

## Effect of Variety and Time of Intercropping of Common Bean (*Phaseolus vulgaris* L.) With Maize (*Zea mays* L.) on Yield Components and Yields of Associated Crops and Productivity of the System at Mid-Land of Guji, Southern Ethiopia

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### Abstract

The field experiments was carried out at Bore Agricultural Research Center (BOARC) on Adola Sub-site, during 2015 and 2016 short rainy season with the objective of determining the most suitable time of introducing common bean and select the best common bean variety into maize and common bean intercrop. The experiment was laid out in randomize complete block design (RCBD) with three replications of factorial combination of three common bean varieties (Haramaya, Ibbado and Hawassa Dume) and four time of intercropping (Simultaneously with maize, 2 WAME, 4 WAME and 6 WAME) along with respective sole crops of common bean varieties and maize BH-661. Highly significant interaction effect of variety and time of intercropping were observed on days to flowering, maturity and plant height, whereby simultaneous intercropping of common bean variety provide longer days to flowering and maturity with taller and vigorous growth than delayed intercropping. A highly significant effect of time of intercropping was observed on number of pod plant-1 and seed pod-1, in which the highest mean number were recorded when common bean was simultaneously planted with maize compared to subsequent interseeding. Highly significant interaction effect of variety and time of intercropping were also observed on common bean varieties on hundred seed weight and grain yields, where drastic reduction of hundred seed weight and grain yields were observed due to delayed intercropping. In regards to maize components, only plant height and grain yield were significantly affected by main effect of time of intercropping, in which the highest mean plant height and grain yield were recorded in delayed time of intercropping common bean. On other hand total LER and GMV of Common bean and maize were significantly affected by main effect of time of intercropping. Simultaneous intercropping of common bean with maize proved LER and GMV of 1.36 and 20246 ETB ha<sup>-1</sup>, respectively. Therefore, simultaneous intercropping of common bean with maize could be recommend for midland of Guji and similar agro-ecology, based on the observed productivity and economic benefit.

**Keywords:** Common bean; GMV; LER; Intercropping; Time of intercropping

### Introduction

High population pressure and scarcity of arable land is a prime developmental challenge in many developing nations to fulfil their food and nutritional requirements. In addition, low soil fertility, limited availability of resources to farmers, nutrient mining and drought are also the main causes for low agricultural productivity in those nations [1]. Intercropping, the agricultural practice of cultivating two or more crops in the same space at the same time is an old and commonly used cropping practice which aims to match efficiently crop demands to the available growth resources and labour. 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[2]. Legume-cereal intercropping especially maize-bean intercropping is a common throughout developing world and can be the ideal ones for sustainable production and food security to resource poor farmers [3].

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 [4]. Choice of compatible species and time of their establishment, therefore, seems relevant management options in improving the efficiency of this system. Aiming to maximize the yields of intercrop components through minimizing competition effects, selection of compatible genotypes and timing of intercropping, based on growth characteristics and requirements of the component species in question, are key agronomic issues in intercropping [5].

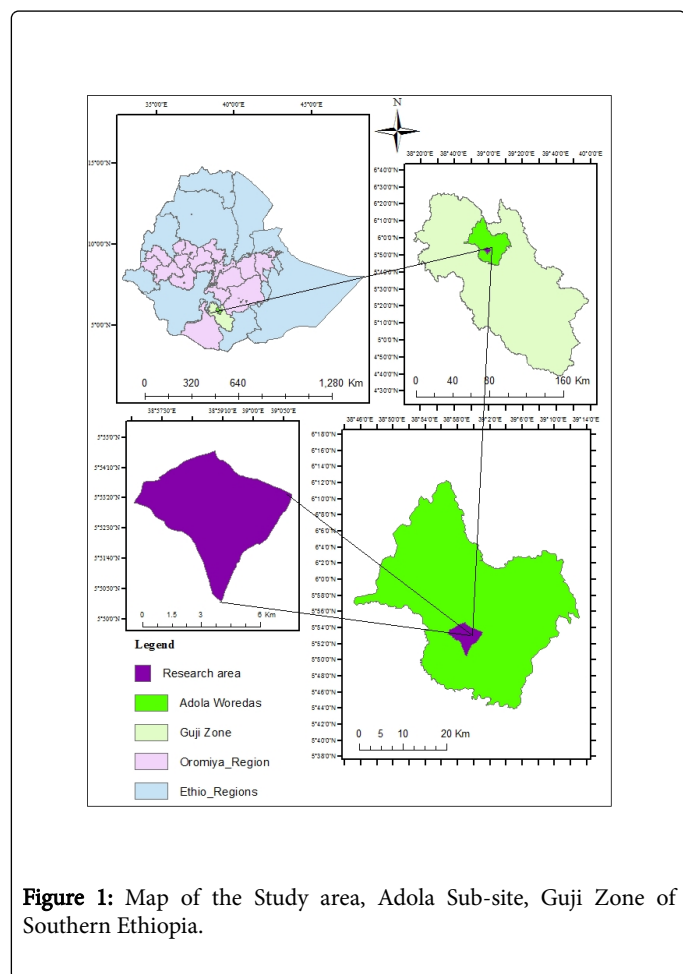
Therefore, varietal selection, understanding the physiology of the species to be grown together, their growth habits, canopy and root architecture, and water and nutrient use are important factors to be considered in intercropping [3]. Similarly complementarities in an intercropping situation can occur when the growth patterns of the component crops differ in time or when they make better use of resources in space. Being the under storey crop in most intercropping systems, growth and yield of legumes are usually suppressed by the dominant crop. 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.

