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Original Article

Evaluation of Yield and Advantage Indices of Maize (*Zea Mayz L.*) and Faba Bean (*Vicia Faba L.*) Intercropping Systems

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ABSTRACT

Objective: For investigation of intercropping of maize and faba bean, an experiment was conducted in Research Station of Agriculture Faculty of Tabriz University during growing season of 2013. **Methods:** Experimental design was randomized complete block design with three replications and seven treatment. Treatments included one row intercropping (1:1), 4 strip intercropping pattern with ratios of (1:2), (1: 3), (2: 1) and (2: 2) maize and faba bean and 2 treatments of faba bean and maize sole culture. **Results:** Based on results, grain yield and biological yield of two species in sole culture was significantly different from other species and reached their highest level. Evaluation of different patterns of intercropping using Land Equivalent Ratio (LER) showed that strip intercropping with ratio 2:2 dedicated highest ratio of LER to itself. Regarding to maize as a major yield in all cropping patterns, economic value or Relative Value Total (RVT) was lower than one, but regarding to economic production of faba bean, RVT of all intercropping was more than one, and among them strip intercropping 2:1 had highest RVT(9.65). Relative Crowding Coefficient (RCC) showed that in treatments which crowding one of two species is more than other, that species is superior competitively.

1.INTRODUCTION

Using new scientific methods for meeting increasingly growing population demands is necessary. Based on this, management of agriculture systems should be reviewed seriously and new strategies should be developed and their priority should be long term sustainability while maintaining production in short term (Senanayake, 1991). Making variation in management methods and different kinds of exploitation of resources, or in other words, increasing agriculture variation is the best approach for attaining sustainable production (Tengberg

et al 1998 and Pinedo-Vasquez et al 2000). Intercropping as a sample of sustain quantity and quality of product in agriculture follows different aims: making ecologic balance, more exploitation of resources and decreasing damage due to pests, illness and weeds (Lithourgidis et al 2007). Intercropping through increasing species in unite area suggested as one of the solution for increasing production in agriculture (Brunner 1998). If exist species in combination use resources differently and in other words, occupy different ecologic nests, intercropping will be successful. This kind of growing leads to species performs complementary. Thus, in designing intercropping in sustain systems, we should

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note that plants that use resource more differently, are more compatible plants at intercropping (Vandermeer,1998). Intercropping with Leguminosae order is the most common intercropping patterns that has long precedence in most area of world (Awal et al, 2006). Intercropping of cereals and Leguminosae is suggested for developing sustain systems of food production, especially in cropping systems that based on consuming foreign institutions (Dapaah, 2003). maize (*Zea mays*) belongs to Poaceae order .maize is one of the important plants that ecologists and specialist showed more interest in intercropping systems in different places of world. Maize intercropping with legumes is an alternative for monoculture system and has many advantages such as reducing input energy, reducing production costs, increasing efficiency of resources and increasing forage production (Awal et al 2006). Faba bean (*Vicia faba*) belongs to Fabaceae order. This plant can supply about 40% of needed Nitrogen of other plants that are cropped after it. This is very important in sustain and organic agriculture (Prinand Dwit, 2005). Agegnehu et al (2006) by investigation of intercropping of bean and oats reported that bean's yield is increased at intercropping than monoculture. Abraham and Singh (1984) found out that row cropping of every four species of yearling legumes (fodder cowpea and grain cowpea, grass pea and soya) with Sorghum increases yield and Sorghum nitrogen relative to monoculture of Sorghum. Thus, in this research the maize and faba bean intercropping is assessed to determine the best combination and efficiency of resource utilization by determining advantageous indices.

2. MATERIALS AND METHODS

The experiment was conducted at the Research Farm of Tabriz University, 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 x 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. Analysis of variance was performed using the software MSTATC and mean comparison at one percent level of probability by Duncan's multiple range test was carried out.

To evaluate the intercropping, indices such as land equivalent ratio (LER) (Equation 1), Relative value total (RVT) (Equation 2) and the relative crowding coefficient (RCC) (Equation 3) were used.

$$LER = (P_1/M_1) + (P_2/M_2) = L_i + L_j \quad (1)$$

Where, P1 and P2 are the yields of two different crops in intercropping and M1 and M2 are the yields of these crops in monocropping LER > 1 shows intercropping advantage and LER < 1 means mono-cropping advantage(Willey, 1979).

$$RVT = (aP_1 + bP_2) / \quad (2)$$

Where P1, P2 and M1 are defined as in equation 2, a and b are the market prices of crops 1 and 2, respectively. If the RVT is greater than one, it's indicating the intercropping advantage. If this index is smaller than one, it's indicating that monoculture would prefer to intercropping. The critical value of RVT is one (Vandermeer, 1989).

$$RCC = (Y_A/Y_B) / (Y'_A/Y'_B) \quad (3)$$

Where, YA is the yield of species A in intercropping, YB is the yield of species B in intercropping, Y'A is the yield of species A in monoculture and Y'B is the yield of species B in monoculture (Spitters, 1983).

