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RESPONSE OF AJWAIN (*TRACHYSPERMUM AMMI*) PLANT TO LICORICE AND MORINGA EXTRACTS FOLIAR APPLICATION UNDER SANDY SOIL CONDITIONS

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

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

ABSTRACT: This research was conducted on ajwain (*Trachyspermum ammi*) at the Experimental Farm of Heliopolis Univ., El-Sharqea Governorate, Egypt, in cooperation with the Department of Horticulture, Faculty of Agriculture, Benha University during the two successive winter seasons of 2018/2019 and 2019/2020 in order to study the impact of spraying licorice aqueous extract at four levels of 0, 10, 20 and 40 g/l and three levels with Moringa ethanol extract as 0, 50, 100 ml/l and their overlap on the vegetative growth and fruit yield of ajwain by using the split-plot design with three observations. The results showed a significant effect for the all used concentrations of licorice and Moringa extracts in all studied traits, application of spraying ajwain plants by licorice aqueous extract at 40 g/l with 100 ml/l Moringa ethanol extract ($L_3 \times M_2$) increased vegetative growth (plant height, number of branches, and herb fresh and dry weights per plant). Also, the same treatment recorded the highest average of fruit yield characters (number of umbels/plant, weight of 1000 fruits, yield/plant and per fed), as well as, the highest values of N, P, and K were gained as a resulting using the same treatment ($L_3 \times M_2$). On contrast, the lowest values of all studied traits obtained with sprayed ajwain plants by tap water ($L_0 \times M_0$) compared to the other treatments in both seasons.

Key words: ajwain, *Trachyspermum ammi*, licorice aqueous extract, Moringa ethanol extract, vegetative growth, yield characters.

INTRODUCTION

Trachyspermum ammi (L.) ajwain is an annual herb plant, branched tall up to 90 cm, leaves rather distant, 2-3 innately divided, and segments linear; a small white flower, seeds are egg-shaped, aromatic, 2-3 mm. long, and grayish brown and belongs to family Apiaceae (Ashraf, 2002; Dwivedi *et al*., 2012; and Jeet *et al*., 2012). Ajwain probably originated in Egypt and the Middle East area. It is very widely cultivated in black soil particularly along the riverbank in Egypt and many other countries like India, Iraq, Iran, Afghanistan, and Pakistan (Gersbach and Reddy, 2002; Munns, 2002; and Rashmi *et al*., 2011). The main constituents include an essential oil of ajwain called thymol which constitutes 35-60% of the essential oil (2 to 5% in the dried fruits). There are also α-pinene, p-cymene, γ-terpinene, and limonene found in the seed (Mohagheghzadeh *et al*., 2007; Nath *et al*., 2008).

This beneficial herb is used in the culinary process as a spice as well as a major ingredient of different kinds of medicines. Ajwain seeds act as a good appetizer, laxative, and stomachic. It is used as an effective remedy in managing ailments like vomiting, mouth diseases, pile, abdominal

tumor, and abdominal pain. Additionally, in Indian, thymol used as medicine, particularly for cholera (Lawless, 1992). Also, Ajwain liquid is used as a preventive measure for the covid-19 i.e. corona virus (Gaddamwar *et al*., 2020)

Recent studies have shown that plant extracts could be used as an alternative that is safer than growth regulators and chemical fertilizers that are chemically synthesized. The most important of these extracts are licorice aqueous extract and Moringa ethanol extract.

Glycyrrhiza glabra (licorice) is a plant that grows in Egypt and some other countries around the world. Some of the compounds found in the licorice root extract are similar to those that promote growth, such as minerals, phenolic compounds, flavonoids, amino acids, vitamins, and also contain mevalonic acid, used in the synthesis of gibberellins. (Shibata, 2000 and Moses *et al*., 2002). Moreover, it contained minerals as P, Mg, Mn, Fe, Cu, and Zn (Musa *et al*., 2002).

Moringa is one of the 13 species of the genus *Moringa* and family Moringnance. In Africa, Arabia, India, Southeast Asia, America, and Pakistan, it is a well-known vegetable (Sengupta and Gupta, 1970). Its roots, leaves, flowers, and fruits have been used as vegetables (Siddhuraju and Becker, 2003). Moringa leaves are potential sources of vitamin A and C, iron, calcium, riboflavin, beta-carotene, and phenolic acid (Nambiar *et al*., 2005). Its leaves and oil are a powerful natural antioxidant (Njoku and Adikwu, 1997). Siddhuraju and Becker (2003) observed antioxidant properties in the solvent extract of Moringa leaves, based on their results, Moringa leaves have been confirmed to be a potential source of natural antioxidants. The composition and mineral content of Moringa leaf obtained from different regions was compared by Jongrungruangchok *et al*. (2010) and reported that Moringa leaf is a rich source of protein, fat, fiber, and moisture. K, Ca, and Fe. In addition. Moringa leaf extract (MLE) is also enriched with zeatin, a purine adenine derivative of the cytokinin plant hormone group (Barciszweski *et al*., 2000).

The significant effects of the licorice and Moringa extracts, using foliar spraying applications on the growth and chemical composition of several plants are stated by several writers. On fennel (Abdallah *et al*., 2016) stated that inoculated plants with mycorrhiza fungi and sprayed with L_2 (40 g/l) or L_3 (60 g/l) aqueous extract of licorice recorded the highest significant values of all growth and yield parameters, without significant difference between them in most cases during both seasons. On contrast, plants inoculated with AM fungi combined with ethanol extract foliar spray of Moringa leaves (M_3) gave the highest herb contents of N, P, and K in both seasons, respectively, and on fennel (Abd El-Azim *et al*., 2017) they recommended using bio-fertilizers and spraying plants with licorice aqueous extract to produce the fennel plant under sandy soil conditions. The best growth and chemical composition were recorded with a combination of bio-fertilizers and licorice aqueous extract.