The determination of the most suitable time of introducing any of the component crops into a mixture is one of the agronomic challenges the small-holder farmers face, as this determines the final yield of the crops. It also reduces the severity of interspecific competition between and among the component crops for the limited growth factors [4]. However, farmers in the study area intercrop maize and common bean without consideration of the appropriate time of intercropping. There is also lack of information on appropriate variety of common bean for intercropping with maize as all the released common bean varieties were developed under sole cropping. Therefore, intercropping did not give the best returns in terms of yield or cash because farmers do not necessarily select the most compatible varieties and time of intercropping for intercropping system. Thus, the objective of the study was to determine the most suitable time of introducing common bean and select the best common bean variety into maize and common bean intercrop.

## Materials and Methods

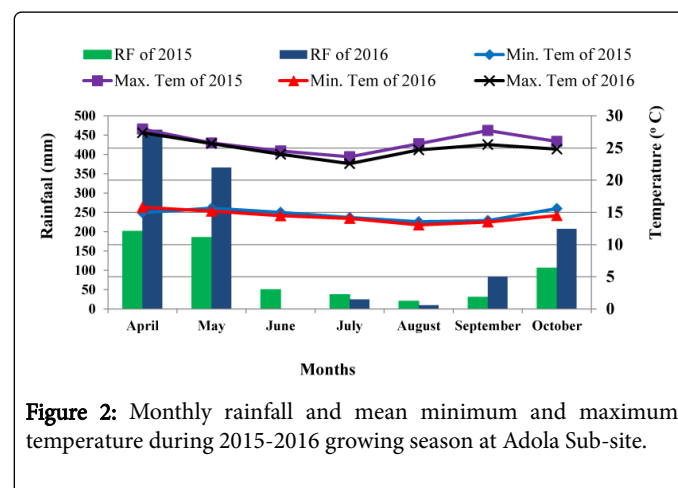
### Description of study area

The experiment was conducted at Bore Agricultural Research Center (BOARC) on Adola Sub-site during the 2015 and 2016 cropping season (March-October) in Oromia National Regional State Guji Zone, Southern Ethiopia (Figure 1).



**Figure 1:** Map of the Study area, Adola Sub-site, Guji Zone of Southern Ethiopia.

BOARC Adola Sub-site is located in Adola Rede district of Guji Zone in Southern Oromia at the distance of about 3 km east of the town Adola. Geographically, the experimental site is situated at the latitudes of 05°50'0"North to 05°55'0" North and longitudes of 38°57'30" East to 39°0'50" East at an altitude of 1718 meters above sea level. The site represents Mid-lands of Guji Zone, receiving high to medium rainfall and characterized by a bimodal rainfall distribution. The first rainy season is from early March up to August and the second season starts in early September and ends to late November. The major soil types are Nitosols (red basaltic soils) and Orthic Aerosols [6]. The soil is clayey in texture and slightly acidic with pH value of around 6.4.



**Figure 2:** Monthly rainfall and mean minimum and maximum temperature during 2015-2016 growing season at Adola Sub-site.

According to the climate data from National Meteorological Agency, Bale Robe Directorate (2005-2014), Adola Rede District had an annual mean rainfall of 978.42 mm with the mean maximum and minimum annual air temperatures of 22.20°C and 10.26°C, respectively (Table 1). The hottest period of the year extends from onward of December up to Marches whereas the coldest period extends from June to December (Table 1). According to meteorological information recorded in the last one decade, maximum rainfall were recorded in the months of May (188.71 mm) and April (173.38 mm) in Adola Rede district (Table 1). During 2015 and 2016 growing seasons Adola sub-site received annual rainfall of 711 and 1315.4 mm, respectively. The annual mean maximum temperature of the two seasons was 27.36 and 26.48°C while the mean minimum temperatures are 12.87°C and 13.3°C, respectively (Figure 2).

Months	2005-2014 Meteorological Data			2015 Meteorological Data			2016 Meteorological Data		
	Total rainfall (mm)	Minimum temperature (°C)	Maximum temperature (°C)	Total rainfall (mm)	Minimum temperature (°C)	Maximum temperature (°C)	Total rainfall (mm)	Minimum temperature (°C)	Maximum temperature (°C)
January	14.49	6.3	24.04	0	7.66	30.34	2	12.02	29.17
February	21.25	7.76	21.57	0	10.32	31.74	0	11.16	31.03
March	78.55	10.42	24.62	26.3	12.73	30.52	41.4	14.42	31.76
April	173.38	12.51	23.11	200.9	14.95	27.94	463.7	15.79	27.37
May	188.71	13.15	22.4	185.3	15.66	25.78	366	15.2	25.68
June	81.85	12.7	21.12	50.1	15	24.53	0	14.48	24.03
July	65.38	11.3	19.39	37.5	14.21	23.63	24.9	14.06	22.57
August	75.5	11.08	20.5	20.4	13.56	25.66	9.8	13.66	24.7
September	73.3	12.33	24.41	30.5	13.73	27.71	83.5	13.5	25.53
October	131.55	11.5	24.16	105.6	14.21	26.02	207.4	14.5	24.83
November	69.84	7.73	18.78	54.4	12.91	26.28	81.7	11.7	25.18
December	4.45	6.27	22.34	0	9.5	28.21	35	8.78	25.99
Total	978.24	-	-	711	-	-	1315.4	-	-
Average	-	10.26	22.2	-	12.87	27.36	-	13.27	26.49

**Table 1:** Monthly total rainfall and mean minimum and maximum temperature of 2005-2014, 2015 and 2016 cropping seasons at Adola Sub-site. Source: National Meteorological Agency, Bale Robe Directorate.

