ISSN 2349-7823

International Journal of Recent Research in Life Sciences (IJRRLS)
Vol. 2, Issue 1, pp: (15-35), Month: January - March 2015, Available at: www.paperpublications.org

Evaluating The Response Of Maize (*Zea Mays* L.), Varieties To Plant Population Densities Of Haricot Bean In Maize-Haricot Bean Intercropping At West Badawacho Woreda, Hadiya Zone, Snnpr

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Abstract: **A field experiment was conducted during 2011 small rainy season (Belg) at Elefeta Farmer Training Center (FTC), in west Badewacho Woreda, Hadiya Zone, with the objectives to determine the optimum proportion of maize-haricot bean intercropping for maximum productivity and economic benefit; evaluate the performance of different maize varieties intercropped with haricot bean; identify the optimum haricot bean population density of intercropped with different maize varieties; and Estimate economic benefits of maize haricot bean intercropping. Three varieties of maize (PHB3253 Jabi, PHB30G19 Shone and Local) were planted intercropped with four haricot bean population densities (D1 = 62,500; D2 = 125,000; D3 = 187500; D4 = 250,000) arranged in Randomized Complete Block Design (RCBD) with three replications. In this study, sole cropped maize's varieties gave significantly (P<0.05) higher above ground biomass than intercropped maize's varieties. The grain yield of sole cropped maize was also greater than that of intercropped by 16.4%. The yield advantage of intercropping of maize in association with haricot bean was higher by 56% in Jabi intercropped with 100% population density than that of sole cropping of the component crops. The total yield, partial land equivalent ratio (LER), and gross monetary value (GMV) were significantly (P<0.05) higher for intercropped maize's varieties. The GMV of sole cropped maize was greater than that of intercropped maize by 16.4%. Monetary advantage was significantly different for each intercropped maize variety. It ranged from 2587.50 ETB ha $^{-1}$ when local maize variety was intercropped with 25% population density to 11006.43 ETB ha $^{-1}$ when Jabi maize variety was intercropped with 100% population density. In general maize intercropping with different population densities of haricot bean raised yield advantage of intercropping over the sole crop as justified by the higher total LER and Monetary Advantage. Maize variety "Jabi" with 100 % haricot bean population density is recommended for intercropping for their better compatibility and economic benefit with haricot bean as compared to other varieties and population densities in the study area.**

Keywords: **Haricot bean, Intercropping, Land equivalent ratio, Maize, Monitory advantage, Population densities, and Varieties.**

1. INTRODUCTION

The success or failure of agriculture may be judged in many ways but the most significant criteria will continue to be the adequacy, sustainability and quality of food supplies as the human population continues to increase (Evans, 1993). The only way to increase agricultural production in the small or marginal units of farming is to increase the productivity per unit time and area (Chatterjee and Maiti, 1984). This may be achieved by breeding more productive varieties or quicker

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maturing varieties with equal yields or improving techniques of culture, fertilizer use, irrigation, and weed and pest control. However, the limitations of these agricultural inputs and rising pressure on the supply of arable land of the tropical regions may lead to more intensive multiple cropping (Evans, 1993).

In Ethiopia, maize (*Zea mays* L.), and haricot bean (*Phaseolus vulgaris L*) are important food security crops. The crops are mostly cultivated in diverse agro ecological zones without irrigation, and using little or no external inputs such as fertilizers or pesticides (Fininsa, 2001).

Maize is one of the most important traditional crops in tropical farming systems. In Ethiopia, it is an important crop because of its high productivity per unit area, suitability to major agro ecologies, compatibility with many cropping systems, and ease of traditional dish preparation. Maize is also a food security crop in the country where recurrent drought is a common phenomenon (Tesfa *et al*., 2001).

In Ethiopia, maize ranks first among cereals in productivity per hectare and in total grain production, while it is second to teff in total hectare coverage. Maize is cultivated on about 1.79 million hectares accounting for 19.54% of nearly 9.16 million hectares of all land allocated to all cereals (CSA, 2009). The major maize producing areas of the country are south, southwest, and west as well as eastern highlands of Hararghe. The national average productivity is 2.4 t/ha which is far below the world average (CSA, 2009).

In Ethiopia, maize is mainly produced for human consumption in different forms such as; bread, roasted and boiled green ears, parched mature grains for local beverage production, etc. It is an important forage crop that can be harvested and fed green as fodder or made into silage.

After the ears are removed, they will be used as animal feed, construction material and firewood (Kebede *et al.*, 1992). Maize is the most important crop in Ethiopia in general and in the southern Ethiopia in particular. In the southern region, cereals account for 75% of the area allocated for food crops. Out of this, maize accounts for 35% of the area allocated for cereals.

In SNNPR, about 3.6 million quintals of maize grain is produced on 269,800 hectares of land (CSA, 2009). Where as in west Badawacho, maize is the first major cereal crop accounting for about 64.7% (7800 ha) of the total cultivated area grown as sole or intercropped with haricot bean, faba beans and other crops. The average productivity is 3.9 to 4.2 t/ha (WBARDO, 2010).

Intercropping is considered as one of crop intensification strategies to increase agricultural productivity per unit area of land. It is the practice of growing two or more crops simultaneously in the same field. Intercropping provides risk reduction potential of subsistence farmers operating under low resources (inputs) situations (Francis, 1986a). The merits of intercropping are higher productivity per unit area by insuring lower risks against the vagaries of weather, disease and pest damages (Willey, 1991). By growing more than one crop at a time in the same field, farmers can also maximize water use efficiency, maintain soil fertility, and minimize soil erosion, which are the serious drawbacks of mono-cropping.

Intercropping also hampers germination and growth of weeds. In most instances intercropping offers the advantage of increasing yield, nutritional diversity and net income. Farmers in different parts of the world intercrop different crops according to their preference based on social and biological needs (Francis, 1986b; Hoshikawa, 1991).

In many parts of Ethiopia, farmers harvest only once in a year, even in high rainfall areas, from sole cropping systems. Such traditional farming does not ensure the production of adequate food for the family especially under conditions where average land holding is very small. In some parts of the country farmers optimize land use intensity through intercropping, relay cropping and even double cropping. But such practices are few (Nigussie and Habtamu, 1994).

Hadiya is among maize and haricot been producing zones in the Southern, Nations Nationalities and People Region (SNNPR). Although most of the mid altitude of the zone is suitable for maize and haricot bean production, the productivity of maize-haricot bean intercropping is limited mainly due to lack of information on suitable varieties and appropriate population densities of component crops.

However, there was no any research conducted in the area regarding maize-haricot bean intercropping and it has been very difficult to address the increasing demand for food security by producing adequate grain yield in quality and quantity.

ISSN 2349-7823

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Therefore, there is a need to conduct research on maize haricot bean intercrop to address specific management issues for greater grain production at West Badawacho District, Hadiya Zone, SNNPR.

The objectives of this study was to (1) determine the optimum proportion of maize-haricot bean intercropping for maximum productivity and economic benefit, (2) evaluate the performance of different maize varieties intercropped with different haricot bean population densities, (3) identify the optimum haricot bean population density of intercropped with different maize varieties, and (4) Estimate economic benefits of maize haricot bean intercropping.

