ISSN 1110-0419

Annals Of Agric. Sc., Moshtohor,
Vol. 43(3): 1245-1269, (2005).

EFFECT OF SOWING DATE AND POTASSIUM FERTILIZATION ON GROWTH, YIELD AND CHEMICAL COMPOSITION OF *Foeniculum vulgare* Mill PLANTS

BY

El-Khayat, A.S.M.* and Hasnaa A.H.Gouda**
* Horticulture Department, Faculty of Agriculture, Moshtohor, Benha University.
** National Organization for Drug Control and Research (NODCAR).

ABSTRACT

Two field experiments were carried out during the seasons of 2003/2004 and 2004/2005 at the Experimental Farm of Fac. of Agriculture at Moshtohor, Benha Univ. to investigate the effect of four sowing dates (15/10, 30/10, 15/11 and 30/11), four treatments of K oxide (control, two sprays, three sprays and four sprays) and their interaction on the growth, yield and chemical composition of *Foeniculum vulgare* Mill plants. A split plot design with three replicates for each treatment was used and each replicate contained 30 plant (15 hill). The main plots were devoted to the four sowing dates and the sub plots were devoted at random to the foliar spraying with 1.5 % of potassium oxide. Plant growth parameters such as plant height, fresh and dry weights of leaves and branches as well as fruit yield/plant and per feddan were recorded and fruit quality was estimated by measuring volatile oil % and its main components. Leaves were chemically analyzed to determine N.P.K. and total carbohydrates percentage. The results obtained showed that the sowing date at 30/11 gave the tallest plants, heaviest fresh and dry weights of leaves and branches as well as increased fruit yield per plant and per feddan and oil percentage compared with all the other treatments for sowing dates, also increased total carbohydrates, N,P and K % in plant leaves compared with the different sowing date treatments.

Potassium fertilization at the high rate (four sprays during growth season) increased plant growth, fruit yield and chemical composition as compared with the lower rate.

The interaction between late sowing date (30/11) with the high level of K fertilizer gave the best results of plant growth, fruit yield and chemical composition compared with all the other treatments.

The G.L.C. determination revealed the presence of each of L-limonene, anethole, ∝-pinene and chavicol compounds in the volatile oil of fruits.

Fourth sowing date (30/11) + four sprays of K at rate 1.5% attained 0.22, 12.25, 0.02 and 87.51% of ∝-pinene, L-limonene, chavicol and anethole compounds in the volatile oil respectively.

In general it could be concluded that the fourth sowing date with four sprays of K at the rate of 1.5% was considered the most suitable treatment for best fennel production with good fruits quality..

Key words: Fennel, *Foeniculum vulgare*, G.L.C. ∝- pinene, L-limonene, anethol, chavicol, and fenchone.

INTRODUCTION

Recently, an increasing interest in the cultivation and production of medicinal plants has been noticed in Egypt in order to cover the increasing demand of the local pharmaceutical industries as well as for export purposes (Belal, 1995). Cultivation of medicinal and aromatic plants in the small farms can decrease migration into towns (El-Kadi, 1988) and the small farmer rural economy provides the basis for strong National Economic Development (Netting, 1993).

The relative export edge of such crops lies in the availability of products as well as the growing world demand. Other relative advantages of this business includes that only scanty areas are required for growing these plants and the need of intensive labour and low water requirements. Medicinal and aromatic plants have the potential of boosting Egyptian exports of high-quality, added-value crops such as chamomile, fennel, peppermint etc. *Foeniculum vulgare* Mill is one of the annual plants, which belongs to *Apiaceae* family, cultivated for fruits which are used for medical and culinary purposes. Fennel seeds are frequently added to bread and biscuit for flavor and aiding digestion (Graves, 1990). Fennel may activate the milk gland and acts to increase the sexy gland in women and men. It is used also in contraction of stomach and intenstine (Abuo Zeid, 1988). Fennel can be added to salad and soup to improve taste, and also may be added to meat in order to keep it for a long time because the volatile oil assists some harmful bacteria and fungus. The medical properties of fruits depend upon the essential oil which is warm, pungent and aromatic, in colic and gastrodynia, few drops of these oil or half of tea spoon full of the seed are sovereign remedies. The essential oil of fennel at 3000 ppm concentration have antiviral properties, (Shukla, *et al.*, 1989 and Meawad *et al.*, 1991). Ruberto *et al.* (2000) emphasised the an antioxidant and antimicrobial activity of fennel fruits. In addition, insecticidal activity against three of Coleoptera stored product insects of fennel fruits was found (Kim and Ahn, 2001). The main constituents of fennel seeds are essential oil with anethole and fenchone, plus fatty acids, proteins, sugars and mucilage. These substances give fennel antispasmodic, carminative, stomachic, galactonic, aromatic and weak diuretic properties (Stodola and Volak 1992). In Germany fennel fruits are licensed as a standard medicinal tea for dyspepsia (Arslan *et al.*, 1989). It is also used in cough syrups and honeys (antitussives and expectorants), and stomach and bowel remedies, especially in paediatrics as aqueous infusion, juice and syrup (Wichtel and Bisset, 1994). In the United States, it is also used as a component of galactagogue preparations (Leung and Foster, 1996).

The intensive farming in Nile Valley soils in Egypt and agricultural practices have forced the farmers to use more fertilizers to get the high benefit. The intensive use of manufactured nitrogen, phosphorous and potassium fertilizers increased the crops productivity. Among the essential nutrients needed by the plant is potassium which plays a highly recognized role in plant life, where an adequate supply of potassium for plant improves the quality and quantity of productivity. Many authors studied the role of potassium such as, Badran and El-Mazity (1989) on cumin, Munshi *et al.* (1990) on *Carlum carvi* and Ali (1993) on *Nigella sativa* who mentioned that potassium increased plant height, number of branches, fresh and dry weight of shoots, seed yield per plant and per fed, oil percentage as well as N,P,K and total carbohydrates percentage in the herb. Also Mohamed (1989) on chamomile, Attia (1993) on caraway, Omer *et al.* (1995) on *Silybum marianum* and Kassem (1997) on *Rosmarinus officinalis* plants found that potassium sulphate at 60 kg/fed increased plant height, number of branches, fresh and dry weights, essential oil percentage as well as N,P and K contents and total carbohydrates content.

Also, many authors studied the effect of sowing date such as: Zaky *et al.* (1988) and Salama (1996) found that, flax yield and its components seed quality and fiber quality of flax plant were significantly increased and reached their maximum values at the third planting date (15/11) which consider the optimum as compared with that of earlier dates (25/10 and 5/11) and those of latest planting date (25/11) and Abd El-Dayem, *et al.* (2002) mentioned that flax yield and its components were affected significantly with planting date treatments, the maximum values were recorded at the third planting date (15/11) as compared with those observed in case of plants which were planted earlier (15/10 and 30/10) or late (30/11).

Also, many investigators concluded, the date of planting affected greatly the different parameters of plant growth. Bhati (1988) on *Coriandrum sativum* cultivates sown on 3th Nov., 18th Nov. or 3th Dec., reported that sowing in Nov. gave significantly highest seed yield and number of umbels/plant.

Also, Matter (1997) on black cumin seeds sown on Nov. 1st, 15th and Dec. 1st found that, early sowing increased the plant height, number of branches per plant, seed yield/plant and fixed oil percentage of seeds. Ibrahim (2000) on fennel sown, in North Sinai on 1st Nov., 15th Nov. and 30th Nov., reported that, the earliest sown seeds produced the tallest plants with most umbels the highest seed yield and oil yield/plant.

This work aimed to improve the average yield of *Foeniculum vulgare* through using the suitable sowing date combined with treating by potassium as a foliar application.

MATERIALS AND METHODS

The study was carried out at the Experimental Farm, and in the laboratory of Ornamental Plants, Faculty of Agriculture, at Moshtohor, Benha

University during two successive seasons of 2003/2004 and 2004/2005, to study the effect of four sowing dates i.e. (15/10, 30/10, 15/11 and 30/11) and four treatments of 1.5% of potassium oxide such as (control, two sprays, three sprays and four sprays), on vegetative growth, yield and volatile oil content as well as chemical composition of fennel plants.

Fennel fruits were obtained from the Medicinal and Aromatic Plants Research Section of the Ministry of Agricultural at El-Kanater El-Khairia Experiment Station. Fennel seeds were sown in rows 50 cm apart in hills at 50 cm in between with four-six seeds per hill. After forty days from sowing, the seedlings were thinned to two seedlings/hill. Plants were fertilized with calcium superphosphate (15.5% P_2O_5) at a rate of 100 kg/fed and ammonium sulphate (20.5% N) at a rate of 150 kg/fed. The dose of nitrogen was applied in two equal portions at 50 and 70 days from sowing, while the amount of P fertilizer was added before sowing during soil preparation in both seasons.

