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# ECONOMICS OF MAIZE (*Zea mays L*) WITH FENUGREEK, FIELD PEA AND HARICOT BEAN INTERCROP IN *FOGERA* PLAIN, NORTH WEST ETHIOPIA

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**Abstract**
A field experiment was conducted in 2013 to evaluate the growth and yield performance, productivity and profitability of maize production under intercropping and sole cropping system under irrigation at Jigna village of Dera District, South Gonder Zone, Ethiopia. A total of 7 treatments, namely; three intercropping of fenugreek, field pea and haricot bean with maize and four sole cropping each, were laid out in Randomized Complete Block Design (RCBD) in three replications. Varieties used for the present study were BH540 hybrid for maize, Challa for fenugreek, Burkitu for field pea and Awash Melkassa for haricot bean. Analysis of variance (ANOVA) was further computed using SAS version 9.2software and mean separation was estimated using least significant difference (LSD). Land Equivalent Ratio (LER) and Gross Monetary Value (GMV) were also estimated. The result shows that mean of intercropping had no significant difference ($p \geq 0.05$) on plant height, cob number per plant and seed per cob of maize with respect to their sole maize. Results of maize intercrop with haricot bean to sole maize was significant ($p \leq 0.05$). Similarly, thousand grain weight of maize had significant ($p \leq 0.05$) difference also. The mean treatments of intercropped fenugreek, field pea, haricot bean with maize and their sole each on plant height, cob (pod) per plant, seed per pod (cob) and thousand grain weight had no significant difference. However, the land equivalent ratios (LER) obtained were 1.28 and 1.18 for maize intercropped with haricot bean and field pea respectively. Productivity was improved in maize intercropped with field pea and haricot bean as depicted by LER values greater than one. Growing maize and haricot bean as sole crops would require 0.28 more unit of land to get the same yield obtained from the intercropping system. Higher GMV of 27619.37ETB/ha and 29799.06 ETB/ha were obtained from maize intercropped with haricot bean and field pea respectively. Therefore, maize intercropping with haricot bean and field pea was economically better than their respective sole crops in the study area.

**Keywords: GMV, Intercropping, LER, sole cropping, and Yield**

## Introduction
The study area has a limited land area per household and constrained to meet basic demand for food, fiber and oil. Because of rapid human population explosion, size of cultivable land at household level is gradually decreasing and most farmers own very small plots of land, especially in the developing countries of Asia and Africa. Hence, there is a need for increased crop production per unit of cultivated land using various techniques including multiple cropping. Intercropping for instance is one of the potential strategies of increasing productivity and simultaneously diversity per unit of cultivated land for the subsistence farmers who operate with low resources and inputs (Francis, 1986). One of the main reasons for intercropping around the world is to produce more than a single crop with same land area (Caballero and Goicoechea, 1995). Studies show that the dry matter production in wheat and beans intercrops was higher compared to single cropping (Ghanbari and Lee, 2002). While, grain and dry matter yield in bean and barley intercrops were more than sole cropping (Martin and Snaydon, 1982).

Maize and beans intercrops in different ratios increase production as a result of reduced competition between species compared to competition within varieties (Odhiambo and Ariga, 2001). Intercropping is as an economic method for higher production with lower levels of external inputs (Willey, 1990). This increase in use efficiency is important, especially for small-scale farmers and also in areas where growing season period is short

(Altieri, 1995). Higher production in intercropping can be attributed to higher growth rate, reduction of weeds and pests and diseases and more effective use of resources due to differences in resource consumption (Willey, 1990; Watiki *et al.*, 1993; Eskandari, *et al*., 2009 and Eskandari, 2012).

Intercropping of cereals with legumes has been popular in humid tropical environments and rain-fed areas of the world due to its advantage in yield increment, weed control, insurance against crop failure, low cost of production and high monetary returns, improvement of soil fertility through the addition of nitrogen by biological fixation, improving yield stability, etc. (Willey, 1979; Ofori and Stern, 1987; Ghosh *et al*., 2004; Poggio, 2005; Tsubo *et al*., 2005; Ghosh *et al*., 2006). Intercropping increases agro-bio diversity of the crop in cropping systems, prevention of diseases and pests, and utilization of the land to its full potential. Leaf cover of the crop is increased with intercropping systems which helps to reduce weed populations once the crops are established (Beets, 1990). Also intercropping has a variety of root systems in the soil which reduce water loss and increase water uptake by the plant and transpiration. The increased transpiration may make the microclimate cooler, with increased leaf cover, helps to cool the soil and reduce evaporation (Innis, 1997).Intercropping maize with legumes crops is a common feature of crop production in densely populated areas of the highlands of Ethiopia including the study area. In the study area, the report of Bureau of Land Use Administration shows that farmers have on average 0.6ha per household which is a very limited farm size (BLA, 2015). For smallholder farmers, the intercropping system is very important for intensification of crop production and to increase economical and diversification of crops in the study area, especially with limited farm land size.

