J. Agric. Sci. Mansoura Univ., 28 (9): 6865 - 6877, 2003

RESPONSE OF *Carum carvi* L. FRUIT AND ESSENTIAL OIL YIELD TO SOWING METHOD , PLANTING DISTANCES AND SOME MICRONUTRIENT APPLICATION METHODS

Ghaly, N. G.; F. R. Moussa and S. I. Younis
Med. and Arom. Plant Dept., Hort. Res. Inst., Agricultural Research Center

ABSTRACT

Two field trials were conducted during 1998 / 1999 and 1999 / 2000 at El-Gimiza Research Station Farm, to study the effect of sowing method (at one side of the ridge or both sides of the ridge), two planting distances (20 or 30 cm) and some micronutrients (mixture of Zn , Mn and Fe) as seed coating or foliar spray on the growth, fruit and oil yield and essential oil constituents of Carum carvi L.

The data showed that the vegetative growth and fruit yield/plant significantly increased with sowing plants at one side of the ridge and wide space of 30 cm, each alone. Where the fruit and oil yield / fed, significantly increased by sowing plants at both sides of the ridge and narrow space of 20 cm, each alone. Essential oil percentage was not affected by sowing method or spacing. The micronutrients (Mixture of Zn, Mn and Fe) increased the growth, fruit and oil yield and essential oil percentage, but seed coating exerts more beneficial effects compared to folair method. The interaction between sowing methods and spacing significantly increased vegetative growth and fruit and oil yield / fed. Carvon was the major constituent of the essential oil forming more than 75%, carvon and limonene slightly decreased by micronutrients application.

The best treatment for fruit (seed) and oil yield was that of coating seed with a mixture of Zn, Mn and Fe and spacing it at 20 cm in both sides of the ridge.

INTRODUCTION

Carum carvi L. belongs to family -, it is a biennial herb but in Egypt, it is annual crop. The fruits (seed) have a nice, spicy, aromatic odours and aromatic taste, the main use of caraway seed oils, is in the flavoring of all kind of food products. e. g., meats, sausages, canned goods; it is employed in pickle compounds, confectionery, oil of caraway seed is considered a mild stomachic and carminative.

Crops grown on both sides of the ridges appears to be useful for increasing seed yield / fed. In this concern, Kamel *et al.*, (1992) found that planting anise on both sides of the ridge (70000 plant / fed) gave highest values of seed yield comparing with the plants grown on one side of the ridge (35000 plant / fed).

Many investigators concerned with the effect of plant density, Mohamed (1997) found that the highest yield of oil per feddan of thyme plant was obtained from the highest density plants and decreased gradually with decreasing the plant density. Kotb *et al.* (1998) showed that the plant height of *Nigella Sativa L.*, branches number, seed yield per plant, per plot and volatile oil percentage were significantly increased by increasing planting

distances. Gill *et al.* (1999), Reddy and Rolston (1999) found that the umbels and seeds per plant of coriander were declined with the increase in plant density in row spacing.

Microelements are needed in relatively very small quantites for good plant growth, their deficiencies cause great disorders in the physiological and metabolic processes of the plant (Kanwer and Dhingra, 1962).

Abd El-Salam (1999) on fennel and Khattab and Omer (1999) on caraway indicated that spraying plants with microelements (Zn, Mn and Fe) caused a highly significant increase in plant growth, fruits yield, volatile oil content and the major oil constituents of caraway (carvone). Also Refaat and Balbaa (2001) found that spraying lemongrass plants with microelements (Zn, Mn and Fe) were beneficial for increasing plant height, essential oil percentage and oil yield.

The efficiencies of micronutrients fertilization are mainly dependent on the method of application and source of micronutrient fertilization, in this regard, Osman *et al.*, (1990) in a field experiment of faba bean using Fe, Mn and Zn chelates by the methods of seed coating, found that this method was efficient for correcting the requierment and suitable balance between such nutrients in alluvial slightly alkaline soils for growth, uptake and high yield production. Hegazy *et al.* (1992) found that the highest faba bean seed yields were obtained by adding the mixture of micronutrients (Zn, Mn and Fe) using seed coating. Gangwar and Singh (1994) found that application of Zn to lentil plants as seed coating or foliar spray resulted in increasing seed yield, this increase was significant by seed coating method, Negm *et al.*, (1997) on pea indicated that seed yields were increased by micronutrients (Zn, Mn and Fe Chelates) either by seed coating or foliar application. Seed coating exerts more beneficial effectes compared to foliar application.

The objective of this study was to evaluate the yield of fruits (seed), essential oil and the constituents of essential oil of caraway as affected by sowing. method , spacing and micronutrients (Zn , Mn and Fe) either by seed coating or by foliar application.

MATERIALS AND METHODS

This experiment was conducted in the Experimental Farm of the Agricultural Research Station at El-Gimiza for two successive seasons 1998 / 1999 and 1999 / 2000 to study the effect of sowing method, spacing and some micronutrients fertilization as seed coating or foliar spray on caraway plant. Seeds (fruits) of caraway (*Carum carvi L.*) were obtained from the Medicinal and Aromatic Plants Section, El-Dokki, ARC. Soil samples were analyzed, the levels of available N, P, K, Zn, Mn and Fe as ppm were found to be 26, 7.8, 600, 1.2 , 8.0 and 12.0 ppm, in a respective order. The pH of the soil water suspension was 8.0 and the E.c. was 1.88 d s/m.

