Scientific J. Flowers & Ornamental Plants
www.ssfop.com/journal
ISSN: 2356-7864 **doi: 10.21608/sjfop.2021.155057**

INFLUENCE OF AQUEOUS LICORICE AND ETHANOL MORINGA EXTRACTS ON THE ESSENTIAL OIL PRODUCTION, AND CHEMICAL CONSTITUENTS OF AJWAIN (*TRACHYSPERMUM AMMI*) PLANTS UNDER SANDY SOIL CONDITION

Eman M. Abou El-Ghait*, Y.F.Y. Mohamed*, M.Y.M. Badawy** and S.H El-Gioushy**

* Horticulture Dept., Fac. Agric., Benha University, Egypt

** Medicinal and Aromatic Plants Dept., Desert Research Center, El-Matariya, Cairo, Egypt

ABSTRACT: Two field experiments were conducted in 2018/2019 and 2019/2020 cropping season, at the Experimental Farm of Heliopolis Univ., El-Sharqea Governorate, Egypt, in cooperation with the Department of Horticulture, Faculty of Agriculture, Benha University to study the influence of licorice aqueous extract at 0, 10, 20, and 40 g/l concentrations and Moringa ethanol extract at 0, 50, and 100 g/l concentrations and their interaction on essential oil content, essential oil composition, and chemical constituents of ajwain (*Trachyspermum ammi*) under sandy soil conditions, in a split plots design of 12 treatments with three replications for each treatment. The main plots were the concentrations of licorice aqueous extract, the subplots were the concentrations of Moringa ethanol extract. The results demonstrated that treating ajwain plants by spraying with the licorice aqueous extract at 40 g/l and Moringa ethanol extract at 100 g/l ($L_3 \times M_2$) scored the highest values of the essential oil percent, oil yield/plant, and oil yield/fed. The same treatment ($L_3 \times M_2$) was recorded the greatest values of the content of the pigment (chlorophyll a, b, total chlorophyll, and carotenoid), also treating ajwain plants by the same treatment was given the highest carbohydrate in the two seasons. However, ajwain plants sprayed with licorice aqueous extract at 0.0 g/l or Moringa ethanol extract at 0.0 g/l ($L_0 \times M_0$) lead to the lowest values of all the above-mentioned traits. In general, the main chemical constituents of ajwain essential oil were γ-terpinene, followed by thymol and p-cymene, along with α- and β-pinenes, α-thujene, myrcene, and Limonene.

Key words: ajwain, *Trachyspermum ammi*, essential oil, Thymol, licorice aqueous extract, and Moringa ethanol extract.

Scientific J. Flowers & Ornamental Plants, 8(1):19-38 (2021).

Received:
31/12/2020
Accepted:
14/1/2021

Corresponding author:
S.H. El-Gioushy
samehgioushy@gmail.com

INTRODUCTION

Trachyspermum ammi commonly known as 'ajwain' is native to Egypt belonging to the highly valued medicinally important family Apiaceae, is an herbaceous herb and has an erect and striate stem which may grow up to 90 cm tall, leaves pinnate, inflorescence compound umbel with 16 umbellets, each containing up to 16 flowers; flowers actinomorphic, white, male and bisexual, fruit, small, grayish brown, ovoid, compressed, about 2 mm long and 1.7 mm wide. (Gersbach and Reddy, 2002; Kamal *et al*., 2012; and Mohammad *et al*., 2014). It is said that the herb is widely grown in arid and semi-arid regions such as Iraq, Iran, Afghanistan, Pakistan, and India, as well as Europe (Shojaaddini *et al*., 2008). The use of plants as medicine is as old as human civilization, where it is used traditionally as a stimulant, carminative, flatulence, atonic dyspepsia, diarrhea, and bronchial problems, lack of appetite, and asthma. Additionally, it has been proven to possess various pharmacological activities like antifungal, antioxidant, antimicrobial, cytotoxic activity, antispasmodic, antilithiasis, diuretic, abortifacient, antitussive, anthelmintic and antifilarial activity (Lawless, 1992; Kaur and Arora, 2008; and Kamal *et al*., 2012). As well as ajwain liquid is used as a preventive measure for the covid-19 i.e. corona virus (Gaddamwar *et al*., 2020).

Ajwain seeds contain 2-5% of a brown-colored known as ajwain oil, is found in secretory channels or glandular ducts (vittae) of seeds, the ajwain oil is an important source of thymol (30–50%), additionally, γ-terpinene, and p-cymene, along with α- and β-pinenes, α-thujene, myrcene, 1,8-cineole, and carvacrol. It is being used in minor quantities in perfumery, food flavoring as preservatives, and, most extensively, in folk medicines, especially for remedies of stomach disorders (Singh and Singh, 2000; and Yadav *et al*., 2011). Anyhow, many factors are impacting oil content in Apiaceous crops such as fertilization, irrigation, and salinity.

Recently, the world has become suffers from environmental pollution issues. Consequently, the present work is mainly directed towards investigating the possibility of replacing inorganic fertilizers the expensive, further associated with land and soil degradation and environmental pollution, as well as affect human health (Phiri, 2010). Consequently, there is an ongoing need to search for safe alternative natural sources of plant nutrients. Natural extracts are one of these alternatives, and are investigated to ensure their effect on crop growth and productivity. (Phiri, 2010).

The licorice plant is a perennial creeper herb plant or undershrub that grows in many parts of the world, such as Syria, Egypt, and Asia Minor, Central Asia, and Europe (Fenwick *et al*., 1990; Zadeh *et al*., 2013). Licorice is extracted from the roots. The active ingredient in licorice is cytricricin, and licorice has been shown to contain sugary substances and mineral salts, the most important of which are P, K, Ca, Mg, Fe, Cu, Zn and soapy substances Foam when pouring juice. It also contains mevalonic acid used in gibberellins synthesis (AL-Marsoumi, 1999 and Abd El-Azim *et al*., 2017), and the same regard (Ibanogiu and Ibanogiu, 2000) stated that the licorice root contains various sugars (up to 18%), flavonoids, saponins, sterols, amino acids, starch, and gums. The active ingredient in licorice is mainly glycyrrhizin, a triterpenoid glycoside, which constitutes up to 14% of the total soluble solids content.

Moringa (*Moringa oleifera* L.) plant, family Moringacea, it has a multitude of medicinal and nutritional values. Its leaves have a large number of important minerals (P, Ca, K, Mg, Fe, Cu, Mn, and Zn), vitamins, amino acids, and antioxidant compounds. (Anjorin *et al*., 2010). In many agricultural systems, Moringa and its products have varying uses. As a crop enhancer, the use of Moringa is an eco-friendly way to increase crop yields at the lowest possible cost (Abd El-Hack *et al*., 2018). There are many applications, such as green manure and natural growth stimulants, for soil and plant. If it is an aqueous or ethanol extract, exogenous application of Moringa leaves extract (MLE) enhances productivity in many crops because MLE has great antioxidant activity and is rich in secondary plant metabolites such as ascorbic acid and total phenols, and cytokinin in the form of zeatin, making it a potential natural stimulant of growth, that may be applied as an environmentally friendly alternative source of chemical fertilizers (Phiri and Mbewe, 2010; Azra *et al*., 2012; and Abdel-Rahman and Abdel-Kader, 2020). In addition, MLE is used to improve plant resistance to abiotic stresses, such as other bio-stimulants (Rady *et al*., 2013).

Therefore, the main objectives of the present study were to study the effect of concentrations of *Glycyrrhiza glabra* aqueous extract and *Moringa oleifera* ethanol extract as well as their interactions on essential oil production, essential oil content and component, and chemical constituents of the ajwain (*Trachyspermum ammi*) plant under sandy soil conditions.

MATERIALS AND METHODS

The experiment was carried out at the Experimental Farm of Heliopolis Univ., El-Sharqea Governorate, Egypt, under supervision of the Department of Horticulture, Faculty of Agriculture, Benha University during the two consecutive winter seasons of 2018/2019 and 2019/2020 in order to study the impact of spraying with licorice aqueous extract and Moringa ethanol extract, as well as their interaction treatments on essential oil production, essential oil content and component, and some chemical constituents of the ajwain (*Trachyspermum ammi*) plant under sandy soil conditions.

Seeds of the ajwain plant were obtained from the Experimental Farm of the Faculty of Agriculture, Cairo University. Seeds were sown directly in the field on 20th October 2018 in the first season and 14th October 2019 in the second season within the drippers of irrigation lines and irrigation was done immediately after sowing, drip irrigation lines with average (4 liter/hour). The experimental unit area was 2.25 × 3 m^2. Every experimental unit contained three rows with 3 m long contains 30 plants per plot. The distance between rows was 75 cm apart and the distance between plants in the same row was 30 cm apart. About 4-5 seeds were sown per hill, and then thinned after three weeks to two plants/hill. The other agricultural practices were carried out as recommended.

Soil and water analysis:

Soil analysis is shown in Table (1). The soil samples representing the experiment area was taken at 0-30 cm depth. The soil physical and chemical analyses of this experiment from Jackson (1973) and Black *et al*. (1982), respectively. The water analysis represented the used irrigation water in Table (2). Both soil and water samples were analyzed in the Desert Research Center laboratories.

The experiment was consisted of 12 treatments arranged in a complete randomized split plot design with three replicates. The main plots included four treatments of licorice aqueous extract rates (0.0 g/l (L_0), 10 g/l (L_1), 20 g/l (L_2), and 40 g/l (L_3) and three treatments of Moringa ethanol extract concentrations (0.0 ml/l (M_0), 50 g/l (M_1) and 100 g/l (M_2) occupied the sub-plots.

