Plant Archives Vol. 20, Supplement 2, 2020 pp. 2388-2395 **e-ISSN:2581-6063 (online), ISSN:0972-5210**

STUDY OF ADAPTATION OF DUTCH FENNEL PLANTS TO IMPROVE GROWTH, YIELD AND PRODUCTION OF VOLATILE OIL CONTENT UNDER INFLUENCE OF HARVEST TIME AND DIFFERENT SOURCES OF POTASSIUM FERTILIZER

Salama Y.A.M.[1] and Rania M.R. Khater[2]

[1]Plant Adaptation Unit-Genetic Resource Department, Desert Research Center, Cairo, Egypt

[2]Medicinal and Aromatic Plants Department, Desert Research Center, Cairo, Egypt

Abstract

This work was conducted at Baluza Research Station, Desert Research Center, North Sinai, the area located on 300 3 '0 "N, 320 36' 0" E. during two successive seasons 2017/2018 and 2018/2019 to study the effect of harvesting time, different sources of potassium and their interaction on plant growth, seed yield, volatile oil production and constituents of dutch fennel plants. The experimental design was split plot which included 8 treatments, two treatments for harvest time (120 and 160 days after planting) in the main plots and four treatments for different sources of potassium in the sub-main plots. The different sources of potassium (control, KCl 60%, K_2NO_3 44.5% and K_2SO_4 48%). Results revealed that the maximum values of plant height (cm), number of umbels, fruit yield / plant (g) / feddan (kg), volatile oil percentage (%), volatile oil yield / plant (ml) / feddan (L) were obtained from interaction treatments second harvest time + KNO_3 in both seasons. Also, gave the highest value of chemical components of the oil G.L.C. analysis fenchone, 1, 8-cineole, anethole and estragole (6.51, 3.58, 87.86 and 1.03), respectively.

Keywords : Dutch Fennel - Harvesting Time – Potassium - Anethole – Estragole.

Introduction

Dutch Fennel (*Foeniculum vulgare* Mill.) plants belongs to the family Apiaceae or Umbelliferae it is winter annual plants. It is cultivated in many places in the world and in Egypt it occupies the fennel crop, it had a the first class by 87.64% of the total cultivated area of the fennel in Egypt and represents 76.75% of the total production of fennel in Egypt during the average period of 2011–2007. Basem, (2012) and Boulos, (1983)

Dutch fennel was introduced to Egypt through the SEKEM Company, where the Dutch type is distinguished from the Egyptian type by the increase in anethole in the essential oil to 75.93%, while Astragol falls to 4.22. In Egyptian varieties, estradiol rises to more than 60%, while anethole decreases to less than 2%, which causes the Egyptian variety to be rejected in pharmaceutical factories abroad. El-Laban *et al*. (2017 and 2020), Al-Kord, (2000).

The fruits fennel contain of volatile oil 3 - 6% and the oil main chemical components of anthole 75% and the fenchone 25% Nofal and Menisi (2019) and Mahfouz and Sharaf-Eldin, (2007) it also contains α-pinene, myrcene, trans-anethole, limonene, methyl chavicol, anisic aldehyde and 1,8-cineole.Fennel fruits are used as gastrointestinal analgesics and infectious gases and diuretics and added to licorice and cinematic compounds to avoid colic and improve mouth odor as it is used as an anti-microbial and inflammatory and anti-oxidant Anand *et al*. (2008) and Patra *et al*. (2002). Fennel oil is used in the manufacture of sweets, perfumes, and soaps. Fruits are also added to bread and biscuits to improve the flavor. Osman and Abd El-Wahab, (2003).

Determining the appropriate date for harvesting to maintain the quality and quantity of seeds on the plant is one of the most important research that must be studied and the reason for this is that the crop plants are exposed to environmental factors that may cause loss of vegetable parts and seeds due to their separation from inflorescences or the crop may be affected by temperature and High or low light when harvesting or excessive humidity when plants are exposed to early rain. Cheyed and Alag (2014) indicated that, the safflower plants are harvested when their stems dry and turn brown. The top leaves are soft and the seeds are easy to separate. This facilitates harvesting, but if the harvest is late it will greatly affect the amount of the crop and the loss in it. Sarkar *et al*. (2007) pointed that, the harvest of sesame plants 45 days after flowering led to a significant increase in plant height, number of branches, capsule branch, capsule plant, seeds capsule, weight of 1000 seeds and seed yield. Zutic *et al*. (2003) on Sage plants Notice that, dry weight increased significantly during harvest in the spring season than in the summer season. There was a significant increase in the essential oil contents of the commercial hybrid sage plant at the harvest were dependent on the developmental stage of the plant Dudai *et al*. (2003).

Potassium is one of the major nutrients that the plant needs in greater quantities than other nutrients. Potassium physiologically stimulates more than 65 enzymes specialized in completing biological processes within the plant Mengel and Kirkby (1989). In addition to its role in raising the ability of the plant to withstand drought, as it has a major role in increasing the efficiency of the plant. Water retention through its effect on the movement of opening and closing stomata Mengel and Helal (1967) and Black (1968).

Due to the economic importance of fennel plants, it had a first class in the export of medicinal and aromatic plants. The study aimed to show the effect of harvest time and different sources of potassium fertilization and their interaction on the productivity of Dutch fennel plants and seed yield, volatile oil and active components in Egypt to achieve the highest economic return.

Material and Methods

The research was carried out at Baluza Research Station, Desert Research Center, North Sinai, the area located on 30^0 3' 0" N, 32^0 36' 0" E. during two successive seasons 2017/2018 and 2018/2019 to study the effect of harvesting time, different sources of potassium and their interaction on plant growth, seed yield, volatile oil production and constituents of dutch fennel plants.

