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Araştırma Makalesi/*Research Article (Original Paper)*

Evaluation of Yield and Yield Components in Intercropping of Maize and Green Bean

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Abstract: Intercropping cultivation of cereal-legume is the most common method in intercropping cultivation. In order to evaluation yield and yield components in intercropping of maize and green bean, an experiment was conducted as split plot design in completely randomized blocks with three replication in crop year 2008-2009 in Macco, Iran. The main factor included three density levels (D_1: 60000 plants of maize + 200000 plants of green bean per hectare, D_2: 75000 plants of maize + 300000 plants of green bean per hectare and D_3: 90000 plants of maize + 400000 plants of green bean per hectare, respectively). The sub factor included five planting arrangements (R_1: pure cultivation of green bean, R_2: pure cultivation of maize, R_3: intercropping %50 green bean + %50 maize, R_4: intercropping %75 green bean + %25 maize and R_5: intercropping of %25 green bean + %75 maize, respectively). The method used of from the mixture was based on replacement system. Examined traits in this study consist of maize and green beans yield in intercropping and pure cultivation in replacement system, compare the yield of pure and intercropping plant, land equity ratio, maize and green bean relative yield, relative crowding and dominance coefficient. Predicted and real of grain yields of maize and green bean at different density and planting ratio in pure and intercropping cultivation was showed that the highest intercropping yield in treatment D_3R_4 with an average 15214.16 kg per hectare. For evaluation of intercropping, Land Equivalent Ratio (LER) and Relative Value Total (RVT) were calculated. The highest amount of LER and RVT were in treatment D_3R_5 about 2.19 and treatment D_3R_4 and D_3R_5 about 2.61, respectively. As a conclusion, the mentioned combinations are economically advisable. In relation to competitive indices, the Relative Crowding Coefficient (RCC) and Agressivity was calculated. The highest RCC related to the maize with 1.36 was observed in D_1R_5 treatment. Also, the green bean in D_2R_3 treatment with 1.05 was indicated the highest RCC. The highest Agressivity in the maize with 4.30 in D_3R_4 treatment was calculated whereas in the highest related to D_3R_5 treatment was revealed in the green bean with 4.52. The Relative Crowding Coefficient and Agressivity were associated the maize in most treatments.

Key words: Intercropping, Land equivalent ratio, Relative value total, Yield components

Mısır ile Yeşil Fasulye Birlikte Yetiştiriciliğinde Verim ve Verim Bileşenlerinin Değerlendirilmesi

Özet: Tahıllarla baklagillerin birlikte ekimi, ürünler arası yaygın bir uygulamadır. Bu araştırma mısır ve taze fasülyenin birlikte ekiminde farklı ekim sıklığı ve ekim desenlerinin verim ve verim bileşenlerinin üzerine etkisinin belirlenmesi amacıyla bölünmüş parseller düzenine göre tam şansa bağlı bloklar deneme deseninde üç tekerrürlü olarak 2009 ürün yılında İran'ın Makü şehrinde yürütülmüştür. Ana faktör üç farklı ekim sıklığı seviyesinden (D_1: 60000 mısır bitkisi + 200000 taze fasülye hektar başına düşen, D_2: 75000 mısır bitkisi + 300000 taze fasülye hektar başına düşen ve D_3: 90000 mısır bitkisi + 400000 taze fasülye hektar başına düşen, sırasıyla) oluşmaktadır. Alt faktör ise beş ekim düzenlemesinden (R_1: 100% taze fasülye ekimi, R_2: 100% mısır ekimi, R_3: %50 taze fasülye + %50 mısır birlikte ekimi, R_4: %75 taze fasülye + %25 mısır birlikte ekimi ve R_5: %25 taze fasülye + %75 mısır birlikte ekimi, sırasıyla) oluşmaktadır. Bu çalışmada mısır ve taze fasülyenin birlikte ekiminde farklı ekim sıklığı ve ekim desenlerinin verim ve verim bileşenlerinin üzerine etkisi, alan eşdeğer oranı (LER), toplam nispi değer (RTV), göreceli sıklık katsayısı (RCC) ve rekabet değerleri hesaplanmıştır. Varyans analiz sonuçlarına

göre mısır tane verimi farklı ekim desenlerinden önemli ölçüde etkilenmiştir. Fasülye tane verimi üzerine farklı ekim sıklığının etkisi önemli olmuştur. En yüksek öngörülen ve gerçek tane verimi hektara 15214.16 kg ile D_3R_4 uygulamasından elde edilmiştir. Karışım şeklindeki ekimin etkinliğini değerlendirmek amacıyla LER ve RTV'ler hesaplanmıştır. En yüksek LER ve RTV sırasıyla yaklaşık 2.19 ve 2.61 ile D_3R_5 ve D_3R_3 ve D_3R_5 uygulamalarında belirlenmiştir. Sonuç olarak yukarıda ifade edilen kombinasyonlar ekonomik olarak tavsiye edilebilir. Rekabet indeksleri bakımından, RCC ve rekabet değerleri hesaplanmıştır. En yüksek RCC 1.36 ile D_1R_5 uygulamalarında mısır bitkisinde belirlenmiştir. Taze fasülye ise D_2R_3 uygulamalarında 1.05 olarak hesaplanmıştır. En yüksek rekabet değeri 4.30 ile D_3R_4 uygulamalarında mısır bitkisinde belirlenmiştir. Taze fasülyede ise D_3R_5 uygulamalarında 4.52 şekilde olarak elde edilmiştir.