Extracts Preparation:

Licorice aqueous and Moringa ethanol extracts were prepared as follows:

Licorice (*Glycyrrhiza glabra*) extract:

The aqueous extract of licorice roots (*Glycyrrhiza glabra*) obtained from the local market, were prepared by soaking licorice roots in one liter of hot tap water (aqua 90 °C) at a rate (0, 10, 20 and 40 g/l) as suggested by Abd El-Azim *et al*. (2017). Then filtering of the solution by wringing using a mutton cloth. The obtained extract re-filtered through No. 2 Whatman filter paper.

L_0 = 0.0 g/l (sprayed with tap water).

L_1 = 10 g/l (added 10 g of licorice roots per one liter hot tap water).

L_2 = 20 g/l (added 20 g of licorice roots per one liter hot tap water).

L_3 = 40 g/l (added 40 g of licorice roots per one liter hot tap water).

Moringa (*Moringa oleifera*) extract:

An amount of 20 g of young Moringa leaves obtained from the Experimental Farm of the Faculty of Agriculture, Benha University, was mixed with 675 ml of 80% ethanol as suggested by Makkar and Becker (1996). The suspension was stirred using a homogenizer to help maximize the amount of the extract. The solution was then filtered by wringing the solution using a mutton cloth, the solution was re-filtered using No. 2 Whatman filter paper, then taking (0, 50 and

Table 1. Physical and chemical analysis of the experimental soil area.

Physical analyses						
Very coarse sand (%)	Coarse sand (%)	Medium sand (%)	Fine sand (%)	Very fine sand (%)	Silt and clay (%)	Soil Texture
11.25	20.50	33.20	25.10	6.94	2.89	Fine sand

Chemical analyses												
pH	E.C.	O. M.	Cations (mmolc l^{-1})				Anions (mmolc l^{-1})			Available (mg/l)		
	(dS m^{-1})	(%)	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	HCO_3^-	SO_4^{--}	Cl^-	N	P	K
7.6	0.93	1.7	3.10	1.01	4.65	0.57	2.50	3.21	3.60	71.2	5.12	65.4

Table 2. Water analysis of the irrigation water.

pH	E.C. (dS m^{-1})	Soluble cations (mmolc l^{-1})				Soluble anions (mmolc l^{-1})			
		Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO_3^{--}	HCO_3^-	SO_4^{--}	Cl^-
7.3	0.38	1.53	0.92	1.03	0.16	0.21	1.37	1.10	0.97

100 ml/l) from this ethanol extract and added to 1-liter tap water, and then spraying of the plants.

M_0 = 0.0 ml/l (sprayed by tap water).

M_1 = 50 ml/l (added 50 ml Moringa extract per one liter tap water).

M_2 = 100 ml/l (added 100 ml Moringa extract per one liter tap water).

Licorice aqueous extract and Moringa ethanol extract were analyzed in the Desert Research Center laboratories, as shown in Table (3).

Treatments application:

Foliar spraying of aqueous licorice and ethanol Moringa extracts in the form of leaf spray in the early morning was applied three times separately in six weeks at one week interval between each extract and the other starting two months after planting in both seasons. Bio film at 1 g/l as a wetting agent, was added to all tested solutions including the control.

Concentration of extracts for foliar spray, licorice were: L_0 (0,0 tap water), L_1 (10 g/l), L_2 (20 g/l) and L_3 (40 g/l) licorice/tap water, while Moringa extraction concentrations were: M_0 (0,0 tap water), M_1 (50 ml/l) and M_2 (100 ml/l) Moringa extract/tap water. All plant received 10 m^3/fed compost was added before planting in each season. The plants were sprayed with the abovementioned treatments by a hand pump mister to the point of runoff. All plants received a chemical fertilization dose of 16 kg/fed of calcium superphosphate (15% P_2O_5), 10 m3/fed of compost during soil preparation, 33 kg/fed of ammonium sulfate (20.5% N), and 16 kg/fed of potassium sulfate (48 percent K_2O) were added as equal parts Sathyanarayana *et al.*, (2017). The first addition was after two months from sowing and the second one added after one month from the first one. All plants received normal agriculture practices whenever they needed.

Statistical analysis:

The obtained results were statistically analyzed. Analysis of variance was performed to determine significant differences. Means were compared using LSD test at 0.05 level according to Snedecor and Cochran (1989).

Harvesting:

The plants of the experiment were harvested on 2nd week of May in both seasons.

Recorded data:

Pigment content (mg/g F.W.) determination:

Chlorophyll a, b, total chlorophyll, and carotenoids were determined in leaf fresh samples of ajwain plants (mg/g F.W.) as described by Inskeep and Bloom (1985).

Table 3. The element's content (mg/l) of licorice aqueous extract and Moringa ethanol extract analysis extracts.

Licorice aqueous extract (mg/100 g DW)		Moring ethanol extract (mg/100 g DW)	
Components	**Values**	**Components**	**Values**
Crude protein	7.97	**Amino acids**	124.7
Total phenol	405.02	**Proline**	26.09
Calcium	104.55	**Calcium**	8.76
Magnesium	174.7	**Magnesium**	1.04
Potassium	341.5	**Potassium**	21.68
Phosphorus	5.20	**Phosphorus**	6.12
Sodium	122.8	**Sodium**	0.67
Iron	1.19	**Iron**	1.87
Manganese	0.40	**Manganese**	0.97
Zinc	0.40	**Zinc**	0.45
Copper	0.18	**Copper**	0.21
Total flavonoids	114.91	**Ascorbic acid**	3.25
Indole 3 acetic acid	+	**Indole 3 acetic acid**	0.87
Gibberelline	+	**Gibberelline**	0.80
Saponins	27.78	**Zeatin**	0.94
Vitamin C	1.20	**Abscic acid**	0.25

Total carbohydrates % determination:

Total carbohydrates percentage in dried herb was determined according to Herbert *et al.*, (1971):

Conc. of total carbohydrates (g %) =

$$\frac{\text{Reading (ppm)} \times \text{dilution}}{\text{W} \times 1000}$$

Where: W= weight of the sample in (g).

Determination of essential oil % and yield:

The essential oil in the fruits was extracted by hydrodistillation according to the method described in British Pharmacoepea (1963). The essential oil percentage was determined in 100 g fruits samples moved into distillation flask in 1000 ml of freshwater. The distillation period extended to four hours. The volatile oil percentage was calculated as ml of oil/100 grams of seeds or fruits using the following equation:

Volatile oil percentage =

$$\frac{\text{Oil volume in the graduated tube}}{\text{Dry weight of samples}} \times 100$$

Oil percentage was used to calculate volatile oil yield/plant as well as volatile oil yield/fed calculated based on the number of plants and oil yield/plant.

GC/MS analysis of essential oil:

The GC/MS analysis for oil samples from the second season only of the experiment was carried out at the Central Laboratory of National Research Center, Giza. Essential oil GC/Mass analysis was performed using a Hewlett-Packard 5890 A series 11 instrument equipped with flame ionization detector (FID) and a carbon wax fused silica column (50 m × 0.25 mm. i.d., film thickness 0.32 µm). The initial column temperature was 50 ºC and held for 3 minutes, then raised to 60 Cº by rate 3.0 ºC per minute and raised to 260 ºC by rate 3.0 ºC per minute and hold at 260 ºC for 5 minutes. The volatile oil components were identified by comparing their retention times and mass spectrum with those of standards, NIST library of the GC/MS system, and literature data.

RESULTS AND DISCUSSION

Photosynthetic pigments:

Chlorophyll a (mg/g):

As regards the leaf content of chlorophyll a to ajwain plants as influenced by the licorice aqueous extract used, Table

(4) showed clearly that ajwain plants which were sprayed with licorice aqueous extract at a concentration of 40 g/l had the richest leaf content from chlorophyll a (0.899 and 1.079 mg/g) in the two seasons, respectively. However, ajwain plants, which were sprayed by tap water, had the lowest leaf chlorophyll a content in the two seasons (0.806 and 0.986 mg/g) respectively.

Herein, leaf content of chlorophyll a, also was impacted by Moringa ethanol extract in both seasons. Where, the highest values of chlorophyll a leaves content were detected from concentration 100 g/l of Moringa ethanol extract which reached to (0.875 and 1.055 mg/g) during both seasons, respectively. Besides, the lowest values of chlorophyll a leaves content were obtained by sprayed ajwain plants with tap water which reached (0.815 and 0.995 mg/g) during both seasons, respectively.

Furthermore, the combination effect between licorice aqueous extract and Moringa ethanol extract treatments, illustrated in Table (4) showed that all combinations between licorice aqueous extract and Moringa ethanol extract were increased leaves chlorophyll a content of ajwain over control, this trend was true in both seasons of this study. However, the highest values of ajwain leaves chlorophyll a content was recorded by using the combined treatment between licorice aqueous extract at 40 g/l concentration and 100 g/l Moringa ethanol extract as (0.919 and 1.099 mg/g) in the two seasons, respectively. Followed descendingly by ($L_3 \times M_1$) and had no significant difference between them in the first season only. On the reverse, the lowest values scored by $L_0 \times M_0$ (sprayed ajwain plants by tap water) in both seasons.

Chlorophyll b (mg/g):

The results of chlorophyll b, using foliar application with all concentrations of licorice aqueous extract demonstrated in Table (4). The results reflected a significant increase in

Table 4. Effect of licorice aqueous extract, Moringa ethanol extract and their interaction treatments on chlorophyll a, chlorophyll b and total chlorophyll of ajwain during the two seasons 2018/2019 and 2019/2020.