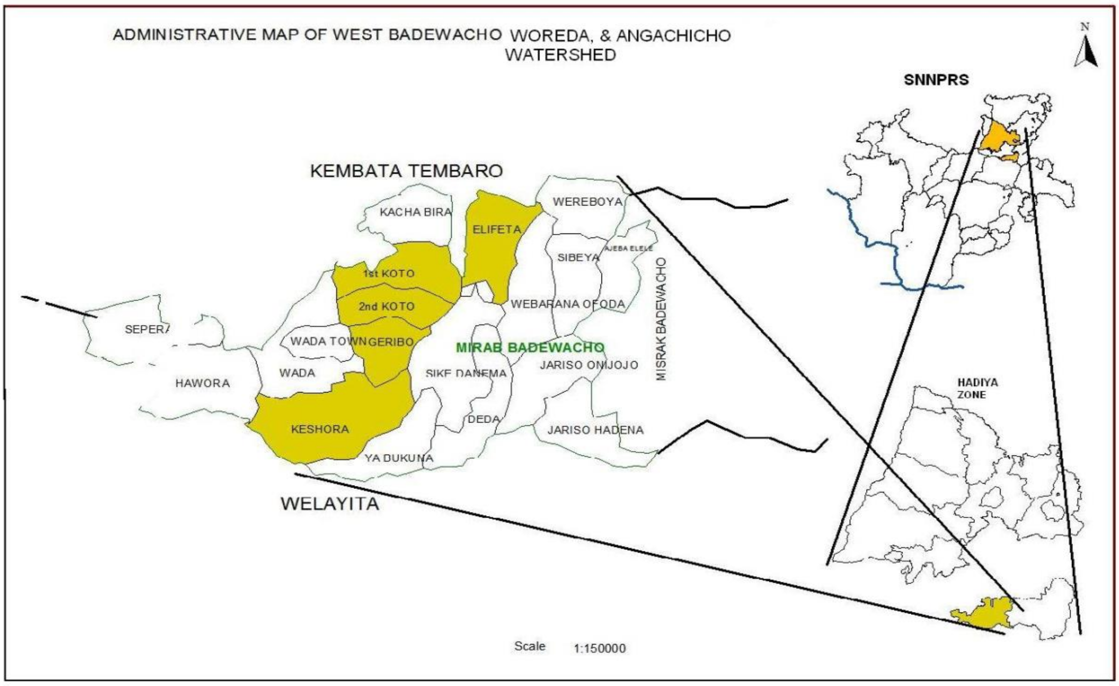
2. MATERIALS AND METHODS

2.1 Description of the Experimental Area:

The experiment was conducted at Elefeta Farmers' Training Centre (FTC), in west Badawacho District, Hadiya zone, during 2011 small rainy season (B*elg)*. West Badawacho District is located in the Southern, Nations, Nationalities, and Peoples' Region (SNNPR), about 352km south of Addis Ababa and lies at 7^0 0.9′N and 37^0 50′E. The total land area of the District is about 19,900 ha. The climatic condition of the District is mainly characterized by cool-sub humid with altitude ranging from 1750 to 2100m.a.s.l. The mean annual rainfall ranges 800 -1200 mm, and mean annual temperature 11 - 27^0C (WBARDO, 2009).

The natural vegetation is dominated by grass land and scattered big trees such as *Gravillea robusta* and *Cordia Africana*, while the exotic species *Eucalyptus* spp tree also has significant cover. The total population of the Woreda is estimated to be 107,000 of which 98% is rural and the remaining 2% urban. The rural population is mainly engaged in crop and animal production. The dominant crops cultivated in the study area includes Maize, Haricot bean, Teff, Sweet potato, Taro, Coffee and Enset.

Elefeta Farmers' Training Centre (FTC) is located five km north of Danema, capital of west Badewacho. The elevation at FTC is 1890 m above sea level and located at latitude of 7^0 0.9′N and 37^0 50′E. The soil of the experimental area is classified as Nitosol with sub-soil stratified as loam to clay loam texture characteristic with pH ranging from 5.5-6. It receives mean annual rainfall of 750-1100 mm and has mean annual temperature of 21 ºC.



(Source: SNNPR Water Resource Bureau, 2008)

Figure 1: The Location Map of Mierab Badewacho Woreda

2.2 Treatment and experimental design:

The experiment was factorial maize-haricot bean intercropping with three factors; i.e. 3 maize varieties and 4 haricot bean population densities arranged in Randomized Complete Block Design (RCBD) with three replications.

Table 1 Description of treatments used in the study

	Maize Varieties (V)		**Intercropped haricot bean population densities (D)**			
No.		**code**	**Intra-row spacing (cm)**	**Population (Plants/ha)**	**Percent of the recommended**	**Code**
1	Local maize	**V1**	25	62,500	25%	**D1**
2	3253 Jabi	**V2**	20	125,000	50%	**D2**
3	30G19 Shone	**V3**	15	187,500	75%	**D3**
	-		10	250,000	100%	**D4**

NB:

Haricot bean inter-row spacing was 40cm for all treatments while the intra-row spacing was varying as per treatment. The spacing for sole haricot bean was 40cm x 10cm. The spacing for the three maize varieties was 80cm x 25cm

Table.2 Treatment combinations

Treatment No.	**Maize varieties (V)**	**Haricot Bean Plant population densities. (D)**	**Treatment Combinassions (VD)**
1	V1	D1	V1D1
2	V1	D2	V1D2
3	V1	D3	V1D3
4	V1	D4	V1D4
5	V2	D1	V2D1
6	V2	D2	V2D2
7	V2	D3	V2D3
8	V2	D4	V2D4
9	V3	D1	V3D1
10	V3	D2	V3D2
11	V3	D3	V3D3
12	V3	D4	V3D4
13	V1 -Sole	-	V1-S
14	V2 -Sole	-	V2-S
15	V3 -Sole	-	V3-S
16	-	Haricot Beans- Sole	HB-S

N.B D1 = 62,500; D2 = 125,000; D3 = 187500; D4 = 250,000 plants per hectare of haricot beans.

2.3 Varietal description:

Three maize varieties and one haricot bean variety were used in the study. The biological and agronomic characteristic of those varieties in terms of plant height, maturity days, seed color, seed size, yield potential at research, adaptability, status of production in the district and year of release are describe as follows:-

i. PHB3253: this variety was released in 1995 and is well adapted to medium altitude zones ranging from 1500 to 2000 m a.s.l. It has white seed with medium size (370g) and matures within 120-140 days. The variety also has medium plant height (180 cm) and can give 7-8 t/ha and 5.5 t/ha grain yield on-station and on-farm level, respectively.

ISSN 2349-7823

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ii. PHB30G19 this variety was released in 2005, and has good adaptation to mid altitude environments ranging from 1000 to 2000 m a.s.l. It has white, large seed (390 g) and matures in 150-180 days. The variety produces tall plant height (190 cm) with strong stems and roots and is highly tolerant to leaf diseases and lodging. It can give 8-9 t/ha and 5.8 t/ha grain yield on-station and on-farm level, respectively.

iii. Local maize **(sutele);** it is well adapted in the district, producing white and medium sized seeds. The variety is tall height and matures in 150-180 days. Its mean yield is about 3.6t/ha (WBARDO, 2009).

iv. Red Wolayta haricot bean variety is indeterminate bush with weak and prostrate stem and branches with the ability to climb. It is well adapted to medium altitude and produces red, medium sized seeds (250 g) that mature in 90-100 days. It can give 2-2.9 t/ha and 1.4 t/ha yields on-station and at-farm level, respectively (Amare, 1992).

