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Effect of different intercropping patterns on yield and yield components of maize (*Zea mays* L.) and faba bean (*Vicia faba* L.)

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ABSTRACT: In order to evaluate the effects of different intercropping arrangements on yield and yield components of maize and faba bean, an experiment was conducted in Research Station of Faculty of Agriculture, University of Tabriz, Tabriz, Iran, 2013. Experimental design was Randomized Complete Block Design (RCBD) with three replications and seven treatments. Treatments were: sole crop of maize, sole crop of faba bean, row intercropping (1:1) and 5 patterns of strip intercropping of maize : faba bean (1:2, 1:3, 2:1 and 2:2) . According to the results, highest plant hight, seed and biological yield were observed in pure crop of maize but, the effects of various plant patterns on grain weight was not significant. Sole cropping patterns had high ratios of pod /plant, seed number in plant, seed yield and biological yield. The results of this experiment indicate that sole cropping of maize and faba bean because of producing high grain yield, is superior to other treatments and can be used in similar climatic conditions.

Keywords: Intercropping, Maize, Yield, Yield components.

INTRODUCTION

The success of modern intensive agriculture in recent years due to the increasing demand for the agricultural products often is accompanied by an increase in soil erosion and environmental pollution follow the excessive use of the agrochemical and fertilizers, and problem of pests and weeds management (Poggio, 2005). Increasing global interest to the organic agriculture in recent years is mainly due to it's emphasis on stability and decreasing the environmental impacts (Wood *et al.,* 2006). Restoring on-farm biodiversity through diversified farming systems that mimic nature is considered to be a key strategy for sustainable agriculture (Jackson *et al.,* 2007). Many researchers believe that applying intercropping patterns in the farming ecosystems is the main reason for increasing the diversity in these systems (Olasant, 1999). Intercropping is defined as the simultaneous growth of two or more species, grown in the same area here they share the use of resources during all or part of their growing season (Mead and Willey, 1980). Intercropping systems can provide many benefits through increased efficiency of land use, enhancing the capture and use of light, water and nutrients, controlling weeds, insects and diseases and increasing the length of production cycles (Liebman and Dyck, 1993; Liebman and *et al.,* 2001; Gao *et al.,* 2010; Coll *et al.,* 2012). Crop choices to be intercropping may determine the successful of intercropping. The different rooting system, life cycle period, nutrient and light requirement and even economic values can be considered to decide the intercropping combination (Seran and Brintha, 2010). Legume and cereal are most common among farmers in the semi-arid tropics and would benefit them in resource limiting condition, compared with corresponding sole crops (Hayder *et al.,* 2003). Maize-faba bean intercropping is used in many parts of the world, especially in the high lands of east and South Africa, and in Mexico (Mbah *et al.,* 2007). It is also practiced in Iran (Rezaei *et al.,* 2010). Faba bean (*Vicia faba* L.) is a cool season legume used as a source of protein in human diets, as a forage crop for animals, and for boosting nitrogen in the biosphere (Duc *et al.,* 2010). Faba beans are often introduced into crop rotation as forage and green-manure legume, and several researchers have referred to the beneficial role of their belowground parts in nutrient cycling in several cropping systems, including cereals (Jensen *et al.,* 2010; Munoz-Romero *et al.,* 2011). Maize as a third cereal product of the world has bean recognized as a common component in most intercropping systems (Adeniyan *et al.,* 2007). Maize is one of the important plants that ecologists and specialists showed more interest in intercropping systems in different places of world (Awal *et al.,* 2006). Oluwasemire *et al.* (2002) stated that millet, when intercropped either with cereals or legumes, used water more efficiently for grain production. Zhang and Li (2003) observed a significant yield increase of intercropping wheat/corn and wheat/soybean systems over sole wheat, which resulted from positive effects of the border row and inner rows of intercropped wheat.

MATERIALS AND METHODS

The experiment was conducted at the research farm of University of Tabriz, Iran (latitude 38.05°N, longitude 46.17°E, Altitude 1360 m above sea level) in 2013. The climate is characterized by mean annual precipitation of 245.75 mm per year and mean annual temperature of 10°C. The soil was clay-loam. The experimental design used was Randomized Complete Block Design (RCBD) with three replicates. There were seven treatments. Sole faba bean, 1:1 Maize / faba bean alternate rows, 1:2 Maize / faba bean alternate rows, 2:1 Maize / faba bean alternate rows, 2:2 Maize / faba bean alternate rows, 1:3 Maize / faba bean alternate rows and Sole Maize.