Fennel plant seeds were sown on October 10^{th} and 15^{th} for the two seasons, respectively. The distance between plants was 30 cm while the distance between rows was 70 cm. The mechanical and chemical properties of the used soil are shown in Table (1) according to (Page *et al.*, 1984). (1). The experimental field was drip irrigated and all agricultural practices of growing dutch fennel plants were done.

The treatments were conducted as follows:

1- The first harvest time

2- The second harvest time

3- The first harvest time + K_2SO_4

4- The second harvest time + K_2SO_4

5- The first harvest time + KNO_3

6- The second harvest time + KNO_3

7- The first harvest time + KCl

8- The second harvest time + KCl

Table 1 : Physical and chemical properties of the experimental soil in at Baluza Research Station, Desert Research Center, North Sinai governorates.

Particle size distribution (%)			Texture class	EC dSm^{-1}	PH	Soluble ions (meq/l)								Available nutrients (ppm)		
						Cations				Anions						
Sand	Silt	Clay				Ca^{+2}	Mg^{+2}	Na^{+1}	K^{+1}	CO^{-3}	HCO^{-3}	SO^{-4}	Cl^{-1}	N	P	K
90	5	5	Sand	1.37	8.20	1.8	2.1	1.5	0.09	-	3.5	0.84	1.51	60	3.65	144

The experimental design was split plot which included 8 treatments, harvest date in the main plots and different sources of potassium in the sub-main plots. The different potassium source (KCl 60 %, KNO_3 44.5 % and K_2SO_4 48 %) was applied in three equal doses in both seasons, the first one as applied a 30 days after planting, whereas the second third and dressing was applied a 30 days later. Harvesting was done in two times, the first time was 120 days after planting and the second time was 160 days after planting.

The following data were recorded:

1. Plant height (cm).

1- Number of umbels.

2- Fruit yield per plant (g).

3- Fruit yield per feddan (kg). was calculated as follows: fruit yield per plant × 20000 for all treatments

4- Volatile oil percentage (%) was determined in the air dried herb by hydro-distillation for 3 hours using a Clevenger type apparatus. The essential oil (%) was calculated as a relative percentage (v/w) (British Pharmacopoeia, 1963).

5- Volatile oil yield / plant (ml) essential oil yield per plant (ml) was calculated as follows: oil percentage × seeds weight (g/plant)/ 100

6- Volatile oil yield / feddan (L) was calculated as follows: essential oil yield per plant × number of plants/feddan (20000 plants/feddan).

G.L.C. analysis was carried out the Medicinal and Aromatic Plants Laboratory - Vegetables and Medicinal and Aromatic Plants Research Department - Horticulture Institute - Agricultural Research Centre.

Statistical analysis

Statistical analysis was done according to Snedecor and Cochran (1980). The differences between means were assessed using the least significance difference (LSD) test at 5% by using computer program of Statistix version[9] (Analytical software, 2008).

Results

Effect of harvest time

(i) Plant height

The effect of harvest time on plant height in the first and second seasons is presented in table (1). The plants that were harvested after 160 days from planting had a significant effect on plant height in both seasons which gave the highest values of plant height (149.76 cm and 157.49 cm) in the first and second seasons, respectively. These results are in agreement with those found by Said-Al-Ahl, and Omer (2009) on coriander (*Coriandrum sativum*, L.) and Khatun *et al*. (2010) on Chickpea (*Cicer arietinum*, L.)

(ii) Number of umbels per plant

The effect of harvest time on the number of braches per plant is presented in table (1). The second harvest time had a significant effect on the number of braches per plant in both seasons, so the highest number of umbels in the first season reached 45.25 cm, where as it reached 48.92 cm when plants were harvested 160 days after planting. These results are in consistent with those obtained by Cheyed and Alag (2014) on safflower plants and Zutic *et al*. (2003) on sage plants

(iii) Fruit weight per plant (g) and feddan (Kg)

Results in table (1) indicate the effect of harvest time on fruit weight per plant (g) and per feddan (Kg) for both seasons. The second harvest time had significant effect on fruit weight per plant (g) and per feddan (kg) in the first and second seasons; the second harvest time recorded the

maximum values of fruit weight per plant (g) (55.13 and 55.57 g) and (1102.7 and 1111.3 kg) per feddan (kg) for both seasons. These results are in line with those reported by Sarkar *et al*., (2007) on sesame plants and Dudai *et al*. (2003) on sage plants

Table 1 : Effect of harvest time on plant height (cm), number of umbels and fruit weights per plant (gm) and feddan(kg) of *Foeniculum vulgare* L. plant during the two seasons of 2017/2018 and 2018/2019.

Parameters / Treatments	Plant height (cm)		No. of umbels		Fruit weights / plant (gm)		Fruit / feddan (kg)	
	S1	S2	S1	S2	S1	S2	S1	S2
First harvest	133.08 B	142.04 B	32.50 B	35.58 B	50.22 B	50.40 B	1004.34 B	1008.0 B
Second harvest	149.76 A	157.49 A	45.25 A	48.92 A	55.13 A	55.57 A	1102.66 A	1111.3 A

(iv) Volatile oil percentage

Data in table (2) indicate that, the maximum percentage of volatile oil was obtained from the second harvest time treatments i.e. 1.99 % and 2.00 % compared with the plants harvested after 120 days from planting. These results are in agreement with those obtained by Ibrahim *et al*. (2012) Sorghum and Hassan *et al*. (2004) on *Thymus vulgaris*, L.