This trial aimed to improve the growth and productivity of the ajwain (*Trachyspermum ammi*) plant by using foliar spray with extracts of some medicinal plants as (*Glycyrrhiza glabra* and *Moringa oleifera*) under sandy soil conditions.

MATERIALS AND METHODS

Field experiment was carried out at the Experimental Farm, of Heliopolis Univ., El-Sharqea Governorate, Egypt, in cooperation with the Department of Horticulture, Faculty of Agriculture, Benha University, during two successive winter seasons of 2018/2019 and 2019/2020, to study the effect of foliar spraying with extractions of two medicinal plants (*Glycyrrhiza glabra* L. and *Moringa oleifera* M.) on vegetative growth, fruit yield, and some chemical constituents of ajwain (*Trachyspermum ammi*) plants under sandy soil condition.

Ajwain seeds were kindly supplied from the Experimental Farm of the Faculty of

Agriculture, Cairo University. Seeds were sown directly in soil on 20th and 14th October 2018 and 2019 respectively, during both seasons. Five seeds were sown per hill within the drippers of irrigation lines and irrigation was done immediately after sowing, drip irrigation lines with average (4 liter/hour), after complete germination, the seedlings were thinned to two plants/hill. The experiment unit area (plot) was 6.75 m^2 contains 30 plants per plot the distance between rows 75 cm apart and between plants in the same row was 30 cm apart.

Extracts Preparation:

Licorice and Moringa 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 powdered licorice roots in one liter of hot tap water aqua (90 °C) at a rate (0, 10, 20 and 40 g l^{-1}) 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 (without licorice extract).
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 100 ml/l) from this ethanol extract and added to 1-liter tap water, and then spraying of the plants.

M_0 = 0.0 (sprayed with tap water).

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

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

Licorice and Moringa extracts were analyzed in the Desert Research Center laboratories, as shown in Table (a).

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

Licorice aqueous extract (mg/100g DW)		Moring ethanol extract (mg/100g DW)	
Components	**Values**	**Components**	**Values**
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

Treatments applications:

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. Biofilm at 1 g/l as a wetting agent, was added to all tested solutions including the control.

Concentrations of extracts for foliar spray, aqueous licorice were: L_0 (0,0), L_1 (10 g/l), L_2 (20 g/l) and L_3 (40 g/l) licorice/tap water (aqua), while Moringa ethanol extraction concentrations were: M_0 (0,0), M_1 (50 ml/l) and M_2 (100 ml/l) Moringa ethanol extract/tap water. The plants were sprayed with the abovementioned treatments by a hand pump mister to the point of runoff. All plant received 10 m^3/fed compost was added before planting in each season. All plants received a chemical fertilization dose of 16 kg/fed of calcium superphosphate (15% P_2O_5), 10 m^3/fed of compost during soil preparation, 33 kg/fed of ammonium sulphate (20.5% N), and 16 kg/feed of potassium sulphate (48 percent K_2O) 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.

The chemical and physical characteristics of experimental farm soil are shown in Table (b). Soil samples representing the experimental area were 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 (c). Both soil and water samples were analyzed in the Desert Research Center laboratories. Drip irrigation system was used.

Experimental layout and statistical analysis:

The layout of the experiment was a split-plot design with two factors. The main plots were licorice aqueous extract and the sub-plots were Moringa ethanol extract, licorice aqueous extract was used by four concentrations 0, 10, 20 and 40 g/l, but, Moringa ethanol extract sprayed by three concentrations 0, 50 and 100 ml/l. The experiment included 12 treatments with three replicates, each replicate contained 10 plants i.e. 30 plants in each treatment. Analysis of variance was performed to determine significant differences. Means were compared using LSD test at 0.05 level according to Snedecor and Cochran (1967).

Harvesting:

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

Data recorded:

The vegetative and yield parameters for the experiment was recorded at harvesting time in the 2nd week of May 2019 and 2020 as follows:

1. Vegetative growth characteristics:

Vegetative growth characteristics were estimated at the beginning of flowering as follows:

- Plant height (cm); length of the main stem from the soil surface to the plant apex at full flowering stage using a measuring tape.
- The number of branches/plant.
- Fresh and dry weights of herb (g/plant); the fresh mass of aerial parts above the soil at full flowering stage. The fresh plants were then reserved under shade to obtain the air-dried weight.

2. Fruit yield measurements:

Fruit yield measurements were recorded at harvesting time as follows:

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

Chemical analyses	pH	E.C. (dS m^{-1})	O. M. (%)	Cations (mmolc l^{-1})				Anions (mmolc l^{-1})			N (mg/l)	P (mg/l)	K (mg/l)
				Ca^{++}	Mg^{++}	Na^{+}	K^{+}	HCO_3^-	$SO4^{--}$	Cl^-			
	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

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	Sandy

Table c. 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

- The number of umbels/plant.
- Weight of 1000 fruits (g).
- Fruit yield/plant (g) and calculated/fed (ton) based on the number of plant and plant yield.

3. Chemical analysis:

N, P, and K percentages in the dry herb were estimated at flowering time. Nitrogen was determined by a modified micro Kjeldahl method as described by (A.O.A.C., 1970). Phosphorus was colorimetrically determined using the method described by (Murphy and Riley, 1962) using a spectrophotometer at 882 µv. Potassium percentage was estimated using flame photometry according to (Cottenie *et al.,* 1982).

