Zagazig Journal of Horticultural Science 2365-2381

Zagazig J. Agric. Res., Vol. 43 No. (6B) 2016

http:/www.journals.zu.edu.eg/journalDisplay.aspx?Journalld=1&queryType=Master

PRODUCTIVITY AND COMPETITION RELATIONSHIPS OF CORIANDER AND FENUGREEK PLANTS AS AFFECTED BY INTERCROPPING SYSTEM AND BIOFERTILIZATION RATE

Esraa M. A. Mohammed*, A.A. Meawad and M.A.I. Abdelkader

Hort. Dept., Fac. Agric., Zagazig Univ., Egypt

ABSTRACT

The present work was conducted at the Agriculture Experimental Farm, Faculty of Agriculture, Zagazig University, Egypt for two consecutive winter seasons of 2013/2014 and 2014/2015 aiming to study the effect of using different intercropping systems between coriander and fenugreek, biofertilization rate and their interaction treatments on fruits and volatile oil yields of coriander plant, seed and fixed oil yields of fenugreek plant and total chlorophyll as well as some competitive relationships [land equivalent ratio (LER), area time equivalent ratio (ATER), land utilization efficiency (LUE), relative crowding coefficient (RCC) and aggressivity (A)] of both crops. The used intercropping system treatments were sole crop of coriander or fenugreek (control), 1:1, 1:2, 1:3, 2:1 and 2: 2 rows of coriander and fenugreek, respectively. Whereas, the used biofertilization rates were 0, 200 and 400 gram of *Rhizobium* per fad. The obtained results showed that, using intercropping system of one row of coriander with three rows of fenugreek increased the values of seed and oil yields per plant as well as total chlorophyll (SPAD-unit) of coriander and fenugreek plants. Furthermore, the maximum increase in this respect was obtained from the treatment of 200 and 400g/faddan of *Rhizobium* inoculation compared with the other ones under study in the first and second seasons, respectively. Studying competitive relationships showed that, coriander and fenugreek plants could be intercropped successfully under Sharkia Governorate conditions in order to maximize the land use efficiency. Generally, the highest values of LER (1.24 and 1.23), ATER (1.17 and 1.15) and LUE % (120.83% and 119.00%) were achieved by the interaction treatment between intercropping system of one row of coriander alternating with three rows of fenugreek (1:3 system) inoculated with 200g and 400g/faddan of *Rhizobium* inoculation rate in the first and second seasons, respectively.

Key words: Coriander, fenugreek, intercropping, *Rhizobium*, yield, LER, ATER, LUE and RCC.

INTRODUCTION

The term of medicinal plants include a various types of plants used in herbalism and some of these plants have a medicinal activities. These medicinal plants consider as a rich resources of ingredients which can be used in drug development and synthesis. Besides, that these plants play a critical role in the development of human cultures around the whole world (Hassan, 2012).

Coriander (*Coriandrum sativum* L.) which belongs to the family Apiaceae (Umbelliferae) is mainly cultivated from its seeds (Mhemdi *et al.*, 2011). It is an annual, herbaceous plant which originated from the Mediterranean and Middle Eastern regions and known as medicinal plants. It contains an essential oil (0.03 to 2.6%) (Nadeem *et al.*, 2013). All parts of this herb are in use as flavoring agent and/or as traditional remedies for the treatment of different disorders in the folk medicine systems of different civilizations. Coriander closely resembles flat leaf parsley. The fruits are mainly responsible for the medical use of coriander and have been used as a drug for indigestion, against worms, rheumatism and pain in the joints (Wangensteen *et al.*, 2004) and have been recommended for

* **Corresponding author. Tel. :** +2001008002904
Email address:mohammedahmed1980@yahoo.com

dyspeptic complaints, loss of appetite, convulsion, insomnia and anxiety (Emamghoreishi *et al*., 2005).

Fenugreek (*Trigonella foenum- graecum* L.) commonly known as methi, is an important self pollinated seed spice crop belonging to subfamily Papilionaceae of the family Leguminosae (Sulieman *et al.,* 2008). Fenugreek is an important leguminous crop grown for seeds, leafy vegetables and fodder. It has medicinal values and numerous pharmacological properties. It can be a very useful annual legume crop for incorporation into crop rotation, for hay and silage making and for fixation of atmospheric nitrogen (Kole and Saha, 2013). Fenugreek is a leguminous as well as medicinal crop and its seeds are used as condiment and dried leaves for flavoring. The vegetative parts are also rich in vitamin A, B and iron. The seeds are also used to resolve inflammatory tumors. In addition to fixing nitrogen, it also covers the surface soil and suppresses weeds and reduces soil erosion. The multiple uses for this plant, in food, as a spice and in medicine, as a colic flatulence in dysentery, diarrhea, as galactagolate, dyspepsia, with loss of appetite, chronic cough, enlargement of liver and spleen, gait and diabetes. Studies indicate that fenugreek seeds substantially contain the steroidal substance diosgenin which is used as a starting material in the synthesis of sex hormones and oral contraceptives (Shalaby and Zaki, 1999).

It is becoming more important to raise crop productivity in order to meet the increasing food requirements often increasing population all over the world. Moreover, crop production per unit area must be increased because of remaining fixed or diminishing suitable land for food production. More than 70% of food crops consumed in humid topics, especially in the tropical Africa come from intercropping. Intercropping, through more effective use of water nutrients and solar energy can significantly enhance crop productivity compared to the growth of sole crops (Midmore, 1993). It has been demonstrated that the advantages of intercropping in vegetables could lead to better land use efficiency as an important component of sustainable farming (Alizadeh *et al.,* 2010).

Intercropping ensures efficient utilization of light and other resources, reduces soil erosion, suppresses weed growth and the reby helps to maintain greater stability in crop yield in okra and cowpea intercropping system (Susan and Mini, 2005). Inoculation of legumes is widely practiced with the objective of increasing production of the legume in question. *Rhizobium* inoculation of fenugreek has been reported to increase seed production (Poi *et al*., 1991). Fenugreek was reported to fix 48% of its total N during the growing season (Desperrier *et al*., 1985). *Rhizobium* inoculation in legumes is accredited for stimulating growth and is an alternative to the expensive inorganic nitrogen fertilizers (Ndakidemi *et al*., 2007).

The aim of this work was to assess the effects of intercropping system between coriander and fenugreek, *Rhizobium* inoculation rate and their interaction treatments on seed and oil yields, total chlorophyll of coriander and fenugreek plants as well as some competitive relationships in order to maximize the land use efficiency of both crops under Sharkia Governorate conditions.

MATERIALS AND METHODS

The present study was conducted at the Agriculture Research Farm, Faculty of Agriculture, Zagazig University (Ghazala Farm), Egypt during the two successive winter seasons of 2013/2014 and 2014/2015.

The present work aimed to study the effect of intercropping system, *Rhizobium* inoculation rate and their interaction on seed and oil yields per plant, total chlorophyll and competitive relationships of coriander and fenugreek plants. The physical and chemical properties of farm soil are shown in Table 1 according to Chapman and Pratt (1971).