(v) Oil content per plant (ml) and feddan (L)

Table (2) shows the effect of harvest time on the Oil content per plant (ml) and feddan (L) in both seasons, harvest time had a significant effect on Oil content per plant (ml) and feddan (L) in the first and second seasons, the treatments of second harvest time gave the highest values of Oil content per plant (ml) and feddan (L) in both seasons, 0.97 ml and 19.39 L in the first season and 0.98 ml and 19.62 L in the second season. These results are similar to those found by Hassan *et al*. (2004) on *Thymus vulgaris* L. and Said-Al-Ahl and Omer (2009) on coriander (*Coriandrum sativum,* L.)

Table 2 : Effect of harvest time on oil percentage, oil content per plant (ml) and feddan (L) of *Foeniculum vulgare* L. plant during the two seasons of 2017/2018 and 2018/2019.

Parameters / Treatments	Oil %		Oil content / plant (ml)		Oil content / feddan (L)	
	S1	S2	S1	S2	S1	S1
First harvest	1.94 B	1.95 B	0.97 B	0.98 B	19.39 B	19.62 B
Second harvest	1.99 A	2.00 A	1.10 A	1.12 A	22.04 A	22.32 A

The positive effects of these treatments (harvesting time, different sources of potassium and their interaction) may be due to the important physiological role of Early harvest in 120 days after planting not available the appropriate environmental conditions, such as the necessity and heat, led to a delay in the growth of the fetus inside the seeds, and thus the percentage of the nodes decreased, and this was reflected in the amount of seeds per plant and acre. It has a large economic return as a result of the lack of loss in the seeds. The harvest of the seeds after 160 days of cultivation led to the availability of environmental conditions suitable for growth as the transportation of nutrients to the plant increases and thus an increase in the physiological processes represented in protein formation and photosynthesis El Laban *et al*. (2017) and (2020) that reflected on an increase in plant growth, seed yield, volatile oil production and constituents of dutch fennel plants, these results are in agreement with those found by The obtained results are in accordance with those obtained by Ibrahim *et al*., 2012 found that, harvesting of Sorghum bicolor (L.) Moench in four different growth stages (the stage of onset of panic (PE), the milky stage (MS), the dough stage (DS) and the physiological maturity stage (PM) to obtain high quality fodder requires harvesting in the PM stage and it can also be harvested in the DS stage to increase the lignin content in the seeds. Harvesting before the DS stage is not preferred Cause of low dryness of the soil in all varieties of sorghum. Hassan *et al*. (2004) The best date for harvesting plants (*Thymus vulgaris* L.) was at the beginning of flowering, as it produced a significant increase in dry weight of the herb for plants and acres and the highest percentage of oil with the increase of thymol, the essential component of the aromatic oil.

Effect of the different sources of potassium

(i) Plant height

Data in table (3) show that, the effect of different sources of potassium on plant height in the first and second season, Potassium nitrate gave the tallest plants (150.23 cm and 160.38 cm) compared with the other treatments and the control in the first season and second season, respectively. These results are in agreement with those found by Yassen *et al*., 2010 and Hussein *et al*., 2011 on *Calendula officinalis.*

(ii) Number of umbels per plant

Table (3) shows that, the effect of different sources of potassium on the number of umbels per plant in both seasons, the different sources of Potassium had a significant effect on the number of umbels per plant in the first and second seasons, the treatments of potassium nitrate gave the highest number of umbels per plant in both seasons, 52.83 umbels in the first season and 55.17 umbels in the second season. These results are in consistent with those obtained by Mehr-Afarin *et al*., 2011 on peppermint and Abbas *et al*., 2014 on marigold plant

Table 3 : Effect of different sources of potassium on plant height (cm), number of umbels and fruit weights per plant (gm) and feddan(kg) of *Foeniculum vulgare* L. plant during the two seasons of 2017/2018 and 2018/2019.

Parameters / Treatments	Plant height (cm)		No. of umbels		Fruit weights / plant (gm)		Fruit / feddan (gm)	
	S1	S2	S1	S2	S1	S2	S1	S2
Control	126.02 D	132.80 D	18.33 D	22.67 D	47.92 D	48.93 D	958. 3 D	978.7 D
K_2SO_4	147.17 B	155.58 B	45.33 B	49.33 B	54.18 B	54.02 B	1083.7 B	1080.3 B
K_2NO_3	150.23 A	160.38 A	52.83 A	55.17 A	56.78 A	56.70 A	1135.7 A	1134.0 A
KCl	142.27 C	150.30 C	39.00 C	41.83 C	51.82 C	52.28 C	1036.3 C	1045.7 C

(iii) Fruit weight per plant (g) and feddan (Kg)

Fruit weight per plant (g) and feddan (Kg) for both seasons are shown in table (3), treatments of potassium nitrate had significant effect of fruit weight per plant (g) and per feddan (kg) for both seasons, the application of potassium nitrate recorded the maximum values of fruit weight per plant (g) and per feddan (kg) for both seasons e.g. 56.78 g versus 56.70 g, 1135.7 kg and 1134 kg for both seasons, respectively. These results are in line with those reported by Gendya *et al*., 2015 on *Anthriscus cerefolium* L plant; Badawy (2016); Shalaby *et al*., (2011) and Abd-Allah (2012) on fennel (*Foeniculum vulgare*, Mill.)

(iv) Volatile oil percentage

Results in table (4) indicate that, applying potassium nitrate increased volatile oil percentage for both seasons, data in table (4) show a significant increase in volatile oil percentage in plants treated with potassium nitrate for both seasons 2.00 % and 2.02 % for the first and second seasons, respectively. These results are similar to those found by Shalaby *et al*. (2011), Badawy, (2016) and Yousef and Abu El-Leel, (2014) on *Foeniculum vulgare* Mill. plants

Table 4 : Effect of different sources of potassium on oil percentage, oil content per plant (ml) and feddan (L) of *Foeniculum vulgare* L. plant during the two seasons of 2017/2018 and 2018/2019.