RESULTS AND DISCUSSION

Vegetative growth characters:

Plant height:

Results in Table (1) showed that the different licorice aqueous extract treatments effected on the average plant height of ajwain plants during both seasons. The results show that, treated plants with sprayed L_3 (40 g/l) aqueous extract of licorice recorded the tallest plants compared to other treatments resulting in significant differences variances in most cases. The values reached (82.22 and 84.56 cm) in the 1st and 2nd seasons, respectively. However, treated plants with L_0 (sprayed with tap water) recorded the shortest plants (71.44 and 73.67 cm) in the 1st and 2nd seasons, respectively.

With regard to the response of plant height to the differential investigated sprayed Moringa ethanol extract, Table (1) shows obviously considerable variations in this respect. Herein, the height plants scored by M_2 sprayed ajwain plants by Moringa ethanol extract at 100 ml/l (80.25 and 82.25 cm) in the 1st and 2nd seasons, respectively. Meanwhile, M_0 (sprayed with tap water) produces the lowest values as (74.50 and 76.50 cm) during both seasons, respectively.

In addition, the effect of spraying with licorice aqueous extract combined with spraying with Moringa ethanol extract on plant height of ajwain plants during the 2018/2019 and 2019/2020 seasons were tabulated in Table (1). Since, the highest values of plant height were obtained by the combination treatment of licorice aqueous extract at 40 g/l rate and the highest rate of Moringa ethanol extract 100 ml/l ($L_3 \times M_2$) as (84.33 and 86.67 cm) in the first and second one seasons, respectively, followed by plants sprayed with licorice aqueous extract at 40 g/l and 50 ml/l Moringa extract ($L_3 \times M_1$) compared to the other treatments under study in the first and second seasons in most cases, respectively. Meanwhile, $L_0 \times M_0$ control (spraying of ajwain plants with tap water) resulted in the lowest values (69 and 71.67 cm) on the tested seasons, respectively.

Table 1. Effect of licorice aqueous extract, Moringa ethanol extract and their interaction treatments on plant height and number of branches/plant 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			
	Plant height (cm)							
L_0	69.00	72.00	73.33	71.44	71.67	73.67	75.67	73.67
L_1	74.33	76.67	81.33	77.44	75.67	78.00	80.00	78.89
L_2	75.33	81.67	82.00	79.67	77.00	83.00	83.67	81.22
L_3	79.33	83.00	84.33	82.22	81.67	85.33	86.67	84.56
Mean	74.50	78.33	80.25		76.50	80.00	82.25	
L.S.D at 5%	A=1.88 B= 1.40 A×B= 3.39				A= 1.37 B= 0.71 A×B= 1.41			
	Number of branches/plant							
L_0	14.67	17.00	18.33	16.67	15.33	18.00	18.33	17.22
L_1	16.33	19.33	20.67	18.78	17.00	20.33	21.33	19.56
L_2	18.00	22.00	22.67	20.89	19.33	23.33	24.33	22.33
L_3	21.00	23.00	24.67	22.89	21.67	24.67	25.33	23.89
Mean	17.50	20.33	21.58		18.33	21.58	22.33	
L.S.D at 5%	A= 0.37 B= 0.43 A×B= 0.87				A= 1.04 B= 0.51 A×B= 1.01			

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).

Number of branches/plant:

The data in Table (1) clearly showed that, plants received foliar spray with licorice aqueous extract treatments at 40 g/l concentration L_3 led to a significant increase in number of branches/plant. The values were 22.89 and 23.89 in the first and second seasons, respectively. Meanwhile, the control treatment L_0 (sprayed with tap water) gave the lowest values (16.67 and 17.22 in the first season and in the second season, respectively).

In this respect, the greatest number of branches/plant were significantly coupled with the treated plants with Moringa ethanol extract sprayed at 100 ml/l concentration (21.58 and 23.33) during both experiment seasons, respectively. However, the least number of branches/plant recorded with applying M_0 sprayed ajwain plants by tap water in the two tested seasons (21 and 21.67) respectively.

With respect to the effect of the interaction between licorice aqueous extract and Moringa ethanol extract on number of branched/plant in both seasons, using all extracts caused an increase in the number of branches/plant compared with control plants, however, the significant increase obtained with combination treatment licorice aqueous extract at 40 g/l concentration and Moringa ethanol extract at 100 ml/l ($L_3 \times M_2$) reached to (24.67 and 25.33) during both seasons, respectively. Followed by ($L_3 \times M_1$) without significant difference between both treatments in the second season. On contrary, ($L_0 \times M_0$) sprayed ajwain plants with tap water were (14.67 and 15.33) respectively, scored the lowest values in both seasons compared with the other treatments.

Herb fresh weight (g):

As shown in Table (2) the results indicated that sprayed ajwain plants with L_3 licorice aqueous extract at 40 g/l resulted in the maximum values of fresh weight as (286.1 and 288.9 g/plant) in the both seasons, respectively. However, the minimum values (228.0 and 230.3 g/plant) were attained with L_0 sprayed with tap water in both seasons, respectively.