Anahtar kelimeler: Birlikte ekim, Alan eşdeğer oranı, Toplam nispi değer, Verim bileşenleri

Introduction

Intercropping is considered as the practical application of ecological principles such as diversity, crop interaction and other natural regulation mechanisms. Nitrogen fixing legumes such as cowpea, pigeon pea, common bean, soybean, French bean, can be included to a greater extent in arable cropping systems via intercrops. Legumes contribute to maintaining the soil fertility via N fixation, which is increased in intercrops due to the more competitive character of the cereal for soil inorganic N. This leads to a complementary and more efficient use of N sources by the crops in the intercrop system (Nyasasi and Kisetu 2014). Components of sustainable agriculture can be agroforestry, intergraded pest management, crop rotation and intercropping cultivation (Ghanbari-Bonjar 2000). The intercropping cultivation is the growth of two or more products simultaneously in a piece of land during a crop season (Sullivan 2003). Intercropping cultivation is performed in the form of increase and replacement so that in an increase system, by eliminating one of the species in the multiple cultivation, a single cultivation can be performed, but in a replacement cultivation system, with consideration to all the situation of one species in intercropping cultivation, a similar species can be replaced and perform single cultivation (Javanshir et al. 2000). Legumes in maize based cropping systems are considered to be better alternatives for securing nitrogen economy and increasing yield of maize besides bonus yield , greater productivity per unit time and space and higher net returns of intercropping system over monoculture (Thayamini and Brintha, 2010). It is eminent to point out that to produce additional food from less expanse of land through more efficient use of natural means with minimal impact on the environment in order to meet the increasing population request (Amos et al. 2012). Ijoyah and Fanen (2012) further reports that the choice of crop combination is key to successful intercropping. Incompatibility factors such as planting density, root system and nutrient competition need to be considered (Ijoyah and Jimba 2012). Intercropping cultivation of cereal-legume is the most common method in intercropping cultivation. Maize is one of the nutritional strategically crop and green bean is full of protein, so they can be a complete starch and protein food per unit area and the physiological and morphological characteristics of these plants can be complementary in the use of environmental resources. Regarded to root form, maize has fibrous and shallow root but bean have deep and direct root. Therefore this difference in root form can make the maximum use from food and moisture in soil. On the other hand, bean has the ability to establish and use the atmospheric nitrogen. So the amount of nitrogen in the soil used and the competition for nitrogen nutrient element which is one of the most important elements, for plant decreased. According to recumbent and creeping growth habit of legume plants, they create good coverage in the soil surface and reduce soil erosion, strangling weeds and prevent water evaporation from the soil surface (Baqeri and Parsa 2008). In fact in intercropping cultivation, optimum use of environmental source such as water, light, soil and food are attributed to the height, how to place aerial and underground and different plants food need (Hashemi-Dezfoli et al. 2001). Surveying of conducted researches in Iran about intercropping farming systems is a confirmation on this claim. Undie et al. (2012) reported that the total farming system productivity is assessed by land equivalent ratio (LER) and the portion of land saved. Land equivalent ratio was first defined as the relative land area required as sole crops to produce the yields achieved in intercropping (Carlson 2008). Tayefehnuri (2004) by increasing cultivation of maize and green bean announced that the usefulness of intercropping cultivation to pure cultivations has increased. Mazaheri (1998) by surveying the intercropping cultivation of maize with beans in different proportions concluded that the mixture of %75 maize and %25 bean with the high density produce the maximum product, which was about %8 more than maize, also he absolved in the mixture of maize and bean its yield reduced to %15 when the bean density increased to double per hectare. According to Song et al., (2007), intercropping increased crop

yield, changed N and P availability, and affected the microbiological properties in rhizosphere of the crop species compared to sole cropping. Sullivan (2003) claims, since plants in intercropping cultivation have the chance to enjoy optimum yield, it is necessary to reduce the amount of seed of each of its components. Pirzad (2000) offered in order to mention yield in intercropping cultivation the density should be more than the desirable density of pure cultivation. Undie et al. (2012) reported that the total farming system productivity is assessed by land equivalent ratio (LER) and the portion of land saved. Land equivalent ratio was first defined as the relative land area required as sole crops to produce the yields achieved in intercropping (Carlson 2008). Tetio-Kagho and Gardner (1988) in the assessment of maize- bean mixture concluded that by increasing the maize crop density to three times, cause %24 reductions in leaf area index and %70 of grain yield in planting bean. Therefore, the objectives of this research are studying the determination of mixture and planting density of maize and green bean and assessment of superior yield of intercropping cultivation to pure cultivation and determining the best arrangement plant density.