The experiment was laid in a split plot design with three replicates for each treatment as the replicate contained 15 hills. The main plots were represented by sowing dates treatments (15/10, 30/10, 15/11 and 30/11). While sub-plots were entitled to four potassium treatments (0.0, 2, 3 and 4) times. The control plants were sprayed with a tap water.

The volume of the spraying potassium solution was maintained just to cover completely the plant foliage till drip at two weeks intervals. A bio-film was used as a setting agent at 1.5 m/L. and the treatments were started after 50 days from planting for both seasons with potassium as salient K liquid (38% potassium oxide produced by Kafer El-Zayat Company for Pesticides and Chemicals) at the concentration of 1.5% as a recommended rate. All the plants received normal agricultural practices.

At harvesting time (10^{th} of May) the following data were recorded: plant height (cm), fresh and dry weights of branches and leaves/plant (g), fruits yield/plant and per feddan.

Total carbohydrates percentage in dry weight of leaves was determined according to Herbert *et al.* (1971). The percentages of N, P and K in the dry leaves were determined at flowering stage according to Wilde *et al.* (1985).

Volatilel oil percentage in the fruits of each treatment was determined by hydro-distillation. The volatile oil of the second season (mixed oil of replicates per treatment) was subjected to G.L.C. analysis for determination of the percentage of the main components carried out by gass liquid chromatography apparatus in the Central Laboratory of Fac. Agric. Cairo University..

All obtained data were statistically analyzed by the use of L.S.D. method according to Snedecor and Cochran (1989) to compare between means of treatments. The physical properties and chemical analysis of soil are shown in Table (A). Data of the mean values of air temperature and relative humidity during both seasons of study are shown in Table (B).

Table (A): Physical and chemical analysis of the used soil.

Analysis		First season 2003/2004	Second season 2004/2005
Physical properties			
Soil texture		Clay	Clay
Clay	%	47.8	48.1
Silt	%	29.7	29.3
Sand	%	21.2	21.5
Chemical analysis			
Ca	(meq/L)	2.46	2.47
Mg	(meq/L)	2.63	2.62
Na	(meq/L)	3.44	3.43
K	(meq/L)	3.5	3.3
N	(meq/L)	184.8	184.3
P	(meq/L)	5.12	5.10
HCO_3	(meq/L)	2.52	2.51
Cl	(meq/L)	3.05	3.06
Fe	ppm	18.30	18.27
Zn	Ppm	1.11	1.13
Mn	ppm	7.52	7.54
Cu	ppm	13.18	13.16
Organic matter	%	1.87	1.86
E.C. (mmhos/cm)		1.80	1.81
pH		7.75	7.77

Table (B): Mean values of temperature and relative humidity during the experimental years.

Month	2003/2004		2004/2005	
	Mean tempe. (°C)	Mean relative humidity (%)	Mean tempe.(°C)	Mean relative humidity (%)
October	25.6	66.03	24.83	60.31
November	21.44	61.68	21.99	60.15
December	16.22	49.34	16.69	50.06
January	15.86	63.71	14.80	64.81
February	15.78	66.31	16.22	59.51
March	18.93	66.90	16.19	60.60
April	21.36	59.17	20.74	60.37
May	31.74	56.05	25.40	55.66

Meteorological data of Qalyoubia Governorate. A.R.C. Dokki, Giza.

RESULTS AND DISCUSSION

1- Effect of sowing date and potassium fertilization on the vegetative growth:

Data in Table (1) revealed that, sowing dates did have a constant trend for increasing plant height of fennel. On the other hand, fennel plants which were usually sprayed two, three, and four times with potassium solution at a rate of 1.5% gave increased plant height compared with the first sowing date without potassium spraying. Generally, the tallest plants were obtained when the plants were sprayed four times with K at rate 1.5% at the fourth sowing date, compared with all other treatments in the first and second seasons, respectively. These results are in agreement with those obtained by several investigators (Badran and El-Maziny 1989, on Cumin, Munshi *et al.*, 1990 on *Carium carvi*, Ali 1993 on *Nigella sativa*) and Ibrahim 2000 on some medicinal plants).

The data in Table (2) indicated that fresh weight of branches/plant was significantly higher in second, third and fourth sowing dates in both seasons of this experiment which gave 14.10, 47.14 and 53.78% respectively over the first date in the first season, while produced 12.46, 25.97 and 43.03% respectively over the first date in the second seasons. These results agreement with obtained by Ibrahim 2000 on some medicinal plants.

This effect might be due to the lower temperature and shorter photoperiod during lately sowing that can help in faster growing of plants than those grown in hoter condition, this was obvious from Table (B) for the mean temperature in Qalyoubia governorate as in the first season recorded 25.06 and 21.44°C, respectively and in the second season the values 24.83 and 21.99°C on Oct. and Nov., respectively. The results were in accordance with those obtained by Bhati (1988) and Mohamed (1992) on *Coriandrum sativum*, Matter (1977) on black cumin seeds and Ibrahim (2000) on fennel plants.

Spraying fennel plants with potassium at rate of 1.5% for two, three and four times in both seasons significantly increased fresh weight of branches at the different sowing dates. The heaviest fresh weight of branches was resulted of spraying potassium at rate of 1.5% of fourth sowing date. It could be noticed from (Table 3) that, branches dry weight/plant was significantly increased at the fourth date over the first, second or third date in both seasons. However, the first and second dates did not significantly differ between each other in the first and second seasons of this experiment. The highest dry weight/plant seemed to be due to the effect of interaction between application potassium oxide three or four sprays at the fourth sowing date. A similar trend results was obtained by Abd El-Dayem *et al.* (2002).

Tables (4 and 5) showed that the fennel plants planted in different dates gave the largest fresh and dry weights of leaves/plant for the two seasons. However, the maximum increase was obtained by planting in the fourth date for the first season and in third and fourth dates for second seasons respectively. Data showed also that there were significant differences due to fertilization treatments in fresh and dry weights of leaves/plant compared with control plants of both seasons. Furthermore, fennel plants treated with four sprays of K at the rate of

1.5% in the fourth sowing date gave the heavest fresh and dry weights of leaves/plant when compared with control plant or any other treatments. In this respect Gardner *et al.* (1985) reported that solar radiation and temperature are two weather variables that have direct and significant effect on crop production. Temperature affects the duration of the crop growth (Wilheim and McMaster, 1995). Consequently influences; yield (McMaster, 1997). Haeder *et al.* (1973) mentioned that, the leaves of wheat plants well supplied with K remain green for a longer time during grain filling, thus providing the ears with assimilates over an extended period. As a result more starch can be synthesized and the grains grow larger. In addition, K also enhances the synthesis of lipids in oleaginous crops, thus improving oil production.

2- Effect of sowing date and potassium fertilization on fruit yield of fennel plants:

Data given in Table (6) indicated that the latest sowing date caused a significant increase in fruit yield/plant in the first season but the second and third dates of sowing in the second season caused a significant increase compared with the first sowing date. It was clear from the results that the fruits yield/plant was significantly affected with the foliar sprays with potassium at rate of 1.5% for the different sowing dates. Generally, the highest fruit yield/plant was obtained when the plants were sprayed with K four times in fourth sowing date in both seasons. This might be due to the favourable effect of this element on photosynthetic activity of leaves which improves the mobilization of photosynthetic materials, having through and direct impact increased weight of seeds (Bottril *et al.*, 1970).

Data in Table (7) indicated that the fruit yield/fed was significantly increased from plants of the third and fourth dates over the first and second dates in the first season, while the second and the third dates gave significantly increased over the first date in the second season.

It may be concluded that, delaying the time of sowing up to the 30th Nov., caused a considerable increment in seed yield. Moreover, the increase seed yield with lately sowing might be attributed to the increase the number of umbels/plant and average weight of seeds/plant with the lately sowing. A similar results were reported by many investigators as Bhati (1988) and Mohamed (1992) on *Coriandrum sativum* and Matter (1997) on black cumin.

Similar trend of results was obtained by Zaky *et al.* (1988) and Salama (1996) found that, flax yield and its components seed quality and fiber quality of flax plant were significantly increased and reached their maximum values at the third planting date (15/11) which consider the optimum as compared with that of earlier dates (25/10 and 5/11) and those of latest planting date (25/11). and Abd El-Dayem, *et al.* (2002) mentioned that flax yield and its components were affected significantly with planting date treatments, the maximum values were recorded at the third planting date (15/11) as compared with those observed in case of plants which were planted earlier (15/10 and 30/10) or late (30/11).

The obtained results (Table, 7) showed that the application of K at rate of 1.5% three or four sprays increased fruits yield/fed when compared to the control plants in first two dates, however, significant differences were detected

when potassium was sprayed two, three or four times at the third or fourth date when compared to the control plants. Generally, the maximum yield/fed was obtained when the plants were sprayed with potassium at rate of 1.5% four sprays at the late planting in both seasons. These results on promotion of vegetative growth by foliar application with potassium support the findings of the other workers i.e Badran and El-Maziny (1989) on cumin, Mohamed (1989) on chamomile, Munshi *et al.* (1990) on *Carium carvi* and Ali (1993) on *Nigella sative* who mentioned that potassium increased plant height, number of branches, fresh and dry weight, of branches, seed yield per plant, oil percentage as well as N,P,K and total carbohydrates percentage in the herb.