2.4 Experimental procedure and management practices:

The experimental field was prepared following the conventional farmers' practices. It was oxen ploughed 4 times before sowing and the three maize varieties and the haricot bean with its different plant population densities were planted following the field layout. The two component crops were planted simultaneously in rows with the rate of two seeds per hill to assure germination and good stand after which the seedlings were thinned to a single plant per hill. The plots were hand weeded at different crop vegetative stages.

Pathways between blocks and plots were 2m and 1m, respectively. Each plot had a size of 4mx3m (12 m^2) accommodating five maize rows with an inter- and intra-row spacing of 80 and 25cm respectively. Each row and plot had 12 and 60 plants, respectively. Only the central three rows of maize were used for data collection. The haricot bean was planted as pair rows having 40 cm space between them and 20 cm far from each maize row. Each plot had 10 rows of H.B with variable intra-row spacing and number of plants per row as per the treatment, in order to achieve the required plant population densities. The central six rows of haricot bean were used for data collection. The total area of the experimental field was 39mx28m= 1092 m^2.

At the time of planting, all plots received Di-ammonium Phosphate (DAP) (18% N, 46% P_2O_5) at the rate of 100 kg ha $^{-1}$ basal application. Nitrogen was applied in the form of urea (46% N) at the rate of 100 kg ha $^{-1}$ in split form in which the first application was done at knee- height stage of maize, while the remaining half was applied just before tassling to all plots except the sole Haricot bean assuming the bean would be benefited from the fixed nitrogen.

The incidence of stalk borer was controlled by the application of Cypermethrin 1% granule one time at knee height when plants were 50-75 cm tall. Other cultural practices were carried out from land preparation up to harvesting as per the recommendation.

2.5 Data collection:

Parameters for maize component:

Days to 50% emergence were recorded when 50% of expected plants in the plot appeared above ground, while days to 50% tassling, when 50% plants in a plot produced tassel. Days to 50% silking were recorded when 50% of plants in a plot produce silk. Days to 90% physiological maturity was recorded when 75% or more plants formed black layer at the base of the germ.

Plant height was measured (in cm) from ground level to the base of the tassel of five randomly selected plants per plot using measuring stick just before maturity and the average was taken for analysis. **Ear height** was measured (in cm) from ground level to the base of the lower productive ear of five randomly taken plants per plot using measuring stick just before maturity and the average was taken for analysis. All leaves present on five randomly sampled plants were detached at leaf sheath, categorized in to small, medium and large leaves as number recorded at tassling. Length and maximum leaf width of each group was measured as **leaf area** per five plants calculated as per equation of McKee (1964) = 0.733 x L (leaf length) x W (maximum leaf width). **Leaf area index** was calculated as the ratio of total leaf area per ground area occupied by the plant (Diwaker and Oswalt, 1992). The ground area was calculated for both sole and intercrop as 80 cm x 25 cm=2000 cm2.

Cob length was measured with ruler (in cm) from base to the terminal point of the cob of five randomly selected cobs per plot and the averages were recorded. Sun dried **above ground biomass** was weighed out of which 250gm sample was taken and oven dried at 70 ^{0}C until constant weight was achieved. Symptoms of major diseases and pests were recorded with 0-5 scale in every plot; where 0 means no symptoms and 5 means severely damaged.

Number of grains per cob was counted from five randomly selected cobs per plots during harvesting while grain yield was taken from the central three rows by excluding plants from the border rows on each side of the plots. At maturity the maize grain yields were harvested, sun dried and weighed after which the moisture content was determined and adjusted to 12.5% moisture content. The grain yield of maize crop was converted from yield per plot to hectare basis.

Hundred-kernel weight was counted using electronic seed counter from a bulk of threshed seed and weighed using sensitive balance. Harvest index was calculated as the ratio of grain yield to above ground biomass per plant multiplied by 100 at harvest from the respective treatments.

Parameters for haricot bean component:

Date of emergence; were recorded when 50% of expected plants in the plot appeared above ground, while **days to 50% flowering** were recorded as number of days from emergence to when 50% of the plans in each plot have produced their first flower. **Days to physiological maturity** were recorded as the numbers of days from emergence to when 95 % of the plants in each plot are matured.

At flowering from five randomly taken plants per plot, **plant heights** were measured in (cm) from ground level to terminal stem using measuring stick and the average were taken for analysis. All leaves present on the five randomly sampled plants were detached and the area measured using CID-202 portable leaf area meter (CID, Inc., USA) at 50% flowering. **Leaf area index** was then calculated as the ratio of total leaf area to ground area occupied by the plant (Diwaker and Oswalt, 1992). Ground area per plant were estimated as 400 cm^2 for sole bean, 1000 cm^2 for 25 % population density, 800 cm^2 for 50 % population density, 600 cm^2 for 75 % population density and 400 cm^2 for 100% population density intercropped haricot bean.

Symptoms of major diseases and pests were recorded with 0-5 scale in every plot; where 0 means no symptoms and 5 means severely damaged. **Above ground biomass** was weighed at harvest after sun drying. **Number of pods per plant** was recorded from five randomly sampled plants per plot at harvest and **number of seeds** per pod was counted from the five randomly sampled pods per plot. **Hundred seed weight** was counted using electronic seed counter from a bulk of threshed seed and weighed using a sensitive balance and adjusted at 10% moisture. **Harvest index** was calculated as the ratio of grain yield to above ground biomass per plot multiplied by 100 from the respective treatments.

Productivity, monetary advantage and monetary value of intercropping:

To consolidate the statistical analysis of the agronomic data, economic analysis was done for each treatment. The partial LER was calculated using the formula LER= Σ (Ypi/Ymi), where Yp is the yield of each crop or variety in the intercrop or poly-culture, and Ym is the yield of each crop or variety in the sole crop or monoculture.

For each crop (i) a ratio is calculated to determine the partial LER for that crop, then the partial LERs are summed to give the total LER for the intercrop (Willey, 1979a).

Gross monetary value (GMV) and Monetary advantage (MA) were calculated from the yield of maize and haricot bean in order to measure the productivity and profitability of intercropping as compared to sole cropping of the component crops. During October 2011, the price for maize and haricot bean was 5.00 and 7.00 Ethiopian Birr per kg at Shone grain market, respectively.

GMV= Yield of component crops X respective market price

Monetary advantage (MA) was calculated as:

$$MA = Yield \times \frac{(LER-1)}{LER}$$

2.6 Data Analysis:

The data were statistically analyzed using SAS statistical computer package program to determine the treatment effects. The means separation was carried out by Duncan's multiple range test (LSD) at p<0.05. Although, analysis was conducted

ISSN 2349-7823

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with two cropping system, three maize varieties and four haricot bean population densities, the degree freedom of cropping system and population densities did lost due to the absence of interaction effect between cropping system and population densities.

3. RESULTS AND DISCUSSION

The two component crops in the intercrop are treated separately in the discussion due to the fact that, they have distinct biological and agronomic characteristics.

Maize Component:

Phenological parameters of maize:

Analysis of variance revealed that days to tassling, silking and physiological maturity were significantly ($P<0.05$) affected by cropping system (Table 3 and Appendix 1). Thus, sole cropped maize took longer days to tassling, silking and maturity than intercropped. This might be because of more efficient use of soil moisture by the sole crop and extending its vegetative growth as described by Morris and Garrity (1993), claiming that water use efficiency by intercrops greatly exceeds the sole crops, by more than 18% and by as much as 99%.