Seeds were sown on 3 rd and 5th November in the first and second seasons, respectively. Each plot contained 5 rows, the width of the ridge was 60 cm. apart and the length was 3.5 m^2. Split - Split - plots design with three replicates was followed in this experiment, sowing methods were main plots,

spacing were sub-plot, while micronutrients (Zn + Mn + Fe) application methods were sub - sub plot.

The main plots were as follows :

1- Planting caraway on one side of the ridge.
2- Planting caraway on both sides of the ridge.

The sub – plots were as follows :

1- Spaced caraway at 20 cm between plants.
2- Spaced caraway at 30 cm between plants.

The sub - sub plots were as followes :

1- Control (untreated plants).
2- Coating seed with mixture (2g of Zn EDTA + 2g of Mn EDTA + 2g of Fe EDTA) were used per one kg of caraway seeds (EDTA i. e. Ethyline Diamine Tetra acetic acid)
3- Spraying plants with mixture of (Zn EDTA, Mn EDTA and Fe EDTA) each one at 100ppm concentration.

Mixture of Zn, Mn and Fe solution was sprayed twice, 30 and 45 days after sowing.

The plants were fertilized at the rate of, 300 kg / fed calcium supper phosphate (15.5% P_2O_5), 50 kg / fed. potassium sulphate (48% K_2O) and half amount of ammonium sulphate (200 kg / fed 20.5% N) was added after one month from planting and the second (200 kg / fed 20.5% N) one month later. Thinning (for one plant per hill) was conducted 30 days after sowing.

Sample of plants of every treatment was taken at harvesting time and the following growth characters were recorded. Plant height (cm), number of branches per plant, number of umbels per plant, seed yield per plant (g) and per feddan (kg), essential oil percentage (V / W) according to Guenther (1961), oil yield (L. / fed.) and determination of essential oil constituents was done by gas liquid chromatography (G.L.C). Statistical analysis was carried out according to Snedecor and Cochran (1972).

RESULTS AND DISCUSSION

1- Plant hieght :

Data presented in Tables (1A and B) clearly showed that, sowing plants at one side of the ridge resulted in the tallest plants which was 124.3 and 122.1 cm against 115.6 and 113.8 cm for both sides of the ridge during the two seasons, respectively.

Also, the tallest plants (121.5 and 119.1 cm) resulted with wide space 30 cm, where the shortest plants (118.4 and 116.7 cm) was obtained from narrow space 20 cm. In this regard, Kotb *et al.* (1998) showed that the plant height of *Nigella sativa L.* was significantly increased by increasing planting distance. This increase may be attributed to favour condition of growth such as light and nutrients which may be more available in wide space. Concerning the effect of Micronutrients, the results in Tables (1 A and B) showed that plant height of caraway was greatly affected by micronutrients application compared to control, but the method of seed coating was supperior to foliar application. Similar results were obtained by Kanwer and Dhingra (1962) on citratus, Osman *et al.* (1990) on faba bean, Abd El-Salam

(1999) on fennel, Khattab *et al.* (1999) on caraway and Refaat *et al.* (2001) on lemongrass.

Data in Tables (1 A and B) also showed that the interaction between sowing methods and spacing application methods were significant only in the first season, while the other double and triple interactions of applied treatments indicated insignificant response.

Table (1) : Effect of sowing method, spacing and micronutrients application methods on plant height (cm) of caraway in 1998/1999 (A) and 1999/2000 (B) 1 (A)

Sowing methods (a)	Spacing (b)	Micronutrients (c)			Means of		L.S.D at 5%	
		Control	Coating	Spray				
One side (a_1)	20cm (b_1)	122.0	125.3	124.0	123.7	(a_1 x b_1)	a	3.82
	30cm (b_2)	123.0	126.6	125.0	124.8	(a_1 x b_2)	b	1.82
Means of a_1 x c		122.5	125.9	124.5	124.3	(a_1)	c	1.47
Both sides (a_2)	20cm (b_1)	113.0	113.3	113.0	113.1	(a_2 x b_1)	a x b	2.58
	30cm (b_2)	116.0	120.6	118.3	118.3	(a_2 x b_2)	a x c	NS
Means of a_2 x c		114.5	116.9	115.6	115.6	(a_2)	b x c	NS
Means of (b x c)	(b_1)	117.5	119.3	118.5	118.4	(b_1)	a x b x c	NS
	(b_2)	119.5	123.6	121.6	121.5	(b_2)		
Means of c		118.5	121.4	120.0				

(B)

Sowing methods (a)	Spacing (b)	Micronutrients (c)			Means of		L.S.D at 5%	
		Control	Coating	Spray				
One side (a_1)	20cm (b_1)	120.6	122.3	121.3	121.4	(a_1 x b_1)	a	2.27
	30cm (b_2)	121.0	125.3	122.0	122.7	(a_1 x b_2)	b	1.16
Means of a_1 x c		120.8	123.8	121.6	122.1	(a_1)	c	1.19
Both sides (a_2)	20cm (b_1)	111.3	114.3	111.0	112.2	(a_2 x b_1)	a x b	NS
	30cm (b_2)	112.6	118.6	115.3	115.5	(a_2 x b_2)	a x c	NS
Means of a_2 x c		111.9	116.4	113.1	113.8	(a_2)	b x c	NS
Means of (b x c)	(b_1)	115.9	118.3	116.1	116.7	(b_1)	a x b x c	NS
	(b_2)	116.8	121.9	118.6	119.1	(b_2)		
Means of c		116.3	120.1	117.3				