### Description of experimental materials

Three best performing common bean varieties namely; Haramaya, Hawasa Dume and Ibbado were used. The varieties have bush type growth habit, vary in seed color, seed size and market class in the study area. Under sole cropping the varieties vary in their maturity period (80-110 days). Maize variety BH-661 with white Kernel and released for mid to highland agro-ecology of Ethiopia was used as associated cereal.

### Treatments, experimental design and crop managements

The experiment was laid out in randomized complete block design (RCBD) with two factors arranged factorially and replicated three times. The factors employed were three haricot bean varieties (Haramaya, Hawassa Dume and Ibbado) and four time of intercropping (Simultaneous with maize, two weeks after maize emergency (2 WAME), four weeks after maize emergency (4 WAME) and six weeks after maize emergency (6 WAME)). The combined treatments of these factors were intercropped with maize variety BH-661. Respective sole crops of common bean varieties and the maize were included. The maize variety was sown in mid-April in both years on plot size of 4.5 m × 5 m (22.5 m<sup>2</sup>) at 75 cm inter- and 25 cm intra- row spacing. The Common bean varieties in sole crop were seeded at spacing of 40 cm by 10 cm, while the intercropped plots were planted in single row between two rows of maize crop at 10 cm intra-row spacing. The spacing used between plot and blocks was 1 and 1.5 m, respectively. At time of sowing all plots of maize received a basal

application of Di-ammonium phosphate (DAP) and urea at rate of 150 and 50 kg ha<sup>-1</sup>, respectively. Whereas sole common bean plot received a basal application of DAP at rate 100 kg ha<sup>-1</sup> during planting. At knee height growth stage of maize, nitrogen in the form of urea was applied at the rate of 50 kg ha<sup>-1</sup> to all plots excepts the sole common bean plots assuming the common bean would be benefited from nitrogen fixation. All required intercultural operations were done as and when required. The four central rows of maize and five rows of common bean, in the both sole and intercropping were harvested in the both years.

At physiological maturity four central rows of maize and five rows of common bean, in the both sole and intercropping were harvested. Common bean varieties were harvested in late July and that of maize in mid-October in both seasons at 90% maturity. Maize grain and yield was adjusted to 12.5% moisture level and that of common bean to 10%.

### Data collected

For common bean varieties days to 50% flowering (DF), days to maturity (DM), plant height (PH), number of pods plant<sup>-1</sup>, number of seeds pod<sup>-1</sup>, 100 seed weight and seed yield were recorded. Days to 50% flower initiation was recorded as the number of days required from planting to the time when 50% of plants in plots produced at least one flower. Days to maturity was recorded as the number of days required from planting to the time when 90% of plants showed a yellow to brown colour in each plot before senescence. Plant height was recorded from ten randomly taken plants from five central rows at

maturity from ground to the tip of the main stem and then the mean was recorded as height per plant (cm). The number of total pods in ten randomly taken plants from five the central rows were counted at maturity and the means were recorded as the number of pods per plant. The number of total seeds from the above pods was counted and then the total number of seeds was divided by the total number of pods to get average number of seeds per pod. Hundred seed was counted from the harvested bulk and their weight (g) was recorded and adjusted at 10% seed moisture. Plants harvested from the five central rows were threshed to determine seed yield, and the seed yield was adjusted to the moisture content of 10%. Finally, yield per plot was converted to per hectare basis and the average yield was reported in kg ha<sup>-1</sup>.

On maize components, plant height (PH), thousand kernel weight (gm) and grain yield (kg ha<sup>-1</sup>) were collected. Maize height was measured from ten randomly sampled plant plot-1 from ground to terminal stem tasseling. Thousand Kernel weight (TKW) was determined after weighting of thousand kernels at 12.5% moisture content. The seeds were counted using electronically seed counter from sampled of threshed seeds from each plot after harvest. Plants harvested from the four central rows were threshed to determine grain yield, and the grain yield was adjusted to the moisture content of 12.5%. Finally, yield per plot was converted to per hectare basis and the average yield was reported in kg ha<sup>-1</sup>.

On Productivity and monetary value of the system; Land equivalent ratio which verifies the effectiveness of intercropping for using the resources of the environment compared to sole planting. The LER values were computed using the following formula described by Willey (1979).

$$LER = \frac{Y_a}{Y_{aa}} + \frac{Y_b}{Y_{bb}}$$

Where, Y<sub>a</sub>=intercrop yield of haricot bean, Y<sub>b</sub>=Intercrop yield of maize, Y<sub>aa</sub>=Sole crop yield of haricot bean and Y<sub>bb</sub>=sole crop yield of maize.

Gross Monetary Value (GMV) was determined to evaluate the economic advantage of intercropping system as compared to sole cropping [7]. GMV was calculated for common bean varieties and maize component crops by multiplying their yields with their respective market price. The total value obtained from the component crops were used to indicate Gross Monetary Value. To estimate the GMV of the crops, common bean seed yield was valued at an average open market price of 9.5 Ethiopian Birr (ETB) kg<sup>-1</sup> while maize at 3.5 Ethiopian Birr (ETB) kg<sup>-1</sup> at the time of the crop harvested in Adola district, Guji Zone, Southern Ethiopia.

### Statistical data analysis

The Analysis of Variance (ANOVA) was carried out using statistical packages and procedures outlined by Gomez [8] using Gen Stat computer software version 15th edition. Mean separation was carried out using least significant difference (LSD) at 5% probability level.

