



EFFECT OF MYCORRHIZA INOCULATION AND FOLIAR SPRAY OF SOME PLANTS EXTRACTS ON FENNEL GROWTH AND PRODUCTIVITY

Sonia A.S. Abdallah^{1*}, H.M.S. Hassan¹ and M.A.I. Mansour²

1. Plant Prod. Dept., Fac. Environ. Agric. Sci., Suez Canal Univ., Egypt

2. Bot. and Microbiol. Dept., Fac. Sci., El-Arish, Suez Canal Univ., Egypt

ABSTRACT

This experiment was conducted during 2013- 2014 and 2014 – 2015 seasons at the Experimental Farm, Fac. of Environ. Agric. Sci., El-Arish, Suez Canal Univ., Egypt, to study the effect of mycorrhiza inoculation (AM) and foliar spray of some plants aqueous extracts (*Glycyrrhiza glabra* L. and *Moringa oleifera* M.) on fennel (*Foeniculum vulgare* Mill) growth and productivity. The applied concentrations of licorice root extract were control (distilled water), 20 gl⁻¹ (L1), 40 gl⁻¹ (L2) and 60 gl⁻¹ (L3), while moringa leaves extract concentrations were control (distilled water), 20 gl⁻¹ (M1), 40 gl⁻¹ (M2) and 60 gl⁻¹ (M3). Both aqueous extracts were applied twice (the first was after one month of cultivation and the second one was after two weeks from the first one). The obtained results showed that inoculated fennel plants with mycorrhiza Fungi and sprayed with L2 (40 gl⁻¹) or L3 (60 gl⁻¹) aqueous extract of licorice roots recorded the highest significant values of all growth and flowering parameters without significant difference between both treatments in most cases in the first season. The same trend was observed in the second season, but only inoculated plants which were sprayed with 60 gl⁻¹ licorice extract gave the highest significant growth and flowering values, i.e., plant height, branch number, herb fresh and dry weights, number of umbels per plant and number of umbellets per umbel (100.03 cm, 9.70, 67.74 g, 24.88 g, 10.66 and 11.33, respectively). Moreover, fennel plants inoculated with AM Fungi combined with spraying (60 gl⁻¹) aqueous extract of licorice roots (L3) resulted in a significant increase of fruit No./umbel, fruit yield/plant and fruit yield/fad. (12.66, 17.51g and 490.28 kg, respectively) during the first season and 13.00, 18.46 g and 516.88 kg, respectively in the second season. On the other hand, fennel plants inoculated with AM Fungi combined with aqueous extract foliar spray of moringa leaves (M3) gave the highest herb contents of nitrogen (0.374 and 0.385 ppm), phosphorus (0.275 and 0.283 ppm) and potassium (148.49 ppm and 156.13 ppm) in both seasons, respectively.

Key words: Fennel, licorice, moringa, arbuscular mycorrhizal fungi (AMF).

INTRODUCTION

Fennel (*Foeniculum vulgare* Mill.) which belongs to family Umbelliferae (Apiaceae) is an annual plant. Vegetative parts of the plant are used as a green salad while fruits have a pleasant, spicy odour and burning sweet taste. It has pharmaceutical, perfumery and food flavoring used.

Fennel fruits contain 1-3% volatile oil, which has disinfectant and anti-inflammatory action, primarily on the respiratory and digestive organs and has an antispasmodic effect on smooth muscle (Stary and Jirasck, 1975). Also, essential oil of fennel is used as flavoring agent in food products such as beverages, bread, pickles, pastries, and cheese. It is also used as a constituent of cosmetic and pharmaceutical products (Piccaglia and Marotti, 2001).

*Corresponding author: Tel. : +201203803713
E-mail address: sonaiattai@gmail.com

Antioxidant and antimicrobial activity of fennel has also been reported (Ruberto *et al.*, 2000).

