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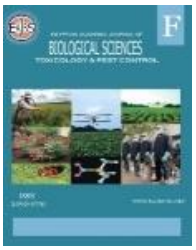

Agro-Ecological and Varietal Effects on The Infestation of Two Types of Aphid (Hemiptera: Aphididae) on Fennel Fruits and Essential Oil Under Middle and Upper Egypt Conditions

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ABSTRACT

The medicinal and aromatic plants in Egypt became vital economic crops for the local and export market. One of these crops is the Fennel (*Foeniculum vulgare* Mill.), it is an important herbaceous plant. The fennel aphids, *Hyadaphis foeniculi* (Passerini) and cabbage aphid, *Brevicoryne brassicae* (Linnaeus) cause reductions on the yield components and amount of essential oil in the fennel fruits. This study was conducted to investigate the aphids infestation on two fennel varieties (*Foeniculum vulgare* var. *vulgare* (Local) and *Foeniculum vulgare* var. *azoricum* (Holland) cultivated in two agro-ecological zones in Middle and Upper Egypt during 2016/2017 and 2017/2018. Depend on the obtained results, there were significant effects of different locations on the infestation level by fennel aphids, while there was no significant interaction between seasons. This results on susceptibility degrees of fennel varieties showed that none of the tested varieties was found completely free from aphid attack. At Al-Fayoum, the Local and Holland were exhibited low resistance in the first season, whereas, both varieties were susceptible (S) in the second season. However, at Luxor, Local var. was low resistance (LR) and susceptible (S) in the first and second seasons respectively. While Holland var. was susceptible (S) in both seasons. The different treatments were similar in both seasons and highly significant compared to untreated plants. The efficient treatments are Tracer and Saif oil followed by KZ Oil + Potassium Soap. It is clear from the results that the local cultivar preferred to cultivate in Luxor, where the best vegetative growth, as well as the highest yield of fruits and the highest productivity of essential oil percentage and the highest oil yield, provided the treatment of plants with Tracer or Saif oil, where they have a strong impact on aphid resistance, which reflected on the production of local fennel type increased. On the other hand, Holland variety, the best yield was given in Al-Fayoum in terms of vegetative growth, fruit yield and oil yield, provided that the plants were treated with Tracer or Saif oil, which was efficient on the reduction the aphid infestation, leading to increased productivity. Our investigation suggested that the agro-ecological region have a high concern in widespread of the medicinal and aromatic plant for high production and quality of the essential oil especially the foreign fennel verities.

INTRODUCTION

Fennel (*Foeniculum vulgare* Mill.) belongs to the family of Apiaceae, an annual and biennial herbaceous plant, depending on the variety. Fennel is a strongly aromatic herb that grows in good soils from sunny mild climatic regions. There are two types of oils that are commercially available, the first type is bitter fennel oil from cultivated *Foeniculum vulgare* Mill. subsp. var. *vulgare* and the second one is sweet fennel *Foeniculum vulgare* subsp. *vulgare* var. (Piccaglia and Marotti, 2012). The essential oils are concentrated in the biomasses and mainly in fruits. The seed of fennel contains 9.5% protein, 10.0 % fat, 18.5 % crude fibre, 42.3 % carbohydrates, and 13.4 % minerals and also rich in vitamins and volatile oil (Ana Clara., *et al*., 2010). Fennel is known for the use of its fruits and its essential oil in the manufacture of perfumes, toothpaste, soaps, and herbal medicine.

Several fennel arts are edible for infestation by pests such as bulbs, leaves, stalks, and fruits (Diaz *et al.,* 2006 and Mokhtar *et al*., 2012). The quality of the oil essence depends on the stage of fruit maturity, as well as, insect attack (Maranca, 1985). Fennel aphids; *Hyadaphis foeniculi* (Passerini) and also, the cabbage aphid, *Brevicoryne brassicae* (Linnaeus) affected the fennel seed yield and they considered major insect pests on fennel (Francisco *et al*., 2015). These aphids attack mainly flowers, fruits, and leaves by sucking the sap, causes wilt, dry of plant organs and impairing the fennel seed (Ferreira and Sousa-Silva, 2004).

In Egypt, there is variation in environmental conditions that affect the plant grow and related pest infestation. Whereas, there is a great influence of the environment on the yield of the coriander herb, seed, and oil (Siddharth and Babasaheb 2014). Under Middle and Upper Egypt conditions, Abd El- Wahab and Mehasen (2009) reported that El-Minia Governorate had the highest fruits and oil yield followed by Assuit location, whereas Sohag and Qena resulted in fewer fruits yield being the least at Qena.

The essential oil is greatly influenced by growing region, stages of maturity Katar *et. al*., (2016). They found considerably different essential oil production among the local landraces.

To protect crops from attacking these aphides, there are some conducted researching efforts to use some safe compounds for suppressing the effects of some piercing-sucking pests attacking the crops (Afsah, 2015 and Mona and Homam, 2012).

