Journal of Biology, Agriculture and Healthcare
ISSN 2224-3208 (Paper) ISSN 2225-093X (Online)
Vol.13, No.9, 2023

Effects of Varieties and Relative Planting Time of Climbing Bean in Hybrid Maize Bean Intercropping on Growth and Phenological Parameters of The Component Crops at Haro Sabu, Western Ethiopia

Solomon Bekele[1*] Chala Debela[2] Jemal Abdulahi[3]
1. Dukam Agricultural office, Dukam, Ethiopia
2. Oromia Agricultural Research Institute, Bako Agricultural Research Center, Bako, Ethiopia
3. School of Plant Sciences, College of Agriculture and Environmental Science, Haramaya University, Ethiopia

Abstract
Maize and climbing bean intercropping is one of the major maize based cropping system in which is very crucial in modern agriculture. The field study was conducted at Haro Sabu Agricultural Research Center, during 2018 cropping season to assess the effects of varieties and relative planting date of climbing bean intercropping with hybrid maize on Growth and phenological of the component crops. The experiment was laid out in Randomized complete Block design (RCBD) with three replication in factorial combination of three climbing bean varieties (Dandesu, Tibe and Waragutu) and four dates of planting (simultaneous planting, 7 days after planting of hybrid maize, 14 days after planting hybrid maize and 21days after planting hybrid maize) along with respective sole crop of climbing bean varieties and hybrid maize, shone variety (PHB30G19). Analysis of variance indicated significantly affected days to tasseling, days to silking, leaf area, leaf area index, plant height, number of ears per plant, thousand kernel weights, and harvest index. Simultaneous planting significantly delayed phenological parameters as compared to other planting time. The highest (3.31cm^2) was obtained from 14days after planting hybrid maize (DAPM) and number of ears per plant (1.20) was obtained from 21DAPM, the thousand kernel weights (276.4g) were obtained at 7 DAPM from variety Tibe. The highest harvest index (35.85) was obtained from 14DAMP. Sole cropped maize significantly delayed days of tasseling and silking, increase plant height, number of ear per plant, above ground biomass and harvest index than the respective intercrop. The highest number of pod per plant (24.06) and seed per pod (5.07) were obtained from variety Tibe. Based on this study intercropping of maize with Tibe variety at14 DAPM could be recommended for the study area.
Keywords: Cropping system, Leaf area index, Intercropping, *Zea mays*
DOI: 10.7176/JBAH/13-9-01
Publication date: June 30th 2023

Introduction

Maize (*Zea mays* L.) is a member of the grass family, Poaceae. It is originated in Central America and was introduced to Ethiopia during the 1600s to 1700s [1]. And become one of the most important cereal crops grown in the country. Maize crop production in 2019 took 28.75% with the production of 96357345 quintals [2]. Considering its importance in terms of wide adaptation, total production and productivity, maize is one of the high priority crops to feed the ever increasing population of the country.

Maize is the number one food crop in the study area (Kelem Wellega Zone), followed by sorghum, millet, tef, wheat and barley in their order of importance and from the total area occupied by cereal crop production in 2019 maize took 41.48% with the production of 3731011.31 quintals and productivity of maize in the zone was 45.48 Qt ha^{-1} and more by 6.84% productivity than maize produced at national level [2].

Common bean (*Phaseolus vulgaris L.*) is one of the major food crop legume used for consumption and cash in came in Ethiopia and has considerable national economic significance and food security ensure in Ethiopia [3]. It ranks third as an export commodity of Ethiopia, contributing about 9.5% of total export value from agriculture. The majority of common bean producers in Ethiopia are small scale farmers, to be used as a major food legume and consumed in different types of traditional dishes in many parts of the country [4].

Common bean seeds contain 20-25% proteins, much of which is made up of the storage Protein phaseolin [5]. Low yield of common bean in Ethiopia is attributed to several production constraints which include lack of improved varieties for the different agro- ecological zones, poor cultural practices such as the availability of land, labor and cash. 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 [6]. 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 [7].

Therefore, solutions for the soil fertility problems found smallholder farmers' among is the strategic combination of organic resources, particularly from nitrogen-fixing legumes, with small amounts of mineral fertilizers [8].

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 labor. 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 [9].