Licorice aqueous extract (A)	Chlorophyll a (mg/g)				Moringa ethanol extract (B) Chlorophyll b (mg/g)				Total chlorophyll (mg/g)			
	M_0	M_1	M_2	Mean	M_0	M_1	M_2	Mean	M_0	M_1	M_2	Mean
First season												
L_0	0.778	0.816	0.823	0.806	0.328	0.349	0.332	0.336	1.106	1.165	1.155	1.142
L_1	0.808	0.850	0.863	0.841	0.364	0.381	0.391	0.379	1.172	1.231	1.254	1.219
L_2	0.801	0.883	0.895	0.860	0.367	0.427	0.435	0.410	1.168	1.310	1.330	1.269
L_3	0.872	0.906	0.919	0.899	0.403	0.438	0.453	0.431	1.275	1.344	1.372	1.330
Mean	0.815	0.864	0.875		0.366	0.399	0.403		1.180	1.263	1.278	
L.S.D at 5 %	A=0.012 B= 0.009 A×B= 0.017				A=0.012 B= 0.009 A×B= 0.017				A=0.012 B= 0.009 A×B= 0.017			
Second season												
L_0	0.958	0.996	1.003	0.986	0.336	0.358	0.365	0.353	1.295	1.354	1.368	1.339
L_1	0.981	1.030	1.043	1.021	0.350	0.391	0.399	0.380	1.338	1.422	1.442	1.401
L_2	0.981	1.063	1.075	1.040	0.378	0.438	0.449	0.422	1.359	1.501	1.524	1.461
L_3	1.052	1.086	1.099	1.079	0.411	0.456	0.471	0.446	1.463	1.542	1.570	1.525
Mean	0.995	1.044	1.055		0.369	0.412	0.421		1.364	1.455	1.476	
L.S.D at 5 %	A=0.012 B= 0.009 A×B= 0.017				A=0.012 B= 0.009 A×B= 0.017				A=0.012 B= 0.009 A×B= 0.017			

Means within the same column for each trait significantly differ from each other according to the LSD at $p< 0.05$.

L_0 (sprayed with tap water); L_1 (added 10 g of licorice/l); L_2 (added 20 g of licorice/l); L_3 (added 40 g of licorice/l); M_0 (sprayed with tap water); M_1 (added 50 ml Moringa ethanol extract/l); M_2 (added 100 ml Moringa ethanol extract /l).

chlorophyll b was enhanced significantly in both seasons. The treatment with the licorice root aqueous extract at 40 g/l concentration gave significantly higher values of chlorophyll b amounted to (0.431 and 0.446 mg/g) in two test seasons, respectively. Meantime, the sprayed ajwain plants with tap water (L_0) had the least values in both seasons amounted to (0.336 and 0.353 mg/g) respectively.

Regarding, the response of chlorophyll b of ajwain plant to the effect of spraying plants with Moringa ethanol extract, data given in Table (4) revealed that chlorophyll b was increased by increasing the amount of spraying Moringa ethanol extract. The sprayed ajwain plants at 100 g/l of Moringa ethanol extract were recorded the highest values (0.403 and 0.421 mg/g) for both seasons, respectively. On the contrary, sprayed ajwain plants by tap water (M_0) were resulted in the least values (0.366 and 0.369 mg/g) for both seasons, respectively.

Concerning, the effect of interaction between licorice aqueous extract and Moringa ethanol extract on chlorophyll b, treated ajwain plants by licorice aqueous extract at 40 g/l concentration with Moringa ethanol extract at 100 g/l concentration gave the highest values of chlorophyll b as (0.453 and 0.471 mg/g) in the 1st and 2nd seasons, respectively. And came in the second place and without a significant difference between them in both seasons ($L_3 \times M_1$) treatment. While, the lowest values detected from treated ajwain plants by sprayed with tap water reached to (0.328 and 0.336 mg/g) in the 1st and 2nd seasons, respectively.

Total chlorophyll (mg/g):

With regard to the changes in total chlorophyll values of ajwain plants as influenced by the licorice aqueous extract, data obtained during both the 2018/2019 and 2019/2020 experimental seasons are shown in Table (4). It is quite clear that there was a positive relation between licorice aqueous extract and the total chlorophyll. Hence, the total chlorophyll was gradually increased with the increment licorice rate from 0.0 to 40 g/l which amounted to (1.330 and 1.525 mg/g) for both seasons, respectively. However, sprayed ajwain plants with tap water gave the lowest values which amounted to (1.142 and 1.339 mg/g) in both seasons, respectively.

In this respect, Moringa ethanol extract has the same effect as licorice aqueous extract on total chlorophyll, where the increase of the values of total chlorophyll were related to increased concentrations of Moringa ethanol extract. Anyway, the maximum values of total chlorophyll recorded with used 100 g/l of Moringa ethanol extract, which reached (1.278 and 1.476 mg/g) in the first and second seasons, respectively. While, the minimum values of total chlorophyll as a result of treated ajwain plants with tap water which reached (1.180 and 1.364 mg/g) in two seasons respectively.

Concerning the impact of the interaction between licorice aqueous extract and Moringa ethanol extract on total chlorophyll, all combined treatments between licorice and Moringa extracts had a positive effect on the values of total chlorophyll in both seasons. Hence, the highest values of total chlorophyll were obtained by combined the licorice aqueous extract at 40 g/l concentration and Moringa ethanol extract at 100 g/l concentration as (1.372 and 1.570 mg/g) during both seasons, respectively. On the other hand, sprayed ajwain plants by tap water resulted in the lowest values as (1.106 and 1.295 mg/g) during two experiment seasons, respectively.

Carotenoids (mg/g):

According to the results presented in Table (5) the highest values of carotenoids were occurred with L_3 application of licorice aqueous extract at 40 g/l concentration in the 1st and 2nd seasons which reached to (0.347 and 0.358 mg/g) respectively. Meanwhile, treated ajwain plants by tap water led to the lowest values of carotenoids (0.266 and 0.277 mg/g) in the first and second one seasons, respectively.

As for the effect of the Moringa ethanol extract on the carotenoids, the highest values of carotenoids were attained with Moringa ethanol extract at 100 g/l concentration amounted to (0.324 and 0.338 mg/g) in the two seasons, respectively. However, the lowest values of carotenoids were achieved with treated ajwain plants by tap water amounted to (0.280 and 0.289 mg/g) in the two seasons, respectively.

With regard to the response of carotenoids to the combined treatments between the licorice aqueous extract and Moringa ethanol extract, the greatest values of carotenoids were reported by the treatment of combined the licorice aqueous extract at 40 g/l concentration plus Moringa ethanol extract at 100 g/l concentration ($L_3 \times M_2$), which amounted during both experimental seasons (0.362 and 0.378 mg/g) respectively. Followed by $L_3 \times M_1$ without a significant difference among them in both seasons. While, $L_0 \times M_0$ treatment ajwain plants that treated by tap water scored the lowest values reached 0.243 and 0.253 mg/g during both seasons, respectively.

Total carbohydrates (%):

In regard to the influence of the licorice aqueous extract on total carbohydrate percentages, results in Table (5) demonstrated that the maximum amount of carbohydrates were resulted from treating ajwain plants with 40 g/l concentration of licorice, reached (23.07% in the first season and 23.94% in the second season). However, treated plants of ajwain by tap water were recorded the minimum amount of carbohydrates which reached (17.37% in the 1st season and 17.83% in the 2nd season).

In this experiment, the influence of the application of the Moringa ethanol extract on total carbohydrates were a positive, where the higher the concentration of the Moringa ethanol extract, the higher the total carbohydrate concentration. Anyway, treating plants of ajwain with 100 g/l concentration of Moringa ethanol extract led to the highest amount of carbohydrates (21.60 and 22.51%) during the two test seasons, respectively. Likewise, treated ajwain plants by tap water were produced the lowest amount of carbohydrates (18.33 and 18.99%) for both seasons, respectively.

Data obtained during both experimental seasons illustrated that the total carbohydrates were affected by all treatments of the interaction between licorice aqueous extract and Moringa ethanol extract. Hence, the greatest values of carbohydrates were obtained with the interaction between licorice aqueous extract at 40 g/l plus 100 g/l of Moringa ethanol extract which reached to (24.17 and 25.30%) during both experimental seasons, respectively and came in second place ($L_3 \times M_1$) without a significant difference among them in the first season only. Meantime, the minimum values of carbohydrates were occurred with sprayed the plants of ajwain by tap water during both experimental seasons which reached to 15.95 and 16.22% respectively. While the rest treatments occupied an intermediate place between the aforesaid treatments.

Many researchers concluded that licorice and Moringa extracts have essential physiological and biochemical roles in the structure of photosynthetic pigments, carbohydrate metabolism, and proteins. Aqueous Licorice and ethanol Moringa extracts are rich in amino acids, vitamins, and growth stimulating photo-hormones that increase the activity of apical meristem tissue resulting in cell division and elongation. Licorice aqueous extract, in turn, contains several minerals such as K, P, Mg, Fe, and other growth stimulants as well as saccharides absorbed by the leaves during spraying, which increase growth activity and thus increase the vegetative growth and chlorophyll content of Al-Sahaf and Al-Marsoumi (2001), triterpenoid saponin, such as glycyrrihysic acid, are of these growth stimulants. Glycyrrihysic acid is first synthesized from Mevalonic acid. Which has a similar effect to GA_3 in reducing complex compounds to simple compounds used by plants to create new proteins required for

Table 5. Effect of licorice aqueous extract, Moringa ethanol extract and their interaction treatments on carotenoids and total carbohydrates of ajwain during the two seasons 2018/2019 and 2019/2020.