Mycorrhizal fungi are beneficial microorganisms and have been considered as bio-fertilizer. It is an obligate group (Javaid, 2007; Javaid *et al.*, 2007; Javaid and Riaz, 2008) found in more than 80 % of land plant families (Smith and Read, 2008). In this association, the fungus is supplied with soluble carbon sources (photosynthesis) by the host plants, whereas the fungus provides the host plant with a better ability to take up water and nutrients from the soil (Entry *et al.*, 2002; Javaid, 2009). Arbuscular Mycorrhizal Fungi (AMF) can also benefit plants by stimulating the production of growth regulating substances, improving osmotic adjustment under drought and salinity stresses and increasing resistance to pests and soil borne diseases (Al-Karaki, 2006). These benefits are mainly attributed to improve phosphorous nutrition (Plenchette *et al.*, 2005). Most horticultural and crop plants establish the symbiosis with AMF. Although the mycorrhizal potential of the symbiosis to improve horticultural production is recognized (Estaun *et al.*, 2002) it has not been implemented under field conditions.

AM fungi are important components of virtually all terrestrial ecosystems and are especially critical in improving plant nutrient and water uptake under semi-arid conditions (Van der Heijden *et al.*, 2006; Allen, 2011). Most terrestrial ecosystems depend on mycorrhiza, which promote the establishment, growth and health of plants. Improved plants productivity by AM fungi was attributed to enhanced uptake of immobile nutrients such as phosphorus, zinc, nitrogen and copper. AM fungi can be integrated in soil management to achieve low-cost sustainable agricultural systems (Hooker and Blackke, 1995). Resistance against biotic (Khaosaad *et al.*, 2007) and abiotic stresses (Auge, 2001; Javaid, 2007; Azcón *et al.*, 2009) has been argued to be due to

the effects of AM fungi on inducing plant hormones production. Phosphate solubilizing microorganisms are another sort of bio-fertilizers which have the ability to solubilize organic and inorganic phosphorus compounds by producing organic acid or phosphatase enzyme.

Glycyrrhiza glabra roots are rich in many essential minerals, flavonoids and natural antioxidants (Morsi *et al.*, 2008). In addition, licorice extract contains protein and amino acid (Asparagin), monosaccharides (glucose, fructose, sucrose and maltose), lignins, tannins, starch, choline, phytosterols, different types of vitamins such as B1, B2, B3, B6, C, E, biotin, folic acid, pantothenic acid, many mineral nutrients (aluminum, calcium, iron, magnesium, cobalt, zinc, phosphorus, sodium, silicone, potassium and stannous) and bitter principles (Rossi, 1999; Arystanova *et al.*, 2001). Foliar spraying with licorice extract has a favorable biological effect on fresh and dry weights of plants, flowering, total yield and fruits quality for several crops; viz, sweet pepper (El-Jawary, 2002), cucumber (Fayad, 2005; Jibouri *et al.*, 2005; Husain and El-Rekaby, 2006), bean (Kamal and Ghanem, 2012), fenugreek (Nasser *et al.*, 2014) and roselle (Hassan and Abd El-Samee, 2015).

Moringa (*Moringa oleifera* L.) belongs to Moringaceae family. Moringa leaf extract is a rich source of amino acids, potassium, calcium, iron, vitamin E, ascorbates, phenolic compounds and growth regulating hormones like zeatin (Makkar and Becker, 1996 and Nagar *et al.*, 2006). Thus it possesses the potential to promote plant growth, hence it can be used as a natural plant growth promoter. Zeatin is the most naturally occurring cytokinin that not only promotes the growth of plants by facilitating cell division and cell elongation as well as its anti-aging potential and protective effects in plants.

Moringa leaf extract has been reported to increase the yield of many crops viz major cereals [maize (*Zea mays* L.), rice (*Oryzae*

sativa L.), sorghum (*Sorghum bicolor* L.); wheat (*Triticum sativum* L.) as reported by Phiri (2010) and Abbas *et al.* (2013), tomato (Culver *et al.*, 2012), common bean (*Phaseolus vulgaris* L.) (Rady and Mohamed, 2015) and roselle (Hassan and Abd El-Samee, 2015).

This trial aimed to improve growth and productivity of fennel by using mycorrhiza inoculation and foliar spray with aqueous extracts of some medicinal plants (*Glycyrrhiza glabra* and *Moringa oleifera*) under North Sinai conditions.

MATERIALS AND METHODS

Field experiment was carried out at the Experimental Farm, Faculty of Environmental Agricultural Sciences, El-Arish, North Sinai Governorate during two successive winter seasons of 2013/2014 and 2014/2015, to study the effect of two foliar spraying with extractions of two medicinal plants (*Glycyrrhiza glabra* L. and *Moringa oleifera* M.) and mycorrhizal symbiosis on vegetative growth, fruit yield, essential oil content and some chemical constituents of *Foeniculum vulgare* Mill plants.

