than planting at 200,000 plants/ha (Akunda,2001). Thus, plant population can be used as a tool to manage crop growth, maximize biomass, the time required for canopy closure and yield.

Therefore, planting density, varietal selection, understanding the physiology of the species to be grown together, their growth habits, canopy and root architecture, and water and nutrient use are important factors to be considered in intercropping (Vandermeer, 1989). These factors affect the interaction between the component crops of intercropping and so affect their use of environmental resources and, as a result, the success of intercropping compared with sole cropping systems.

However, farmers in the study area intercrop maize and soybean without consideration of the appropriate densities of the component crops to intercrop and appropriate variety of soybean. Therefore, inter cropping did not give the best returns in terms of yield or cash. Thus the objective of this study is to determine the effect of varieties and population density of soybean intercropped with maize on phenological and growth parameters of the component crops

MATERIALS AND METHODS

Description of the Study Area

The study was conducted at Haro Sabu Agricultural Research Center (HSARC) during the main cropping season from June to October 2013. HSARC was located in western Ethiopia in Oromiya region at 550 km away from Addis Ababa. It lies at latitude of 8^{o} 52'51" N and longitude 35^{o}13'18'' E and altitude of 1515 m above sea level. It has a warm humid climate with average minimum and maximum temperature is 14^{o}C and 30^{o}C, respectively. The area receives average annual rain fall of 1000 mm and its distribution pattern is uni-modal. The rain periods covers from April to October. The soil type of the experimental site was reddish brown and its pH is 5.82. The area were characterized by coffee dominant based farming system and crop-livestock mixed farming system in which cultivation of maize, sorghum, finger millet, haricot bean, soybean, sesame, banana, mango, sweet potato and coffee are the major crops grown in the area. Improved maize variety (BHQPY-545) was used as main crops and three soybeans varieties namely Boshe, Ethio Yugoslavia and Didesa were used.

Treatments and Experimental Design

The experiment consisted of two factors, namely three soybean varieties and three soybean plant populations. Three different proportions of a plant population of 333,333ha^{-1}, were considered as optimum for sole cropped soybeans, were taken as the intercrop soybean plant populations: 25% (83,333 plants ha^{-1}), 50% (166,666 plants ha^{-1}) and 75% (249,999 plants ha^{-1}) were intercropped as additive series between the two maize rows at the same time. Uniform populations of 44,444 plants ha^{-1} were maintained for maize in both intercropping and sole cropping. The experiment was arranged in Randomized complete Block design with three replication in factorial arrangement of three soybean varieties and three soybean plant populations totaling nine intercropping treatments and there were four additional treatments (sole maize, sole Boshe, sole Ethio Yugoslavia and sole Didesa) totaling thirteen treatments. The spacing for sole and intercropping maize was 75cm x 30cm and the gross plot size was 15.75m^{2} (3.75m x4.2m) and the net plot area was 6.75m^{2} (2.25m x3m). Each intercrop maize plot consisted of five rows of maize and four row of soybean. The spacing of sole soybean was 60cm x 5cm and the gross plot size 15.12 (3.6m x4.2m) and the net plot area was 7.2m^{2}(2.4m x3m). Soybean was intercropped between two maize rows at 37.5cm away from maize row with inter row 5.3cm, 8cm and 16cm representing 75%, 50% and 25% of the recommended population, respectively. The central three rows of soybean were harvested and one row was used for destructive sampling. *i.e* for counting number of nodule per plant and for measuring Leaf area and Leaf area index.

Experimental Procedures

Both maize and soybean varieties were planted simultaneously on June 13, 2013. Two seeds per hill of both maize and soybean were planted and thinned to one plant per hill one week after emergence. At planting full dose of DAP (18% N, 46% $P_2O_{5,}$) at the rate of 100 kg ha^{-1} was applied uniformly into all plots. Half of N in the form of urea (46% N) at the rate of 200 kg ha^{-1} was applied into sole maize and maize/soybean intercropped plots at the time of planting and the remaining half N was applied at knee height growth stage of maize. Urea (N) was not applied in to sole soybean assuming the soybean could benefit from self-fixed nitrogen. Hand hoeing and weeding were done as required. Both maize and soybean were harvested from the net plot after they attained their normal physiological maturity, *i.e.* when 75% of plants in a plot formed black layer at the point of attachment of the kernel with the cob for maize and when 95% of pod color changed to yellow and their leaves started shading for soybean and the both maize and soybean were threshed manually.

