

Effect of Maize (*Zea mays*.L) on Bean (*Phaseolus vulgaris* L.) Yield and its Components in Maize-Bean Intercropping

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Abstract: *This study was carried out to determine the performance of haricot bean varieties in the intercropping with maize hybrid. It was designed as RCBD design having three replications. The experimental materials were including 4 haricot bean varieties (Awash Melka, Awash-1, Dimtu and Nasir) and one maize hybrid (BH-540). Analysis result revealed that there is a significant difference among the haricot bean for the grain yield in the over all of two locations. It also showed that all the varieties showed comparative yield advantage if they will be intercropped with maize hybrid (BH-540) than the sole cropping system. The highest land equivalent ration was obtained by Dimtu (1.64). This indicated that 64 % more efficient to use Dimtu in the intercropping with BH-540 hybrid than the sole cropping system. Moreover, the relative yield advantage for Dimtu in the intercropping obtained 5817 kg/ha. It can be drawn a conclusion that using of intercropping system for the varieties used in the study will have yield advantage than the sole cropping system. The bean varieties which were intercropped with maize hybrid showed significant different for most of the traits such as days to flowering, Plant height, number of pods per plant, number of seeds per plant and hundred seed weight. But all of the traits for Maize showed no significant difference for all varieties in the intercropping as well as for the sole one. This indicates that bean yield in the intercropping varies with the bean varieties used. Therefore, it is important to find a compatible variety of bean to increase production in the bean- maize intercropping.*

Keywords: Haricot bean, Maize, intercropping, Economic Grain yield, Northwestern Ethiopia

1. Introduction

Intercropping consists of simultaneous culture of two or more crops in the same field in order to reach land equivalent ratios that show nature prefers multiple species rather than single species [1], [2]. It has been traditionally practiced in many parts of the world [3], [4] and has some advantages over monocultures [4]. Intercropping supplies efficient resource utilization, reduces risk to the environment and production costs, and provides greater financial stability, making the system more suitable particularly for labor-intensive, small farmers [3]. Intercropping presents a large level of risk reduction for the smallholder. If one crop is entirely lost to pest or drought damage, the farmer may still harvest the other crop in the field. Given the unpredictable rainy season and the different water requirements of each crop, planting many varieties of the same crop in an intercropped field gives the farmer a better chance that some crops will survive [5]. Regarding to increasing growth of the world population, demolition and overthrow of ecological balance of the systems, it is of a great importance to increase agricultural products and environmental preservation. Intercropping is considered one of the methodologies used to achieve this goal [6], [7].

Growing crops in mixture is the main feature of the traditional cropping systems of the tropics [8]. Recent research findings have shown that mixed cropping shall continue to be more profitable than sole cropping for the small scale or peasant farmers in the tropics, since it provides security in food output which is considered more important than food maximization in the developing world [9]

Spatial arrangement of intercrops is an important management practice that can improve radiation interception through more complete ground cover. There is, therefore, potential for higher productivity of intercrops when intra-specific competition is less than inter-specific competition for a limiting resource such as solar radiation or nutrients. Much of the poor crop yields obtained in the developing countries may be attributed in part to improper crop arrangement with its attendant waste of environmental resources and wrong intra-specific mixtures [10]. Research suggests that a biological advantage to intercropping may result from complementary use of growth resources. Component crops may differ in their use of growth resources over time and space such that when grown together they make more efficient use of light, water, and nutrients than when grown separately. In addition, competition from weeds may be lessened by a combination of crop species occupying two or more niches in the field [11],[12] hypothesized that intercropping exhibited biological advantages over sole cropping when inter-specific competition for growth resources was less than intra-specific competition.

Farmers in the Benishangule gumze have traditionally used maize-bean intercropping for food production. However, little is known about the effect of competition between the species on physio- agronomic attributes of maize and bean. Therefore the present study was conducted to evaluate the potential of haricot bean varieties for their intercropping with maize hybrid.