Growing maize during dry season with irrigation is expanding yearly in the study area of *Fogera* Plain. During the dry season, irrigation enhances practicing of mix cropping for more than twice a year. Despite the expansion of maize production in dry season as a sole crop, maize production under irrigation has never been intercropped with other crops in the study area. Therefore, the objective of this study was to evaluate and recommend the best performance in growth and yield and comparing the productivity and profitability of maize production under intercropping and sole cropping systems.

**Materials and Methods**

The experiment was conducted in dry season under irrigation in *Fogera* Plain, South *Gonder* Zone, Ethiopia to evaluate the growth and yield performance of maize intercropped with fenugreek, field pea and haricot bean and compare profitability under inter- and sole- cropping system. The experiment has two parts in field trail study; the economic and agro biodiversity, and biological benefits of maize (*Zea mays* L) intercrop compared to sole, which was conducted simultaneously in 2013 (Molla and Getachew, 2018).

***Description of the Study Area***

The study was carried out in *Dera Woreda* (District) of *Fogera* Plain, Amhara Regional State. The experiment was specifically conducted in *Jigna* rural village or Kebele, which is located at 42.16km North of *Bahir Dar* ($19^0$ 37′ E and $11^0$51′ N and 1807 m.a.sl). The mean annual temperature has been reported to be $17.5^0$c with $10^0$C and $28^0$C minimum and maximum temperatures respectively (Data of source WoRA). The site receives average total rainfall of 1000mm annually with summer main rainy season from May to September (WoRA, 2012 and 2013).

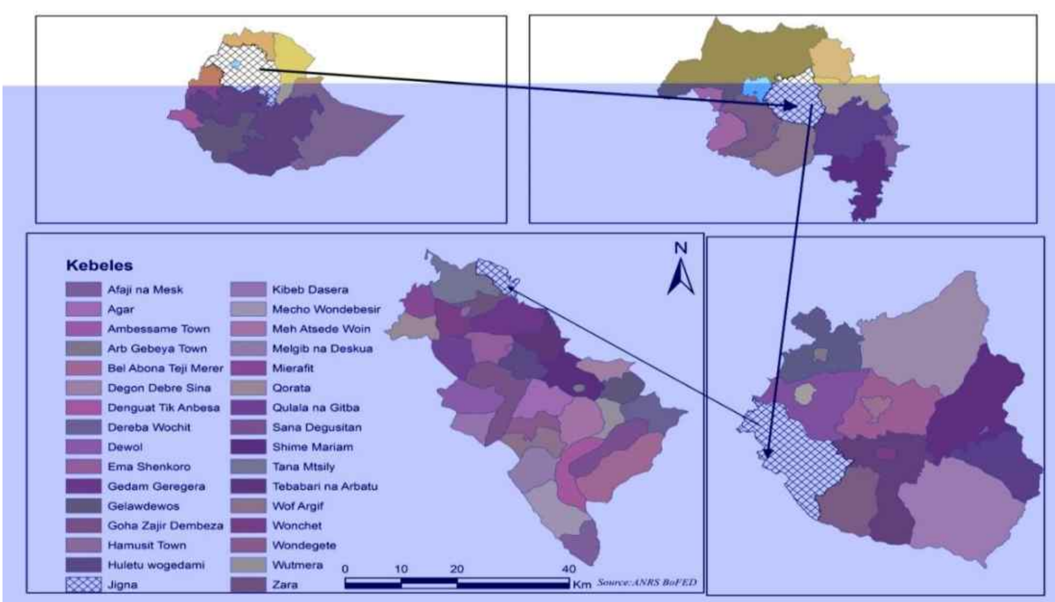


**Figure 1: Map of the study area**

***Experimental Treatments and Design***

The experimental plot was selected near the River *Gumara* to ease irrigation practice. Before planting, uniform seedbed was prepared by plowing three times using local oxen plough as the practice of local farmers. Sowing of seeds was made properly as per planned experimental treatments and sowed on 25 December 2013. Three intercrops of maize with fenugreek, haricot bean and field pea, and their four sole crops are shown in Table 1. The treatments were laid out under a randomized complete block design (RCBD) with three replications.

