Evaluation and Demonstration of Haricot Bean (*Phaseolus vulgaris* L.) intercropped with Maize (*Zea Mays* L.) On Yield and Yield Component of Maize and Common Bean at South Ari, Southern Ethiopia

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### ABSTRACT

Field experiment was conducted during 2015 cropping seasons to evaluate of row intercropping Maize with Common Bean. The experiment was laid out in randomized complete block design with four replications. The results showed that the yields of maize and haricot bean from the treatment (one Maize: two Common bean, one maize: one Common bean, maize sole and Common bean sole) produced 55.6 q/ha: 17.2 q/ha, 43.3 q/ha: 26.4 q/ha and 61.1 q/ha: 27.2 q/ha yield, respectively. Therefore, one maize: one Common bean of row intercropping was superior to other intercropping treatments. The LER and MAI indicated the practice of intercropping of one Maize with one Common bean was more advantageous than the conventional monoculture crop. Even if significant yield difference was not observed for sole maize and haricot bean among the treatment, one maize intercrop with two common bean proportion with LER of 1.54 and MAI of 12.609 and one maize mix one Common bean proportion with LER of 1.68 and MAI of 15559. Proved to be best than planted at sole indicating the practice of one maize with one haricot bean intercropping was more advantageous and profitable than the conventional monoculture crop.

**Keywords:** Maize, Haricot Bean, Intercropping, Land Equivalent Ratio and Monetary Advantage Index,

**Academic Discipline and Sub-Discipline:** Agriculture/Plant sciences

**Subject Classification:** Agronomy

**Type:** Quasi-Experiment

### 1. INTRODUCTION

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 [10]. With increasing pressures on agricultural land arisen out of population growth, farmers have to explore new ways to intensify production per unit area of land [20].

Maize (*Zea mays* L.) is the most important cereal after wheat and rice with regards to cultivation area in the world [13]. In Ethiopia, it is one of the major staple crops ranking first in yield potential per hectare and fourth in total area after teff (*Eragrostis tef*), barley and sorghum [9].

Common bean (*Phaseolus vulgaris* L.) is a major food legumes and ranks third most important worldwide food crop next to soybean and peanut. It is an important pulse crop distributed and grown in different parts of Ethiopia depending on climatic and socio-economic factors [18]. It plays an important role in human nutrition and market economies of some rural and urban areas of the Ethiopia [3].

Among legumes, haricot bean, *Phaseolus vulgaris*, constitute a significant part of human diet in Ethiopia (Ali et al., 2003) [2]. Apart from this, haricot bean has been cultivated as a field crop for a very long time and hence, it is the important food legume produced in the country [2]. Haricot bean is a principal food crop particularly in Southern and Eastern part of Ethiopia, where it is widely intercropped with maize and sorghum, respectively, to supplement farmers’ income [6]. It is considered as the main cash crop and protein source of the farmers in many low lands and mid altitude zones of Ethiopia [15]. In the past two to three years, Ethiopia has been a major supplier of red beans into northern Kenya and this market has shown most rapid growth [7].

Intercropping usually benefits from increased light interception, root contact with more soil, increased microbial activity and can act as a deterrent to pests and weeds of the other crop. In intercropping with a leguminous, a non-leguminous which needs nitrogen may benefit, since legumes will fix nitrogen in the soil [14]. In Egypt, previous research on intercropping of haricot and maize have been emphasized on economic aspects i.e. yield and profit gain [5]. Maize/legume intercropping has become one of the solutions for food security among small scale maize producers [19].

The farmers’ common practices are monoculture cropping system in south omo zone, south ari woreda. Due to acute land scarcity necessitates farmers to use other alternatives to improve their productivity. There is no research conducted in the study area regarding with haricot bean-maize row intercropping before this study conducted. Therefore, to solve the above problem this study was undertaken to evaluation the benefit of intercropping with sole cropping on yield for farmers.
2. MATERIALS AND METHODS

2.1 Description of the Study Area

On farm experiment was conducted in South Ethiopia during 2015 rain season at south Ari woreda of South Omo zone which is 10 km away from Jinka town. The sites are situated at 653432N and 231980E with an altitude of 2100 m.a.s.l. This area receives a mean annual rainfall of 1000 mm with maximum and minimum temperatures of 35oc and 15oc, respectively.