In regard to the effect of Moringa ethanol extract on fresh weight, the highest

Table 2. Effect of licorice aqueous extract, Moringa ethanol extract and their interaction treatments on herb fresh and dry weights 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			
	Herb fresh weight (g)							
L_0	206.7	237.0	240.3	228.0	208.3	239.7	242.0	230.3
L_1	216.3	253.0	262.3	243.9	218.0	255.3	263.3	245.6
L_2	248.0	278.7	289.3	272.0	250.7	281.0	291.0	274.2
L_3	266.0	294.3	298.0	286.1	267.7	296.7	302.3	288.9
Mean	234.3	265.8	272.5		236.2	268.2	274.7	
L.S.D at 5 %	A= 12.08 B= 5.41 A×B= 10.81				A= 4.79 B= 3.77 A×B= 7.55			
	Herb dry weight (g)							
L_0	37.67	42.33	44.00	41.33	42.33	47.00	49.33	46.22
L_1	40.33	51.00	54.67	48.67	44.67	55.33	59.67	53.22
L_2	47.33	63.33	64.67	58.44	52.67	67.67	69.00	63.11
L_3	57.67	65.67	66.33	63.22	62.33	70.33	72.00	68.22
Mean	45.75	55.58	57.42		50.50	60.08	62.50	
L.S.D at 5 %	A= 1.65 B= 1.59 A×B= 3.19				A= 2.54 B= 2.26 A×B= 4.45			

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).

values were (272.5 and 274.7 g/plant) detected from using Moringa ethanol extract at 100 ml/l during both seasons, respectively. On contrast, M_0 sprayed ajwain plants with tap water gave the lowest values were (234.3 and 236.2 g/plant) during both seasons, respectively.

Concerning the effect of interaction between licorice and Moringa extracts on ajwain fresh weight, the highest values of fresh weight (298.0 and 302.3 g/plant) in the 1st and 2nd seasons, respectively, were recorded with foliar spray by aqueous Licorice at 40 g/l concentration and 100 ml/l Moringa ethanol extract ($L_3 \times M_2$). $L_3 \times M_1$ came second place, without a significant difference between both treatments in both seasons. While the lowest values resulted from the control treatment (sprayed ajwain plants by tap water). The values reached (206.7 and 208.3 g/plant) in the 1st and 2nd seasons, respectively.

Herb dry weight (g):

Data shown in Table (2) resealed that the effect of spraying the licorice aqueous extract on herb dry ajwain weight has a positive effect. Where data show that treated ajwain plants with 40 g/l (L_3) aqueous extract of licorice roots resulted in a significant increase in dry weight, reached (63.22 and 68.22 g/plant) during both the experimental seasons 2018/2019 and 2019/2020, respectively. In comparison, treated ajwain plants with 0.0 g/l licorice aqueous extract (L_0) gave the lowest values (41.33 and 46.22 g/plant) during the experimental seasons 2018/2019 and 2019/2020, respectively.

With respect to the impact of Moringa ethanol extract on dry weight, in both seasons, the significantly highest values resulted from the treatment of applying sprayed ajwain plants with (M_2) 100 ml/l Moringa ethanol extract as (57.42 and 62.50 g/plant) in the first season and second season, respectively. On the other hand, the lowest values of dry weight were occurred by M_0 (sprayed with tap water) in the first season and second season, reached (45.75 and 50.50 g/plant) respectively.

As regards the impact of the interaction between aqueous licorice and ethanol

Moringa extracts on the dry weight of ajwain plants, the highest values of dry weight as (66.33 and 72.00 g/plant) were recorded with treated ajwain plants by ($L_3 \times M_2$) sprayed of licorice aqueous extract at 40 g/l companied with Moringa ethanol extract at 100 ml/l during both seasons, respectively. Followed by ($L_3 \times M_1$) no significant difference between them. While, the lowest values obtained with ($L_0 \times M_0$) sprayed ajwain plants with tap water were reached to (37.67 and 42.33 g/plant) during both seasons, respectively. In addition, other investigated treatments were in between the aforesaid two treatments.

The effects could be attributed to enhance the impact of the aqueous licorice and ethanol Moringa extracts on the vegetative growth characteristics, where to which contains several various important compounds such as triterpene saponins (including glycyrrhizin), mevalonic acid which is the initiator in the synthesis of gibberellins in plants, and growth-regulating hormones like zeatin and Indole, respectively. Which has an active role in cell division, which is reflected in the increase in the length, number of branches, the fresh and dry weights/plant (Makkar and Becker, 1996; Shibata, 2000 and Zadeh *et al*., 2013). It is well known that licorice and Moringa extracts are a rich sources of potassium and contains large amounts of calcium, copper, iron, magnesium, manganese, phosphorus, zinc, as well as amino acids (Nagar *et al*., 2006), which play an important role in cell division and expansion as well as stimulate the photosynthesis process and this in turn reflects the increase in plant growth (Isbruker and Burdo, 2006). It also contains essential nutrients (N, P, and K), which are very important for plant growth and development (Makkar and Becker, 1996; and Abd El-Azim *et al*., 2017). These results may explain the great benefits of licorice and Moringa extracts to supply the plants with organic and non-organic food requirements (Prabhu *et al*., 2010 and Saleh *et al*., 2013).

These results were in harmony with those reported by Abdallah *et al*. (2016) on fennel, showed that inoculated fennel plants with mycorrhiza fungi and sprayed with L_2 (40 g/l) or L_3 (60 g/l) aqueous extract of licorice roots recorded the highest significant values of all growth parameters without significant difference between both treatments in most cases; El-Alakmy (2016) on *Mentha longifolia*. Who stated that the significantly highest increase for vegetative growth characters resulted when plants were treated by spraying licorice extract at 5 g/l with extract at 4%; Hamad *et al*. (2017) on dill plants who showed that, the highest plant height and dry weight plant obtained by sprayed with (40 g/l) or M_2 (60 g/l) extracts of Aloe and Moringa leaves, Abdel-Rahman and Abdel-Kader, (2019) on fennel who indicated that, treated plants with *Moringa a oleifera* leaf extracts (MLE) and benzyladenine (BA) resulted in a significant increase in the vegetative growth compared to untreated plants; and in the same the regard Massoud *et al*. (2019) on caraway the maximum means values for growth characters and plant dry weight were obtained by the plants treated with the high rate of vinasse (100%) in combinations with licorice extracts at 2% in both seasons.