**Table 1: Study treatments**

| Treatment code | Description |
|---|---|
| $T_1$ (MFg) | Maize intercrop with fenugreek in single row between maize rows |
| $T_2$ (MFp) | Maize intercrop with field pea in single row between maize rows |
| $T_3$ (MHb) | Maize intercrop with haricot bean in single row between maize rows |
| $T_4$ (M) | Sole maize |
| $T_5$ (Fg) | Sole Fenugreek |
| $T_6$ (Fp)) | Sole Field pea |
| $T_7$ (Hb) | Sole haricot bean |

Planting materials used were selected based on its height to minimize shade effect, and tolerance of hot and high temperature relative to the other varieties of the same crop to minimize irrigation frequencies. Hence, BH540 hybrid has short height in maize and *Challa*, *Burkitu* and *Awash Melkassa* varieties were relatively tolerant to hot and high temperature with fenugreek, field pea and haricot bean, respectively. The plot size was 3m × 2.7m (8.1m$^2$). Spacing between replications and plots was 1.5m and 1.0m, respectively. Number of rows per plot for maize in both intercropping and sole was 5, and number of seed per row was 10, while number of rows per plot for fenugreek, field pea and haricot bean in the sole cropping was 16, 16 and 8 respectively. Seed planted per row for fenugreek and field pea was 55 and for haricot bean 28. Indeed, all fenugreek, field pea and haricot bean were planted in a single row between maize rows with total of 4 rows each per maize intercropped plot.

The recommended inter- and intra-row spacing were used for all experimental crops. Maize inter- and intra- row spacing was 75cmx30cm, while for fenugreek, field pea and haricot bean, inter- and intra row spacing was 20cmx5cm, 20cmx5cm and 40cmx10cm respectively. Only intra-row spacing was applied for the secondary crops of the intercropped plots. Planting rows were marked with pegs at recommended inter-row spacing of each crop and lined with strings. Sowing of seeds was made manually along stretched strings at recommended intra-row spacing of the crops. All recommended DAP was 100kg/ha and half of the recommended Urea (50kg/ha) were applied in side bands few centimeters away from maize rows at planting. Half of the Urea (50kg/ha) was divided equally into two and side dressed to maize rows at knee height and booting growth stages. In addition to this for secondary crops, DAP 100kg/ha and urea as a starter 50kg/ha base were applied at planting time. Crops were irrigated every week for a month in the early time of growth and later every 10 days as per farmers experience in the study area. Two times of hand weeding were carried out before the flowerings of crops.

***Data Collection***

Growth and yield related parameters were recorded following their respective days of emergence, flowering, maturity, number of cob/ pod per plant, seed per pod/cob, yield per plot, thousand grain and biomass weight, following standard methods and procedures. In all cases the border plants were excluded as data. Parameters were hence collected from 10 randomly selected plants of the net plot areas.

***Productivity of the system***

The concept of Land Equivalent Ratio (LER) is as an index of combined yield for evaluating the effectiveness of all forms of intercropping. LER is defined as the total land area required under sole cropping given the yields obtained in the intercropping mixture. It is expressed as:

$$LER = (Yij/Yii) + (Yji/Yjj)$$

Where Yii and Yjj are sole crop yields of the component crops i and j, and Yij and Yji are intercrop yields (Mead and Willey, 1980). The Partial LER values, Li and Lj, represent the ratios of the yields of crops i and j, when grown as intercrops, relative to sole crops expressed thus;

$$Li = (Yij/ Yii) \text{ and } Lj = (Yji/Yjj)$$

LER is the sum of the two partial land equivalent ratios, i.e;