This experiment included 14 and 21 treatments in the first and second seasons, respectively, which were the combinations between seven intercropping systems and two or three *Rhizobium* inoculation rates which were; control (without inoculation), 200 and 400 g /fad., as *Rhizobium meliloti* (1×10^6). The intercropping system treatments were as follows:

Table 1. Physical and chemical properties of experimental farm soil (average of two seasons)

Mechanical analysis				Soil texture
Clay (%)	Silt (%)	Fine sand (%)	Coarse sand (%)	Clay
43.49	9.10	13.52	33.89	

Chemical analysis														
Time	pH	E C m.mohs/ cm	Organic mater (%)	Soluble cations (meq. / l)				Soluble anions (meq. / l)			Available (ppm)			
				Mg^{++}	Ca^{++}	K^{+}	Na^{+}	Cl^{-}	HCO_3^{-}	SO_4^{--}	N	P	K
Pre-sowing	7.87	0.95	0.52	2.8	1.5	1.3	3.8	4.5	1.5	3.4	17.0	8.30	71.0
Post-harvest	7.81	0.93	0.54	2.4	1.7	1.4	3.6	4.3	1.6	3.2	17.8	9.40	73.9

1- and 2- Sole cropping systems of each coriander and fenugreek. Such treatment was used as control for both crops.

3- Intercropping system of 1:1; since planting one row of coriander alternated with one row of fenugreek. Such pattern provides the proportional area of 50: 50 of each coriander and fenugreek, respectively.

4- Intercropping system of 1:2; since planting one row of coriander alternated with two rows of fenugreek. Such pattern provides the proportional area of 33.3: 66.7 of each coriander and fenugreek, respectively.

5- Intercropping system of 1:3; since planting one row of coriander alternated with three rows of fenugreek. Such pattern provides the proportional area of 25: 75 of each coriander and fenugreek, respectively.

6- Intercropping system of 2:1; since planting two rows of coriander alternated with one row of fenugreek. Such pattern provides the proportional area of 66.7 : 33.3 of each coriander and fenugreek, respectively.

7- Intercropping system of 2:2; since planting two rows of coriander alternated with two rows of fenugreek. Such pattern provides the proportional area of 50: 50 of each coriander and fenugreek, respectively.

These treatments were arranged in a split plot in randomized complete blocks design with three replicates. Each replicate contained twelve rows. Intercropping systems were randomly arranged in the main plots and *Rhizobium* rates were distributed randomly in the sub plots. The plot area was 14.4 m^2 (2 × 7.20 m) included twelve rows; each row was 60 cm apart and two meters in length. The seeds were sown on row in hills on both sides. The distances between hills were 30 cm for coriander and 20 cm for fenugreek plants.

Seeds of coriander (*Coriandrum sativum* L. cv Giza1) were obtained from Agriculture Research Centre (ARC), Dokky, Giza. Whereas, seeds of fenugreek (*Trigonella foenum*graecum L.) were obtained from Research Centre of Medicinal and Aromatic Plants, Dokky, Giza. Seeds of both coriander and fenugreek crops were sown on 13th November of both seasons. Seeds inoculated with *Rhizobium* root nodules bacteria. Arabic gum (16%) was used as an adhesive agent. Seeds were handly sown then immediately irrigated. After three weeks from sowing, seedlings were thinned to be one plant / hill for coriander and two plants/hill for fenugreek.

All plants received NPK fertilization at the rate of 200 kg/fad., of ammonium sulphate (20.5% N), 200 kg/fad., of calcium super phosphate (15.5% P_2O_5) and 50 kg/fad., of potassium sulphate (48% K_2O). Phosphorus and potassium fertilizers were added during soil preparation as soil application. While, nitrogen fertilizer was divided into three equal portions and added to the soil at 25, 50 and 75 days from sowing. All the plants received normal agricultural practices whenever they needed.

Recorded Data

Plant productivity

At harvest, the central rows of each plot were used for yield determinations of coriander as well as fenugreek plants. Fruits of coriander were harvested after 120 days from seed sowing to determine fruit yield per plant (g). Whereas, pods of fenugreek were harvested after 110 days from seed sowing to determine seed yield per plant (g).

Chemical analyses

The chemical constituents were determined in air dried harvested fruits and seeds of coriander and fenugreek, respectively.

The volatile oil from air-dried fruits of coriander plants was extracted by hydro distillation for 3 hr., according to Guenther (1961). Oil yield per plant was calculated. Fixed oil of fenugreek seeds was extracted using petroleum ether in a soxcelt system HT apparatus according to the methods of AOAC (1984). Then, oil yield per plant was calculated. Total chlorophyll (SPAD unit) was determined in corainder and fenugreek fresh leaves by using SPAD- 502 meter Markwell *et al.* (1995).

Competitive relationships

Various competition indices were determined as follows:

Land equivalent ratio (LER)

This parameter gives an indication to the relative land area required, as sole cropping, to produce the same yields achieved by intercropping. When the LER is greater than one, the intercropping favors the growth and yield of the species. In contrast, when LER is lower than one the intercropping negatively affects the growth and yield of the intercropped plants. It was determined for coriander and fenugreek yields recorded per faddan according to Mead and Willey (1980) equation as follows:

LER coriander . fenugreek = Lc + Lf ,

$$Lc = \frac{Ycf}{Ycc} \quad , \quad Lf = \frac{Yfc}{Yff}$$

Where:

Lc and Lf are the relative yield of coriander and fenugreek, respectively. Ycc and Yff are the yields per faddan of coriander and fenugreek sole crops, respectively. Ycf and Yfc are the yields of coriander and fenugreek, respectively, as intercrops.

Area time equivalent ratio (ATER)

It was calculated according to Hiebsch and McCollum (1987) equation as follows:

$$ATER = \frac{Ycf / Ycc \times tc + Yfc / Yff \times tf}{T}$$

Where:

Ycf = intercropped yield of coriander, Ycc = sole yield of coriander, Yfc = intercropped yield of fenugreek, Yff = sole yield of fenugreek, tc = the duration of coriander in days, tf = the duration of fenugreek in days, and T= the total duration of intercropping system in days.

Land utilization efficiency (LUE%)

By using LER and ATER values, the land utilization efficiency (LUE %) was calculated according to Mason *et al.* (1986) equation as follows:

$$LUE = \frac{LER \times ATER}{2} \times 100$$

Aggressivity (A)

Aggressivity value was calculated according to Mc Gilchrist (1965) equation as follows:

1. For combination of 50:50 and 100:100, they were calculated according to the following equations:

$$Acf = Lc - Lf \ , \ Afc = Lf - Lc$$

2. For the other combination ratios, the used equations were:

$$Acf = \frac{Ycf}{Ycc \times Zcf} - \frac{Yfc}{Yff \times Zfc}$$

$$Afc = \frac{Yfc}{Yff \times Zfc} - \frac{Ycf}{Ycc \times Zcf}$$

Where:

Ycf=yield of coriander intercropped with fenugreek, Yfc=yield of fenugreek intercropped with coriander, Ycc = sole yield of coriander, Yff = sole yield of fenugreek, Zcf = sowing proportion of coriander and Zfc = sowing proportion of fenugreek.