Otherwise, competition among mixtures and population densities of the component crops in cereal legume intercropping is the major aspect affecting yield as compared with sole cropping of cereals. A number of indices such as land equivalent ratio (LER), competitive ratio (CR), relative crowding coefficient (K), aggressive (A), growth monetary value (GMV), net return (NR) and area-time equivalent ratio (ATER), and intercropping advantage have been proposed to describe competition within and economic advantages of intercropping systems.

Many researchers have expressed 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 [10]. Some scholars indicated that simultaneous planting of climbing bean in BH-661 maize variety is the best practices to get the highest net benefits. Alternatively, farmers could also prefer to use planting of the beans 15 days after BH-546 variety of maize planted. Moreover, intercropping of bean after 20 or more days planting of Gibe 2 could be used to advise the farmers as other options where there are limited accesses to hybrid varieties [11]. A positive nitrogen balance by soybean crop was obtained due to the effect of increased crop duration and nitrogen application [12].

The total mixture densities and the relative proportion of component crops are important in determining yields and production efficiencies of cereal-legume intercrop systems [13]. 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 [14]. About 50% sorghum and 100% groundnut associate gave the highest relative pod yield of groundnut component as compared the highest proportions [15]. The intercrops of maize with bean in 100% of the sole maize population (44,444 plants/ha) and 50% of the sole bean population (125,000 plants/ha) gave high yield [16]. Thus, plant population can be used as a tool to manage crop growth, maximize biomass, the time required for canopy closure and yield.

Therefore, Date of planting, 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 [17]. The farming communities in western Oromia, Ethiopia intercrop maize with climbing bean without considering date of planting of the component crops to intercrop. There is shortage of information on appropriate variety of climbing bean for intercropping with hybrid maize as the released climbing bean varieties were developed under sole cropping. Therefore, intercropping did not give the best returns in terms of yield because farmers do not necessarily select the most compatible varieties and date of planting for beans variety used for intercropping. Although climbing beans are highly accepted by farmers, their major short-coming is that they require stakes to support their growth and or should be grown in association with other crops on which they climb. Staking is a very valuable agronomic practice in climbing bean production [18].

Farmers intercrop this bean type with hybrid maize so that hybrid maize is used as a support. It has been observed that date of planting the intercropped hybrid maize and bean varieties have impact on the performance of both crops. But investigation on climbing bean and hybrid maize has not been reported. Therefore, the objective of the present study was to assess the effects of varieties and relative planting date of climbing bean in intercropping with hybrid maize on leaf area index and yield related traits of the component crops

MATERIALS AND METHODS

Description of the Study Area

The experiment was carried out at Haro Sabu Agricultural Research Center (HSARC) during the main cropping seasons. The Center is located in western Oromia region at 550 km away from Addis Ababa. It lies at latitude of 8° 52’51” N and longitude 35°13’18’’ E and altitude of 1515 m above sea level. According to National Meteorological Agency, Asossa Branch Directorate, (2017) Haro Sabu has warm humid climate with average minimum and maximum temperatures of 12.44°C and 28.5°C, respectively. It receives average annual rain fall of 1492 mm and its distribution pattern is uni-modal. The major rain period covers from May to October. The soil type of the experimental site is reddish brown and sandy clay loam in texture and its pH is 5.55. The area is characterized by coffee dominant based farming system and crop-livestock mixed farming system in which maize, sorghum, finger millet, climbing bean, soybean, sesame, banana, mango, and sweet potato are the major crops grown in the area.

Experimental Materials

One improved maize hybrid Shone variety and three climbing common bean varieties (Dandesu, Tibe and Waragutu) were used as listed in table below.

Table 1: Description of hybrid maize and climbing bean varieties

Crop Variety	Year of release	Releasing institute	Crop type	Adaptation zone	Days to maturity	Yield (t/ha)
Maize/Shone	2006	PHSEPLC	Hybrid	1000-2000	162	7-11
Climbing bean						
Dandesu	2010	BARC	climbing	1200-1900	90-110	2.9
Tibe	2004	BARC	climbing	1200-1900	90-120	2.6
Waragutu	NA	Local	climbing	1200-1900	NA	NA

*BARC= Bako Agricultural Research Center, NA=Not available, masl=meter above sea level, PHSEPLC= Pioneer hybrid seed Ethiopia PLC

Treatments and Experimental Design

The treatments consisted of two factors, namely three climbing bean varieties (Dandesu, Tibe and Waragutu) and four date of bean planting, namely the same date of planting with hybrid maize, 7 days after maize planted, 14 days after maize planted and 21 days after maize planted. And there were four additional treatments (sole maize, sole Dandesu, sole Tibe and sole Waragutu) totally 16 treatments. The experiment was arranged in randomized complete block design (RCBD) with three replication in factorial arrangement (Table 2).