$$LER = Li + Lj$$

The Land Equivalent Ratio (LER) is the most frequently used index to determine the effectiveness of intercropping relative to growing crops separately (Willey,1985). Generally, the value of LER is determined by several factors including density and competitive abilities of the component crops in the mixture, crop morphology and duration, and management variables that affect individual crop species (Enyi, 1973, Natarajan and Willey, 1980 and Fawusi, *et al*., 1982). It had been suggested that in density studies of cereal legume intercrop systems, the sole crop yields used as a standardization factors for estimating LER should be at the optimum densities of the crops (IRRI, 1974). This prevents the confounding of beneficial interactions between components with a response to change in density (Trenbath, 1976). As an index of combined yield, LER provides a quantitative evaluation of the yield advantage due to intercropping (Willey, 1979). Although component crops may give greatly different yields, the estimate of relative yields with sole crops at optimum or recommended densities as references gives comparable scales for both components, permitting comparisons of various crop combinations. LER could be used either as an index of biological efficiency to evaluate the effects of various agronomic variables (fertility levels, density and spacing, comparison of cultivars performance, relative time of sowing, and crop combinations, etc.) on an intercrop system in a locality or as an index of productivity across geographical locations to compare a variety of intercrop systems (Chetty and Reddy. 1984). According to Hall (1974), partial LER is more applicable to intercropping experiments than the relative crowding coefficient K, used in measuring competitive ability in competition studies. LER is based on land area only and does not take the duration of component crops into consideration. However, crop production is a function of both crop duration (time) and land area because land occupancy by a given intercrop system is frequently of longer duration than for sole crops. In this situation, the concept of area time equivalent ratio (ATER) is developed.

Land Equivalent Ratio (LER) and Gross Monetary Value were considered in the present study to estimate the productivity of the cropping system (Willey, 1979).

$$LER = \frac{\text{Intercrop maize yield}}{\text{Sole maize yield}} + \frac{\text{yield of intercrop Fg, Fp and Hb}}{\text{Sole yield of Fg, Fp and Hb}}$$

Where,
LER=1: No advantage of intercropping
LER<1: Intercropping reduces total yield
LER>1: Intercropping increases total yield thus beneficial
Therefore, if the result of LER is greater than one, intercrop is better than sole crop.

Gross Monetary Value (GMV) was also computed by multiplying the yields of maize, fenugreek, field pea and haricot bean with their respective unit prices. The total values obtained from the combined crops in the intercrop were used to compare the Gross Monetary Value of sole crops. To estimate the GMV of combined and sole crops, grain yields were valued using the average open market retail prices of Amhara Regional State, Ethiopia in the year 2012 Central Statistics Agency report (CSA, 2012). The average retail prices of Amhara Region in the year 2012 were Birr 527, 2022, 950 and 793 per 100kg for maize, fenugreek, field pea and haricot bean, respectively(CSA, 2012).

***Data Analysis***
The analysis of variance (ANOVA) was carried out using statistical packages and procedures out lined by Gomez and Gomez, 1984). Randomized Complete Block Design using SAS (Statistical Analysis Software) version 9.2. Whenever the ANOVA results showed significant difference between treatments, mean separation was further carried out using least significant difference (LSD) test at the 95% level of confidence respective levels of error. Correlation analysis was also carried out to estimate the relationship between yield and yield components as influenced by intercropping. Correlation coefficient values (r) were calculated and test of significance was analyzed using Pearson correlation procedure in SAS software.

**Results and Discussion**
***Growth and Yield Components***
The analysis of variance indicated that effects of intercropping had no significant difference ($p \geq 0.05$) on plant height, cob number per plant and seed per cob of maize. However, thousand grain weight of maize had significant ($p<0.05$) difference with intercropping (Table 2). The highest mean is assigned the letter "a" and descending "ab" "b" and "c". Since treatments intercropped maize with fenugreek, field pea, and haricot bean on plant height and cob (pod) per plant all have "a", they are not different. Similarly, on seed per pod (cob), treatment intercrop of maize with fenugreek, field pea, haricot bean and sole maize all have similar common "a", and had no significant difference ($p \geq 0.05$). However, maize intercropped with haricot bean have significant ($p<0.05$) difference). On thousand grain weight, treatment intercrop of maize with fenugreek, haricot bean and sole maize have no significant difference. However, treatment intercrop of maize with field pea, fenugreek and sole maize have significant ($p<0.05$) difference in intercrop. Treatment intercrop of fenugreek, field pea, haricot bean with respect of their sole (fenugreek, field pea and haricot bean) on plant height, cob (pod) per plant, seed per pod (cob) and thousand grain weight had no significant difference.