2- Number of branches / plant :

The main effect of sowing methods, spacing and micronutrients application methods in Tables (2 A and B) indicate that sowing plants at one side of the ridge significantly increased branches number which reached 7.52 and 6.20 against 4.63 and 4.36 for sowing it at both sides in the two seasons, respectively. The largest number of branches was recorded with the wide space 30cm (7.0 and 5.58) against (5.15 and 4.98) for narrow space 20 cm in the first and second seasons, respectively. Similar results were mentioned by Kotb *et al.* (1998) on *Nigella sativa L.*

Also, branches number was significantly affected by micronutrients application compared to control plants, seed coating method was more effective than foliar application, in both seasons. Similar findings were found by Kanwer and Dhingra (1962) on citratus, Osman *et al.* (1990) on faba bean, Abd El-Salam (1999) on fennel and Khattab *et al.* (1999) on caraway.

Table (2) : Effect of sowing method, spacing and micronutrients application methods on branches number / plant of caraway in 1998 / 1999 (A) and 1999 / 2000 (B). 2 (A)

Sowing methods (a)	Spacing (b)	Micronutrients (c)			Means of		L.S.D at 5%	
		Control	Coating	Spray				
One side (a_1)	20cm (b_1)	5.70	7.30	6.20	6.40	(a_1 x b_1)	a	1.24
	30cm (b_2)	7.70	9.40	8.80	8.63	(a_1 x b_2)	b	0.32
Means of a_1 x c		6.70	8.35	7.50	7.52	(a_1)	c	0.21
Both sides (a_2)	20cm (b_1)	3.40	4.30	4.00	3.90	(a_2 x b_1)	a x b	0.45
	30cm (b_2)	5.00	5.80	5.30	5.37	(a_2 x b_2)	a x c	0.29
Means of a_2 x c		4.20	5.05	4.65	4.63	(a_2)	b x c	NS
Means of (b x c)	(b_1)	4.55	5.80	5.10	5.15	(b_1)	a x b x c	NS
	(b_2)	6.35	7.60	7.05	7.0	(b_2)		
Means of c		5.45	6.70	6.08				

(B)

Sowing methods (a)	Spacing (b)	Micronutrients (c)			Means of		L.S.D at 5%	
		Control	Coating	Spray				
One side (a_1)	20cm (b_1)	4.70	6.20	5.80	5.57	(a_1 x b_1)	a	0.58
	30cm (b_2)	5.50	7.70	7.30	6.83	(a_1 x b_2)	b	0.09
Means of a_1 x c		5.10	6.95	6.55	6.20	(a_1)	c	0.20
Both sides (a_2)	20cm (b_1)	3.80	4.90	4.50	4.40	(a_2 x b_1)	a x b	0.13
	30cm (b_2)	3.20	5.30	4.50	4.33	(a_2 x b_2)	a x c	NS
Means of a_2 x c		3.50	5.10	4.50	4.36	(a_2)	b x c	0.28
Means of (b x c)	(b_1)	4.25	5.55	5.15	4.98	(b_1)	a x b x c	NS
	(b_2)	4.35	6.50	5.90	5.58	(b_2)		
Means of c		4.30	6.02	5.52				

Tables (2 A and B) also showed that sowing plants, at one side of the ridge combined with wide space 30 cm resulted in the largest branches number in both seasons. The interaction between sowing methods and micronutrients application methods was significant in the first season, while the interaction between spacing and micronutrients application methods was only significant in the second season. The triple interaction in Table (2A and B) was insignificat.

3- Number of umbels / plant :

Data in Tables (3 A and B) indicated that sowing plants at one side of the ridge recorded largest number of umbels / plant (135.72 and 127.17) against the least values (112.0 and 114.33) for sowing it at both sides of the ridge in the first and second seasons, respectively. Also the same Tables, showed that umbels number / plant were significantly increased with the wide space (30 cm) comparing to the narrow space (20 cm).

As for the double and triple interactions of the applied treatments, the results in Tables (3 A and B) indicated that there was an increase in umbels number / plant, this increase was significant during the second season only.