Relative crowding coefficient (RCC)

Another coefficient that is used, is the relative crowding coefficient (RCC or K) which is a measure of the relative dominance of one species over the other in a mixture (De Wit, 1960). The K was calculated as follows:

K = (K coriander × K fenugreek),

$$K_{coriander \times fenugreek} = \frac{Ycf \; Zfc}{(Ycc - Ycf)\, Zcf}$$

$$K_{fenugreek \times coriander} = \frac{Yfc \; Zcf}{(Yff - Yfc)\, Zfc}$$

Where Zcf is the sown proportion of coriander in mixture with fenugreek, Zfc is the sown proportion of fenugreek in mixture. When the product of the two coefficients (K coriander × K fenugreek) is greater than one, there is a yield advantage, when K is equal to one there is no yield advantage, and when it is less than one there is a disadvantage.

Statistical Analysis

All collected data were subjected to analysis of variance and means of treatments were compared with the least significant difference (LSD) test at P ≤0.05 and 0.01. The statistical calculations were performed with statistix software version 9 (Analytical Software, 2008).

RESULTS AND DISCUSSION

Productivity and Total Chlorophyll of Coriander Plant

Effect of intercropping system

Data presented in Tables 2, 3 and 4 reveal that, alternating one row of coriander with three rows of fenugreek (1:3 system) gave the highest values of fruit and volatile oil yield per coriander plant as well as total chlorophyll (SPAD-unit) in coriander leaves compared to the other ones under study during the two tested seasons. Furthermore, in many cases there was highly significant increase in the above mentioned parameters of coriander by using intercropping system treatments compared to sole planting pattern. However, increasing number of rows of fenugreek under cropping system with one row of coriander increased gradually fruit and oil yields per plant and total chlorophyll during both seasons. These results are in harmony with those found by Tohura *et al.* (2014) on mungbean intercropped with maize plants, Abd El-Latif (2015) on cowpea when intercropped with maize plants, Adafre (2016) on maize intercropped with haricot bean and Abdelkader and Mohsen (2016) on fennel intercropped with onion regarding seed yield per plant. Moreover, similar results were reported, regarding oil yield per plant, by Maffei and Mucciarelli (2003) on peppermint when intercropped with soybean and Abdelkader and Mohsen (2016) on coriander intercropped with onion. Also, HongJiao *et al.* (2011) on cabbages when intercropped with garlic and Abdelkader and Hassan (2016) on dill intercropped with fenugreek showed similar results on total chlorophyll.

Effect of biofertilization rate

The data given in Tables 2, 3 and 4 show that, the highest values of fruit yield per plant was obtained from the treatment of 200 and 400 g *Rhizobium* inoculation rate in the first and second seasons, respectively. Furthermore, volatile oil yield per plant and total chlorophyll significantly increased by using *Rhizobium* inoculation rates compared to uninoculated plants in the two seasons. Generally, increasing biofertilization rate gradually increased fruit and oil yield per plant as well as total chlorophyll of coriander plant in the first and second seasons. Since, Abdelaziz *et al.* (2007) on *Rosemarinus officinalis*, Mahfouz and Sharaf-Eldin (2007) on fennel (*Foeniculum vulgare* L.), Leithy *et al.* (2009) on geranium plants and Helal *et al.* (2011) on dill came to similar results.

Effect of interaction between intercropping system and biofertilization rate

Concerning the effect of interaction treatments between intercropping system and *Rhizobium* inoculation rate on oil yield per plant and total chlorophyll of coriander, data in Tables 2, 3 and 4

Table 2. Effect of intercropping system, *Rhizobium* inoculation rate and their interaction on fruit yield (g) per coriander plant during the two seasons of 2013/2014 and 2014 /2015

Intercropping system (I) (Row ratio)	*Rhizobium* inoculation rate (R) (g/fad.)						
	0.00	200	Mean (I)	0.00	200	400	Mean (I)
	First season (2013/2014)			Second season (2014/2015)			
Sole coriander	11.20	12.05	11.63	11.03	11.26	11.78	11.36
Coriander + fenugreek (1:1)	11.36	12.23	11.79	11.85	12.51	13.67	12.68
Coriander + fenugreek (1:2)	13.13	13.91	13.52	12.37	13.13	13.91	13.14
Coriander + fenugreek (1:3)	14.18	16.19	15.18	13.98	15.00	16.58	15.19
Coriander + fenugreek (2:1)	10.67	12.76	11.71	11.89	12.88	13.45	12.74
Coriander + fenugreek (2:2)	10.93	12.07	11.50	11.27	12.45	13.41	12.38
Mean (R)	11.91	13.20		12.07	12.87	13.80	
LSD at 5%	(I)=0.28	(R)=0.18	(I)(R)=0.42	(I)=0.22		(R)=0.16	(I)(R)=0.38
LSD at 1%	(I)=0.40	(R)=0.25	(I)(R)=0.59	(I)=0.31		(R)=0.22	(I)(R)=0.54

Table 3. Effect of intercropping system, *Rhizobium* inoculation rate and their interaction on volatile oil yield (g) per coriander plant during the two seasons of 2013/2014 and 2014 /2015

Intercropping system (I) (Row ratio)	*Rhizobium* inoculation rate (R) (g / fad.)						
	0.00	200	Mean (I)	0.00	200	400	Mean (I)
	First season (2013/2014)			Second season (2014/2015)			
Sole coriander	0.140	0.156	0.148	0.150	0.190	0.210	0.183
Coriander + fenugreek (1:1)	0.187	0.210	0.198	0.200	0.230	0.270	0.233
Coriander + fenugreek (1:2)	0.213	0.307	0.260	0.240	0.300	0.330	0.290
Coriander + fenugreek (1:3)	0.340	0.414	0.377	0.330	0.410	0.430	0.390
Coriander + fenugreek (2:1)	0.224	0.240	0.232	0.230	0.250	0.300	0.260
Coriander + fenugreek (2:2)	0.150	0.170	0.160	0.190	0.240	0.250	0.227
Mean (R)	0.207	0.248		0.223	0.270	0.298	
LSD at 5%	(I)=0.014	(R)=0.004	(I)(R)=0.016	(I)=0.014		(R)=0.008	(I)(R)=0.022
LSD at 1%	(I)=0.020	(R)=0.006	(I)(R)=0.023	(I)= 0.019		(R)=0.011	(I)(R)=0.030

Table 4. Effect of intercropping system, *Rhizobium* inoculation rate and their interaction on coriander total chlorophyll (SPAD unit) during the two seasons of 2013/2014 and 2014 /2015

Intercropping system (I) (Row ratio)	*Rhizobium* inoculation rate (R) (g / fad.)						
	0.00	200	Mean (I)	0.00	200	400	Mean (I)
	First season (2013/2014)			Second season (2014/2015)			
Sole coriander	20.00	20.10	20.05	19.95	20.35	22.90	21.06
Coriander + fenugreek (1:1)	24.61	28.37	26.49	24.60	28.00	29.30	27.30
Coriander + fenugreek (1:2)	26.31	31.25	28.78	27.80	29.90	32.60	30.10
Coriander + fenugreek (1:3)	32.25	37.00	34.62	32.80	34.80	37.10	34.90
Coriander + fenugreek (2:1)	25.38	30.50	27.94	25.55	29.50	31.90	28.98
Coriander + fenugreek (2:2)	20.50	30.27	25.38	20.95	32.20	30.50	27.88
Mean (R)	24.84	29.58		25.27	29.55	30.29	
LSD at 5%	(I)=1.64	(R)=0.77	(I)(R)=2.12	(I)=3.85		(R)=1.28	(I)(R)=6.55
LSD at 1%	(I)=2.34	(R)=1.08	(I)(R)=3.00	(I)= 5.48		(R)= 3.59	(I)(R)=9.02

demonstrate that, the highest values in this connection were obtained by the interaction treatment of intercropping system of one row of coriander with three rows of fenugreek (1:3 system) and the highest rate of *Rhizobium* inoculation (200g and 400g per fad. during first and second seasons, respectively). Compared to the other ones under study. In addition, fruit and volatile oil yield per coriander plant as well as total chlorophyll were increased with all interaction treatments between intercropping systems and *Rhizobium* inoculation rates compared with control (sole crop system without *Rhizobium* inoculation) during both seasons with highly significant differences, in most cases. These results are in accordance with those found by Nawar and Abdel-Galil (2008) on sunflower intercropped with soybean regarding seed yield and Musa *et al.* (2012) on cowpea intercropped with maize plant regarding chlorophyll.