3- Effect of different sowing date and potassium fertilization on chemical composition of fennel plant:

a- Volatile oil percentage and composition:

Data in Table (8) revealed that, sowing dates at 30/10, 15/11 and 30/11 caused a significant increase in volatile oil percentage compared with early sowing date (15/10) in the first season, while the oil percentage significantly unvaried between various sowing dates in the second season. These results agreement with obtained by Ibrahim 2000 on some medicinal plants.

Studying oil percentage of each sprays number with K oxide at each date, showed that each spray treatment produced significantly more volatile oil % than control plant (un sprayed with K). The maximum effect was obtained when the plants were sprayed with potassium at the rate of 1.5% four times at late planting for both seasons. The results indicated that fennel fruit oil percentage was ranging from 3.0-5.0% at maturity stage.

These results are in line with those of vegetative growth and flowers yield, since the chemical K fertilizer induced rapid plant growth which led to more metabolites accumulation involving synthesizing of more secondary products as volatile oil. These results are in agreement with those obtained by Kandil (2002) on fennel.

The relative percentage of the main constituents of essential oil of fennel fruits as affected by sowing dates, potassium fertilizations and the interaction between the two factors, are shown in Table (9) and Figs. (1:16). Four compounds have been identified. Approximately 100% of essential oil constituents was identified where the major compound was found to be anethole in all treatments and ranged from 46.41 to 88.27%. This was followed by L-limonene which ranged from 4.15 to 28.19%. The third compound was ∝-pinene which ranged from 0.01 to 6.48% while last compound was chavicol which ranged from 0.01 to 4.17%. These results are in agreement with Wagner (1999) who mentioned that, the essential oil percentage of fruit sweet fennel (*Foeniculum dulcis fructose*) was 2% and the essential oil contained about 80% anethole, while the essential oil percentage of bitter fennel (*Foeniculium amari fructose*) was 4% and the essential oil contained 60% anethole and about 15% fenchone.

Table (1): Effect of sowing date and potassium fertilization on the plant height (cm) of *Foeniculum vulgare* Mill. during 2003/2004 and 2004/2005 seasons.

Treatments	First season					Second season				
A / B	15/10	30/10	15/11	30/11	Mean	15/10	30/10	15/11	30/11	Mean
0.0 control	85.5	98.5	108.7	121.5	103.6	104.5	110.9	120.0	123.7	114.8
K (two sprays)	96.5	116.0	121.0	131.7	116.3	112.5	122.3	128.5	130.5	123.5
K (Three sprays)	101.0	122.5	125.7	138.5	121.9	119.5	134.1	134.0	140.7	132.1
K Four sprays	124.5	129.5	130.0	139.7	130.9	132.0	140.0	141.5	146.0	139.9
Mean	101.9	116.6	121.4	132.9		117.1	136.8	131.0	135.2	

L.S.D.	5%	1%	5%	1%
A = (sowing dates)	5.4	6.95	5.2	6.87
B = (potassium levels)	4.5	5.72	6.3	8.02
(A x B) = Interaction	7.8	9.13	8.8	10.13

Table (2): Effect of sowing date and potassium fertilization on fresh weight of branches/plant (g) of *Foeniculum vulgare* Mill. during 2003/2004 and 2004/2005 seasons.

Treatments	First season					Second season				
A / B	15/10	30/10	15/11	30/11	Mean	15/10	30/10	15/11	30/11	Mean
0.0 control	151.7	153.5	182.5	203.5	172.8	151.7	169.5	198.5	235.7	188.9
K (two sprays)	171.5	196.7	267.0	271.0	226.6	204.5	238.0	247.7	284.5	243.7
K (three sprays)	192.3	223.5	323.5	331.5	267.7	275.0	305.5	332.0	390.0	325.6
K (four sprays)	237.5	285.5	335.0	352.0	302.5	283.5	315.7	374.0	398.0	342.8
Mean	188.25	214.8	277.0	289.5		228.7	257.2	288.1	327.1	

L.S.D.	5%	1%	5%	1%
A = (sowing dates)	14.8	18.51	15.3	19.2
B = (potassium levels)	19.7	23.82	20.4	24.15
(A x B) = Interaction	23.4	27.21	23.8	27.92

Table (3): Effect of sowing date and potassium fertilization on the dry weight of branches/plant of *Foeniculum vulgare* Mill. during 2003/2004 and 2004/2005 seasons..

Treatments	First season					Second season				
A / B	15/10	30/10	15/11	30/11	Mean	15/10	30/10	15/11	30/11	Mean
0.0 control	98.5	98.5	102.5	118.5	104.50	100.5	102.0	109.5	130.5	110.63
K (two sprays)	120.5	121.5	130.0	131.5	125.88	121.5	130.0	132.5	133.5	129.38
K (three sprays)	125.5	128.5	154.5	157.5	141.50	135.5	142.0	149.0	165.0	147.88
K (four sprays)	129.5	135.5	158.5	161.0	146.13	137.5	143.0	152.0	165.5	149.50
Mean	118.50	121.00	136.38	142.13		123.75	129.25	135.75	148.63	

L.S.D.	5%	1%	5%	1%
A = (sowing dates)	5.64	7.43	6.1	7.82
B = (potassium levels)	7.18	9.89	6.7	9.15
(A x B) = Interaction	9.45	12.04	9.5	11.67

Table (4): Effect of sowing date and potassium fertilization on the fresh weight of leaves/plant of *Foeniculum vulgare* Mill. during 2003/2004 and 2004/2005 seasons..

Treatments	First season					Second season				
A / B	15/10	30/10	15/11	30/11	Mean	15/10	30/10	15/11	30/11	Mean
0.0 control	42.0	42.8	46.6	53.9	46.33	44.8	48.4	51.7	56.0	50.98
K (two sprays)	53.0	53.6	67.0	69.8	60.85	56.2	58.5	58.6	60.5	58.45
K (three sprays)	56.5	59.9	80.8	82.9	70.03	59.8	62.7	65.4	68.9	64.20
K (four sprays)	72.6	73.5	84.9	87.0	79.50	62.6	63.9	66.7	68.6	65.45
Mean	56.00	57.5	69.8	73.4		56.6	58.4	60.7	63.5	

L.S.D.	5%	1%	5%	1%
A = (sowing dates)	7.6	9.2	7.8	9.7
B = (potassium levels)	8.3	10.06	8.4	10.25
(A x B) = Interaction	10.6	13.52	10.8	13.42

Table (5): Effect of sowing date and potassium fertilization on the dry weight of leaves/plant of *Foeniculum vulgare* Mill. during 2003/2004 and 2004/2005 seasons..

Treatments	First season					Second season				
A / B	15/10	30/10	15/11	30/11	Mean	15/10	30/10	15/11	30/11	Mean
0.0 control	19.5	20.5	20.9	23.9	21.2	20.7	20.8	22.7	26.8	22.8
K (two sprays)	24.2	25.3	26.2	26.6	25.6	26.3	27.0	27.2	27.4	27.0
K (three sprays)	24.5	26.0	30.1	32.1	28.2	27.9	28.5	28.9	29.6	28.7
K (four sprays)	15.1	28.3	32.5	33.2	29.8	28.3	28.5	29.2	29.8	29.0
Mean	23.3	25.0	27.4	29.0		25.8	26.2	27.0	28.4	

L.S.D.	5%	1%	5%	1%
A = (sowing dates)	2.4	3.26	1.85	2.45
B = (potassium levels)	3.2	4.58	2.23	2.87
(A x B) = Interaction	4.1	5.67	3.43	4.09

Table (6): Effect of sowing date and potassium fertilization on fruit yield/plant of *Foeniculum vulgare* Mill. during 2003/2004 and 2004/2005 seasons..

Treatments	First season					Second season				
A / B	15/10	30/10	15/11	30/11	Mean	15/10	30/10	15/11	30/11	Mean
0.0 control	31.72	32.16	32.64	33.06	32.40	33.50	35.60	36.40	34.10	34.90
K (two sprays)	37.60	38.10	39.30	39.94	38.68	35.00	37.24	39.80	40.34	38.10
K (three sprays)	38.30	41.36	41.44	43.74	41.22	36.60	39.60	41.14	44.50	40.46
K (four sprays)	39.30	42.10	42.70	45.16	42.32	41.50	42.40	44.00	46.00	43.48
Mean	36.68	38.44	39.02	40.48		36.66	38.72	40.34	41.24	

L.S.D.	5%	1%	5%	1%
A = (sowing dates)	1.11	1.34	1.24	1.41
B = (potassium levels)	1.78	1.94	1.81	1.85
(A x B) = Interaction	2.07	2.28	2.16	2.23

Table (7): Effect of sowing date and potassium fertilization on the fruit yield/fed. (kg) of *Foeniculum vulgare* Mill. during 2003/2004 and 2004/2005 seasons..