Table 2: List of combination

1	Dandesu intercropped with maize at the same date of maize planting
2	Tibe intercropped with maize at the same date of maize planting
3	Waragutu intercropped with maize at the same date of maize planting
4	Dandesu intercropped with maize 7 days after maize planted
5	Tibe intercropped with maize 7 days after maize planted
6	Waragutu intercropped with maize 7 days after maize planted
7	Dandesu intercropped with maize 14 days after maize planted
8	Tibe intercropped with maize 14 days after maize planted
9	Waragutu intercropped with maize 14 days after maize planted
10	Dandesu intercropped with maize 21 days after maize planted
11	Tibe intercropped with maize 21 days after maize planted
12	Waragutu intercropped with maize 21 days after maize planted
13	Sole maize
14	Sole Dandesu
15	Sole Tibe
16	Sole Waragutu

Experimental Design and Managements

The experimental plots were ploughed and harrowed by a tractor to get a fine seedbed and leveled manually before the field layout was made. Both hybrid maize and climbing bean varieties were planted simultaneously on 8 June, 2018, likewise climbing bean varieties were planted 7, 14 and 21after maize planted. Two seeds per hill of both maize and climbing bean were planted and thinned to one plant per hill one week after emergence. At time of planting, all plots of maize receive full NPSB (18% N, 38% P_2O_5, 7% S, and 0.1% B) at recommended rate of 100 kg ha^{-1} NPSB and urea at knee height growth stage of the maize. The distances between beans plants in the intercrops were 10 cm and thus the climbing bean plant population in the intercropped were 133,333 plants ha^{-1} whereas 250,000 plants ha^{-1} for sole crops with spacing of 40 cm between rows and 10 cm between plants. However, the plant population for both sole and intercrop of maize were 44,444 plants ha^{-1} with 75×30 cm plant spacing. The gross plot of maize was 5 rows of 3 m length at inter row spacing of 75 cm (3.75 x 3 m =11.25 m^2). The middle 3 rows of maize and beans between the rows of maize were harvested thus the net plot size was 4.05 m^2 (2.25 x 1.8 m^2) for maize and 3.75 (2.5 x 1.5 m^2) for beans. The sole maize gross and net plot size were the same as for inter cropped maize. The sole beans gross plot had 9 rows with 40 cm apart and the middle 7 rows were harvested the net plot size were 8.4 (2.8m^2 x 3 m^2). Hand weeding and hoeing were done as required. Finally, hybrid maize and climbing bean were harvested from the net plot after they reached 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 climbing bean and both maize and climbing bean were threshed manually.

Data Collection and Measurements

Maize component

Phenological and Growth parameters

Days to tasseling and silking: Days to tasseling was recorded when 50% of plants showed protruded tassels and

was expressed in numbers of days from the day to planting. Similarly, days to silking was recorded as the number days from planting to the time when 50% of plants in a plot protruded silk.
Days to physiological maturity: It was recorded as the number of days from planting to when 75% of plants in a plot formed black layer at the point of attachment of the kernel with the cob.

Growth parameters
Leaf Area (cm^2): Leaf area was measured at 50% of days to tasseling. Leaf Area was taken from five plants of central rows and three representative active leaves (lower, middle and top) per plant. Leaf length was measured from the tip of the ligule to the apex and its maximum width was taken from mid-way along its length using a measuring tape. Area of each leaf was determined by multiplying length (L), maximum width (W) and constant factor (0.733), i.e. L x W x 0.733 as described by [19]. Total leaf area of the plant was calculated as the product of total leaf number and average leaf area of three leaves area per plant.
Leaf area index: Leaf Area (cm^2): Leaf area was measured at 50% of days to tasseling. Leaf Area was taken from five plants of central rows and three representative active leaves (lower, middle and top) per plant. Area of each leaf was determined by multiplying length (L), maximum width (W) and constant factor (0.733), i.e. L x W x 0.733 as described by [19]. Leaf length was measured from the tip of the ligule to the apex and its maximum width was taken from mid-way along its length using a measuring tape. Total leaf area of the plant was calculated as the product of total leaf number and average leaf area of three leaves area per plant.
Plant height (cm^2): Height of ten randomly taken plants in the central rows of each plot was measured from the soil surface to the base of the tassel at time of physiological maturity. The average was calculated and expressed per plot bases.
Number of ears per plant: It was recorded from ten randomly taken plants per net plot area at harvest.
Number of kernel per ear: It was recorded from ten randomly taken ears from net plot area.
Above ground dry biomass (t ha^{-1}): All maize stalks from each net plot were harvested near to the ground level and sun dried for seven days to constant weight and the total above ground dry biomass including the cobs from each net plot area was measured.