Productivity and Total Chlorophyll of Fenugreek Plant

Effect of intercropping system

It is quite clear from the data in Tables 5, 6 and 7 that, increasing rows number of fenugreek under one row of coriander increased fenugreek seed and oil yield per plant as well as total chlorophyll in leaves. However, in many cases it was observed that the abovementioned characters were decreased by increasing row number of fenugreek under cropping system with two rows of coriander during both seasons. In most cases, alternating one row of coriander with three rows of fenugreek (1 : 3 system) recorded the highest significant increases in seed and fixed oil yields per plant and total chlorophyll of fenugreek plant. These results are in agreement with those stated by Shahien *et al.* (1996) on cowpea when intercropped with maize and Meawad *et al*. (2004 a) on guar when intercropped with roselle at 1:1 system. On the other hand, the decrease recorded in this respect was also reported by Tohura *et al.* (2014) on mungbean when intercropped with maize and Abdel El-Latif *et al.* (2015) on maize intercropped with cowpea plants.

These results might be attributed to intra-competition between fenugreek plants to light and nutrient.

Effect of biofertilization rate

Data in Tables 5, 6 and 7 present the records of seed and oil yield per plant and total chlorophyll of fenugreek grown under different

Table 5. Effect of intercropping system, *Rhizobium* inoculation rate and their interaction on seed yield (g) per fenugreek plant during the two seasons of 2013/2014 and 2014 /2015

Intercropping system (I) (Row ratio)	*Rhizobium* inoculation rate (R) (g / fad.)						
	0.00	**200**	**Mean (I)**	**0.00**	**200**	**400**	**Mean (I)**
	First season (2013/2014)			**Second season (2014/2015)**			
Sole fenugreek	5.97	6.13	6.05	5.83	6.12	6.44	6.13
Coriander + fenugreek (1:1)	5.92	6.47	6.19	6.22	6.70	7.09	6.67
Coriander + fenugreek (1:2)	6.06	6.89	6.47	6.59	7.00	7.64	7.07
Coriander + fenugreek (1:3)	6.06	7.16	6.61	6.66	7.11	7.57	7.11
Coriander + fenugreek (2:1)	5.01	6.71	5.86	5.81	6.34	6.69	6.28
Coriander + fenugreek (2:2)	5.12	6.71	5.91	6.33	6.93	7.43	6.89
Mean (R)	5.69	6.67		6.07	6.70	7.14	
LSD at 5%	(I)=0.10	(R)=0.90	(I)(R)=0.17	(I)=0.14		(R)=0.10	(I)(R)=0.24
LSD at 1%	(I)=0.14	(R)=0.12	(I)(R)=0.25	(I)=0.21		(R)=0.14	(I)(R)=0.33

Table 6. Effect of intercropping system, *Rhizobium* inoculation rate and their interaction on fixed oil yield (g) per fenugreek plant during the two seasons of 2013/2014 and 2014 /2015

Intercropping system (I) (Row ratio)	*Rhizobium* inoculation rate (R) (g / fad.)						
	0.00	**200**	**Mean (I)**	**0.00**	**200**	**400**	**Mean (I)**
	First season (2013/2014)			**Second season (2014/2015)**			
Sole fenugreek	11.90	12.20	12.05	11.72	12.05	12.73	12.17
Coriander + fenugreek (1:1)	11.80	12.17	11.99	11.86	12.93	12.69	12.49
Coriander + fenugreek (1:2)	12.73	13.09	12.91	12.71	12.82	12.87	12.80
Coriander + fenugreek (1:3)	13.30	13.90	13.60	13.63	13.63	13.61	13.62
Coriander + fenugreek (2:1)	11.11	11.84	11.48	11.08	11.51	11.50	11.36
Coriander + fenugreek (2:2)	11.05	11.78	11.42	11.05	11.64	11.65	11.45
Mean (R)	11.93	12.50		12.01	12.43	12.510	
LSD at 5%	(I)=0.038	(R)=0.019	(I)(R)=0.051	(I)= 0.019		(R)=0.014	(I)(R)=0.03
LSD at 1%	(I)= 0.054	(R)=0.027	(I)(R)=0.071	(I)= 0.026		(R)=0.019	(I)(R)=0.06

Table 7. Effect of intercropping system, *Rhizobium* inoculation rate and their interaction on fenugreek total chlorophyll (SPAD unit) during the two seasons of 2013/2014 and 2014 /2015

Intercropping system (I) (Row ratio)	*Rhizobium* inoculation rate (R) (g / fad.)						
	0.00	200	Mean (I)	0.00	200	400	Mean (I)
	First season (2013/2014)			Second season (2014/2015)			
Sole fenugreek	22.49	23.13	22.81	22.65	23.20	23.50	23.11
Coriander + fenugreek (1:1)	24.47	25.51	24.99	26.30	28.60	29.55	28.15
Coriander + fenugreek (1:2)	29.39	32.68	31.03	29.90	30.80	32.15	30.95
Coriander + fenugreek (1:3)	34.22	39.71	36.96	34.40	34.90	39.25	36.18
Coriander + fenugreek (2:1)	24.76	31.45	28.10	28.25	30.90	31.05	30.06
Coriander + fenugreek (2:2)	28.32	29.58	28.95	24.30	25.90	29.65	26.61
Mean (R)	27.27	30.34		27.63	29.05	30.86	
LSD at 5%	(I)=1.23	(R)=0.60	(I)(R)=1.61	(I)=0.68		(R)=0.41	(I)(R)=1.07
LSD at 1%	(I)=1.75	(R)=0.85	(I)(R)=2.28	(I)= 0.96		(R)= 0.56	(I)(R)=1.48

rates of *Rhizobium* inoculation during both seasons. Generally, the abovementioned parameters were gradually increased by increasing biofertilization rate in both seasons. Also, the highest values in this regard were obtained with 200g and 400 g/fad., in the first and second seasons, respectively. Furthermore, *Rhizobium* inoculation rate highly significantly increased seed and oil yield per plant and total chlorophyll compared to uninoculated treatment. These results coincided with those reported by Faramawy (2014) on *Prosopis chilensis* and Hamad (2014) on fenugreek plant.