Material and Methods

Plant material and field trial

The experiment was conducted as split plot in completely randomized blocks with three replications. The main factor included three density levels (D_1: 60000 plants of maize + 200000 plants of green bean per hectare, D_2: 75000 plants of maize + 300000 plants of green bean per hectare and D_3: 90000 plants of maize + 400000 plants of green bean per hectare, respectively). The sub factor included five planting arrangements (R_1: pure cultivation of green bean, R_2: pure cultivation of maize, R_3: intercropping %50 green bean + %50 maize, R_4: intercropping %75 green bean + %25 maize and R_5: intercropping of %25 green bean + %75 maize, respectively). Seed bed preparation included ploughing, disk harrowing and cultivation. Sowings were performed manually by planting twice more seeds than the expected plant densities and then, rows were thinned to the required densities. The planted green bean was *Green veladat* 532 variety that produced in Iran. This variety gives the first green pods after 45 day from sowing and is an orthotropic type variety. The maize variety was *KSC704* that produced in Iran. This variety is suitable for forage and grain production and maturity period of them is 125-135 day.

Soil and weather conditions

This field experiment was carried out with a latitude of 39°, 20' and longitude of 44°, 23’ at an altitude of 1411 m above mean sea level in 2009 crop year in Macoo city from Iran. This area has a mean annual temperature of 11.6 ^{o}C Rainfall of crop year 2009-2010 was 400.4 ml Also during the growing season the mean minimum, maximum and average daily temperature was 11.6, 22.08 and 16.84 ^{o}C respectively. Total rainfall during the experiment was 47.65 ml and the total evaporation was 173.05 ml. Maximum rainfall occurred in June. For single and intercropped maize treatments, a basal application of nitrogen and phosphorous were carried out at sowing time, using urea and P_2O_5 fertilizers at the rate of 190 kg/ha and 180 kg/ ha, respectively. About 60 kg/ha urea was also added to the soil when maize plants were 40-50 cm height. The remaining urea 60 kg/ha was added to the soil when maize was in anthesis – silking interval. The sole-cropped green bean received 90 kg/ha of P_2O_5 during planting. The center of stack in this experiment line spacing for maize and bean was 60 cm for both of them the densities were adjusted by changing the distances on the cultivated lines each experimental unit was of five length and 3.6 m width and the experimental included 45 experimental units. Plots were irrigated as at when needed. Weed control was performed manually. Maize was harvested at complete maturity and green bean plants were harvested when the most pods fully matured. Maize and green bean plants were cut from ground surface and vegetative parts of plants oven dried at 78°C for 48 hours and dry weight was recorded as biological yield. Determine the whole studied characteristics of 10 plants from middle rows; each sub-plot was sampled by removing the marginal effects. 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 green bean.

Computation and data analysis

Predicted yield (prediction yield is equal to the multiplying proportion of product *a* in intercropping in the yield of the pure culture the product) and real yield obtained in practice is examined.

In order to evaluate the competitive effects among component crops and to determine intercropping yield in mixture and sole crop Land Equivalent Ratio (LER) and Relative Value Total (RVT) were calculated (Mazaheri, 1998).

$$LER = \frac{Y_{ab}}{Y_{aa}} + \frac{Y_{ba}}{Y_{bb}} \quad (1)$$

It is calculated as:

Where, Y_{ab} and Y_{ba} are the yields of two different crops in intercropping and Y_{aa} and Y_{bb} are the yields of those of these crops in sole cultures. Formula is used If LER is greater than one, intercropping will be better than pure cultivation (Mazaheri, 1998) and if LER is less than one, pure cultivation will be better (Hauggaard-Nielsen *et al.*, 2001; Sullivan, 2003).

Any result would signify an intercropping advantage; any result below one signifies a sole culture advantage. The problem with LER is that such calculation does not account for the value of the crops that are being sown (Moseley, 1994).

The solution to this problem is provided in calculating Relative Value Total (RVT) of the crop mixtures. Such calculation is relevant for the farmer that has monetary value as his farming goal (Vandermeer, 1992). RVT is given as

$$RVT = \frac{(ap_1 + bp_2)}{am_1} \quad (2)$$

Where a, b are price yields of two different crops and p_1, p_2 and m_1 the yields of two different crops in intercropping crop 1 and 2 respectively.

By using dominance, the extra product of plant to other one is determined. If sample *a* is intercropping by sample *b* by replacement method.

Relative Crowding Coefficient can be summarized as follow:

$$RCC_{ab} = (Yab / Yaa) / (Yba / Ybb) \quad (3)$$

$$RCC_{ba} = (Yba / Ybb) / (Yab / Yaa)$$

Dominance is given as:

$$A_{ab} = (Yab / Yaa) - (Yba / Ybb) \quad (4)$$

$$B_{ab} = (Yba / Ybb) - (Yab / Yaa)$$

Where, Y_{ab} and Y_{ba} are the yields of two different crops in intercropping and Y_{aa} and Y_{bb} are the yields of those of these crops in monocultures. If the dominant coefficient is zero, it means the inside and outside species competition is the same and there is no competition between two species. If the dominance coefficient is greater than zero, then the competitive power of species a is more than b in intercropping and if the dominance competition is less than zero, then the competitive power of species b is more in intercropping (Dabagh-Mohammadi-Nasab, 2003; Zhang and Li, 2003).