Days to tassling, silking and physiological maturity were also significantly ($P<0.05$) affected by varieties, days to tassling ranging from 74 days for Jabi variety to 91.25 days for Local, days to silking ranging from 77.83 days for Jabi variety to 95 days for Local, whiles days to maturity ranging from 142.42 days for Jabi to 152.42 days for Local variety (Table 3 and Appendix 1). Days to tassling and days to silking were significantly ($P<0.05$) influenced by population densities, days to tassling ranging from 79 days for 100 % population density to 81 days for 25% population density whiles days to silking ranging from 82.55 days for 100 % population density to 85 days for 25 % population density. However, physiological maturity in this study was not significantly affected by population densities (Table 3 and Appendix Table 1).

Table.3. Phenological parameters of maize varieties as affected by cropping system and population densities of component haricot bean in west Badewacho during 2011belg rain season

Treatments	Days to tassling	Days to silking	Days to maturity
Cropping systems			
Sole	81.22[a]	85.88[a]	149.67[a]
Intercropped	80.28[b]	83.81[b]	148.08[b]
LSD	0.58	1.28	1.43
Varieties			
V1	91.25[a]	95.00[a]	152.42[a]
V2	74.42[c]	77.83[c]	142.42[c]
V3	75.42[b]	78.75[b]	149.42[b]
LSD	0.41	0.49	1.61
Population densities			
D1	81.00[ab]	85.00[a]	148.33[a]
D2	81.33[a]	84.22[b]	148.11[a]
D3	80.55[b]	83.66[b]	148.44[a]
D4	79.00[c]	82.55[c]	147.44[a]
LSD	0.48	0.58	1.86
CV (%)	0.94	1.99	1.26

Means in the same column followed by the same letters are not significantly different at 5% level of significance according to Duncan's Multiple Range Test.

V1, V2 &V3 indicates Local, Jabi and Shone maize varieties respectively.

D1, D2, D3 & D4 indicates 62500,125000, 187500 & 250000 haricot bean plants /ha respectively.

Growth parameters of maize:

Plant height was significantly (P<0.05) different among varieties, ranging from 182.96 cm for Jabi variety to 198.80 cm for Local. The possible reason for the difference in plant height is due to their difference in genotype. Plant height was also significantly (P<0.05) different among population densities, ranging from 178.49cm for maize intercropped with 25% population density of haricot bean to 201.87cm for 75% population density (Table 4 and Appendix Table 2). Similarly, Tolera (2003) reported an increasing of plant height with increasing population level of maize plant. He suggests that the plants in the higher population density become taller as a result of competition of plants for light. Ear height was significantly (P<0.05) different in respective of cropping system varieties and population densities (Table 4 and Appendix Table 2).

Leaf area index was not significantly different among varieties, different population densities as well as their interaction but it was significantly (P<0.05) affected by cropping system. Leaf area index values ranged from 3.11 when intercropped with different population densities of haricot bean to 3.61 for sole varieties. Similarly, Sivaraman and Palaniappan (1995), Demesew (2002), Tolera (2003) and other authors in maize/bean intercropping reported that intercropping significantly reduced leaf area index and dry matter accumulation of maize as compared to mono-cropping. Cob lengths were also significantly (P<0.05) different in respect to cropping system and population densities but not significantly different among varieties (Table 4 and Appendix Table 2).

Table.4. Growth parameters of maize varieties as affected by cropping system and population densities of component haricot bean in west Badewacho during 2011belg rain season

Treatments	Plant heights (cm)	Ear heights (cm)	Leaf area index	Cob length
Cropping systems				
Sole	197.31[a]	102.36[a]	3.61[a]	20.36[a]
Intercropped	190.71[a]	90.84[b]	3.11[b]	19.46[b]
LSD	13.09	7.18	0.46	0.55
Varieties				
V1	198.80[a]	108.92[a]	2.82[a]	19.59[a]
V2	182.96[b]	83.79[b]	3.36[a]	19.35[a]
V3	190.35[b]	79.79[b]	3.14[a]	19.42[a]
LSD	15.54	8.37	0.56	0.59
Population densities				
D1	178.49[b]	84.94[b]	2.88[a]	20.15[a]
D2	190.41[ab]	88.17[b]	3.17[a]	19.62[ab]
D3	201.87[a]	100.22[a]	3.03[a]	19.59[bc]
D4	192.05[ab]	90.01[b]	3.35[a]	18.89[c]
LSD	17.94	9.66	0.65	0.69
CV (%)	9.07	10.09	18.96	3.66

Means in the same column followed by the same letters are not significantly different at 5% level of significance according to Duncan's Multiple Range Test.

V1, V2 &V3 indicates Local, Jabi and Shone maize varieties respectively.

D1, D2, D3 & D4 indicates 62500,125000, 187500 & 250000 haricot bean plants /ha respectively.

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Above ground biomass and yield components of maize:

The above ground biomass was significantly (P<0.05) influenced by cropping system (Table 5 and Appendix Table 3). Thus, the sole crop was superior to the intercrop, which might be because of high interspaces competition for growth resources especially for soil moisture in the intercropped than in the sole crop. Similarly, Sivaraman and Palaniappan (1995), Demesew (2002), Tolera (2003), reported that intercropping practice reduced dry matter accumulation in comparison with sole cropping.

Aboveground biomass was also significantly (P<0.05) different among varieties and population densities, ranging from 13.09 t/ha for Local variety to 20.93 t/ha for Shone, while that of population densities ranged from 16.19 t/ha for maize with 75% haricot bean population density to 18.19 t/ha for 50% population density (Table 5 and Appendix Table 3).

Numbers of grain per cob were not significantly affected by cropping system and population densities. However, numbers of grain per cob was higher in sole crop than intercropped ones and numbers of grain was higher at 50% population density than the rest population densities. Numbers of grain per cob were significantly (P<0.05) different among varieties. The difference in number of grain per cob might be because of inherent characteristics of the varieties (Table 5 and Appendix Table 3). Hundred-kernel weight were significantly (P<0.05) affected by cropping systems and varieties but was not significantly different in different population densities. Its range was from 33.85 g for Local variety to 37.58 g for Shone variety (Table 5 and Appendix Table 3).

Table.5. Above ground biomass and yield component of maize varieties as affected by cropping system and population densities of haricot bean in west Badewacho during 2011 belg rain season

Treatments	No. of grain Per cob	100-kernel weight	Above ground biomass t/ha
Cropping systems			
Sole	514.56[a]	37.60[a]	19.74[a]
Intercropped	496.58[a]	36.16[b]	17.35[b]
LSD	49.55	1.02	0.73
Varieties			
V1	397.75[b]	33.85[b]	13.09[c]
V2	530.67[a]	37.04[a]	18.03[b]
V3	561.33[a]	37.58[a]	20.93[a]
LSD	56.44	1.18	0.75
Population densities			
D1	500.67[a]	36.04[a]	16.84[b]
D2	509.56[a]	36.27[a]	18.19[a]
D3	503.00[a]	36.46[a]	16.19[b]
D4	473.11[a]	36.86[a]	17.38[ab]
LSD	65.17	1.37	0.87
CV (%)	12.98	3.65	5.36

Means in the same column followed by the same letters are not significantly different at 5% level of significance according to Duncan's Multiple Range Test.

V1, V2 &V3 indicates Local, Jabi and Shone maize varieties respectively.

D1, D2, D3 & D4 indicates 62500,125000, 187500 & 250000 haricot bean plants /ha respectively.