Fruits yield parameters:

Number of umbels/plant:

The data shown in Table (3) indicate that foliar spraying of licorice aqueous extract significantly increased the number of umbels/plant compared to control in both seasons. The maximum mean values of the number of umbels/plant registered by applying 40 g/l of the licorice aqueous extract (63 and 65.33) respectively during the two seasons. While, the lowest values (51.78 and 53.11) during the two seasons studied were produced with L_0 (sprayed ajwain plants with tap water).

With regard to the number of umbels/plant, there were substantial variations between treatments during the addition of Moringa ethanol extract to the

Table 3. Effect of licorice aqueous extract, Moringa ethanol extract and their interaction treatments on number of umbels/plant and weight of 1000 fruits 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			
	Number of umbels/plant							
L_0	48.67	52.67	54.00	51.78	50.00	54.00	55.33	53.11
L_1	51.33	56.67	57.33	55.11	52.67	58.00	58.67	56.44
L_2	55.33	62.33	63.33	60.33	56.33	63.67	65.33	61.78
L_3	59.00	64.33	65.67	63.00	60.00	67.00	69.33	65.44
Mean	53.58	59.00	60.08		54.75	60.67	62.17	
L.S.D at 5 %	A= 3.83 B= 1.08 A×B= 2.16				A= 0.745 B= 0.743 A×B= 1.49			
	Weight of 1000 fruits							
L_0	0.783	0.847	0.900	0.843	0.863	0.890	0.943	0.899
L_1	0.857	0.920	0.950	0.909	0.867	0.960	0.983	0.937
L_2	0.900	1.050	1.123	1.024	0.943	1.147	1.190	1.093
L_3	0.967	1.157	1.197	1.107	1.020	1.220	1.240	1.160
Mean	0.877	0.993	1.043		0.923	1.054	1.089	
L.S.D at 5 %	A= 0.034 B= 0.027 A×B= 0.055				A= 0.115 B= 0.027 A×B= 0.547			

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).

treatments as the highest average reached (60.8 and 62.17) with sprayed plants by M_2 100 ml/l Moringa ethanol extract, in both seasons respectively. While the lowest rate of number of umbels/plant (53.58 and 54.75) detected from (M_0) sprayed ajwain plants by 0.0 ml/l Moringa ethanol extract in both seasons, respectively .

The number of umbels/plant of ajwain was scored by combining between aqueous licorice and ethanol Moringa extracts, where the highest values (65.67 and 96.33) were attained with (L_3 × M_2) sprayed plants by 40 g/l aqueous licorice and 100 ml/l Moringa ethanol extract during both seasons, respectively. Meanwhile, sprayed ajwain plants by tap water (L_0 × M_0) led to lowest values during both seasons (48.67 and 50.00) respectively.

Weight of 1000 fruits (g):

It appears form results of Table (3) that, the minimum of weight of 1000 fruits reached to (0.843 and 0.899 g) obtained with (L_0) treated ajwain plants by tap water in the first and the second seasons, respectively. Meantime, the maximum rats of weight of 1000 fruits as a result of treated ajwain plants by aqueous licorice at 40 g/l concentration in the first and the second seasons as (1.107 and 1.160 g) respectively.

Spraying with the Moringa ethanol extract led to the emergence of significant differences between the treatments as the highest average of weight of 1000 fruits in the treatment of 100 ml/l reached to (1.043 g in the first season and 1.089 g in the second season). While the lowest average of the weight of 1000 fruits in the treatment of sprayed by tap water reached to 0.877 in the 1st season and 0.923 in the 2nd season.

The results of overlap between the spraying with aqueous licorice and ethanol Moringa extracts showed that the highest average of the weight of 1000 fruits in the treatment of 40 g/l licorice aqueous extract with 100 ml/l Moringa ethanol extract reached to (1.197 and 1.240 g) in both seasons, respectively, and came in the second place compared for plants sprayed by (L_3 × M_1) sprayed plants by licorice at 40 g/l concentration and Moringa ethanol extract at 50 ml/l concentration. While the lowest

average of the weight of 1000 fruits (0.738 and 0.863 g) achieved with (L_0 × M_0) sprayed ajwain plants with tap water in both seasons, respectively.

Fruits yield/plant (g):

Table (4) indicates that there are significant differences in values of fruit yield/plant between treatments during spraying with the licorice aqueous extract as the highest values in plants treated with the 40 g/l concentration of licorice aqueous extract reached to (9.25 and 9.52 g) during the experimental seasons 2018/2019 and 2019/2020, respectively. However, the lowest values in the treatment of sprayed ajwain plants by licorice aqueous extract at 0.0 g/l reached to (6.56 and 6.98 g) respectively, during both the 2018/2019 and 2019/2020 experimental seasons.

With regard to the changes in fruit yield/plant of ajwain plants affected by the Moringa ethanol extract concentrations, the highest values were reported with sprayed plants by M_2 Moringa ethanol extract at 100 ml/l concentration reached to (8.55 and 8.89 g) during both the 2018/2019 and 20192020 experimental seasons, respectively. By contrast, the lowest values of fruit yield/plant were reported with M_0 treated ajwain plants by sprayed with tap water reached to (6.76 and 7.04 g) during both 2018/2019 and 2019/2020 experimental seasons, respectively.