3. RESULTS AND DISCUSSION

3.1. Biological yield

Considering results of table of variance analysis, effect of different intercropping patterns on biological yield of maize is significant at one percent level (table 1). Comparing mean biological yield of maize at intercropping unit area showed that highest and lowest biological yield are obtained in sole culture (2909g/m²) and strip intercropped maize and faba bean

(695.9g/m²), respectively (Fig1). Rezaei-Chianeh and et al (2011) showed that biological yield of maize is reduced relative to sole culture at intercropping with faba bean. In this research major part of reducing of biological yield of corn in unit area at intercropping relative to sole culture is result of reducing contribution of corn bush at intercropping unit area than sole culture. Results of analysis of variance showed that effect of different patterns of cropping on biological yield of faba bean is significant at 1% probability level (table 1). Pattern of sole culture with 451.9g/m² produced highest biological yield and has significant difference with other patterns of cropping, while cropping pattern 2: 1 of maize and faba bean had lowest biological yield by producing 125g/m² (Fig 1). Getachew and et al (2006)

reported that biological yield of bean at intercropping reduced significantly relative to sole culture. Considering results of RCC (table3) and comparing means of biological yields, it seems that by increasing maize ratio at intercropped and consequent it, more competition of maize than faba bean and especially its shading, faba bean's yield is reduced, while in strip intercropping 1: 3 of maize and faba bean yield of faba bean is improved. In fact, since bean has higher ratio and its competitive power is more in this cropping pattern, its yield increased, and regarding to previous research it appears rational.

Table 1. Analysis of variance for grain and biological yield in intercropping maize and faba bean

S.O.V	df	Mean square			
		Grain yield		Biological yield	
		Maize	Faba bean	Maize	Faba bean
Replication	2	28686.658 ^{ns}	974.371 ^{**}	187439.96 ^{ns}	26511.369 ^{**}
Treatments	5	468843.826 ^{**}	1184.307 ^{**}	2057159.246 ^{**}	45911.071 ^{**}
Error	10	19214.266	107.08	134441.86	2165.367
CV (%)		19.27	25.73	23.22	18.9

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

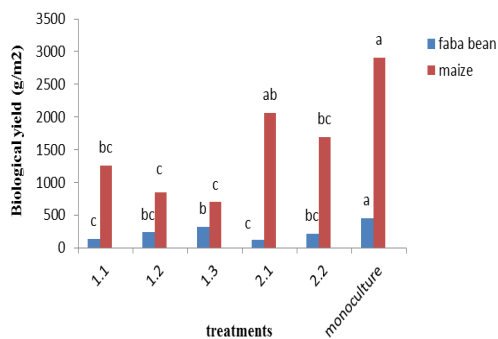


Figure 1. Mean comparison of maize and faba bean biological yield in different patterns of culture

3.2. Grain yield

Considering results of variance analysis table effect of different patterns of intercropping on yield is significant at 1% level of probability (table 1). Comparing mean yield of maize with faba bean in different patterns of intercropping shows similar trend in biological yield (Fig 2). Highest yield of corn in sole culture (1366g/m²) and

lowest yield of maize in strip intercropping (1:3) of maize and faba bean obtained 278.9g/m². Sadeghi and et al (2009) at intercropping corn with legume said that reducing grain yield and biological yield in combined treatment relative to sole culture corn is result of legume competition with corn for adsorbing water and nutritional elements. According to Ofori and Stern (1987), when two plants incorporated in same time, competition for resource is more, so reduced yield at intercropping in such systems will be observed more. In this experiment replacing rows of corn in sole culture with bean rows in intercropping reduced corn yield in unite area. Results of analysis of variance showed that effect of different patterns of cropping on biological yield of faba bean is significant at 1% probability level (table 1). Comparing mean yield of faba bean with that of maize in different pattern of intercropping showed that faba bean sole culture in 71.3g/m² produced highest grain yield and cropping pattern 2:1 with 12.94g/m² had the lowest grain yield (Fig 2). Elmore and et al reported that in intercropping of soya and sorghum, yield of soya is reduced. in this research order of grain yield in cropping

indicated that the more ration of bean in combination, the more yield of bean in unite area of combination.