Table (3): Effect of sowing method, spacing and micronutrients application methods on umbels number / plant of caraway in 1998 / 1999 (A) and 1999 / 2000 (B). 3 (A)

Sowing methods (a)	Spacing (b)	Micronutrients (c)			Means of		L.S.D at 5%	
		Control	Coating	Spray				
One side (a_1)	20cm (b_1)	118.0	136.0	128.0	127.33	(a_1 x b_1)	a	4.31
	30cm (b_2)	134.3	152.0	146.0	144.10	(a_1 x b_2)	b	4.82
Means of a_1 x c		126.15	144.0	137.0	135.72	(a_1)	c	4.60
Both sides (a_2)	20cm (b_1)	95.0	116.0	108.0	106.33	(a_2 x b_1)	a x b	NS
	30cm (b_2)	111.0	124.0	118.0	117.67	(a_2 x b_2)	a x c	NS
Means of a_2 x c		103.0	120.0	113.0	112.00	(a_2)	b x c	NS
Means of (b x c)	(b_1)	106.50	126.0	118.0	116.83	(b_1)	a x b x c	NS
	(b_2)	122.67	138.0	132.0	130.89	(b_2)		
Means of c		114.58	132.00	125.0				

(B)

Sowing methods (a)	Spacing (b)	Micronutrients (c)			Means of		L.S.D at 5%	
		Control	Coating	Spray				
One side (a_1)	20cm (b_1)	106.0	126.0	122.0	118.0	(a_1 x b_1)	a	1.90
	30cm (b_2)	124.0	145.0	140.0	136.33	(a_1 x b_2)	b	2.69
Means of a_1 x c		115.0	135.5	131.0	127.17	(a_1)	c	1.54
Both sides (a_2)	20cm (b_1)	98.0	115.0	112.0	108.33	(a_2 x b_1)	a x b	3.80
	30cm (b_2)	117.0	123.0	121.0	120.33	(a_2 x b_2)	a x c	2.18
Means of a_2 x c		107.5	119.0	116.5	114.33	(a_2)	b x c	2.18
Means of (b x c)	(b_1)	102.0	120.5	117.0	113.17	(b_1)	a x b x c	
	(b_2)	120.5	134.0	130.5	128.33	(b_2)	3.08	
Means of c		111.25	127.25	123.75				

4- Fruit yield (gm) plant :

The obtained data in Tables (4 A and B) indicated that planted caraway at one side of the ridge attained 30.1 and 26.7% (fruit yield / plant) over sowing it at both sides of the ridge, in two seasons, respectively.

Moreover data also showed that the wide distance (30 cm) resulted in significant increase in the fruit yield / plant in comparison with narrow distance (20 cm). Similar results were obtained by Kotb *et al.* (1998) on *Nigella sativa* L., Gill *et al.* (1999) and Reddy *et al.* (1999) on coriander.

Data in Tables (4 A and B) showed that application of micronutrients significantly increased fruit yield / plant either by the method of seed coating or folair spray as compared to untreated plants, it was observed that the method of seed coating with micronutrients recorded the highest fruit yield / plant (23.0 and 22.3 gm) during the two seasons, respectively. Microelements are needed in relatively very small quantites for good plant growth, their dificiencies cause great disorders in the physiological and metabolic processes of the plant (Kanwer and Dhingra, 1962).

The interaction between sowing methods and spacing was significant during the two seasons, while the interaction between sowing methods and

micronutrients application methods in Tables (4 A and B) was significant in the second season only.

As for the other double and triple interactions of the applied treatments, the data in the same Tables, indicated insignificant response.

Table (4) : Effect of sowing method, spacing and micronutrients application methods on fruit yield (gm) / plant of caraway in 1998 / 1999 (A) and 1999 / 2000 (B). 4 (A)

Sowing methods (a)	Spacing (b)	Micronutrients (c)			Means of	L.S.D at 5%
		Control	Coating	Spray		
One side (a_1)	20cm (b_1)	22.6	26.5	24.6	24.5 (a_1 x b_1)	a 1.27
	30cm (b_2)	24.8	28.3	26.4	26.5 (a_1 x b_2)	b 0.68
Means of a_1 x c		23.7	27.4	25.5	25.5 (a_1)	c 1.00
Both sides (a_2)	20cm (b_1)	15.1	15.9	15.3	15.4 (a_2 x b_1)	a x b 0.96
	30cm (b_2)	19.4	21.5	19.9	20.2 (a_2 x b_2)	a x c NS
Means of a_2 x c		17.2	18.7	17.6	17.8 (a_2)	b x c NS
Means of (b x c)	(b_1)	18.8	21.2	19.9	19.9 (b_1)	a x b x c NS
	(b_2)	22.1	24.9	23.1	23.3 (b_2)	
Means of c		20.4	23.0	21.5		

(B)

Sowing methods (a)	Spacing (b)	Micronutrients (c)			Means of	L.S.D at 5%
		Control	Coating	Spray		
One side (a_1)	20cm (b_1)	21.5	25.3	23.0	23.2 (a_1 x b_1)	a 0.25
	30cm (b_2)	22.3	27.3	24.5	24.7 (a_1 x b_2)	b 1.37
Means of a_1 x c		21.9	26.3	23.7	23.9 (a_1)	c 0.92
Both sides (a_2)	20cm (b_1)	14.3	16.1	15.3	15.2 (a_2 x b_1)	a x b 1.94
	30cm (b_2)	19.2	20.5	20.0	19.9 (a_2 x b_2)	a x c 1.30
Means of a_2 x c		16.7	18.3	17.6	17.5 (a_2)	b x c NS
Means of (b x c)	(b_1)	17.9	20.7	19.1	19.2 (b_1)	a x b x c NS
	(b_2)	20.7	23.9	22.2	22.0 (b_2)	
Means of c		19.3	22.3	20.6		

5- Fruit yield (kg) / fed :

As shown in Tables (5 A and B) marked values of fruit yield / fed. (963.8 and 948.9 kg / fed) were obtained by sowing plants at both sides of the ridge against (703.1 and 661.5) for sowing it at one side of the ridge, in the two seasons, respectively. These results were in agreement with Kamel *et al.*, (1992) which found that planting anise on both sides of the ridges gave highest values in seed yield comparing with the plants grown on one side of the ridge.