Parameters / Treatments	Oil %		Oil content per plant (ml)		Oil content / feddan (L)	
	S1	S2	S1	S2	S1	S2
Control	1.90 D	1.91 D	0.91 D	0.94 D	18.21 D	18.73 D
K_2SO_4	1.99 B	1.99 B	1.08 B	1.09 B	21.54 B	21.60 B
K_2NO_3	2.01 A	2.02 A	1.14 A	1.15 A	22.82 A	22.89 A
KCl	1.96 C	1.97 C	1.01 C	1.03 C	20.29 C	20.65 C

(v) Oil content per plant (ml) and feddan (L)

Data of oil content per plant (ml) and feddan (L) in fruits for the two seasons as affected by the different sources of potassium are shown in table (4). The maximum value of oil content per plant (ml) and per feddan (L) was produced from the treatment of Potassium nitrate for both seasons. The treatment of potassium nitrate gives the highest values of oil content per plant (ml) and feddan (L) (1.14 ml and 22.82 L) in the first and (1.15 ml and 22.89 L) in the second seasons, respectively compared to the control treatment or the other treatments.

The different sources of potassium fertilization have a significant effect on all traits compared to untreated plants and this is consistent with what was reached AL-Qubaie, (2002) on *Hibiscus sabdariffa* L. plants; Han, and Lee (2005) on Eggplant; Han *et al*., (2006) on pepper and cucumber Plants and Hassan and Hamad (2010) on khella (*Ammi visnaga*) plants where they emphasized that potassium It works to increase the rate of accumulation of carbohydrates as a result of stimulation of the enzymes responsible for the transport of carbohydrates and thus the speed in the production of proteins, which was reflected in an increase in the length of the plant and the weight of the seeds / plant / feddan and the amount and the ratio of oil / plant / feddan.

Effect of interaction

(i) Plant height

Data in table (5) shows that, the effect of the interaction between different sources of potassium and harvest time on plant height, treatments indicated a significant effect on plant height compared to the control treatment in first and second seasons. Also, results showed that, the interaction treatment of potassium nitrate plus the second harvest time gave the tallest plants (160.60 cm and 168.83 cm) in the first and second seasons, respectively compared to the control treatment or the other treatments. These results are similar to those found by Ali, (2002) and Kandil (2002) on *Foeniculum vulgare* Mill.

(ii) Number of umbels per plant

Table (5) reveals that, the interaction treatments between the different sources of potassium and harvest time significantly affected the number of umbels per plant in both seasons. The second harvest time with potassium nitrate significantly increased the number of umbels per plant 60.33 and 62.33 per plant in both seasons, respectively. These results are in agreement with those obtained by Mehr-Afarin *et al*., 2011 on peppermint; BeikNejad, 2007 on soybean and Abbas *et al*., 2014 on marigold plant

Table 5 : Effect of interaction between harvest time and different sources of potassium on plant height (cm), number of umbels and fruit weights per plant (gm) and feddan(kg) of *Foeniculum vulgare* L. plant during the two seasons of 2017/2018 and 2018/2019.

Parameters / Treatments	Plant height (cm)		No. of umbels		Fruit weights / plant (gm)		Fruit / feddan (kg)	
	S1	S2	S1	S2	S1	S2	S1	S2
First harvest	123.30 H	130.27 H	16.67 H	19.33 G	47.40 G	48.57 G	948.0 G	971.3 G
Second harvest	128.73 G	135.33 G	20.00 G	26.00 F	48.43 FG	49.30 FG	968.7 FG	986.0 FG
First harvest + K_2SO_4	137.13 E	146.00 E	38.00 E	41.67 D	51.23 E	50.77 E	1024.7 E	1015.3 E
Second harvest +K_2SO_4	157.20 B	165.17 B	52.67 B	57.00 B	57.13 B	57.27 B	1142.7 B	1145.3 B
First harvest + K_2NO_3	139.87 D	151.93 D	45.33 D	48.00 C	53.00 D	52.27 D	1060.0 D	1045.3 D
Second harvest + K_2NO_3	160.60 A	168.83 A	60.33 A	62.33 A	60.57 A	61.13 A	1211.3 A	1222.7 A
First harvest + KCl	132.03 F	139.97 F	30.00 F	33.33 E	49.23 F	50.00 EF	984.7 F	1000.0 EF
Second harvest + KCl	152.50 C	160.63 C	48.00 C	50.33 C	54.40 C	54.57 C	1088.0 C	1091.3 C

(iv) Fruit weight per plant (g) and feddan (Kg)

As a general trend, it could be concluded that the fruit weight per plant (g) and per feddan (kg) was increased for both seasons. Fruit weight per plant (g) and per feddan (kg) as affected by potassium nitrate as well as the second harvest time were presented in table (5) indicating that, all the treatments inoculated with KCl, K_2NO_3, K_2SO_4 and the two harvest times resulted in increases in fruit weight per plant (g) and feddan (kg) for both seasons compared with the control treatments. The highest values of fruit weight per plant (g) and per feddan (Kg) were obtained from the interaction treatment of the second harvest time combined with potassium nitrate for both seasons 60.57 g and 1211.3 kg for the first season 61.13 g and 1222.7 kg for the second season, respectively. The difference between the treatments and control treatments was significant for both seasons. These results are similar to those found by Hassan and Hamad (2010) on *Ammi visnaga* and Gendya *et al*., 2015 on *Anthriscus cerefolium*, L. plant

(v) Volatile oil percentage

Data in table (6) show that, the interaction treatments between different sources of potassium and harvest time gave the highest oil percentage in the first and second seasons. With regard to the volatile oil percentage, it was indicated that all the interaction treatments induced significant differences compared with the untreated plants for both seasons. The highest volatile oil percentage produced from the plants treated with potassium nitrate combined with the second harvest time i.e. 2.05 and 2.05 % for the first and second seasons, respectively. These results are similar to those found by Han *et al*. (2006) on pepper and cucumber and Ibrahim *et al*. (2012) on sorghum plants.