2. Materials and Methods

Description of the Study Area

The experiment was conducted in Pawe Agricultural Research Center Pawe District (11^o18'N and 036^o 24'E)

Metekel Zone Benishangule Gumuze National Regional State Northwestern Ethiopia in 2013 main-cropping season. Pawe is found 573 kilometers away from Addis Ababa. The topography is slightly undulating from hill-tops towards rivers. The altitude of the area ranges between 1000 – 1200 m.a.s.l. The soils are broadly categorized as Vertisols which account for 40 – 45 % of the area; Nitisols which account for 25 – 30 %; and intermediate soils of a blackish brown color, which account for 25 – 30 %. The specific soil type of the site is well drained Nitosol with the pH value ranging from 5.3 to 5.5. Besides, Pawe district is well known for its high and torrential rainfall with a unimodal rainfall pattern that extends from May to October. The area receives an intensive rainfall amounting to 1860.3 mm. The mean annual maximum and minimum temperatures are 32.6 and 16.5^o C respectively (Source: PARC). And also this activity was conducted at Dibatie District which is the same methodology & cropping season. The Dibatie district is located in Metekel zone 105 km away from Pawe, 78 km from Gilgel Beles; 547km away from Addis Ababa and the soil of experimental area is nitosol. The altitude of this experimental site is 1400 meter above sea level. The climate is tropical hot humid with an annual rainfall ranging from 850 to 1200mm concentrated from May to October, with the average temperature of 25^oc. Both of these two locations are categorized among the most maize and haricot bean producing area in the Benishangule gumze region.

Table 1: Description of haricot bean varieties and maize hybrid use in the experiment

no	variety /hybrid	Release by	year of release
1	Awash Melka	MARC/EIAR	1990
2	Awash-1	MARC/EIAR	1990
3	Nasir	MARC/EIAR	2003
4	Dimtu	MARC/EIAR	2003
5	BH-540 (maize)	BARC/EIAR	1995

Source: [13]. MARC=Mekassa Agricultural Research Center, EIAR= Ethiopian Institute of Agricultural Research, BARC=Bako Agricultural Research Center

Experimental Design & Methods of Data Collection

The experimental design was planned as RCBD design with 3 replications having the plot size 4m x 3.75m, the experimental materials were including 4 haricot bean varieties (Awash Melka, Awash-1, Dimtu and Nasir) and one maize hybrid (BH-540). All the recommended agronomic practices were followed during the course of experimentation. Data like days to 50% flowering (DF), days to 95% maturity (DM), Plant number of pods per plant (NPP), number of seeds per plant (NSPP), number of seeds per pod (NSPP) and hundred seed weight (HSW) were collected specifically for haricot bean and the data which were collected for maize such as stand count at harvest, number of cobs at harvest and field weight. Data such as height (PH), stand count at harvest (SCH) and adjusted grain yield (AGY) were collected for both crops. Seed yield per plot was measured in grams after moisture of the seed was adjusted to 12.5 % for haricot bean and 10 % for maize crop.

Data Analysis

The Land Equivalent Ratio - LER is considered to be one of the most appropriate indices to evaluate the efficiency of intercropping system in producing better yields as compared

with yields in sole cropping. The index was used to assess maize-bean intercropping advantages relative to sole cropping [14]. LER defined as the land area required as sole crops to produce the same yields as Inter-Cropping and it was determined according to the equation below as stated by [15].

$$LER = LA + LB = \frac{YA}{SA} + \frac{YB}{SB}$$

Where LA and LB are the LER's for individual crops, (called partial LER's) and YA and YB are the individual crop yields in intercropping, where SA and SB are their yields as sole crops. The partial LERs are then summed up to give the total LER for the intercrop. Land equivalent ratio (LER) is also the amount of sole-cropped land required to produce the same yields as one unit of intercropped land.

All the data collected were subjected to statistical analysis software appropriate to RCBD design in a randomized complete block using SAS soft ware (version, 9.0). Analyses of variance (ANOVA) were constructed to examine competition effect between component crop maize and haricot bean and its interaction on the variables measured. Treatment and location means were separated and compared using Duncan's Multiple Range Test (DMRT) at P<5% probability level [16].