Tables (5 A and B) showed that sowing plants at narrow space of 20 cm resulted in highest yield of fruits (922.8 and 894.6 kg / fed) against (744.0 and 715.9 kg / fed) with wide space of 30 cm. Kotb *et al.*, (1998) on Nigella Sativa L., came to the same results. On the other hand, fruit yield / fed gave opposite trend to fruit yield / plant, this was due to the high number of plants resulted from sowing it on both sides of the ridge or spaced at 20 cm.

Also, data showed that fruit yield / fed from the three application methods of micronutrients were in order to: seed coating > foliar spray > control, the highest fruit yield / fed of (881.0 and 857.7 kg / fed) were

obtained from seed coating method. Similar results were obtained by Osman *et al.* (1990) and Hegazy *et al.* (1992) on faba bean, Abd El-Salam (1999) on fennel, Khattab *et al.* (1999) on caraway, Gangwar and Singh (1994) on lentil and Negm *et al.*, (1997) on pea.

In addition the data also showed that the interaction between sowing method and spacing were significant in both seasons. While the other double and trible interactions of the applied treatments indicated insignificant response. However the highest fruit yield / fed was recorded with the plants sown on both sides of the ridge, spaced at 20 cm and coating seed with mixture of micronutrients. (1058.9 and 1072.3 kg/fed).

Table (5) : Effect of sowing method, spacing and micronutrients application methods on fruit yield (kg) / fed of caraway in 1998 / 1999 (A) and 1999 / 2000 (B).5 (A)

Sowing methods (a)	Spacing (b)	Micronutrients (c)			Means of	L.S.D at 5%
		Control	Coating	Spray		
One side (a_1)	20cm (b_1)	752.5	882.4	819.1	818.0 (a_1 x b_1)	a 42.78
	30cm (b_2)	550.5	628.2	586.0	588.2 (a_1 x b_2)	b 35.41
Means of a_1 x c		651.5	755.3	702.5	703.1 (a_1)	c 31.22
Both sides (a_2)	20cm (b_1)	1005.6	1058.9	1018.9	1027.8 (a_2 x b_1)	a x b 50.07
	30cm (b_2)	861.3	954.6	883.5	899.8 (a_2 x b_2)	a x c NS
Means of a_2 x c		933.4	1006.7	951.2	963.8 (a_2)	b x c NS
Means of (b x c)	(b_1)	879.0	970.6	919.0	922.8 (b_1)	a x b x c NS
	(b_2)	705.9	791.4	743.7	744.0 (b_2)	
Means of c		792.4	881.0	826.8		

(B)

Sowing methods (a)	Spacing (b)	Micronutrients (c)			Means of	L.S.D at 5%
		Control	Coating	Spray		
One side (a_1)	20cm (b_1)	715.9	842.4	765.9	774.7 (a_1 x b_1)	a 34.27
	30cm (b_2)	495.0	606.0	543.9	548.3 (a_1 x b_2)	b 40.20
Means of a_1 x c		605.4	724.2	654.9	661.5 (a_1)	c 39.97
Both sides (a_2)	20cm (b_1)	952.3	1072.2	1018.9	1014.4 (a_2 x b_1)	a x b 56.85
	30cm (b_2)	852.4	910.2	888.0	883.5 (a_2 x b_2)	a x c NS
Means of a_2 x c		902.3	991.2	953.4	948.9 (a_2)	b x c NS
Means of (b x c)	(b_1)	834.1	957.3	892.4	894.6 (b_1)	a x b x c NS
	(b_2)	673.7	758.1	715.9	715.9 (b_2)	
Means of c		753.9	857.7	804.5		

6- Essential oil percentage :

Data in Tables (6 A and B) showed insignificant response in the essential oil percentage with the main effect of sowing method and spacing. While the same Table (6 A and B) showed significant increase with micronutrients additions either by foliar spray or with seed coating method comparing to untreated plants. Seed coating method was beneficially effective for increasing essential oil percentage which were (2.48 and 2.53%) against (2.38 and 2.38%) with foliar method, in two seasons, respectively. Similar results were obtained with Abd El-Salam (1999) on fennel, Khattab *et al.* (1999) on coriander and Refaat *et al.* (2001) on lemongrass.

Tables (6 A and B) showed that the interaction between sowing method and spacing were significant only in the first season. While sowing plants at 20 or 30 cm combined with the method of seed coating were significant in the second season. On the other hand, the interaction between

Tables (6 A and B) showed that the interaction between sowing method and spacing were significant only in the first season. While sowing plants at 20 or 30 cm combined with the method of seed coating were significant in the second season. On the other hand, the interaction between sowing method and micronutrients application method and interaction between the three factors was insignificant in both seasons.