(vi) Oil content per plant (ml) and feddan (L)

Table (6) shows clearly that oil content per plant (ml) and feddan (L) in fennel fruits showed significant values when applying all sources of potassium compared with the control treatment. The treatment of potassium sulphate was the most effective treatment that gave as high content as 1.24 ml and 24.83 L for the first season versus 1.25 ml and 25.10 L for the second season. These results are in agreement with those obtained by AL-Qubaie, (2002) on *Hibiscus sabdariffa* L. plants and Hassan *et al*. (2004) on *Thymus vulgaris,* L.

Table 6 : Effect of interaction between harvest time and different sources of potassium on oil percentage, oil content per plant (ml) and feddan (L) of *Foeniculum vulgare* L. plant during the two seasons of 2017/2018 and 2018/2019.

Parameters / Treatments	Oil %		Oil content / plant (ml)		Oil content / feddan (L)	
	S1	S2	S1	S2	S1	S2
First harvest	1.89 H	1.91 H	0.90 G	0.92 G	17.92 G	18.50 G
Second harvest	1.91 G	1.92 G	0.93 F	0.95 FG	18.50 F	18.95 FG
First harvest +K_2SO_4	1.94 E	1.96 E	1.00 E	1.00 E	19.89 E	19.87 E
Second harvest +K_2SO_4	2.03 B	2.04 B	1.16 B	1.17 B	23.18 B	23.33 B
First harvest + K_2NO_3	1.96 D	1.98 D	1.04 D	1.04 D	20.81 D	20.68 D
Second harvest + K_2NO_3	2.05 A	2.05 A	1.24 A	1.25 A	24.83 A	25.10 A
First harvest + KCl	1.92 F	1.94 F	0.94 F,	0.97 F	18.93 F	19.42 EF
Second harvest + KCl	1.99 C	2.01 C	1.08 C	1.09 C	21.65 C	21.88 C

(vii) Effect of harvest time and different sources of potassium fertilization and their interaction on the chemical constituents

The data in table (7) and figures (1 and 2) show that the extracted oil contained many which were identified by gas liquid chromatography, they were α-pinene, limonene, fenchone, 1,8-cineole, anethole and estragole . It can be observed from the results that these identified components were influence by different treatments.

It was found from the data that , the treatment of second harvest time (160 days after planting) plus potassium nitrate caused higher values of Anethole 87.86 % while estragole 1.03 %. α-Pinene compound missed in all treatments except the second harvest time 0.92 % treatment, while there was estragole compound in all treatments except the first harvest time plus K_2NO_3

Table 7 : Effect of interaction between harvest time and different sources of potassium the chemical compounds of the extract oil of *Foeniculum vulgare* L. plant in season 2018/2019.

Chemical compounds / Treatments	α-pinene	Limonene	Fenchone	1,8-Cineole	Anethole	Estragole
First harvest time	-	0.79	12.14	5.70	80.39	0.98
Second harvest time	0.92	10.88	0.58	5.12	80.82	1.68
First harvest time + K_2SO_4	-	6.64	0.53	7.93	84.35	0.37
Second harvest time +K_2SO_4	-	-	7.11	4.25	86.84	1.81
First harvest time + K_2NO_3	-	-	9.68	4.65	85.67	-
Second harvest time + K_2NO_3	-	-	6.51	3.58	87.86	1.03
First harvest time + KCl	-	-	8.23	6.04	83.95	1.78
Second harvest time + KCl	-	-	8.48	4.46	86.36	0.72

The positive effect of interactions between the appropriate harvest time and the sources of potassium fertilization The harvest after 160 days + the addition of potassium nitrate due to the arrival of the plant to the appropriate physiological maturity stage in which it is completed the growth of the fetus, the building process increases and the demolition processes decrease. The necessary nutrients are available for this, as potassium nitrate fertilizer is available in both potassium and nitrogen elements, which appears in an increase in plant growth, seed yield, oil for plants and acres, and as a result of the availability of nutrients that lead to an increase in vital processes. Such as photosynthesis and protein formation, these results are in consistent with those found by Hassan and Hamad (2010) on *Ammi visnaga* and Dudai *et al*. (2003) on sage plants.

Conclusion

To achieve the Egypt plan for sustainable development 2020, importing new varieties of seeds leads to an increase in the economic return of Egypt and due to the economic importance of fennel plants, the introduction of the dutch fennel variety to Egyptian agriculture leads to an increase in the economic return of the country and the farms, because the fennel is importance in Egypt it's rank the first class in Egypt's exports of medicinal and aromatic plants. Therefore, the study aimed to improve the growth of dutch fennel plants.

So, recommend that to obtain the highest production of fruits and oil per plant and feddan, planting Dutch fennel use potassium nitrate fertilizer (44.5% K) as a source of potassium with the harvest of plants after 160 days of cultivation.