As for the interaction effect between licorice aqueous extract and Moringa ethanol extract, all resulted combinations increased the fruit yield/plant in the two seasons. Where, the highest values as a result from the combined treatments between licorice aqueous extract at 40 g/l concentration with Moringa ethanol extract at 100 ml/l concentration L_3 × M_2 as (9.94 and 10.13 g) in the two seasons, respectively, followed descendingly treated plants by licorice aqueous extract at 40 g/l and Moringa ethanol extract at 50 ml/l concentration in the two seasons, no significant difference between them. In the meantime, sprayed ajwain plants by tap water were due to the lowest values as (5.40 and 5.86 g) in the two seasons, respectively.

Table 4. Effect of licorice aqueous extract, Moringa ethanol extract and their interaction treatments on fruit yield/plant and fruit yield/fed 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			
	Fruit yield/plant							
L_0	5.40	7.13	7.16	6.56	5.86	7.44	7.63	6.98
L_1	5.73	7.81	8.01	7.19	6.06	8.01	8.34	7.47
L_2	7.67	8.73	9.09	8.51	7.82	8.95	9.45	8.74
L_3	8.25	9.56	9.94	9.25	8.43	10.01	10.13	9.52
Mean	6.76	8.31	8.55		7.04	8.60	8.89	
L.S.D at 5 %	A= 0.06 B= 0.08 A×B= 0.16				A= 0.14 B= 0.07 A×B= 0.14			
	Fruit yield/fed							
L_0	201.5	266.2	267.2	244.9	218.8	277.9	284.9	260.5
L_1	214.0	291.7	299.2	268.3	226.4	299.0	311.2	278.9
L_2	286.2	326.0	339.2	317.2	291.8	334.1	352.7	326.2
L_3	308.0	356.9	371.2	345.4	314.7	373.6	378.2	355.5
Mean	252.4	310.2	319.2		262.9	321.2	331.7	
L.S.D at 5 %	A= 2.29 B= 3.08 A×B= 6.16				A= 5.04 B= 2.79 A×B= 5.59			

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).

Fruits yield/fed (kg):

Data presented in Table (4) reveal that the heaviest fruits yield/fed recorded by treated ajwain plants by (L_3) licorice aqueous extract at 40 g/l concentration amounted to (345.4 and 355.5 kg) during the both seasons, respectively. While the lowest values as a result of treated ajwain plants with control (L_0) tap water during both seasons.

As for Moringa ethanol extract levels treatments, data presented in the same Table illustrated that there was a positive relationship between the values of the fruits yield/fed and Moringa ethanol extract levels, hence as the levels of Moringa ethanol extract increased the values of fruits yield/fed increased till reach the highest increases with the highest level 100 ml/l as (319.2 and 331.7 kg) in the two seasons, respectively. Meanwhile, sprayed ajwain plants with tap water led to the minimum values of fruit yield/fed as (252.4 and 262.9 kg) in the two seasons, respectively.

Concerning the response of ajwain plants fruits yield/fed to the interaction between licorice aqueous extract and Moringa ethanol extract, data obtained during both 2019 and 2020 experimental seasons are presented in Table (4). It was quite evident that all combinations of treatments varied considerably, however the rate of their effectiveness differed obviously from one treatment to another. Anyhow it could be generally observed that the response of fruit yield/fed to sprayed treatments. In this respect, the highest values of fruit yield/fed achieved with treated ajwain plants by licorice aqueous extract at 40 g/l and 100 ml/l Moringa ethanol extract in the two seasons reached to (371.2 and 378.2 kg) respectively, followed by ($L_3 \times M_1$) with no significant differences between them in the second season. On contrast, treated ajwain plants with tap water recorded the lowest values reached to (201.5 and 218.8 kg) in the two seasons, respectively.

Further studies supposed that aqueous licorice and ethanol Moringa extracts stimulate growth as it contains a series of plant growth promoters, of these, (Abdallah *et al*., 2016; Badawy, 2016; Abd El-Azim *et al*., 2017; and Mazrou, 2019) reported that, aqueous extract of licorice or Moringa extract when applied as a foliar spray on fennel, Caraway, fennel, and coriander, respectively showed an increase in yield and quality of fruits. This may be attributed to the high amino acid content of the licorice or Moringa extracts involved directly in the metabolism (Abd El-Azim *et al*., 2017; and Mazrou, 2019). Our results are in agreement with the reports of Abdallah, *et al*. (2016) found that treating fennel plants by mycorrhiza (AM) and spraying with 60 g/l licorice recorded the highest significant yield parameters such as, number of umbels/plant as well as, resulted in a significant increase of fruit yield/plant and fruit yield/fad. Abd El-Azim *et al*. (2016) indicated that, on *Foeniculum vulgare*. Using licorice extract as a foliar spray application recorded a significant increase in the number of umbels/plant, fruit weight/plant, fruit yield/fed. El-Alakmy (2017) point out that, application of spraying licorice extract at 5 g/l with Moringa extract at 4% on *Mentha longifolia* caused the highest values of yield fresh weight/fed, yield dry weight/fed. Concerning Moringa exyract, Abou-Sreea and Matter (2016) showed that, spraying fennel plants at 50 ppm (GA_3) plus 10% of Moringa leaf aqueous extract due to the highest fruit yield/plant and fruit yield/fed. Badawy (2016) who found that treating caraway seeds by soaking plus foliar spray by seaweed or Moringa extracts recorded the highest fruit weight/plant and fruit yield/fed. Hamad *et al*. (2017) illustrated that spraying with (40 g/l) or M_2 (60 g/l) extracts of aloe and Moringa leaves on dill plants gave the highest values of all yield components such as fruit yield/plant, and fruit yield/fed compared of the other treatments. Abdel-Rahman and Abdel-Kader (2019) showed that treated fennel plants with *Moringa oleifera* leaf extracts (MLE) and