The chemical and physical characteristics of experimental farm soil and irrigation water are shown in Table 1. Drip irrigation system was used.

Fennel seeds were kindly supplied from the National Research Center, Doki, Giza, Egypt. Seeds were sown directly in soil on 15th September during both seasons. The experimental unit area was 20 m² (20 m long x 1m wide). Every experimental unit contained three dripper lines with 20 m long.

The distance between lines was 50 cm and distance between plants in the same row was 30 cm. Five seeds were sown per hill, then thinned after three weeks to one plant/ hill. The other agricultural practices were carried out as recommended.

Fertilizer and Medicinal Plant Extraction

Nitrogen fertilizer was applied at the rate of 100 kg. fad.⁻¹ of ammonium sulphate (20.5% N). It was added through fertigation system during plant life. Ordinary calcium super phosphate (15.5% P₂O₅) and potassium sulphate (48% K₂O) were added during soil preparation at the rates of 200 and 30 kg. fad.⁻¹, respectively. Mycorrhizal fungi were used in two treatments (un-inoculated and inoculated).

Inoculation of AM fungi

To increase the spore count, *i.e.*, inoculum potential in the soil to be used for open field experiments, mixed spores were collected from the rhizosphere of many plants which cultivated in the farm of Medicinal and Aromatic Plants, Fac. Environ. Agric. Sci., El-Arish, Suez Canal Univ., such as rosemary, chamomil, common sage, lavender and aloe. Spores were then surface sterilized as described by Ravolanirina *et al.* (1987) and used for inoculation with onion (*Allium cepa* L.) as a recommended trap crop in an autoclaved soil for a period of four months to increase spore density. Heavily colonized adventitious roots of growing onion were also chopped into small fragments and mixed thoroughly with the associated rhizospheric soil (containing hyphae and spores) to form root balls. Spores and heavily colonized roots, in the form of root balls, were then transferred to the experimental field and incorporated into the soil at a depth of 2-3 cm below fennel plants according to Menge and Timmer (1982).

Extraction and purification:

From each rhizosphere soil sample, spores were extracted from 100 g soil aliquots using the technique of Gerdemann and Nicholson (1963).

Identification

In order to facilitate rapid determination of spore density, spore suspensions were filtered through 7 cm diameter Whitman filter paper No 1, marked with small squares (1:1cm) to examine spores. Before identification, spores were stained with Meltzer's reagent. After staining, spores were picked up with a micro-pipette and placed on a clean glass slide, then

Table 1. Some initial chemical and physical characteristics of soil and chemical analysis of irrigation water

Parameter	Soil		Irrigation water
	First season (2013-14) Second season (2014-15)		
	Soluble ions	meq.l ⁻¹ (soil past extract)	
Ca ⁺⁺	3.03	3.09	18.12
Mg ⁺⁺	2.11	2.20	20.20
Na ⁺	3.18	4.49	17.72
K ⁺	0.48	0.31	0.25
Cl ⁻	2.00	2.30	38.40
Co ₃ ⁻	0.00	0.00	0.00
Hco ₃ ⁻	2.00	2.40	6.25
So ₄ ⁻	3.78	4.40	11.64
EC (dsm ⁻¹)	0.68	0.91	5.65
pH (1:2.5)	8.10	8.20	6.70
Organic carbon (g.kg ⁻¹)	0.93	1.22	-
Organic matter (g.kg ⁻¹)	1.60	2.10	-
Ca CO ₃ (g.kg ⁻¹)	3.95	3.95	-
	Particular size distribution (%)		
Clay	0.16	0.16	-
Silt	0.33	0.33	-
Fine sand	76.1	76.1	-
Coarse sand	18.71	18.71	-
Soil texture	Sandy soil	Sandy soil	-