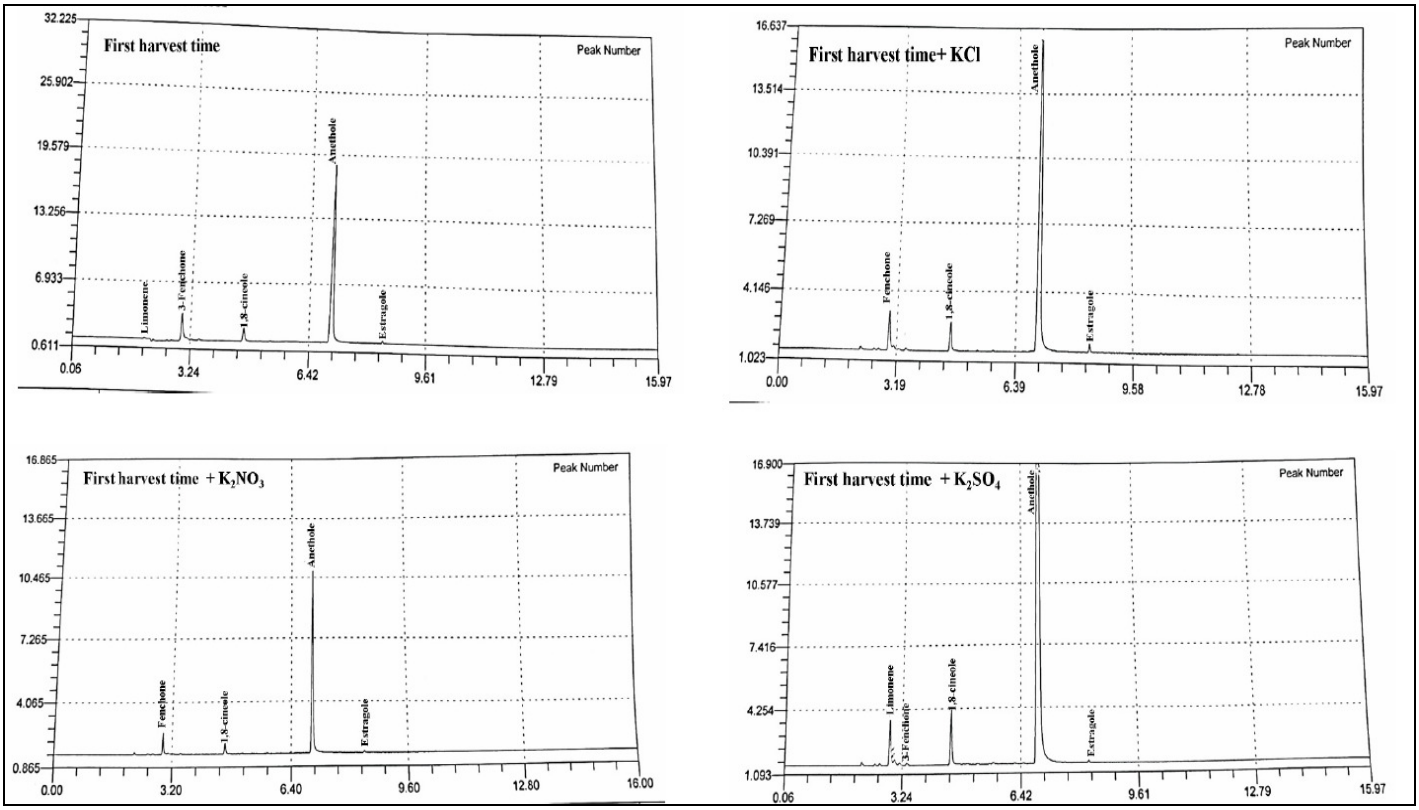

Fig. 1 : G.L.C. analysis of extract fennel oil in first harvest time with different sources of potassium fertilization in season 2018/2019.