Soil Sampling and Analysis

Soil sample was taken at a depth of 0-30 cm in a zigzag pattern randomly from the experimental field. Composite samples were prepared for analysis to determine the physico-chemical properties of the soil of the experimental site. The composited soil sample was air-dried, ground and sieved to pass through a 2 mm sieve. Total nitrogen was determined following kjeldahl procedure as described by (Cottenie, 1980); the soil pH was determined by using a digital pH meter (Page, 1982). Organic carbon was determined following wet digestion method as described by (Walkley and Black, 1934); and the available phosphorous was measured using Olson II methods (Olsen *et al.,* 1954); cation exchange capacity (CEC) was determined by ammonium acetate method (Cottenie, 1980)and soil texture was determined by Bouyoucons Hydrometer method (Bouyoucos,1962).

Statistical Data Analysis

Analysis of variance was carried out using General Linear Model of ANOVA using SAS version 9.0 software (SAS Institute Inc. 2002). Mean separation was carried out using Least Significance Difference (LSD) test at 5% probability level.

RESULTS AND DISCUSSION

Physicochemical Properties of the Soil

Result of the laboratory analysis for the soil samples taken before planting of the experimental site indicate that the soil had total nitrogen content of 0.436% which was high, medium organic matter content (4.715%), low Available phosphorus (6.283ppm) and medium CEC (23 Cmol (+) /kg). The analytical results indicated that the textural class of the experimental site was mainly of sandy loam soil with a proportion of 73% sand, 6 % clay and 21% silt. The soil reaction (pH) of the experimental site was 5.82 showing moderate acidity.

Maize Component

Phenological parameters

All the phenological parameters of maize, namely days to 50% tasseling, 50% silking and 75% physiological maturity were not significantly affected by the main and interaction effects of varieties and plant population of the associated soybean. Likewise, cropping system also showed non-significant effect on days to 50% tasseling and silking and 75% physiological maturity. The absence of significant effects on the maize component could be due to the dominant nature of maize as compared to soybean in resource utilization. In agreement with this result, Tilahun (2002) reported no significant differences in days to silking and tasseling of maize in maize/faba bean intercropping. Similarly, non-significant effects of cropping system on the phenological parameters of maize were reported by Yesuf (2003) and Demessew (2002) in maize/common bean intercropping system. In contrast to this result, Wogayehu (2005) reported significant effect of the associated bean varieties on days to 50% tasseling and days to 50% maturity of the maize component.

Table 1: Main effects of varieties and plant population of the intercropped soybean and cropping system on phenological parameters of maize component

Treatment	Days to 50% tasseling	Days to 50% silking	Days to physiological maturity
Soybean population per ha			
75% (249,999)	84.44	86.55	141.00
50% (166,666)	84.00	86.77	140.11
25% (83,333)	83.56	86.88	139.33
LSD (0.05)	NS	NS	NS
Soybean varieties			
Boshe	84.11	86.44	140.55
Didesa	84.11	87.22	140.11
Ethio Yugoslavia	83.77	86.55	139.77
LSD (0.05)	NS	NS	NS
CV (%)	1.13	1.16	1.43
Cropping system			
Sole	85.00	88.00	140.67
Intercropping	84.33	86.33	139.87
LSD (0.05)	NS	NS	NS
CV (%)	0.48	0.93	0.59

LSD = Least Significant Difference; CV = Coefficient of Variation; NS =Non Significant

Growth parameter

Leaf area and leaf area index of maize were not significantly affected by the associated soybean varieties and the interaction of varieties by population but plant population of soybean had significant ($P<0.05$) effect on LAI. Though statistically not significant higher leaf area (8085.40 cm^2) and leaf area index (3.57) of maize were recorded in association with soybean variety Boshe intercropped with maize and the lowest leaf area (7903.90cm^2) and LAI (3.48) was recorded in intercropping with soybean variety Ethio Yugoslavia (Table 2). This might be due early maturity of variety Boshe that had less competition with maize for growth factors while the reduction of leaf area and leaf area index of maize in intercropping with variety Ethio Yugoslavia could be due to high vegetative growth and height of the variety which shaded the maize at early growth stage. In line with this result, Tsubo and Walker (2003) on maize/bean intercropping reported that the photosynthetic organ becomes thinner and reduces its area due to shading. Similarly, the highest leaf area (8142 cm^2) and LAI (3.61) of maize component was obtained at plant population of 50% of soybean while the lowest leaf area (7821.60 cm^2) and LAI (3.44) of maize was obtained in association with 75% of soybean (Table 2) which might be due to increased competition for growth resources as the density of the associated soybean bean increased. In agreement with this result, Stewart and Dwyer (1999) reported that high plant density of the associated bean produced lower LA and LAI of the associated maize. In contrast to the results of this study, Yesuf (2003) reported that the LAI of sorghum was increased with the increase in the population density of haricot bean in the mixture.