The obtained data's were variance analyzed by SAS statistical software and the average was compared with a Least Significant Difference test (LSD) and while EXCEL software for sketching curves and graphs.

Results and Discussion

Maize and green beans Yield in pure and intercropping cultivations as an alternative method

Figure 1. (a) and (b) shown row intercropping, where two plant species are cultivated in separate alternate rows (maize with climbing bean). The most important goal in field experiments is to achieve maximum yield. Analysis of variance showed that the levels of different density, at the ear length, ear number wood ear diameter and biological yield in maize plant and the pod length and number of stem branches in green bean plant no statistically significant (Table 1 and 3). Comparison of different levels of treatment in maize showed the maximum plant height with an average of 294.7 cm and the green bean plant the maximum plant height with an average of 36.55 cm, the yield and biologic yield respectively with an average of 5843 kg/he and 13357 kg/he in the highest density or treatment D_3 (Maize 90000 plants +

green beans 400000 plants per hectare). The highest average of seed weight of 18.72 g in maize plant and the number of seeds per plant with an average of 80.06 numbers per the lowest density or treatment D_1 (Maize 60000 plants + green bean 200000 plants per hectare) were obtained (Table 2 and 4). Analysis of variance indicated that the levels of different plant ratio, at the ear length and ear number in maize plant and the pod length, biological yield in green bean plant no statistically significant (Table 1and 3).

Table 1. Analysis of variance for yield and yield components of maize in intercropping system

		M S									
Sources of Variations	d. f	Plant height	Number of ear	Ear length	Wood ear diameter	Number of rows per ear	Number of grain rows per ear	Number of grains per ear	Seed hundred weight	Grain yield	Biological yield
Replication	2	359.96	0.02	1.06	1.83	1.32	2.01	11408.14	0.99	1093112.26	544969.23
Density (A)	2	601.74*	0.05	6.02	6.15	0.04	26.76	57865.77	16.92*	6839962.3	35699228.0
Error	4	38.16	0.03	5.67	3.63	1.12	5.42	10637.93	1.84	1840815.51	10797956.2
Planting ratio	3	547.88*	0.02	1.95	18.04*	1.26*	7.5	13720.39*	1.3**	3228839.13**	29779195.9
A*B	6	14.89	0.03	1.14	3.39	0.3	2.35	3556.72	0.31	599337.25	3864897.58
Error	18	20.12	0.02	1.61	6.67	0.33	3.11	3436.14	0.21	604481.35	3315366.6
CV (%)		1.56	8.32	5.96	5.66	3.95	4.20	10.99	2.30	9.30	7.90

*, **: Significant at $p \leq 0.05$ and $p \leq 0.01$, respectively

Table 2. Mean comparison of plant height, number of ear, ear length, wood ear diameter, number of rows per ear, number of grain rows per ear, seed hundred weight, grain yield and biological yield of maize in intercropping system

Treatments	Plant height (cm)	Wood ear diameter (mm)	Number of rows per ear	Number of grain rows per ear	Seed hundred weight (gr)	Grain yield (kg/ha)	Biological yield (kg/ha)
Density							
D_1	280.60 c	45.78	14.52	619.27	18.72 a	8016.00	21965.00
D_2	286.00 b	46.28	14.33	602.71	18.6 a	8505.00	23410.00
D_3	294.70 a	44.14	13.99	576.66	18.19 b	8565.00	23775.00
LSD5%	5.27	3.03	0.67	43.5	0.53	913.60	2140.00
Means within the same column and rows and factors, followed by the same letter are not significantly difference (P <0.05)							
Planting ratio							
R_1	296.10 a	43.88 b	13.73 b	566.08 c	18.37 b	7880.00 b	21950.00 b
R_2	289.60 b	47.54 a	14.89 a	637.73 a	19.86 a	9157.00 a	25310.00 a
R_3	285.30 b	45.67 ab	14.48 ab	615.97 b	17.93 b	8491.00 ab	23680.00 ab
R_4	277.50 c	44.51 b	14.02 b	578.74 c	18.26 b	7920.00 b	21260.00 b
LSD5%	6.08	3.50	0.78	47.92	0.62	1055.00	2471.00

Means within the same column and rows and factors, followed by the same letter are not significantly difference (P <0.05)

D_1 (60000 plants of maize + 200000 plants of green bean per hectare), D_2 (75000 plants of maize + 300000 plants of green bean per hectare), D_3 (90000 plants of maize + 400000 plants of green bean per hectare), R_1 :pure cultivation of maize, R_2 :intercropping %75 maize + %25 green bean, R_3 :intercropping of %50 maize + %50 green bean, R_4 :intercropping of %25 maize + %75 green bean.

