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Effect of Iron and Zinc Foliar Application and Plant Spacing on Productivity of Oil Lettuce (*Lactuca scariola var. Oleifra*) in Calcareous Soils

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ABSTRACT

Field trials were carried out during 2016/17 and 2017/18 growing seasons at Mariout Experimental Station, Desert Research Center, Egypt, to investigate the effect of foliar application with iron and zinc (control, 150 mg iron /L, 100 mg zinc /L and 150 mg iron + 100 mg zinc /L) and different plant distances (10, 20 and 30 cm between plants) on growth, yield and yield components as well as oil content of prickly oil lettuce under calcareous soil conditions. The experimental design was a split plot, whereas the main plots involved iron and zinc treatments and the sup main plots involved plant distances. The obtained results cleared that iron and zinc foliar application significantly affected on all traits, except number of branches/plant and harvest index, also plant spacing significantly affected on all traits, except plant height and 1000-seed weight during the two seasons, respectively. The interaction between iron and zinc foliar application and plant spacing had significant effects on all traits as an average for both seasons. Foliar application of iron and zinc together as a combination treatment caused an increase in all yield traits as compared with untreated plants in both seasons. Increasing the distance between plants from 10 to 20 and/or 30 cm significantly decreased seed yield/fad and seed yield/plant in both seasons. Oil percentage was increased when plants were transplanted at 20 cm a part. However, the oil yield was gradually decreased by increasing the distance between plants up to 30 cm. In general oil lettuce plants which treated by150 mg iron + 100 mg zinc /L and transplanted at 10 cm a part produced the highest values of seed and oil yield.

Keywords: Oil lettuce, yield, quality, plant spacing, iron and zinc application.

INTRODUCTION

Prickly oil lettuce (*Lactuca scariola* var. *oleifra*) is an erect annual herb belonging to the family Asteraceae. It has been cultivated in Upper Egypt since ancient times to its higher content of oil. Nowadays, oil lettuce was cultivated in limited area in Upper Egypt as a winter oil crop by intercropping with the other crops, and then it may be good id**e**a to increase its cultivated area at North Egypt, especially in new regions. Foliar application with nutrients and plant population are most important for crop production as well as for seed quality. Some researchers reported that seed yield faddan was increased by increasing plant population (Mekki *et al*., 1998 on oil lettuce (*Lactuca scariola* L.) and Sampaio *et al*., 2017 on safflower). However, seed yield/plant as well as 100-seed weight of sunflower was reduced as plant population decreased (El-Hity *et al*., 1994 and Nasr-Allah *et al*., 1994). Seed oil content was affected by different plant spacing (Kene *et al*., 1992 on sunflower, Mekki *et al*., 1998 on oil lettuce and Sampaio *et al*., 2017 on safflower).

Foliar spraying is a new method for crop feeding in which micronutrients in the form of liquid are used into leaves (Nasiri *et al*., 2010). Micronutrients are defined substances that are crucial for crop growth, they have a major role in cell division and development of meristematic tissues, photosynthesis, respiration and acceleration of plant maturity. One of the most important roles of micronutrients is keeping balanced crop physiology. Zinc and iron take over different roles in crop, such as formation, partitioning and utilization of photosynthesis assimilates. Growth limitation, symbiosis, nodulation, photosynthesis, dry matter production and plant nutrient disorder were caused due to lack of zinc and iron.

Therefore, the present study aimed to investigate the response of oil lettuce yield and seed quality to foliar application with iron and zinc and different plant spacing under calcareous soil conditions.

MATERIALS AND METHODS

Field trials were conducted during 2016/17 and 2017/18 growing seasons at Mariout Experimental Station, Desert Research Center, Egypt, to investigate the role of iron and zinc foliar application and the distance between plants on the yield and its compounds as well as oil content of prickly oil lettuce (*Lactuca scariola* var. *oleifra*) under transplanting conditions at calcareous soil. Each experiment included 12 treatments, which were the combinations of four treatments of iron and zinc foliar application and three distances between plants.