**Table 2: Comparison between Mean of intercropped maize with fenugreek, field pea, and haricot bean on growth and yield components and sole**

| Treatment | Plant Height (cm) | Cob/ Pod per Plant | Seed per Pod/ Cob | Thousand Grain Weight (gm) |
|---|---|---|---|---|
| **Maize** | | | | |
| M with Fg | 155.97ab | 1.10 a | 270.67ab | 328.28b |
| M with Fp | 153.13ab | 1.06a | 263.00ab | 340.36a |
| M with Hb | 131.70ab | 0.97a | 196.00b | 334.58ab |
| SM | 179.03a | 1.20a | 316.00a | 332.62b |
| **SEm ±** | **6.59** | **0.03** | **16.24** | **1.30** |
| **CV** | **14.43** | **10.51** | **20.77** | **1.00** |
| **Sign.diff.** | **NS** | **NS** | **NS** | ***** |
| **Fenugreek** | | | | |
| Fg + | 23.67a | 2.07a | 3.08a | 11.48a |
| SFg | 24.10a | 3.70 a | 6.26a | 14.34a |
| **SEm ±** | **0.15** | **0.32** | **0.47** | **0.47** |
| **CV** | **3.75** | **33.48** | **26.12** | **14.64** |
| **Sign.diff.** | **NS** | **NS** | **NS** | **NS** |
| **Field Pea** | | | | |
| Fp + | 109.97a | 4.60a | 3.70a | 232.37a |
| SFp | 106.40a | 4.20a | 3.61a | 240.15a |
| **SEm ±** | **1.21** | **0.09** | **0.06** | **4.09** |
| **CV** | **5.68** | **11.59** | **3.58** | **7.72** |
| **Sign.diff.** | **NS** | **NS** | **NS** | **NS** |
| **Haricot Bean** | | | | |
| Hb + | 72.00a | 14.70a | 4.85a | 184.22a |
| SHb | 62.30a | 14.80a | 4.23a | 170.32a |
| **SEm ±** | **1.94** | **0.44** | **0.12** | **3.45** |
| **CV** | **13.60** | **15.84** | **14.14** | **6.86** |
| **Sign.diff.** | **NS** | **NS** | **NS** | **NS** |

***Key :M=Maize, SM=Sole maize, Fg=Fenugreek, SFg=Sole fenugreek, Fp=Field pea, SFp=sole field Pea, Hb=haricot bean, SHb=sloe haricot bean, Fg+, FP+, Hb+= intercropped fenugreek, field pea & haricot bean with maize, NS=Non significant,*=significant, **=highly significant.***
****treatments with the same letters are not significantly different***

Sisay and Zewdu (2002), noted the non-significant effect of intercropping on plant height of sorghum at harvest. Also, there was a study that plant height of sorghum was not statistically different in intercropped and sole sorghum (Yesuf, 2003). Similarly in maize and cowpea intercropping experiment, plant height of maize was not affected due to intercropping (Wanki and Fuwusi, 1982). It was also reported that in maize haricot bean intercropping, plant height of maize in intercropped treatments did not differ significantly with that of sole maize (Amare, 1992). In contrast to these findings, growth parameters, such as plant height and number of internodes were significantly higher in intercropped sorghum with lablab (*Lablab purpureus L.*) than in sole sorghum cropping (Ibrahim *et al*., 1993). In other studies, it was also reported that the difference in plant height of the cereals was not significant in Bambara groundnut + sorghum, and Bambara groundnut + maize mixtures, but was significant in Bambara groundnut + pearl millet intercrop (Karikari *et al*., 1999). This contradiction could be due to the difference in the nature of intercrops involved particularly in legumes species incorporated to the system, because legumes differ in their competitive abilities compared to the cereal component for the limited growth factors. Even though, there was no difference in plant height, pod number per plant, and seed per pod ($p \geq 0.05$), however, slight difference was observed in Table 2. This could be associated with less moisture stress effect of intercrop on field pea than that of sole field pea, while maize might partially had a shade effect on the soil and on the secondary crop field pea. That might not have been subjected to serious moisture stress caused by shortage of irrigation water during the growing period compared to sole field bean. Similarly, this condition was also observed on plant height and thousand grain weight of intercropped haricot bean that were slightly greater than that of the sole cropping . The results obtained in this study are in agreement with Davis and Garcia, (1987).In agreement with the present finding, seed weight of green gram per plant in the intercropping was 93.0mg compared to 52.0mg in the sole cropping (Sisay, 2004).