Seed bed preparation included ploughing, disk harrowing. Each plot size was 3 m × 4 m containing 8 ridges each of 4 m length and the distance between and on rows for maize were considered 50 and 15 cm, respectively and 50 and 10 cm, respectively for faba bean. Before sowing, seeds were treated with 2 g/kg benomyl. In the 3-4 leaf stage, plants were thinned to achieve the desired density. The final density for maize and faba bean were 13 and 20 plants per square meter, respectively. To facilitate the emergence, the first irrigation was performed immediately after planting and subsequent irrigation in weekly intervals. About 60 kg ha-1 urea was also added to the soil when maize plants were 40-50 cm height. The remaining urea 60 kg ha-1 was added to the soil when maize was in anthesis - silking interval. The plots were hand Weeding in different vegetative stages. At the end of the growing season and physiological maturity of corn and faba bean, sampling for yield of both plants were performed on all plots as follow: the side plots and 50 cm of both ends of plots were excluded and sampling done on the remainder plots.

Maize and faba bean plants were cut from ground surface and vegetative parts of plants oven dried at 78°C for 48 h and dry weight was recorded as biological yield. Seeds were detached from the cubs and pods and weighed after adjusting the seeds moisture constants levels to 14% in maize and to 15% in faba bean. For measuring the yield components of the two species, in each plot five plants of maize and faba bean accidently were selected after removing marginal effects and traits were measured. Analysis of variance was performed using the software MSTATC and mean comparison by Duncan's multiple range test was carried out.

RESULTS AND DISCUSSION

A. Yield and yield components of maize

Plant height. Comparing of the average of maize plant height shows that the highest height (220 cm) and the lowest height (170.5 cm) of maize observed in sole culture pattern and 1:2 treatment of maize and faba bean, respectively, which did not show significant differences with the other treatments of intercropping (Table 1 and 2). As the taller plant in the intercropping are the more successful in competition with the others for light, thus won't grow up more, so that following the competition of neighboring plants for the other sources (water and minerals) became dwarf and weak stable plants (Mazaheri, 1998).

Table 1: Analysis of variance for yield and yield components of maize mixed with faba bean.

		Mean squares			
S.O.V	**df**	**Plant height**	**100 seed weight**	**Grain yield**	**Biological yield**
Replication	2	14.347^{ns}	0.616^{ns}	28686.658^{ns}	187439.96^{ns}
Treatments	5	930.347*	4.858^{ns}	468843.826**	2057159.246**
Error	10	111.09	3.496	19214.266	134441.86
CV (%)		5.69	10.28	19.27	23.22

** Significant at the 0.01 and ns, non-significant

Table 2: Mean comparison for yield and yield components of maize mixed with faba bean.

Treatments	**Plant height (cm)**	**100seed weight(g)**	**Grain yield($g.m^{-2}$)**	**Biological yield ($g.m^{-2}$)**
Faba bean (sole)	-	-	-	-
Maize (sole)	220a	15.59a	1366a	2909a
1:1 Maize/Faba bean	177.5b	19.45a	599bcd	1257bc
2:2 Maize/Faba bean	181.5b	18.93a	728.8bc	1693bc
2:1 Maize/Faba bean	182.8b	18.65a	945.3b	2065ab
1:2 Maize/Faba bean	170.5b	18.57a	398.1cd	852.8c
1:3 Maize/Faba bean	178.5b	17.61a	278.9d	695.9c

Means within a column followed by the same letter are not significant different (Duncan's test: P<= 0.05).

During the experimental efforts of Yunusa (1989) in the intercropping of maize and soybean, the height of maize plant in sole culture was more compared to the intercropping. The results obtained from sunflower and cotton plants intercropping which showed that the height of cotton plant reduced significantly due to interspecific competition (Aladakatti *et al.*, 2011) were coincident with our results.

100 -seed weights. Although the differences between the weights of 100 seed in sole culture and intercropping treatments were not statistically significant, the highest weight of 100 seed achieved in row intercropping treatment (1:1) (Table 1 and 2). Our results agree well with those of Agegnehu *et al.* (2006) showed that there were non-significant differences between the weights of 1000 barley seeds in different combinations of barley and faba bean cumulative intercropping.

Grain yield. Different patterns of maize and faba bean intercropping had significant effect on the grain yield of maize (Table1). In this regard the highest yield (1366 gm^{-2}) was seen in the sole culture pattern and the lowest one (278.9 gm^{-2}) was observed in 1:3 strip intercropping pattern (Table 2). Higher yield of maize in sole culture compared to it's intercropping with faba bean is normally because of the higher number of maize bushes. The reduction in grain yield of maize introduced late into a maize-legume intercrop has also been demonstrated by other workers. For example, Nnoko and Doto (1980) intercropped maize and soybean at four planting schedules. The results indicated that in all cases, grain yield of the cereal component declined.

Biologic yield. There were significant differences between different patterns of sole culture and intercropping for biologic yield (Table 1). Maize biologic yield in sole culture (2909gm^{-2}) was more than the different patterns of intercropping and the lowest yield (695.9 gm^{-2}) was seen in 1:3 pattern cropping of maize and faba bean(Table 2). In sorghum-cowpea intercrop study, Sole crops of sorghum and cowpea also recorded higher values for both biological yield) Oseni and Aliyu, 2010).