## Results and Discussion

### Common bean component

**Phenological parameters:** Data over two years were pooled in order to have clear information on the effects of common bean varieties and time of intercropping because of the similarities in responses as

revealed by absence of treatment by year interaction. In this study, combined analysis of variance over years showed that phenological parameters, namely days to flowering and days to maturity were significantly (P<0.01) affected by varieties, time of intercropping and their interaction. Variety Haramaya, Ibbado and Hawassa Dume reached to flower initiation on average 48, 45 and 41.8 days for simultaneous intercropping, respectively, while these varieties took on average 44, 40 and 36 days when intercropped at two weeks after maize emergency. The flower initiation was further reduced to 33 to 34 days when these varieties were intercropped at four weeks after maize emergency (4 WAME).

Means with in same column followed by the same letter (s) are not significantly different at 5% level of significance, LSD=least significant difference, CV=Coefficient of Variation, WAME=Weeks after maize emergency.

Likewise, cropping system also showed significant effects on days to flowering and maturity (Table 2). Intercropping resulted in shorter days to flowering compared to sole cropping of all common bean varieties.

Treatments	DF	DM	PH (cm)
BH-661+Haramaya Simultaneous	48a	84.83a	94.95a
BH-661+Haramaya 2 WAME	44bc	75de	55.9b
BH-661+Haramaya 4 WAME	33f	77.67bcd	37.88de
BH-661+Haramaya 6 WAME	0g	0g	0g
BH-661+Ibbado Simultaneous	45b	80ab	47.32c
BH-661+Ibbado 2 WAME	40d	75.67cd	39.14cd
BH-661+Ibbado 4 WAME	34ef	70.67e	30.04ef
BH-661+Ibbado 6 WAME	0g	0g	0g
BH-661+Hawassa Dume Simultaneous	41.83cd	81.67ab	30.77ef
BH-661+Hawassa Dume 2 WAME	36e	79.83bc	26.13f
BH-661+Hawassa Dume 4 WAME	34ef	81ab	29.23f
BH-661+Hawassa Dume 6 WAME	0g	0g	0g
LSD (5%)	2.68	4.4	8.3
CV (%)	5.3	6.4	15
<b>Cropping system</b>			
Intercropping	29.65c	81.68b	32.61c
Sole Haramaya	48.17a	98.5a	96.08a
Sole Ibbado	43.83b	81.17b	48.88b
Sole Hawassa Dume	46.67a	84.33b	39.08c
LSD (5%)	6	8.4	12.38
CV (%)	8.1	5.6	13.1

**Table 2:** Interaction effect of common bean varieties and time of Intercropping on days to flowering (DF), days to maturity and plant height (PH) of bean in maize-bean intercropping over two seasons (Pooled data of two years).

In other case, the respective days to reach to physiological maturity for variety Haramaya, Ibbado and Hawassa Dume were 84.83, 80 and 81.67 days at simultaneous intercropping, respectively. Whereas, when they were intercropped at two weeks and four weeks after maize emergency all varieties matured earlier, although it was significantly at par with simultaneous cropping for variety Hawassa Dume. Generally, trends of drastic decline of days to flowering and maturity of haricot bean varieties were observed with delayed introduction of common bean after maize. Delaying common bean planting to six weeks compared to maize planting resulted in complete failure of common bean plant probably due to increased shading by maize plants and reduced availability of moisture for survival of seedlings. The reduced days to flowering and maturity of haricot bean varieties in delayed intercropping seems to be related to high competition for nutrient, light and moisture by the well-established maize crop which resulted in forced maturity of common bean. Similarly, Tamiru [9], reported significant difference among the intercropped Soybean varieties on days to flowering and maturity and attributed this to resource competition and the inherent genetic character of the varieties. Willey [10] also reported significant difference among the intercropped common bean varieties on days to flowering and maturity and attributed this to the inherent genetic character of the varieties.

### Growth parameter

The main and interaction effect of varieties and time of intercropping over two seasons showed highly significant ( $P < 0.01$ ) difference on plant height (Table 2). The highest plant height (94.95 cm) was recorded from variety Haramaya and the lowest height (29.23 cm) was recorded from variety Hawassa Dume at simultaneous and four weeks after maize emergency (4 WAME) intercropped, respectively. Generally, trends of drastic decline plant height of Common bean varieties were observed with delayed intercropping and also the overall poorest growth was observed. Generally, the variation in plant height due to intercropping time was much higher for Haramaya variety followed by Ibbado variety. On the other hand, plant height was not affected due to intercropping time for variety Hawassa Dume. This variation might be attributed to varietal difference and resource competitions between the component crops that determine the growth and development of the crop.

Cropping system showed significant ( $P < 0.05$ ) effects on plant height. On the average, the highest plant height was recorded from sole Haramaya Varieties (96.08 cm) whereas lower plant height (32.61 cm) was recorded from intercropped common bean. This reduction could be due to resources competition in intercropping. This result was in agreement with [11] where the highest plant height was recorded from sole cropped variety Awash melka but the lower plant height was recorded from intercropped common bean with maize.

**Yield and yield component:** The analysis of variance over two seasons showed that number of pod per plant was not significantly ( $P > 0.05$ ) affected by variety and interaction with time of intercropping, but it was significantly affected by time of intercropping and cropping system. The highest number of pod per plant (6.5) was recorded at simultaneous intercropping while the lowest number of pod per plant at late intercropping (2 and 4 WAME). Delaying introduction of the common bean in already established maize stand resulted generally in progressive decline in the number of pod per plant (Table 3). The case might have also been that the level of shading during grain filling stage of the later seeded legumes was higher than before as maize attains its maximum growth therefore, resulting in drastic reductions in number

of legume pods per plant and seeds per pod for delayed intercrop treatments. With regards of cropping system, the highest number of pod per plant (17.33) was obtained from sole Ibbado variety while intercropping system had the lowest (2.71) (Table 3). The decrease in number of pod per plant might be due to the competition effect of maize component. Carruthers [12] related this situation to the reduction of photosynthesis due to shading of associated crops to a level that the legume plants compensated by decreasing the amount of assimilate allocation to reproductive growth or grain production.

