

Evaluation of Productivity and Competition Indices of Safflower and Fenugreek As Affected By Intercropping Pattern and Foliar Fertilization Rate

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ABSTRACT

This experiment was conducted for two consecutive seasons of 2013/2014 and 2014/2015 at the Experimental Farm, Faculty of Agriculture, Zagazig University, Egypt, to evaluate the effect of different intercropping patterns (safflower: fenugreek at different row ratios; 1:1, 1:2 and 1:3 in comparison with sole cropped of each specie), different foliar fertilization levels (0, 2 and 4 g/l) and their combination treatments on growth, yield components and some active ingredients as well as competitive indices of safflower and fenugreek. The obtained results revealed that the most of parameters of both crops under evaluation were increased with intercropping pattern treatments compared to safflower or fenugreek sole crop in the first and second seasons, also, the same trend were achieved by foliar fertilization at 4 g/l. Furthermore, the maximum increase in land equivalent ratio and area time equivalent ratio as well land utilization efficiency percentage were obtained from the treatment of 2 and 4 g/l in combined with 1:2 and 1:3 intercropping patterns in both seasons compared with control. In all mixtures, positive aggressivity values for safflower showed that safflower was the dominant specie whereas the negative values for fenugreek showed that it was the dominated one.

Key words: Safflower, fenugreek, intercropping, fertilization, yield and competitive indices

Introduction

Safflower (*Carthamus tinctorius* L.) -an oilseed crop- is a member of the family Compositae or Asteraceae. *Carthamus* is the latinized synonym of the Arabic word *Qartum*, or *gurtum*, which refers to the color of the dye extracted from safflower flowers (Singh, 2006). Safflower is more drought resistance than other oilseeds and can produce good yield in dry region, while its salt tolerance is a valuable asset as the area affected by some degree of salinity steadily increases world-wide (Weiss, 2000). In addition to the colouring properties, safflower petals are used for curing several chronic diseases such as hypertension, coronary heart ailments, rheumatism and male and female fertility problems (More *et al.*, 2005 and Rajvanshi 2005).

Trigonella foenum-graecum L. (fenugreek) is member of Leguminosae (currently known as Fabaceae) family and encompass renowned culinary and medicinal uses in the history of old civilizations. Egyptians use fenugreek for embalming their prestigious majestic dead bodies while Romans and Greek were found to use it as cattle fodder (Newall, 1996). Fenugreek leaves and seeds are consumed in different countries around the world for different purposes such as medicinal uses, making food, roasted grain as coffee-substitute (in Africa), controlling insects in grain storages, perfume industries, and etc. Fenugreek can be a very useful legume crop for incorporation into short-term rotation and for hay and silage for livestock feed, for fixation of nitrogen in soil and its fertility, and etc (Sadeghzadeh-Ahari *et al.*, 2009).

Intercropping is claimed to be one of the most significant cropping techniques in sustainable agriculture. Much research and many reviews attribute to its utilization a number of environmental benefits, from promoting land biodiversity to diversifying agricultural outcome. Though, intercropping is thought to be a useful means of minimizing the risks of agricultural production in many environments, including those typical of underdeveloped or marginal areas (Carrubba *et al.*, 2008). Multiple cropping (i.e. intercropping or mixed cropping) plays an important role in agriculture because of the effective utilization of resources, significantly enhancing crop productivity compared with that of monocultured crops (Li *et al.*, 2001).

The macronutrients, N, P, and K, are often classified as 'primary' macronutrients, because deficiencies of N, P and K are more common than the 'secondary' macronutrients, Ca, Mg, and S. Most of the macronutrients are represent 0.1 to 5%, or 100 to 5000 parts per million (ppm), of dry plant tissue (Wiedenhoeft, 2006).

Thus the objective of the present study was to assess the effect of foliar fertilization rate for safflower and/or fenugreek in an intercropping pattern on the species growth yield components, active ingredients and some competitive indices under Sharkia governorate condition.

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Materials and Methods

The present study was conducted at the Experimental Farm, Faculty of Agriculture, Zagazig University, Egypt, during two consecutive seasons of 2013/2014 and 2014/2015. This experiment included 12 treatments, which were the combinations between four intercropping patterns and three foliar fertilization levels which were; control (without foliar fertilization), 2 and 4 g/l of solution commercially known as Garlovit, which consists of the following minerals: N (15%) – P₂O₅ (13%) – K₂O (16%) – chelated Zn (50 ppm) – chelated Mn (100ppm) and chelated Cu (50ppm) as well as it consists of sucrose (1%) – citric acid (1%) - hexamine (0.001%) which obtained from United Agriculture Development Company (UAD). The intercropping pattern treatments were sole cropping pattern of either safflower or fenugreek which used as control for both components characters, one row of safflower alternated with one row of fenugreek (1:1), one row of safflower alternated with two rows of fenugreek (1:2) and one row of safflower alternated with three rows of fenugreek (1:3). The foliar fertilization levels were applied as foliar application at 35, 55 and 75 days after sowing. Each experimental unit received 3 liters of nutrition solution using spreading agent (Super Film at a rate of 1ml /l). The untreated control plants were sprayed with tap water. The twelve treatments were arranged in split plot design with three replicates, where cropping pattern treatments were distributed in the main plots, while foliar fertilization levels were randomly arranged in the sub-plots. All plants received normal agricultural practices whenever they needed.