Licorice aqueous extract (A)	Moringa ethanol extract (B)							
	M_0	M_1	M_2	Mean	M_0	M_1	M_2	Mean
	First season				Second season			
	Carotenoids (mg/g)							
L_0	0.243	0.274	0.282	0.266	0.251	0.285	0.294	0.277
L_1	0.266	0.299	0.307	0.291	0.275	0.307	0.316	0.299
L_2	0.289	0.341	0.346	0.326	0.301	0.354	0.363	0.339
L_3	0.356	0.356	0.362	0.347	0.328	0.369	0.378	0.358
Mean	0.280	0.318	0.324		0.289	0.329	0.338	
L.S.D at 5 %	A= 0.012 B= 0.009 A×B= 0.017				A= 0.012 B= 0.009 A×B= 0.017			
	Total carbohydrates (%)							
L_0	15.95	17.78	18.37	17.37	16.22	18.28	19.00	17.83
L_1	17.05	20.05	20.92	19.34	17.72	21.01	21.79	20.17
L_2	19.17	22.07	22.97	21.40	20.03	23.03	23.97	22.34
L_3	21.13	23.90	24.17	23.07	22.01	24.50	25.30	23.94
Mean	18.33	20.95	21.60		18.99	21.71	22.51	
L.S.D at 5 %	A= 0.51 B= 0.33 A×B= 0.66				A= 0.33 B= 0.33 A×B= 0.66			

Means within the same column for each trait significantly differ from each other according to the LSD at $p < 0.05$.

L_0 (sprayed with tap water); L_1 (added 10 g of licorice/l); L_2 (added 20 g of licorice/l); L_3 (added 40 g of licorice/l); M_0 (sprayed with tap water); M_1 (added 50 ml Moringa ethanol extract/l); M_2 (added 100 ml Moringa ethanol extract /l).

growth (Al-Sahaf and Al-Marsoumi, 2003 and Al-Ajeeli, 2005). In addition, magnesium plays a role in increasing the growth of leaves, cell division, and biological plant activity, as well as the building of chlorophyll. In addition, it increases chlorophyll content in leaves and triggers essential physiological processes within the plant.

These results are in agreement with those obtained on dill plants by El-Gamal and Ahmed (2016), they found that foliar application of Moringa leaf extract (MLE) (1:30), increased significantly chlorophyll content over non sprayed plants. On fennel, Abou-Sreea and Matter (2016) found that the highest content of chlorophyll (a, b) and carotenoids has been given from the interaction between 150 ppm GA_3 with 30% of Moringa leaf extract (MLE). While, the highest contents of total carbohydrates percentage were obtained from the moderate level of GA_3 (100 ppm) combined with 20% of MLE.

On oil traits:

Essential oil percentage:

Data in Table (6) indicated that the values of oil percentage were significantly affected by different concentrations of licorice root aqueous extract in both seasons of the study. The highest significant oil percentage (5.09 and 5.37%) was recorded from the sprayed ajwain plants at 40 g/l concentration of licorice root (L_3). On the other side, ajwain plants treated by tap water (L_0) gave the lowest values of oil percentage reached to 3.35 and 3.70% in both seasons of the study, respectively.

In this respect, the effective treatment on enhancing the oil percentage was the application of Moringa ethanol extract at 100 ml/l (M_2) which resulted in the highest oil percent amount to 4.62 and 4.83% during the two seasons, respectively. However, the lowest percentage of oil was produced as a result of M_0 treated ajwain plants with tap water (3.65 and 3.88%) during the two seasons, respectively.

Table 6. Effect of licorice aqueous extract, Moringa ethanol extract and their interaction treatments on oil traits (oil percentage, oil yield/plant and oil yield/fed) of ajwain during the two seasons 2018/2019 and 2019/2020.

Licorice aqueous extract (A)	Moringa ethanol extract (B)											
	Oil percentage				Oil yield/plant				Oil yield/fed			
	M_0	M_1	M_2	Mean	M_0	M_1	M_2	Mean	M_0	M_1	M_2	Mean
	First season											
L_0	3.06	3.35	3.65	3.35	0.15	0.22	0.24	0.20	5.51	8.21	8.98	7.57
L_1	3.22	3.97	4.33	3.84	0.16	0.29	0.32	0.26	6.21	10.76	12.02	9.66
L_2	3.81	4.86	5.01	4.55	0.27	0.40	0.43	0.36	10.11	14.79	15.86	13.59
L_3	4.52	5.25	5.51	5.09	0.35	0.47 B	0.51	0.44	12.98	17.59	19.23	16.60
Mean	3.65	4.36	4.62		0.23	0.34	0.38		8.70	12.84	14.02	
L.S.D at 5 %	A=0.052 B= 0.106 A×B= 0.212				A=0.012 B= 0.009 A×B= 0.017				A=0.54 B= 0.32 A×B= 0.65			
	Second season											
L_0	3.51	3.67	3.93	3.70	0.21	0.28	0.30	0.26	7.73	10.27	11.26	9.76
L_1	3.41	4.09	4.46	3.98	0.21	0.33	0.37	0.30	7.75	12.29	13.93	11.32
L_2	3.94	4.98	5.11	4.68	0.31	0.45	0.48	0.41	11.56	16.67	18.08	15.44
L_3	4.65	5.64	5.83	5.37	0.39	0.56	0.59	0.52	14.70	21.15	22.16	19.34
Mean	3.88	4.59	4.83		0.28	0.40	0.44		10.43	15.10	16.36	
L.S.D at 5 %	A=0.175 B= 0.109 A×B= 0.219				A=0.036 B= 0.009 A×B= 0.017				A=1.30 B= 0.55 A×B= 1.10			

Means within the same column for each trait significantly differ from each other according to the LSD at $p< 0.05$.
L_0 (sprayed with tap water); L_1 (added 10 g of licorice/l); L_2 (added 20 g of licorice/l); L_3 (added 40 g of licorice/l); M_0 (sprayed with tap water); M_1 (added 50 ml Moringa ethanol extract/l); M_2 (added 100 ml Moringa ethanol extract /l).

Results in Table (6) illustrated that the oil percentage was significantly affected by different concentrations of licorice root aqueous extract, Moringa ethanol extract and their interactions in both seasons of the study. Anyway, the highest significant oil percentage (5.51 and 5.83%) in the 1st and 2nd seasons, respectively, was recorded from the interaction between licorice aqueous extract at 40 g/l and 100 ml/l Moringa ethanol extract. In this regard, $L_3 \times M_1$ came in the second place, without significant differences with above-mentioned treatment in the second season. Meanwhile, the lowest significant oil percentage as 3.06 and 3.51% was recorded from the ($L_0 \times M_0$) treated ajwain plants with tap water in both seasons respectively.

Oil yield/plant (ml):

Concerning the response of oil yield/plant to the various investigated licorice aqueous extract treatments, Table (6) showed that differences in most cases were relatively so pronounced to be taken into consideration from the statistical standpoint. Hence, the great amounts of oil yield/plant were produced when due to subjected ajwain plants to L_3 treatment (40 g/l foliar spray of licorice aqueous extract) had significantly the highest values of oil yield/plant as recorded 0.44 and 0.52 ml/plant during 1st and 2nd experimental seasons, respectively. On contrast, treated ajwain plants by tap water (L_0) led to the lowest amounts of oil yield/plant (0.20 and 0.26 ml/plant) during the 1st and 2nd experimental seasons, respectively.

As to the effect of Moringa ethanol extract on oil yield/plant of ajwain plant, where application of Moringa ethanol extract at 100 ml/l concentration recorded the highest values of oil yield/plant during both seasons reached (0.38 and 0.44 ml/plant) respectively. Meantime, the lowest values of oil yield/plant during both seasons scored with treated ajwain plants by tap water reached to (0.23 and 0.28 ml/plant) respectively.

In this regard, the highest amount of oil yield/plant as a result of combining between licorice aqueous extract at 40 g/l concentration and 100 ml/l of Moringa ethanol extract during both 2018 and 2019 and 2019 and 2020 experimental seasons reached to 0.51 and 0.59 ml/plant respectively, followed discerningly with significant differences by spraying ajwain plants with 40 g/l of licorice aqueous extract and Moringa ethanol extract at 50 ml/l ($L_3 \times M_1$) in both seasons. However, the least amount of oil yield/plant were attained with treated ajwain plants with tap water reached to 0.15 and 0.21 ml/plant during both experimental seasons, respectively. The rest treatments occupied an intermediate place between the aforesaid treatments. As shown in Table (6).

Oil yield/fed (litter):

Results of Table (6) clearly demonstrated that all licorice aqueous extract treatments increased the oil yield/fed during both experimental seasons. Anyway, used licorice aqueous extract at 40 g/l concentration recorded the highest oil yield/fed which produced the highest values as (16.60 l/fed in the first season and 19.34 l/fed in the second season). On the opposite, the lowest oil yield/fed obtained with treated ajwain plants by tap water with produced the lowest values (7.57 l/fed in the first season and 9.76 l/fed in the second one).

Referring to the influence of Moringa ethanol extract on oil yield/fed of ajwain plant, tabulated data in Table (6) revealed that noticeable differences could be indicated between three levels of Moringa ethanol extract during both experimental seasons. Hence, the largest oil yield/fed was obtained with 100 ml/l Moringa ethanol extract which produced the highest values reached to (14.02 and 16.36 l/fed) in the two seasons, respectively. On the other hand, sprayed ajwain plants by tap water resulted in the lowest values reached to 8.70 and 10.43 l/fed in the two seasons, respectively.

Concerning the effect of the interaction between licorice aqueous extract and Moringa ethanol extract on oil yield/fed, combined between licorice aqueous extract at 40 g/l concentration with Moringa ethanol extract at 100 ml/l ($L_3 \times M_2$) led to the largest values of oil yield/fed which amounted to 19.23 and 22.16 l/fed during the first and second one seasons, respectively. Followed by $L_3 \times M_1$ without significant difference between them in the second season. While the lowest values of oil yield/fed achieved with treated ajwain plants by tap water in both seasons amounted to 5.51 and 7.73 l/fed, respectively.