***Yield and biomass***

Grain yield and biomass of maize, fenugreek, field pea and haricot bean as influenced by intercropping and sole cropping are presented in Table 3. The analysis of variance revealed that intercropping of maize with fenugreek, field pea and haricot bean didn't show significant (P≥0.05) effect on the grain yield, however significant effect on biomass of maize was observed. The grain yield and biomass of sole maize were superior to that of intercrop. Similarly, except the grain yield of haricot bean, the mean grain yield and biomass of sole fenugreek, field pea and haricot bean were superior to that of intercrop. These higher differences between the sole- and inter-crop for maize grain yield and biomass would be associated with competition between the main and secondary crops in the intercrop for limited growth resources. Similar to the current findings, mono-cropping resulted in superior grain yield of maize/sorghum compared with different intercrop treatments (Shehu *et al*., 1999). Also, seed yields of mono-crops of soybean, maize and sorghum were higher in intercrops (Pal *et al*., 1993). They ascribed this yield variation in intercropping to the high plant density per unit cultivated area. Some findings also revealed that sorghum grain yield in sole cropping were higher than that of the inter-crops (Tamado and Eshetu, 2000 and Yesuf, 2003). Significant grain yield reduction on sorghum crop was recorded in the intercrop compared to that of sole crop (Sisay, 2004). Sorghum crop suffered with yield reduction due to its intercrop with beans (Sisay, *ibid*). The same author reported no significant difference between intercropping and sole cropping for sorghum yields. Likewise, the panicle weight per plant of maize/sorghum was not significantly affected by intercropping with haricot bean (Tamado and Eshetu, 2000). Grain yield of sorghum was similar either mono-cropped or intercropped with varying population of beans (Carr *et al*., 1992).

**Table 3: Comparison between Sole and Intercropped maize with fenugreek, field pea and haricot bean on grain yield and biomass**

| Treatment | Grain yield (Kg/ha) | Biomass (Kg/ha) |
|---|---|---|
| **A. Maize** | | |
| M with Fg | 3984 ab | 9853.10b |
| M with Fp | 3978 ab | 9960.50b |
| M with Hb | 2904 b | 7367.90c |
| SM | 4671a | 11134.10a |
| SEm ± | 2.37 | 30.37 |
| CV | 20.46 | 0.75 |
| Sign.diff | NS | * |
| **B. Fenugreek** | | |
| Fg + | 31b | 56.50 b |
| SFg | 328a | 352.60a |
| SEm ± | 0.39 | 1.1 |
| CV | 30.78 | 14.64 |
| Sign.diff. | * | 0.27 |
| **C. Field Pea** | | |
| Fp + | 930 b | 1068.80b |
| SFp | 2826a | 2667.90a |
| SEm ± | 2.38 | 3.75 |
| CV | 18.14 | 0.3 |
| Sign.diff. | * | * |
| **D. Haricot Bean** | | |
| Hb + | 1553a | 1704.70b |
| SHb | 2399a | 2596.00a |
| SEm ± | 1.4 | 4.55 |
| CV | 14.7 | 0.05 |
| Sign.diff. | NS | * |

***Key: M=Maize, SM=Sole Maize, Fg=Fenugreek, SFg=Sole fenugreek, Fp=Field pea, SFp=Sole field Pea, Hb=haricot bean, SHb=Sole haricot bean, Fg+, FP+, Hb+ = intercropped fenugreek, field pea & haricot bean with maize, NS=Non significant, *=significant, **=highly significant.***
****treatment means with the same letters are not significantly different***

Biomass of fenugreek, field pea and haricot bean showed a significant difference ($p \leq 0.05$) between inter- and -sole cropping. Similarly grain yield had a significant difference between inter- and sole-cropping of fenugreek and field pea but the mean of haricot bean inter- and sole- crop did not show any significant difference. Sole fenugreek, field pea and haricot bean produced slightly higher grain yield and biomass per hectare compared to the intercrop. The highest yield of field pea and haricot bean was 2826kg/ha and 2399kg/ha respectively, and 2667.9kg/ha and 2596kg/ha for biomass also, were recorded in the sole crops. High grain yields in fenugreek, field pea and haricot bean for sole crop were more than that of intercrop. This could be due to competition exerted by maize component for growth factors. However, thousand grain weight of haricot bean in the sole crop was less than that of the intercrop (Table 2). Similar to this finding, Demesew (2002) reported that grain yield per hectare of haricot bean was not affected significantly ($P \geq 0.05$) by intercropping. The results obtained in this study are in contrast with Davis and Garcia (1987) who reported reduction in hundred seed weight of haricot bean in maize intercrop compared to sole crop. This was perhaps is associated with competition exerted by maize plants for resources.