benzyladenine (BA) recorded a significant increase in the number of umbels/plant, fruit yield/plant and fed compared to untreated plants. Therefore, it could be recommended that spraying fennel plants with 5% aqueous MLE + 100 ppm BA for obtaining higher fruit yield. Mazrou (2019) stated that Moringa extract application significantly increased the number of umbels/plant, fruit yield/plant, and ha as well as the weight of 100 seeds during both seasons compared to untreated plants. A gradual increase was observed in fruit yield with increasing MLE level from 50 to 200 g l^{-1} resulted. Applying MLE at 200 g l^{-1} led to enhanced coriander fruit yield/ha in both seasons, respectively. They found that spraying contributed to increasing the content of carbohydrates needed for the synthesis of protein and fat stored in the seed, thereby increasing productivity per unit area and weighting 1000 seeds that reflected positively on the yield of fruits.

Chemical composition:

Nitrogen percentage:

Data in Table (5) clearly showed that treating ajwain plants with foliar spray for all licorice aqueous extract concentrations resulted in an increase in nitrogen content in both seasons, anyway, the highest values of nitrogen percentage as a result of treated ajwain plants with 40 g/l licorice aqueous extract as (2.66 and 2.73 %) in both seasons, respectively. However, the lowest values as a result of treated ajwain plants with tap water as (1.96 and 2.02%) respectively, in both seasons.

The results of spraying with Moringa ethanol extract showed the existence of significant differences between treatments as the highest average for the content of nitrogen in the treatment of M_2 100 ml/l reached to (2.50 and 2.58 %) during both seasons, respectively. while the lower content of nitrogen in the M_0 treatment amounted to (2.10 and 2.17 %) during both seasons, respectively.

During the interaction between licorice aqueous extract and Moringa ethanol extract was found that the highest average concentration of nitrogen in the treatment of 40 g/l licorice aqueous extract with sprayed ajwain plants with Moringa ethanol extract at 100 ml/l concentration which amounted to (2.81 and 2.88%) in the first season and the second one season, respectively. Meanwhile, the lowest average concentration of nitrogen amounted to (1.75 and 1.77%) with the interaction of ($L_0 \times M_0$) treated ajwain plants with sprayed by tap water treatment in the first season and the second one season, respectively.

Phosphorus percentage:

Data presented in Table (5) demonstrated that all applied licorice aqueous extract treatments significantly succeeded in increasing the values of phosphorus content in the herb of ajwain plants. Anyway, the best results of phosphorus % as a result from the treatment of ajwain plants by (L_3) 40 g/l licorice aqueous extract in the two seasons, reached to (0.36 and 0.40%) respectively, Likewise, treated ajwain plants with tap water led to the lowest values (0.24 and 0.28 %) in both seasons, respectively.

Spraying with the Moringa ethanol extract achieved the emergence of significant differences between the treatments as the highest average of the phosphorus content in the treatment ajwain plants with 100 ml/l Moringa ethanol extract amounted to 0.33 and 0.38% during both seasons, respectively. Besides, the lowest values for this trait in the comparison treatment that sprayed with tap water reached to 0.26 and 0.30% during both seasons, respectively.

The interaction data between licorice aqueous extract and Moringa ethanol extract showed that the highest values phosphorus content reached to 0.38% in the first season and 0.43% in the second season in the sprayed ajwain plants with 40 g/l of licorice aqueous extract with treatment that sprayed ajwain plants with 100 ml/l Moringa ethanol

Table 5. Effect of licorice aqueous extract, Moringa ethanol extract and their interaction treatments on chemical composition (N, P, and K) 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	M_0	M_1	M_2	Mean
	Nitrogen percentage (%)				Phosphorus percentage (%)				Potassium percentage (%)			
First season												
L_0	1.75	2.03	2.11	1.96	0.21	0.24	0.26	0.24	2.35	2.63	2.71	2.56
L_1	1.67	2.34	2.42	2.24	0.23	0.29	0.31	0.28	2.57	2.94	3.02	2.84
L2	2.23	2.56	2.66	2.48	0.27	0.35	0.36	0.33	2.83	3.16	3.26	3.08
L3	2.45	2.72	2.81	2.66	0.32	0.37	0.38	0.36	3.05	3.32	3.41	3.26
Mean	2.10	2.41	2.50		0.26	0.31	0.33		2.70	3.01	3.10	
L.S.D at 5 %		A= 0.036 B= 0.039 A×B= 0.077				A= 0.012 B= 0.009 A×B= 0.017				A= 0.036 B= 0.039 A×B= 0.077		
Second season												
L_0	1.77	2.07	2.20	2.02	0.26	0.28	0.29	0.28	2.48	2.77	2.90	2.72
L_1	2.05	2.39	2.49	2.31	0.27	0.33	0.35	0.32	2.75	3.09	3.19	3.01
L2	2.32	2.64	2.73	2.57	0.31	0.39	0.40	0.37	3.02	3.34	3.43	3.27
L3	2.53	2.77	2.88	2.73	0.36	0.41	0.43	0.40	3.23	3.47	3.58	3.43
Mean	2.17	2.47	2.58		0.30	0.36	0.38		2.87	3.17	3.28	
L.S.D at 5 %		A= 0.063 B= 0.009 A×B= 0.017				A= 0.012 B= 0.009 A×B= 0.017				A= 0.063 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).

extract, and came in the second place compared for plants treated by (L_3 × M_2) without a significant difference between them. However, the lowest values in phosphorus content during the treatment that sprayed with tap water (L_0 × M_0) which amounted to 0.21% in the first season and 0.26% in the second season.