Effect of interaction between intercropping system and biofertilization rate

Tables 5, 6 and 7 reveal that, seed and oil yields per fenugreek plant and total chlorophyll in leaves under each treatment of intercropping system were increased with increasing biofertilization rates. Furthermore, the highest values in this regard were obtained by intercropping one row of coriander with three rows of fenugreek and inoculated with the highest rate of *Rhizobium* inoculation (200g and 400g per fad.) in first and second season, respectively. Moreover, in many cases seed and oil yield per fenugreek plant as well as total chlorophyll were significantly increased with all interaction treatments between intercropping system and *Rhizobium* inoculation rate compared with control (sole crop system without inoculation). These results coincided with those reported by Nawar and Abdel-Galil (2008) on sunflower intercropped with soybean, Saleem *et al.* (2011) on maize when intercropped with mashbean and (Sharma *et al.*, 2012) on pigeonpea intercropped with greengram and combined with biofertilization. Such increases in seed and oil yields per fenugreek plant due to interaction between intercropping system and biofertilization rate might be attributed to the reducing in inter and intra competition between coriander and fenugreek plants for light and nitrogen element. Furthermore, as mentioned just before, both intercropping and biofertilization treatments (each alone) increased total chlorophyll, in turn, they together might maximize their effects leading to more seed and oil yields.

Competitive Relationships Between Coriander and Fenugreek Plants

Effect of intercropping system

In assessments of crop productivity of sole cropping systems, a useful expression is total yield (seed yield per unit area). However, in intercropping systems, direct comparison is difficult because products are different for the different plant species growing separately. In this case, crop productivity must be evaluated using a common unit. A widely used method is the land equivalent ratio (LER) and area time equivalent ratio (ATER) as well as land utilization efficiency (LUE%). In most cases, intercropping coriander with fenugreek in five systems row ratios significantly ($P < 0.05$) affected the competitive relationships indicators. The combined yield advantage in terms of LER, ATER and LUE % indices were greatest in the cases of coriander-fenugreek mixture at the 1:3 seeding ratio (1.18, 1.21 ; 1.11, 1.14 and 114.66, 117.97) in the first and second seasons, respectively, followed by the same combination at the 1:2 seeding ratio (Tables 8, 9 and 10). This indicates that 19 % (0.19 fad.), more area would be required by a sole cropping system to equal the yield of intercropping system of 1:3. LER, ATER and LUE % were significantly influenced by intercropping system treatments compared to sole crop for each crop.

A similar trend to that of LER and ATER and LUE% was also observed for relative crowding coefficient (Table 11). Indeed, intercropping of coriander and fenugreek at 1:3, 1:2 and 2:1 were more productive than growing them separately, as can be seen from the above mentioned values which were greater than 1.00.

Similar results were reported by Meawad *et al.* (2004 b) on roselle intercropped with guar, Bantie (2015) on maize intercropped with potato, Abdelkader and Hamad (2015) on safflower intercropped with fenugreek, Abdelkader and Hassan (2016) on dill intercropped with fenugreek and Weisany *et al.* (2016) on dill intercropped with common bean.

The main reasons for higher yields determined as LER, ATER and LUE (%) of intercropped plants are that the component crops are able to use natural resources differently and make better overall use of natural resources than grown separately, as stated by Willy and Reddy (1981).

Positive aggressivity values for coriander demonstrate that coriander was the dominant specie whereas the negative values for fenugreek indicate that it was the dominated one (Tables 12 and 13). Results show that the highest positive aggressivity of coriander was recorded with 1:3 intercropping pattern compared with 1:1 and 1:2 patterns during both seasons.

In this conection, Meawad *et al.* (2004 b) suggested that roselle plants were aggressive to guar by using the intercropping system treatments of 2:1 and 3:1, whereas guar plants were aggressive to roselle by using the intercropping system treatments of 1:1 and 1:2. Also, Abdelkader and Hassan (2016) showed that fenugreek component intercropped with dill (aggressivity of fenugreek with dill) was the aggressor crop in 1:1 and 2:2 cropping patterns.

3.2. Effect of biofertilization rate

Data in Tables 8, 9, 10 and 11 show that, in many cases the maximum increases in LER, ATER, LUE and RCC were obtained from the treatments of 200g (during first season) and 400g (during second season) *Rhizobium* /fad. (1.14 and 1.17), (1.11 and 1.12), (112.31 and 114.70 %) and (2.313 and 2.062) compared with the other ones under study in the first and second season, respectively. Furthermore, *Rhizobium* inoculation increased the above mentioned indicators compared to uninoculated treatment (control) in the two consecutive seasons. During second season in most cases, increasing of *Rhizobium* inoculation rate significantly affected aggressivity value (Tables 12 and 13).

Consulting the available literature, there was no information concerning the effect of biofertilization rate on competitive relationships between coriander and fenugreek plants.

Effect of interaction between intercropping system and biofertilization rate

Data illustrated in Tables 8, 9, 10 and 11 reveal that, LER), ATER, LUE and RCC were increased with all interaction treatments between intercropping systems and biofertilization rates compared with interaction treatment of 2:2 system and without *Rhizobium* inoculation rate in the first and second seasons. However, the interaction treatment between intercropping system of one row of coriander + three rows of fenugreek (1:3 system) and 200 g or 400 g/fad., of biofertilization was superior in this respect compared to the other ones under study in the first

Table 8. Effect of intercropping system, *Rhizobium* inoculation rate and their interaction on land equivalent ratio (LER) during the two seasons of 2013/2014 and 2014 /2015

Intercropping system (I) (Row ratio)	*Rhizobium* inoculation rate (R) (g / fad.)						
	0.00	200	Mean (I)	0.00	200	400	Mean (I)
	First season (2013/2014)			Second season (2014/2015)			
Coriander + fenugreek (1:1)	1.06	1.08	1.07	1.12	1.14	1.18	1.15
Coriander + fenugreek (1:2)	1.11	1.17	1.14	1.16	1.17	1.21	1.18
Coriander + fenugreek (1:3)	1.12	1.24	1.18	1.20	1.21	1.23	1.21
Coriander + fenugreek (2:1)	0.98	1.13	1.05	1.06	1.06	1.06	1.06
Coriander + fenugreek (2:2)	0.98	1.10	1.04	1.10	1.16	1.19	1.15
Mean (R)	1.05	1.14		1.12	1.15	1.17	
LSD at 5%	(I)=0.02	(R)=0.01	(I)(R)=0.03	(I)=0.02		(R)=0.01	(I)(R)= 0.04
LSD at 1%	(I)=0.03	(R)=0.02	(I)(R)=0.04	(I)=0.03		(R)=0.02	(I)(R)= 0.05

Table 9. Effect of intercropping system, *Rhizobium* inoculation rate and their interaction on area time equivalent ratio (ATER) during the two seasons of 2013/2014 and 2014 /2015

Intercropping system (I) (Row ratio)	*Rhizobium* inoculation rate (R) (g / fad.)						
	0.00	200	Mean (I)	0.00	200	400	Mean (I)
	First season (2013/2014)			Second season (2014/2015)			
Coriander + fenugreek (1:1)	1.02	1.04	1.03	1.08	1.09	1.13	1.10
Coriander + fenugreek (1:2)	1.06	1.11	1.08	1.09	1.12	1.14	1.12
Coriander + fenugreek (1:3)	1.05	1.17	1.11	1.13	1.14	1.15	1.14
Coriander + fenugreek (2:1)	0.96	1.11	1.03	1.03	1.03	1.03	1.03
Coriander + fenugreek (2:2)	0.94	1.05	0.99	1.06	1.11	1.14	1.10
Mean (R)	0.94	1.11		1.08	1.09	1.12	
LSD at 5%	(I)=0.02	(R)=0.01	(I)(R)=0.03	(I)=0.02	(R)=0.01		(I)(R)=0.03
LSD at 1%	(I)=0.03	(R)=0.02	(I)(R)=0.04	(I)=0.03	(R)=0.02		(I)(R)=0.05