2.3 Treatments and Experimental Design

The treatments included four cropping system (1Maize:2 Common bean, 1Maize:1 Haricot bean, sole Maize and Common bean). Maize seed (variety "Gibe-1") and Common Bean seed (variety "hawasa domi") was used for intercropping. The experiment design was Randomized Complete Block Design (RCBD) with four replications. Plot size was 3m x 4m=12m² Maize was the principal crop and spaced b/n row and plant were used 75cm and 25cm, respectively. Sole common bean was planted 40 cm and 10cm spaced b/n row and plant, respectively. Intercropping one common bean with one maize was planted at the middle of the maize and also 2 Common bean was planted by 25 cm spaced within maize. The recommended fertilizers were applied with the rate of 100 kg Urea/ha and 100kgDAP/ha. The half dose of Urea and full dose of Dap was applied at planting time and the remaining half dose of Urea was equally side dressed before flowering time. Weeding and other recommended management practices were carried out as per the requirement of the crop.

The local market price of Maize and Haricot bean was 4 birr/kg and 8 birr/kg, respectively during harvesting seasons.

2.4 Land equivalent ratio

This verifies the effectiveness of intercropping for using the resources of the environment compared to sole planting. The LER values were computed using the following formula described by [1, 17, 16 and 21].

LER= \frac{Y_{ab} + Y_{ba}}{Y_{aa} Y_{bb}}

Where,

Y_{ab} = Intercrop yield of crop 'a'
Y_{ba} = Intercrop yield of crop 'b'
Y_{aa} = Pure stand crop yield of 'a'
Y_{bb} = Pure stand crop yield of 'b'
LER= 1: no advantage of intercrop
LER<1: intercropping reduce total yield
LER>1: intercropping increase total yield thus beneficial

2.5 Monetary Advantage Index (MAI):

The most important part of recommending a cropping pattern is the cost: benefit ratio more specifically total profit, because farmers are mostly interested in the monetary value of return. The yield of all the crops in different intercropping systems and also in sole cropping system and their economic return in terms of monetary value were evaluated to find out whether maize yield and additional Haricot bean yield are profitable or not. This was calculated with monetary advantage (MA). It is expressed as

MAI= \frac{(P_{ab}+P_{ba}) \times LER - 1}{LER}

Where, P_{ab} = Pa \times Y_{ab}; P_{ba} = Pb \times Y_{ba}; Pa = Price of species 'a' and Pb = Price of species 'b'. The higher the index value, the more profitable is the cropping system [11].

2.6 Data collection

2.6.1 Maize Data Collection

2.6.1.1 Plant height (cm): Plant height was recorded as the height of plant grown from the ground level from five randomly sampled plants at the end of 50% flowering in each plot.

2.6.1.2 Number of cobs per plant: was counted from five randomly sampled plants per plot at the end of harvest in each plot.
2.6.1.3 Cobs length (cm): Cobs length was measured of cobs from from five randomly sampled plants at the end of harvest in each plot.

2.6.1.4 Grain Yield (kg/ha): Grain yield were measured from the net plot area and expressed as kg/ha. Grain yield was adjusted to 12.5% moisture content using a digital moisture tester.

2.6.1.5 Dry biomass (kg/plot): dry biomass were measured from the net plot area and expressed as kg/ha.

2.6.1.6 Thousand Seed weight: Seed weight was determined by taking a random harvested grain yield by using seed counter and adjusted them to 12.5% moisture content

2.6.2 Haricot bean collection

2.6.2.1 Plant height (cm): Plant height was recorded as the height of plant grown from the ground level from five randomly sampled plants at the end of 50% flowering in each plot.

2.6.2.2 Number of branch per plant: Number of branch was counted from the same five randomly selected plants at the end of harvest in each plot.

2.6.2.3 Number of pods per plant: Number of pods was counted from the same five randomly selected plants at the end of harvest in each plot

2.6.2.4 Number of seeds per pod: Was taken from the same five randomly selected pods at the end of harvest and each of seeds were counted manually in each plot.

2.6.2.5 Grain Yield (kg/ha): Bean yields were measured from the net plot area and expressed as kg/ha. Bean yield was adjusted to 12% moisture using a digital moisture tester

2.6.2.6 Thousand Seed weight: Seed weight was determined by taking a random harvested grain yield by using seed counter and adjusted them to 12.5% moisture content

2.6.2.7 Dry biomass (kg/plot): dry biomass were measured from the net plot area and expressed as kg/ha.

2.7 Statistical Analysis

All the relevant data were recorded and being subject to analysis. Analysis of variance was performed using the GLM procedure of sas statistical software version 9.1. Effect were considered significant in all statistical calculations if the P-value were <0.05. Means were separated using least significant difference (LSD) test.