In this regard, it can be suggested that the stimulating effect of extracts of licorice aqueous and Moringa ethanol on the increase in the yield of essential oil may be due to their enhancing effect on the characteristics of vegetative growth and the composition of plant chemicals. It was generally suggested that the use of concentrations of extracts (licorice and Moringa) and, in particular, dual treatment (foliar spray for ajwain plants with licorice aqueous extract at 40 g/l plus a concentration of 100 ml/l of Moringa ethanol extract significantly increased volatile oil output such as (oil percentage, oil yield/plant and oil yield/fed). The increase in these characteristics may be due to the increase in the absorption of nutrients, in particular N, P, K, Ca, Mg, Cu, Zn, Fe, and Mn, which existed in licorice, and Moringa extracts which were sprayed on plants during the vegetative growth, which reflected an increase in the dimensions of the glandular duct (vittae) which there is an essential oil in the fruits of the ajwain plants, or the increase in the biological processes in the plant, such as photosynthesis, which led to an increase in carbohydrate content, which appeared evident in the results obtained in this experiment. Also, as a result of the increase in total carbohydrates content caused an increase in volatile oil content. These results are supported by Sakr (2001), which claimed that the mean number of oil glands per millimeter square of the *Mentha piperita* leaf blade was increased by the use of inorganic and organic fertilizers. Al-Swaefy (2002) also recorded an increase in the width of the glandular ducts (vittae) due to the application of different concentrations of macro and microelements. Shibata (2000) and Moses *et al*. (2002) stated that the extract of licorice contains certain compounds that have similar effects. For growth promoters such as minerals, phenolic compounds, flavonoids, amino acids, vitamins and also contains mevalonic acids used in gibberellins synthesis. As well as Moringa extract, it is a rich source of amino acids, K, Ca, Fe, vitamin E, ascorbates, phenolic compounds, and growth-regulating hormones such as zeatin. In addition, trace elements, vitamins, and micronutrients Ali *et al*. (2018). This pattern is also confirmed by the content of the elements in the two extracts (analysis of licorice and Moringa extracts used in this study), which have already been stated in the materials and methods used.

A number of studies have documented that the foliar application of licorice and/or Moringa extract has had an enhancement impact on oil production. On *Coriandrum sativum* (Abd-ElKafie *et al*., 2016) on dill (Hamad *et al*., 2017) and on caraway (Massoud *et al*., 2019), as well as on fennel (El-Serafy and El-Sheshtawy, 2020).

Essential oil GC/Mass analysis:

The analysis of the essential oils in Ajwain plant Table (7) and Figures (1-12) demonstrated that the presence of 14 compounds with the presence of γ-Terpineneas the main component in the most treatments ranged from 33.39 to 52.74 in the second season. The highest percent was produced from sprayed ajwain plants by $L_0 \times M_3$, while the least percent was recorded with $L_4 \times M_1$. Followed by thymol ranged from 12.28 to 43.98, the higher percentage was obtained as a result of sprayed ajwain plants by $L_4 \times M_1$, and came in the second place treated ajwain plants by ($L_4 \times M_1$) treatment, which reached to 41.59 percent, meanwhile the lowest percent of thymol was obtained from ($L_2{\times}M_2$) treatment. *p*-Cymene compound came in third place, which ranged from 14.72 to 26.38. à-Pinene came in the fourth-place, it amounted from 3.10 to 7.98 in the second season.

Generally, the data in the same Table showed that there was a positive effect between treating ajwain plants be sprayed licorice extract and the increase in thymol percentage in the ajwain essential oil. By contrast, treated ajwain plants with sprayed by Moringa extract had a negative effect on the increase in Thymol percentage in the ajwain essential oil in the second season.

In this context, Abd El-Wahab (2008) on ajwain, demonstrated that, the highest component percentage was thymol followed decently by ñ-cymene, ã-terpinene and M-pinene. Jeet *et al*. (2012) illustrated that, the volatile oil of ajwain thymol, γ-terpinene, para-cymene and α and β-pinene). Also, Omer *et al*. (2014) mentioned that, the major components of essential oil constituents of *Trachyspermum ammi*, are γ-terpinene, thymol and p-cymene.

CONCLUSION

It was found that foliar application of licorice aqueous extract and Moringa ethanol extract enhanced the all photosynthetic pigments characters (chlorophyll a, b, total chlorophyll, and carotenoids) and total carbohydrate as well as, oil traits (oil percentage, oil yield/plant, and oil yield/fed) and essential oil constituents of ajwain plants. Anyway, spraying ajwain plants by licorice aqueous extract a concentration at 40 g/l and Moringa ethanol extract at 100 ml/l gave the highest values of all characters mentioned afore.

REFERENCES

Abd El-Wahab, M.A. (2008). Effect of some trace elements on growth, yield and chemical constituents of *Trachyspermum ammi* L. (ajwain) plants under Sinai conditions. Research Journal of Agriculture and Biological Sciences, 4(6):717-724.

Table 7. Effect of interaction between licorice aqueous extract and Moringa ethanol extract treatments on essential oil components of *Trachyspermum ammi* (ajwain) plant under sandy soil conditions in second season 2019/2020.

Compounds	R. T	Concentration of compounds (%)											
		Sprayed with tap water (L_0)			Licorice aqueous extract at 10 g/l concentration (L_1)			Licorice aqueous extract at 20 g/l concentration (L_2)			Licorice aqueous extract at 40 g/l concentration (L_3)		
		M_0	M_1	M_2	M_0	M_1	M_2	M_0	M_1	M_2	M_0	M_1	M_2
à-Thujene	4.05	0.38	0.30	0.48	0.35	0.44	0.49	0.27	0.46	0.47	0.23	0.37	0.40
Phellandrene	4.11	0.03	-	0.02	0.01	0.13	0.01	0.06	0.01	0.01	-	0.01	-
à-Pinene	4.21	3.46	3.47	6.22	3.66	6.27	7.98	3.99	3.45	5.82	3.66	3.65	3.10
Sabinene	5.08	0.25	0.45	0.47	0.34	0.31	0.47	0.23	0.42	0.46	0.19	0.33	0.34
ß-Pinene	5.21	0.06	0.07	0.07	0.06	0.08	0.08	0.04	0.07	0.08	0.04	0.06	0.06
á-Myrcene	5.48	0.21	0.18	0.27	0.26	0.13	0.30	0.11	0.22	0.24	0.10	0.17	0.14
à- Terpinene	6.19	0.32	0.18	0.45	0.33	0.27	0.19	0.26	0.34	0.24	0.19	0.35	0.35
p-Cymene	6.58	22.68	18.98	19.68	20.13	14.72	26.38	16.68	22.97	25.22	18.13	20.76	19.69
γ-Terpinene	7.34	44.04	42.43	52.74	37.50	65.08	51.26	36.61	46.25	51.54	33.39	41.82	41.81
α -Terpineol	8.73	0.21	0.04	0.11	0.22	0.21	0.06	0.17	0.09	0.08	0.26	0.14	0.20
Limonene	10.86	0.11	0.08	0.07	0.13	0.06	0.14	0.11	0.09	0.09	0.11	0.10	0.07
Estragol	12.44	-	7.05	-	-	-	-	-	-	-	-	-	
Terpinene-4-ol	14.75	0.04	0.08	0.03	0.08	-	0.03	0.06	0.04	0.03	0.08	0.05	0.04
Thymol	14.97	28.11	26.63	19.37	36.78	12.28	12.46	41.59	25.52	15.68	43.98	32.15	33.68
Total identified		99.90	99.94	99.98	99.85	99.98	99.85	99.97	99.93	99.96	99.96	99.96	99.92
Unknown		0.10	0.06	0.02	0.15	0.02	0.015	0.03	0.07	0.04	0.04	0.04	0.08
Total		100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

M_0 (sprayed with tap water); M_1 (added 50 ml Moringa ethanol extract/l); M_2 (added 100 ml Moringa ethanol extract/l).

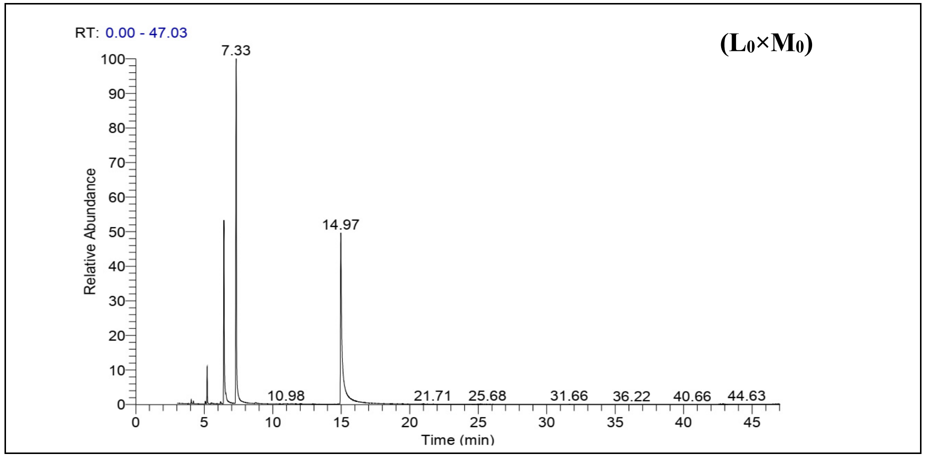

Fig. 1. Effect of spraying by tap water on the essential oil constituents using GC/Mass analysis.

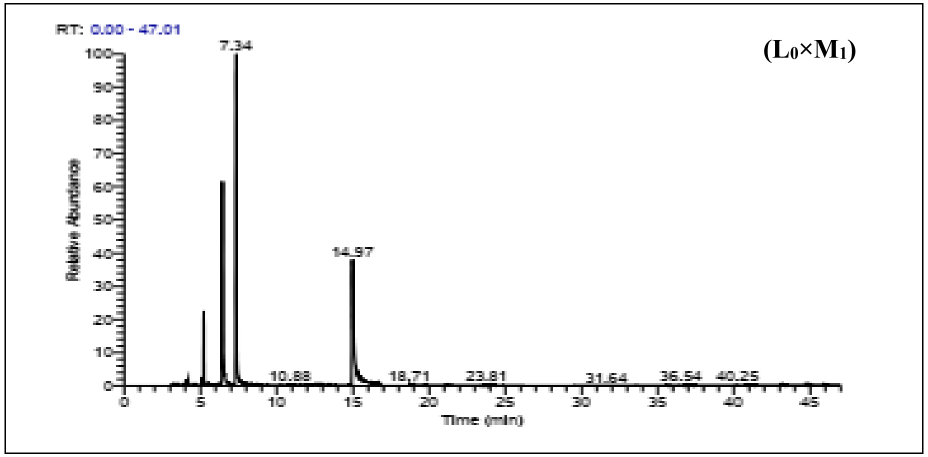

Fig. 2. Effect of spraying by Moringa ethanol extract at 50 ml/l on the essential oil constituents using GC/Mass analysis.