***Total Land Productivity and Gross Return***

The analyses of Land Equivalent Ratio (LER) and Gross Monetary Value (GMV) are presented in Table 4. Differences between sole and intercrops were observed for both LER and GMV. The highest Land Equivalent Ratio of 1.28 was obtained from maize with haricot bean intercrop, followed by 1.18 in maize with field pea, and lowest LER (0.94) from maize with fenugreek . Productivity was improved in maize intercropped with field pea and haricot bean as depicted by LER values greater than one. This indicated that intercropping of maize with haricot bean and field pea was better than sole planting of maize and haricot bean or field pea regardless of the biomass. Growing of maize and haricot bean as sole crops would require 0.28 more units of land to get same yield obtained from the intercropping system. This intercropping system resulted in the highest cumulative total yields than either of maize, field pea or haricot bean. Intercropping of maize with fenugreek was better than sole maize. However, the highest Gross Monetary Value of 29799.06ETB/ha was obtained from maize and field pea intercrop. This is because field pea has high demand and price in domestic markets with increasing trend in the whole season of 2013/14, while the price of haricot bean decreased due to a decrease in demand in the international market. Similar to that of LER, the lowest Gross Monetary Value was obtained from the mixture of maize and fenugreek. There was a decrease in both LER and GMV in fenugreek and maize intercrop. Sole fenugreek and the sole haricot bean produced the lowest Gross Monetary Value (6632.16 ETB/ha and (19024.07ETB/ha respectively). This is directly related to the production of less yield per hectare associated with the availability of less moisture. LER, Gross Monetary Value (GMV) was used to evaluate economic advantage. The highest GMV of 29799.06ETB/ha was obtained from maize and field pea intercrop. However, productivity increased to LER value of 1.28 in maize and haricot bean intercrop. In this finding, LER values greater than unity were obtained from all intercropped treatments (except fenugreek intercropped with maize) indicating that intercropping is better than its sole cropping.

**Table 4: Effect of intercropping maize with fenugreek, field pea and haricot bean on grain yield, total land equivalent ratio (LER) and gross monetary value (GMV*)***

| **Treatment** | **Yield Kg/ha** | | | | **LER Result** | **MV** | | | | **GMV (Birr/ha)** |
|---|---|---|---|---|---|---|---|---|---|---|
| | Maize | **Fg** | **Fp** | **Hb** | | **Maize** (Birr/ha( | **Fg** (Birr/ha) | **Fp** (Birr/ha) | **Hb** (Birr/ha) | |
| **M+Fg** | 3984 | 31 | _ | _ | 0.94c | 20,995.68 | 626.82 | _ | _ | 21,622.50 |
| **M+Fp** | 3978 | _ | 930 | _ | 1.18ab | 20,964.05 | _ | 8835 | _ | 29,799.06a |
| **M+Hb** | 2904 | _ | _ | 1553 | 1.28a | 15,304.08 | _ | _ | 12,315.29 | 27,619.37ab |
| **SM** | 4671 | _ | _ | _ | 1,00c | 24,616.17 | _ | _ | _ | 24,616.17 |
| **SFg** | _ | 328 | _ | _ | 1,00c | _ | 6,632.16 | _ | _ | 6,652.16 |
| **SFp** | _ | _ | 2826 | _ | 1,00c | _ | _ | 26847 | _ | 26,847 |
| **SHb** | _ | _ | _ | 23.99 | 1,00c | _ | _ | _ | 19,024.07 | 19,024.07 |

**Source for price: CSA (Amhara Region Retail Price for the year 2013/14 Report)**

***Key: Fg=fenugreek, Fp=field pea, Hb=haricot bean, BLI=Block one, BLII=Block two, BLIII=Block three, M+ Fg=maize intercropped with fenugreek, M+ Fp= maize intercropped with field pea, M +Hb=maize intercropped with haricot bean, SM=sole maize, SFg=sole fenugreek, SFp=sole field pea, SHb=sole haricot bean, Kg/ha=kilogram per hectare. *treatment means with the same letters are not significantly different.***

It was also reported that intercropping led to greater land area utilization (LER=1.08-1.26) and increased the net returns by 183.27-346.18ETB/ha over intercropping swedge rape, Ethiopian mustard with French bean (Khola and Singh, 1996). This finding is in agreement with the previous studies reported by on cereal and legumes intercropping (Tarhalkar and Rao, 1981). The authors obtained higher monetary returns from intercropping of sorghum with cowpea compared to their sole crops. Many research results also indicate efficient use of labor, plus high and dependable gross returns per hectare from intercropping systems (Francis, 1986; Besong *et al*., 1993; Aleman and Ohlander, 2000). In a two year experiment conducted to determine the effect of intercropping of mung bean with different proportions of millet and sorghum on the productivity and economic returns per unit area, all intercrop combinations improved productivity and gave higher economic returns per unit area compared with the monoculture of mung bean, sorghum, and pearl millet (Chowachury, 1989 and Umrani *et al*., 1984).