Both the sole cropped and inter cropped maize showed no significant difference on LA and LAI. Nevertheless sole cropped maize had greater leaf area (8193.30 cm^2) and leaf area index (3.60) than inter cropped maize which had LA of 8010.20cm^2 and LAI of 3.50 (Table 2). The decrease in LA and LAI of intercropped maize could be due to inter specific competition between associated crops for growth resources like soil moisture, nutrient and light under intercropping system than sole cropping. The higher leaf area of sole maize could most likely be due to more availability of growth factors that resulted in enhanced vegetative growth of the plant resulting in the development of large leaf area and better interception of light for photosynthesis. This result was in agreement with Demesew (2002) and Wogayehu (2005) who reported that inter cropping of maize with common bean reduced the LAI of the maize component. In contrast, Bandyopadhyay and De (1986a) reported that leaf area index of sorghum was increased when it was intercropped with the legumes green gram, groundnut, and cowpeas.

Analysis of variance showed that the plant height of intercropped maize was not significantly affected by the main effect of soybean varieties, plant population and the interaction of main effects as well as the cropping system. Similarly, Wogayehu (2005) reported that plant height was not significantly affected when maize and sorghum were intercropped with common bean. Similar to the result of this study, Muoneke *et al*. (2007) reported that varieties of soybean did not significantly affect plant height of maize in maize soybean intercropping system.

Table 2: Main effects of varieties and plant population of the intercropped soybean and cropping system on growth parameters of the maize component

Treatment	Leaf area (cm^2)	Leaf area index	Plant height (cm)
Soybean population per ha			
75% (249,999)	7821.60	3.44b	204.33
50% (166,666)	8142.00	3.61a	205.22
25% (83,333)	8067.10	3.57ab	204.56
LSD (0.05)	NS	0.15	NS
Soybean varieties			
Boshe	8085.40	3.57	204.66
Didesa	8041.30	3.56	205.44
Ethio Yugoslavia	7903.90	3.48	204.00
LSD (0.05)	NS	NS	NS
CV (%)	4.48	4.30	3.86
Cropping system			
Sole	8193.30	3.60	205.67
Intercropping	8010.20	3.50	204.60
LSD (0.05)	NS	NS	NS
CV (%)	2.73	2.81	1.83

Means within the same column followed by the same letter or by no letters of each factor do not differ significantly at 5% probability level; LSD = Least Significant Difference (P< 0.05); CV = Coefficient of Variation; NS =Non Significant

Soybean Component

Crop Phenology

The analysis of variance revealed that days to 50% flower initiation and days to physiological maturity were highly significantly(P<0.01) varied for the associated soybean. Varieties ‘Didesa’ and ‘Ethio Yugoslavia’ reached to 50% flower initiation on average 76.78 and 76.11 days, respectively, while variety Boshe took on the average 64.22 days. Similarly, the respective days to reach to 95% physiological maturity for variety Didesa, Ethio Yugoslavia' and Boshe were 142.44, 141.55 and 117.33 days, respectively (Table 3). From this result, it is clear that variety 'Boshe' flowered and matured earlier than the two soybean varieties. This difference observed in phenological parameters could be due to the inherent characteristics or genetic makeup of the varieties. Similarly, Wogayehu (2005) reported significant difference among the intercropped haricot bean varieties on days to flowering and maturity and attributed this to the inherent genetic character of the varieties.

The main effect of plant population and interaction of varieties and population showed statically no significant effect on days to flowering and days to physiological maturity. This result was in agreement with studies, for instance of Tilahun (2002), Tolera (2003), Yesuf (2003), and Sisay (2004) who worked on intercropping of different pulse crops with cereals and found that days to 90% physiological maturity of the legume components were not significantly affected by planting density. Moreover, days to 50% flowering and days to 95% physiological maturity of the soybean component were not significantly affected by the interaction and the cropping system.