Iron and zinc foliar application:

1-Without iron and zinc (control).
2-150 mg iron /L in the form of EDTA chelate (13%).
3-100 mg zinc/L in the form of EDTA chelate (13%).
4-150 mg iron /L + 100 mg zinc/L in the form of EDTA chelate (13%).

Plants were sprayed with iron and zinc twice, at flowering stage and three weeks later.

Plant distance:

1-10 cm between plants (70,000 plants/faddan).
2-20 cm between plants (35,000 plants/faddan).
3-30 cm between plants (23,333 plants/faddan).

The plot area was 10.5 m^2 *i.e.* 1/400 faddan, contained of 5 rows, 3.5 m in length and 60 cm a part.

The nursery land was well prepared. Seeds of oil lettuce, which mainly collected from Upper Egypt (Esna) as local variety, were drilled in the nursery on 27th October and 5th November in the first and second seasons, respectively.

The seedlings were transplanted after thirty days old on 27^{the} November and 5th December in the first and second seasons, respectively. Nitrogen fertilizer at the rate of 50 kg N/fad was added as two equal portion supplied from ammonium nitrate (33.5% N), the first portion was added after 30 days from transplanting and the second one was added in 3 weeks later.

A representative samples were taken during the growth period (90 days from transplanting), *i.e.* six guarded plants were chosen at random from second and fourth ridges of each plot to determinate the following traits:

Growth characters:

-Plant height (cm).
-Number of branches/plant.
-Plant fresh weight (g).
-Plant dry weight (g).
- Leaf area/plant (cm^2): It was determined by using a digital planimeter.

- Leaf area index (LAI) = $\frac{\text{Leaf area/plant}}{\text{Land area/plant}}$

according to (Watson, 1952).

Yield and yield components:

Plants were harvested on 28th May and 14th April 14, in the first and second seasons, respectively, to record the following traits:

-1000-seed weight (g).
-Seed yield/plant (g).
-Seed yield/fad (kg).
- Straw yield /fad (kg).
- Biological yield/fad (kg).

Biological, straw and seed yield were determined on the basis of per sub plot.

- Harvest index (%) = $\frac{\text{Seed yield (kg/fad)}}{\text{Biological yield (kg/fad)}}$

- Oil percentage. Oil seed percentage was determined according to the method described in the official and tentative methods in the American oil chemist (A.O.C.S., 1964) by using a Soxhlt apparatus.
- Oil yield/fad (kg). Oil yield/fad was calculated by multiplying seed yield (kg/fad) by seed oil percentage.

Statistical analysis:

The treatments were arranged and analyzed as a split plot design according to (Snedecor and Cochran, 1969) with three replicates, whereas the main plots were occupied by iron and zinc foliar application treatments and the sup main plots were devoted to plant distance treatments, New L.S.D. test at the level of 5% of significance was used for the comparison between means according to (Waller and Duncan, 1969).

Table 1. Some physical and chemical properties of the experiment soil (averages of the two growing seasons)

Particle size distribution			Texture class	Chemical Analysis					
Sand (%)	Silt (%)	Clay (%)		pH	EC ds/m	$CaCo_3$ (%)	Available ppm		
							N	P	K
52	19	29	Sandy clay loam	8.3	1.2	24.1	366.1	3.5	697.0

RESULTS AND DISCUSSION

A. Effect of iron and zinc foliar application:

Growth characters:

The results presented in Table 2 illustrated that plant height, plant fresh weight, plant dry weight, leaf area/plant and leaf area index were significantly affected by foliar application with iron and zinc in the first and second seasons. Spraying oil lettuce plants with combined application of 150 mg iron/L and 100 mg zinc /L together increased the previous studied traits by 3.46, 9.56, 8.79, 4.87 and 5.49 %, respectively, as an average for both seasons compared with untreated planted (without iron and zinc application). On the other side, number of branches was not affected significantly by using foliar application with iron and zinc in the two seasons, respectively as shown in Table 2. Such increases in these growth traits may be due to the interaction effect of zinc and iron on metabolic activities like synthesis of IAA, metabolism of auxins and synthesis of nitrate reductase enzyme in plant. These findings are at line with those obtained by El-Foully *et al.* (2001) on sunflower, Kassab (2005) on mung bean, Ravi *et al.* (2008) on safflower, Babaeian *et al.* (2011) and Farokhi *et al.* (2014) on sunflower whom, indicated that growth parameters *i.e.* plant height, leaf area/plant and leaf area index were influenced significantly by combined application of iron and zinc as a foliar spray. Nassrin *et al.* (2012) on corn detected that iron and zinc spraying at 3 and 4 mg/L were effective on plant height, leaf area index, and total dry weight. Also, Taha *et al.* (2013) evaluated growth and biological yield of safflower treated with iron and zinc foliar application. He found that the vegetative growth characters (plant height, number of primary and secondary branches) were significantly affected by the foliar application. Foliar application by Zn at 0.6% significantly promoted the plant height, followed by application by the combination between Fe: Zn at 0.3 : 0.6%.

Yield and yield components:

Significant effects were detected due to iron and zinc foliar application on 1000-seed weight, seed yield/plant, seed yield/fad, straw yield/fad and biological yield/fad (Tables 3 and 4) in the first and second seasons. On the other side, harvest index had not significantly affected by foliar application with iron and zinc for both seasons. Seed yield/fad was increased by 14.03 and 10.91 % when oil lettuce plants sprayed with 150 mg iron + 100 mg zinc /L compared with untreated plants (control) during the first and the second seasons, respectively. Such increases in seed yield/fad may be due to the increase in seed yield/plant and seed index (1000-seed weight) under both conditions of iron and zinc application. This means that the addition of iron and zinc as a foliar application plays an important role in enhancing of enzymatic activity in microelement, which effectively increased photosynthesis and ultimately translocation of assimilates to the seed. Regarding straw and biological yield /fad, the increase was 14.40 and 11.97% for straw yield and 14.37 and 11.83% for biological yield during the first and the second seasons, respectively. These results agreed with those reported by Kassab (2005) on mung bean, Ravi *et al.* (2008), Elnaz *et al.* (2010) and Babaein *et al.* (2011) on sunflower. They pointed out that foliar application of micronutrients (iron and zinc) in growth various stages of sunflower had significant positive effect on 1000-seed weight, plant height, biological yield, seed yield and oil content. Mostafavi (2012) and Ghavami *et al.* (2015) on safflower reported that iron and zinc foliar application had positive effects on seed yield and its components compared with untreated plants. Also, Elnaz *et al.* (2010) found that the highest seed yield and 1000-seed weight were obtained from foliar application of iron + zinc treatments.

Table 2. Averages of plant height, plant fresh weight, plant dry weight, leaf area /plant and leaf area index as affected by iron and zinc foliar application and plant spacing in 2016/2017 and 2017/2018 seasons

Characters Treatments	2016-2017 season						2017-2018 season					
	Plant height (cm)	Number of branches/ plant	Plant fresh weight (g)	Plant dry weight (g)	Leaf area/plant (cm^2)	Leaf area index	Plant height (cm)	Number of branches/ plant	Plant fresh weight (g)	Plant dry weight (g)	Leaf area/plant (cm^2)	Leaf area index
(A):												
A 0	97.67	3.29	472.03	59.00	2775.0	2.62	98.60	3.32	487.94	60.33	2788.3	2.62
A 1	99.60	3.29	493.32	61.67	2822.5	2.67	100.33	3.31	501.24	61.99	2853.2	2.70
A 2	99.48	3.28	479.50	60.04	2812.8	2.65	100.02	3.32	481.69	58.30	2848.7	2.69
A 3	101.69	3.30	515.53	64.44	2897.0	2.75	101.36	3.31	536.28	65.37	2937.3	2.78
New L.S.D. $_{(0.05)}$	2.29	N.S	8.18	1.06	41.8	0.02	2.06	N.S	12.73	1.76	46.4	0.02
(B):												
B 1	99.96	2.99	319.48	39.96	2221.9	3.70	100.33	3.04	345.56	42.63	2246.5	3.74
B 2	99.36	3.37	503.06	62.91	3004.0	2.50	100.01	3.39	505.79	62.66	3022.8	2.52
B 3	99.50	3.51	647.74	80.99	3254.6	1.81	99.89	3.53	654.02	79.19	3301.4	1.83
New L.S.D. $_{(0.05)}$	N.S	0.05	11.34	1.13	22.4	0.04	N.S	0.01	6.92	0.97	24.8	0.01