Thus, the objectives of this study are to determine whether fennel aphids cause significant effect in biomass yield, seed weight and essential oil content of fennel crops at different agro-ecological zones. Also, to determine the relative susceptibility of fennel varieties to aphid infestation. In addition to, evaluate the effects of some treatments on the infestation of fennel aphid, *Hyadaphis foeniculi* (Passerini) and cabbage aphid, *Brevicoryne brassicae* (Linnaeus) and their effects on the amount of essential oil in the fennel seeds, and yield components.

MATERIALS AND METHODS

Study Locations:

The present work was carried out on fennel plants cultivated in two agro-ecological zones in middle Egypt at Itsa district, Al-Fayoum Governorate and Upper Egypt at Esna district, Luxor Governorate during 2016/2017 and 2017/2018 seasons. The coordination of the study region is presented in Table (1) and Figure (1) presented the location in Egypt's map.

Table (1): The coordinates of studied areas at Al-Fayoum and Luxor Governorates

Study region	Latitude (N)	Longitude (E)
Itsa, Al-Fayoum	29° 13' 57"	30° 44' 47"
Esna , Luxor	25° 16' 10"	32° 24' 00"

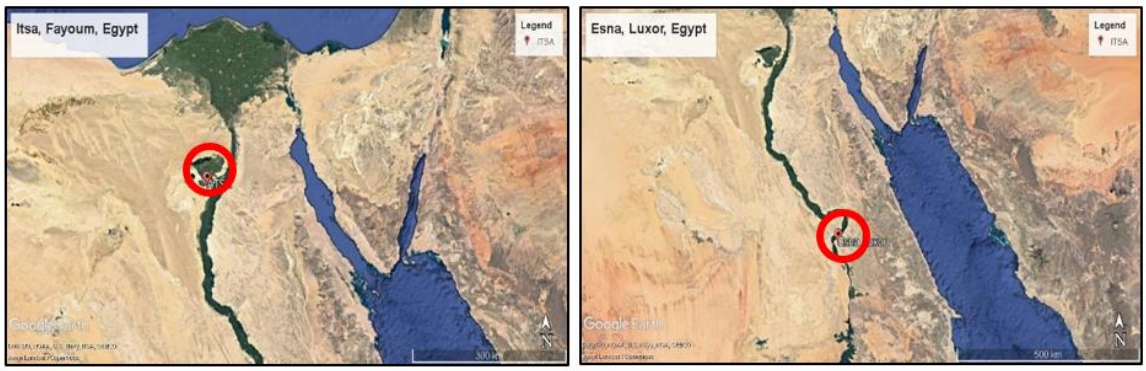

Fig. 1: Maps of studied locations at Fayoum and Luxor Governorates, Data SIO, NOAA, U.S. Navy. Image landsate, Google Inc. Google Earth, 7.1.2.2041

Physical and chemical analyses of soil were analyzed at Water and Soil Lab. (A.R.C.) according to the methods of Donald, (1996), shown in Table (2).

Table 2: Physical and chemical analyses of the soil experimented in AL-Fayoum and Luxor Governorate.

Soil characteristics	**Values**	
	Al-Fayoum	Luxor
Coarse sand (%)	8.10	13.6
Fine sand (%)	20.55	69.1
Silt (%)	30.70	6.1
Clay (%)	40.65	5.78
Soil texture	Loamy	Sandy soil
Bulk density (Mg m^{-3})	2.11	1.70
Hydraulic conductivity (cm	36.00	35.0
$CaCO_3$ ($g.kg^{-1}$)	1.02	1.90
Organic matter ($g.kg^{-1}$)	3.02	0.19
EC (dSm^{-1})	1.25	2.19

The layout of the Experiment:

Field experiments were carried out during two successive seasons (2016/2017 and 2017/2018) cultivated with fennel seeds var. Local and Holland at two locations Al-Fayoum and Luxor Governorates. Seeds of two fennel types were sown on 5th and November 12th in the first and second seasons, respectively in experimental units. The area of each treatment was 350 m^2 (2 kirates). 2.5×3 meters each unit including five rows of 60 cm apart and 3-4 seeds were spaced in hills at 25 cm in between. Cultivated plants were distributed in randomized complete blocks design (RCBD) with 5 replicates.

The agricultural practices were carried out during the study period after six weeks, the thinning was done lifting one plant per hill. Frequent visits to the field were made to detect the first appearance of aphid, *Hyadaphis foeniculi* and *Brevicoryne brassicae* on the fennel plants. The population of aphids was counted early in the morning before 8.0

AM. Observations on aphid population were recorded at 10 days interval from the appearance of aphid insect till the harvesting of the crop. The investigation was done by direct count of aphid individuals on five plants each replicates. Aphid investigation was counted in the small plant throughout the shaking plant on a white paper sheet and then counted. Further, Three umbels (lower, middle and upper), each of the five tagged plants, was labeled to record the aphid population, according to Hake *et al.*, (2017). The taxonomy of the insect was done in Piercing and Sucking Insect Research Department, Plant Protection Research Institute.

Plant Materials:

The fennel seeds were obtained from the Medical and Aromatic Plants Farm, El-Kanater El- Khairiya, Kalyobia Governorate. Horticulture Research Institute, and were sown directly in the open field.