Grain yield of maize:

Sole cropped maize varieties had significantly (P<0.05) higher grain yield than intercropped by an average of 855 kg/ha 16.4% (Table 6 and Appendix Table 3). Davis and Garcia (1987), Harwood *et al.* (2000), Tolessa *et al.* (2002), Tolera (2003) also concluded that planting haricot beans in association had no appreciable effect on the yield of maize. However,

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Francis *et al*., (1982) also reported a drastic maize yield reduction as high as 31% when intercropped with climbing bean. Similarly, Tamado and Eshetu (2000) found out that the presence of sorghum and/or bean in intercrop reduced the yield of maize in bean row intercrop as compared to sole maize at Babile (low rainfall area). Kimani *et al*. (1999) indicated that although intercropping maize with bean tended to lower maize grain yield, the effects were not significant.

Grain yield was also significantly (P<0.05) different among varieties which might be associated with inherent characteristics of individual varieties (Table 6 and Appendix Table 3). Its range was from 3066.67kg/ha for Local maize to 5128.17 kg/ha for shone maize variety. Grain yield was significantly (P<0.05) different with in different population densities. Its ranged from 4166.11 kg/ha for the maize intercropped with 100% haricot bean population density to 4527.00 kg/ha for 50 % population density.

Harvest index of maize:

Analysis of variance of this study revealed that, cropping systems did not significantly affect the harvest index (Table 6 and Appendix Table 3). However, relatively higher harvest index was recorded for intercropping than sole cropping. This might be because of high competition in the intercropping increased the partitioning of dry matter to seed and decreased the amount of biomass obtained for sole cropping as compared to intercropping. Ludlow and Muchow (1988) reported that a higher transfer of assimilates to the grain would maximize the harvest index and reduce the proportion of dry matter produced early in growth that may be left as stover.

Harvest index values were significantly (P<0.05) different among varieties and population densities. Its range was from 23.94% for local maize variety to 27.19% for Jabi, while that of population densities ranging from 23.88% for maize intercropped with 100% haricot bean population density to 26.88% for 25 % population density. Generally, maize harvest index showed reduction with an increase in intercropped haricot bean plant population densities. Thus maximum maize harvest index (26.88%) was obtained at the lowest (62500 plants/ha) haricot bean plant population density. The higher maize harvest index with reduced intercropped haricot bean plant population density might be due to higher seed yield per plant at lower plant density (Table 6 and Appendix Table 3).

Table.6. Grain Yield and Harvest index of maize varieties as affected by cropping system and population densities of component haricot bean in west Badewacho during 2011 belg rain season

Treatments	**Grain yield Kg/ha**	**Harvest index (%)**
Cropping systems		
Sole	5213.33[a]	25.23[a]
Intercropped	4358.33[b]	26.25[a]
LSD	143.6	1.19
Varieties		
V1	3066.67[c]	23.94[b]
V2	4879.00[b]	27.19[a]
V3	5128.17[a]	24.57[a]
LSD	138.33	1.23
Population densities		
D1	4496.67[a]	26.88[a]
D2	4527.00[a]	25.26[b]
D3	4242.00[b]	24.91[b]
D4	4166.11[b]	23.88[b]
LSD	159.73	1.42
CV (%)	5.36	6.10

ISSN 2349-7823

International Journal of Recent Research in Life Sciences (IJRRLS)
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Means in the same column followed by the same letters are not significantly different at 5% level of significance according to Duncan's Multiple Range Test.

V1, V2 &V3 indicates Local, Jabi and Shone maize varieties respectively.

D1, D2, D3 & D4 indicates 62500,125000, 187500 & 250000 haricot bean plants /ha respectively.

Stalk borer infestation of maize:

Stalk borer infestation was significantly (P<0.05) affected by cropping system (Table 7 and Appendix Table 4). Thus, stalk borer infestation was lower in intercropped maize varieties than sole cropped maize. Ogenga-Latigo *et al.*, (1993) accredited this to modification of crop microclimate and increased abundance or effectiveness of natural enemies attributed to the reduction of the pest in intercropping. This result was in line with Amare (1992) and Nigussie (1994) as they reported that, intercropped maize was less subjected to attack by stalk borer than the sole. Similarly, Skovgård and Päts (1997) reported that intercropping of maize with cowpea reduced number of stem borers of maize per plant by 15-25% as compared to the sole; despite they suggested that for sustainable management the practice should be integrated with other control methods. Besides, the prevailing weather condition and early cessation of rainfall might have influenced the occurrence of pests.

Nevertheless, applying Cypermethrin 1% granule during the early periods of the attack controlled from further spread of the pest in the experimental field. Stalk borer infestation was also significantly (P<0.05) different among maize varieties ranging from 2.08 for Shone variety to 8.33 for the local. The significant difference in stalk borer infestation might be because of inherent characteristics of the individual varieties (Table 7 and Appendix Table 4). Stalk borer infestation was not significantly (P<0.05) different with in different population densities. In general, Shone and Jabi showed relatively better tolerance to stalk borer infestation than the local variety.

Table.7. Stalk borer infestation of maize varieties grown in sole and intercropping with in different population densities haricot bean at west Badewacho in 2011

Treatments	Stalk borer infestation
Cropping systems	
Sole	8.89[a]
Intercropped	4.95[b]
LSD	1.92
Varieties	
V1	8.33[a]
V2	2.78[b]
V3	2.08[b]
LSD	2.54
Population densities	
D1	5.74[a]
D2	3.89[a]
D3	4.81a
D4	3.15[a]
LSD	2.93
CV (%)	43.78

Means in the same column followed by the same letters are not significantly different at 5% level of significance according to Duncan's Multiple Range Test.

V1, V2 &V3 indicates Local, Jabi and Shone maize varieties respectively.

D1, D2, D3 & D4 indicates 62500,125000, 187500 & 250000 haricot bean plants /ha respectively.

Haricot bean Component:

Phenological and growth parameters of haricot bean:

Analysis of variance of this study revealed that, days to flowering was significantly ($P<0.05$) affected by cropping systems, ranging from 41.83 days for the intercropped to 43.33 days for sole cropped (Table 8 and Appendix Table 5). This might be because of more efficient use of soil moisture in the intercrop as described by Morris and Garrity (1993).

Days to flowering was significantly ($P<0.05$) different with in different population densities, ranging from 40.33 days for 100% population density to 42.67 days for 25% population density. A prolonged period to flowering was observed for lower population densities (62,500 plants ha^{-1}). This was probable due to relatively less competition between plants for sun light, space, water and nutrients at lower densities which allowed the crop more vegetative growth leading to delayed flowering. Smith *et al.*, (2001) reported that days to flowering of pigeon pea decrease with increasing pigeon pea population when intercropped with maize.

Days to physiological maturity was significantly ($P<0.05$) affected by cropping systems, ranging from 90.33 days for sole cropped to 92.89 days for intercropped (Table 8 and Appendix Table 5). This might be due to the shading effect of maize plants on haricot bean. Days to physiological maturity was also significantly ($P<0.05$) different with in different population densities, ranging from 92 days for 25% population density to 93.33 days for 100% population density.

Haricot bean plant height was significantly ($P<0.05$) affected by cropping systems (Table 8 and Appendix 5). Its range was 32.73cm for intercropping to 37.10cm for sole cropping. This result indicates that lowest plants height was recorded in intercropped haricot bean, due to high interspaces competition resulting in limitation of growth resource. Plant height was also significantly ($P<0.05$) different with in different population densities (Table 8 and Appendix Table 5). Its range was 32cm for 25% population density to 33cm for 100% population density. The reason for increasing plant height with highest population density could be due to the increased competition of plants for light. Similarly, Tolera (2003) reported an increasing of plant height with increasing population level on maize plant. They suggest that the plants in the higher population density become taller as a result of competition of plants for light.