(A) Means iron and zinc foliar application.
(B) Means plant spacing.
A 0 means without iron and zinc foliar application.
A 1 means 150 mg iron /L.
A 2 means 100 mg zinc /L.
A 3 means 150 mg iron +100 mg zinc /L.
B 1 means 10 cm between plants.
B 2 means 20 cm between plants.
B3 means 30 cm between plants.
*** Means significant at 0.05 % level and N.S means not significant.**

Table 3. Averages of plant branches number, 1000-seed weight, seed yield/plant, seed yield /fad and straw yield /fad as affected by iron and zinc foliar application and plant spacing in 2016/2017 and 2017/2018 seasons

Characters Treatments	2016-2017 season				2017-2018 season			
	1000-seed weight (g)	Seed yield /plant (g)	Seed yield /fad (kg)	Straw yield /fad (kg)	1000-seed weight (g)	Seed yield /plant (g)	Seed yield /fad (kg)	Straw yield /fad (kg)
(A):								
A 0	0.92	7.98	306.08	2079.3	0.96	8.48	311.73	2104.3
A 1	0.99	8.56	331.11	2242.1	1.02	9.04	333.80	2252.7
A 2	0.98	8.47	326.66	2211.1	1.00	9.00	329.22	2228.4
A 3	1.07	9.34	349.03	2378.3	1.12	9.67	345.75	2356.1
New L.S.D. $_{(0.05)}$	0.06	0.02	9.89	4.8	0.02	0.21	13.96	5.8
(B):								
B 1	1.01	7.99	367.13	2529.6	1.04	8.15	373.82	2567.4
B 2	0.98	9.13	321.45	2164.5	1.01	10.01	326.65	2204.1
B 3	0.99	8.65	297.33	1987.9	1.03	8.98	289.90	1934.6
New L.S.D. $_{(0.05)}$	N.S	0.21	11.15	1.9	N.S	0.25	11.42	1.8

(A) Means iron and zinc foliar application.
(B) Means plant spacing.
A 0 means without iron and zinc foliar application.
A 1 means 150 mg iron /L.
A 2 means 100 mg zinc /L.
A 3 means 150 mg iron +100 mg zinc /L.
B 1 means 10 cm between plants.
B 2 means 20 cm between plants.
B3 means 30 cm between plants.
*** Means significant at 0.05 % level and N.S means not significant.**

Seed oil content as well as oil yield/fad were significantly affected when plants treated with iron and zinc application together (Table 4). The addition of iron and zinc as foliar application caused significant increases in both seed oil content and oil yield/fad Oil yield was increased by 15.86 and 12.46 % when plants were sprayed with 150 mg iron + 100 mg zinc /L compared with untreated plants (control treatment) in both seasons, respectively. Such increase in oil yield may be due to the increase of seed yield/fad and seed oil content under the conditions of foliar application because oil content behaved the opposite trend with seed yield. Similar observations were reported by Elnaz *et al.* (2010) on sunflower, Galavi *et al.* (2012) on safflower, Ghavami *et al.* (2015) on safflower and Farokhi *et al.* (2014) on sunflower, whom found that oil yield and percentage significantly affects due to foliar application of iron and zinc. Elnaz *et al*. (2010) found that the highest oil yield and oil percentage were obtained from foliar application of iron + zinc treatments. Galavi *et al*. (2012) on safflower illustrated that foliar application of iron and zinc had a significant effect on seed and biological yield, 1000-seed weight and seed oil percentage, but the harvest index was not significantly influenced by applied treatments. Kassab (2005) indicated that foliar application of Zn and Fe significantly increased yield and its components of mung bean plants. Also, Kumar (2016) on safflower reported that foliar spry with iron and zinc significantly increased seed and oil yield by 28.24 and 34.75 percent, respectively.