Table 3: Main effects of varieties and plant population of the intercropped soybean with maize on phenological parameters of the soybean component

Treatment	Days to 50% flower initiation	Days to 95% physiological maturity
Soybean population per ha		
75% (249,999)	72.11	134.00
50% (166,666)	72.67	133.78
25% (83,333)	72.33	133.56
LSD (0.05)	NS	NS
Soybean varieties		
Boshe	64.22b	117.33b
Didesa	76.78a	142.44a
Ethio Yugoslavia	76.11a	141.55a
LSD (0.05)	1.14	1.11
CV (%)	1.58	0.83
Cropping system		
Sole	71.66	133.11
Intercropping	72.06	133.18
LSD (0.05)	NS	NS
CV%	0.32	0.73

Means within the same column followed by the same letter or by no letters of each factor do not differ significantly at 5% probability level; LSD = Least Significant Difference ($P< 0.05$); CV = Coefficient of Variation; NS =Non Significant

Growth parameters

The main effect of plant population had highly significant ($P<0.01$) effect on LA, LAI and number of primary branches of soybean but there was non significant effect on plant height and number of effective nodules per plant whereas all growth parameter of soybean were not significantly affected by the interaction effect of soybean varieties and plant population. The highest leaf area pert plant (3,392.60 cm^2) and the lowest (2,100.20cm^2) LA were obtained from plant population of 25% and 75% of soybean, respectively. On the other hand, the highest LAI (4.96) and lowest LAI (2.80) were obtained from 75% and 25% soybean population, respectively (Table 4).

In general, leaf area per plant was decreased with increase in plant density; but the reverse was true for LAI which could be due to increase in ground area as plant density of soybean was decreased. These result agreed with that of Daniel (2006) who reported that LAI of soybean increased with increase in plant density, *i.e.* when plant density increased from 20 plants/m^2 to 30 plants/m^2 brought significant increase in LAI from 4.9 to 6.1, respectively. Similarly Demesew (2002) reported the highest LA per plant (436.04cm^2) at low haricot bean density (25%) and the lowest LA (344.56cm^2) from 100% haricot bean density intercropped with maize and the highest LAI (0.86) from at high haricot bean density (100%) and the lowest value of LAI (0.28) at low haricot bean density (25%).

The highest number of primary branches (6.22) was recorded from 25% soybean population while the lowest number of primary branches (3.78) was recorded from 75% soybean population (Table 4).The reduction in number of primary branches at the highest plant density might be due to intra and inter specific competition for growth resource. This result was in line with Daniel (2006) who reported lower number of branches per plant of soybean at the higher plant density *i.e.* when the plants increased from 20 plants/m^2 to 50 plants /m^2, number of branches per plant was decreased from 6.9 to 4.8.

The main effect of soybean varieties showed highly significant ($P<0.01$) differences on plant height, number of primary branches and number of effective nodules per plant but LA and LAI were not significantly different among the intercropped soybean varieties. The highest plant height (123.89 cm) was recorded from variety Ethio Yugoslavia and the lowest height (82.89cm) was recorded from variety Boshe. The highest number of primary branches per plant was obtained from variety Boshe (7.33) and the lowest were from variety Ethio Yugoslavia (3.33) (Table 4). This variation might varietal differences that determine the growth and development of the crop. This results showed that variety Didessa had significantly higher number of effective nodules (30.33 plant^{-1}) than varieties Boshe (24.11 plant^{-1}) and Ethio Yugoslavia (20.67 plant $^{-1}$) (Table 4). The difference in nodulation might be probably due to differential compatibility with effective indigenous *rhizobium* in the soil of the experimental field. The result of this study was also in agreement with Muoneke *et al.* (2007) and Otieno *et al.* (2009) who reported significantly different nodule number in soybean varieties intercropped with maize and attributed this to genetic characteristics and mutual association ability of the varieties with effective indigenous *rhizobia*. The finding also revealed that nodulation potential of legume crops in intercropping systems are enhanced under the influence of strong competition between companion crops for limited nutrient sources.