Treatments	First season					Second season				
A / B	15/10	30/10	15/11	30/11	Mean	15/10	30/10	15/11	30/11	Mean
0.0 control	1015.04	1029.12	1044.48	1057.92	1036.8	1072.00	1139.20	1164.80	1091.20	1116.80
K (two sprays)	1203.20	1219.20	1257.60	1278.08	1237.76	1120.00	1191.68	1273.60	1290.88	1219.20
K (three sprays)	1225.60	1323.52	1326.08	1399.68	1319.04	1171.20	1267.20	1316.48	1424.00	1299.72
K (four sprays)	1257.60	1347.20	1366.40	1445.12	1354.24	1328.0	1356.8	1408.00	1472.00	1391.36
Mean	1173.76	1230.08	1248.64	1295.36		1173.12	1239.04	1290.88	1319.68	

L.S.D.	5%	1%	5%	1%
A = (sowing dates)	17.8	21.4	15.2	19.8
B = (potassium levels)	22.6	25.7	24.2	27.6
(A x B) = Interaction	29.3	32.9	28.5	32.3

Table (8): Effect of sowing date and potassium fertilization on the fruit volatile oil percentage of *Foeniculum vulgare* Mill. during 2003/2004 and 2004/2005 seasons..

Treatments	First season					Second season				
A / B	15/10	30/10	15/11	30/11	Mean	15/10	30/10	15/11	30/11	Mean
0.0 control	3.10	3.24	3.26	3.54	3.29	3.31	3.45	3.52	3.55	3.46
K (two sprays)	3.70	4.00	4.35	4.47	4.13	4.15	4.35	4.47	4.59	4.39
K (three sprays)	3.80	4.60	4.68	4.74	4.46	4.23	4.48	4.58	4.61	4.48
K (four sprays)	4.15	4.70	4.72	4.86	4.61	4.37	4.53	4.58	4.70	4.55
Mean	3.69	4.14	4.25	4.40		4.02	4.20	4.29	4.36	

L.S.D.	5%	1%	5%	1%
A = (sowing dates)	0.05	0.08	N.S	N.S
B = (potassium levels)	0.11	0.13	0.11	0.15
(A x B) = Interaction	0.15	0.19	0.16	0.19

Table (9): Effect of sowing date and foliar application with potassium on the identified constituents of fennel fruits volatile oil obtained from G.L.C. analysis and calculated as relative percentages.

Constituents / Treatments	∝-Pinene	L. Limonene	Chavicol	Anethol
October 15th + 0.0 potassium	0.64	6.84	0.50	88.27
+ two sprays	0.72	9.10	4.17	79.64
+ three sprays	6.48	8.35	0.12	84.83
+ four sprays	0.13	21.66	1.07	55.07
October 30th + 0.0 potassium	2.55	25.79	1.77	46.41
+ two sprays	0.01	9.23	0.48	73.20
+ three sprays	1.76	11.37	0.20	76.13
+ four sprays	2.11	28.19	1.17	52.40
November 15th + 0.0 potassium	0.61	6.49	0.43	82.40
+ two sprays	3.09	25.20	0.26	54.01
+ three sprays	4.16	4.77	0.09	87.91
+ four sprays	0.92	5.69	0.94	71.55
November 30th + 0.0 potassium	0.53	7.16	0.56	80.76
+ two sprays	0.50	5.55	0.00	83.00
+ three sprays	0.47	4.15	0.69	83.00
+ four sprays	0.22	12.25	0,02	87.51

The anethole percentage of fennel fruits oil was influenced by the different sowing dates, sprays number with K at the rate of 1.5% and the interaction between them. The obtained data in Table (9) and Figs. (1:16) revealed that sowing date of October 15th was the most effective which increased the anethole percentage over that of the medium or the late one. The anethole component percentage decreased with applying 1 5% of K at the rates of two. three or four sprays at first planting date compared with unsprayed plants. The opposite trend of this was attained in the second, third and fourth sowing dates (October 30th, November 15th and November 30th). As for L-limonene compound, sowing date of October 30th + spraying fennel plants with 1.5% of K four times attained a higher value for this compound compared with all other treatments. However, the lowest value of the same compound (L-limonene) was obtained by lating sowing date (November 30th) + spraying fennel plants with three sprays of K at rate 1.5%. As for ∝ -pinene compound, cultivating fennel seeds in October 15th combined with spraying plants by 1.5% of K three times gave the highest percentage of ∝-pinene in essential oil compared with all other treatments, while the lowest value of this compound was attained by second sowing date X spraying plants with 1.5% of K two times during growth seasons. Regarding chavicol compound, the data in Table (9) and Figs. (1:16) cleared that, earlist sowing date (October 15th) X two sprays of 1.5% K during growth season, gave the highest percentage of chavicol compound in the oil whereas last sowing date (November 30th) X two sprays of 1 5% K during growth season attained the lowest value

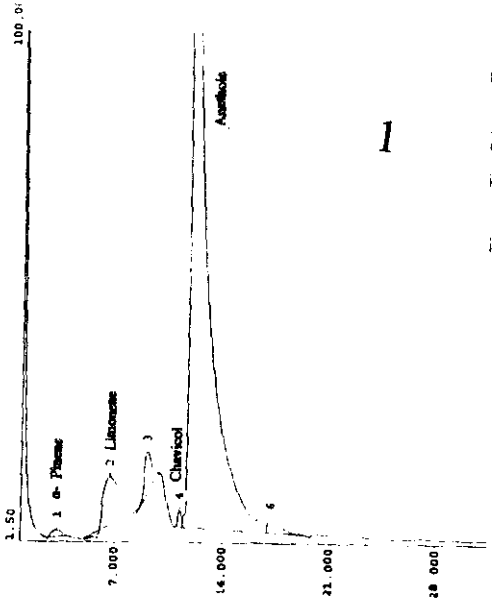

Fig. (1): GLC chromatogram of fennel oil distilled from fruits of plants sown at October 15th.

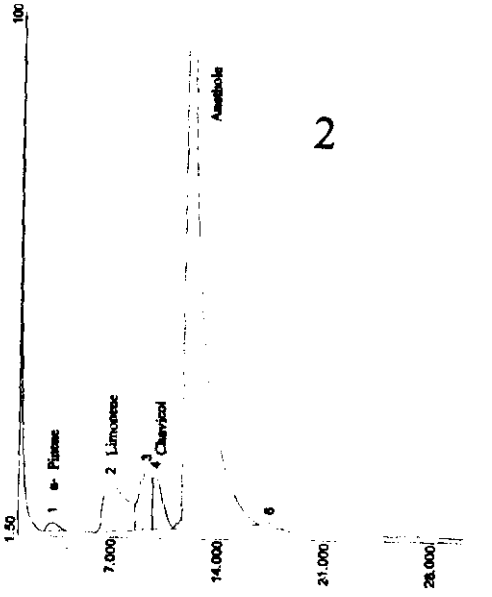

Fig. (2): GLC chromatogram of fennel oil distilled from fruits of plants sown at October 15th and treated by potassium two sprays.

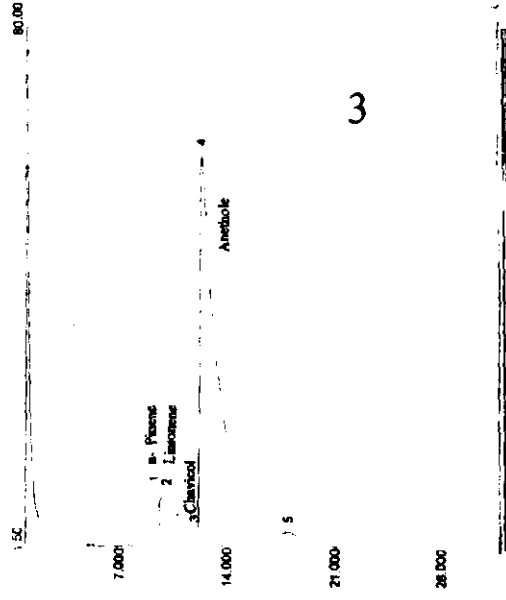

Fig. (3): GLC chromatogram of fennel oil distilled from fruits of plants sown at October 15th and treated by potassium three sprays.