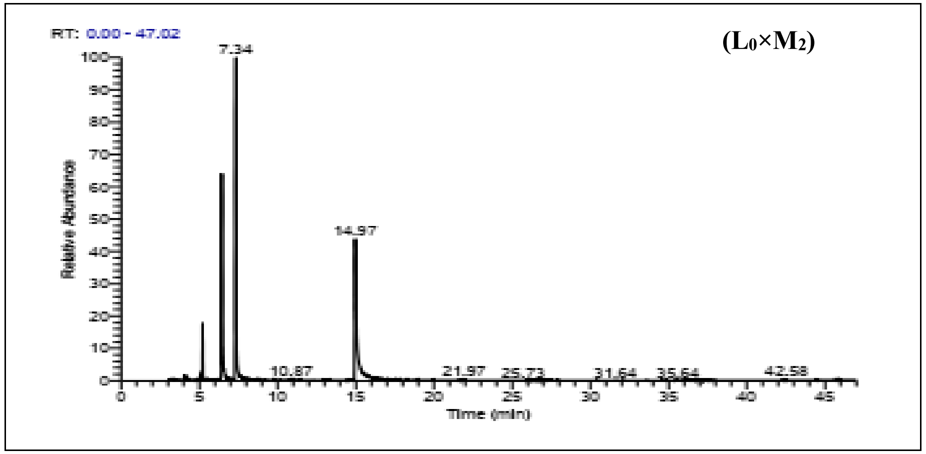

Fig. 3. Effect of spraying by Moringa ethanol extract at 100 ml/l on the essential oil constituents using GC/Mass analysis.

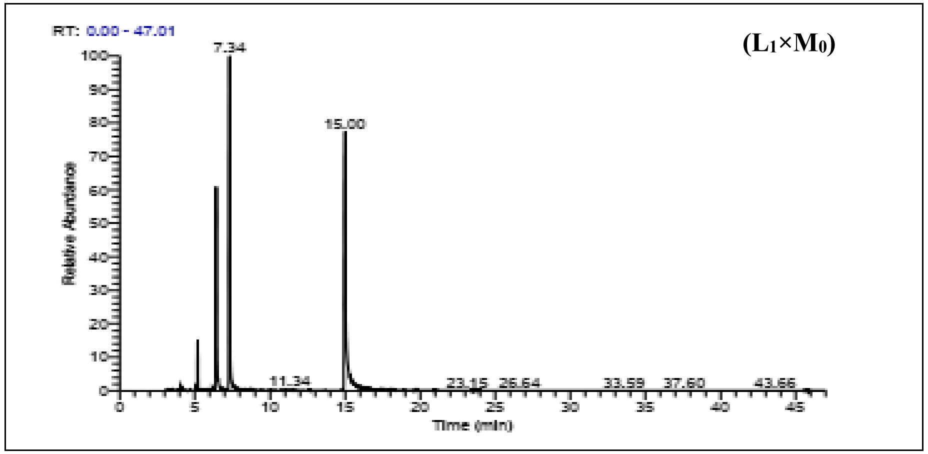

Fig. 4. Effect of spraying by licorice aqueous extract at 10 g/l on the essential oil constituents using GC/Mass analysis.

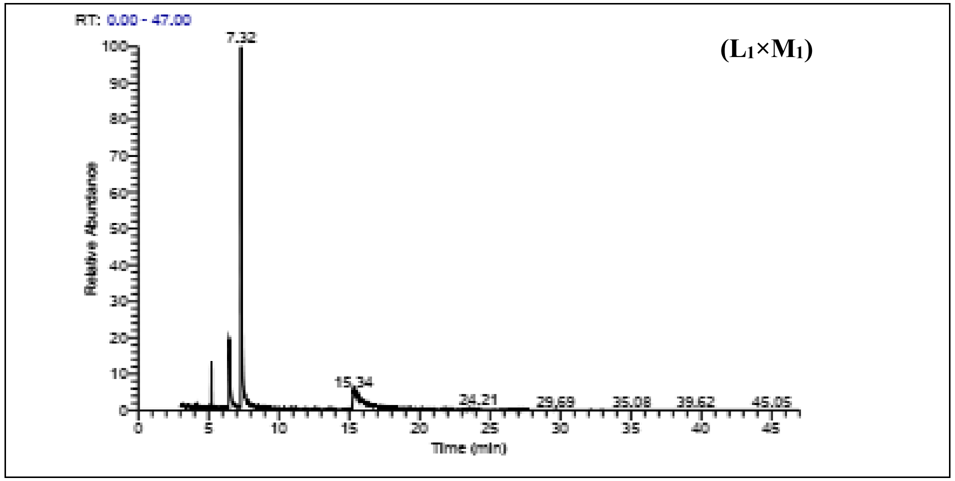

Fig. 5. Effect of interaction between spraying by licorice aqueous extract at 10 g/l with Moringa ethanol extract at 50 ml/l on the essential oil constituents using GC/Mass analysis.

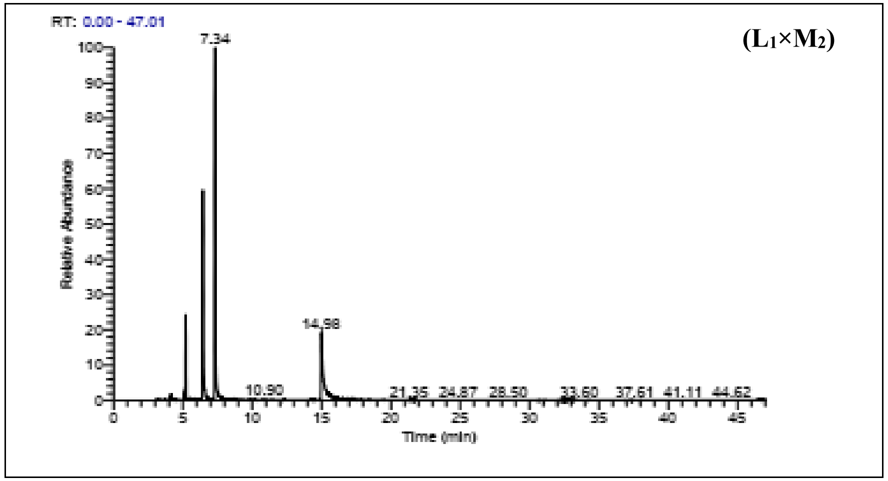

Fig. 6. Effect of interaction between spraying by licorice aqueous extract at 10 g/l with Moringa ethanol extract at 100 ml/l on the essential oil constituents using GC/Mass analysis.

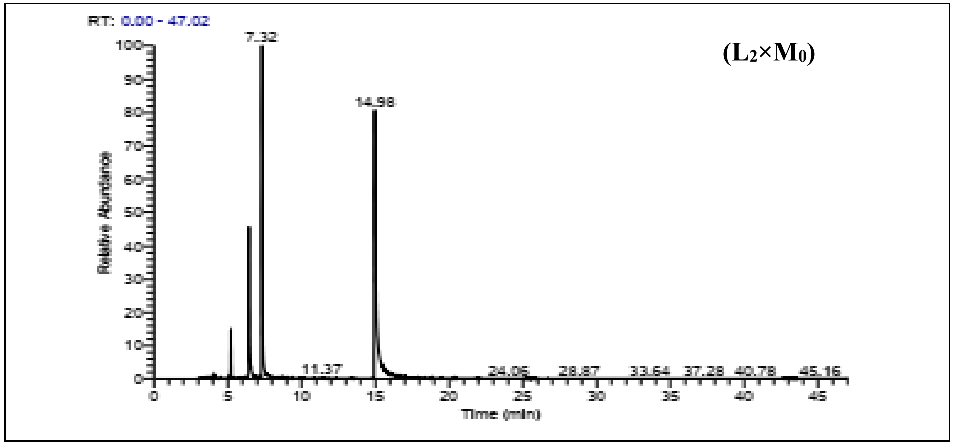

Fig. 7. Effect of spraying by licorice aqueous extract at 20 g/l on the essential oil constituents using GC/Mass analysis.

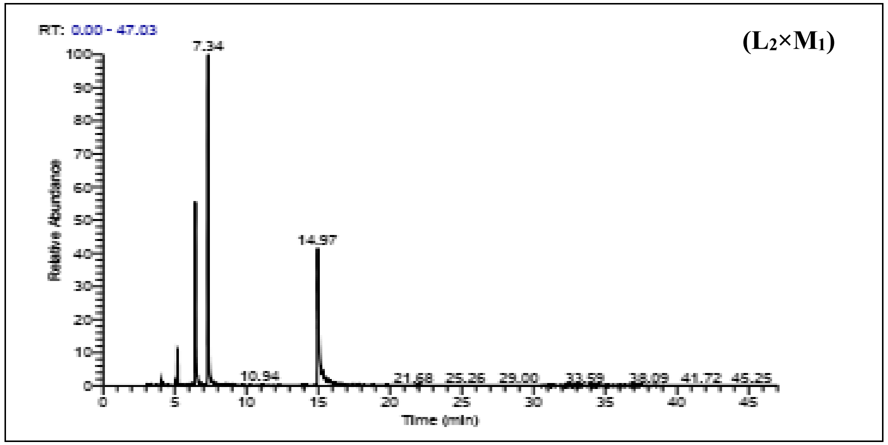

Fig. 8. Effect of interaction between spraying by licorice aqueous extract at 20 g/l with Moringa ethanol extract at 50 ml/l on the essential oil constituents using GC/Mass analysis.