Number of seed per pod showed a highly significant ( $P < 0.01$ ) variation among variety and time of intercropping and cropping system, while the interaction effect was not significant. Among the varieties, the highest number of seed per pod was obtained from variety Hawassa Dume (2.54) while the lowest number of seed per pod was from variety Ibbado (1.96). This difference observed on number of seed per pod could be due to the inherent characteristics or genetic makeup of the varieties. The lowest number of seed per pod of common bean was obtained in delayed introduction in already established maize stand. Delaying introduction of the common bean variety in already established maize stand resulted, generally in progressive decline in the number of seeds pod-1 (Table 3). This finding agree with that of Adipala and Saban [13,14] who reported that delaying introduction of legumes in already established maize stand, resulted decline of number of seeds per pod.

Treatments	PPP	SPP
<b>Bean varieties</b>		
Haramaya	2.54	2.08ab
Ibbado	2.54	1.96b
Hawassa Dume	3.04	2.54a
LSD (5%)	NS	0.48
<b>Time of intercropping</b>		
Simultaneous	6.5a	3.8a
2 WAME	2.4b	2.8b
4 WAME	1.9b	2.2c
6 WAME	0c	0d
LSD (5%)	0.64	0.56
CV (%)	24	26
<b>Cropping system</b>		
Intercropping	2.71c	2.19c
Sole Haramaya	15.17ab	3.33b
Sole Ibbado	17.33a	3.33b
Sole Hawassa Dume	14.67b	4.5a
LSD (5%)	3.4	0.83
CV (%)	15.5	14.2

**Table 3:** Main effect of common bean varieties and time of intercropping on pods plant-1 (PPP) and seeds pod-1 (SPP) of bean in maize-bean intercropping over two seasons (Pooled data of two years).

Means with in same column followed by the same letter (s) are not significantly different at 5% level of significance, LSD=least significant difference, NS=not significance, CV=Coefficient of Variation, WAME=Weeks after maize emergency.

Cropping system also had significant ( $P<0.05$ ) effect on number of seed per pod. The highest number of seed per pod (4.5) was recorded from sole cropped of Hawassa Dume variety followed by the other two varieties (3.3 each), all of which are significantly higher than the intercropped common bean (Table 3). The lower number of seed per pod could be due to the high competition for resource among the component crops. Moreover, higher number of seed per pod in sole cropped common bean might be due to less competition for resource per unit area under sole cropping than in intercropping. This result was in conformity with the result reported by Chui [15] where intercropping reduced soybean biological yield by 87% when compared with sole cropping, principally because of reduced plant growth and photosynthetic assimilation [16].

Means with in same column followed by the same letter (s) are not significantly different at 5% level of significance, LSD=least significant difference, CV=Coefficient of Variation, WAME=Weeks after maize emergency.

Treatments	HSW (gm)	YLD (kg ha <sup>-1</sup> )
BH-661+Haramaya Simultaneous	42.83bcd	1315.5a
BH-661+Haramaya 2 WAME	53.0a	664.0d
BH-661+Haramaya 4 WAME	42.5cd	69.6fg
BH-661+Haramaya 6 WAME	0.0f	0.0g
BH-661+Ibbado Simultaneous	49.67abc	853.6c
BH-661+Ibbado 2 WAME	55.83a	301.0e
BH-661+Ibbado 4 WAME	50.0ab	109.8fg
BH-661+Ibbado 6 WAME	0.0f	0.0g
BH-661+Hawassa Dume Simultaneous	30.0e	994.1b
BH-661+Hawassa Dume 2 WAME	35.5de	201.5ef
BH-661+Hawassa Dume 4 WAME	30.0e	67.9g
BH-661+Hawassa Dume 6 WAME	0.0f	0.0g
LSD (5%)	7.48	132.63
CV (%)	13.4	20.5
<b>Cropping system</b>		
Intercropping	32.86a	381b
Sole Haramaya	42.17a	2147a
Sole Ibbado	44.83a	1703a
Sole Hawassa Dume	27.5c	1912a
LSD (5%)	7.29	800.11

CV (%)	11.3	20.4
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**Table 4:** Interaction effect of common bean varieties and time of Intercropping on hundred seed weight (HSW) and seed yield (YLD) of bean in maize-bean intercropping over two seasons (Pooled data of two years).

Hundred seed weight of common bean was significantly ( $P<0.01$ ) affected by variety, time of intercropping and their interaction and cropping system. The highest hundred seed weight (53 gm) was recorded from Haramaya variety intercropped two weeks after maize emergency (2 WAME) and the lowest hundred seed weight (30 gm) was obtained from variety Hawassa Dume intercropped at simultaneous and four weeks after maize emergency (4 WAME) (Table 4). The difference in hundred seed weight might be because of inherent characteristics of the variety and due to high interspecific competition and crowding out of the weaker plants by vigorous ones.

Consistent with this result, Jibril [17] reported a significant difference in hundred seed weight of common bean in maize-bean intercropping due to varietal difference. Similarly Tamiru [9] also reported significant difference in hundred seed weight of soybean in maize-soybean intercropping.