Relative Susceptibility of Fennel Varieties Against Aphid:

The data obtained on aphid population from the experimental field were transformed into the classification of the susceptibility degree of each fennel cultivar were depended on the general mean number (X) of the aphid and the standard deviation (SD) as reported by Chiang and Talekar (1980). The categories of susceptibility as the follow: Highly susceptible (HS) = more than $\bar{X}$ +2SD, Susceptible (S) = between $\bar{X}$ and $\bar{X}$ +2SD, Low resistant (LR) = between $\bar{X}$ and $\bar{X}$ -1SD, moderately resistant (MR) = between $\bar{X}$ -1SD and $\bar{X}$-2SD, and Highly resistant (HR) = less than $\bar{X}$-2SD.

Spray Program:

The untreated plots (control) were not sprayed with any insecticide to allow for natural aphid infestation. All treatments were covered by yellow sticky traps, the traps used in this study were constructed from yellow cardboard and coated by insect adhesive (stickers), were held by small wooden sticks, the traps were released every week to attract adult of aphids. All the traps constructed 20 cm above the surface of the plant at a rate of 15 traps / feddan. The spray was made with a hand-operated knapsack sprayer with 20-liter water.

Each treatment was treated with fixed spray in the early morning with two applications of potassium soap (1 liter /100 liter water) immediately after pest appearance followed by micronized sulfur (250 g /100 liter water) after 10 days.

The third spray was a different treatment as the following:

Treat.**1:** Untreated (sprayed with water only)

Treat.**2**: Mineral oil (KZ oil 95% EC), at 1 liter + Potassium 150 ml / 100 liter water**.**

Treat.**3**: Potassium Soap (Potassium salts of fatty acids) 1 liter + 1 liter (KZ oil 95% EC).

Treat.**4**: BREV-AM (Orang oil 9% SL) at a rate of 400 ml /100-liter water.

Treat.**5** TRACER (Spinosad 24% SC), at a rate of 35 ml /100 liter water.

Treat.**6**: SAIF oil (Azadiractin 0.03% EC) at a rate of 500 ml /100-liter water.

The spray program was repeated three times during the cultivation season.

Horticultural Characters:

There are some measurement has been recorded as the following: Plant height (cm); the number of total branches/plant; umbels number/plant; seeds yield/plant (gm) and fedd (ton); essential oil %; essential oil yield/plant (gm) and fedd. (L).

Gas-Liquid Chromatography (GLC) Analysis:

The volatile oil obtained from the fruits of three fennel varieties which were analyzed using the DsChrom 6200 Gas chromatograph equipped with a flame ionization detector for separation of volatile oil constituents. The analysis conditions were as follows: the chromatography apparatus was fitted with capillary Colum BPX-5, 5% phenyl (equiv.) polysillphenylene- siloxane 30m x 0.25mm IDx0.25 µm film. The temperature program increased with a rate of 10 ^{o}C /min from70 to200 ^{o}C. Flow rates of

gases were nitrogen at ml/min, hydrogen at 30ml/min and ml/min or air. Detector and injection temperatures were 300 ºC and 250 ºC, respectively. The obtained chromatogram and report of GC analysis for each sample of variables were analyzed to calculate the percentage of the main component of volatile oil.

Meteorological Data:

Data concerning meteorological information of the different locations during the two seasons of 2016/2017 and 2017/2018 were obtained from the Central Laboratory for Agriculture Climate (CLAC), Agricultural Research Center (ARC). Collected data are summarized and presented as a means of the two seasons (Fig2).

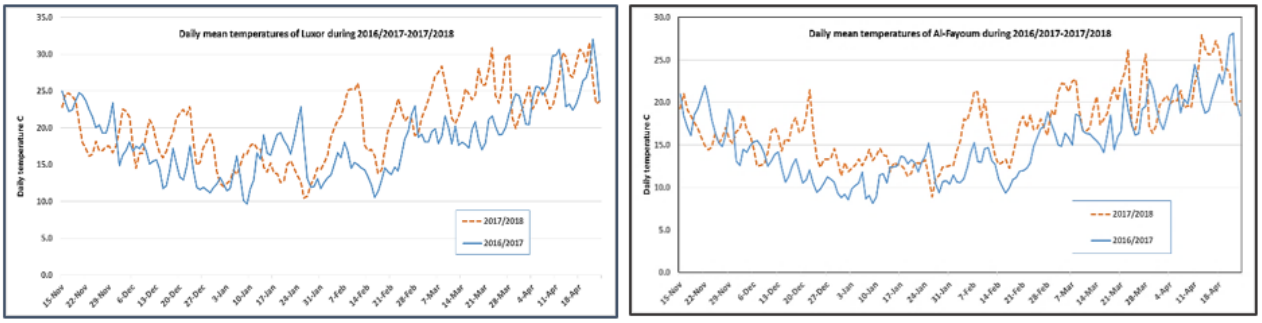

Fig.2: Meteorological data of daily mean temperatures for Al-Fayoum and Luxor during two successive seasons of 2016/2017 and 2017/2018.