The analysis of variance indicated, leaf area index values were significantly ($P<0.05$) different in cropping systems and population densities (Table 8 and Appendix Table 5). Leaf area index increased as population density increased. The greater LAI of the higher population density was not mainly contributed from their higher leaf area or branch number per plant but from the greater number of plant per unit area. This result in line with that of Geremew (2006) who stated that leaf area index increased with increased cowpea population density in cowpea/sorghum intercropping. Population density had significant effect on LAI in black gram, the highest population density showed the highest LAI. (Adjei-Twum *et.al.*,1986). Biswas *et al.*, (2002) also reported that the leaf area index was significantly influenced by plant at different growth period.

Table.8. Phenological and growth parameters of haricot bean intercropped with three maize varieties at different population densities of haricot bean in west Badewacho during 2011 belg rain season.

Treatments	Days to flowering	Days to maturity	Plant height cm	Leaf area Index
Cropping systems				
Sole	43.33^{a}	90.33^{b}	37.10^{a}	3.28^{a}
Intercropped	41.83^{b}	92.89^{a}	32.73^{b}	1.96^{b}
LSD	0.85	1.52	2.19	0.34
Varieties				

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V1	41.83[a]	91.83[a]	32.60[ab]	1.93[a]
V2	41.67[a]	92.67[a]	32.18[b]	1.95[a]
V3	42.00[a]	93.67[a]	33.40[a]	2.00[a]
LSD	0.58	1.06	1.08	0.23
Population densities				
D1	42.67[a]	92.00[b]	32.00[b]	1.24[d]
D2	42.33a	93.22[ab]	32.60[ab]	1.54[c]
D3	42.00[a]	93.00[ab]	33.04[ab]	2.13[b]
D4	40.33[b]	93.33[a]	33.27[a]	2.93[a]
LSD	0.68	1.22	1.25	0.27
CV (%)	1.65	1.35	4.84	14.26

Means in the same column followed by the same letters are not significantly different at 5% level of significance according to Duncan's Multiple Range Test.

V1, V2 &V3 indicates Local, Jabi and Shone maize varieties respectively.

D1, D2, D3 & D4 indicates 62500,125000, 187500 & 250000 haricot bean plants /ha respectively.

4.2.2. Above ground biomass and yield components of haricot bean:

Above ground biomass was significantly ($P<0.05$) affected by cropping system in which the higher value was recorded for the sole cropping (Table 9 and Appendix Table 6). Thus, sole cropping was superior to intercropping, haricot bean planted in association with maize faced strong competition for growth resource (nutrient, moisture, sun light) and lack of enough space for root and canopy development, consequently resulted in lower above ground biomass. This result in agreement with that of Wogayehu (2005) who indicated that intercropping decreased bean biomass as compared to sole cropping system in maize/ bean intercropping system.

Above ground biomass was also significantly ($P<0.05$) different for different plant population densities. Its range was 1.31 ton/ha for the 25% population density to 3.99 ton/ha for 100% population density. The obtained trend is that above ground biomass increase with increase in population density up to 100% population density. The observed trend is in agreement with Demesew (2002) who reported that the highest amount of total above ground biomass was recorded at the maximum plant density of 250,000ha^{-1}.

Number of pod per plant was significantly ($P<0.05$) affected by cropping systems (Table 9 and Appendix Table 6). Demesew (2002) and Tolera (2003) also reported similar result that, intercropping of bean with maize had negative effect on number of pods per plant, consequently pod production in sole cropping was superior to intercropping. Number of pod per plant was also significantly ($P<0.05$) different with in different population densities, ranging from 15.67 for 100% population density to 16.76 for 50% population density.

The expected reason is the intensive increased intra-space plant competition with increasing plant population density. The result is related to the findings reported by Teshome *et al.*, (1995) that showed significant increase in number pod per plant as both intra-and inter-row spacing decreased.

Number of seed per pod was significantly ($P<0.05$) affected by cropping systems (Table 9 and Appendix Table 6) in which sole cropping was significantly higher than intercropping. Number of seed per pod was also significantly influenced by population density (Table 8). The maximum number of seed per pod (4.91) was obtained from the lowest population density (62,500), while the minimum (4.41) was obtained from the highest (250,000) population density. Fewer number of seed per pod from the highest population could be due to high competition for growth resources resulting in poor seed formation. On the contrary, Walelign, (2006) reported that the amount of seed per pod was not significantly affected by population density in pigeon pea.

Hundred seed weight was not significantly affected by cropping systems, although it was relatively higher for sole cropped than intercropped (Table 9 and Appendix Table 6). However, hundred seed weight was significantly ($P<0.05$) different with in different population densities. Its range was 24.63g for 100% population density to 26.11g for 25% population density. The lowest hundred seed weight (24.63g) was recorded for 100% population density, while the

ISSN 2349-7823

International Journal of Recent Research in Life Sciences (IJRRLS)
Vol. 2, Issue 1, pp: (15-35), Month: January - March 2015, Available at: www.paperpublications.org

highest (26.11g) for 25% population density. The trend is that, hundred seeds weight increased with the decrease in population density. This was due to less competition between plants at low population density.

Table.9. Above ground biomass and yield components of haricot bean intercropped with three maize varieties at different population densities of haricot bean in west Badewacho during 2011 belg rain season.

Treatments	Above ground biomass (ton/ha)	Number of pod per plant	Number of seed per pod	100-seed weight (g)	Grain yield (kg/ha)	Harvest index (%)
Cropping systems						
Sole	5.36^{a}	18.33^{a}	5.51^{a}	25.25^{a}	2159.2^{a}	40.04^{a}
Intercropped	2.7^{b}	16.18^{b}	4.65^{b}	25.17^{a}	1083.72^{b}	40.63^{a}
LSD	262.27	1.24	0.50	0.36	71.41	2.09
Varieties						
V1	2.69^{a}	16.40^{a}	4.74^{a}	25.22^{a}	1020.86^{b}	40.33^{a}
V2	2.79^{a}	16.67^{a}	4.63^{a}	25.33^{a}	1155.13^{a}	42.28^{a}
V3	2.69^{a}	15.48^{b}	4.58^{a}	25.21^{a}	1058.49^{b}	40.27^{a}
LSD	0.14	0.89	0.34	0.25	43.28	3.92
Population densities						
D1	1.31^{d}	16.44^{ab}	4.91^{a}	26.11^{a}	596.96^{d}	45.69^{a}
D2	2.45^{c}	16.76^{ab}	4.68^{ab}	25,28^{b}	1040.51^{c}	42.50^{ab}
D3	3.14^{b}	15.87^{ab}	4.62^{ab}	25.00^{b}	1218.48^{b}	38.79^{bc}
D4	3.99^{a}	15.67^{b}	4.41^{b}	24.63^{c}	1456.69^{a}	36.99^{c}
LSD	0.16	1.02	0.39	0.28	49.98	4.52
CV (%)	7.09	6.47	8.75	1.15	5.52	3.92

Means in the same column followed by the same letters are not significantly different at 5% level of significance according to Duncan's Multiple Range Test.

V1, V2 &V3 indicates Local, Jabi and Shone maize varieties respectively.