Table 10. Effect of intercropping system, *Rhizobium* inoculation rate and their interaction on land utilization efficiency percentage (LUE%) during the two seasons of 2013/2014 and 2014 /2015

Intercropping system (I) (Row ratio)	*Rhizobium* inoculation rate (R) (g/fad.)						
	0.00	200	Mean (I)	0.00	200	400	Mean (I)
	First season (2013/2014)			Second season (2014/2015)			
Coriander + fenugreek (1:1)	104.44	106.66	105.55	109.89	112.14	115.58	112.54
Coriander + fenugreek (1:2)	108.73	113.97	111.35	112.65	114.30	117.85	114.93
Coriander + fenugreek (1:3)	108.49	120.83	114.66	116.84	117.90	119.00	117.91
Coriander + fenugreek (2:1)	98.13	112.35	105.24	104.93	104.69	104.17	104.60
Coriander + fenugreek (2:2)	95.93	107.73	101.83	107.90	113.64	116.91	112.82
Mean (R)	103.14	112.31		110.44	112.53	114.70	
LSD at 5%	(I)=1.86	(R)=1.46	(I)(R)=2.97	(I)=2.34	(R)=1.45		(I)(R)=3.54
LSD at 1%	(I)=2.71	(R)=2.08	(I)(R)=4.27	(I)= 3.41	(R)= 1.98		(I)(R)=4.96

Table 11. Effect of intercropping system, *Rhizobium* inoculation rate and their interaction on relative crowding coefficient (RCC) during the two seasons of 2013/2014 and 2014 /2015

Intercropping system (I) (Row ratio)	*Rhizobium* inoculation rate (R) (g / fad.)						
	0.00	200	Mean (I)	0.00	200	400	Mean (I)
	First season (2013/2014)			Second season (2014/2015)			
Coriander + fenugreek (1:1)	1.301	1.428	1.364	1.631	1.794	2.070	1.832
Coriander + fenugreek (1:2)	1.648	2.181	1.914	2.091	2.256	2.756	2.368
Coriander + fenugreek (1:3)	1.760	4.489	3.124	3.212	3.570	4.092	3.625
Coriander + fenugreek (2:1)	0.968	1.967	1.467	5.410	5.320	5.200	5.310
Coriander + fenugreek (2:2)	0.911	1.501	1. 206	1.505	1.915	1.191	1.537
Mean (R)	1.318	2.313		2.769	2.971	3.062	
LSD at 5%	(I)=0.72	(R)=0.44	(I)(R)=1.00	(I)=0.52	(R)=0.26		(I)(R)= 0.70
LSD at 1%	(I)=1.04	(R)=0.62	(I)(R)=1.44	(I)=0.76	(R)=0.35		(I)(R)= 0.99

Table 12. Effect of intercropping system, *Rhizobium* inoculation rate and their interaction on aggrissivity value (A) of coriander (Acf) during the two seasons of 2013/2014 and 2014 /2015

Intercropping system (I) (Row ratio)	*Rhizobium* inoculation rate (R) (g / fad.)						
	0.00	200	Mean (I)	0.00	200	400	Mean (I)
	First season (2013/2014)			Second season (2014/2015)			
Coriander + fenugreek (1:1)	+0.07	+0.03	+0.05	+0.05	+0.05	+0.08	+0.06
Coriander + fenugreek (1:2)	+0.30	+0.14	+0.22	+0.08	+0.09	+0.08	+0.08
Coriander + fenugreek (1:3)	+0.30	+0.41	+0.35	+0.24	+0.21	+0.21	+0.22
Coriander + fenugreek (2:1)	+0.23	+0.06	+0.14	+0.09	+0.04	+0.03	+0.05
Coriander + fenugreek (2:2)	+0.12	+0.01	+0.06	+0.01	+0.03	+0.04	+0.03
Mean (R)	+0.20	+0.13		+0.09	+0.08	+0.09	
LSD at 5%	(I)=0.03	(R)=0.01	(I)(R)=0.04	(I)=0.03		(R)=N.S	(I)(R)=0.06
LSD at 1%	(I)=0.04	(R)=0.03	(I)(R)=0.06	(I)=0.04		(R)=N.S	(I)(R)=0.09

Table 13. Effect of intercropping system, *Rhizobium* inoculation rate and their interaction on aggrissivity value (A) of fenugreek (Afc) during the two seasons of 2013/2014 and 2014 /2015

Intercropping system (I) (Row ratio)	*Rhizobium* inoculation rate (R) (g / fad.)						
	0.00	200	Mean (I)	0.00	200	400	Mean (I)
	First season (2013/2014)			Second season (2014/2015)			
Coriander + fenugreek (1:1)	-0.07	-0.03	-0.05	-0.05	-0.05	-0.08	-0.06
Coriander + fenugreek (1:2)	-0.30	-0.14	-0.22	-0.08	-0.09	-0.08	-0.08
Coriander + fenugreek (1:3)	-0.30	-0.41	-0.35	-0.24	-0.21	-0.21	-0.22
Coriander + fenugreek (2:1)	-0.23	-0.06	-0.14	-0.09	-0.04	-0.03	-0.05
Coriander + fenugreek (2:2)	-0.12	-0.01	-0.06	-0.01	-0.03	-0.04	-0.03
Mean (R)	-0.20	-0.50		-0.21	-0.28	-0.46	
LSD at 5%	(I)=0.03	(R)=0.01	(I)(R)=0.04	(I)=0.03		(R)=N.S	(I)(R)=0.06
LSD at 1%	(I)=0.04	(R)=0.03	(I)(R)=0.06	(I)=0.04		(R)=N.S	(I)(R)=0.09

and second seasons, respectively. Furthermore, under each biofertilization rate treatments, these indicators were increased by using intercropping system treatments except that (1:1, 2:1 and 2:2 systems) which showed a decrease in this connection comparing to the other interaction treatments under study.

Similar results were stated by Meng *et al.* (2015) who showed that inoculating with both *Arbuscular mycorrhizae* fungi (AMF) and *Rhizobium* in soybean/maize intercropping system improved the nitrogen fixation efficiency of soybean and promoted nitrogen transfer from soybean to maize, resulting in the improvement of yield advantages of legume/non-legume intercropping.

Aggressivity reached to its maximum values (0.41 and 0.24) by using combination treatment of 2:2 or 1:3 intercropping system treatments with 200g or zero g/fad., of biofertilization compared to the other ones under study in the first and second seasons, respectively (Tables 12 and 13).

This result was in harmony with this obtained by Wahla *et al.* (2009) found that in all intercropping systems (barley + lentil, barley + gram, barley + methra, barley + linseed and barley + canola) at different nutrient levels, barley was dominant over all intercrops except canola in barley + canola system, where it proved to be better competitor.