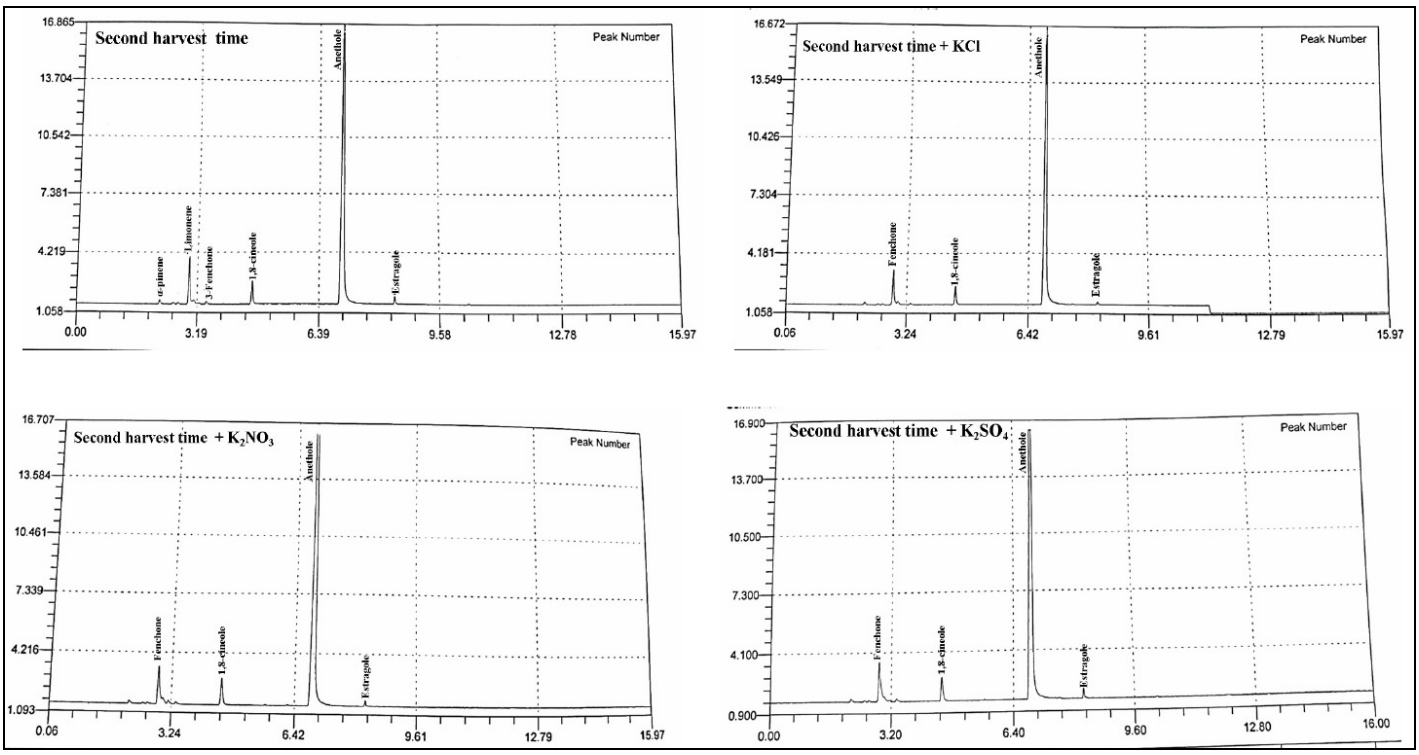

Fig. 2 : G.L.C. analysis of extract fennel oil in second harvest time with different sources of potassium fertilization in season 2018/2019.

References

Abbas, M.; Ali, F.; Rahim, N.; Kolsoum, R. and Mohammad, M.H. (2014). Effects of different fertilizer sources on vegetative characteristics of pot marigold plant (*Calendula officinalis* L.). International Journal of Biosciences. ISSN: 2220-6655 (Print) 2222-5234 (Online) http://www.innspub.net, 5(1): 242-249,

Abd-Allah, Wafaa H.A.E. (2012). Effect of sowing dates and fertilization treatments on growth and production of Indian fennel compared with varieties of fennel plants grown in Egypt under Sinai conditions. Ph.D. Thesis, Fac. Agric., Benha Univ., Egypt.

Ali, A.R.F. (2002). Physiological Studies on *Foeniculum vulgare* Mill. Plant under Sinai conditions, M.Sc. thesis, Fac. Agric., Cairo Univ., Egypt (2002).

Al-Kordy, M.A.A. Mother (2000). Plant selection in local germplasm of fennel *Foeniculum vulgare* Mill. Annals of Agric. Sci. Moshtohor, 38(4): 2199-2215.

AL-Qubaie, A.A. (2002). Effect of fertilization with Potassium and bio-fertilization with yeast on the tolerance of *Hibiscus sabdariffa* L. plants to irrigation with saline water. J. Agric. Sci. Mansoura Univ., 27(9): 6111-6122.

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

Anand, P.; Kunnumakara, A.; Sundaram, C.; Harikumar, K.; Tharakan, S.; Lai, O.; Sung, B. and Aggarwal, B. (2008). Cancer is a preventable disease that requires major lifestyle changes. Pharmaceut. Res., 25: 2097-2116.

Badawy, M.Y.M. (2016). Effect of mycorrhiza and mineral fertilization on growth and oil productivity of *Foeniculum vulgare* Mill. plant under Sinai conditions. Bull. Fac. Agric., Cairo Univ.; 67: 245-255.

Basem, D.H.D. (2012). Production of fennel and cumin crops in Asyut Governorate. Assiut J. Agric. Sci., 3(6): 150-167.

BeikNejad, S. (2007). The effect of application of different amounts of potassium and magnesium on agronomic traits of soybean genotypes. Master's Thesis in Agriculture, Islamic Azad University, Bojnoord, 78.

Black, C.A. (1968). Soil plant relationship. 2P nd P. Ed. John Wiley and sons, Inc. New York.

Boulos, L. (1983). Medicinal Plants of North Africa, ref. Public, Inc. Clair River, Algonac, Michigan 4800 /P. 109.

British Pharmacopoeia (1963). In "Determination of Volatile Oil in Drugs". The Pharmaceutical Press, London.

Cheyed, S.H. and Alag, M.K. (2014). Losses percentages of safflower cultivars as influenced by harvesting date. The Iraqi Journal of Agricultural Sciences, 45(7): 721-728.

Sarkar, M.N.; Salim, M.; Islam, N. and Rahman, M.M. (2007). Effect of Sowing Date and Time of Harvesting On The Yield And Yield Contributing Characters of Sesame (*Sesamum indicum* L.) Seed. Int. J. Sustain. Crop Prod. 2(6): 31-35.

Dolapo, B.A. and Albert, T.M. (2017). Planting Dates and Harvesting Stages Influence on Maize Yield under Rain-Fed Conditions. J. of Agri. Sci.; 9(9): ISSN: 1916-9752. E-ISSN: 1916-9760.

Dudai, N.; Lewinsohn, E.; Larkov, O.; Katzir, I.; Ravid, U.; Chaimovitsh, D.; Sa'adi, D. and Putievsky, E. (2003). Dynamics of yield components and essential oil production in a commercial hybrid sage (*Salvia officinalis x Salvia fruticosa* cv. Newe Ya'ar No. 4). J. Agric. Food Chem., 47: 4341-4345.

El-Gendya, A.G.; El-Goharya, A.E.; Omera, E.A.; Hendawya, S.F.; Husseina, M.S.; Petrovab, V. and Stanchevac, I. (2015). Effect of nitrogen and potassium fertilizer on herbage and oil yield of chervil plant

(*Anthriscus cerefolium* L.). Industrial Crops and Products. 69: 167-174.