D1, D2, D3 & D4 indicates 62500,125000, 187500 & 250000 haricot bean plants /ha respectively.

4.2.3 Grain yield of haricot bean:

In the current study, cropping system significantly affected haricot bean grain yield. Consequently sole haricot bean had significantly (P<0.05) higher grain yield than intercropped (Table 9 and Appendix Table 6). The yield of sole haricot bean was greater than intercropped by 1025.5kg/ha (47.5%). The yield reduction in the component haricot bean intercropped with maize might have been associated with the aggressive competition of maize for growth resources (Willey and Osiru, 1972) since maize is taller than haricot bean in stature. The higher yield reduction of haricot bean when intercropped with maize could be due to interspecies competition and depressive effect of maize crop. A 59% yield reduction of bean was reported by Pilbeam *et al.*, (1994) in bean/maize intercropping, where as Fininsa (1997) reported bean yield reduction of 67% and maize of 24% in intercropping, and Tolera (2003) reported bean yield reduction of 45%. Grain yield was significantly (P<0.05) different with in different population densities. Its range was from 593.9kg/ha for 25% population density to 1678.7kg/ha for 100% population density.

4.2.4 Harvest index of haricot bean:

Haricot bean harvest index values were not significantly influenced by the cropping systems. Although, relatively higher harvest index was recorded for intercropping than sole cropping (Table 9 and Appendix Table 6). This might be due to high competition in the intercropping resulting in increased partitioning of dry matter to the seed and decreased the amount of biomass than the sole crop. Ludlow and Muchow (1988) similarly reported that higher transfer of assimilates to the grain would maximize the harvest index and reduce the proportion of dry matter produced early in growth that may be left as a Stover.

However, harvest index values were significantly ($P<0.05$) different with in different population densities, ranging from 36.99% for 100 % population density to 45.69% 25% population density. The harvest index was reduced with increased plant population density, as a result maximum harvest index (44.99%) was obtained at the lowest plant density (62500 plants/ha), which might be due to higher seed yield per plant at lower plant density (Table 9 and Appendix Table 6).

4.2.5. Angular leaf spot and Common bacteria blight:

Common bacteria blight and angular leaf spot severity of bean were recorded at 50% flowering and at harvest with visual scoring on plot basis using standard scale 0-5 (CIAT, 1987). Common bacteria blight was not observed in the study area. Thus, might be because of the prevailing weather condition was not as such conducive for common bacteria blight occurrence.

Incidence of angular leaf spot was not significantly affected by cropping system. However, incidence of angular leaf spot in intercropped haricot bean slightly lower than sole cropped. Allen et al., (1996) reported that angular leaf spot severity can be reduced by using cultivars mixture and intercropping with cereals. Similarly, Amare (1992) found out that in Ethiopia, maize intercropped with common bean reduced the severity of angular leaf spot. Incidences of angular leaf spot were not significantly different in respect of maize varieties and population densities (Table 10 and Appendix Table 7).

Table.10. Angular leaf spot of haricot bean intercropped with three maize varieties at different population densities of haricot bean in west Badewacho during 2011 belg rain season.

Treatments	Angular leaf spot infestation
Cropping systems	
Sole	24.33[a]
Intercropped	18.61[a]
LSD	6.21
Varieties	
V1	19.33[a]
V2	17.50[a]
V3	19.00[a]
LSD	4.27
Population densities	
D1	20.11[a]
D2	18.44[a]
D3	19.11[a]
D4	16.78[a]
LSD	4.94
CV (%)	26.26

Means in the same column followed by the same letters are not significantly different at 5% level of significance according to Duncan's Multiple Range Test.

V1, V2 &V3 indicates Local, Jabi and Shone maize varieties respectively.

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D1, D2, D3 & D4 indicates 62500,125000, 187500 & 250000 haricot bean plants /ha respectively.

4.3. Partial Land Equivalent Ratio:

Partial Land Equivalent Ratio (LER) of maize was not significantly (P<0.05) different in respect to varieties and different population densities as well as their interaction. But PLER values for haricot bean was significantly (P<0.05) affected by the component maize varieties and different population densities (Table 11 and Appendix Table 8). In case of varieties, its range was from 0.47 for shone variety to 0.53 for Jabi, while for population densities from 0.27 for 25% population density to 0.67 for 100 % population density. Partial land equivalent ratio of haricot bean increased from 0.27 to 0.67 by increasing haricot bean population density from 62,500 to 250,000 plants per ha^{-1} in intercropping with maize varieties. Mariga *et.al*.,(2001), reported a higher land equivalent ratio for higher population densities of pigeon pea in maize/ pigeon pea intercropping.

Agronomic productivity of intercropping was also evaluated using total LER, in which, the total LER values for all intercropped treatments were greater than one, indicating that all the treatments had advantage in land use. Especially, the highest total LER of 1.56 was obtained when Jabi maize variety intercropped with 100% haricot bean population density. This implies that the association of maize and haricot bean variety is complementary to each other on growth resource utilization. These results are similar to those reported by Mutungarimi *et al.*, (2001) who observed that the intercropping of maize and beans in the same row resulted in highest LER value to other intercrops.

Table.11. Productivity of intercropping of maize varieties as affected by cropping system and population densities of haricot bean in west Badewacho during 2011 belg rainy season

Treatments	Partial LER of maize	Partial LER of haricot bean	Total LER
Cropping systems			
Sole	-	-	-
Intercropped	-	-	-
LSD	-	-	-
Varieties			
V1	0.80[a]	0.48[b]	1.28[b]
V2	0.85[a]	0.53[a]	1.39[a]
V3	0.84[a]	0.47[b]	1.32[b]
LSD	0.06	0.01	0.05
Population densities			
D1	0.87[a]	0.27[d]	1.15[d]
D2	0.83[a]	0.48[c]	1.31[c]
D3	0.81[a]	0.56[b]	1.37[b]
D4	0.81[a]	0.67[a]	1.48[a]
LSD	0.07	0.02	0.06
CV (%)	8	3.36	4.73

Means in the same column followed by the same letters are not significantly different at 5% level of significance according to Duncan’s Multiple Range Test.

V1, V2 &V3 indicate Local, Jabi and Shone maize varieties respectively.

D1, D2, D3 & D4 indicate 62500,125000, 187500 & 250000 haricot bean plants /ha respectively.

The statistical analysis of this study indicated that intercropping combinations had significant effect (P<0.05) on TLER in respect to varieties and population densities ranging from 1.28 for Local maize variety to 1.39 for Jabi variety, while population densities; from 1.15 for 25% population density to 1.48 for 100% population density (Table 11 and Appendix Table 8).

The total LER results revealed that it would require the 0.56 more units of land to have the same yields as intercropping system when maize varieties are solely planted. This might be because of efficient utilization of growth resources in time and space by intercropping system (Rao and Willey, 1980).

Thus, the highest total LER (1.56) could be due to more efficient utilization of resources by intercropping under stress condition. Similarly, Nigussie (1994) reported intercrop advantage of (49%) from low rainfall area (Melkassa) than Awassa (33%), which is a medium rainfall area. Likewise, Tamado and Eshetu (2000) in sorghum, maize and common bean intercropping reported that yield advantage was higher at Babile (low rainfall area) to Alemaya (medium rainfall area).