Climbing bean component
Phenological and Growth parameters
Days to flower initiation: It was recorded as the number of days from planting to the time when 50% of the plants in each plot produced at least one flower.
Days to physiological maturity: It was recorded as the number of days from planting to the time when 95% of pods reached maturity, *i.e.* color of pod changed to yellow.
Number of primary branches: It was determined by taking five randomly taken plants per plot at harvesting time. The average of five plants was taken as number of primary branches per plot.
Number of pods $plant^{-1}$: It was determined by counting total number of pods from five randomly taken plants from each net plot at the time of harvest and expressed as number of pods per plant.
Number of seeds per pod: It was determined by counting total seeds of counted pods from five randomly taken plants from each net plot and divided by the total number of pods and expressed as number of seeds per pod.

Data Analysis
Analysis of variance was carried using General Linear Model of ANOVA using SAS version 9.0 software. Mean separation was carried out using least significance difference (LSD) test at 5% probability level.

RESULTS AND DISCUSSIONS
Maize Component
Phenological and Growth parameters
All the phenological parameters of hybrid maize, namely days to 50% tasseling, 50% silking and 75% physiological maturity were significantly affected by the date of climbing bean planting. Likewise cropping system showed significant effect on days to 50% tasseling and silking, but non-significant on 75% physiological maturity. Simultaneous planting significantly delayed all phenological parameters indicating that there might be competition for resource when both are planted at the same time. While the effect of 7 and 21 days after planting of hybrid maize was the same.

On other hand sole planting of hybrid maize significantly delayed days to tasseling, days to silking as compared to intercropping. This indicates that there was high competition of resources when beans are planted at the same time with maize and weak, long and twisted stem and branches enabling reproductive adaptation (which results in pods distributed from the base to the top of the plant or production of pods for a long time), can disturb phenological parameters of maize. In line with the result that significant effect of the associated bean varieties on days to 50% tasseling and days to 50% maturity of the maize component reported by [20].

Table 3: Main effects of varieties and date of planting of intercropped climbing bean and cropping system on phenological parameters of maize component

Treatment	DT	DS	DAPHM
Climbing bean varieties in date of planting			
Simultaneous	80.00[a]	84.00[a]	136.00[a]
7 DAPM	78.67[b]	82.67[b]	134.78[b]
14 DAPM	78.00[c]	82.00[c]	134.22[c]
21 DAPM	78.44[b]	82.44[b]	134.78[b]
LSD (0.05)	0.29	0.29	0.38
Climbing bean varieties			
Dandesu	78.75	82.75	134.92
Tibe	78.75	82.75	135
Waragutu	78.83	82.83	134.92
LSD (0.05)	NS	NS	NS
CV (%)	0.38	0.36	0.29
Cropping system			
Sole	79.00[a]	83.00[a]	135.00
intercropping	78.77[b]	82.77[b]	134.94
LSD (0.05)	0.11	0.11	NS
CV (%)	0.04	0.04	0.17

Means within the same column followed by different letter of each factor differ significantly at 5% probability level; LSD = Least Significant Difference; CV = Coefficient of Variation; DT= days tasseling; DS=days of silking; DPM=Days to physiological maturity, DAPHM = days after planting of hybrid maize.