Statistical Analysis:

Statistical analysis was carried out Complete Randomize Block design according to COSTAT Statistical Software L.S.D .test was used to compare the means of treatments.

RESULTS AND DISCUSSION

Comparative Studies:

In this study, fennel plants were infested by many aphids' species. The obtained results indicated that the most aphid infestation was with *Hyadaphis foeniculi* and *Brevicoryne brassicae*. While there was a little infestation by *Myzus persicae* (Sulzer) and *Aphis gosspii* (Glover). Hamed (1979), found that the same species of aphids were infested fennel.

The aphid population fluctuation between (e.g. *Foeniculum vulgare* var. *vulgare* (Local) and *Foeniculum vulgare* var. *azoricum* (Holland) of fennel at two agro-ecological zones Al-Fayoum and Luxor Governorates during two successive seasons (2016/2017 and 2017/2018) were assessed.

Figure (3) illustrated that the population densities of fennel aphid have varied on two varieties at Al-Fayoum governorate, the fennel plants were infested with aphids from 35 to 165 days after planting. The mean numbers of aphids /plant in the fennel var. Holland was higher than var. Local, which reached 245.39 and 153.34 in the first season, while for the second season were 316.15 and 212.55, respectively. However, at Luxor governorate, the aphid infestation was higher than Al-Fayoum in both seasons. Where the mean numbers of aphids/sample in the fennel var. Holland was higher than var. Local, which reached a 364.68 and 290.20 in the first season, while for the second season were 528.58 and 395.22, respectively.

The analysis of the ecological conditions of Al-Fayoum and Luxor during both seasons are indicated in Figure (3). The relationships between aphid infestation and

weather factors indicted that there was a positive significant impact on the incidence of aphid due to the temperatures. The obtained results were agreed with Patel *et al*., (2011) and Pareek *et al*., (2013) recorded that the population of aphid have a positive correlation with maximum temperature, minimum temperature.

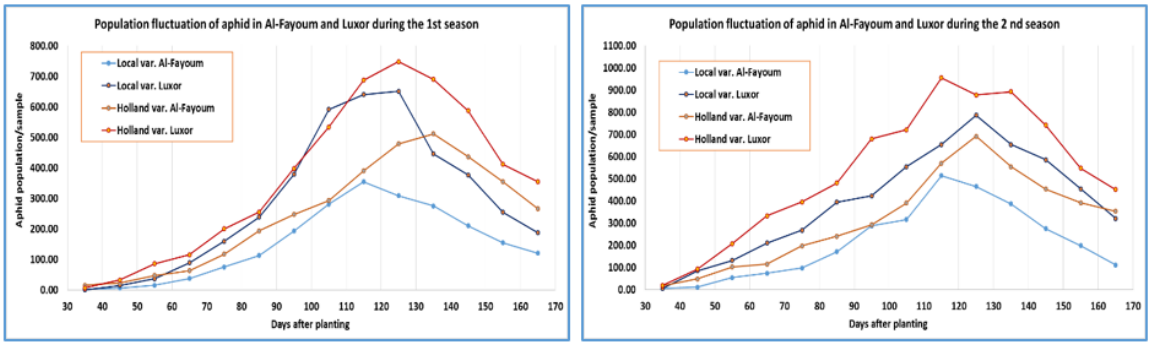

Fig. 3: Population fluctuation of aphid on different fennel varieties in Al-Fayoum and Luxor Governorate during two successive seasons of 2016/2017 and 2017/2018.

Data presented in Table (2) showed that the interaction effect of variety and location on the variation of aphid infestation. Statistical analysis revealed that there was a highly significant interaction between locations. According to F value 30.21 and L.S.D value 58.717. There was a low significant interaction between varieties in Al-Fayoum. According to F value 4.75 and L.S.D value 30.06. However, the statistical analysis indicated that there was a highly significant interaction between varieties in Luxor. According to F value 59.63 and L.S.D value 98.46. While there was no significant interaction between seasons.

Relative Susceptibility of Fennel Varieties Against Aphid:

The data presented in Table (3) revealed that the two varieties of fennel were screened for their relative susceptibility to fennel aphid at two agro-ecological regions during two successive seasons of 2016/2017 and 2017/2018.

The results on relative susceptibility of fennel varieties revealed that none of the variety was found completely free from aphid attack. At Al-Fayoum, the Local and Holland were found low resistance in the first season, whereas, both varieties were susceptible (S) in the second season. However, at Luxor, Local var. was low resistance (LR) and susceptible (S) in the first and second season respectively. While Holland var. was susceptible (S) in both seasons.

Hake *et al*., (2017) reported that the variation in resistance against aphid by different varieties of fennel may be due to early / late flowering habit. It has been reported that aphid incidence was generally more severe on the lateflowering varieties than early flowering because the aphid preferred to infest the inflorescence that Local var. was early than Holland var. for the plant flowering.

Table 3: Statistical analysis of the aphid population and susceptibility degrees between fennel varieties at two agro-ecological regions during two successive seasons.