3. RESULT

3.1 Response of maize component

The analysis of variance Results from mean square showed that Plant height, cobs number per plant, cobs length , dry biomass , thousand seed weight , and grain yield for maize were not affected significantly(p<0.05) due to intercropping with haricot bean(Table 1). The maximum grain yields of maize (61.1q/ha) and (43.3q/ha) were recorded for the treatments sole maize and one maize with one haricot bean, respectively (Table 2). The highest plant height of (245.5cm) and the shortest (19.8 cm) were noted from sole maize and one maize with one haricot bean, respectively (Table 2). The maximum number cobs per plant of (13.3) and the minimum (1.2) were recorded from sole maize and one maize with one haricot bean, respectively (Table 2). The longest cobs length (20.8cm) and the least (255 cm) were noted from one (maize with haricot bean) and sole maize, respectively (Table 2). The maximum biomass (238.9q/ha) and the minimum (200q/ha) were recorded from one maize with one haricot bean and sole maize intercropping, respectively (Table 2).

3.2 Response of Haricot bean component

The analysis of variance Results from mean square showed that Plant height, Brach number per plant, pod number per plant , seed number per pod, dry biomass , thousand seed weight , and grain yield for Haricot bean were not affected significantly(p<0.05) due to intercropping with maize (Table 3)

The maximum grain yields of haricot bean (27.2 q/ha) and (17.2q/ha) were recorded for the treatments sole haricot bean and one maize with two haricot bean, respectively (Table 4). Equals plant height of (55.5cm) were noted from all treatment (Table 4). The maximum pod number per plant of (14.5) and the minimum (10.9) were recorded from one maize with two haricot bean and sole haricot bean, respectively (Table 4). The maximum seed number per pod of (5.7) and the minimum (5.1) were recorded from one maize with one haricot bean and sole haricot bean, respectively (Table 4). The more Brach number of (8 ) and the least (6.8 ) were noted from one maize with two haricot bean and one maize with one haricot bean, respectively (Table 4). The maximum biomass (75.6 q/ha) and the minimum (61.1q/ha) were recorded from sole haricot bean and one haricot bean with one maize intercropping, respectively (Table 4).

4. DISCUSSIONS

According to the result of mean separation, grain yield of maize was not significantly difference among the treatment (Table 2). The result showed that haricot bean component did not exert much competition on maize component. This result is in agreement with the previous findings of [8, 22] on maize/common bean intercropping reported that, maize grain yield wasn’t significantly affected by haricot bean. Also similar case [4] on maize/haricot bean intercropping found non-significant difference on maize grain yield due to existence of haricot bean. The maximum and minimum grain yields
of (61.1 q/ha) and (43.3 q/ha) were recorded for the treatments sole maize and one haricot bean with one maize intercropping respectively. From the above findings, it could be suggested that the presences intercrop one haricot bean with one maize, two haricot beans with one maize and monoculture that was similar to monoculture of maize. so presence of haricot bean intercrop doesn’t significant affect on maize crops. However, total yield the combination of maize and beans benefited from the addition of the common beans.

According to the result of mean separation, grain yield of Haricot bean was not significantly difference among the treatment (Table 4). Also result was in agreement with the previous findings showed that maize-haricot bean intercropping was not significantly difference exert on grain yield of haricot bean. Similarly [4] reported that the yields of intercropping haricot bean are the same in the monocrops. From the above findings, it could be suggested that presences intercrop one maize with one haricot bean , two haricot beans with one maize and monoculture of maize component. However, total yield the combination of maize and beans benefite from the addition of maize.

Table 1. Analysis of Variance for 6 parameters for maize component in maize-haricot intercropping at debub ari woreda, in 2007 cropping season.