Cropping system showed highly significant ($P<0.01$) effects on number of effective nodules per plant and significant ($P<0.05$) effect on leaf area index. But leaf area, plant height and number of primary branches were not significantly affected by the cropping system. On the average, the highest LAI (6.18) was obtained from sole soybean whereas lower LAI (4.01) was recorded from intercropped soybean (Table 4).This reduction could be due to increase in ground area as plant density of soybean was decreased in intercropping. This result was in agreement with Zerihun (2011) where the highest LAI (5.90) was recorded from sole cropped variety Didesa but lower LAI (2.64) was recorded from intercropped with maize. Similarly, a significant reduction of LAI in intercropped haricot bean with maize was observed due to the effect of intercropping as compared with its sole crop from 2.42 to 0.56 (Demisew, 2002). Similarly, Mudita *et al.* (2008) reported greater LAI in sole cropped soybean than the intercropped soybean.

Higher number of effective nodules per plant (46.44) was recorded from sole soybean than intercropped (24.99) soybean (Table 4).This might be due to the fact that application of nitrogen for the associated maize in the intercropping treatments could have reduced nodulation potential of soybean. Moreover, the shading effects of associated maize might have reduced light interception potential of the associated soybeans and reduced the photosynthetic assimilate (Ghosh *et al*., 2006). Reduced assimilate might have resulted in limited food supply for associated *Rhizobium* bacteria, and consequently their atmospheric fixation capacity were diminished (Fujita *et al*., 1992; Tisdale *et al*., 1999).

Table 4: Main effects of varieties and plant population of the intercropped soybean with maize on growth parameters of the soybean component

Treatment	LA (cm^2)	LAI	PH (cm)	NENPP	NPB
Soybean population per ha					
75% (249,999)	2100.20b	4.96a	108.22	28.00	3.78c
50% (166,666)	2452.70b	4.10b	108.33	24.56	4.78b
25% (83,333)	3392.60a	2.80c	100.22	22.56	6.22a
LSD (0.05)	492.97	0.82	NS	NS	0.89
Soybean varieties					
Boshe	2699.40	3.74	82.89c	24.11ab	7.33a
Didesa	2446.20	3.90	110.00b	30.33a	4.11b
Ethio Yugoslavia	2799.80	4.21	123.89a	20.67b	3.33b
LSD (0.05)	NS	NS	9.41	6.50	0.88
CV (%)	18.62	20.82	8.92	25.99	18.00
Cropping system					
Sole	2457.00	6.18a	102.22	46.44a	4.44
Intercropping	2644.60	4.01b	105.05	24.99b	4.97
LSD (0.05)	NS	2.88	NS	0.41	NS
CV (%)	5.59	13.44	2.76	0.33	8.77

Means within the same column followed by the same letter or by no letters of each factor do not differ significantly at 5% probability level; LSD = Least Significant Difference ($P< 0.05$); CV = Coefficient of Variation; NS =Non Significant; LA= Leaf area; LAI= Leaf area index; PH= Plant height; NENPP= Number of effective nodule per plant; NPB= Number of primary branches.

CONCLUSION

Intercropped soybean varieties and plant population and interaction effect of soybean and plant population as well as cropping system had no significant effect on phenology of maize such as days to tasseling, silking and physiological maturity of maize component. Similarly, all growth parameters of maize leaf area, leaf area index and plant height were not affected significantly by the associated soybean varieties, plant population and their interaction effect and cropping system except LAI which was significantly affected by plant population. Highest LAI was recorded from 50% soybean population while the lowest LAI was obtained from 75% soybean population

Phenology of soybean varieties showed highly significant ($P<0.01$) differences due to varieties. Variety Boshe was significantly earlier by 12 and 25 days in flower initiation and physiological maturity, respectively from variety Didesa and Ethio Yugoslavia variety. LA, LAI and number of primary branches of the soybean components showed highly significant ($P<0.01$) difference due to plant population. The highest LA and number of primary branches were obtained in soybean population of 25%. However, the highest LAI was obtained from 75% soybean population.

Plant height, number of effective nodules per plant and number of primary branches of soybean varieties were significantly ($P<0.01$) affected by soybean variety but LA and LAI were not significantly affected. Variety Boshe was shorter than Didesa and Ethio Yugoslavia variety. Similarly, Boshe had higher number of primary branches than the two varieties. Higher number of effective nodules per plant was recorded from variety Didesa while the lowest effective nodule per plant was recorded from variety Ethio Yugoslavia. The result revealed that cropping system had a significant effect on LAI and number of effective nodules per plant where higher LAI and effective nodules per plant were recorded from sole cropped soybean variety than the intercropping system.

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