Location	Variety	Season	Mean numbers /Sample	Mean numbers between locations	Mean numbers between Varieties	Susceptibility Degree
Al-Fayoum	Local	First	153.34	231.86 B	182.94 B	LR
		Second	212.55			S
	Holland	First	245.39		280.77 A	LR
		Second	316.15			S
Luxor	Local	First	290.20	394.67 A	342.71 B	LR
		Second	395.22			S
	Holland	First	364.68		446.63 A	S
		Second	528.58			S

F value between locations = 30.21*** L.S.D = 58.717 Low resistant (LR)
F value between variety in Al-Fayoum = 4.75 * L.S.D = 90.06 Susceptible (S)
F value between variety in Luxor = 59.63*** L.S.D = 98.46
F value between seasons = 1.02 INSIG.

Efficacy of Different Treatments Against Aphid Species of Fennel:

The effect of foliar spray applications with different treatments on aphid population was showed in Table (4). The obtained data revealed that plants sprayed with different treatments were similar in both seasons highly significantly compared to untreated plants fennel, and plants received the lowest mean numbers of aphid were under treatment no. 3 and 4 followed by 2. While, the moderate mean value of aphid were obtained from plants sprayed with treatment no. 1, and the highest numbers of aphid were under treatment no. 5, which were similar to the untreated plants.

Statistical analysis revealed highly significant differences between treatments, whereas F values 15.16, 47.24, 88.94 and 125.10 with L.S.D. values 39.14, 26.24, 32.77 and 49.90 for the tested treatments, for Local and Holland var. in Al-Fayoum and Luxor, respectively in the first season. Whereas F values 57.2, 34.46, 11.32 and 53.58with L.S.D. values 7. 8, 10.2, 10.9 and 24.26 for the tested treatments, for Local and Holland var. in Al-Fayoum and Luxor, respectively during the second season. Charles *et al*., (2006) indicated that the use of essential oil of alfazema is more effective in controlling the fennel aphid *Hyadaphis foeniculi* than essential oil of citronella. Bana, (2007) and Afsah (2015), indicated that solfan, KZ oil, and Achook had a great effect on the population density of some piercing-sucking pests attacking gooseberry. Lekha, (2002) and Chaudhary *et al*., (2015), studied the comparative efficacy of different neem-based biopesticides against aphids in coriander. Found that azadirachtin sprayed 5 ml/lit was the most effective measure for the control of aphid population as well as for increasing the seed yield.

Table 4: Efficacy of different treatments against aphid species of fennel during two successive seasons 2016/2017 and 2017/2018 in Al-Fayoum and Luxor Governorate.

No.	Compounds	Mean number of aphids/ sample							
		Al-Fayoum				Luxor			
		Local		Holland		Local		Holland	
		2016	2018	2016	2018	2016	2018	2016	2018
1	KZ Oil	109.3 BC	96.5 C	118.3 BC	119.06 C	159.7 B	160.4 B	240.0 B	246.33 B
2	KZ Oil + Potassium Soap	95.4 BCD	86.06 D	101.7 C	115.06 C	122.3 CD	139.6 C	178.0 CD	183.16 C
3	TRACER	57.8 D	54.8 E	59.2 D	64.2 E	97.0D E	100.66 D	130.7 DE	139.4 D
4	SAIF oil	78.4 CD	80.8 D	68.1 D	92.7 D	74.3 E	79.8 E	104.7 E	111.26 E
5	BREV-AM	122.1 B	130.933 B	131.3 B	142.26 B	154.7 BC	158.06 B	185.3 C	193.06 C
6	Untreated	200.3 A	225.33 A	221.7 A	242.33 A	353.8 A	409.93 A	596.3 A	604.16 A
F VALUE		15.16***	57.2***	47.24***	34.46***	88.94***	11.32***	125.10***	53.58***
L.S.D		39.14	7. 8	26.24	10.2	32.77	10.9	49.90	24.26

Effect of Different Treatments on Growth Vegetative, Yield And Essential Oil Of Fennel:

A- The Local Variety (*Foeniculum vulgare var. vulgare*):

A.1- Effect on Vegetative Growth:

Regarding the effect of foliar spray treatments, the data in Table (5) cleared that, all treatments significantly increased the growth parameters of local fennel var. compared to untreated in both seasons. The highest values from plant height (169.26 and 182.98 cm) and number of umbel/plant (44.62 and 50.90/plant) were obtained from plants sprayed with Tracer of Fayoum and Luxor location respectively, in the first season, while the highest values from number of branches/plant (14.18 and 16.17 cm) were obtained from plants applied with Saif oil in the two locations, in the first season. In the second season, a similar trend had been obtained.

A.2- Effect on Fruits Yield:

Regarding the effect of foliar spray treatments on fruit yield per plant and per fed of local Egyptian fennel type in Fayoum and Luxor, the data in Tables (5&6) showed that the entire foliar compound treatments increased significant fruit yield per plant and per fed, compared to the control. Application of Tracer gave the highest values from fruit yield per plant 54.73 and 61.48 g/plant (1422.98 and 1598.48 kg/fed) were obtained from plants treated with Tracer in Fayoum and Luxor location in the first season, followed by plants treated with Saif oil giving 51.54 and 57.93 g/plant (1340.04 and 1506.18 kg/fed), in the first season. In the second season, a similar trend had been obtained. Telci *et al*., (2006) concluded that biomass and seed yields were affected by ecological variation and variety *Coriandrum sativum L.* (*var. vulgare Alef*. and var. *microcarpum DC*.).