Table 2: RCBD analysis of variance and expected mean square

Source of variation	Df	Mean square	Expected mean square
Replication	r-1	Ms _r	$\sigma_e^2 + g\sigma_r^2$
Genotypes/treatments	g-1	Ms _g	$\sigma_e^2 + r\sigma_g^2$
Error	(r-1)(g-1)	Ms _e	σ_e^2

Where, r = number of replications; ms_r = mean square due to replications; g = number of genotypes; ms_g = mean square due to genotypes; ms_e = mean square of error; σ_g^2 , σ_r^2 and σ_e^2 are variances due to genotype, replication and error, respectively.

RCBD ANOVA was computed using the following model:

$$Y_{ij} = \mu + r_j + g_i + \varepsilon_{ij}$$

Where, Y_{ij} = the response of trait Y in the ith genotype and the jth replication

μ = the grand mean of trait Y

r_j = the effect of the jth replication

g_i = the effect of the ith genotype

ε_{ij} = experimental error effect.

3. Results and Discussion

The result revealed that Awash melka intercrop with maize BH-540 scores (15cm) height and its sole records (25cm), this implies that the competition between haricot bean and maize is very high; as we observe the plant height of haricot bean intercrop with maize and it's; sole crops longer height than intercrops. There is a significance difference between treatments in the traits of plant height, days to 50% flowering; number of pods per plant, seeds per plant and hundred seed weight, but other agronomic traits has no significance difference among treatments. In general the result showed that there was high competition between

maize and haricot bean. The grain yield product indicated that sole crops score good yield than mixed crops; but Dimtu and Nassir scores maximum yield (665kg/ha) and (631kg/ha) in intercropping than sole crops (631kg/ha) and

(627kg/ha) respectively. Dimtu and Nassir varieties were good for intercropping ability in Pawe area (table 3).

Table 3: Mean values for the traits of haricot bean in the bean-maize intercropping at Pawe on station

Treatments	Plht	Sch	df	dm	nppp	nspp	spp	hsw	AGY(kg/ha)
A.Melka vs BH-540	15 e	266 a	45 a	70 a	2.4 bc	4 a	6.8 bc	15 ab	432 a
Awash-1 vs BH-540	27 cd	230 a	36 b	63 a	1.7 c	3 a	6 bc	16 ab	452 a
Dimitu vs BH-540	30.6 cd	233 a	40 ab	64 a	2.3 bc	5 a	7 bc	18.67 a	665 a
Nassir vs BH-540	21 de	265 a	37 ab	64 a	1.5 c	3 a	4 c	19 a	631 a
Awash melka	25 cde	287 a	40 ab	67 a	4.9 ab	4 a	23 a	15 ab	634 a
Awash-1	45 a	242 a	36 b	65 a	5.5 a	5 a	19 a	11 b	627 a
Dimitu	35 bc	265 a	40 ab	71 a	3.6 abc	5 a	15 ab	17 ab	631 a
Nassir	45 ab	300 a	36 b	66 a	5.9 a	4 a	20 a	16 ab	627 a
CV(%)	19.90	23.89	6.21	6.21	45.80	35.76	44.27	23.23	27.93
LSD (P<5%)	10.99	109.21	4.22	7.19	2.79	2.60	9.90	6.52	286.81
Mean	31.56	261.00	38.79	66.2	3.48	4.17	12.78	16.04	586.32

Where Trt=treatment, plht=plant height, sce=standcount at emergence, df= days to flowering, dm=days to maturity, nppp=number of pods per plant, nspp=number of seeds per pod, spp=seeds per plant, hsw= hundred seed weight, mc= moisture content, AGY=adjusted grain yield. Means with the same letter are not significantly different

The ANOVA result for the combination of the locations showed that the sole cropping haricot bean varieties scored longer heights than Intercropping due to growth limitation factor like light intensity, moisture, air penetration etc maize acting as a shade and suppressed beans growth. There is significance differences observed from plant height, days to flowering, days to maturity, and number of pods per plant,

number of seeds per pod, seeds per plant, hundred seed weight and Grain yields; but there is no significance difference among stand count at harvest. As we focus on the overall grain yield results .Nassir scores good yield (500kg/ha) in intercrop and (1001kg/ha) in sole cropping; this implies that good preferable genetic performance for intercropping than sole cropping cultures in overall locations of Pawe and Dibatie districts. The reason for the lower maize and haricot bean yields among the intercrops concerning the smaller sowing distances within the row was the enhanced interspecies and intra-species competition for the basic factors (table 4).The following picture:1 shows haricot bean-maize intercropping