The plot area was 2 × 9 m included fifteen rows; each row was 60 cm apart and two meters in length. The seeds were sown on row in hills on one side. The distances between hills were 30 and 20 cm for safflower or fenugreek plants, respectively. Seeds of both safflower and fenugreek were obtained from Research Centre of Medicinal and Aromatic Plants, Dokky, Giza and were sown on 12th and 20th October during first and second seasons, respectively. Seeds were sown then immediately irrigated. After three weeks from planting, seedlings were thinned to be one plant / hill for safflower and two plants / hill for fenugreek. The physical and chemical properties of the experimental farm soil are shown in Table 1.

Table 1: Physical and chemical properties of the experimental soil

Characters	Clay%	Silt%	Sand%	Texture	pH	Organic mater	Available nutrients (ppm)		
							N	P	K
Values	48.78	22.46	27.76	Clay	7.85	1.75	17.6	8.90	72.8

At harvesting stage, plant height (cm), branch number /plant and total plant dry weight (g) were estimated. Seed yield /plant (g) was determined, and then seed yield (kg/ feddan) was calculated for safflower and fenugreek plants. A sample of dry petals of safflower and seeds of both crops was randomly taken from each treatment for chemical analysis. Total chlorophyll content (SPAD unit) was determined in safflower and fenugreek fresh leaves by using SPAD- 502 meter Markwell *et al.* (1995). Furthermore, total nitrogen (%) was determined in seeds of both crops according to the methods described by Chapman and Pratt (1978) and was multiplied by 6.25 to calculate protein (%) then protein content / seed of plant (g) was calculated for safflower and fenugreek plants. Moreover, carthamin percentage was assessed according to the method described by Harborne (1973) then carthamin yield per plant was calculated through multiply carthamin percentage by dry petals yield per safflower plant. Seed fixed oil of safflower and fenugreek was extracted using petroleum ether in a soxhlet system HT apparatus according to the methods of A.O.A.C. (1984). Oil percentage and oil yield per plant (g) and per feddan (kg) were calculated. The trigonelline seed content (mg/g) of fenugreek was determined according to the equation; trigonelline alkaloid= absorbance of test at 268 nm / Absorbance of standard (Gorham, 1986).

Competitive indices:

Land equivalent ratio (LER):

This gives an indication to the relative land area sole cropping that is required, to produce the same yields achieved by intercropping. The value of unity is the critical value. When the LER is greater than one, the intercropping favors the growth and yield of the species. On another hand, when LER is lower than one the intercropping negatively affects the growth and yield of the plants grown in mixture. It was determined for safflower and fenugreek yield recorded per feddan according to the equation as follows: $LER = L_s + L_f$

$$L_s = \frac{Y_{sf}}{Y_{ss}}, \quad L_f = \frac{Y_{fs}}{Y_{ff}}$$

where Y_{ss} and Y_{ff} are the yields per feddan of safflower and fenugreek, respectively, as sole crops and Y_{sf} and Y_{fs} are the yields of safflower and fenugreek, respectively, as intercrops components (Mead and Willey, 1980).

Area Time Equivalent Ratio (ATER):

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

$$ATER = \frac{Y_{sf} / Y_{ss} \times t_s + Y_{fs} / Y_{ff} \times t_f}{T}$$

Where; Y_{sf} = intercrop yield of safflower, Y_{ss} = sole yield of safflower, Y_{fs} = intercrop yield of fenugreek, Y_{ff} = sole yield of fenugreek, t_s = the duration of safflower in days, t_f = 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:

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

Aggressivity (A):

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

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

$$Asf = L_s - L_f, \quad Afs = L_f - L_s$$

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

$$Asf = \frac{Y_{sf}}{Y_{ss} \times Z_{sf}} - \frac{Y_{fs}}{Y_{ff} \times Z_{fs}}, \quad Afs = \frac{Y_{fs}}{Y_{ff} \times Z_{fs}} - \frac{Y_{sf}}{Y_{ss} \times Z_{sf}}$$

Where; Y_{sf} = intercrop yield of safflower, Y_{fs} = intercrop yield of fenugreek, Y_{ss} = sole yield of safflower, Y_{ff} = sole yield of fenugreek, Z_{sf} = sowing proportion of safflower and Z_{fs} = sowing proportion of fenugreek.