B. Effect of plant spacing:

Growth characters:

Data in Table 2 cleared that the effects of plant spacing were significant on all the studied characters *i.e.* number of branches/plant, plant fresh and dry weight, leaf area/plant and leaf area index in both seasons. These characters significantly increased by increasing the distances between oil lettuce plants from 10 to 20 and 30 cm by 12.03 and 4.15% for number of branches/plant, 51.91 and 29. 03 % for plant fresh weight, 52.20 and 27.56 % for plant dry weight, 34.88 and 8.78 % for leaf area/plant as an average of both seasons, respectively. On the other hand, leaf area index was decreased by increasing the distances between plants from 10 to 20 or 30 cm, whereas plants transplanted at 10 cm a part recorded the highest values of leaf area index in both seasons. This decreasing in leaf area index due to increase in plants spacing may be due to the decreasing of number of plants per unit area and leaf area/plant compared to land area/plant at the same distance conditions. Plant height had not significantly affected by destines between plants (Table 2) in both seasons. The reduction in vegetative growth of lettuce due to increasing plant density (decreasing the distances between plants) was attributed to inter and intra-plant competition for light, nutrients and water necessary for growth and development. These results are at line with those obtained by Qayyum (1988) on safflower, who reported that narrow row spacing is favored almost all the growth characteristics. Singh (1994) concluded that growth parameters of safflower crop are significantly influenced by plant populations. Osman and Awed (2010) found that plant spacing had significant effects on sunflower growth characteristics. Emongor *et al*. (2015) showed that plant density had significant effects on growth and development of safflower, and stated that increasing safflower plant density from 100,000 to 250,000 plants ha^{-1} significantly reduced branches number/plant and leaf area/plant.

Also, Sampaio *et al*. (2017) on safflower showed that increasing densities reduce the number of branches.

Yield and yield components:

Data presented in Tables (3and 4) clear that plants which transplanted at 10 cm a part had the highest seed, straw and biological yield /fad in the two seasons, respectively. Seed yield/fad was decreased by 12.53 and 9.38 % when the distance between plants was increased from 10 to 20 or 30 cm as in average of both seasons, respectively. This means that wide space resulted in less number of plant/unit area which caused a depression of seed yield (kg/fad). However, seed yield/plant (g) was also significantly affected by plant spacing in both seasons. The highest seed yield/plant was observed when plants were transplanted at 20 cm a part, but it was significantly reduced when the distance between plants was increased up to 30 cm. The high seed yield/plant at 20 cm between plants could be explained by the less competition between plants compared with 10 cm between plants and also, may be due to less competition of weeds, which extracted more nutrients when distance between plants was increased from 20 to 30 cm. Some workers reported that seed/unit area was reduced by increasing the distance between hill in sunflower and safflower plants (Kandil *et al*., 1987; Abo-Shetaia 1990; zaffaroni and Schneiter, 1991; Parmar and Kharwara, 1992 and Mekki and Hassanein, 1995). Also, Mikke *et al*., 1998 reported the similar findings on oil lettuce (*Lactuca scariola* L.). They pointed out that seed yield was decreased when the distance between plants was increased, whereas seed index was not significantly affected by the distance between plants. Concerning straw and biological yield, the decreasing in these traits due to increasing the distance between plants may be due to the decreasing of plants number/unit area. Harvest index behaved the opposite trend, it was increased significantly by increasing the distance between plants from 10 to 20 up 30 cm a part, whereas maximum values was achieved at distance 30 cm between plants (Table 4) for two seasons, respectively. On the other side, seed index (1000 seed weight) was not significantly affected by the distance between plants (Table 3) during both seasons.