4.4. *Monetary Value (MV) and Monetary Advantage (MA) of intercropping:*

Gross monetary value of sole maize (TMVa, ETB ha $^{-1}$) was significantly (P<0.05) higher than intercropping (Table 9 and Appendix Table 10). The gross monetary value of sole maize was greater than that of intercropping by 4018.5 ETB ha $^{-1}$ (16.4%). Gross monetary value of sole haricot bean (TMVb, ETB ha $^{-1}$) was significantly (P<0.05) higher over intercropping (Table 12 and Appendix Table 9). The gross monetary value of sole haricot bean was greater than that of intercropping by 7529 ETB ha $^{-1}$ (49.81%).

Table.12. Gross Monetary Value (GMV) and Monetary Advantage (MA) of maize varieties as affected by cropping system and population densities of haricot bean in west Badewacho during 2011 belg rainy season

Treatments	GMV of maize in ETB ha^{-1}	GMV of haricot bean in ETB ha^{-1}	Monitory advantage (MA) in ETB ha^{-1}
Cropping systems			
Sole	24502.7^{a}	15115^{a}	-
Intercropped	20484.2^{b}	7586^{b}	-
LSD			
Varieties			
V1	14413.3^{c}	7570^{a}	5037.6^{b}
V2	22861.6^{b}	7641^{a}	8830.2^{a}
V3	24177.6^{a}	7547^{a}	7479.2^{a}
LSD	713.63	2550.6	1091.7
Population densities			
D1	21134.3^{a}	6279^{a}	3583.4^{c}
D2	21421.6^{a}	7509^{a}	6932.00^{b}
D3	19948.9^{b}	8261^{a}	8134.3^{ab}
D4	19431.9^{b}	8295^{a}	9013.1^{a}
LSD	824.03	2714.2	1260.6
CV (%)	4.11	36.59	18.65

Means in the same column followed by the same letters are not significantly different at 5% level of significance according to Duncan's Multiple Range Test.

V1, V2 &V3 indicate Local, Jabi and Shone maize varieties respectively.

D1, D2, D3 & D4 indicate 62500,125000, 187500 & 250000 haricot bean plants /ha respectively.

Monetary advantage of intercropping was used to calculate the absolute value of the genuine yield advantage (Willey, 1979a). Monetary advantage (MA, ETB ha^{-1}) of intercropping were significantly ($P<0.05$) different among varieties and population densities. In case of varieties, its range was from 5037.6 ETB ha^{-1} for Local variety to 8330.20 ETB ha^{-1} for Jabi variety, while population densities its range was from 3583.4 ETB ha^{-1} for 25% population density to 9013.1 ETB ha^{-1} for 100 % population density. Since intercropping adds extra income and warrants insurance against a risk to the farmers, intercropping of maize component was found to be advantageous than single cropping of maize as there is a scarcity of land and a need to diversify production. Therefore, the inclusion of maize under intercropping with a haricot bean intercropping scheme raised yield advantage of intercropping over the single crop per year as revealed by the highest total LER, total monetary value and monetary advantage.

5. SUMMARY AND CONCLUSIONS

The increasing human population on one hand and shortage of arable land in the other leads to multiple cropping in west Badewacho, Hadiya zone Southern Ethiopia. Intercropping helps to diversify production and answers against risk for subsistence farmers'. It is obvious that intercropping intensifies and diversifies production in time and space dimension.

This study was therefore conducted to determine the optimum proportion in maize-haricot bean intercropping for maximum productivity and economic benefit, evaluate the performance of different maize varieties intercropped with haricot bean, identify the optimum haricot bean population density of intercropped with different maize varieties, and estimate economic benefits of maize haricot bean intercropping.

Three varieties of maize (Local, Jabi, and Shone) were planted in intercropping with four levels of haricot bean plant population densities (D1= 62500, D2= 125000, D3= 187500 & D4 250000) along with their respective sole crops in randomized complete block design with three replications. For the maize component, plant height, numbers of grain per cob and harvest index were not significantly affected by cropping system.

Cropping system had significant effect on, days to tasslling, days to silking, days to physiological maturity, ear height, leaf area index, cob length, 100-kernel weight, above ground biomass and grain yield. Days to tassling, days to silking, days to physiological maturity, plant height, ear height, number of grain per cob, 100-kernel weight, above ground biomass, grain yield harvest index and stake borer infestation were significantly different in respect to varieties.

Days to tassling, days to silking, plant height, ear height, cob length, above ground biomass, grain yield and harvest index were significantly different in respect to population densities.

For the haricot bean component, days to flowering, days to maturity, plant height, leaf area index, number of pod per plant, number of seed per pod, above ground biomass and grain yield were significantly affected by cropping system. Cropping system had not significant effect on leaf area, 100-seed weight and harvest index. Days to flowering, days to maturity, plant height, leaf area index, number of pod per plant, above ground biomass, grain yield, 100-seed weight and harvest index were significantly different with in different population densities.

Grain yield of sole cropped maize was significantly ($P<0.05$) higher than intercropped, by 855 kg/ha (16.4%). Partial Land Equivalent Ratio (LER) values of maize were not significantly ($P<0.05$) different for maize varieties as well as different haricot bean population densities. Grain yield of sole cropped haricot bean was significantly ($P<0.05$) higher than the intercropped, by 1025.5kg/ha which is 47.5%. The statistical analysis indicated that intercropping combinations had significant effect ($P<0.05$) on TLER in respect of varieties and population densities. The higher TLER value (greater than one) for intercropped maize justifies that planting maize in association with haricot bean was advantageous than planting it as sole crop as it adds extra income and diversifies production. The highest total LER of intercropping was 1.56 indicating that intercropping of maize with haricot bean gave 56% yield advantage for Jabi over sole cropping. Thus the intercropping maize and with 100% haricot bean plant population density would be complementary on resource utilization.

Gross monetary value of sole maize (TMVb, ETB ha^{-1}) was significantly ($P<0.05$) higher over intercropping by 4018.5 ETB ha^{-1} which is 16.4%. Similarly, the gross monetary value of sole haricot bean (TMVb, ETB ha^{-1}) was significantly ($P<0.05$) higher over intercropping by 7529 ETB/ha (49.81%). Monetary advantage was significantly different for intercropped maize varieties, ranging from 2587.50 ETB ha^{-1} when Local maize variety was intercropped with 25%

population density to 11006.43 ETB ha $^{-1}$ when Jabi maize variety was intercropped with 100% population densities. This means the association of maize in intercropping with haricot bean was better than planting as sole crop at the study area.

Total monetary value was consistent with the total grain yield of maize intercropped with haricot bean unlike that of the total LER. This justified the need for further economic evaluation of intercropping system.

In general, the inclusion of maize under intercropping with different population densities of haricot bean increased yield advantage of intercropping over sole crop during the study season as justified by the higher total LER and Monetary Advantage. According the result of this study, maize variety "Jabi" with 100% haricot bean plant population density" could be recommended for intercropping in the target area, based on its better compatibility and economic benefit than other varieties and plant population densities.

ACKNOWLEDGEMENTS

The author is very much indebted to his beloved wife w/o Etalemahu Muleta for her unreserved financial, material and moral support from the conception until completion and no word to thank her favor. The author takes this opportunity to thank his Mother W/or Leke Bokan, his brothers Ato Mesfine Nigussie and Tilahun Nigussie and all his extended families for their constant and unlimited encouragement throughout the study time. The author also acknowledges Ato Mehary Bugedu and his family for their support during the fieldwork. The author also have special respect to his friends, Ato Demissie Tilahun, Ato Tesfaye, and student Gebre Hasiso for their honorable moral, technical, and financial support.

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