El-Laban, H.M.; Fetouh, M.I.; Rania, M.R. Khater; El-Gioushy, S.H. (2017). Response of Dutch Fennel to Algae Extract Partial Replacement of Mineral NPK under Sinai Conditions. J. Plant Production, Mansoura Univ., 8(6): 693–698.

El–Laban, H.M.; Fetouh, M.I.; Rania, M.R. and El-guoshy, S.M. (2020). Effect of plant density on vegetative growth, fruits yield, essential oil and chemical constituents of Dutch Fennel under Sinai conditions. ES J Agri Curr Res. 1(1): 1001.

Han, H.S. and Lee, K.D. (2005). Phosphate and potassium solubilizing bacteria effect on mineral uptake, soil availability and growth of Eggplant. Research Journal of Agriculture and Biological Sciences 1(2): 176-180.

Han, H.S.; Supanjani, S. and Lee, K.D. (2006). Effect of co-inoculation with phosphate and potassium solubilizing bacteria on mineral uptake and growth of pepper and cucumber. Plant Soil Environ. 52(3): 130–136

Hassan, A.; Naghdi, B.; Darab, Y.; Sajed, M.A. and Fatemeh, N. (2004). Effects of spacing and harvesting time on herbage yield and quality/quantity of oil in thyme, *Thymus vulgaris* L. Industrial Crops and Products, 19: 231–236.

Hassan, E.A. and Hamad, E.H. (2010). Microbial solubilization of phosphate-potassium rocks and their effect on khella (*Ammi visnaga*) growth. Ann. Agric. Sci. 55. 37-53.

Hussein, M.M.; Sakr, R.A.; Badr, L.A. and Mashat, K. (2011). Effect of Some Fertilizers on Botanical and Chemical Characteristics of Pot marigold plants (*Calendula officinalis* L.). Journal of Horticultural Science & Ornamental plants, 3(3): 220-231.

Ibrahim, A.; Omer, K.; Metin, D.; Huseyin, G. and Saban, Y. (2012). Effect of Harvesting Time on Yield, Composition and Forage Quality of Some Forage Sorghum Cultivars. Int. J. Agric. Biol., 14(6): ISSN Print: 1560–8530; ISSN Online: 1814–9596

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. PhD Thesis, Technischen Universitat Carolo-Wilhemina zu Braunschweig - Germany.

Khatun, A.H.; Bhuiyan, M.A.; Nessa, A. and Hossain, S.M. (2010). Effect of Harvesting Time on Yield and Yield Attributes of Chickpea (*Cicer arietinum* L.). Bangladesh J. Agril. Res. 35(1): 143-148. ISSN 0258-7122.

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

Mehr-Afarin, A.; Naghdibadi, H.; Pour-Hadi, M.; Hadavi, A.; Ghavami, N.; Kadkhoda, Z. (2011). Conducted phytochemical response peppermint (*Mentha piperita* L.) to application of bio-fertilizers and urea. Journal of Medicinal Plants, 1(5): 107-118.

Mengel, K. and Kirkby, E.A. (1989). Principles of plant Nutrition. International potash institute Bern, Switzerland.

Mengel, K. and Helal, M. (1967). Plant physiology, J; 57:223.

Nofal, I.M.S. and Menisi, F.A. (2019). Essential oils and their plants. Academic Library, Part 1

Osman, A.H. and Abd El-Wahab, M.A. (2003). Production of Medicinal and Aromatic Plants in New Lands. Published by Desert Research Center, Ministry of Agriculture, Egypt, 204.

Page, A.L.; Miller, R.H. and Keeney, D.R. (1984). Methods of Soil Analysis. part 2: Chemical and Microbiological Properties. Second edition. Agronomy J. 9: 2, Am. Soc. Agron. Inc., Soil Sci. Soc. Am. Inc. Pub. Madison, Wisconsin, USA.

Patra, M.; Shahi, S.K.; Midgely, G. and Dikshit, A. (2002). Utilization of essential oil as natural antifungal against nail infective fungi. Flavor and Fragrance J.; (17): 91-94.

Said-Al Ahl, H.A.H. and Omer, E.A. (2009). Effect of spraying with zinc and / or iron on growth and chemical composition of coriander (*Coriandrum sativum* L.) harvested at three stages of development. J. of Medicinal Food Plants, 1(2): 30-46.

Shalaby, A.S; Hendawy, S.F. and Khalil, M.Y. (2011). Evaluation of some types of fennel (*Foeniculum vulgare* Mill.) newly introduced and adapted in Egypt. Journal of Essential Oil Research, 23 (4): 35-42.

Snedecor, G.W. and Cochran, W.G. (1980). In "Statistical Methods". 7th Ed. Iowa State Univ., Press, Amer., Iowa, USA.

Yassen, A.A.; Habib, A.M.; Sahar, M.Z. and Khaled, S.M. (2010). Effect of different sources of potassium fertilizers on growth yield, and chemical composition of *Calendula officinalis*. J. Amer. Sci. 6:1044–1048.

Yousef, R.M.M. and Abu El-Leel, Omneya F. (2014). Growth, essential oil production and genetic study of some fennel varieties under different compost levels in sandy soil. J. Agric. Chem. and Biotechn., Mansoura Univ; 5 (12): 331 – 356.

Zutic, I.; Putievsky, E. and Dudai, N. (2003). Influence of Harvest Dynamics and Cut Height on Yield Components of Sage (*Salvia officinalis* L.). Journal of Herbs, Spices and Medicinal Plants, 10(4): 49-61.