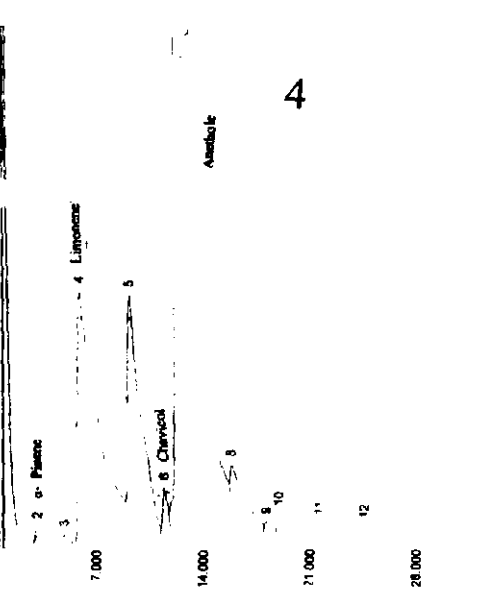

Fig. (4): GLC chromatogram of fennel oil distilled from fruits of plants sown at October 15th and treated by potassium four sprays.

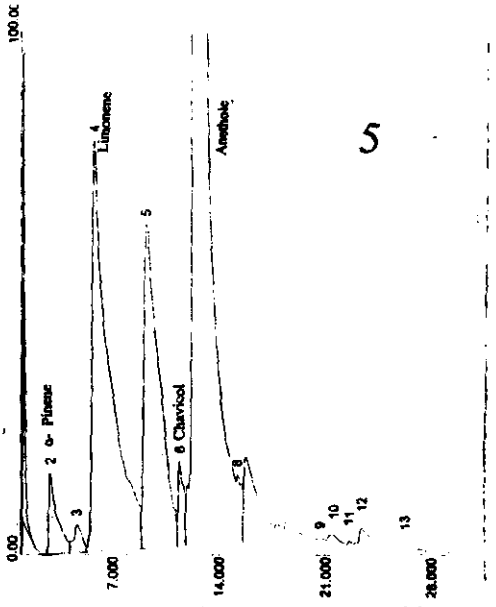

Fig. (5): GLC chromatogram of fennel oil distilled from fruits of plants sown at October 30th.

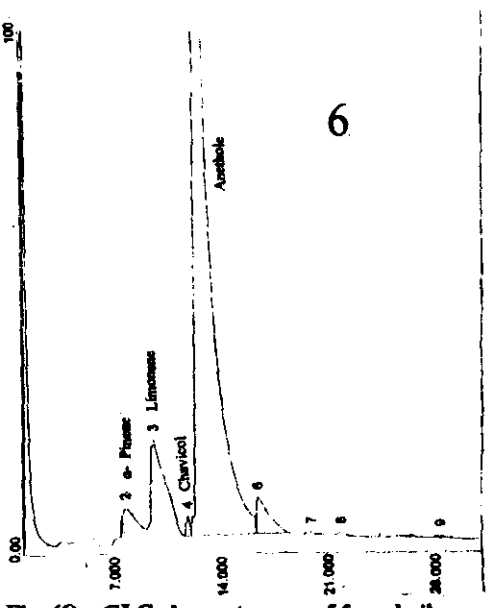

Fig. (6): GLC chromatogram of fennel oil distilled from fruits of plants sown at October 30th and treated by potassium two sprays.

Fig. (7): GLC chromatogram of fennel oil distilled from fruits of plants sown at October 30th and treated by potassium three sprays.

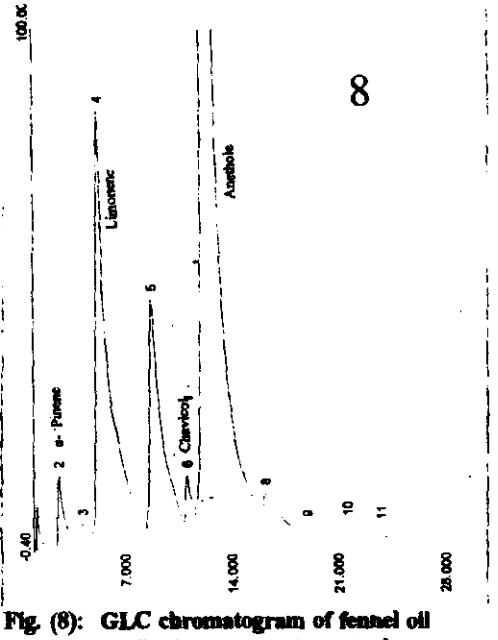

Fig. (8): GLC chromatogram of fennel oil distilled from fruits of plants sown at October 30th and treated by potassium four sprays.

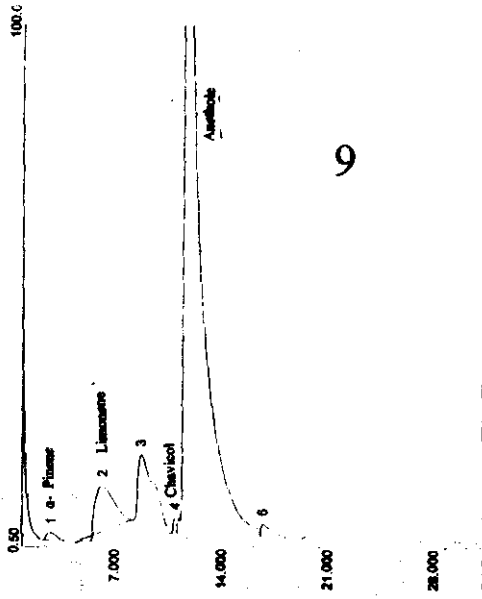

Fig. (9): GLC chromatogram of fennel oil distilled from fruits of plants sown at November 15th.

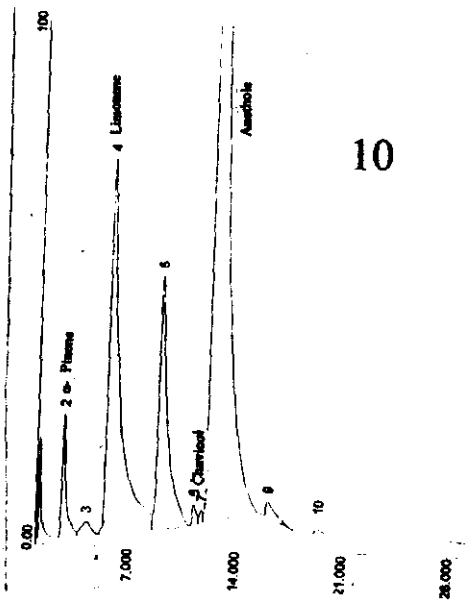

Fig. (10): GLC chromatogram of fennel oil distilled from fruits of plants sown at November 15th and treated by potassium two sprays.

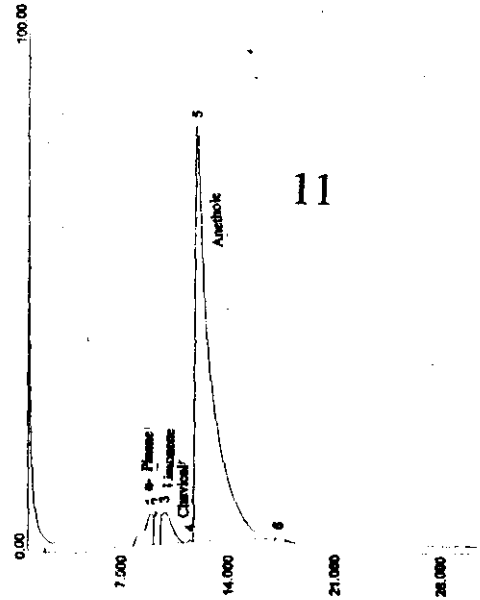

Fig. (11): GLC chromatogram of fennel oil distilled from fruits of plants sown at November 15th and treated by potassium three sprays.

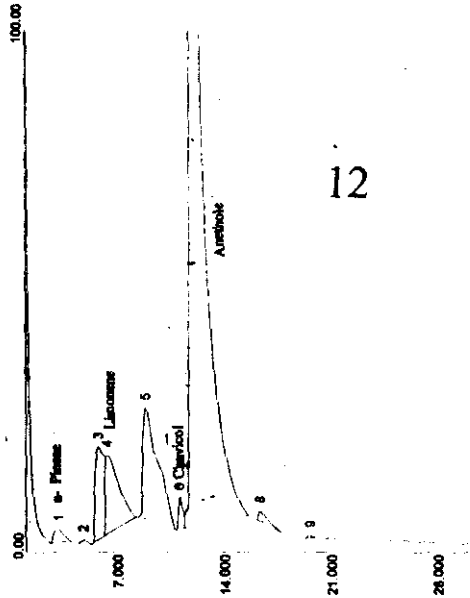

Fig. (12): GLC chromatogram of fennel oil distilled from fruits of plants sown at November 15th and treated by potassium four sprays.