Table 3. Analysis of variance for yield and yield components of green bean in intercropping system

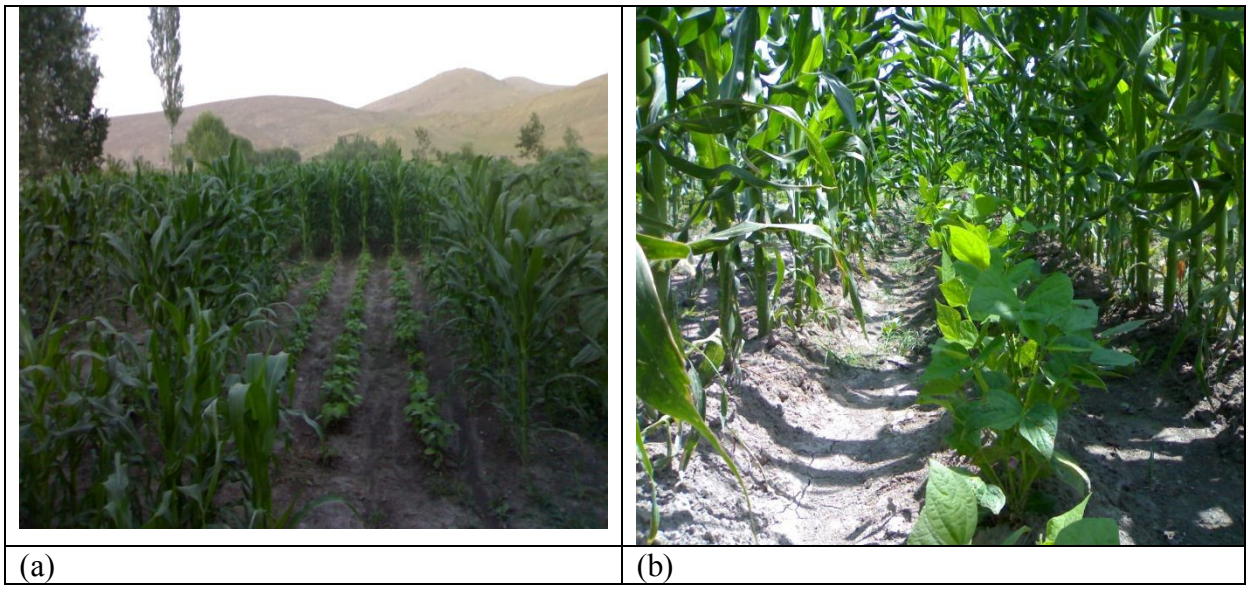
		MS							
Sources of Variations	d.f	Plant height	Number of stem branches	Pod length	Number of grain per pod	Number of grains per plant	Seed hundred weight	Grain yield	Biological yield
Replication	2	1.96	0.002	2.51	1.23	193.93	3.15	2020627.11	15018962.11
Density (A)	2	18.91**	0.08	1.62	0.13	1725.63*	5.31	9179317.45*	76678998.52*
Error	4	0.70	0.40	0.79	0.53	141.38	4.71	762549.45	5921290.19
Planting ratio(B)	3	5.18**	0.59**	0.38	0.25	50.81	0.23	212999.05	337863.33
A*B	6	0.44	0.09	1.24	0.15	87.47	9.62	190707.29	1430186.41
Error	18	0.73	0.14	0.77	0.13	59.16	3.29	120694.75	665392.27
CV (%)		2.43	9.12	7.99	7.49	11.35	5.90	6.90	6.85

*, **: Significant at $p \leq 0.05$ and $p \leq 0.01$, respectively.

Table 4. Mean comparison of plant height, number of stem branches, number of pod number of grain per plant,grain yield of and Biological yield maize in intercropping system

Treatments	Plant height (cm)	Number of stem branches	Number of pod	Number of grain per plant (plants/m2)	Grain yield (kg/ha)	Biological yield (kg/ha)
Density						
D_1	34.04 c	4.2	296.7 c	80.06 a	4116.00 c	9208.00 c
D_2	35.17 b	4.02	384.6 b	67.07 b	5153.00 b	12280.00 b
D_3	36.55 a	3.93	450.45 a	56.12 c	5843.00 a	13357.00 a
LSD5%	1.00	0.43	49.29	9.03	289.00	958.60
Means within the same column and rows and factors, followed by the same letter are not significantly difference (P <0.05).						
Planting ratio						
R_1	34.46 b	4.01 ab	363.70	65.61	4938.00	11030.00
R_2	34. 86 b	3.77	375.40	66.31	4945.00	11630.00
R_3	35.49 ab	4.39 a	389.80	70.93	5264.00	12060.00
R_4	36.19 a	4.02 ab	380.10	68.16	5002.00	11740.00
LSD5%	1.16	0.50	56.92	10.46	3441.00	1107.00
Means within the same column and rows and factors, followed by the same letter are not significantly difference (P <0.05).						