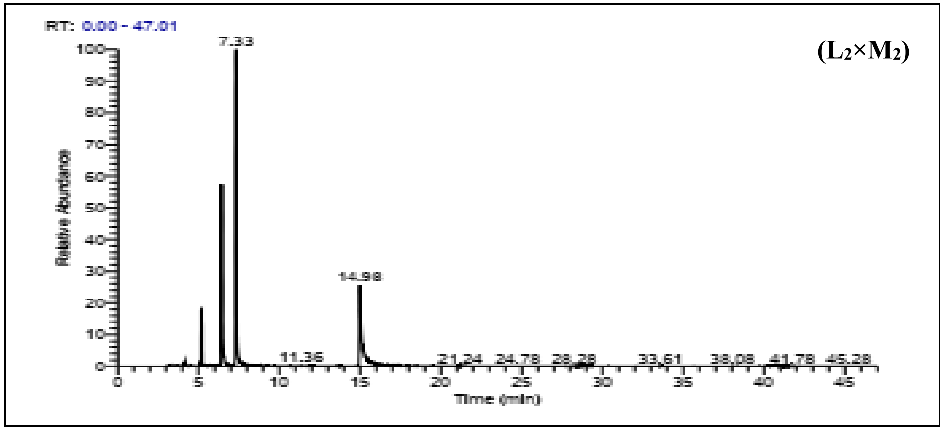

Fig. 9. Effect of interaction between spraying by licorice aqueous extract at 20 g/l with moringa ethanol extract at 100 ml/l on the essential oil constituents using GC/Mass analysis.

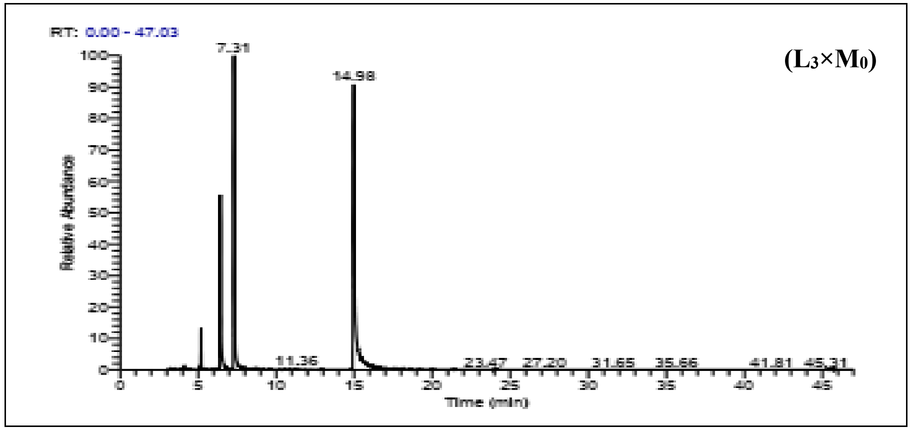

Fig. 10. Effect of spraying by licorice aqueous extract at 40 g/l on the essential oil constituents using GC/Mass analysis.

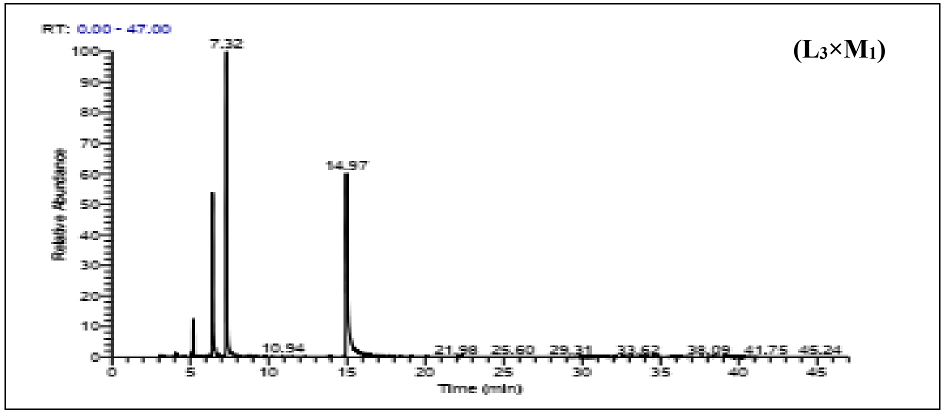

Fig. 11. Effect of interaction between spraying by licorice aqueous extract at 40 g/l with Moringa ethanol extract at 50 ml/l on the essential oil constituents using GC/Mass analysis.

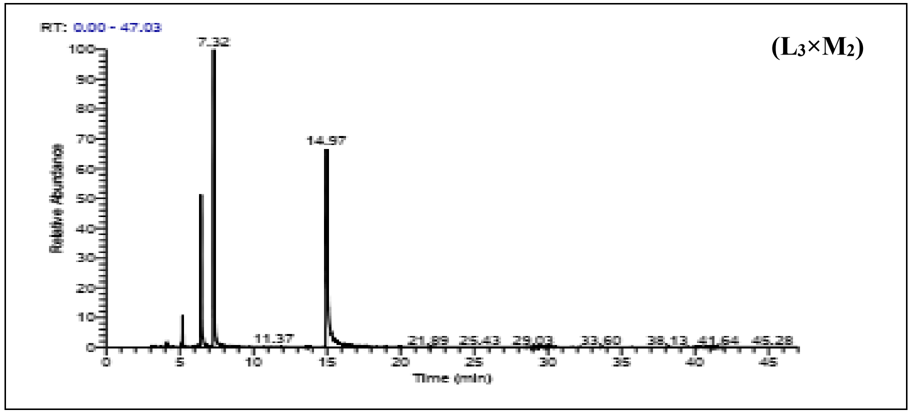

Fig. 12. Effect of interaction between spraying by licorice aqueous extract at 40 g/l with Moringa ethanol extract at 100 ml/l on the essential oil constituents using GC/Mass analysis.

Abd El-Azim, W.M.; Khater, R.M.R. and Badawy, M.Y.M. (2017). Effect of bio-fertilization and different licorice extracts on growth and productivity of *Foeniculum vulgare*, Mill. plant. Middle East Journal of Agriculture Research, 6(1):1-12.

Abd El-Hack, M.E.; Alagawany, M.; Elrys, A.S.; Desoky, E.M.; Tolba, H.M.N.; Ahmed S.M.; Elnahal, S.M.; Elnesr, S.S. and Swelum, A.A. (2018). Effect of forage *Moringa oleifera* L. (moringa) on animal health and nutrition and its beneficial applications in soil, plants and water purification. Agriculture, 8(145):1-22.

Abd-ElKafie, O.M.; Sidky, M.M.; Kasem, M.M. and Abd-ElBaki, S.M. (2016). Improving the vegetative growth and chemical contents of coriander (*Coriandrum sativum* L.) plant by using moringa leaf extract. J. Plant Production, Mansoura Univ., 7(12):1357-1363.

Abdel-Rahman, S.S.A. and Abdel-Kader, A.A.S. (2020). Response of fennel (*Foeniculum vulgare*, Mill.) plants to foliar application of moringa leaf extract and benzyladenine (BA). South African Journal of Botany, 129:113-122.

Abou-Sreea, A.I.B. and Matter, F.M. (2016). Using moringa leaf extract as biostimulant and giberrellic acid for enhancing fennel (*Foeniculum vulgare* var. azoricum mill.) growth and oil yield. Acta Scientiae et Intellectus, 2(1):7-20.

Al-Ajeeli, T.A.Z. (2005). Effect GA_3 and Some Nutrients to Produce Glycyrrhizgin and Some Other Components in The Plant Licorice (*Glycyrrhiza glabra* L.). Ph.D. Thesis, Fac. Agriculture, Baghdad Univ., Iraq.

Ali, E.F.; Hassan, F.A.S. and Elgimabi, M. (2018). Improving the growth, yield and volatile oil content of *Pelargonium graveolens* L. Herit. by foliar application with moringa leaf extract through motivating physiological and biochemical parameters. South African Journal of Botany, 119:383-389.

Al-Marsoumi, H.G.K. (1999). Effect of Some Factors in Recipes Vegetative Growth and Flowering and Holds Seed in Three Varieties of Onion (*Allium cepa* L.). Ph.D. Thesis, Fac. Agric., Baghdad Univ, Iraq.

Al-Sahaf, F.H. and Al-Marsoumi, H.G.K. (2001). Effect of seed soaking and plant spray with GA3, Liquorices root extract and Nutrients on growth and flowering traits in Onion, IPA. Agric. Res. Centre., 2001, 11(2):18-20.

Al-Sahaf, F.H. and Al-Marsoumi, H.G.K. (2003). Effect of spray GA3 and licorice extract and nutrients in the production of seeds of onion (*Allium cepa* L.), The Iraqi Journal of Agricultural Sciences, 34(2): 37-46.

Al-Swaefy, H.M.F. (2002). Physiological Studies on *Trachysprumum ammi*, L. (*Carum capticum*, Benth.) Plant. Ph.D. Thesis, Fac. Agric., Cairo Univ., Egypt, 168 p.

Anjorin, T.S.; Ikokoh, P. and Okolo, S. (2010). Mineral composition of *Moringa oleifera* leaves, pods and seeds from two regions in Abuja, Nigeria. Int. J. Agric Biol., 12:431-434.