Cropping system also had significant ( $P<0.05$ ) effect on hundred seed weight of common bean variety. The higher hundred seed weight (44.83 gm) was recorded from sole cropped Ibbado variety than sole cropped Hawassa Dume variety. However, the hundred seed weight obtained under two sole cropped common bean varieties and intercropped were in statistical parity.

Seed yield of common bean component was significantly ( $P<0.01$ ) affected due to varietal differences, time of intercropping and their interaction. Similarly cropping system also showed significant effect on seed yield of bean. In all varieties, simultaneous maize and common bean planting gave the highest common bean grain yield as compared to subsequent plantings. Seed yield of the three varieties of common bean in intercropping generally exhibited an extreme decline as their planting was delayed after maize, which implies the presence of severe competition for resource as maize crop becomes well established. In previous studies, maize has been shown to be a great competitor in mixtures and had the advantage of being taller than cowpea and might intercept more light than cowpea [18]. Competition for nutrients can also result in substantial crop yield reductions in mixed cropping systems [19]. Maize has a competitive advantage because its roots occupy both shallow and deeper soil layers and have a superior ability to recover soil mineral N, whereas root systems of legumes are smaller and confined to the upper soil layer [20]. This finding is similar with that of [14] Saban who reported that simultaneous intercropping of common bean varieties yielded the highest grain yield as compared to the subsequent seeding. Similarly, [21] Chemeda also reported a reduction in bean seed yield with delayed interseeding. In accordance with this result, reduction in seed yield of other legume crops due to delaying planting in maize also reported by Curruthers [12] and Lawson [22].

Mean grain yield of common bean in the intercrop systems was 381 kg ha<sup>-1</sup> which was significantly lower than the sole crop yield of Haramaya, Ibbado and Hawassa Dume varieties which recorded 2147, 1703 and 1912 kg ha<sup>-1</sup>, respectively (Table 4). For instance, the yield of intercropped common bean was reduced by 82.25% as compared to sole Haramaya Variety. Lower grain yield of intercropped common

bean might be due to increase inter-specific competition in intercropping than sole cropping. In consistence with this result, Muoneke [23] reported similar yield reduction in soybean inter cropped with maize and sorghum and attributed the yield depression to inter specific competition and the depressive effect of the cereals.

### Maize components

**Growth parameters:** Analysis of variance over two seasons showed that plant height of intercropped maize was not significantly ( $P>0.05$ ) affected by main effect of common bean varieties and their interaction effects, but it was significantly affected by main effect of time of intercropping as well as by cropping system. With regard to time of intercropping, higher maize plant height were recorded when common bean varieties were planted four weeks after maize emergency and the trend of increased height were observed with delayed under seeding of common bean varieties (Table 5). This result contradicted with the findings of Saban [14] which reported higher height of maize crop when legume crops were simultaneous planted with maize.

Treatments	PH (cm)	CPP	TKW (gm)	GYLD (kg ha <sup>-1</sup> )
<b>Bean varieties</b>				
Haramaya	239.7	1.3	401.7	3518
Ibbado	232.9	1.3	393.8	3919
Hawassa Dume	232	1.4	375	3689
LSD (5%)	NS	NS	NS	NS
<b>Time of intercropping</b>				
Simultaneous	220.2b	1.2	393.9	2923c
2 WAME	240.6a	1.3	389.4	3511bc
4 WAME	242.9a	1.4	387.2	4106ab
6 WAME	235.8a	1.6	390	4295a
LSD (5%)	14.19	NS	NS	805.05
CV (%)	6.2	29.8	7.3	16.6
<b>Cropping system</b>				
Intercropping	234.9b	1.36	365	3708.5
Sole Maize	255.2a	1	350	3975.5
LSD (5%)	14.47	NS	NS	NS
CV (%)	3	4.1	6.4	19.9

**Table 5:** Main effect of common bean varieties and time of intercropping on Maize plant height (PH), number of Cob plant-1 (CPP), thousand kernel weight (TKW) and grain yield (GYLD) in maize-bean intercropping over two seasons (Pooled data of two years).

Means with in same column followed by the same letter (s) are not significantly different at 5% level of significance, LSD=least significant difference, NS=not significance, CV=Coefficient of Variation, WAME=Weeks after maize emergency.

Sole cropped maize had significantly higher plant height (255.2 cm) than the intercropped system. The reduction of height of the

intercropped maize might be associated with interspecific competition between the intercrop components for growth resources (light, water, nutrients etc.) and depressive effects of common bean on maize at early growth stage because both crop were planted simultaneously and bean was emerged early than maize. In accordance with this result, [24] Hirpha reported that height of sole cropped sorghum was significantly higher than intercropped sorghum.

**Yield and yield component:** Number of cob per plant and thousand kernel weights were not significantly affected by varietal differences, time of intercropping, their interaction and due to cropping system. Similar with this result, [14] Saban reported that thousand grain weight of maize not significantly affected by cowpea intercropping and interseeding time of legume crops.

Grain yield of intercropped maize was not significantly affected by main effect of common bean varieties, interaction and cropping system. However, main effect of time of intercropping was significantly affect grain yield of maize. In this regard, association of maize with common bean after six weeks maize emerged gave the highest grain output (4295 kg ha<sup>-1</sup>), almost higher than sole maize. Simultaneous intercropping however, reduce maize grain yield by 31.9% as compared to intercropping six weeks after maize emergency (Table 5). This indicates an increased trend of mean grain yield of maize with delaying the time of common bean intercropping. In agreement with this result, [14] Saban reported an increased mean of Maize grain yield with delaying the time of legume intercropping. Similarly, [21] Chemedda also reported that delayed bean planting increased maize grain yield in maize/bean cropping systems.