D_1 (60000 plants of maize + 200000 plants of green bean per hectare), D_2 (75000 plants of maize + 300000 plants of green bean per hectare), D_3 (90000 plants of maize + 400000 plants of green bean per hectare), R_1 :pure cultivation of green bean , R_2 :intercropping %75 green bean + %25 maize, R_3 :intercropping of %50 green bean + %50 maize, R_4 :intercropping of %25 green bean+ %75 maize.



(a) (b)

Figure 1. (a) and (b) Row intercropping, where two plant species are cultivated in separate alternate rows (maize with green bean plant)

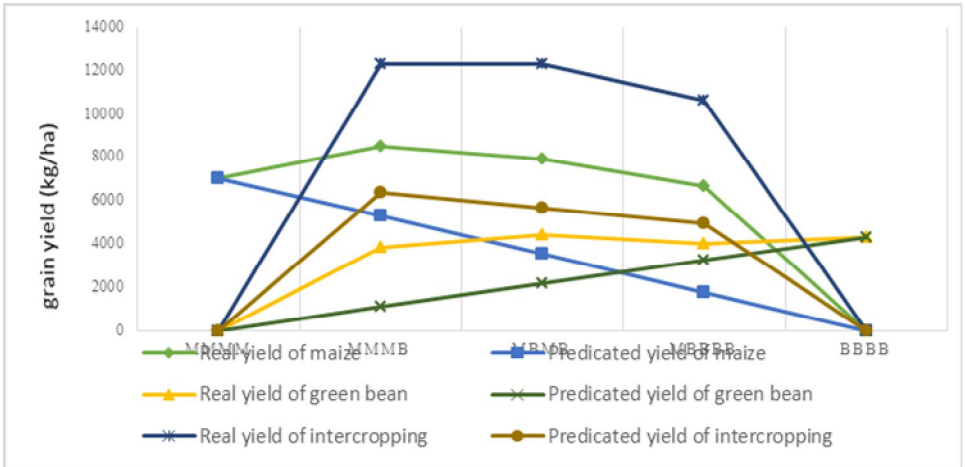


Figure 2. Grain yield of maize and green bean of intercropping in level D_1

The comparison of different levels of plant ratio treatment showed up that the highest plant height of maize with an average of 296.1 cm in treatment R_1 (Pure maize cultivations) that was significantly different from other treatments of intercropping cultivation. Also the maximum wood ear diameter with an average 47.54 mm, number of rows per ear with an average 14.89 numbers, number of seed per ear with an average of 637.73 numbers, seed weight with an average of 19.86 gr, seed yield and biologic yield respectively with an average of 9157 kg/ha and 25310 kg/ha belonged to treatment R_2 (%75 of intercropping cultivation of maize+ %25 green beans). In green bean plant the maximum plant height with an average of 36.19 cm occurred in treatment R_4 (%25 of intercropping cultivation of green beans + %75 maize) and the maximum plant number of stem branches with an average of 4.39 number in R_3 (intercropping %50 green bean + %50 maize) treatment (Table 2 and 4).

Because many system of intercropping cultivation have a legume nitrogen stabilizer in many cases show a better yield than single cultivation it would be because of biological nitrogen fixation by bean and reduce the competition for nitrogen absorb. It seems that the reason for increasing the seed yield and biologic yield in intercropping cultivation treatment to pure cultivation can be due to the more relationships between species and nitrogen fixation by green bean system and placing it in maize (Terán and Singh, 2002).