Recommendation

This study suggests that coriander/fenugreek association can be used by farmers instead of coriander sole crop, especially at 1:3 cropping system, under Sharkia Governorate conditions. Use of the *Rhizobium* inoculation especially at 400 g/fad. for fenugreek, in the intercropping pattern of 1:3, enhanced coriander and fenugreek productivity and maximized land equivalent ratio as well as land utilization efficiency.

REFERENCES

Abdelaziz, M., R. Pokluda and M. Abdelwahab (2007). Influence of compost, microorganisms and NPK fertilizer upon growth, chemical composition and essential oil production of *Rosemarinus officinalis* L. Not. Bot. Hort. Agrobot. Cluj., 35 (1): 86-90.

Abdelkader, M.A.I. and E.H.A. Hamad (2015). Evaluation of productivity and competition indices of safflower and fenugreek as affected by intercropping pattern and foliar fertilization rate. Middle East J. Agric. Res., 4 (4): 956-966.

Abdelkader, M.A.I. and A.A.M. Mohsen. (2016). Effect of intercropping patterns on growth, yield components, chemical constituents and competition indices of onion, fennel, and coriander plants. Zagazig J. Agric. Res., 43 (1): 67-83.

Abdelkader, M.A.I. and H.M.S. Hassan (2016). Effects of intercropping pattern and phosphorus fertilizer rate on growth, yield, active ingredients and some competitive indices of dill and fenugreek plants. Minufiya J. Agric. Res. 41(1): 141-160.

Abd El-Latif, E.M., M.S. Abd El-Salam, S.F. El-Habbasha and M.A. Ahmed (2015). Effect of maize- cowpea intercropping on light interception, yield and land use efficiency. Int. J. Chem. Tech. Res., 8 (6): 556-564.

Adafre, A.N. (2016). Advantages of maize-haricot bean intercropping over sole cropping through competition indices at west Badewacho woreda, Hadiyazone, SNNPR. Acad. Res. J. Agric. Sci. and Res., 4(1): 1-8.

Alizadeh, Y., A. Koocheki and M.N. Mahallati (2010). Yield, yield components and potential weed control of intercropping bean (*Phaseolus vulgaris* L.) with sweet basil (*Ocimum basilicum* L.). Iranian J. Field Crops Res., 7(2): 541-553.

Analytical Software (2008). Statistix Version 9, Analytical Software, Tallahassee, Florida, USA.

AOAC (1984). Official Methods of Analysis. 12th Ed., Association of Official Analysis Chemists, Washington DC, USA.

Bantie, Y.B. (2015). Determination of effective spatial arrangement for intercropping of maize (*Zea mays* L.) and potato (*Solanum tuberosum*) using competition indices in Ethiopia. J. Hort., 2 (2):1-7.

Chapman, H. and P. Pratt (1971). Methods of analysis for soils, plants and waters. Univ. of California Bull. No.376, Davis, Cal., 96616. U.S.A.

Desperrier, N., J.C. Baccou and Y. Sauvaire (1985). Nitrogen fixation and nitrate assimilation in field grown fenugreek (*Trigonella foenum-graecum*). Plant and Soil, 92: 189-199.

De Wit, C.T. (1960). On competition. Verslag Landbouw-Kundige Onderzoek, 66: 1–28.

Emamghoreishi, M., M. Khasaki and M.F. Aazam (2005). *Coriandrum sativum*: evaluation of its anxiolytic effect in the elevated plus-maze. J. Ethnopharmaco, 96 : 365–370.

Faramawy, F.M.K. (2014). Response of *Prosopis chilensis* to biofertilization under calcareous soil of Ras Sudr 1- vegetative growth. Annals of Agric. Sci., 59 (2): 253-262.

Guenther, E. (1961). The Essential Oil D. Von Nostrand Comp., New York, 1: 236.

Hamad, E.S.H.A. (2014). Effect of *Rhizobium* inoculation and magnesium foliar spray on growth, yield attributes and chemical constituents of fenugreek. Zagazig J. Agric. Res., 41 (6): 1165-1176.

Hassan, B.A.R. (2012). Medicinal plants (Importance and Uses). Pharmacent Anal. Acta., 3-10.

Helal, F.A., S. A. Mahfouz and F.A.S. Hassan (2011). Partial substitution of mineral nitrogen fertilizer by bio-fertilizer on (*Anethum graveolens* L.) plant. Agric. Biol. J. N. Am., 2 (4): 652-660.

Hiebsch, C.K. and R.E. McCollum (1987). Area×time equivalency ratio: a method for evaluating the productivity of intercrops. Agron. J., 79: 15–22.

HongJiao, C., Y. MinSheng, K. Ryall, L. ShiYou and W. HongYi (2011). Physiological response of Chinese cabbage to intercropping systems. Agron. J., 103 (2): 331-336.

Kole, P.C. and A. Saha (2013). Correlation coefficients of component characters with seed yield and their direct effect in path analysis in fenugreek grown under six environments. J. Hort. and Forestry, 5 (1): 17-20.

Leithy, S., S.G. Maybelle and A.M. Gomaa (2009). Associative impact of bio- and organic fertilizers on geranium plants grown under saline conditions. Int. J. Acad. Res., 1(1): 17-23.

Maffei, M. and M. Mucciarelli (2003). Essential oil yield in peppermint/soybean strip intercropping. Field Crops Res., 84: 229-240.

Mahfouz, S.A. and M.A. Sharaf-Eldin (2007). Effects of mineral vs. biofertilizer on growth, yield, and essential oil content of fennel (*Foeniculum vulgare* Mill.). Int. Agrophysics, 21: 361-366.

Markwell, J., J.C. Osterman and J.L. Mitchell (1995). Calibration of the Minolta SPAD-502 leaf chlorophyll meter. Photosynthesis Res., 46: 467-472.

Mason, S.C., D.E. Leihner and J.J. Vorst (1986). Cassava-cowpea and cassava-peanut intercropping.1. Yield and land use efficiency. Agron. J., 78: 43-46.

Mc Gilchrist, C.A. (1965). Analysis of competition experiments. Biometrics 21: 975- 985.

Mead, R. and R.W. Willey (1980). The concept of a ‘land equivalent ratio’ and advantages in yields from intercropping. Exp. Agric., 16: 217–228.

Meawad, A.A, A.A. Helal and E.H. Amer (2004a). Effect of intercropping systems on growth, yield components, guaran production and chemical constituents of guar plant. Zagazig J. Agric. Res., 31(1): 81-96.

Meawad, A.A., A.A. Helal and E.H. Amer (2004 b). Effect of intercropping systems on land equivalent ratio, aggressivity and correlation coefficients of roselle and guar. Zagazig J. Agric. Res., 31 (1): 61-79.

Meng, L., Z. Aiyuan, W. Fei, H. Xiaoguang, W. Dejiang and S. Li (2015). *Arbuscular mycorrhizal* fungi and *Rhizobium* facilitate nitrogen uptake and transfer in soybean/ maize intercropping system. Front Plant Sci., 6: 339.

Mhemdi, H., E. Rodier, N. Kechaou and J. Fages (2011). A supercritical tuneable process for the selective extraction of fats and essential oil from coriander seeds. J. Food Eng., 105 (4) : 609-616.

Midmore, D.J. (1993). Agronomic modification of resource use and intercrop productivity. Field Crops Res., 34: 357–380.