Competitive ratio (CR):

It is another way to assess competition between different species. The CR gives a better measure of competitive ability of the crops and is also advantageous as an index over aggressivity (Willey and Rao, 1980). The CR represents simply the ratio of individual LERs of the two component crops and takes into account the proportion of the crops in which they are initially sown. The CR is calculated according to the following formula:

$$CR_{safflower} = \frac{LER_{safflower}}{LER_{fenugreek}} \left(\frac{Z_{fs}}{Z_{sf}} \right), \quad CR_{fenugreek} = \frac{LER_{fenugreek}}{LER_{safflower}} \left(\frac{Z_{sf}}{Z_{fs}} \right)$$

Statistical analysis:

Data of the present work were statically analyzed and the differences between the means of the treatments were considered significant when they were more than the least significant differences (L.S.D) at the 5% level by using computer program of Statistix version 9 (Analytical software, 2008).

Results and Discussion

Effect of intercropping pattern, foliar fertilization level and their combination treatments on safflower and fenugreek productivity

Growth parameters

Data presented in Tables 2 and 3 reveal that, in most cases plant height and branch number /plant as well as total dry weights of safflower or fenugreek plants were increased with intercropping pattern treatments compared to safflower or fenugreek sole crops in the first and second seasons. The highest significant increases were achieved with one row of safflower: two or three rows of fenugreek. These results are in similar with those stated by Sarkar and Raghav (2010) on capsicum when intercropped with maize and Bitew *et al.* (2014) on lupine intercropped with wheat, barley and finger millet. Such results could be attributed to that in legume / non-legume intercropping patterns, plants benefit from the direct transfer of fixed N_2 , as reported by Graham and Vance (2000). Moreover, all foliar fertilization treatments significantly increased the above mentioned parameters compared

with control. The maximum increases in this respect were obtained from the treatment of the highest level of foliar fertilization compared with the other ones under study. These results coincided with those found by Abbas and Ali (2011) on roselle plant and Golzarfar *et al.* (2011) on safflower plant.

Table 2: Effect of intercropping pattern, foliar fertilization level and their combination treatments on some growth parameters of safflower plant during 2013/2014 and 2014/2015 seasons

Treatments		Growth parameters					
		Plant height (cm)		Branch number / plant		Total dry weight (g)	
		Seasons		Seasons		Seasons	
		1 st	2 nd	1 st	2 nd	1 st	2 nd
Intercropping pattern (safflower: fenugreek)							
Sole safflower		87.78B	91.78D	7.44 C	7.67C	91.80D	92.42C
1 : 1		91.11B	95.33C	8.89B	8.22C	95.39C	94.14C
1 : 2		101.89A	102.89B	10.00A	10.11B	112.64B	106.12B
1 : 3		105.44A	107.33A	10.56A	11.56A	119.33A	117.94A
Foliar fertilization level (g/l)							
0.00		91.75C	94.5C	8.00C	8.00C	100.38C	95.48C
2.00		96.67B	99.08B	9.17B	9.25B	104.54B	102.20B
4.00		101.25A	104.42A	10.50A	10.92A	109.44A	110.29A
Intercropping	Fertilization level (g/l)	Intercropping patterns × Foliar fertilization level					
Sole safflower	0.00	82.00h	88.00g	6.33h	6.67g	88.37h	89.40 f
	2.00	89.33fg	89.33fg	7.33gh	7.33efg	92.13g	92.43def
	4.00	92.00d-g	98.00cd	8.67ef	9.00cd	94.89f	95.43de
1 : 1	0.00	88.33gh	93.67e	7.67fg	7.33fg	93.90f	91.22ef
	2.00	90.33efg	92.67ef	8.67ef	8.33de	94.36f	94.09def
	4.00	94.67c-f	99.67c	10.33bcd	9.00cd	97.90e	97.12d
1 : 2	0.00	97.67cde	95.67de	8.67ef	8.33de	104.60d	93.99def
	2.00	101.67bc	105.67b	10.00cd	9.67c	114.52c	103.40c
	4.00	106.33ab	107.33b	11.33ab	12.33ab	118.78b	120.98b
1 : 3	0.00	99.00bcd	100.67c	9.33de	9.67c	114.64c	107.32c
	2.00	105.33b	108.67b	10.67abc	11.67b	117.16b	118.87b
	4.00	112.00a	112.67a	11.67a	13.33a	126.20a	127.64a

Table 3: Effect of intercropping pattern, foliar fertilization level and their combination treatments on some growth parameters of fenugreek plant during 2013/2014 and 2014/2015 seasons