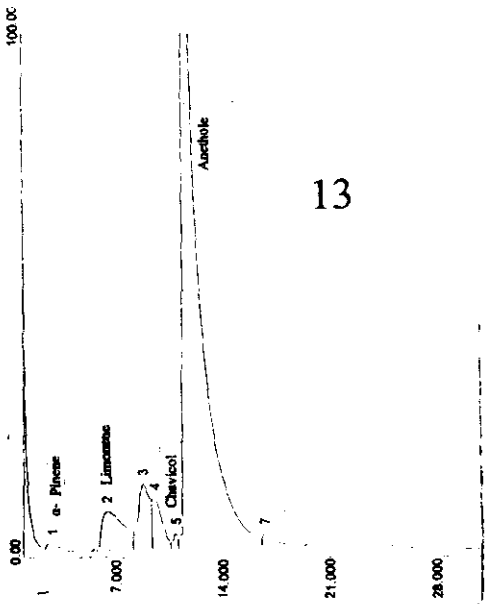

Fig. (13): GLC chromatogram of fennel oil distilled from fruits of plants sown at November 30th.

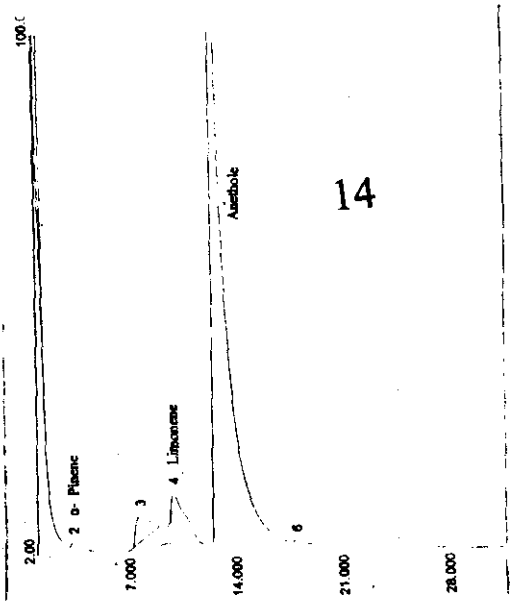

Fig. (14): GLC chromatogram of fennel oil distilled from fruits of plants sown at November 30th and treated by potassium two sprays.

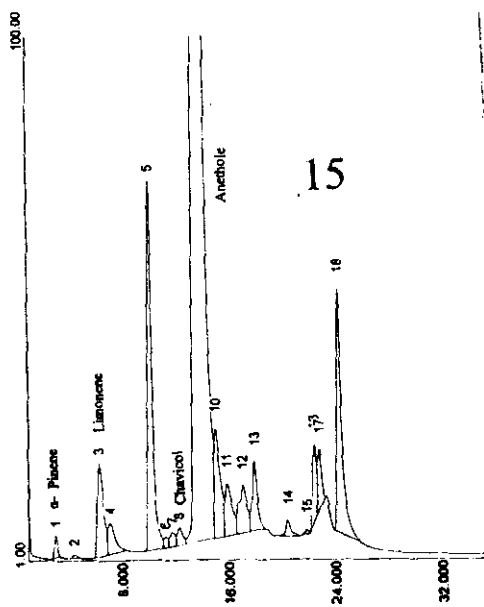

Fig. (15): GLC chromatogram of fennel oil distilled from fruits of plants sown at November 30th and treated by potassium three sprays.

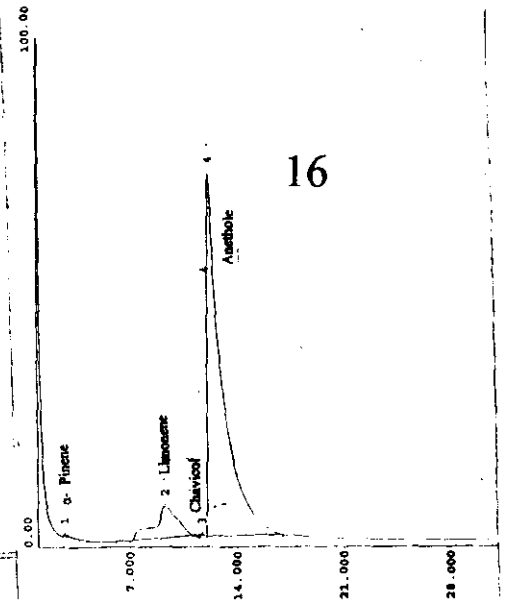

Fig. (16): GLC chromatogram of fennel oil distilled from fruits of plants sown at November 30th and treated by potassium four sprays.

b- Total carbohydrates percentage:

Data illustrated in Table (10) showed that, the total carbohydrates percentage in leaves of fennel plants was varied between various planting dates. The highest value in both seasons was attained by sowing fennel seeds at the last date (30/11), this treatment increased total carbohydrates percentage over early sowing date (15/10) by 5.44 and 7.81% in the first and second seasons, respectively.

In this respect Bowler *et al.* (1992), Elstner and Osswald 1994 and Mckerise *et al.*, 1996, mentioned that higher temperature stress either accelerates the formation of toxic reactive oxygen species (ROS) within plant tissues or impair the normal defense mechanisms that protect tissues from (ROS) toxic effect. Such stress induces higher O_2 photo reduction within chloroplast or electron transport disturbance and donation of electron to O_2 within mitochondria, all led to generation of toxic ROS. Those ROS (H_2O_2, OH, O_2,.....) damaged chloroplast, reduced carbohydrates synthesis and exportation and hastened oxygen senescence (Dicknson *et al.*, 1991), attacked cell membranes and led to their degradation and leakage of cell solutes, denaturation of proteins and enzymes, damage of nucleic acids, degradation of chlorophyll and suppression of all metabolic processes, finally senescence and death of cells and tissues, hence, stimulates flower abortion and reduction of yielded fruits (Stroev 1989; Cakmak and Marschner, 1992 and Taiz and Zeiger 1998).

The obtained results in Table (10) showed that, the total carbohydrates percentage in fennel leaves was affected by foliar application of potassium. The increase of spraying times gradually increased total carbohydrates percentage in plant leaves compared with control plants in both seasons. The maximum increase in total carbohydrates percentage was attained as a result of K application three or four times at the fourth sowing date in both seasons.

c- Minerals content:

Nitrogen percentage:

Data in Table (11) revealed that the latest sowing date significantly increased the N % of fennel leaves compared with the first sowing date in the first season. Generally, the fourth sowing date resulted in the highest N % compared with the first, second or third sowing date in both seasons. The results in the same Table indicated that, the spraying treatments with K at the rate of 1.5% increased N% in each sowing date. The highest values of N% were 2.53 and 2.29% obtained from K spraying with four sprays in the fourth sowing date in the first and second seasons, respectively.

Phosphorous percentage:

Data presented in Table (12) indicated that sowing dates had a constant trend on phosphorous accumulation in fennel plant in the two seasons. The latest sowing dates slightly increased P % in plant leaves compared with early sowing date (15/10), as the highest value in both seasons was attained by sowing fennel seeds in 30/11. On the other side, the data in the same Table (12), generally revealed that, all potassium treatments (separated or combined with sowing dates)

Table (10): Effect of sowing date and potassium fertilization on the total carbohydrates percentage of *Foeniculum vulgare* Mill. during 2003/2004 and 2004/2005 seasons..

Treatments	First season					Second season				
A / B	15/10	30/10	15/11	30/11	Mean	15/10	30/10	15/11	30/11	Mean
0.0 control	18.38	18.46	18.61	19.40	18.71	19.20	19.46	19.65	20.70	19.75
K (two sprays)	20.65	21.0	22.13	22.80	21.65	20.47	21.63	22.40	22.83	21.83
K (three sprays)	21.75	21.91	21.37	23.12	22.04	21.81	22.18	22.92	23.00	22.48
K (four sprays)	21.89	22.52	23.45	23.52	22.85	21.82	22.68	23.14	23.35	22.75
Mean	20.67	20.97	21.39	22.21		20.83	21.49	22.03	22.47	

L.S.D.	5%	1%	5%	1%
A = (sowing dates)	0.74	0.97	0.63	N.S
B = (potassium levels)	0.95	1.14	0.87	1.13
(A x B) = Interaction	1.18	1.56	1.03	N.S

Table (11): Effect of sowing date and potassium fertilization on nitrogen percentage of *Foeniculum vulgare* Mill. during 2003/2004 and 2004/2005 seasons..

Treatments	First season					Second season				
A / B	15/10	30/10	15/11	30/11	Mean	15/10	30/10	15/11	30/11	Mean
0.0 control	1.70	1.78	1.84	1.90	1.81	1.72	1.81	1.83	1.93	1.82
K (two sprays)	1.78	1.88	1.95	2.24	1.96	1.80	1.92	1.98	2.11	1.95
K (three sprays)	1.80	1.96	1.97	2.25	2.00	1.88	1.98	2.00	2.20	2.02
K (four sprays)	1.97	2.02	2.03	2.53	2.14	2.06	2.12	2.08	2.29	2.14
Mean	1.81	1.91	1.95	2.23		1.87	1.96	1.97	2.13	

L.S.D.	5%	1%	5%	1%
A = (sowing dates)	0.10	N.S	0.10	N.S
B = (potassium levels)	0.11	N.S	0.13	N.S
(A x B) = Interaction	0.18	N.S	0.18	N.S

Table (12): Effect of sowing date and potassium fertilization on phosphorous percentage of *Foeniculum vulgare* Mill. during 2003/2004 and 2004/2005 seasons..