Data in Table 4 also cleared that 20 cm plant distances resulted significantly higher oil percentage compared with 10 or 30 cm. However, oil yield/fad was gradually decreased with increasing plant spacing from 10 to 20 and/or 30 cm such depression in oil yield was estimated by 8.48 and 12.91kg/fad when the distance between plants was increased from 10 to 20 and/or 30 cm as an average of two seasons, respectively. This means that low plant population resulted in a reduction of oil yield through the reduction in seed yield/unit area (Tables 3 and 4). Some workers reported that increasing space between hills decreased oil % (Zaffaroni and Schneiter, 1991). However, Kene *et al*. (1992) and Nasr-Allah *et al.* (1994) found that the lowest values of oil % was recorded with 30 cm a part and the highest values of oil yield/fad was obtained with 20 cm between sunflower plants. These results are in harmony of these recorded by Osman and Awed (2010) on sunflower, whom found that plant spacing had a significant effects on sunflower yield and yield components *i.e.* 100-seed weight, seed yield per plant , oil percentage and oil yield in the two seasons. They added, 10 cm plant spacing for seed and oil yield, it appears that it could be recommended for producing desirable yield. Mekki *et al*. 1998 showed that oil percentage and yield of oil lettuce were significantly affected by the distance between plants. Mohamadzadeh *et al*. (2011) on safflower showed that grain yield and its components influenced by row spacing were significant. Also, Sampaio *et al*. (2017) on safflower showed that increasing densities caused an increase in the productivity of grains and oil. Opposite results were observed by Masoume *et al*. (2011) whom, reported that safflower grain yield and its yield components influenced by row spacing were significant. Row spacing of 30 cm had the highest seed yield (1214 kg/ha) and biological yield (3562 kg/ha).

Table 4. Averages of biological yield /fad, harvest index, oil % and oil yield/fad as affected by iron and zinc foliar application and plant spacing in 2016/2017 and 2017/2018 seasons

	2016-2017 season				2017-2018 season			
Characters Treatments	**Biological yield /fad (kg)**	**Harvest index (%)**	**Oil (%)**	**Oil yield /fad (kg)**	**Biological yield /fad (kg)**	**Harvest index (%)**	**Oil (%)**	**Oil yield /fad (kg)**
(A):								
A 0	2385.2	12.85	33.59	102.84	2416.0	12.90	33.68	104.90
A 1	2573.5	13.08	33.80	111.63	2586.5	13.07	33.89	112.73
A 2	2537.5	13.01	33.84	110.59	2557.6	13.04	33.75	111.10
A 3	2727.9	12.78	34.14	119.15	2701.9	12.74	34.19	117.97
New L.S.D. $_{(0.05)}$	24.1	N.S	0.02	7.71	15.9	N.S	0.02	4.41
(B):								
B 1	2896.8	12.71	32.67	119.99	2941.3	12.74	32.80	122.65
B 2	2486.0	12.98	34.83	111.98	2530.7	12.95	34.81	113.70
B 3	2285.2	13.09	34.03	101.20	2224.5	13.12	34.03	98.67
New L.S.D. $_{(0.05)}$	12.7	0.35	0.01	3.34	10.5	0.36	0.01	3.79

(A) Means iron and zinc foliar application.
(B) Means plant spacing.
A 0 means without iron and zinc foliar application.
A 1 means 150 mg iron /L.
A 2 means 100 mg zinc /L.
A 3 means 150 mg iron +100 mg zinc /L.
B 1 means 10 cm between plants.
B 2 means 20 cm between plants.
B3 means 30 cm between plants.
*** Means significant at 0.05 % level and N.S means not significant.**