Treatments		Growth Parameters					
		Plant height (cm)		Branch number / plant		Total dry weight (g)	
		Seasons		Seasons		Seasons	
		1 st	2 nd	1 st	2 nd	1 st	2 nd
Intercropping pattern (safflower: fenugreek)							
Sole fenugreek 1 : 1 1 : 2 1 : 3		42.67D	42.11C	8.44C	7.67C	12.61C	12.92C
		44.67C	45.11B	8.56BC	8.33BC	12.84C	13.09BC
		48.00B	50.78A	9.00B	8.44B	13.79B	13.58AB
		50.00A	49.89A	10.33A	9.33A	14.41A	13.73A
Foliar fertilization level (g/l)							
0.00 2.00 4.00		43.58C	44.00C	7.75C	7.25C	12.07C	11.90C
		46.50B	47.33B	9.25B	8.42B	13.61B	13.35B
		48.92A	49.58A	10.25A	9.67A	14.57A	14.75A
Intercropping	Fertilization level (g/l)	Intercropping patterns × Foliar fertilization level					
Sole fenugreek	0.00	40.67d	39.33f	7.33e	6.67g	11.77f	11.90fg
	2.00	42.00d	42.00e	8.67cd	7.67ef	12.33ef	12.67ef
	4.00	45.33c	45.00d	9.33bc	8.67bcd	13.73cd	14.20bcd
1 : 1	0.00	42.00d	42.67e	7.67de	7.00fg	11.60f	11.40g
	2.00	45.33c	44.67d	8.67cd	8.33cde	13.10de	13.33de
	4.00	46.67bc	48.00c	9.33bc	9.67ab	13.83cd	14.53abc
1 : 2	0.00	45.00c	47.67c	7.33e	7.33efg	11.73f	12.07fg
	2.00	47.67b	51.33b	9.33bc	8.33cde	14.20bc	13.47de
	4.00	51.33a	53.33a	10.33b	9.67ab	15.43a	15.22a
1 : 3	0.00	46.67bc	46.33cd	8.67cd	8.00def	13.17de	12.22fg
	2.00	51.00a	51.33b	10.33b	9.33bc	14.80ab	13.93cd
	4.00	52.33a	52.00ab	12.00a	10.67a	15.27a	15.03ab

It is well known that chemical fertilizers could enhance plant growth due to the role of nitrogen in nucleic acids and protein synthesis, and phosphorus as an essential component of the energy compounds (ATP and ADP) and phosphoprotein, also the role of potassium as an activator of many enzymes (Helgi and Rolfe, 2005) as well as Cu, Mn and Zn are activators of specific enzymes (Voss, 1998).

In addition, plant height and branch number per plant as well as total dry weight of safflower or fenugreek were significantly increased with all combination treatments between intercropping patterns and NPK fertilization rates compared with control (sole crop pattern without foliar fertilization) in both seasons, in most cases. The increases in the above mentioned parameters due to combination between intercropping pattern and foliar fertilization levels might be attributed to the reducing in inter and intra competition between safflower and fenugreek plants for light and nutrients as reported by Abd El-Zaher *et al.* (2009). It is clear that at the highest foliar fertilization rate (4g/l), there was little competition between both species on nutrients which resulted in the maximum values of plant height, number of branches and dry weight per plant of both species.

Yield components:

Data given in Tables 4 and 5 suggest that, alternating one row of safflower with three rows of fenugreek (1:3 pattern) or one row with two rows (1:2 pattern) recorded the highest seed yield for both species compared with the other patterns under study. However, seed yield per feddan of safflower or fenugreek was significantly decreased with intercropping pattern treatments compared to sole crop in the first and second seasons. Concerning oil yield per feddan, it was found that pure stand of safflower or fenugreek gave the highest values compared to intercropping patterns treatments.

Table 4: Effect of intercropping pattern, foliar fertilization level and their combination treatments on yield components of safflower plant during 2013/2014 and 2014/2015 seasons

Treatments	Yield components					
	Seed yield / plant (g)		Seed yield / feddan (Kg)		Oil yield / feddan (Kg)	
	Seasons		Seasons		Seasons	
	1 st	2 nd	1 st	2 nd	1 st	2 nd
Intercropping pattern (safflower: fenugreek)						
Sole safflower	22.93C	23.35D	509.75A	518.93A	174.82A	176.08A
1 : 1	27.94B	28.64C	310.49B	318.25B	109.99B	110.91B
1 : 2	30.21A	32.40B	223.58C	239.74C	80.72C	86.09C
1 : 3	31.15A	33.89A	180.84D	188.28D	66.12D	68.74D
Foliar fertilization level (g/l)						
0.00	26.47C	27.53C	288.47C	298.20C	99.73C	101.22C
2.00	27.91B	29.62B	304.55B	315.75B	107.34B	110.54B
4.00	29.80A	31.56A	325.36A	334.96A	116.66A	119.60A
Intercropping	Fertilization level (g/l)	Intercropping patterns × Foliar fertilization level				
Sole safflower	0.00	21.54j	22.89g	478.61c	508.68b	161.82c
	2.00	22.84i	23.17g	507.50b	514.91b	172.71b
	4.00	24.42h	23.99g	542.61a	533.21a	189.92a
1 : 1	0.00	26.73g	26.01f	297.20e	288.99e	102.97e
	2.00	27.56fg	28.61e	306.21e	317.95d	108.59e
	4.00	29.54de	31.30cd	328.25d	347.81c	118.40d
1 : 2	0.00	28.67ef	29.79de	212.18g	220.45h	74.91gh
	2.00	30.11cd	32.33c	222.84fg	239.24g	81.71fg
	4.00	31.85b	35.07ab	235.72f	259.54f	86.09f
1 : 3	0.00	28.92de	31.44c	166.04i	174.70j	59.22j
	2.00	31.13bc	34.36b	181.63h	190.88i	66.91i
	4.00	33.40a	35.87a	194.85h	199.27i	72.22gh