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>DF</th>
<th>PH</th>
<th>CN</th>
<th>CL</th>
<th>TSW</th>
<th>GY</th>
<th>BIOM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Replication</td>
<td>3</td>
<td>416.5”&lt;sup&gt;ns&lt;/sup&gt;</td>
<td>0.83”&lt;sup&gt;ns&lt;/sup&gt;</td>
<td>16.9ns</td>
<td>701.5”&lt;sup&gt;ns&lt;/sup&gt;</td>
<td>3.33ns</td>
<td>66.2ns</td>
</tr>
<tr>
<td>Treatment</td>
<td>2</td>
<td>430&quot;&lt;sup&gt;ns&lt;/sup&gt;</td>
<td>0.83&quot;&lt;sup&gt;ns&lt;/sup&gt;</td>
<td>1.0ns</td>
<td>580.7&quot;&lt;sup&gt;ns&lt;/sup&gt;</td>
<td>3.63ns</td>
<td>21ns</td>
</tr>
<tr>
<td>Error</td>
<td>6</td>
<td>1081.9</td>
<td>0.083</td>
<td>1.22</td>
<td>939.9&quot;&lt;sup&gt;ns&lt;/sup&gt;</td>
<td>2.53</td>
<td>95.22</td>
</tr>
<tr>
<td>CV (%)</td>
<td>14</td>
<td>26.6</td>
<td>5.5</td>
<td>11.7</td>
<td>34.2</td>
<td>46.4</td>
<td></td>
</tr>
</tbody>
</table>

All the above trait were non-significant at (p<0.05) PH= Plant height in cm, CN=cobs number per plant, Cl =cob length in cm, 100 seed weight in g, GY=grain yield in kg and above ground dry biomass in kg.

Table 2. Mean value of maize plant height, cobs number per plant, cobs length, 1000 seed weight, grain yield and biomass.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>PH</th>
<th>CN</th>
<th>CL</th>
<th>TSW</th>
<th>GY</th>
<th>BIOM</th>
</tr>
</thead>
<tbody>
<tr>
<td>1M:2CB</td>
<td>245.3a</td>
<td>1a</td>
<td>20.3a</td>
<td>248a</td>
<td>5a</td>
<td>21.5a</td>
</tr>
<tr>
<td>1M:1CB</td>
<td>225a</td>
<td>1a</td>
<td>20.8a</td>
<td>268a</td>
<td>3.9a</td>
<td>23a</td>
</tr>
<tr>
<td>Maize sole</td>
<td>245.5a</td>
<td>1.3a</td>
<td>19.8a</td>
<td>269a</td>
<td>5.5a</td>
<td>18.5a</td>
</tr>
<tr>
<td>LSD@0.05</td>
<td>57</td>
<td>0.5</td>
<td>1.9</td>
<td>53</td>
<td>2.9</td>
<td>16.9</td>
</tr>
</tbody>
</table>

Means followed by the same letter within a column are not significantly different from each other at (p<0.05) level of significant.

Table 3. Analysis of variance for 7 traits for haricot bean component in maize-haricot intercropping 2015 cropping season at debub ari woreda.

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Df</th>
<th>PH</th>
<th>BN</th>
<th>PN</th>
<th>SN</th>
<th>100swt</th>
<th>GY</th>
<th>BIOM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Replication</td>
<td>3</td>
<td>118.8&quot;&lt;sup&gt;ns&lt;/sup&gt;</td>
<td>1.96&quot;&lt;sup&gt;ns&lt;/sup&gt;</td>
<td>5.25&quot;&lt;sup&gt;ns&lt;/sup&gt;</td>
<td>2.29</td>
<td>4235</td>
<td>0.10&quot;&lt;sup&gt;ns&lt;/sup&gt;</td>
<td>3.3&quot;&lt;sup&gt;ns&lt;/sup&gt;</td>
</tr>
<tr>
<td>Treatment</td>
<td>2</td>
<td>15.2&quot;&lt;sup&gt;ns&lt;/sup&gt;</td>
<td>0.48</td>
<td>5484</td>
<td>0.99&quot;&lt;sup&gt;ns&lt;/sup&gt;</td>
<td>10.8&quot;&lt;sup&gt;ns&lt;/sup&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Error</td>
<td>6</td>
<td>57.1&quot;&lt;sup&gt;ns&lt;/sup&gt;</td>
<td>1.56&quot;&lt;sup&gt;ns&lt;/sup&gt;</td>
<td>6713</td>
<td>0.09</td>
<td>4.08</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CV%</td>
<td>45</td>
<td>23.3</td>
<td>36.3</td>
<td>16</td>
<td>35.8</td>
<td>13.8</td>
<td>40</td>
<td></td>
</tr>
</tbody>
</table>

All the above trait were non-significant at (p>0.05) PH= Plant height in cm, BN=branch number per plant, PN=pods number per plant, SN =Seed number per pod, 100 seed weight in g, GY=grain yield in kg and BIOM=above ground biomass in kg.
Table 4: Mean value of Haricot bean plant height, Brach number per plant, pod number per plant seed number per pod, 1000 seed weight, grain yield and biomass