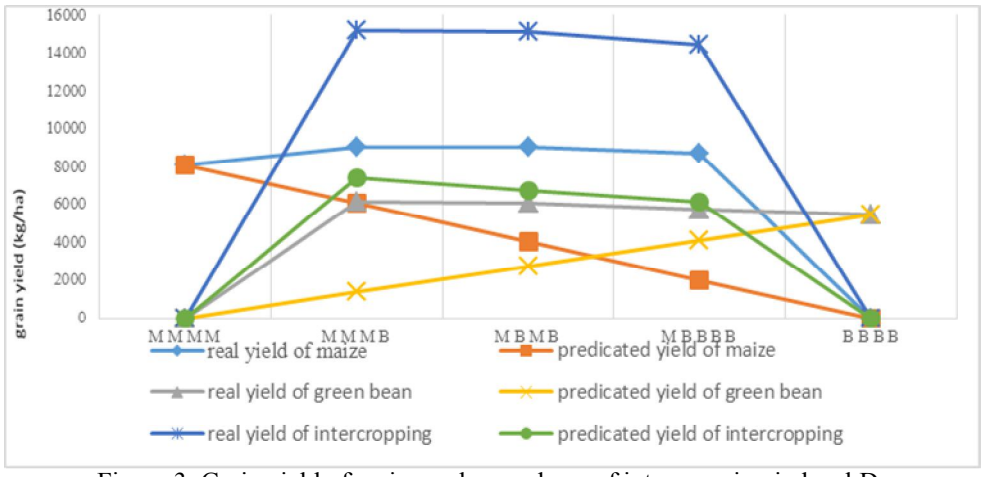


Figure 3. Grain yield of maize and green bean of intercropping in level D_2

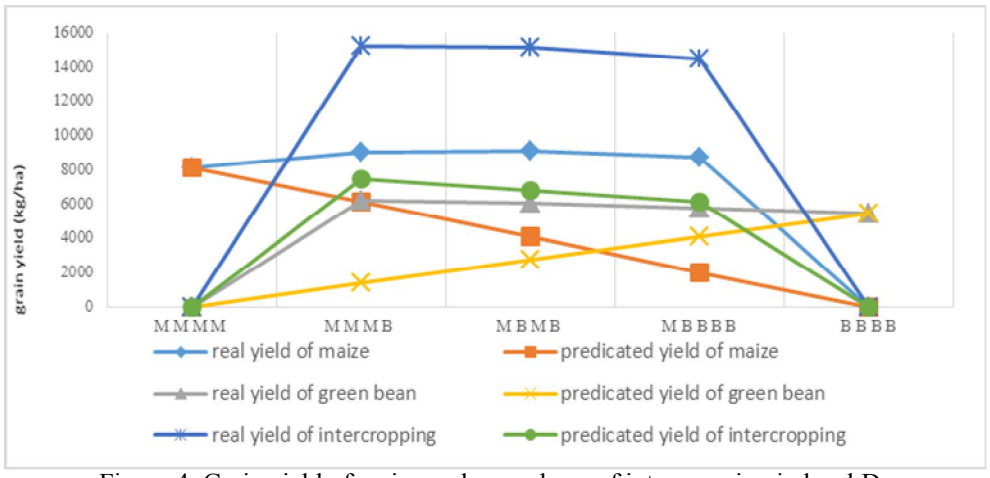


Figure 4. Grain yield of maize and green bean of intercropping in level D_3

Adhikary et al. (1991) and Barbour et al. (1980) concluded in their researches this yield increasing. Rahmani (2004), Abraham and Singh (1984) and Bandula-premalal et al. (1993) reached a similar conclusion in their research. Tohidy Nejad and Mazaheri (2004) in studying the intercropping cultivation of maize and sunflower in Jiroft region concluded that the intercropping cultivation of these plants gave the maximum yield per unit area of plants to itself. Amjadian (2005) also reached the similar conclusion in an intercropping cultivation of maize and soybean. Hashemi-Dezfoli *et al.* (2001) found similar results

in their experiments. Mazaheri et al. (2002) in a research to study the grain yield and some agronomic characteristics in pure and intercropping cultivation of maize and soybean showed that in intercropping cultivations soybean yield per unit area increased significantly and two crops showed positive effect on each other. Tayefehnuri (2004) and Pourtaghi (2004) declared with increasing bean density, the yield increased and highest yield was obtained at high densities. Ghanbari and Taheri-Mazandarani (2003) and Jadoski et al. (2000) declared that with reducing the density, the competition with in a species decreased and bean yield increased. Barzegari et al. (2005) in a research to study the various combinations of intercropping cultivation of bean and maize declared that in the case of intercropping cultivation the amount of bean seed yield and biological yield increased per unit area yield.

Actual and predicted yield of maize and bean seed

Predicted and real for grain yields of maize and green bean at different density and planting ratio in intercropping system. Predicted yield (prediction yield is equal to the multiplying proportion of product ***a*** in intercropping in the yield of the pure culture the product.) and real yield obtained in practice is examined. Table 5 show the predicted and actual yield of maize and green bean seeds in different densities and ratios intercropping cultivations. The maximum intercropping real and predicted yield of maize obtained in treatment D_2R_4 and the maximum intercropping predicted and real yield of green bean respectively obtained in treatment D_3R_5 and D_3R_4 (Figure 2, 3 and 4).

Table 5. Predicted and real for grain yields of maize and green bean at different density and Planting ratio in intercropping system

	Density/ Planting ratio	MMMB (R_4)	MBMB (R_3)	MBBB (R_5)
Predicted for grain yields of maize	D1	5271,00	3514.00	1757.00
	D2	6384.24	4256.16	2128.08
	D3	6075.00	4050.00	2025.00
Real for grain yields of maize	D1	8449.33	7868.33	6626.00
	D2	9971.00	8534.00	8405.33
	D3	9050.00	9069.33	8727.33
difference	D1	3178.33	4354.33	4869.00
	D2	3568.76	4277.84	6277.25
	D3	2975.00	5019.33	6702.33
Predicted for grain yields of green bean	D1	1068.58	2137.16	3205.74
	D2	1271.66	2543.33	3814.99
	D3	1363.29	2726.58	4087.89
Real for grain yields of green bean	D1	3786.50	4393.66	3984.56
	D2	5054.00	5339.50	5130.66
	D3	6164.16	6055.66	5720.00
difference	D1	2717.92	2259.50	778.82
	D2	3782.34	2796.17	1315.67
	D3	4800.87	3329.08	1630.13
Predicted for grain yields in intercropping	D1	6339.58	5651.16	4962.74
	D2	7655.90	6799.49	5943.07
	D3	7838.29	6776.58	6114.87
Real for grain yields in intercropping	D1	12235.83	12264.99	10610.56
	D2	15025.00	13873.50	13535.99
	D3	15214.16	15124.99	14447.73
difference	D1	5895.42	6613.83	5647.82
	D2	7369.10	7074.01	7592.92
	D3	7775/87	8348/41	8332.46