Table (6): Effect of sowing method, spacing and micronutrients application methods on essential oil percentage of caraway in 1998 / 1999 (A) and 1999 / 2000 (B). 6 (A)

Sowing methods (a)	Spacing (b)	Micronutrients (c)			Means of	L.S.D at 5%
		Control	Coating	Spray		
One side (a_1)	20cm (b_1)	2.33	2.46	2.34	2.37 (a_1 x b_1)	a NS
	30cm (b_2)	2.37	2.48	2.40	2.41 (a_1 x b_2)	b NS
Means of a_1 x c		2.35	2.47	2.37	2.39 (a_1)	c 0.043
Both sides (a_2)	20cm (b_1)	2.38	2.52	2.41	2.43 (a_2 x b_1)	a x b 0.033
	30cm (b_2)	2.36	2.48	2.38	2.40 (a_2 x b_2)	a x c NS
Means of a_2 x c		2.37	2.50	2.39	2.41 (a_2)	b x c NS
Means of (b x c)	(b_1)	2.35	2.49	2.37	2.40 (b_1)	a x b x c NS
	(b_2)	2.36	2.48	2.39	2.41 (b_2)	
Means of c		2.35	2.48	2.38		

(B)

Sowing methods (a)	Spacing (b)	Micronutrients (c)			Means of	L.S.D at 5%
		Control	Coating	Spray		
One side (a_1)	20cm (b_1)	2.37	2.49	2.34	2.40 (a_1 x b_1)	a NS
	30cm (b_2)	2.33	2.60	2.37	2.43 (a_1 x b_2)	b NS
Means of a_1 x c		2.35	2.54	2.35	2.41 (a_1)	c 0.049
Both sides (a_2)	20cm (b_1)	2.37	2.49	2.40	2.42 (a_2 x b_1)	a x b NS
	30cm (b_2)	2.32	2.56	2.41	2.43 (a_2 x b_2)	a x c NS
Means of a_2 x c		2.34	2.52	2.40	2.42 (a_2)	b x c 0.070
Means of (b x c)	(b_1)	2.37	2.49	2.37	2.41 (b_1)	a x b x c NS
	(b_2)	2.32	2.58	2.39	2.43 (b_2)	
Means of c		2.34	2.53	2.38		

7- Oil yield (L. / fed) :

Data presented in Tables (7 A and B) clear that sowing plants at both sides of the ridge resulted in the highest value of oil yields / fed (23.36 and 23.03 L. / fed) against (16.85 and 16.01 L. / fed) for sowing it at one side of the ridge, in two seasons, respectively. Also the data showed that narrow space of 20 cm resulted in the highest oil yield / fed (22.25 and 21.60 L./fed) against (17.93 and 17.44 L./fed) for the wide one of 30 cm. In this regard, Mohamed (1997) found that the highest yield of oil per feddan of thyme plant was obtained from the highest density plants and decreased gradually with decreasing the plant density.

The data also showed that the application of micronatrients (Zn + Mn + Fe) gave significant increase in oil yield / fed, seed coating method recorded the highest oil yield / fed (21.90 and 21.69 L. / fed) in two seasons, respectively. Refaat *et al.*, (2001) on Lemongrass, came to the same results. Data shown in Tables (7 A and B) indicated that the combined effect of the sowing methods and spacing was significant in the first season, while the

other double interactions were insignificant. As for the triple interaction, essential oil yield / fed followed the same trend of fruit yield / fed. Where the highest yield of oil was obtained from sowing plants on both sides of the ridge, spaced at 20 cm and coating seed with mixture of micronutrients (26.68 and 26.70 L. / fed).

Table (7) : Effect of sowing method, spacing and micronutrients application methods on essential oil yield L. / fed of caraway in 1998 / 1999 (A) and 1999 / 2000 (B).7 (A)

Sowing methods (a)	Spacing (b)	Micronutrients (c)			Means of	L.S.D at 5%	
		Control	Coating	Spray			
One side (a_1)	20cm (b_1)	17.53	21.71	19.16	19.46 (a_1 x b_1)	a	0.68
	30cm (b_2)	13.05	15.58	14.06	14.23 (a_1 x b_2)	b	0.84
Means of a_1 x c		15.29	18.65	16.61	16.85 (a_1)	c	0.95
Both sides (a_2)	20cm (b_1)	23.93	26.68	24.55	25.05 (a_2 x b_1)	a x b	1.18
	30cm (b_2)	20.33	23.67	21.02	21.67 (a_2 x b_2)	a x c	NS
Means of a_2 x c		22.13	25.17	22.78	23.36 (a_2)	b x c	NS
Means of (b x c)	(b_1)	20.73	24.19	21.85	22.25 (b_1)	a x b x c	NS
	(b_2)	16.69	19.62	17.54	17.93 (b_2)		
Means of c		18.71	21.09	19.69			

(B)

Sowing methods (a)	Spacing (b)	Micronutrients (c)			Means of	L.S.D at 5%	
		Control	Coating	Spray			
One side (a_1)	20cm (b_1)	16.97	20.98	17.92	18.62 (a_1 x b_1)	a	2.84
	30cm (b_2)	11.54	15.76	12.89	13.39 (a_1 x b_2)	b	1.53
Means of a_1 x c		14.26	18.37	15.04	16.01 (a_1)	c	1.70
Both sides (a_2)	20cm (b_1)	22.57	26.70	24.45	24.57 (a_2 x b_1)	a x b	NS
	30cm (b_2)	19.78	23.30	21.40	21.49 (a_2 x b_2)	a x c	NS
Means of a_2 x c		21.18	25.00	22.93	23.03 (a_2)	b x c	NS
Means of (b x c)	(b_1)	19.77	23.84	21.18	21.60 (b_1)	a x b x c	NS
	(b_2)	15.66	19.53	17.15	17.44 (b_2)		
Means of c		17.72	21.69	19.17			

8- Essential oil constituents :

Separation of oil samples by GLC revealed two identified constituents; carvon and limonene. Carvon was the major constituent of the essential oil forming more (75%), carvon and limonen slightly decreased by micronutrients application, as shown in Table 8 and Fig. 1 , 2 and 3.