Potassium percentage:

Data illustrated in Table (5) emphasized that, sprayed ajwain plants of 40 g/l licorice aqueous extract gave the highest values for this trait which reached to (3.26 and 3.43% in the first and second seasons, respectively). While the lowest average of potassium content obtained with sprayed ajwain plants by 0.0 of licorice aqueous extract which amounted to (2.56 and 2.72% in the first and second seasons, respectively).

Referring to the influence of Moringa ethanol extract treatments on average potassium content, the treated ajwain plants by M_2 spraying Moringa ethanol extract at 100 ml/l concentration recorded their highest average as (3.10 and 3.28%) during both experimental seasons, respectively. Furthermore, the lowest average of potassium content was result from M_0 spraying ajwain plants by tap water which amounted to (2.70 and 2.87%) during both experimental seasons, respectively.

In this regard, regarding the response of potassium percentage to the interaction between licorice aqueous extract and Moringa ethanol extract treatments. The potassium content was increased as a result of spraying ajwain plants with (L_3 × M_2) licorice at 40 g/l concentration and Moringa ethanol extract at 100 ml/l concentration treatment of both in the two experimental seasons which reached to (3.41 and 3.58%) respectively, followed by (L_3 × M_1) with a significant difference between them in both seasons. On the opposite, spraying ajwain

plants by tap water ($L_0 \times M_0$) resulted in the lowest values of this trait during both seasons which amounted to (2.35 and 2.48%) respectively.

The increase in nitrogen, phosphorus, and potassium percentages may be due to the effect of licorice root aqueous extract in increasing endogenous hormones like GA_3 in treated plants which increased the metabolic processes function and its effect in element content in tissue (Thanaa *et al*., 2016). Take into account, also, the fact that Moringa extract is a rich source of amino acids, potassium, calcium, iron, vitamin E, ascorbates, phenolic compounds, and growth-regulating hormones such as zeatin (Makkar and Becker, 1996 and Nagar *et al*., 2006).

These results were in parallel line with those achieved by Abd El-Azim *et al*. (2016) on fennel, application of licorice extract as a foliar spray gave highest values of content of (N, P and K %) in herb. Abd El-Azim, *et al*. (2017) reported that, the obtained of highest values N, P, and K percentage of fennel as result in application of a mixture of Bio-fertilizer and cold water licorice root extract. As Moringa extract, Abd-ElKafie *et al*. (2016) showed that, the highest values of N, P and K % in leaves of coriander (*Coriandrum sativum* L.) plant were recorded by using the boiled Moringa leaf extracts MLE at 100%. El-Gamal and Ahmed (2016) revealed that, foliar application of seaweed (SW) at 0.5 ml/l or Moringa extract (MLE) (1:30) on dill (*Anethum graveloens* L.), increased significantly N, P and K percentages over non sprayed plants. Abdel-Rahman and Abdel-Kader (2019) demonstrated that, treated fennel plants with Moringa extract (MLE) and/or benzyladenine (BA) led to a significant increase in the N, P and K contents in leaves compared to untreated plants.

CONCLUSION

Conclusively, from the results obtained, it could be recommended that the spraying of ajwain plants with combinations of licorice aqueous extract at a concentration of 40 g/l plus 100 ml/l of Moringa ethanol extract be used to improve the growth, yield of fruits, chemical constituents of ajwain (*Trachyspermum ammi* L.) plant.

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أستجابة نبات النخوة الهندي للرش الورقي بمستخلصات العرقسوس والمورنجا 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 التجربة على نبات النخوة الهندي بالمزرعة التجريبية بجامعة هليوبوليس، محافظة الشرقية، مصر بالتعاون مع قسم البساتين، كلية الزراعة، جامعة بنها خلال موسمي الشتاء المتتاليين ٢٠١٩/٢٠١٨. و ٢٠٢٠/٢٠١٩ بهدف دراسة تأثير الرش بمستخلص العرقسوس المائي في أربعة تركيزات ٠ و ١٠ و ٢٠ و ٤٠ جم/لتر والرش بثلاث تركيزات بمستخلص المورنجا هي ٠ ، ٥٠ ، ١٠٠ مللى/لتر على بعض صفات النمو الخضري ومحصول الثمار وفقاً لتصميم القطع المنشقة بثلاث مكررات وتمت مقارنة المتوسطات باستخدام اختبار LSD. أظهرت النتائج تأثيرًا معنويًا لجميع التراكيز المستخدمة من مستخلص العرقسوس المائي ومستخلص المورنجا في جميع الصفات المدروسة ، كما أدى رش نباتات النخوة بمستخلص العرقسوس المائي بتركيز ٤٠ جم/لتر مع ١٠٠ مللى/لتر من مستخلص المورنجا إلى زيادة النمو الخضري (ارتفاع النبات ، عدد الأفرع ، ووزن العشب الطازج والجاف للنبات). كما سجلت نفس المعاملة أعلى متوسط لصفات محصول الثمار (عدد النورات/نبات ، وزن ١٠٠٠ ثمرة ، ومحصول الثمار/نبات والفدان) ، وكذلك تم الحصول على أعلى قيم النيتروجين والفوسفور والبوتاسيوم باستخدام نفس المعاملة ($L_3 \times M_2$) ، على النقيض من ذلك ، تم الحصول على أقل القيم لجميع الصفات المدروسة بنباتات النخوة المعاملة بالرش بواسطة ماء الصنبور ($L_0 \times M_0$) في كلا الموسمين مقارنة بالمعاملات الأخرى في الموسمين.