<table>
<thead>
<tr>
<th>Treatments</th>
<th>PH</th>
<th>BN</th>
<th>PN</th>
<th>SN</th>
<th>1000SWT</th>
<th>GY</th>
<th>BIOM</th>
</tr>
</thead>
<tbody>
<tr>
<td>1M:2HB</td>
<td>52.2 (^a)</td>
<td>8 (^a)</td>
<td>14.5 (^b)</td>
<td>5.7 (^a)</td>
<td>240 (^b)</td>
<td>1.55 (^a)</td>
<td>3.5 (^a)</td>
</tr>
<tr>
<td>1M:1HB</td>
<td>55.2 (^a)</td>
<td>6.8 (^a)</td>
<td>14 (^a)</td>
<td>5.7 (^a)</td>
<td>259 (^b)</td>
<td>2.38 (^b)</td>
<td>4.8 (^a)</td>
</tr>
<tr>
<td>Haricot bean</td>
<td>52.2 (^a)</td>
<td>7.6 (^a)</td>
<td>10.9 (^a)</td>
<td>5.1 (^a)</td>
<td>189 (^a)</td>
<td>2.45 (^b)</td>
<td>6.8 (^a)</td>
</tr>
<tr>
<td>sole</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LSD@ 0.05</td>
<td>40</td>
<td>3</td>
<td>8.2</td>
<td>1.6</td>
<td>141</td>
<td>0.5</td>
<td>3.5</td>
</tr>
</tbody>
</table>

Means followed by the same letter within a column are not significantly different from each other at (p<0.05) level of significance.

Picture: Pictorial presentation of common bean-maize intercropping at south ari woreda (field view)

4. INTERCROPPING INDICES

4.1 Intercropping efficiency: The present study of intercropping has focused on the effect of intercropping on land equivalent ratio and gross return/land area. All association involving the two type intercropping showed a LER value of greater than one (Table 6) indicating the superior productivity of the combination rather than growing the two crops separately. However, specific combination which showed LER values of 1.3 and above would be recommended which is considered practically acceptable for intercropping production [12]. The high LER (1.68) was recorded from one maize with one haricot bean intercropping (Table 5). This result showed 68% more land would be needed to produce the
combined yield of two crops if they were to be grow as pure stands. In this case, one maize with one haricot bean row intercropping has a given yield advantage and profit.

4.2 Monetary advantage Index (MAI) The MAI was higher at 15,559 was recorded from one maize intercropping with one haricot bean (Table 6). The result showed this cropping system are more profitable for some the reasons related to cost benefit agendas regarding the input cost and relative yield advantages obtained from the individual treatments. The result is in line to the previous study of [11].

Table 5. Land equivalent ratio (LER) and Monetary Advantage Index (MAI) intercropping maize- haricot bean was planted in the 2015 cropping season at Debub ari woreda

<table>
<thead>
<tr>
<th>No</th>
<th>Treatment</th>
<th>Grain yield in q/ha</th>
<th>LEV</th>
<th>MAI</th>
<th>value/ha (Eth.birr)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M:1HB</td>
<td>55.5</td>
<td>17.2</td>
<td>1.54</td>
<td>12,609</td>
</tr>
<tr>
<td></td>
<td>M:2HB</td>
<td>43.3</td>
<td>26.4</td>
<td>1.68</td>
<td>15,559</td>
</tr>
<tr>
<td></td>
<td>Maize sole</td>
<td>61.1</td>
<td>-</td>
<td>-</td>
<td>24,440</td>
</tr>
<tr>
<td></td>
<td>Haricot bean sole</td>
<td>-</td>
<td>27.2</td>
<td>-</td>
<td>21,760</td>
</tr>
<tr>
<td>LSD at 0.05</td>
<td>2.76</td>
<td>0.5</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

5. SUMMARY AND CONCLUSION

The study indicates that there is no adverse effect in the yield of maize and common bean whether it intercropped or sole planted. The yield of the main crop was comparable whether intercropped or not. The LER shows maize-common bean intercropping practice is more efficient in utilization of resources by intercropping than the conventional monoculture crop. Yield advantage and economic benefit assessment method shows advantage of intercropping than sole planting. Therefore, row intercropping one common bean with one maize proportion with LER of 1.68 and MAI of 15559 proved to be best than planted at sole. So, indicating this intercropping pattern was more advantageous and profitable than the conventional monoculture crop for some of the reasons related to cost benefit agendas regarding the input cost and relative yield advantages obtained from the individual treatments.

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REFERENCES