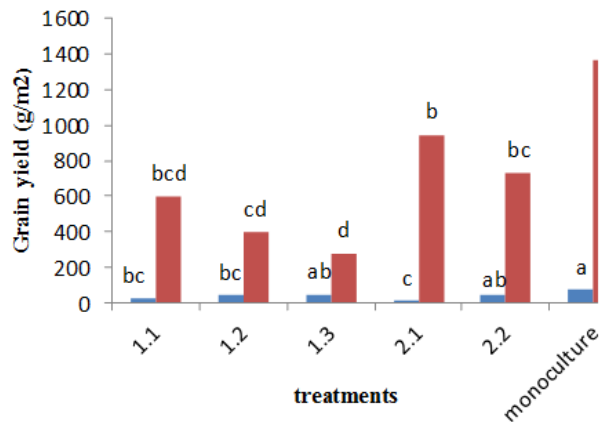


Figure 2. Mean comparison of maize and faba bean grain yield in different patterns of culture

3.3. Land equivalent ratio (LER)

Strip intercropping (2:2) had more LER that was equivalent to 1.15. Lowest LER related to row combination of 1: 1. In strip intercropping (2:2) LER

which is more than one is efficiency indicative of this combination (Table 2). In this combination faba bean had more part of LER. In cereals- legume intercropping, cereal component determine combination yield of intercropping and legume component is reduced more in high crowding, but system efficiency following from trends and changes of corporation component of legume product, because LER ratio is combination result of relative yields of two components (Banik et al 2006). By comparing corn- soya and corn- Cowpea intercropping, Allenand Ebura (1983) concluded that corn- Cowpea intercropping relative to everyone sole culture, had yield superiority 27- 32 %. In corn-soya intercropping yield increased to 22%.

Table 2. Area Time Equevalent Ratio of maize (LER_m), Area Time Equevalent Ratio of faba bean(LER_f), land equivalent ratio (LER), relative value total (RVT), Relative crowding coefficient maize on faba bean(RCC_m), Relative crowding coefficient faba bean on maize(RCC_f) of maize(m) intercropping with faba bean(f).

Treatment	LER _m	LER _f	LER	RVT _m	RVT _f	RCC _m	RCC _f
1:1	0.44	0.36	0.8	0.46	6.3	1.2	0.88
1:2	0.29	0.56	0.87	0.3	4.54	0.51	1.93
1:3	0.2	0.65	0.85	0.2	3.4	0.3	3.25
2:1	0.69	0.18	0.87	0.7	9.65	3.8	0.26
2:2	0.53	0.62	1.15	0.57	7.92	0.85	0.65

Economic evaluation of maize-faba bean intercropping (RVT)

Relative Value Total (RVT) is indicative of total ratio of intercropping gross income relative to sole culture. Placing sole culture of maize in relation and comparing intercropping with it, obtained relative value total was lower than one (table 2). Based on this results, earned gross income from all intercropping was lower than maize sole culture. In maize -soya bean -ever green strip intercropping RVT rate reported from 0/46 to 1/007 (Dabgh Mohammadi Nasab and et al 2006).

For economic production of faba bean in RVT relation and comparing income of intercropping with sole culture faba bean, relative value total in all of the corporation patterns was more than one (table 3). This is indicative of economic efficiency of intercropping relative to sole culture faba bean. Most of efficiency was of strip intercropping 2:1 (9.45). In corn- soya-ever green, by considering soya sole culture as a basis of comparison of gross income, relative value total for all treatments was more than one and it is reported from 3/97 to 8/8 (Dabgh Mohammadi Nasab and et al 2006).

3.4. Competitive evaluation of intercropping of maize and faba bean (RCC)

Regarding to definition of relative crowding coefficient, ratio of relative yield of every specie than other specie showed that this index in maize at cropping pattern 2: 1 and 1: 1 and for faba bean at cropping pattern 1: 2 and 1:3 was larger than unit. When RCC is more than one it is indicative of competitive superiority of that species than other species which is contributing in combination. In contrast, smaller index suggested that overwhelmed species in that pattern are weak. Based on Khan and et al (2001) higher RCC of cotton in intercropping with other some species is indicative of its competitive superiority.

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