D_1 (60000 plants of maize + 200000 plants of green bean per hectare), D_2 (75000 plants of maize + 300000 plants of green bean per hectare), D_3 (90000 plants of maize + 400000 plants of green bean per hectare), MMMB (Intercropping %75 maize + %25 green bean), MBMB (Intercropping %50 maize + %50 green bean) and MBBB(Intercropping %25 maize + %75 green bean)

Evaluation indicators of intercropping

Land Equivalent Ratio (LER)

In this study, the amounts of relative equality of land were calculated the Land Equivalent Ratio in all treatments was more than one (Table 6). This can be a useful indicator of maize and green bean intercropping. Because of morphological differences between two species and therefore creation of different stages and utilization of resources. Treatment D_3R_5 gave the maximum amount of LER about 2.19. The high proportion of LER was due to difference in time and place in ecological niche, consumption of nutrients and water. Based on experiments performed by Katang (1989) the maximum value of LER in intercropping of beans and sweet maize was 1.32. He concluded that bean is the best plant species for intercropping with maize. Pourtaghi (2004) and Dabagh-Mohammadi-Nasab (2003) announced in intercropping of maize and pinto bean and intercropping of sorghum and soybean, the highest value of LER is achieved at the highest density of both plants.

Relative Value Total (RVT)

Another indicator used in assessment of intercropping is RVT, which evaluate intercropping in terms of economic value. By placing the numbers associated with each parameter in the formula of this index, the economic value of each treatments of intercropping can be calculated and interpreted. In calculations of this research, the daily price tested products was used, so that the price of each kilogram of maize seed was calculated about 0.9 dollar and green bean, about 1.8 dollar. These prices was approved by the Iranian ministry of Agriculture. Treatment D_3R_4 and D_3R_5 showed the highest value of RVT about 2.61. Tayefehnuri (2004) by planting intercropping of maize and pinto bean reported that in all the intercropping, the value of RVT is more than one and the highest value was obtained in high density about 1.34 of two plants (Table 6).

Table 6. Land equivalent ratio (LER), relative value of total (RVT), Relative Crowding Coefficient and Dominance for grain yields of maize and green bean at different density and planting ratio in intercropping system

Density	Planting ratio	LER	RVT	RCC		Real yield of maize in intercropping / Predicted yield of maize in intercropping	Real yield of green bean in intercropping / Predicted yield of green bean in intercropping	Dominant
				Maize	Green bean			
D_1	R_3	1.73	2.37	1.09	0.92	2.23	2.05	0.18
D_1	R_4	1.5	2.07	1.01	0.99	3.77	1.24	2.53
D_1	R_5	1.68	2.27	1.36	0.73	1.6	3.54	-1.94
D_2	R_3	1.98	2.25	0.96	1.05	2	2.09	-0.09
D_2	R_4	1.92	2.19	0.98	1.02	3.94	1.34	2.6
D_2	R_5	2.09	2.42	1.18	0.85	1.56	3.97	-2.4
D_3	R_3	2.17	2.61	1.01	0.99	2.23	2.22	0.01
D_3	R_4	2.07	2.48	1.03	0.97	4.3	1.39	2.91
D_3	R_5	2.19	2.61	1.07	1.01	1.48	4.52	-3.04

Evaluation indicators of competitiveness

Relative Crowding Coefficient (RCC)

RCC is ability of a species to use limited resource in intercropping with its ability to gain the same resource in intercropping system by using yield comparing and shows the competitive advantage of intercropping components (Snaydon, 1991). Relative Crowding Coefficient of maize in most treatment was higher than Relative Crowding Coefficient of green been. Its maximum value was observed in treatment D_1R_5 about 1.36. The highest value of Relative Crowding Coefficient of green been in treatment D_2R_3 (Table 6). Pirzad (2000) reported that in maize and soybean cultivation, maize is competitively superior to soybean.

Dominance

Dominance is an index that shows the relative yield difference between two species and generally shows the intensity of competition quantitative. By using this method, the extra value of each crop to another can be determined (Dabagh-Mohammadi-Nasab, 2003). Actual yield of maize in the most treatments of intercropping system compare to Predicted yield of maize was higher than actual yield of been in intercropping to predicted yield of been. The highest value for maize was in treatment D_3R_4 with an average of 4.3 and for been in treatment D_3R_5 with an average of 4.52 and the total dominance was observed in treatment D_3R_4 with an average of 2.91 (Table 6). Tayefehnuri (2004) and Pourtaghi (2004) by planting intercropping of maize and bean announced that maize was dominance rather than been.

Conclusion

Based on the results of the experiment, treatment D_3R_5 and D_3R_3 respectively produced the highest grain yield of maize and green been per unit area, respectively. Evaluation of different treatments of intercropping by LER and RVT showed that in all the treatments the value of LER and RVT was more than one. This is due to high density of vegetation and better use of environmental resource.

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