These results agreed with those found by Naeem *et al.* (2004) on sunflower intercropped with mung bean, Rashid *et al.* (2006) on sorghum when intercropped with mung bean or guar and Mahapatra (2011) on blackgram when intercropped with sabai grass. Such, result seems to be conflicted with the above mentioned result which suggested that intercropping system of safflower + fenugreek (1:3 or 1:2) produced the highest values of seed yield per plant. These paradoxical results can be interpreted in the light of that the higher population of safflower plants within area unit (feddan) in sole safflower or fenugreek pattern could be condensed the lack of seed yield per plant in these treatments compared with 1:3 or 1:2 ratios. Generally, yield components of safflower and fenugreek were gradually increased with increasing foliar fertilization levels. These results are in harmony with those reported by Abbas and Ali (2011) on roselle plant and Njogu *et al.* (2015) on tea plant using NPK foliar application. Moreover, the combination treatments between intercropping pattern of one row of safflower + two or three rows of fenugreek (1:2 or 1:3 patterns) and highest level of foliar fertilization level at 4g/l were superior in increasing seed

yields of safflower or fenugreek plant compared to the other ones under study in the first and second seasons, in most cases. The enhancing effect of combination between of intercropping patterns and foliar fertilization on seed yield per plant might be due to the role of nutrients on the plant physiological processes and intercropping system (1:3) which was previously mentioned in the case of plant growth as an increase in this parameters might be reflected on seed yield per safflower or fenugreek plant. Also, seed yield per feddan was decreased with all combination treatments between intercropping patterns and foliar fertilization level compared with control (sole crop system without foliar fertilization) in both seasons. Furthermore, under each intercropping pattern seed and oil yield per feddan of safflower or fenugreek was increased with increasing foliar fertilization level. These results were demonstrated by Saleem *et al.* (2011) on maize-legume intercropping system since yield and yield attributes were evaluated under different fertility treatments. Also, Layek *et al.* (2015) on soybean + cereal intercropping systems under nitrogen fertilization rates has been found similar results.

Table 5: Effect of intercropping pattern, foliar fertilization level and their combination treatments on yield components of fenugreek plant during 2013/2014 and 2014/2015 seasons

Treatments		Yield components					
		Seed yield / plant (g)		Seed yield / feddan (Kg)		Oil yield / feddan (Kg)	
		Seasons		Seasons		Seasons	
		1 st	2 nd	1 st	2 nd	1 st	2 nd
Intercropping pattern (safflower: fenugreek)							
Sole fenugreek		9.28C	9.41C	618.52A	627.41A	62.05A	63.22A
1 : 1		9.96B	10.16B	331.86D	338.52D	34.23D	34.91C
1 : 2		11.60A	11.29A	515.52C	501.69C	53.47C	51.88B
1 : 3		11.60A	11.66A	580.00B	583.22B	59.87B	60.48A
Foliar fertilization level (g/l)							
0.00		9.22C	9.02C	444.21C	433.98C	44.00C	43.06C
2.00		10.85B	10.96B	523.70B	529.39B	53.55B	54.21B
4.00		11.76A	11.91A	566.52A	574.76A	59.66A	60.60A
Intercropping	Fertilization level (g/l)	Intercropping patterns × Foliar fertilization level					
Sole fenugreek	0.00	8.07h	7.93e	537.78d	528.89d	51.81de	52.00d
	2.00	9.47f	9.80c	631.11b	653.34b	62.92c	65.57bc
	4.00	10.30e	10.50bc	686.67a	700.00a	71.41a	72.10a
1 : 1	0.00	8.73g	8.83de	291.12i	294.45h	29.40i	29.45g
	2.00	10.13e	10.50bc	337.78h	350.00g	35.02h	36.17f
	4.00	11.00d	11.13b	366.68g	371.12g	38.26g	39.10ef
1 : 2	0.00	9.97e	9.67cd	442.93f	429.60f	44.47f	42.42e
	2.00	11.53c	11.23b	512.55e	499.22de	53.47d	51.76d
	4.00	13.30a	12.97a	591.07c	576.25c	62.45c	61.47c
1 : 3	0.00	10.10e	9.66cd	505.00e	483.00e	50.32e	48.35d
	2.00	12.27b	12.30a	613.33bc	615.00bc	62.77c	63.35c
	4.00	12.43b	13.03a	621.67b	651.67b	66.52b	69.73ab

Chemical constituents:

Results under discussion in Tables 6 and 7 indicate that, total chlorophyll content (SPAD unit) of leaves and protein content of seeds as well as carthamin content of petals per safflower plant, in the same line, total chlorophyll content (SPAD unit) of leaves and protein content of seed as well as trigonilline content per fenugreek plant were increased with intercropping pattern treatments compared to sole crop in most cases. However, intercropping patterns of 1:2 and 1:3 recorded the highest increases in most of the above mentioned parameters of both plants compared with the other ones under study. These results agreed with those stated by Karimzadeh *et al.* (2015) on dill essential oil production when intercropped with berseem plant. In addition, the above mentioned constituents were gradually increased with increasing foliar fertilization levels. The highest concentration of foliar fertilization gave the maximum values of the above mentioned parameters. Results from a parallel investigation showed significant correlation between tea leaf chemical constituents and nutrients NPK levels applied (Njogu *et al.*, 2014). Matter and El Sayed (2015) found that NPK fertilizer led to improve plant N percentage, total chlorophyll and essential oil % of caraway plant.