Growth parameter

Plant height, Leaf area and leaf area index of intercropped hybrid maize were significantly ($P<0.01$) affected by date of planting but not significantly affected by the associated climbing bean varieties and their interaction. Also cropping system showed significant effect on plant height, Leaf area and Leaf area index. Simultaneous planting significantly reduced plant height, LA and LAI as compared to other planting dates. In general, higher LA and LAI, taller plants were recorded under climbing bean varieties planted at 7, 14 and 21 DAPHM as compared to simultaneous planting. This might be due to reduced resource competitions between the components crops planted at least 7 days after maize planting. [21], reported higher maize plant height under mixture of 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

Sole cropped maize had greater leaf area (7898.20 cm^2) and leaf area index (3.46) and found taller than the intercropped one (Table 4). The decrease in LA, LAI and plant height of intercropped maize can be due to inter specific competition between associated crops for growth resources like soil moisture, nutrient and light under intercropping system than sole cropping system. In line with this result, [22] in maize-bean intercropping reported that the photosynthetic organ becomes thinner and reduces its area due to shading.

Table 4: Main effects of varieties and date of planting the intercropped climbing bean and cropping system on growth parameters of the maize component

Treatment	LA(cm^2)	LAI	PH
Climbing bean varieties in date of planting			
Simultaneous	5561.0[b]	2.66[c]	181.51[c]
7 DAPM	6607.8[a]	3.05[b]	206.86[b]
14 DAPM	6958.7[a]	3.31[a]	215.93[ab]
21 DAPM	7000.2[a]	3.14[ab]	218.41[a]
LSD (0.05)	503.14	0.23	9.47
Climbing bean varieties			
Dandesu	6364.1	3.05	203.77
Tibe	6643.4	3.05	207.76
Waragutu	6643.4	3.01	205.49
LSD (0.05)	NS	NS	NS
CV (%)	7.88	7.72	4.71
Cropping system			
Sole	7898.20[a]	3.46[a]	231.83[a]
Intercropping	6531.90[b]	3.03[b]	205.68[b]
LSD (0.05)	1048.40	0.23	8.35
CV (%)	4.14	0.06	1.09

Means within the same column followed by different letter of each factor differ significantly at 5% probability level; LSD = Least Significant Difference (P< 0.05); CV = Coefficient of Variation; LA = leaf area; LAI=leaf area index; PH=plant height; DAPHM =days after planting hybrid maize

Hybrid Maize yield components

Number of Kernels per Ear

Analysis of variance shown that date of planting and the cropping system had highly significant (P<0.01) effect on number of kernels per ear. However, there is no significant effect of varieties and interaction. The highest (16) number of kernels per ear was gained from 21 days after planting of hybrid maize, while the lowest (12.44) was obtained from simultaneous planting (Table 5). The decreased number of kernel per ear at simultaneous planting could be due to high inter- specific competition for growth resources between maize and climbing common bean varieties than 7, 14 and 21 days after maize planted. Significantly higher Number of kernels per ear (16.00) was obtained from sole cropped maize than the intercropped maize with (14.66) kernels (Table 5). More number of kernels set per ear might be related to greater dry matter partitioning to the ear and to more number of kernels set per unit dry matter allocated to the ear and kernel during the critical period as the report of [23].

Table 5: Main effects of varieties and date of planting of the intercropped climbing bean and cropping system on number of kernel per ears (NKPE), harvest index (HI) and grain yield (GY) of the hybrid maize component

Treatment	NKPE	GY(t ha^{-1})	HI (%)
Climbing bean varieties in Date of planting			
Simultaneous	12.44[b]	2.84[b]	29.91[b]
7 DAPM	15.11[a]	6.63[a]	34.18[a]
14 DAPM	15.11[a]	6.92[a]	35.85[a]
21 DAPM	16.00[a]	7.05[a]	35.56[a]
LSD (0.05)	1.04	0.45	2.82
Climbing bean varieties			
Dandesu	14.40	5.73	33.82[b]
Tibe	14.60	5.92	36.05[a]
Waragutu	15.00	5.94	31.77[b]
LSD (0.05)	NS	NS	2.44
CV (%)	7.24	7.47	8.52
Cropping system			
Sole	16.00[a]	8.10[a]	44.02[a]
Intercropping	14.66[b]	5.86[b]	33.88[b]
LSD (0.05)	1.37	1.92	3.53
CV%	2.54	8.10a	2.58

Means within the same column followed by different letters of each factor differ significantly at 5% probability level; LSD = Least Significant Difference (P< 0.05); CV = Coefficient of Variation.