Treatments	First season					Second season				
A / B	15/10	30/10	15/11	30/11	Mean	15/10	30/10	15/11	30/11	Mean
0.0 control	0.48	0.49	0.51	0.52	0.50	0.50	0.51	0.52	0.53	0.52
K (two sprays)	0.49	0.51	0.52	0.54	0.52	0.51	0.52	0.53	0.54	0.53
K (three sprays)	0.51	0.52	0.54	0.56	0.53	0.51	0.54	0.54	0.55	0.54
K (four sprays)	0.54	0.54	0.55	0.56	0.55	0.54	0.54	0.56	0.55	0.55
Mean	0.51	0.52	0.53	0.55		0.52	0.53	0.54	0.54	

L.S.D.	5%	1%	5%	1%
A = (sowing dates)	N.S	N.S	N.S	N.S
B = (potassium levels)	N.S	N.S	N.S	N.S
(A x B) = Interaction	N.S	N.S	N.S	N.S

Table (13): Effect of sowing date and potassium fertilization on potassium percentage of *Foeniculum vulgare* Mill. during 2003/2004 and 2004/2005 seasons..

Treatments	First season					Second season				
A / B	15/10	30/10	15/11	30/11	Mean	15/10	30/10	15/11	30/11	Mean
0.0 control	1.50	1.54	1.62	1.66	1.58	1.57	1.57	1.62	1.67	1.61
K (two sprays)	1.68	1.70	1.76	1.80	1.74	1.62	1.63	1.75	1.82	1.71
K (three sprays)	1.72	1.79	1.85	1.89	1.81	1.72	1.72	1.83	1.85	1.78
K (four sprays)	1.80	1.85	1.87	1.95	1.87	1.84	1.89	1.88	1.95	1.89
Mean	1.68	1.72	1.78	1.83		1.69	1.70	1.77	1.82	

L.S.D.	5%	1%	5%	1%
A = (sowing dates)	0.07	0.10	0.06	0.08
B = (potassium levels)	0.11	0.13	0.09	0.12
(A x B) = Interaction	0.13	0.16	0.12	0.16

caused a slight increase in phosphorous percentage in both seasons and the control plants had lowest value which reached 0.48 and 0.50% in the first and second seasons respectively. Generally, the plants sprayed with potassium at the rate of 1.5% four times in late sowing date attained the highest value of phosphorous in fennel plants in both seasons. These results are in accordance with the findings of Selim *et al.* (1993) on roselle.

Potassium percentage:

Data in Table (13) indicated that, the sowing dates treatments had a constant effect on potassium percentage in fennel plants in both seasons. The late sowing dates improved potassium % in plant leaves comparing with early sowing date. The sowing date at 30/11 gave the highest increases of potassium % in plant leaves compared with early sowing date (15/10), as the differences were highly significant. The data showed that all foliar sprays with potassium treatments tended to increase potassium % in fennel plants in the two seasons. The most effective treatment in this respect was four sprays of K at the rate of 1.5% in the fourth sowing date which gave 1.95% in each season. These results are in accordance with those reported on roselle plants by Selim *et al.* (1993).

In general it can be concluded that the fourth sowing date + spraying four times of potassium at the rate of 1.5% during growth season was considered as the most suitable treatment for best fennel production with good fruit quality.

REFERENCES

Abd El-Daym, M.A.; Shams, S.A.A. and Abo Kaied, H.M.H. (2002): Effect of planting dates and seeding rates on yield and its components of flax (*Linun usitatissimum*, L.) grown under newly reclaimed land. Annals Of Agric. Sc., Moshtohor, 40(2): 741-749.

Abdel-Al, Z.E.; Khalaf-Allah, A.; El-Shal. M. and Abdel-Kader, M. (1975): Fundamental of vegetable. Dar El-Matbdat, (Arabic Text. Book) 43p.

Abuo Zeid, E.N. (1988): Aromatic Plants and their Agricultural plants Distribution and Pharmaceutical Products. El Dar El Arabia For Publications. Cairo (In Arabic).

Ali, A.F. (1993): Response of Nigella sativa L. plants to some fertilization and growth regulators treatments. Ph.D. Thesis Fac. Agric., Minia Univ. pp. 113.

Arslan, N.; Bayrak, A. and Akgul, A. (1989): The yield and components of essential oil in fennel of different origins (*Foeniculum vulgare* Mill) grown in Ankara Turkey conditions. Herbe Jubg., 28(3): 27-32.

Attia, F.A. (1993): The physiological response of caraway (*Carium carvi* L.) to nitrogen and potassium fertilization. Minia J. Agric., Res., & Dev. 15. 345-358 pp.

Badran, F.S. and El-Maziny, M.Y. (1989): Response of cumin (*Cuminum cyminum*, L.) plants grown under sandy calcareous soil condition to irrigation frequency and potassium fertilization. Proc. Ann. Conf. Arab Soc. Medicinal Plant Res. Cairo Egypt. Feb. 1989.

Belal, A.E. (1995): Environmental management of fuel wood resources in Wadi Allaqi. Report. IDRCP-921001.

Bhati, D.S. (1988): Effect of nitrogen application and row spacing on coriander (*Coriandrum sativum*) production under irrigated condition in semi arid Rajasthan. Ind. Jour. Agric. Sci., 58(7): 568-569.

Bottrill, D.E.; Possingham, J.V. and Kriedemann, P.E. (1970): The effect of nutrients deficiencies on photosynthesis and respiration in spinach. Plant and Soil, 32: 424-438 pp..

Bowler, C.; Montogu, M.V. and Inze, D. (1992): Superoxide dismutase and stress tolerance Ann Rev. Plant Physiol. Plant. Mol. Biol., 48: 223-250.

Cakmak, T. and Marschner, H. (1992): Magnesium deficiency and high light intensity enhance activities of superoxide dismutase, ascrobite peroxidase and glutathione verductase in bean leaves. Plant Physiol., 98: 1222-1227.

Dicknson, C.D.; Altabella, T. and Chrispeels, M.S. (1991): Slow growth phenotype of transgenic tomato expressing oplastic invertast. Plant Physio., 95: 420-425.

El-Kadi, G. (1988): Market mechanisms and spontaneous urbanization in Egypt: the Cairo case, International Journal of Urban and Regional Research, 12: 22-37.

Elstner, E.F. and Osswald, W. (1994): Mechanisms of oxygen activation during plant stress. Proc. R. °C. Edin., 102B: 131-154. Strov. E.A. (1989) Biochemistry Mir Pub. 2 Prevy Rizsky Pereulok, 1-110 GSP. Moscew, 129820 USSR, 344 pp..

Gardner, F.P.; Pearce, R.B. and Mitchell, R.L. (1985): Physiology of Crop Plants. Iowa State University Press. Ames.

Graves, G. (1990): "Medicinal Plants" Brocken Books, London.

Haeder, H.E.; Mengel, K. and Forster, H. (1973): J. Sci. of Food and Agric., 24: 1479-87..

Herbert, D.; Philpps, P.J. and Strange, R.E. (1971): Determination of total carbohydrate. Method in Microbiol, 58: 209-344.

Ibrahim, Zahira, T.Z. (2000): Effect of some culture practice on growth and chemical composition of some medicinal plants under condition of North sinai. Ph.D. Thesis, Fac. Agric. Kafer El-Sheikh, Tanta Univ.

Kandil, M.A.M.H. (2002): The effect of fertilizers for conventional and organic farming on yield and oil quality of fennel (*Foeniculum vulgare* Mill.) in Egypt. Von Der Gemeinsamen Naturwissenschaftilichen Fakulät der Technischen Universität Carolo-Wilhelmina Zu Braunschweig Zur Erlangung des Grades eines Doktors der Naturwissenschaften (Dr. ver.nat.) 2002.

Kassem, A.M. (1997): Effect of chemical fertilization on *Rosmarinus officinals* plants. M.Sc. Thesis Fac. Agric. Cairo Univ. p.89 .

Kim, D.H. and Ahn, Y.I. (2001): Contact and fumigant activities of constituents of *Foeniculum vulgare* fruit against three coleoptera stored product insects. Pest Management Science, 57: 301-306.

Leung, A.Y. and Foster, S. (1996): Encyclopaedia of common natural Ingredients Used in Food, Drugs and Cosmetics. Second ed. New York. John Wiley and Sons, Inc.

Matter, F.M. (1997): Effect of sowing dates, sow spacing and gamma radiation on growth, yield and chemical composition of black cumin Ph.D. Thesis, Fac. Agric., Fayoum, Cairo Univ.