### Land productivity and gross monetary evaluation

The productivity of this experiment was evaluated by calculated total land equivalent ratio (LER) and Gross Monetary Value (GMV). The total land equivalent ratio (LER) was calculated by adding land equivalent ratio of maize and common bean. Total land equivalent ratio (LER) of maize and common bean intercrops were significantly ( $P<0.05$ ) affected by time of intercropping and cropping system. However, the interaction of variety and time of intercropping and main effect of variety had no significant effect on total land equivalent ratio. In all the intercrops, the LER was more than unity, which showed that land utilization efficiency of maize-common bean intercropping was more advantageous than for sole cropping. In other words, more lands will be required in the monoculture of either of the component crops to produce the same yield obtained from their intercropping. A LER greater than 1.0 has been reported previously with bean maize intercropping [14]. The higher LER (1.36) was obtained at simultaneous intercropping followed by intercropping at two weeks after maize emergency (1.13) and the lowest was intercropping at six weeks after maize emergency (1.09) (Table 6). The highest LER (1.36) indicates that simultaneous intercropping of common bean with maize gave a 36% yield advantage than planting maize or common bean interdependently as sole crops. This result was in agreement with report of [25] were LER of maize/common bean range from 1.29-1.69 in Ethiopia. Similarly, [26] Habte reported LER of 1.4-1.42 from maize/ common bean intercropping. Similarly, [27] Tamiru observed LER of 1.43-1.54 for maize/common bean intercropping.

Means with in same column followed by the same letter (s) are not significantly different at 5% level of significance, LSD=least significant difference, NS=not significance, CV=Coefficient of Variation, WAME=Weeks after maize emergency.

Cropping system showed significant effect on LER where of intercropping was (1.17) which showed 17% yield advantage and efficient land utilization by intercropping as compared to sole cropping. This value of LER in intercropping treatments compared to sole cropping of common bean might be due to better utilization of land, light, nutrient and water.

Treatments	LER	GMV (ETB ha <sup>-1</sup> )
<b>Bean varieties</b>		
Haramaya	1.18	17180
Ibbado	1.21	16718
Hawassa Dume	1.12	15913
LSD (5%)	NS	NS
<b>Time of intercropping</b>		
Simultaneous	1.36a	20246a
2 WAME	1.13b	15983b
4 WAME	1.10b	15156b
6 WAME	1.09b	15032b
LSD (5%)	0.13	2470.76
CV (%)	11.6	15.2
<b>Cropping system</b>		
Intercropping	1.17a	16604
Sole Bean	1.0b	18247
Sole Maize	1.0b	13913
LSD (5%)	0.13	NS
CV (%)	6.6	14.3

**Table 6:** Main effect of common varieties and time of intercropping on land equivalent ratio (LER) and Gross Monetary Value (GMV) in maize-bean intercropping over two seasons (Pooled data of two years).

In addition to LER, Gross Monetary Value (GMV) was used to evaluate economic advantages. The GMV of intercrops was not significantly ( $P > 0.05$ ) affected by main effect of variety, interaction and cropping system. However, it was significantly affected by main effect of time of intercropping. The highest GMV of 20246 ETB ha<sup>-1</sup> was obtained at simultaneous intercropping of common bean with maize and the lowest GMV of 15032 ETB ha<sup>-1</sup> was obtained from intercropping of common bean at six weeks after maize emergency (Table 6). In line with this, [28] Hirpa reported the highest economic return at simultaneous intercropping of legumes with maize.

## Conclusion and Recommendation

High population pressure and scarcity of arable land have been compelled planting of two or more crops on the same pieces of land at the same time. Thus, the only way to increase agricultural production is to increase yield per unit area. Hence, maize/common bean intercropping could increase incomes obtained by smallholder farmers, through enhancing efficient utilization of land. According to the result

of this study simultaneous intercropping of common bean variety with maize resulted longer days to flowering and maturity compared with subsequent intercropping. Similarly, taller plant heights with better canopy at simultaneous intercropping with maize was also observed on common bean variety, while delaying intercropping of common bean variety in maize stand was observed to result in shorter plant height. Hence, it could be concluded that simultaneously intercropped bean variety exhibited a high degree of morphological plasticity compared to subsequent intercropping, presumably in response to increased competition for resources such as light, water, nutrients etc. The result of this study also confirmed that yield parameters of common bean variety namely, number of pod per plant and seed yield were adversely affected by delayed time of intercropping common bean variety in an already established maize crop, which consequently reduced total seed yield, probably due to the shading effect of the taller component maize. Significant treatment combination was observed on grain yield of common bean variety, which showed that intercropping of Haramaya Variety simultaneously with maize provided better grain yield compared to other variety. Regards to maize component, grain yield was significantly affected by main effect of time of intercropping were delay common bean variety intercropping provide higher maize grain yield. On other hand total LER and GMV of Common bean and maize were significantly affected by main effect of time of intercropping. Simultaneous intercropping of common bean with maize proved LER and GMV of 1.36 and 20246 ETB ha<sup>-1</sup>, respectively. Therefore, simultaneous intercropping of common bean with maize could be recommend for midland of Guji and similar agro-ecology, based on the observed productivity and economic benefit.