Thousand Kernel Weight

The analysis of variance shown highly significant (P<0.01) and significant (P<0.05) effect of planting date and varieties and their interaction effect on thousand kernel weight of the maize component and non-significance on cropping system. The highest TKW (276.4g) was recorded from the 7 DAPHM of the climbing bean variety Tibe, while the lowest (186.5g) was recorded from simultaneous planting of climbing bean variety Waragutu (Table 6). The lowest TKW at simultaneous planting of variety Waragutu might be due to high competition for growth resources by Waragutu variety. In line with this result, [24] who reported significant planting patterns and planting densities on maize thousand kernel weight under intercropping with Faba bean. Likewise, [25] observed that the initial grain weight after pollination was a key factor in the early growth of the kernel.

Table 6: Interaction effect of the intercropped hybrid maize and date of planting on thousands kernel weight (g) of hybrid maize in maize-climbing bean intercropping

Climbing bean date of planting	Climbing bean Variety		
	Dandesu	Tibe	Waragutu
Simultaneous	193.1^{f}	212.9^{ef}	186.5^{f}
7 DAPHM	235.7^{c-e}	276.4^{a}	261^{a-c}
14 DAPHM	223.5^{de}	262.7^{ab}	264.8^{ab}
21 DAPHM	260.3^{a-c}	241.5^{b-d}	271.9^{a}
Intercropping mean	240.86		
Sole mean	287.3		
	CBV x DP of planting	Cropping system	
LSD (0.05)	6.6	NS	
CV (%)	27.04	9.1	

LSD = Least Significant Difference (P<0.05); CV=Coefficient of Variation DAPHM = days after planting of hybrid maize; DP=date of planting; CBV= climbing bean variety

Climbing bean component

Crop Phenology and Growth Parameters

The analysis of variance revealed that days to 50% flower initiation and days to physiological maturity were highly significantly (P<0.01) affected by climbing bean varieties and the date of planting. Cropping system shown significant effect on days to 50% flower initiation and significant effect on days to physiological maturity. Simultaneous planting and 7 DAPHM significantly delayed flower initiation, while 14 and 21 DAPHM hastened flower initiations (Table 7). The delayed flower initiation might be due to high competition of resources when bean is planted early. Variety Tibe and variety Waragutu significantly delayed and hastened flower initiation, respectively. This variation might be varietal differences that determine the growth and development of the crop. Similarly, [20] reported significant difference among the intercropped haricot bean varieties on days to maturity and attributed this to the inherent genetic character of the varieties. Intercropped climbing common bean hastened flower initiation and DAPHM than sole climbing common bean. This could be due to high competition for growth resources.

Number of primary branches

The main effect of variety and cropping system was significant (P<0.05), while the effects of planting date was highly significant (P<0.01) effect on number of primary branches of climbing bean, but there was non-significant effect of interaction. The number of primary branches of climbing bean at simultaneous planting and 21 days after planting maize was lower as compared to 7 and 14 days after planting maize. The lower number of primary branches in the intercropped climbing bean at Simultaneous planting and 21 days after maize planted might be due to shading effect by the associated maize for radiation that produce lower number and thinner leaves per plant which makes less partitioning to branches. Sole cropped climbing bean gave higher (2.86) number of primary branches than intercropped (2.19). The redaction in number of primary branches of climbing bean might be due to the competition effect of maize component. Similar to this result, [26] reported reduction in number of primary branches of climbing common bean due to intercropping.

Table 7: Main effects of varieties and date of planting of the intercropped climbing bean with maize on phonological and growth parameters of the climbing bean component

Treatment	DFI	DPM	NPB (per plant)
Climbing bean date of planting			
Simultaneous	50.22[a]	88.55[a]	1.86[b]
7 DAPHM	49.66[a]	88.00[b]	2.46[a]
14 DAPHM	48.00[b]	88.11[ab]	2.66[a]
21 DAPHM	47.66[b]	87.66[b]	1.77[b]
LSD (0.05)	0.85	0.48	0.25
Climbing bean varieties			
Dandesu	45.50[b]	84.25[c]	2.10[b]
Tibe	56.42[a]	93.58[a]	2.35[a]
Waragutu	44.75[c]	86.42[b]	2.13[ab]
LSD (0.05)	0.74	0.42	0.22
CV (%)	1.78	0.57	11.97
Cropping system			
Sole	50.00[a]	90.22[a]	2.86[a]
Intercropping	48.89[b]	88.08[b]	2.19[b]
LSD (0.05)	2.12	0.43	0.23
CV%	1.22	0.14	2.59

Means within the same column followed by the different letters of each factor differ significantly at 5% probability level; LSD = Least Significant Difference (P< 0.05); CV = Coefficient of Variation; DAPM = days after planting of maize; DFI= days of flower initiation; DPM= days of physiological maturity; NPB= number of primary branches.