Mckersie, B.D.; Bowley, S.R.; Harjanto, E. and Leprince, O. (1996): Water deficit tolerance and field performances of transgenic alfalfa over xpressing superoxide dismutase. Plant Physiol, 111: 1177-1181.

McMaster, G.S. (1997): Phenology, development, and growth of wheat (*Triticum aestivum* L.) shoot apex: A review. Advaces in Agron., 59: 63-118.

Meawad, A.A.; Awad, A.E. and Abdel-Kader, M. (1991): Physiological studies on fennel plants 1-Effect of N,P and K fertilization on the growth, flowering fruit and oil yield, as well as, chemical constituents. Egypt J. Appl. Sci., 6(9): 636-646.

Mohamed, M.B. (1992): Yield response of coriander to sowing date and amidin fertilization on the central clay plains of Sudan Beitrage zur Tropschen Landwirtschaft und velerinarm edizin, 30(1): 25-31.

Mohamed, S.A. (1989): Effect of mineral nutrition on some morphological anatomical characters and yield of chamomile and fennel plants. M.Sc. Thesis, Fac. Agric. Fayoum, Cairo Univ. pp 97.

Munshi, A.M.; Zagar, G.H.; Baba, G.H. and Bhat, G.N. (1990): Effect of plant density and fertilizer levels on the growth and seed yield of black zeera under rain-fed conditions. Hort. Abst., 61(4): 3058.

Netting, R.M. (1993): Smallholders, Householders: Farm families and the ecology of intensive, sustainable agriculture. Standford University Press.

Omer, E.A.; Ibrahim, M.E.; Razin, A.M. and Ahmed, S.S. (1995): Effect of spacing, nitrogen and potassium fertilization on *Silybum marianum*, L. cultivated in newly reclaimed lands. Egypt. J. Hort., 22: 97-108.

Ruberto, G.; Barattata, M.; Deans, S.G. and Dorman, H.D.J. (2000): Antioxidant and antimicrobial activity of *Foeniculum vulgare* essential oils. Planta Medica, 66: 687-693.

Salama, A.M. (1996): Influence of planting date and nitrogen fertilizer levels on agronomic characteristics of three flax cultivars. J. Agric. Sci. Mansoura Univ., 21(3): 881-891.

Selim, S.M.; Rokba, A.M.; Hassan, M.R. and Hassanain, M.A. (1993): Effect of sowing dates, nitrogenous and potassium fertilization on roselle plant II- Effect on chemical composition. Egypt. J. Hort. 20(1): 97-109.

Shukla, H.; Dubey, P. and Chaturvedi, R. (1989): Antiviral properties of essential oils of *Foeniculum vulgare* and *Pimpinella anisum*. Agronomie (1989)9(3): 277-279 (c.f. Hort. Abst., 60(4): 2801).

Snedecor, G.W. and Cochran, W.G. (1989): Statistical Method 8th Fd., Iowa State Univ., Press; Iowa, U.S.A.

Stodola, J. and Volak, J. (1992): The illustrated Encyclopedia of Herbs. Edited by: Sarah Bunney, Chancellor Press, Michelin House, London. P. 145.

Stroev, E.A. (1989): Biochemistry ISBN, 5-03-000543-USSR, P: 344-345.

Taiz, L. and Zeiger, E. (1998): Plant Physiology Stress Physiology, Sinauer Associates. Inc. Publishers Sunderland, Massachusetts. PP. 725-757.

Wanger, H. (1999): Arzneidrogen und ihre inhaltssoffe Band 2. Wissenschaftliche Verlagsgesellschaft mbH Stuttgart.

Wichtel, M. and Bisset, N.G. (1994): Herbal Drugs and Phytopharmaceuticals Stuttgart: Medpharm Scientific Publishers.

Wilde, S.A.; Corey, R.B.; Lyer, J.G. and Voigt, G.R. (1985): Soil and Plant Analysis for Tree Culture 3rd Ed. Oxford and IBH Publishing Co. New Delhi.

Wilhelm, W.W. and McMaster, G.S. (1995): The importance of phyllochron in studying the development of grasses Crop Sci., 53: 1-2.

Zaky, Laila, M.; Abd El-Hamid, M. and El-Farouk, M. (1988): Effect of planting time and nitrogen fertilizer source on flax production. Annals Of Agric. Sc., Moshtohor, 26(1), 85-102.

تأثير ميعاد الزراعة والتسميد بالبوتاسيوم على النمو والمحصول والتركيب الكيماوى لنباتات الشمر

عبدالله صالح محمد الخياط*، حسناء عبالحسيب حسن جوده**

* قسم البساتين ــ كلية الزراعة بمشتهر ــ جامعة بنها.

** الهيئة القومية للرقابة والبحوث الدوائية.

أجريت هذه الدراسة فى تجربتين حقليتين خلال موسمى الزراعة ٢٠٠٣/٢٠٠٤، ٢٠٠٤/٢٠٠٥ بمزرعة التجارب والبحوث الزراعية بكلية الزراعة بمشتهر ــ جامعة بنها على نباتات الشمر لدراسة تأثير مواعيد الزراعة (١٥/١٠، ٣٠/١٠، ١٥/١١، ٣٠/١١) وأربعة معاملات من أوكسيد البوتاسيوم بتركيز ١,٥% (بدون رش، رشتان، ثلاث رشات، أربع رشات) وكذلك التفاعل بينهما على النمو والمحصول والمحتوى الكيماوى لنباتات الشمر حيث كانت الفترة بين الرشة والتى تليها ١٥ يوم.

وقد إتبع تصميم القطع المنشقة مرة واحدة فى ثلاث مكررات وكل مكررة إحتوت على ١٥ جوره (٣٠ نبات) ونفذت معاملات ميعاد الزراعة فى القطع الرئيسية ومعاملات التسميد بالبوتاسيوم فى القطع المنشقة وتم رش نباتات الكنترول بماء الصنبور وتم أخذ بيانات النمو والمحصول وأجريت بعض التحاليل الكماوية مثل:ــ

- إرتفاع النبات والوزن الطازج والجاف للأوراق والأفرع ومحصول البذرة (الثمار) للنبات الواحد. وكذلك المحصول بالنسبة للفدان، وتم تقدير متوسط النسبة المئوية للزيت الطيار فى البذور(الثمار) والنسبة المئوية لمكونات الزيت الطيار بإستخدام التحليل الكروماتوجرافى الغازى (G.L.C.) والنسبة المئوية لكل من النيتروجين والفوسفور والبوتاسيوم والكربوهيدرات الكلية فى أوراق النبات، وكانت أهم النتائج المتحصل عليها كمايلى:ــ
- أدت زراعة بذور نباتات الشمر فى ١١/٣٠ الى زيادة كل من طول النبات والوزن الطازج والجاف لأوراق والأفرع وكذلك وزن البذور(الثمار) للنبات الواحد أو للفدان وكان هذا الإتجاه ثابتا فى موسمى الزراعة لهذه التجربة.
- أدى ميعاد الزراعة فى ١١/٣٠ إلى زيادة النسبة المئوية للزيت الطيار فى بذور(ثمار) النبات كما أدى الى زيادة النسبة المئوية لكل من الكربوهيدرات

الكلية والنيتروجين والفوسفور والبوتاسيوم فى أوراق النبات وذلك بالمقارنة بالمعاملات الأخرى لمواعيد الزراعة.

- أدى التسميد بالبوتاسيوم الى زيادة الصفات المختلفة تحت الدراسة بالمقارنة بنباتات الكنترول وأدى إستخدام البوتاسيوم بمعدل ٤ رشات فى الموسم الى الحصول على أفضل النتائج بالمقارنة بالمعاملات الأخرى للتسميد فى هذه التجربة
- أدى التفاعل بين الزراعة فى ١١/٣٠ والتغذية بالبوتاسيوم بمعدل ٤ رشات فى الموسم الى الحصول على أفضل القيم بالنسبة للنمو الخضرى والمحصول وكذلك المحتوى الكيماوى بالمقارنة بكل المعاملات فى هذه التجربة، أدى التحليل الكروماتوجرافى للزيت الطيار لثمار نباتات الشمر الى وجود المكونات الآتية (الفابينين، ل ــ ليمونين ــ كافيكول وكذلك الأنيثول، وأدت زراعة بذور نباتات الشمر فى ١١/٣٠ والتغذية بالبوتاسيوم بتركيز ١,٥% بمعدل ٤ رشات فى الموسم الى الحصول على ٠,٢٢، ١٢,٢٥، ٠,٠٢ وكذلك ٨٧,٥١% لكل من مركب الفانبين، ل ــ ليمونين، الكافيكول والأنيثول على التوالى.
- ومن هذا يستنتج أنه للحصول على محصول كبير وعالى الجودة من البذور (الثمار) ينصح بالزراعة فى ١١/٣٠ وتسميد النباتات بالبوتاسيوم رشا بتركيز ١,٥% أربع مرات خلال موسم النمو.