The combination treatments between intercropping patterns of 1:2 or 1:3 and 4g/l foliar fertilization level were mostly superior in this respect compared to the other ones under study in both seasons. The enhancing of spraying plants with foliar fertilization on the above mentioned components may be attributed to the reduction in competition between both species on nutrient resources.

Table 6: Effect of intercropping pattern, foliar fertilization level and their combination treatments on some chemical constituents of safflower plant during 2013/2014 and 2014/2015 seasons

Treatments		Some chemical constituents					
		Total chlorophyll content of leaves (SPAD)		protein content / plant seed (g)		Carthamin content / plant petals (mg/100g)	
		Seasons		Seasons		Seasons	
		1 st	2 nd	1 st	2 nd	1 st	2 nd
Intercropping pattern (safflower: fenugreek)							
Sole safflower		46.34C	45.77C	6.07C	6.03D	0.056D	0.055D
	1 : 1	48.36A	47.43B	6.56BC	6.37C	0.061C	0.060C
	1 : 2	47.86B	47.52B	6.73AB	6.89B	0.066B	0.064B
	1 : 3	48.05B	48.57A	7.22A	7.14A	0.070A	0.069A
Foliar fertilization level (g/l)							
0.00		46.91C	46.21C	6.12B	6.10C	0.059C	0.059C
2.00		47.58B	47.34B	6.77A	6.64B	0.063B	0.062B
4.00		48.47A	48.42A	7.04A	7.08A	0.066A	0.066A
Intercropping	Fertilization level (g/l)	Intercropping patterns × Foliar fertilization level					
Sole safflower	0.00	45.48h	44.08g	5.87e	5.81f	0.054h	0.053h
	2.00	46.25g	45.55fg	6.02de	6.00f	0.056g	0.055g
	4.00	47.30e	46.95de	6.33cde	6.27e	0.057fg	0.057f
1 : 1	0.00	48.28bc	46.30ef	6.00de	5.92f	0.058f	0.058f
	2.00	48.29bc	47.80bc	7.02bc	6.43e	0.060e	0.059e
	4.00	48.50b	48.18b	6.66b-e	6.75d	0.063cd	0.082cd
1 : 2	0.00	46.80f	46.44e	6.18de	6.31e	0.061de	0.061de
	2.00	47.81d	47.69bcd	6.70bcd	6.83d	0.065c	0.063c
	4.00	48.97a	48.41b	7.31ab	7.52b	0.070b	0.069b
1 : 3	0.00	47.06ef	47.28cd	6.44cde	6.36e	0.064c	0.064c
	2.00	47.96cd	48.29b	7.34ab	7.29c	0.072b	0.069b
	4.00	49.13a	50.14a	7.88a	7.79a	0.074a	0.075a

Table 7: Effect of intercropping pattern, foliar fertilization level and their combination treatments on some chemical constituents of fenugreek plant during 2013/2014 and 2014/2015 seasons

Treatments		Some chemical constituents					
		Total chlorophyll content of leaves (SPAD)		Protein content / plant seed (g)		Trigonilline content / plant (mg/g)	
		Seasons		Seasons		Seasons	
		1 st	2 nd	1 st	2 nd	1 st	2 nd
Intercropping pattern (safflower: fenugreek)							
Sole fenugreek		39.67C	39.33C	0.729C	0.776B	0.0324C	0.0332B
	1 : 1	40.67B	41.00B	0.778B	0.781B	0.0339B	0.0338B
	1 : 2	42.89A	43.11A	0.767BC	0.783B	0.0410A	0.0398A
	1 : 3	43.44A	42.78A	0.798A	0.796A	0.0408A	0.0400A
Foliar fertilization level (g/l)							
0.00		39.25C	37.83C	0.729C	0.734C	0.0305C	0.0295C
2.00		41.58B	42.17B	0.781B	0.791B	0.0379B	0.0377B
4.00		44.17A	44.67A	0.815A	0.824A	0.0427A	0.0429A
Intercropping	Fertilization level (g/l)	Intercropping patterns × Foliar fertilization level					
Sole fenugreek	0.00	38.67gh	37.33d	0.715g	0.737ef	0.0267i	0.0257g
	2.00	38.67gh	38.33d	0.759ef	0.772d	0.0327g	0.0350de
	4.00	41.67de	42.33c	0.797bcd	0.821bc	0.0380e	0.0390c
1 : 1	0.00	38.33h	37.67d	0.736fg	0.756de	0.0290h	0.0293f
	2.00	40.67ef	41.33c	0.781ode	0.777d	0.0343f	0.0340e
	4.00	43.00c	44.00b	0.816b	0.811bc	0.0383e	0.0380cd
1 : 2	0.00	39.67fg	37.67d	0.719g	0.717f	0.0333fg	0.0323ef
	2.00	42.67de	44.00b	0.778de	0.803c	0.0410d	0.0393bc
	4.00	46.33a	47.67a	0.803bc	0.830ab	0.0487a	0.0477a
1 : 3	0.00	40.33f	38.67d	0.745f	0.727f	0.0330fg	0.0307f
	2.00	44.33b	45.00b	0.806b	0.813bc	0.0437c	0.0423b
	4.00	45.67a	44.67b	0.843a	0.848a	0.0457b	0.0470a