Climbing bean yield component

Number of pod per plant

The analysis of variance showed that number of pod per plant was highly significantly ($p<0.01$) affected by the main effect of date of planting and significantly ($p<0.05$) after by variety and cropping system while not significantly affected by the interaction. The highest number of pod per plant (21.31) was recorded from 14 days after maize planted while the lowest number of pods per plant (12.84) was obtained from 21 DAPM (Table 8). Delaying introduction of the climbing bean in already established maize stand resulted generally in progressive decline in the number of pod per plant. 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 pods per plant for delayed intercrop treatments. Similar to this result, [21] the lowest number of pod per plant at late intercropping (2 and 4 weeks after maize emergence) of intercropped common bean. Among the varieties Tibe had the highest (24.06) number of pods per plant and the lowest (12.18) number of pods per plant was obtained from Waragutu variety. The difference number of pods per plant among the varieties might be due to the different inherent genetic makeup crops. Significantly higher number of pods per plant (25.62) was obtained from sole cropped climbing bean than intercropped climbing bean (16.59). The reduction of pod per plant in intercropping could be attributed to increased competition among plants for growth factors.

Number of seeds per pod

The main effect of variety and cropping system significantly ($p<0.05$) and planting date highly significantly ($p<0.01$) affected number seed per plant, while the interaction was not significant. Significantly highest number of seed per pod (5.94) was obtained from 14 days after planting of maize, while the lowest (4.00) was obtained from planting time of 21days after planting of maize. The lower number of seed per pod could be due to the high competition for growth resource among the component crops. These findings agree with that of, [21] drastic reductions in number of pods per plant and seeds per pod for delayed intercrop treatments (2 and 4 weeks after maize emergence) of intercropped common bean. Regarding varieties the highest number of seed per pod (5.07) obtained from variety Tibe and the lowest (4.62) was obtained from variety Waragutu. This difference in number of seed per pod among the varieties is due to the inherent genetic characteristics of the varieties. Significantly higher number of seed per pod (6.55) was obtained from sole cropped than (4.82) intercropped climbing bean varieties. 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 climbing bean might be due to less competition for resource per unit area under sole cropping than in intercropping.

Table 8: Main effects of varieties and date planting of the intercropped climbing bean with maize on yield components and yield of the climbing bean component

Treatment	NPPP	NSPP
Climbing bean date of planting		
Simultaneous	14.60[c]	4.10[c]
7 DAPM	17.62[b]	5.25[b]
14 DAPM	21.31[a]	5.94[a]
21 DAPM	12.84[c]	4.00[c]
LSD (0.05)	2.92	0.25
Climbing bean varieties		
Dandesu	13.53[b]	4.77[b]
Tibe	24.06[a]	5.07[a]
Waragutu	12.18[b]	4.62[b]
LSD (0.05)	2.53	0.22
CV (%)	17.99	5.26
Cropping system		
Sole	25.62[a]	6.55[a]
Intercropping	16.59[b]	4.82[b]
LSD (0.05)	3.7	0.23
CV%	4.99	1.15

Means within the same column followed by the different letters of each factor differ significantly at 5% probability level; LSD = Least Significant Difference (P< 0.05); CV = Coefficient of Variation; NPPP= Number of pod per plant; NSPP= Number of seed per pod; DAPM = days after planting of maize.

Hundred seed weight

The analysis of variance revealed that highly significant (P<0.01) effect of variety, date of planting, their interaction and significant (P<0.05) effect of cropping system on hundred seed weight. The highest hundred seed weight (34.5g) of climbing bean was obtained from 7 days after planting of maize of variety Waragutu and the lowest (16.9 g) was obtained from simultaneous planting of variety Dandesu (Table 9). This indicates that HSW of varieties is affected differently by planting date. The difference in hundred seed weight variety might be because of inherent characteristics of the variety and due to high inter specific competition and crowding out of the weaker plants by vigorous ones. In agreement with this result, [27] hundred seed weight of common bean was significantly affected by variety, time of intercropping and their interaction and cropping system. Likewise, [20] reported on maize-common bean intercropping found that hundred seed weight was significantly (P<0.05) different among varieties. Sole cropped climbing bean gave significantly higher hundred seed weight (33.48g) as compared to the intercropped climbing bean (25.60g).