Table 5: Effect of different treatments on vegetative growth of Local var. in Al-Fayoum and Luxor Governorate during two successive seasons of 2016/2017 and 2017/2018

Treatments	Plant height (cm)		No. of branches /plant		No. of Umbels /plant		Fruits yield /plant	
	Fayoum	Luxor	Fayoum	Luxor	Fayoum	Luxor	Fayoum	Luxor
2016/2017								
Untreated	101.55	139.17	11.31	10.75	27.09	29.87	33.89	30.5
KZ Oil	158.39	172.67	11.12	12.33	36.87	38.82	44.1	41.02
KZ Oil+ Potassium Soap	151.54	166.77	12.48	13.25	41.16	40.88	46.6	51.63
TRACER	169.26	182.98	13.91	14.86	44.62	50.90	54.73	٦١,٤٨
Saif Oil	167.54	182.62	14.18	16.17	42.63	46.46	51.54	57.93
BREV-AM	160.99	175.50	12.16	13.63	37.97	41.38	45.55	42.89
LSD at 5%	11.02	11.64	2.14	2.01	12.88	14.50	15.59	19.20
2017/2018								
Untreated	114.65	140.00	9.54	11.89	26.67	28.98	31.44	27.79
KZ Oil	154.65	156.76	10.47	12.28	3٥.72	34.44	39.08	41.46
KZ Oil+ Potassium	147.66	162.03	12.24	11.65	٣٦,٦	3٨.83	45.55	49.12
Tracer	167.45	171.90	12.99	13.62	41.87	٤٩.55	50.01	54.05
Saif Oil	167.03	169.88	13.47	15.34	40.93	47.62	49.75	50.64
BREV-AM	157.87	181.95	11.01	11.67	34.71	41.21	41.92	44.59
LSD at 5%	14.24	14.55	2.53	2.63	9.81	10.98	13.05	18.92

A.3- Effect on Essential Oil %:

Data presented in Table (6) revealed that all treatments significantly increased the essential oil compared to untreated plants in both seasons. The highest percentage from essential oil were obtained from plants sprayed with Tracer in Fayoum and Luxor location in the first (2.85 and 2.71 %) and second seasons (1.85 and 2.01 %) respectively, followed by plants treated with Saif oil (2.71 and 2.15 %) and (1.80 and 1.95 %), respectively. Telci *et al*., (2006) reported that essential oil % and oil yield were affected by ecological variation and variety.

A.4- Effect on Oil Yield:

Results in Tables (6) also, show the effect of foliar spray application essential oil yield per plant and per Fadden of Egyptian fennel type plants in Fayoum and Luxor. It is clear that the highest oil yield/plant 1.56 and 1.67 ml (40.55 and 43.32 L/fed.) were obtained from plants applied with Tracer in Fayoum and Luxor, respectively in the first season. In the second season, a similar trend had been obtained.

Table 6: Effect of different treatments on the essential oil of Local var. in Al-Fayoum and Luxor Governorate during two successive seasons of 2016/2017 and 2017/2018

Treatments	Fruit yield/fed (Kg)		Oil %		Oil yield /plant		Oil yield /fed	
	Fayoum	Luxor	Fayoum	Luxor	Fayoum	Luxor	Fayoum	Luxor
2016/2017								
Untreated	881.14	793.00	١.٠١	1.09	0.34	0.33	8.90	8.64
KZ Oil	1146.6	1066.52	1.85	1.95	0.82	0.80	21.21	20.80
KZ Oil+ Potassium	1211.6	1342.38	1.80	2.00	0.84	1.03	21.81	26.85
Tracer	1422.98	1598.48	٢.85	2.71	1.56	1.67	40.55	43.32
Saif Oil	1340.04	1506.18	٢.٧١	2.15	1.40	1.25	36.32	32.38
BREV-AM	1184.30	1115.14	1.79	1.88	0.82	0.81	21.20	20.96
LSD at 5%	210.02	230.12	0.53	0.45	0.44	0.41	1.55	1.49
2017/2018								
Untreated	817.44	722.54	1.05	0.90	0.33	0.25	8.58	6.50
KZ Oil	1016.08	1077.96	1.70	1.71	0.66	0.71	17.27	18.43
KZ Oil+ Potassium Soap	1184.3	1277.12	1.75	1.80	0.80	0.88	20.73	22.99
Tracer	1300.26	1405.3	1.85	2.01	0.93	1.09	24.05	28.25
Saif Oil	1293.5	1316.64	1.80	1.95	0.90	0.99	23.28	25.67
BREV-AM	1089.92	1159.34	1.61	1.57	0.67	0.70	17.55	18.20
LSD at 5%	203.10	219.03	0.33	0.42	0.25	0.37	1.52	1.44

B- Holland Variety (*Foeniculum vulgare var. azoricum):*

B.1- Effect on Vegetative Growth:

The results presented in Tables (7) and revealed that the vegetative growth of the Holland var. plant was significantly influenced by different treatments compared with untreated plants. The highest values were obtained from plants treated with Saif oil in Al-Fayoum and Luxor location from plant height (92.59 and 91.59 cm), number of branches/plant (13.72 and 12.32/plant) and number of umbels/plant (41.50 and 38.14/plant), respectively in the first season, followed by plants treated with Tracer. In the second season, a similar trend had been obtained.