Table (8) : Effect of micronutrients application methods on the main constituents of essential oil of caraway .

Oil Constituents %	Treatments		
	Control	Seed coating	Spraying
Carvon	79.09	78.10	75.45
Limonene	11.36	10.85	11.00

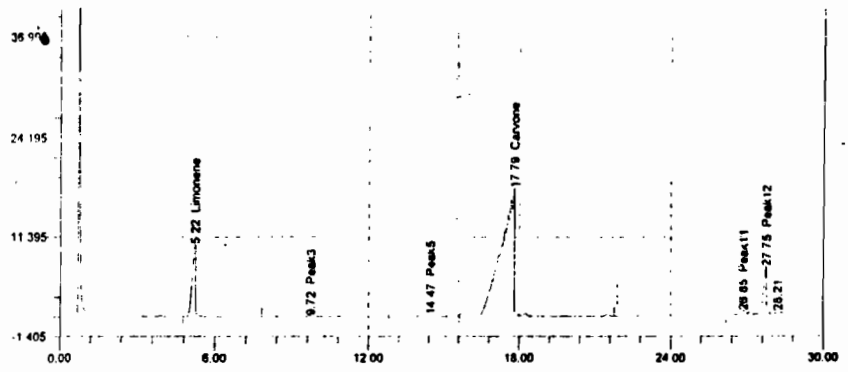

Fig (1) : Main components of the control of caraway essential oil.

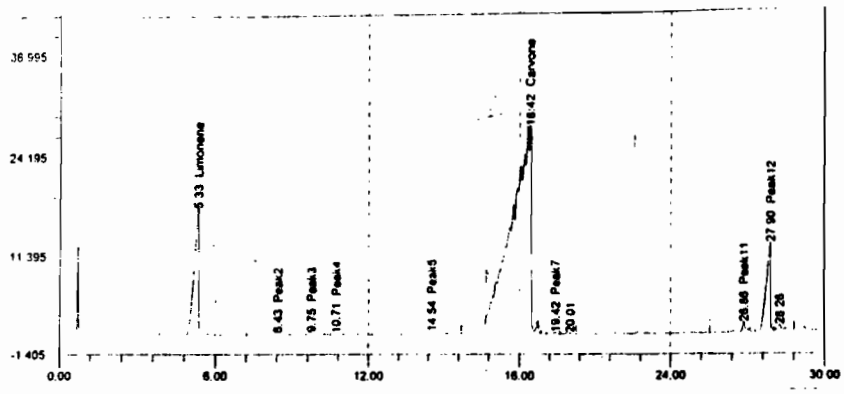

Fig (2) : Main components of caraway essential oil as affected by seed coating method.

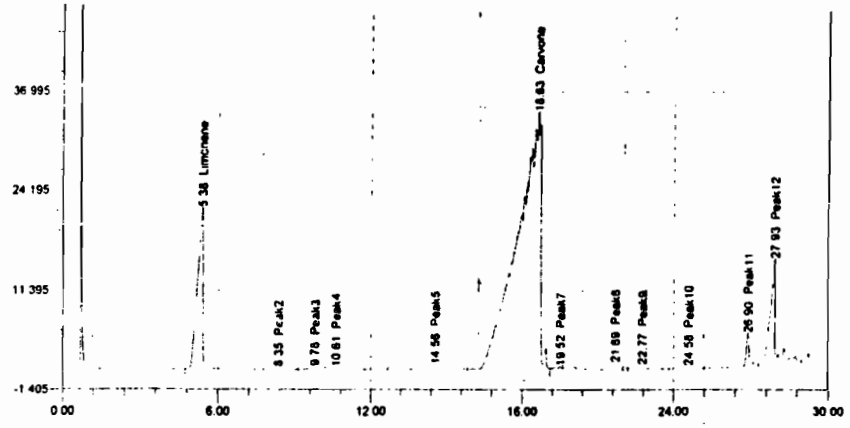

Fig (3) : Main components of caraway essential oil as affected by spraying method.

REFERENCES

Abd El-Salam, I. (1999) Physiological studies on *Foeniculum vulgare* Mill. plant. Ph. D. Thesis., Fac. Agric., Cairo Univ.

Gangwar, K. S. and N. P. Singh (1994) Studies on zinc nutrition on lentil in relation to dry matter accumulation, yield and N, P uptake. Indian J. of Pulscs Res. 7 (1) : 23 – 35 (C. F. Field Crop Abst.) 48 (10) : 7561.

Gil, A.; E. de. La. Fuente ; A. Lenardis ; S. Lorenzo ; J. Marengo and de. La. Fuente, E. (1999) Coriander (*Coriandrum sativum* L.) yield response to plant populations. J. Herbs, Spices and Medicinal Plants, 6 (3): 63 – 73.