Table 9: The interaction effect of varieties and date of planting of the intercropped climbing bean with hybrid maize on hundred seed weight (g) of the climbing bean component

	Climbing bean Variety		
Climbing bean date of Planting	Dandesu	Tibe	Waragutu
Simultaneous	16.9[i]	23.53[f]	32.05[c]
7 DAPM	19.6[h]	24.53[e]	34.5[a]
14 DAPM	23.27[f]	27.63[d]	33.0[b]
21 DAPM	17.27[i]	20.6[g]	34.4[a]
Intercropping mean	25.60[b]		
Sole mean	33.48[a]		
	CCBV x Date of planting		Cropping system
LSD (0.05)	0.40		0.75
CV (%)	1.9		0.72

Means within the same table followed by the different letters of each factor differ significantly at 5% probability level; CV=coefficient variation; LSD = Least Significant Difference (P<0.05); CCBV=climbing common bean variety; DAPM = days after planting maize.

SUMMARY AND CONCLUSIONS

Intercropping is the growing of more than one crop species more or less simultaneously and at different time of planting in the same field during a growing season and commonly used cropping practice which aims to match efficiently crop demands to the available growth resources and labor. Sowing of component crops in different

times is an important agronomic approach in intercropping systems. 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.

The result indicate that date of planting had significant effect of phenology of maize and growth parameters of maize leaf area, leaf area index and plant height but variety and interaction were not affected significantly. Analysis of variance indicated that the number of ears per plant, thousand kernel weight and harvest index of maize were increased as date of planting climbing beans increased from 7, 14 and 21days after maize planted. The highest number of ears per plant (1.20) recorded from 21 days after maize planted (DAMP) and the highest thousand kernel weight of maize (276.4g) was obtained from the combinations of 7 DAMP of climbing bean Tibe variety while the lowest thousand kernel weight of maize (186.5g) was obtained from combination of simultaneous planting local variety Waragutu and hybrid maize variety Shone. The highest number of harvest index (35.85%) was recorded from 14 DAMP and lowest (29.91) was recorded from simultaneous planting of climbing bean and hybrid maize. The highest maize grain yield (7.05t ha^{-1}) was obtained from 21 DAMP and the lowest (2.84 t ha^{-1}) was obtained from the simultaneous planting and yield of maize gradually increased with delaying sowing of climbing bean.

Climbing bean varieties had highly significant ($P<0.05$) effect on number of pod per plant, hundred seed weight, number of seed per pod and grain yield. Variety Waragutu had the highest hundred Seed weight (33.48g), however the lowest number of seed per pod (4.62t ha^{-1} also the lowest pod per plant (12.18 t ha^{-1}) likewise the lowest grain yield (1.17 t ha^{-1}) while the highest number of pods per plant (24.06), highest number of seed per pod (5.07) and highest number of grain yield (2.36) was recorded from variety Tibe at14 DAMP. Hundred seed weight of climbing bean was significantly ($P<0.05$) affected by the interaction of date of planting. The highest hundred seed weight (34.5g) was obtained from variety Waragutu intercropped at 7 DAMP. The lowest (16.9g) was obtained from Simultaneous planting Dandesu variety. Almost all yield and yield components of climbing bean were significantly affected by cropping systems. The highest number of pod per plant (37.62), number of seed per pod (6.55 t ha^{-1}).Thus, the results showed that proper decision should be given while practicing intercropping of hybrid maize and climbing bean. In this regard, planting climbing bean 14 days after planting of maize shone variety was the best in intercropping system to maximize the productivity and compatible variety. Tibe was the best relative variety in intercropping with maize.

Acknowledgment
The authors acknowledged Oromia Agricultural Research Institute (OARI) and Haro Sabu Agricultural Research Centre for supporting the field experiment implementation. Special thanks to all members of Cereal crops Research Technology Generation Team for their assisting in data collection and field management.

Conflict of interest statement
The authors declare that there is no conflict of interest regarding the publication of this article.

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