Musa, E.M., A.E.E. Elsidding, A.M. Isam and E.E. Babiker (2012). Effect of intercropping, *Bradyrhizobium* inoculation and N,P fertilizers on yields, physical and chemical quality of cowpea seeds. Front. Agric. China, 5 (4): 543-551.

Nadeem, M., F.M. Anjum, M.I. Khan, S. Tehseen, A. El-Ghorab and J.I. Sultan (2013). Nutritional and medicinal aspects of coriander (*Coriandrum sativum* L.). A review. Brit. Food. J., 115(5): 743-755.

Nawar, F.R.R. and A.M. Abdel-Galil (2008). Effect of tillage systems and nitrogen fertilization on yield and yield components of intercropped soybean to sunflower in calcareous soils. Annals of Agric. Sci. (Cairo), 53 (1): 145-156.

Ndakidemi, P.A., F.D. Dakora, E.N. Nkonya, D. Ringo and H. Mansoor (2007). Yield and Economics benefits of common bean (*Phasculus vulgaris* L.) and soybean (*Glycine max* L. Merr) Inoculation in Northern Tazania. Aust. J. Exp. Agric., 46: 571-577.

Poi, S.C., T.K. Basu, K. Behari and A. Srivastav (1991). Symbiotic effectiveness of different strains of *Rhizobium meliloti* in selecting inoculants for improvement of productivity of *Trigonella foenum-graecum*. Environ. and Ecol., 9: 286-287.

Saleem, R., I.L.A. Zammurad, M.A. Muhammad, A. Muhammad, M. Muhammad and M.A. Khan (2011). Response of maize-legume intercropping system to different fertility sources under rainfed conditions. Nat. Agric. Res. Cent., Islamabad – Pakistan 27 (4): 503-511.

Shahien, A.H., A.A. Abdel-Aziz and A.A. Kheraba (1996). Effect of cultivars, irrigation and intercropping system on yield and its components, pod characters and return of cowpea. Zagazig J. Agric. Res., 23 (4): 571-590.

Shalaby, M.A.F. and N.M. Zaki (1999). Effect of some plant growth promoters on growth and yield of fenugreek (*Trigonella foenum-graecum* L., cv. Giza-30) plants. Egypt. J. Appl. Sci., 14 (11): 52-67.

Sharma, A., S.R. Pandit, P.S. Dharmaraj and M. Chavan (2012). Response of pigeonpea to biofertilizers in pigeonpea based intercropping system under rainfed conditions. Karnataka. J. Agric. Sci., 25 (3): 322-325.

Sulieman, A.M.E., A.O. Ali and J. Hemavathy (2008). Lipid content and fatty acid composition of fenugreek (*Trigonella foenum-graecum* L.) seeds grown in Sudan. Int. J. Food Sci. and Technol., 43 (2): 380-382.

Susan, A.J. and C. Mini (2005). Biological efficiency of intercropping in okra (*Abelmoschus esculentus*, L. Moench). J. Tropical Agric., 43 (1-2): 33-36.

Tohura, T., M.S. Ali, M.M. Rahman and F.T Z. Mony (2014). Yield performance of mungbean maize intercropping grown under different planting geometry. Int. J. Sustain Agril. Tech., 10 (9): 22-27.

Wahla, I.H., R. Ahmed, A. Ehsanullah, A. Ahmed and A. Jabbar (2009). Competitive functions of components crops in some barley based intercropping systems. Int. J. Agric. Biol., 11: 69–72.

Wangensteen, H., A.B. Samuelsen and K.E. Malterud (2004). Antioxidant activity in extracts from coriander. Food Chem., 88: 293–297.

Weisany, W., R. Yaghoub and K.G. Golezani (2016). *Funneliformis mossea* elaters seed essential oil content and composition of dill in intercropping with common bean. Industrial Crops and Prod., 79: 29-38.

Willy, R.W. and M.S. Reddy (1981). A field technique for separating above and below ground interaction for intercropping of: An experiment with pearl millet/groundnut. Exp. Agric., 17: 257- 264.

تأثير نظام التحميل ومعدل التسميد الحيوي على الإنتاجية والعلاقات التنافسية لنباتات الكسبرة والحلبة

إسراء مجدي عرفات محمد - على عبد الحميد معوض - محمد أحمد إبراهيم عبد القادر

قسم البساتين - كلية الزراعة - جامعة الزقازيق - مصر

أجري هذا العمل بمزرعة كلية الزراعة جامعة الزقازيق خلال موسمين شتويين متتاليين ٢٠١٤/٢٠١٣ و٢٠١٤/ ٢٠١٥ بهدف دراسة تأثير نظم التحميل المختلفة بين الكسبرة والحلبة، ومعدلات التسميد الحيوي ومعاملات التفاعل بينهما على محصول الثمار والزيت العطري لنبات الكسبرة ومحصول البذور والزيت الثابت لنبات الحلبة والمحتوى الكلي للكلوروفيل وكذلك العلاقات التنافسية (نسبة المكافئ الأرضي ونسبة المكافئ الأرضي لوحدة الزمن وكفاءة استخدام الأرض ومعامل الحشد النسبي والعدوانية) لكلا المحصولين، كانت معاملات نظم التحميل المستخدمة هي الزراعة المنفردة لكل من الكسبرة والحلبة (المقارنة)، ١:١ و٢:١ و٣:١ و١:٢ و٢:٢ من خطوط الكسبرة والحلبة، على الترتيب، بينما كانت معاملات التسميد الحيوي هي صفر، ٢٠٠ و٤٠٠ جرام من جراثيم الريزوبيم للفدان، وقد أظهرت النتائج المتحصل عليها أن نظام التحميل خط واحد من الكسبرة مع ثلاث خطوط من الحلبة أعطى أعلى القيم من حيث محصول البذور والزيت للنبات والمحتوي الكلى من الكلوروفيل (لوحدة القياس) لنباتات الكسبرة والحلبة، كذلك، كانت أعلى زيادة في هذا الصدد مع استخدام التلقيح بالريزوبيم بمعدل ٢٠٠ جرام أو٤٠٠ جرام/فدان مقارنة بالمعاملات الأخرى تحت الدراسة في الموسم الأول والثاني، على الترتيب، أيضاً، من خلال دراسة العلاقات التنافسية، أظهرت النتائج أنه يمكن تحميل نباتات الكسبرة والحلبة بنجاح تحت ظروف محافظة الشرقية وذلك لتعظيم كفاءة استخدام الأرض، عموماً، أمكن الحصول على أعلى القيم لنسبة المكافيء الأرضي ونسبة المكافيء الأرضي لعامل الزمن وكفاءة استخدام الأرض (١.٢٤ و ١.٢٣) و (١.١٧ و ١.١٥) و١٢٠.٨٣% و ١١٩.٠٠%) باستخدام معاملة التفاعل بين التحميل بنظام خط واحد من الكسبرة مع ثلاث خطوط من الحلبة (٣:١) مع التلقيح بالريزوبيم بمعدل ٢٠٠ أو ٤٠٠ جرام للفدان في الموسم الأول والثاني، على التوالي.

المحكمون :

١- أ.د. السيد محمد أحمد المحروق أستاذ النباتات الطبية والعطرية والزينة – كلية الزراعة – جامعة كفر الشيخ.

٢- أ.د. هشـــام عبدالعـــال الشامي أستاذ النباتات الطبية والزينة العطرية – كلية الزراعة – جامعة الزقازيق.