Azra, Y.; Basra, S.M.A.; Ahmad, R. and Wahid, A. (2012). Performance of late sown wheat in response to foliar application of *Moringa oleifera* Lam. leaf extract. Chilean Journal of Agricultural Research, 72(1):92-97.

Black, C.A.; Evans, D.O.; Ensminger, L.E.; White, J.L.; Clark, F.E. and Dinauer, R.C. (1982). Methods of Soil Analysis, Part 2, Chemical and Microbiological Properties, 2nd Ed. Soil Sci., Soc. of Am. Inc. Publ., Madison, Wisconsin, U. S.A., 1159 p.

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

El-Gamal, S.M.A. and Ahmed, H.M.I. (2016). Response of dill (*Anethum graveloens* Linn.) to seaweed and moringa leaf extracts foliar application under different sowing dates. Alex. J. Agriculture. Sci., 61(5):469-485.

El-Serafy, R.S. and El-Sheshtawy, A.A. (2020). Effect of nitrogen fixing bacteria and moringa leaf extract on fruit yield, estragole content and total phenols of organic fennel. Scientia Horticulturae 265:1-10.

Fenwick, G.R.; Lutomski, J. and Nieman, C. (1990). Liquorice, *Glycyrrhiza glabra* Linn L.Composition, uses and analysis. Journal of Food Chemistry. 38(2):119-143.

Gaddamwar, A.G.; Rajput, P.R. and Parsodkar, V.J. (2020). Extraction of basil, padina, ajwain and development of oxygen garden in the school yard as a preventive measure for covid-19. International Journal for Research in Applied Science & Engineering Technology, 8(4):1408-1411.

Gersbach, P.V. and Reddy, N. (2002). Non-invasive localization of thymol accumulation in *Carum copticum* (Apiaceae) fruits by chemical shift selective magnetic resonance imaging. Ann Bot., 90(2):253-257.

Hamad, E.H.A.; El-Basuony, M.S.S. and Abdelkader, M.A.I. (2017). Enhancing dill (*Anethum Graveolens* L.) growth and yield by NPK fertilization and some plant extracts. International J. of Agriculture and Economic Development, 5(2):57-78.

Herbert, D.; Phipps, P. and Strange, R. (1971). Determination of total carbohydrates, Methods in Microbiology, 5(8):290-344.

Ibanogiu, E. and Ibanogiu, S. (2000). Foaming behaviour of liquorice *Glycyrrhiza glabra* extract. Food Chem., 70(3): 333-336.

Inskeep, W.P. and Bloom, P.R. (1985). Extinction coefficients of chlorophyll a & b in NN-dimethylformade and 80% acetone. Plant Physiol., 77:483-485.

Jackson, M.L. (1973). Soil Chemical Analysis. Prentice-Hall of Indian Private, New Delhi, India, 478 p.

Jeet, K.; Devi, N.; Narender, T.; Sunit, T.; Lalit, S. and Raneev, T. (2012). *Trachyspermum ammi* (Ajwain), A comprehensive Review. International Research Journal of Pharmacy, 3(5):133-138.

Kamal, J.; Nisha, D.; Thakur, N.; Tomar, S.; Shalta, L. and Thakur R. (2012). *Trachyspermum ammi* (Ajwain): A comprehensive review. International Research Journal of Pharmacy, 3 (5):133-138.

Kaur, G.J. and Arora, D.S. (2008). In vitro antibacterial activity of three plants belonging to the family Umbelliferae. International Journal Antimicrob Agents. 31(4):393–95.

Lawless, J. (1992). The Encyclopedia of Essential Oils Element Book, Ltd. Long Mead, Shoftesbury, Dorest, Great Britain, 31 p.

Makkar, H.P.S. and Becker, K. (1996). Nutritional value and antinutritional components of whole and ethanol extracted *Moringa oleifera* leaves. Animal Feed Sci. and Technol., 63:211-288.

Massoud, G.F.; Dapor, A.S. and El-Shoura, A.M. (2019). Allelopathic effect of ecofriendly botanical extracts and application of vinasse as alternative source of mineral potassium fertilizers on yield and oil quality of Caraway plant. Middle East Journal of Agriculture Research, 8(4):1290-1305.

Mohammad, M.Z.; Mahmoodreza, M. Soliman, M.S. and Peyman P. (2014). An overview on ajwain (*Trachyspermum ammi*) pharmacological effects; modern and traditional. Journal of Natural Remedies. 14 (1):48-105.

Moses, T.N.; Abdul-Jabbar, W.A. and Elwy, A.N. (2002). A study of some local licorice root powder components (*Glycyrrihiza glabra* L.). Iraqi J. of Agric. Sci., 33(4): 30-38.

Omer, E.A.; Said-Al-Ahl, H.A.H. and El Gendy, A.G. (2014). Yield and essential oil of ajwain (*Trachyspermum ammi*) plant cultivated in saline soil of north Sinai in Egypt. J. Essent. Oil-Bear. Plants 17(3):469-477.

Phiri, C. and Mbewe, D.N. (2010). Influence of *Moringa oleifera* leaf extracts on germination and seedling survival of three common legumes. Int. J. Agric. Biol., 12:315-317.

Phiri, C. (2010). Influence of *Moringa oleifera* leaf extracts on germination and early seedling development of major cereals. Agric. Biol. J.N Amer., 1(5):774-777.

Rady, M.M.; Bhavya, V.C. and Howladar, S.M. (2013). Common bean (*Phaseolus vulgaris* L.) seedlings overcome NaCl stress as a result of presoaking in *Moringa oleifera* leaf extract. Sci. Hortic., 162:63-70.

Saker, Weam R.A. (2001). Effect of Some Organic and Inorganic Fertilizers on *Mentha piperita*. M.Sc. Thesis, Fac. Agric., Cairo Univ., Egypt. 147 p.

Sathyanarayana, E.; Hadole, S.S. and Ghawade, S.M. (2017). Effect of nutrient levels on nutrient uptake by ajwain crop (*Trachyspermum ammi* L. Sprague). International Journal of Chemical Studies, 5(4):1987-1990.

Shibata, S. (2000). A drug over the millennia pharmacognosy, chemistry and pharmacology of licorice. J. of the Pharmaceutical Society of Japan, 120: 849-862.

Shojaaddini, M.; Moharramipour, S. and Sahaf, B. (2008). Fumigant toxicity of essential oil from *Carum copticum* against Indian meal moth, Plodia interpunctella. J. Plant. Prot. Res., 48(4):411–419.

Singh, I. and Singh, V.P. (2000). Antifungal properties of aqueous and organic extracts of seed plants against *Aspergillus flavus* and A. *niger*. Phytomorphology, 50(2):151-7.

Snedecor, G.W. and Cochran, W.G. (1989). Statistical Methods, 8th ed. Iowa State University Press, Ames, 503 p.

Yadav, R.; Chandan, K.P.; Deepika, G. and Rahul, K. (2011). Health benefits of Indian aromatic plant ajwain (*Trachycpermum ammi*). Int. J. Pharm. Technol, 3:1356-1366.

Zadeh, J.B.; Kor, Z.M. and Goftar, M.K. (2013). Licorice (*Glycyrrhiza glabra* Linn) as a valuable medicinal plant. International Journal of Advanced Biological and Biomedical Research, 1(10): 1281-1288.

تأثير مستخلصات العرقسوس والمورنجا على إنتاج الزيوت العطرية والمكونات الكيميائية لنبات النخوة الهندى تحت ظروف التربة الرملية

إيمان مختار ابوالغيط*، يسرى فهمي يوسف محمد*، مصطفى يحي محمد**، سامح حسن الجيوشي النجار**
* قسم البساتين، كلية الزراعة، جامعة بنها، مصر
** قسم النباتات الطبية والعطرية، مركز بحوث الصحراء، المطرية، القاهرة، مصر

تم إجراء تجربتان حقليتان بالمزرعة التجريبية لجامعة هليوبيلس، محافظة الشرقية، مصر بالتعاون مع قسم البساتين، كلية الزراعة، جامعة بنها لدراسة تأثير الرش بمستخلصات العرقسوس والمورنجا على إنتاج الزيوت العطرية والمكونات الكيميائية لنبات النخوة الهندي تحت ظروف التربة الرملية في الموسمين التجريبين ٢٠١٩/٢٠١٨ و٢٠٢٠/٢٠١٩. وكان تصميم التجربة بنظام القطع المنشقة حيث تم وضع مستخلص العرقسوس المائي في القطع الرئيسية بأربع تركيزات (٠,٠

و١٠ و٢٠ و٤٠ جم/لتر) وتم وضع تركيزات مستخلص المورنجا في القطع المنشقة (٠,٠ و٥٠ و١٠٠ مللي/لتر). أظهرت النتائج أن معاملة نباتات النخوة الهندي بالرش بمستخلص العرقسوس المائي بتركيز ٤٠ جم/لتر ومستخلص المورنجا بتركيز ١٠٠ مللي/لتر ($L_3 \times M_2$) أدى إلى الحصول على أعلى قيم لنسبة الزيت العطري ومحصول الزيت/نبات ومحصول الزيت/فدان. سجلت نفس المعاملة ($L_3 \times M_2$) أعلى قيم لمحتوى أصباغ التمثيل الضوئي (الكلوروفيل أ ، ب ، الكلوروفيل الكلي ، والكاروتينويد)، كما سجلت معاملة نباتات النخوة بنفس المعاملة أعلى نسبة كربوهيدرات مقارنة بباقي المعاملات تحت الدراسة خلال الموسمين. ومع ذلك، فإن نباتات النخوة التي تم رشها بماء الصنبور ($L_0 \times M_0$) أعطت أدنى قيم لجميع الصفات المذكورة أعلاه. بشكل عام، كانت المركبات الفعالة الرئيسية للزيت العطري لنبات النخوة الهندي هي γ-terpinene يليها thymol وp-cymene بالإضافة إلى α-pinene، α-thujene، myrcene و Limonene.