B.2- Effect on Fruits Yield:

Data in Tables (7&8) showed that all foliar spray treatments caused significant increases fruit yield per plant and per fad of Holland var., the highest values of 49.08 and 45.96 g/plant (1276.08 and 1194.96 kg/fed) were obtained from plants sprayed with Saif oil in Al-Fayoum and Luxor locations, respectively in the first season. Followed by plants treated with Tracer, giving 47.78 and 43.71 g/plant (1234.48 and 1136.46 kg/fad). In the second season, a similar trend had been obtained.

B.3- Effect on Essential Oil %:

Presented data in Table (8) showed that different application treatments resulted significantly increase the percentage of essential oil %, compared with untreated plants in both seasons. The highest values were obtained from plants treated with Saif oil in Al-Fayoum and Luxor location in the first (3.21 %, 3.11%) and second (3.70 and 3.11 %) seasons, respectively. Followed by plants treated with Tracer, giving in first (3.09 and 3.00 %) and in second (3.01 and 2.90 %) seasons, respectively.

B.4- Effect on Oil Yield:

It is clear from the results recorded in Table (8) that, in general, foliar spray with different treatments gave significantly increase oil yield per plant and per Fadden compared with control. The highest values (1.58 and 1.43 ml) and (40.96 and 37.16 L) were obtained from plants treated with Saif oil compound in Fayoum and Luxor location, respectively in the first season resulted.

Table 7: Effect of different treatments on vegetative growth of Holland var. in Al-Fayoum and Luxor Governorate during two successive seasons of 2016/2017 and 2017/2018.

Treatments	Plant height (cm)		No. of branches /plant		No. of umbels /plant		Fruits yield /plant	
	Fayoum	Luxor	Fayoum	Luxor	Fayoum	Luxor	Fayoum	Luxor
2016/2017								
Untreated	72.51	63.43	9.75	8.52	26.16	25.58	٣٠,٢١	25.27
KZ Oil	81.80	76.65	10.32	9.76	3٣.06	27.32	٣٦,٢١	29.53
KZ Oil+ Potassium Soap	85.36	73.76	10.59	11.76	3٥.81	28.45	٤١,٢١	٣٨,٥٨
Tracer	90.63	84.87	10.98	11.2	3٩.85	3٦.21	٤٧,٤٨	٤٣,٧١
Saif Oil	92.59	91.59	13.72	12.32	٤١.50	3٨.14	٤٩,٠٨	٤٥,٩٦
BREV-AM	88.00	75.75	10.69	9.38	30.98	28.80	٣٧,٢٩	٣١,١٣
LSD at 5%	11.14	10.25	1.03	2.01	8.81	7.72	8.44	12.04
2017/2018								
Untreated	72.87	68.98	9.96	8.75	24.10	25.58	26.87	20.14
KZ Oil	8٢.97	70.36	10.26	9.39	31.02	27.32	٣٥,٥	٢٥,٠٧
KZ Oil+ Potassium Soap	8٥.70	72.24	10.61	10.20	3٢.52	28.45	٣٩,٧٤	٣٨,٠١
Tracer	90.51	74.78	11.99	10.84	35.14	30.14	٤٥,٣٨	٤٢,٥١
Saif Oil	92.21	77.59	12.28	10.97	3٧.50	33.28	٤٦,٦١	43.29
BREV-AM	82.60	69.70	9.78	10.83	28.58	28.80	36.79	27.30
LSD at 5%	9.31	8.76	1.11	2.03	5.30	8.94	10.57	14.55

Table 8: Effect of different treatments on essential oil of Holland var. in Al-Fayoum and Luxor Governorate during two successive seasons of 2016/2017 and 2017/2018.