## References

- McCann JC (2005) Maize and Grace. Africa's Encounter with a New World Crops 1500-2000. Harvard University Press, Cambridge.
- Lithourgidis AS, Dordas CA, Damalas CA, Vlachostergios DN (2011) Annual intercrops: An alternative pathway for sustainable agriculture. Australian Journal of Crop Science 5: 396-410.
- Abera T, Tana T, Pant LM (2005) Grain and LER of maize bean intercropping as affected by inorganic and organic fertilizers and population density in western oromia, ethiopia. Asian Journal of Plant Science 4: 458-465.
- Muoneke CO, Ndukwe OM, Umana PE, Okpara DA, Asawalam DO (2012) Productivity of vegetables cowpea (*Vigna unguiculata* L. Walp) and maize (*Zea mays* L.) intercropping system as influenced by component density in a tropical zone of southeastern Nigeria. International Journal of Agricultural Research and Development 15: 835-847.
- Banik P, Sasmal T, Ghosal PK, Bagchi DK (2000) Evaluation of mustard (*Brassica campestris* Var. Toria) and legume intercropping under 1:1 and 2:1 row-replacement series systems. Journal of Agronomy and Crop Science 185: 9-14.
- Worku W (2005) Evaluation of Common bean (*Phaseolus vulgaris* L.) varieties intercropped with maize (*Zea mays* L.) for double cropping at Haramaya and Hirna areas, Eastern Ethiopia. MSc Thesis, Haramaya, Ethiopia.
- Vandermeer JH (1989) The ecology of intercropping. Cambridge University press. Cambridge. UK.
- Gomez KA, Gomez AA (1984) Statistical Procedures for Agricultural Research, 2nd edn, John Wiley and Sons, New York, p: 680.
- Hirpa T (2014) Effect of intercrop row arrangement on maize and haricot bean productivity and the residual soil. World Science Research Journal 2: 69-77.
- Willey RW (1979) Intercropping: Its importance and research needs. Competition and yield advantage. Field Crops 32: 1-10.



11. Getahun A, Abady S (2016) Effect of Maize (*Zea may* L.) on Bean (*Phaseolus vulgaris* L.) yield and its components in Maize-Bean intercropping. *International Journal of Science and Research* 5: 126-133.
12. Carruthers K, Prithiviraj B, Cloutier D, Fe Q, Martin RC, et al. (2000) Intercropping of corn with Soybean, Lupine and forages: Silage yield and quality. *European Journal of Agronomy* 12: 103-115.
13. Adipala E, Ocaya CP, Osiru DSO (2002) Effect of time of planting cowpea (*Vigna unguiculata* (L.) walp.) relative to maize (*Zea mays* L.) on growth and yield of cowpea. *Tropicicultura* 20: 49-57.
14. Saban Y, Mehmt A, 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.
15. Chui AN, Richard S (2003) Influence of spatial arrangements of maize on performance of an associated soybean intercrop. *Fields Crop Research* 8: 187-198.
16. Kipkemoi PL, Wasike VW, Oro PA, Riungu TC, Bor PK, et al. (2003) Effects of Intercropping Pattern on Soybean and Maize Yield in Central Rift Valley of Kenya. Kenya Agricultural Research Institute, Nairobi, Kenya.
17. Temesgen J, Kufa T, Wondimu Z (2015) Effect of planting density of hybrid Maize and common bean varieties on the productivity of intercropping system at Jimma, South West Ethiopia. *Global Journal of Life Science and Biological Research* 1: 9-19.
18. Muoneke CO, Asiegbe JE (1997) Effects of okra planting density and spatial arrangement in intercrop with maize on the growth and yield of the component species. *Journal of Agronomy and Crop Science* 179: 201-207.
19. Hardter R, Horst WJ (1990) Nitrogen and phosphorus use in maize sole cropping and maize/cowpea mixed cropping systems on an Alfisol in northern Guinea Savannah of Ghana. *Biology and Fertility of Soils* 10: 267-275.
20. Hauggaard Nielsen H, Ambus H, Jensen ES (2001) Temporal and spatial distribution of roots and competition for nitrogen in pea-barley intercrops; a field study employing 32P technique. *Plant and Soil* 236: 63-74.
21. Fininsa C (1997) Effects planting pattern, relative plating date and intra-row spacing on a Haricot bean/Maize intercrop. *African Crop Science Journal* 5: 15-22.
22. Lawson YDI, Dzomeku IK, Drish YJ (2007) Time of planting Mucuna and Canavalia in an intercrop system with maize. *Journal of Agronomy* 6: 534-520.
23. Muoneke CO, Ogwuche MO, Kalu BA (2007) Effect of maize planting density on the performance of maize/soybean intercropping system in a Guinea Savanna agro-ecosystem. *African Journal of Agricultural Research* 2: 667-677.
24. Hirpha D (2005) Effect of moisture conservation methods and plant density of component crops on performance of sorghum/bean intercropping in Meiso district, west Hararge. MSc Thesis, Haramaya University, Ethiopia.
25. Lulie B, Worku W, Beyene S (2016) Determinations of haricot bean (*Phaseolus vulgaris* L.) planting density and spatial arrangements for staggered intercropping with maize (*Zea mays* L.) at wondo genet, Southern Ethiopia. *Academic Research Journal of Agricultural Science and Research* 4: 297-320.
26. Habte A, Kassa M, Sisay A (2016) Maize (*Zea mays* L.)-Common bean (*Phaseolus vulgaris* L.) intercropping response to population density of component crop in Wolaita Zone Southern Ethiopia. *Journal of Natural Sciences Research* 6: 69-74.
27. Hirpa T (2013) Maize productivity as affected by intercropping date for companion legumes. *Peak Journal of Agricultural Sciences* 1: 70-82.
28. Hirpa T (2013) Effect of interceding date on growth and yield of three legume crop intercropped with maize (*Zea mays* L.). *Journal of Biological and Chemical Research* 30: 652-673.