Guenther, E. (1961) "The Essential Oils" , Vol. IV, Van Nostrand Co., Inc., New York.

Hegazy, M. H. ; D. Abadi and S. A. Genaidy (1992). Effect of some micronutrients and methods of application and rhizobium inoculation on faba bean. Egypt. J. Agric. Res., 70 (4).

Kamel, A. S. ; M. A. El-Masry and A. M. Aly (1992). Yield and competitve relationships as influenced by intercropping three medicinal crops with faba bean. Egypt. J. Agric. Res., 70 (4).

Kanwer, J. S. and F. R. Dhingra (1962). Effect of micronutrients sprays on the chemical composition of citratus leaves and incidence of chlorosis Ind. J. Agric. Sci., 32 : 309.

Khattab, M. E. and E. A. Omer (1999). Influence of excessive fertilization with micronutrients on the growth, yield, essential oil and micro-elements of some Apiaceae plants. Egypt. J. Hort., 26 (3): 249 – 266.

Kotb Shadia ; M. I. Eid and A. F. Aly (1998). Effect of sowing dates and planting distances on *Nigella sativa*. Egypt. J. Agric. Res., 76 (3): 1145 – 1157 .

Mohamed, M. A. (1997). Effect of plant density and date of cutting on *Thymus vulgaris* L. Plant. Egypt. J. Hort., 24 (1): 1 – 6.

Negm, A. Y ; A. M. Abdel – Samad ; O. Abdel – Aziz and A. F. A. Waly (1997). Yield and some seed constituents of pea as affected by some micronutrients application methods. Egypt J. Agric. Res., 75 (4).

Osman, A. O. ; M. Hegazy and S. Ghaly (1990). The effect of seed coating with certain micronutrients on the yield of faba bean. Agric. Res. Rev., Egypt (In Press).

Reddy, K. and MP. Rolston (1999). Coriander (*Coriandrum sativum* L.) seed production : nitrogen , row spacing , sowing rate and time of sowing. J. of Applied seed Production, 17 : 49 – 53 ; 8 Ref.

Refaat, A. and L. K. Balbaa (2001). Yield and quality of lemongrass plants (*Cymbopogon flexuosus stapf*) in relation to foliar application of some vitamins and microelements. Egypt, J. Hort., 28 (1): 41 – 57.

Snedecor. G.W. and W.G. Cochran. (1972). Statistical Method 6th , Ed The Iowa State Univ. Press, Am, Iowa, USA , PP. 593.

J. Agric. Sci. Mansoura Univ., 28 (9), September, 2003

استجابة محصول الثمار والزيت الطيار للكراوية لبعض طـــرق ومســـافات الزراعة ، وطرق إضافة بعض المغذيات الصغرى

نوال جورج غالى ، فاتن رمزى موسى ، سامى إبراهيم يونس
قسم النباتات الطبية والعطرية – معهد بحوث البساتين – مركز البحوث الزراعية

أجرى هذا البحث فى موسمين متتالين ١٩٩٨ / ١٩٩٩ & ١٩٩٩ / ٢٠٠٠ فى مزرعة محطـــة بحوث الجميزة لدراسة طرق الزراعة (على ريشة واحدة وعلى ريشتين من الخط) ، ومسافات الزراعـة (٢٠ ، ٣٠ سم بين النباتات) وطرق إضافة بعض المغذيات الصغرى [زنك + منجنيز + حديد (مخلبـــى)] أمـــا بتغليف البذور أو بالرش.

وقد أظهرت النتائج أن الزراعة على ريشة واحدة من الخط ، وأن المسافة الواسعة ٣٠ سم كل علـى حدة ، أدى إلى زيادة معنوية فى النمو الخضرى ومحصول الثمار للنبات ، بينما الزراعة على جانبى الخـط ، المسافة الضيقة ٢٠ سم ، كل على حدة أدى إلى زيادة معنوية فى محصول الثمار والزيت للفدان ولكن النسـبة المئوية للزيت الطيار لم تتأثر بطريقة الزراعة أو المسافات ، وقد أدى إضافة المغذيات الصغرى [زنـــك + منجنيز + حديد (مخلبى)] إلى زيادة كل من النمو الخضرى ، محصول الثمار والزيـــت والنســبة المئويـة للزيت الطيار ولكن طريقة الإضافة بتغطية البذور كان لها تأثيرا معنويا بالمقارنة بطريقة الرش.

كان للتفاعل بين طرق الزراعة والمسافات تأثيرا معنويا على زيادة النمـــو الخضـــرى ومحصـــول الثمار والزيت الطيار . ويعتبر الكارفون المكون الرئيسى لزيت الكراوية حيث يكون أكثر من ٧٥% ولكـــن المعاملة بالمغذيات الصغرى أدت إلى انخفاض طفيف فى نسبة الكارفون والليمونين.

وقد تم الحصول على أعلى قيمة من محصول الثمار والزيت من تغطية البذور بالعناصر الصغرى [زنـك + منجنيز + حديد (مخلبى)] والزراعة على جانبى الخط على مسافة ٢٠ سم بين النباتات ، وهى المعاملة التـى يوصى باستخدامها في الزراعة .