Treatments	Fruit yield/fed (Kg)		Oil %		Oil yield/plant		Oil yield/fed	
	Fayoum	Luxor	Fayoum	Luxor	Fayoum	Luxor	Fayoum	Luxor
2016/2017								
Untreated	٧٨٥,٤٦	657.02	1.62	1.42	0.49	0.36	12.72	9.33
KZ Oil	٩٤١,٤٦	767.78	2.65	2.20	0.96	0.65	24.95	16.89
KZ Oil+ Potassium Soap	١٠٧١,٤٦	1003.08	2.85	2.71	1.17	1.05	30.54	27.18
Tracer	١٢٣٤,٤٨	1136.46	3.09	3.00	1.47	1.31	38.15	34.09
Saif oil	١٢٧٦,٠٨	1194.96	٣.٢١	٣.11	1.58	1.43	40.96	37.16
BREV-AM	٩٦٩,٥٤	809.38	2.81	2.٢٣	1.05	0.69	27.24	18.05
LSD at 5%	195.22	175.47	0.86	0.84	0.42	0.60	5.91	6.25
2017/2018								
Untreated	698.62	523.64	1.52	1.38	0.41	0.28	10.62	7.23
KZ Oil	923.00	651.82	2.30	2.00	0.82	0.50	21.23	13.04
KZ Oil+ Potassium Soap	1033.24	988.26	2.٧7	2.٥١	1.10	0.95	28.62	24.81
Tracer	1179.88	1105.26	3.01	2.٦0	1.37	1.23	35.51	32.05
Saif oil	1211.86	1099.54	٣.٧	٣.10	1.72	1.34	44.84	34.09
BREV-AM	956.54	709.80	2.44	1.91	0.90	0.52	23.34	13.56
LSD at 5%	189.11	177.55	0.22	0.19	0.15	0.25	6.01	7.14

Effect of Foliar Applications on Essential Oil Composition of Fennel Fruits from Two Varieties:

Six constituents were separated and identified by GC analysis in fennel fruits essential oil (e.g. α-pinene, Myrecene, Limonene, M.chavicol (Estragol), Anethol and Fenchone). The unidentified compound ranged from (2.47 - 9.9 %). Data in Table (9) showed the fractionated components of the essential oil of local fennel and Holland var. in the second season. In this context, Shalaby and Hendawy (2011) mentioned that the

local Egyptian variety characterized by low Anethole (1.10 - 2.46%) and high estragole (53.00- 66.91%). While, Abd-Elaaty *et. al.,* (2011) revealed that, estragole was the major compound in the oil of the vulgare (local) cultivar, with a concentration of 58 % compared to only 12% and 6% in the oils of Azoricum (Holland) and Dulce cultivars, respectively. Essential oil composition depends upon internal, environmental and agricultural practices as well as factors affecting the plant such as genetics and ecological conditions (Telic *et. al.*, 2006 and Fuente *et. al.,* 2003).

Table 9: The chemical composition (area %) of the essential oils of fennel fruits from two Varieties in Al-Fayoum & Luxor Governorate during the second season 2017/2018.

Region	Variety	Treatments	α-pinene	Myrecene	Limonene	M.chavicol (Estragol)	Anethol	Fenchone	Other components
Al-Fayoum	Local	Tracer	1.54	0.56	6.35	33.45	43.21	11.87	3.02
		Saif Oil	1.75	0.49	5.51	37.37	41.87	10.54	2.47
		Untreated	2.20	1.50	7.21	56.01	17.40	12.10	3.50
	Holland	Tracer	0.55	0.65	5.74	3.54	72.34	10.11	7.07
		Saif Oil	1.12	0.94	5.12	4.32	67.35	11.21	9.90
		Untreated	2.10	1.10	6.50	39.41	32.50	9.14	9.25
Luxor	Local	Tracer	1.87	1.12	4.50	45.11	31.٠1	9.50	6.١٠
		Saif Oil	2.32	0.89	4.32	52.12	26.4	8.91	5.04
		Untreated	2.60	1.70	6.12	63.41	13.42	6.11	6.64
	Holland	Tracer	1.45	0.57	4.21	7.32	69.21	10.65	6.59
		Saif Oil	1.90	0.65	3.87	9.11	63.5	11.57	9.40
		Untreated	2.40	1.20	5.24	45.7	28.50	8.11	8.85

CONCLUSION

Depend on the study results, there are significant effects of different locations on infestation by fennel aphid *Hyadaphis foeniculi* and *Brevicoryne brassicae*, and its effect on plant growth, seed yield, and essential oil. Also, the fennel aphids attacked umbels and might thus cause to failure of fruit setting and they also attacked during the phase of seed development. There was no significant interaction between seasons. This results in the relative susceptibility of fennel varieties that revealed that the different locations affected the susceptibility degrees. The efficiency of the aphid treatments with some of safe material the fennel plant received the lowest number of aphid under treatments of Tracer and Saif oil followed by KZ Oil + Potassium Soap While, the moderate number of aphid was under treatment KZ Oil However, the highest number of aphid was under treatment orang oil which was closed to untreated. In case of severe infestation, the growing points and flower stalks wither and dry up and at flowering and fruiting stage, the seeds are not formed and if they are formed, they are shriveled and of poor quality.

It is clear from the previous results that the Egyptian local cultivar preferred to cultivate in Luxor, where the best vegetative growth as well as the highest yield of fruits and the highest productivity of essential oil percent and the highest oil yield provided the treatment of plants with Tracer or Saif oil, where they have a strong impact on resistance aphid, which reflected on the production of local fennel type increased. On the other hand, Holland variety, the best yield was given in Fayoum in terms of vegetative growth, fruit yield and oil yield, provided that the plants were treated with Traces or Saif oil, which was efficient on the reducing the aphid infestation, leading to increased productivity. Based on the above, the study concluded that the successful cultivation of the Egyptian local type in Luxor and the Holland variety in Fayoum with the treatment of plants with compound Tracer or Saif oil.

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