Effect of intercropping pattern, foliar fertilization level and their combination treatments on some competitive indices between safflower and fenugreek plants.

Land equivalent ratio (LER), area time equivalent ratio (ATER) and land utilization efficiency (LUE)

Data recorded in Table 8 reveal that, the LER and ATER for safflower and fenugreek were above 1.00 in all mixture proportions of intercropping patterns (1:1, 1:2 and 1:3) in both seasons. This confirms the advantage of these intercropping patterns to get more production from the same area of land as compared with the same unit of area in which sole crop is applied. Furthermore, the highest values of LER, ATER and LUE were significantly recorded by using 1:2 or 1:3 intercropping patterns without significant difference between both of them during both seasons. 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 Willey and Reddy (1981).

Table 8: Effect of intercropping pattern, foliar fertilization level and their combination treatments on land equivalent ratio (LER), area time equivalent ratio (ATER) and land utilization efficiency (LUE) indices during 2013/2014 and 2014/2015 seasons

Treatments	Some competitive indices					
	LER		ATER		LUE (%)	
	Seasons		Seasons		Seasons	
	1 st	2 nd	1 st	2 nd	1 st	2 nd
Intercropping pattern (safflower: fenugreek)						
1 : 1	1.147B	1.154B	1.040B	1.046B	109.35B	109.97B
1 : 2	1.272A	1.261A	1.106A	1.102A	118.90A	118.16A
1 : 3	1.279A	1.291A	1.091A	1.106A	118.52A	119.83A
Foliar fertilization level (g/l)						
0.00	1.235A	1.209B	1.082A	1.057B	115.86A	113.28B
2.00	1.236A	1.232AB	1.081A	1.082AB	115.85A	115.70AB
4.00	1.227A	1.266A	1.074A	1.114A	115.06A	118.97A
Intercropping	Fertilization level (g/l)	Intercropping patterns × Foliar fertilization level				
1 : 1	0.00	1.163b	1.125e	1.055bc	1.104ab	110.88bc
	2.00	1.139b	1.154de	1.032c	1.047c	108.60c
	4.00	1.139b	1.182c-e	1.032c	1.076bc	108.56c
1 : 2	0.00	1.268a	1.246a-c	1.103ab	1.083b	118.56a
	2.00	1.253a	1.228b-d	1.090abc	1.076bc	117.20ab
	4.00	1.296a	1.311a	1.123a	1.146a	120.95a
1 : 3	0.00	1.275a	1.256a-c	1.087abc	1.074bc	118.14a
	2.00	1.315a	1.313a	1.120a	1.124a	121.74a
	4.00	1.247a	1.305ab	1.066abc	1.119a	115.68ab

This indicates that 31.5 and 31.3 % (31.5 and 31.3 feddan) more area would be required by a sole cropping pattern to equal the yield of intercropping pattern of 1:3 combined with foliar fertilization at level of 2 g/l in the first and second seasons, respectively. In this regard Mohamed *et al.* (2006) revealed that intercropping of cassava with cowpea was beneficial in increasing the land use efficiency. In addition, cassava ATER was higher in cassava+cowpea combinations. Muhammad *et al.* (2008) reported that values of area time equivalent ratio showed 5-13 % advantage in cotton+cowpea and 9-23 % disadvantage in cotton+sorghum intercropping.

Aggressivity (A) and competitive ratio (CR):

Data listed in Table 9 illustrate the effect of intercropping pattern, foliar fertilization level and their combination treatments on aggressivity (A) values of safflower (Asf) and fenugreek (Afs) which calculated for seed yield per feddan of safflower and fenugreek, respectively. Positive aggressivity values for safflower demonstrate that safflower was the dominant specie whereas the negative values for fenugreek indicate that it was the dominated one. Results show that the highest positive aggressivity of safflower was recorded with 1:3 intercropping pattern compared with 1:1 and 1:2 patterns during both seasons. Increasing of foliar fertilization level did not significantly affect on aggressivity value. It is worth to mention that there were no significant differences between most of combination treatments between intercropping pattern and foliar fertilization level.