C. Effect of the interaction:

Regarding the interaction, combined data showed that all previous studied characters had significantly affected by the interaction between plant spacing and foliar application of iron and zinc as an average for both seasons. Whereas the highest mean values of plant height and seed yield/plant were recorded when plants were transplanted at 20 cm a part and sprayed with 150 mg iron + 100 mg zinc /L. Maximum values of plant fresh and dry weight and leaves area per plant were observed at distance 30 cm between plants and sprayed with 150 mg iron + 100 mg zinc /L. Maximum mean values of leaf area index, seed and oil yield/fad were detected at 10 cm distance and 150 mg iron + 100 mg zinc /L, as for seed index and the highest mean values was observed by plants which transplanted at 10 or/and 30 cm distance between plants with applying 150 mg iron + 100 mg zinc /L. Transplanting oil lettuce plants at 10 cm between plants and treating with 150 mg iron /L without zinc application recorded the maximum mean values of biological and straw yield per fad. The highest mean value of harvest index was observed at 30 cm distance and 100 mg zinc /L without iron application. Oil lettuce plants which transplanted at 20 cm a part and treated with 100 mg zinc /L without iron recorded the highest mean value of oil percentage (Table 5).

Table 5. The interaction effect between iron and zinc foliar application and plant spacing on all studded characteristics as an average for both seasons

Characters Treatments		**P.H. (cm)**	**B.N. /P.**	**P.F. W. (g)**	**P.D W. (g)**	**L.A/P. (cm^2)**	**L.A.I.**	**1000 S.W. (g)**	**S.Y. /P. (g)**	**S.Y. /F. (kg)**	**St.Y. /F. (kg)**	**Bi.Y. /F. (kg)**	**H.I. (%)**	**O. (%)**	**O. Y. /F. (kg)**
	B1	99.3	2.97	325.7	40.7	2165	3.61	0.96	7.50	335.3	2234	2569	13.05	32.66	109.5
A0	B2	98.1	3.34	489.1	61.1	2946	2.46	0.93	8.99	308.3	2130	2438	12.65	34.44	106.2
	B3	97.0	3.60	625.1	77.1	3234	1.80	0.94	8.19	283.6	1911	2195	12.92	33.82	95.9
	B1	99.9	3.06	332.5	41. 6	2240	3.73	1.02	8.08	374.6	2855	3229	11.60	31.89	119.5
A1	B2	100.0	3.37	506.3	63.3	3013	2.51	0.99	9.56	327.2	1954	2282	14.34	35.03	114.6
	B3	100.0	3.49	653.1	80.6	3261	1.81	1.01	8.77	296.0	1933	2229	13.28	34.62	102.5
	B1	101.9	3.00	323.3	39.8	2218	3.70	1.00	7.95	364.9	2545	2910	12.54	33.14	120.9
A2	B2	98.1	3.39	483.6	59.9	3002	2.50	0.98	9.53	325.1	2384	2709	12.00	35.09	114.1
	B3	99.3	3.52	634.9	77.8	3273	1.82	1.00	8.73	294.1	1730	2024	14.53	33.16	97.5
	B1	99.5	3.04	348.7	43.1	2314	3.86	1.11	8.74	407.1	2561	2968	13.72	33.26	135.4
A3	B2	102.6	3.42	538.6	66.8	3094	2.58	1.07	10.20	335.5	2270	2605	12.88	34.72	116.5
	B3	102.5	3.47	690.4	84.8	3345	1.86	1.11	9.57	300.8	2271	2572	11.70	34.52	103.8
New L.S.D $_{0.05}$		2.5	0.16	13.5	1.7	42.5	0.10	0.02	0.28	11.7	3.6	13.4	0.44	0.07	3.9