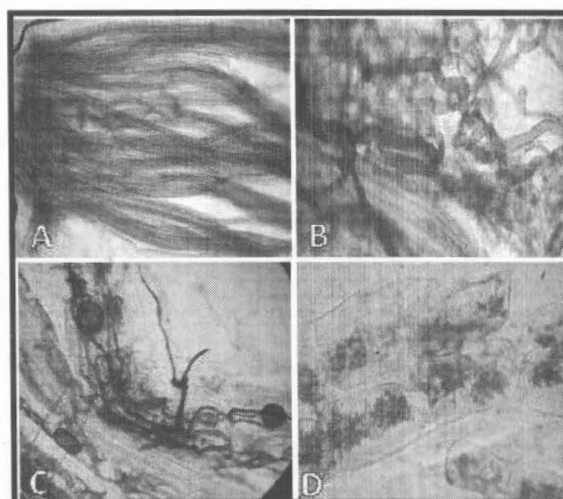


Fig. 1. AM structures in fennel roots

- A. Roots without inoculation by AMF B. Hyphae within roots
 C. Vesicles within roots D. Arbuscular within roots

examined to detect different morphological properties such as spore shape, longest dimension, wall thickness, and hyphae. Some hyphae may be attached to suspensor-like cells. Identification was carried out according to Gerdemann and Trappe (1974). Stained spores were then mounted in poly-vinyl alcohol-lactic acid-glycerol (PVLG) to make permanent slides.

Determination of root colonization:

To measure the rate of development of endomycorrhiza inside the roots of host plants (trap-crops), all root samples were prepared for staining then examined for the presence of hyphae or any AM structures according to (Philips and Hayman, 1970) as shown in Fig.1.

Preparation of Aqueous Extract Solutions

Roots of licorice (*Glycyrrhiza glabra* L.) and leaves of moringa (*Moringa oleifera* M.) were collected from the farm of medicinal and aromatic plants, Fac. Environ. Agric. Sci, El-Arish, Suez Canal Univ. Roots and leaves of both plants were collected. The plant material was dried in an oven at 70° C for 48 hr. Then the dried material was ground in a grinder and passed through a 40 mesh screen. To prepare the extracts, 50 g of each ground plant material were macerated in 500 ml distilled water. Solutions were placed in orbital shaker at room temperature for 24 hr. The extracts were filtered using Whatman filter paper No.1 (Dayananda *et al.*, 2010).

The obtained extracts were diluted in order to achieve the concentrations. Treatment concentrations of licorice were: control (distilled water), (L1) 20 g^l⁻¹, (L2) 40 g^l⁻¹ and (L3) 60 g^l⁻¹ while moringa leaves extraction concentrations were: control (distilled water), 20 g^l⁻¹ (M1), 40 g^l⁻¹ (M2) and 60 g^l⁻¹ (M3). Each aqueous extract was applied twice after one month of cultivation and after two weeks from the first application.

Measurements

After 120 days from sowing and before harvesting, eight random plants from each treatment were used to determine the following growth criteria; plant height (cm), branch

number, herb fresh and dry weights (g), flowering characteristics as number of umbels per plant and number of umbellets per umbel. Also yield components as fruit number per umbel, fruit yield per plant (g), fruit yield per fad., (kg) and volatile oil percentage were determined at the harvesting date (4th April during both seasons). Volatile oil was extracted from dried fruits by water distillation using Clevenger apparatus (Clevenger, 1928), then volatile oil percentage has been calculated. Herb contents (ppm) of nitrogen and phosphorus were determined according to AOAC (1975). Potassium content was determined in herb according to the method described by (Jackson, 1973).

Experiment Design and Statistical Analysis

The complete randomized block design (CRBD) was used in this experiment with three replicates. All collected data were analyzed with analysis of variance (ANOVA) procedure using MSTAT- C Statistical Software Package (Michigan State University, 1983). Differences between means were compared by using Duncan's multiple range tests at 0.05 (Duncan, 1955).

RESULTS AND DISCUSSION

Effect of AM Fungi Inoculation Combined with Foliar Spray of Licorice and Moringa Aqueous Extract on Vegetative Growth and Flowering Characters of Fennel Plant

Data illustrated in Table 2 show the effect of AM Fungi inoculation combined with spraying of licorice and moringa aqueous extracts on vegetative growth and flowering characters of fennel plants during 2013 -2014 and 2014-2015 seasons. Data clear that inoculated fennel plants with AM fungi and sprayed with L2 (40 g^l⁻¹) or L3 (60 g^l⁻¹) aqueous extract of licorice roots recorded the highest significant values of all growth and flowering parameters without significant difference between both treatments in most cases in the first season.