***Correlation among Growth and Yield Parameters of main crop (maize)***

Based on the statistical procedure mentioned by Gomez (1985), correlation between growth and yield components as influenced by intercropping of maize with fenugreek, field pea and haricot bean was analyzed and the results are presented in Table 5. Days of 50% emergence was not significantly correlated with any of the traits considered in this study. Days of flowering was positive and highly significantly correlated with plant height (0.95**), seed per pod (0.93**), days of maturity (0.96**), yield per hectare (0.93**), thousand grain weight (0.94**) and biomass weight per hectare (0.94**). Plant height was positive and highly significantly correlated with seed per pod (0.85**), days of maturation (0.85**), yield per hectare (0.90**) thousand grain weight (0.96**) and biomass yield (r=0.86**). Days of maturation (0.96**), yield (0.85**), thousand grain weight (0.77**) and biomass yield (0.99**) had high correlation with seed per pod. Days of maturity significantly correlated with yield (0.87**), thousand grain weight (0.84**) and biomass yield (0.97**). Grain yield per hectare was also highly significantly correlated with days of flowering (0.93**), plant height (0.90**), seed per pod (0.85**), days of maturity (0.87**), thousand grain weight(0.88**) and biomass yield (0.85**). Pod per plant was negatively correlated with other growth and yield components. This negative and insignificant correlation of pod per plant with other agronomic traits was due to poor pod setting and production as a result of shade effect and moisture stress occurring during growth period (because of decrease in the level of river water).

**Table 5: Correlation analysis on agronomic parameters (Pearson correlation coefficients)**

| | DEm50 | DF50 | PP | PTHT | SP | DM90 | Yi (Kg/ha) | Gw1000 (gm) | Bmw (Kg/ha) |
|---|---|---|---|---|---|---|---|---|---|
| **DEM50** | 1 | 0.34 | -0.22 | 0.27 | 0.36 | 0.38 | 0.19 | 0.30 | 0.37 |
| **DF50** | | 1 | -0.40 | 0.95** | 0.93** | 0.96** | 0.93** | 0.94** | 0.94** |
| **PP** | | | 1 | -0.44 | -0.58 | -0.40 | -0.27 | -0.29 | -0.58 |
| **PTHT** | | | | 1 | 0.85* | 0.85** | 0.90** | 0.96** | 0.86** |
| **SP** | | | | | 1 | 0.96** | 0.85** | 0.77** | 0.99** |
| **DM90** | | | | | | 1 | 0.87** | 0.84** | 0.97** |
| **YiPlgm** | | | | | | | 0.99** | 0.88** | 0.87** |
| **YiKg/ha** | | | | | | | 1 | 0.88** | 0.85** |
| **gwgm1000** | | | | | | | | 1 | 0.78** |
| **BmwKg/ha** | | | | | | | | | 1 |

**** Key: DEm50=days of 50% emergency, DF50=days of 50% flowering, PP=pod per plant, PTHT= plant height, SP=seed per pod, DM90=days of 90% maturation, YiPl= yield per plot in gram, Yiha=yield per hectare in quintal, GW1000=thousand grain weight in gram, BmWPt =biomass weight per plant in gram,* =significant and **= highly significant at 5% and 1% probability level***

**Conclusion**

The results show productivity was improved in maize intercropping with field pea and haricot bean as depicted by LER values greater than one. This indicated that intercropping of maize with haricot bean and field pea was better than sole planting of maize and haricot bean or field pea regardless of the biomass. Growing maize and haricot bean as sole crops would require 0.28 more unit of land to get the same yield obtained from the intercropping system. This intercropping system resulted in the highest cumulative total yields than either of maize, field pea or haricot bean. Generally, the highest LER value of 1.28 and Gross Monetary Value of 27619.37ETB/ha were obtained from intercropping maize with haricot bean. This was followed by LER value of 1.18 and Gross Monetary Value of 29799.06ETB/ha obtained from intercropping maize with field pea. In this experiment, maintaining of diversity was observed with the benefit of biomass, which is used for cattle feed or sold as for income. Therefore, it is recommended that during dry season under irrigation, maize can be intercropped with haricot bean and field pea for more economic gains and diversity.

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