Picture 1: Bean-Maize intercropping field performance photograph



Picture 2: PARC 2013 Main Cropping season Haricot bean-Maize Intercropping



Bean-Maize Intercropping Field Performance Picture August, 2013

Table 4: Mean values for grain yield and its components of haricot bean in the bean -maize of two districts (Location X Treatment)

Treatments	plht	sch	df	dm	nppp	nspp	spp	hsw	AGY(kg/ha)
A.Melka vs BH-540	15.5 e	413 a	47.5 a	81 ab	2.4 bc	4.3 ab	8.4 bc	18.5 ab	343 ab
Awash-1 vs BH-540	28.5 bcd	177 a	41 bcd	79 ab	2.3 bc	3.5 ab	6 c	17.5 b	254 b
Dimitu vs BH-540	24.3 cd	32 a	45 ab	79 ab	2.2 bc	4.2 ab	7.5 c	28.3 a	419 ab
Nassir vs BH-540	20 d	346 a	41 bcd	77 b	1.8 c	3.3 b	5.5 c	28 a	500 ab
Awash melka	37 abcd	302 a	43 bc	78 ab	6.9 abc	4.3 ab	28 a	17.5 b	724 ab
Awash-1	51 ab	240 a	38 cd	78 ab	8.2 ab	4.5 ab	24.5 ab	14 b	454 ab
Dimitu	47 abc	195 a	42 bcd	83 a	8.8 a	5 a	29.5 a	19.5 ab	669 ab
Nassir	60 a	370 a	37.5 d	77 b	6.9 abc	3.8 ab	28.5 a	20 ab	1001.8 a
R-Square	0.8	0.6	0.9	1.0	0.8	0.6	0.9	0.8	0.6
Mean	35.4	295.6	41.7	78.8	5.0	4.1	17.2	20.4	545.6

Means with the same letter are not significant different.

ANOVA mean values results of haricot bean varieties showed that there is significant differences between treatments are observed on those of plant height (511.3), days to 50% flowering (22.1) and seeds per plant (252.2), but the rest agronomic traits showed no significance

difference between treatments at 5% level of significance; in addition, location play its own role on the effect of grain yield and other agronomic traits between treatments, days to 50%, days to maturity, number of pods per plant, seeds per plant and hundred seed weight are subjected to locations, but other traits are less subjected for locations (table 5).

Table 5: Overall ANOVA result for haricot bean in the bean -maize intercropping two locations (Pawe X Dibatie).

Source of Variation	D.freedom	Plht	Sch	df	dm	nppp	nspp	spp	hsw	AGY(Kg/ha)
Treatment	7	511.3*	14244ns	22.1*	8.6ns	18.3ns	0.6ns	252.2*	52.3ns	116486.2ns
Location	1	394ns	19182.2ns	144*	2550*	35.7*	0.0ns	344.1*	317.9*	27930.7ns
Error	7	112.9	11218.3	4.3	5.8	6.4	0.4	48.7	19.2	83070.6
CV (%)		30.0	35.8	4.9	3.0	51.8	15.5	40.5	21.4	52.8
LSD(p<0.05)		25.1	250.4	4.9	5.7	6.0	1.5	16.5	10.3	681.5

Where, plht= plant height, sch= stand count at harvest, df=days to flowering, dm=days to maturity, nppp=number of pods per plant, nspp=number of seeds per pod, spp= seeds per plant, hundred seed weight, mc=moisture content and AGY= adjusted grain yield.

Based on the result which showed in table 6, there is not significantly different between treatments. Maize BH-540 combine with Dimtu scored good magnitude of grain yield (5301kg/ha) than sole maize (5200 kg/ha).