B. Yield and yield components of faba bean

Number of pod per plant. Comparing average numbers of pod per plant indicate that the more pod per plant (4.8) achieved in sole culture pattern and the lower one (2.47) achieved in maize and faba bean 1:3 cropping pattern (Table 4). Decreasing the number of faba bean pods per plant in intercropping to the sole culture can be contributed to rise in interspecific competition. Also increase in the competition for light and minerals and consequently enhance shading in intercropping lead to decrease in photosynthesis and so more abscission and lower pods per plant. Based on the results obtained from Carruthers *et al.* (2000) the number of soybean pod per plant in intercropping with maize decreased compared to the sole culture. Also Getachew *et al.* (2006) reported more faba bean pod per plant in mono culture compared to it's intercropping with barley.

Number of grain per pod. There were no significant differences between the different patterns of cropping for the number of faba bean grain per pod (Table 3). As the number of grain per pod is controlled genetically, so it seems that the plant prefers filling the grains even in low number for it's surviving.

Number of grain per plant. The results showed that there were significant differences among different patterns of intercropping and sole culture for the number of grain per plant at 1% probability level (Table 3). As seen in Table 4 the greatest number of grain per plant (7.83) achieved in sole culture pattern and the lowest one (3.67) was seen in maize and faba bean 1:2 cropping pattern. In fact in sole culture pattern the greater number of pod caused to increase in the number of grain per plant.

100-seed weights. The 100 seed weight was not significantly affected by cropping patterns (Table 3). Hans and Shiblez (1978) suggested that the number of grain per pod and the 1000 seed weight were not affected by environmental impacts.

Grain yields. The results obtained from analysis from variance showed that the grain yield of faba bean was significantly affected by the type of cropping (Table 3).

Table 3: Analysis of variance for yield and yield components of faba bean mixed with maize.

		Mean squares					
S.O. V	df	Number of pod per plant	Number of grains per pod	Number of grains per plant	100 seed weight	Grain yield	Biological yield
Replication	2	0.227^{ns}	0.009^{ns}	0.016^{ns}	3.814^{ns}	974.371**	26511.369**
Treatments	5	2.321*	0.073^{ns}	8.43**	17.162^{ns}	1184.307**	45911.071**
Error	10	0.473	0.031	0.334	6. 259	107.08	2165.376
CV (%)		19.78	11.04	10.87	2.59	25.73	18.9

*' ** Significant values at (P≤0.05) and (P≤0.01)respectively, ns, non-significant.

The highest (71.3 gm^{-2}) and the lowest (12.94 gm^{-2}) grain yield were observed in the faba bean sole culture and maize and faba bean 2:1 strip intercropping, respectively (Table 4). Although a comparison of the faba bean mean yield components showed non-significant differences between the different patterns of cropping for the number of grain per pod and the 100 seed weight, the faba bean sole culture pattern with the highest number of pod per plant was the pioneer.

This finding suggests that increase in the grain yield of faba bean is a result of the high number of pod per plant and not affected by the other components of the yield. Also the results of this study indicate that in cropping patterns of high faba bean density the yield of this plant is more compared to the treatments with low density of faba bean. Banik *et al.* (2006) reported that the yield of lens grain was significantly decreased in lens and wheat intercropping.

Biologic yield. The results obtained from analysis of data variances showed significant differences ($P<0.01$) between the treatments for biologic yield of faba bean (Table 3). The highest (451.9 gm^{-2}) and the lowest (125 gm^{-2}) biological yield were achieved in sole culture and, maize and faba bean 2:1 strip intercropping, respectively (Table 4). Getachew *et al.* (2006) reported that the biologic yield of faba bean in intercropping decreased compared to the sole culture treatment as a result of increasing interspecific competition. Furthermore a study on the intercropping of white clover and wheat indicated a decrease in the yield of white clover when compared with the sole crop (Thorsted *et al.*, 2006).

Table 4: Mean comparison for yield and yield components of faba bean mixed with maize.

Treatments	Number of pod per plant	Number of grains per pod	Number of grains per plant	100 seed Weight(g)	Grain yield($g.m^{-2}$)	Biological yield ($g.m^{-2}$)
Maize (sole)	-	-	-	-	-	-
Faba bean (sole)	4.8a	1.66a	7.83a	94.8a	71.3a	451.9a
1:1 Maize/Faba bean	3.87ab	1.76a	6.23b	94.82a	25.94bc	131.1c
2:2 Maize/Faba bean	3.8abc	1.73a	6.13b	94.82a	44.56ab	216.8bc
2:1 Maize/Faba bean	3.36bc	1.34a	4.1c	99.42a	12.94c	125c
1:2 Maize/Faba bean	2.57bc	1.52a	3.67c	95.63a	39.99bc	233.3bc
1:3 Maize/Faba bean	2.47c	1.55a	3.9c	99.79a	46.6ab	318.7b

Means within a column followed by the same letter are not significant different (Dunkan's test; $P<= 0.05$).

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