Competitive ratio (CR) is only used as a measure of intercrop competition (inter-specific competition) Trydeman *et al.* (2004). Intercropped safflower had higher values of CR safflower in all mixtures compared with CR fenugreek during both tested seasons (Table 10). This indicates to higher competitive ability of safflower for resources than fenugreek component. The results show that intercropped safflower had higher competitive ratios

in all proportions with fenugreek, indicating that safflower was more competitive ($CR > one$) than fenugreek ($CR < one$). The highest CR values for safflower were obtained in mix-proportion of 1:3 pattern with foliar fertilization level of 4g/l as well as combination treatment of 1:3 pattern without foliar fertilization in second season. Similar results were recorded by Dhima *et al.* (2007) when intercropped common vetch with cereals, Takim (2012) in maize-cowpea intercropping mixtures and Adhikary *et al.* (2015) on corn intercropped with vegetables like cowpea, chilli, brinjal and okra as well as Choudhuri and Jana (2015) on potato and mustard intercropping system (2:1 row ratio). Moreover, Dua *et al.* (2015) found that aggressivity values indicated that maize was a dominant species whereas, potato was dominated species when maize was supplied with N (50 or 100%), irrespective of N dose to potato.

Table 9: Effect of intercropping pattern, foliar fertilization level and their combination treatments on Aggressivity values between safflower and fenugreek components during 2013/2014 and 2014/2015 seasons

Treatments		Aggressivity values			
		Aggressivity of safflower (Asf)		Aggressivity of fenugreek (Afs)	
		First season	Second season	First season	Second season
Intercropping pattern (safflower: fenugreek)					
1 : 1		+ 0.0729B	+ 0.0719B	- 0.0729B	- 0.0719B
1 : 2		+ 0.0696B	+ 0.1877AB	- 0.0696B	- 0.1877AB
1 : 3		+ 0.1063A	+ 0.2779A	- 0.1063A	- 0.2779A
Foliar fertilization level (g/l)					
0.00		+ 0.0899A	+ 0.1671A	- 0.0899A	- 0.1671A
2.00		+ 0.0770A	+ 0.1712A	- 0.0770A	- 0.1712A
4.00		+ 0.0819A	+ 0.1991A	- 0.0819A	- 0.1991A
Intercropping	Fertilization level (g/l)	Intercropping patterns × Foliar fertilization level			
1 : 1	0.00	+ 0.0797ab	+ 0.0113b	- 0.0797ab	- 0.0113b
	2.00	+ 0.0680ab	+ 0.0820b	- 0.0680ab	- 0.0820b
	4.00	+ 0.0710ab	+ 0.1223b	- 0.0710ab	- 0.1223b
1 : 2	0.00	+ 0.0970ab	+ 0.0840b	- 0.0970ab	- 0.0840b
	2.00	+ 0.0980ab	+ 0.2523ab	- 0.0980ab	- 0.2523ab
	4.00	+ 0.0137b	+ 0.2267ab	- 0.0137b	- 0.2267ab
1 : 3	0.00	+ 0.0930ab	+ 0.4060a	- 0.0930ab	- 0.4060a
	2.00	+ 0.0650ab	+ 0.1793ab	- 0.0650ab	- 0.1793ab
	4.00	+ 0.161a	+ 0.2483ab	- 0.161a	- 0.2483ab

Table 10: Effect of intercropping pattern, foliar fertilization level and their combination treatments on competitive ratio between safflower and fenugreek components during 2013/2014 and 2014/2015 seasons

Treatments		Competitive ratio (CR)			
		CR of safflower		CR of fenugreek	
		First season	Second season	First season	Second season
Intercropping pattern (safflower: fenugreek)					
1 : 1		1.136A	1.136A	0.882B	0.888A
1 : 2		1.088B	1.159A	0.948A	0.816A
1 : 3		1.058B	1.235A	0.923A	0.826A
Foliar fertilization level (g/l)					
0.00		1.103A	1.150A	0.912A	0.838A
2.00		1.086A	1.174A	0.922A	0.863A
4.00		1.092A	1.206A	0.919A	0.830A
Intercropping	Fertilization level (g/l)	Intercropping patterns × Foliar fertilization level			
1 : 1	0.00	1.148a	1.021b	0.873b	0.980a
	2.00	1.134a	1.154ab	0.889b	0.869a
	4.00	1.126a	1.234ab	0.883b	0.813a
1 : 2	0.00	1.082ab	1.069b	0.929ab	0.768a
	2.00	1.082ab	1.224ab	0.925ab	0.840a
	4.00	1.010b	1.184ab	0.990a	0.841a
1 : 3	0.00	1.078ab	1.360a	0.934ab	0.766a
	2.00	1.052ab	1.145ab	0.953ab	0.878a
	4.00	1.133a	1.199ab	0.883b	0.834a

Conclusion

The above mentioned results demonstrate that on plant level the highest seed yields and active ingredient contents of both crops were belonged to intercropping patterns of 1:2 or 1:3 (safflower :fenugreek) sprayed with 4 g/l Garlovit. Also, intercropping advantage indices (LER, ATER and LUE) supported this result since the above mentioned treatments were more advantageous than other treatments and seems promising in the development of sustainable both crops production with a limited use of external inputs.

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