The bean varieties associated with maize showed significant different for most of the traits days to flowering , , Plant height , number of pods per plant, number of seeds per plant, hundred seed weight (table2). But all of the traits for

Maize showed no significant difference (table 7 and table 8). This indicates that bean yield in intercropping varies with the bean varieties used. It is important to find a compatible variety to increase production in the bean- maize intercropping. Whenever there are alternative varieties which used to cultivate in one area, it has to look also for their compatibility ability when they are intercropping with for example the common one variety.[16] indicated that crop compatibility is the most essential factor for a feasible intercropping system. Thus, the success of any intercropping system depends on the proper selection of crop species where competition between them for light, space moisture and nutrients is minimum.

Table 6: result of different traits for maize hybrid n the Intercropping at Pawe on station

Treatments	Plant height(cm)	stand count at harvest	No. cobs at harvest	field weight	Adjusted Grain Yield(kg/ha)
A.Melka vs BH-540	168 a	42 a	46 a	10:00 AM	4519 a
Awash-1 vs BH-540	178 a	43 a	49 a	12:00 AM	4850 a
Dimitu vs BH-540	174 a	44 a	48 a	12:00 AM	5301 a
Nassir vs BH-540	182 a	48 a	52 a	11:00 AM	5169 a
Maize BH-540	177 a	45 a	50 a	12:00 AM	5200 a
cv(%)	8.21	11.22	5.78	15.58	15.35
LSD (P<5%)	27.13	9.36	5.33	3.28	1447
Mean	175.6	44.33	49.07	11.2	5007.98

Means with the same letter are not significantly different between treatments.

The ANOVA result showed that field weight mean separation is significantly different between treatments; but

other parameters are not significantly different between treatments. Locations play very crucial role for plant height, stand count at harvest and field weight; but number of cobs at harvest and grain yield are not significantly different between two locations (table 7).

Table 7: Over all ANOVA result for maize agronomic traits in the Intercropping with Haricot bean (treatment X Location) overall result

Agronomic Characters		plht	sch	Ncobs	Fw	Adj.GY
Source of variation	d.freedom					
Treatment	4	15 ^{ns}	7 ^{ns}	6.4 ^{ns}	1*	42997.8 ^{ns}
Location	1	1932*	32*	6.4 ^{ns}	1.6*	378691.6 ^{ns}
Error	4	37	3.7	7	1	81209.8
CV (%)		3.2	4.1	5.4	2.8	5.4
LSD(p<0.05)		16.8	5.3	7.5	0.9	91.2

Where, plht=plant height, sch=stand count at harvest, Ncobs= number of cobs at harvest, mc=seed moisture content and Adj.GY= adjusted grain yield,*= significant difference at alpha 5% & ns= non significant.

The two locations over all mean value for all the traits showed that there is no significant difference for both sole maize BH-540 and combination (inter-crop) maize variety. Dimtu inter crop with maize variety score highest amount of grain yield for maize (5398kg/ha) than sole maize (5299.5 kg/ha) across the two locations (table 8).

Table 8: Maize Grain Yield and associated agronomic traits mean result. Combined over locations

Treatments	Plant height(cm)	stand count at harvest	No. cobs at harvest	field weight	Adjusted Grain Yield(kg/ha)
A.Melka vs BH-540	187.5 a	46 a	50 a	10 a	5042 a
Awash-1 vs BH-540	189 a	45 a	50 a	11.5 a	5092.5 a
Dimitu vs BH-540	191.5 a	45 a	47 a	11.5 a	5398 a
Nassir vs BH-540	193.5 a	49.5 a	52 a	10.5 a	5180 a
Sole Maize BH-540	187 a	45.5 a	50 a	11.5 a	5299.5 a
R-Square	0.93	0.80	0.52	0.93	0.62
Mean	189.70	46.20	49.80	11.00	5202.00

The highest LER recorded for Awash Melka intercropping at both Pawe (2.33) and Dibatie (1.34) locations. All intercropping in the two locations showed an advantage for the land use efficiency over the sole one. The highest

relative grain yield advantage recorded by Dimtu intercropping (5932 kg/ha) and followed by Awash Melka (5819 kg/ha) (table 9).