(A) Means iron and zinc foliar application.
(B) Means plant spacing.
A 0 means without iron and zinc foliar application , A 1 means 150 mg iron /L, A 2 means 100 mg zinc /L and A 3 means 150 mg iron +100 mg zinc /L.
B 1 means 10 cm between plants, B 2 means 20 cm between plants and B3 means 30 cm between plants.
P.H. means plant height, B.N./P. means number of branches/plant, P.F.W. means plant fresh weight, P.D.W. means plant dry weight, L.A/P. means leaf area/plant, L.A.I. means leaf area index, 1000 S.W.means1000 seed weight, S.Y./P. means seed yield /plant, S.Y./F. means seed yield /fad, St.Y./F. means straw yield /fad, Bi.Y./F. means biological yield /fad, H.I. means harvest index, O. means oil percentage and O. Y./F. means oil yield /fad.

CONCLUSION

It could be recommended that iron and zinc foliar application and plant spacing had a valuable on yield, yield components, oil percentage and oil yield of oil lettuce under the conditions of this study, whereas the maximum mean values of seed and oil yield (407.1 and 135.4 kg/fad) respectively, were obtained when plants were transplanted at 10 cm a part and sprayed with 150 mg iron + 100 mg zinc /L together, while the highest mean value of oil percentage (35.09 %) was recorded at 20 cm a part and applying 100 mg zinc /L without iron as an average of both seasons (Table 5).

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تاثير الرش الورقى بالحديد والزنك ومسافات الزراعة على انتاجية خس الزيت بالأراضى الجيرية

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أجريت تجربتان حقليتان خلال الموسمين الشتويين ٢٠١٧/٢٠١٦ و٢٠١٧/ ٢٠١٨ بمحطة بحوث مريوط التابعه لمركز بحوث الصحراء لدراسة تأثير الرش الورقى بالحديد والزنك المخلبى (بدون رش حديد وزنك، ١٥٠ ملليجم حديد/لتر، ١٠٠ ملليجم زنك/لتر، ١٥٠ ملليجم حديد + ١٠٠ ملليجم زنك/لتر) و مسافات الزراعة (١٠، ٢٠، ٣٠ سم بين النباتات) على بعض الصفات الخضرية والمحصول ومكوناته ومحتوى الزيت فى خس الزيت. صممت التجربة فى نظام القطع المنشقة حيث شغلت معاملات الرش الورقى بالحديد والزنك القطع الرئيسية بينما وزعت المسافات بين النباتات على القطع الشقية فى ثلاث مكررات. أوضحت النتائج وجود تأثير معنوى لمعاملات الرش الورقى بالحديد والزنك على كل الصفات التى تم تناولها فى هذه الدراسة عدا صفتى عدد الأفرع/نبات و دليل الحصاد أيضا كان هناك تأثير معنوى للمسافات بين النباتات على كل الصفات التى تم دراستها عدا صفتى ارتفاع النبات و وزن الـ١٠٠٠ بذرة وذلك خلال موسمى الزراعة. تأثرت كل الصفات تحت الدراسة معنويا بالتداخل بين الرش الورقى بالحديد والزنك و المسافات بين النباتات كمتوسطات قيم للموسمين. أدى الرش بمزيج من الحديد والزنك بمعدل١٥٠ ملليجم حديد + ١٠٠ ملليجم زنك/لتر إلى زيادة معنوية فى كل مكونات المحصول مقارنة بعدم الرش بأى منهما فى كلا الموسمين. انخفض محصول البذور/فدان بزيادة المسافة بين النباتات حتى ٣٠ سم وتحققت أعلى نسبة زيت عند الزراعة على مسافة ٢٠ سم بين النباتات فى حين انخفض محصول الزيت تدريجيا بزيادة مسافة الزراعة حتى ٣٠ سم وذلك خلال موسمى الزراعة. بصفة عامة أعطت نباتات خس الزيت المعاملة بـمزيج من ١٥٠ ملليجم حديد + ١٠٠ ملليجم زنك/لتر والمنزرعة على مسافة ١٠ سم أعلى قيم لمحصول البذور ومحصول الزيت تحت ظروف هذه الدراسة.