Table 9: Maize Haricot bean Intercropping Relative Grain Yield Advantages and LER result of two districts (Pawe and Dibatie)

Treatments	Maize Grain Yield(kg/ha)		Haricotbean Grain Yield(kg/ha)		RYT(M+HB=Kg/ha)		LER	
	Pawe	Dibatie	Pawe	Dibatie	Pawe	Dibatie	Pawe	Dibatie
A.Melka vs BH-540	4519 a	5565 a	634 a	254 cd	5153	5819	2.33	1.34
Awash-1 vs BH-540	4850 a	5335 a	627 a	56 d	5477	5391	2.31	1.18
Dimitu vs BH-540	5301 a	5495 a	631 a	173 d	5932	5668	1.97	1.26
Nassir vs BH-540	5169 a	5191 a	627 a	369 bcd	5796	5560	1.94	1.23
Maize BH-540 (Sole)	5200 a	5399 a						
Awash melka (sole)	432 a	814 b						
Awash-1 (Sole)	452 a	281 cd						
Dimitu (Sole)	665 a	707 bc						
Nassir (Sole)	631 a	1376.5 a						

Means with the same letter are not significantly different between treatments.

Where, HB+M= haricot bean and maize total grain yield kilogram per hectare

LER=Land Equivalent Ratio

The analysis result revealed that there is a significant difference among the haricot bean for the grain yield in the over all of two locations. In terms of land equivalent ratio

result, all the varieties showed comparative advantage if they will be intercropped with maize hybrid (BH-540) then they can perform than the sole cropping system. The highest land equivalent ration was obtained by Dimtu (1.64). This indicated that 64 % more efficient to use Dimtu in the intercropping with BH-540 hybrid than the sole cropping system. In addition, the relative yield advantage for Dimtu in the intercropping obtained 5817 kg/ha (table 10).

Table 10: Haricot bean-Maize Intercropping Compatibility Overall (Treatment X Location) Grain Yield Advantages and Land Use Efficiency

Treatments	Haricotbean Grain Yield(Kg/ha)	Maize Grain Yield(Kg/ha)	RYT(M+HB=kg/ha)	LER
A.Melka vs BH-540	343 ^{ab}	5042 ^a	5385	1.43
Awash-1 vs BH-540	254 ^b	5092.5 ^a	5346	1.52
Dimitu vs BH-540	419 ^{ab}	5398 ^a	5817	1.64
Nassir vs BH-540	500 ^{ab}	5180 ^a	5680	1.48
Maize BH-540(Sole)	Sole Maize	5299.5 ^a	5299.5	
Awash melka(Sole)	724 ^{ab}			
Awash-1(Sole)	454 ^{ab}			
Dimitu(Sole)	669 ^{ab}			
Nassir (Sole)	1001.8 ^a			

Means with the same letter are not significantly different between treatments.

Where, HB+M= haricot bean and maize total grain yield kilogram per hectare and LER=Land Equivalent Ratio

4. Conclusion and Recommendation

The analysis result revealed that there is a significant difference among the haricot bean for the grain yield in the over all of two locations. In terms of land equivalent ratio result, all the varieties showed comparative advantage if they will be intercropped with maize hybrid (BH-540) then they can perform than the sole cropping system. The highest land equivalent ration was obtained by Dimtu (1.64). This indicated that 64 % more efficient to use Dimtu in the intercropping with BH-540 hybrid than the sole cropping system. In addition, the relative yield advantage for Dimtu in the intercropping obtained 5817 kg/ha. It can be drawn a conclusion that using of intercropping system for the varieties used in the study will have yield advantage than the sole cropping system.

The bean varieties which intercropped with maize hybrid showed significant different for most of the traits such as days to flowering , Plant height , number of pods per plant, number of seeds per plant and hundred seed weight. But all of the traits for Maize showed no significant difference for all varieties as well as for the sole one .This indicates that bean yield in the intercropping varies with the bean varieties used. Therefore, It is important to find a compatible variety of bean to increase production in the bean- maize intercropping.

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