Table 2. Effect of AM Fungi inoculation combined with foliar spray with licorice and moringa aqueous extracts on vegetative growth and flowering of fennel plant during 2013/14 and 2014/15 seasons

Treatment		Plant height (cm)	Branch No.	Herb fresh weight (g)	Herb dry weight (g)	No. of umbels /plant	No. of umbellets /umbel
AMF inoculation	Foliar spray (g ^l ⁻¹)						
First season (2013-2014)							
Inoculated	Control	62.16 f	3.33 ef	37.58 f	9.81 f	5.66 hi	7.66 de
	L1	83.16 c	7.33 bc	58.45 bc	19.28 bc	9.00 a-c	9.66 ab
	L2	94.43 ab	8.33 ab	60.36 b	20.84 ab	9.33 ab	10.00 ab
	L3	98.03 a	9.33 a	66.02 a	22.69 a	9.66 a	10.33 a
	M1	80.83 c	7.00 cd	53.93 c-e	16.78 cd	7.33 d-g	9.00 bc
	M2	90.56 b	7.33 bc	60.36 b	18.86 bc	7.66 d-f	9.33 ab
	M3	93.96 ab	7.66 bc	61.57 ab	20.52 ab	8.33 b-d	9.50 ab
Un-inoculated	Control	53.33 g	2.88 f	34.85 f	9.68 f	5.33 i	6.50 e
	L1	60.77 f	4.33 e	51.90 de	14.90 de	7.33 d-g	7.33 de
	L2	73.83 d	6.00 d	54.90 cd	17.74 bc	7.66 d-f	7.66 de
	L3	82.18 c	7.33 bc	58.56 bc	19.37 bc	8.00 c-e	8.00 cd
	M1	57.60 fg	6.00 d	49.57 e	13.89 e	6.33 g-i	7.00 de
	M2	60.33 f	7.00 cd	54.22 c-e	17.25 cd	6.66 f-h	7.33 de
	M3	68.43 e	7.00 cd	55.35 cd	17.65 c	7.00 e-g	7.66 de
Second season (2014-2015)							
Inoculated	Control	64.16 e	4.33 f	39.48 g	11.83 g	6.66 cd	8.66 b-d
	L1	85.16 c	8.00 bc	60.84 b-d	20.82 b-d	8.66 b	8.77 bc
	L2	96.43 ab	8.33 b	62.29 bc	22.29 bc	9.33 b	9.66 b
	L3	100.03 a	9.70 a	67.74 a	24.88 a	10.66 a	11.33 a
	M1	82.90 c	6.33 e	57.50 c-e	20.83 b-d	8.33 bc	8.66 b-d
	M2	92.60 b	7.33 c-e	62.31 bc	21.66 b-d	9.00 b	9.00 bc
	M3	95.93 ab	7.66 b-d	64.98 ab	22.70 bc	9.33 b	9.66 b
Un-inoculated	Control	58.33 f	3.40 g	36.95 g	11.79 g	6.33 d	6.66 e
	L1	72.80 d	6.33 e	53.35 ef	17.91 e	7.33 b-d	7.33 de
	L2	85.30 c	7.00 de	56.20 d-f	19.73 de	7.66 bc	7.77 c-e
	L3	86.96 c	7.33 c-e	57.12 c-e	20.41 cd	8.22 bc	8.00 cd
	M1	66.36 e	6.50 e	51.59 f	15.67 f	7.00 cd	7.33 de
	M2	69.30 de	6.70 de	59.16 cd	19.23 de	7.33 b-d	8.00 cd
	M3	73.46 d	7.04 c-e	59.19 cd	19.95 de	7.66 bc	8.20 cd

Means having the same letter (s) within the same column are not significantly different according to Duncan's multiple range test at 5% level of probability

The same trend was observed in the second season, but only inoculated plants sprayed with 60 g l⁻¹ licorice extract (L3) gave the highest significant growth and flowering values; *i.e.*, (plant height, branch number, herb fresh and dry weights, number of umbels per plant and number of umbellets per umbel (100.03 cm, 9.70, 67.74 g, 24.88 g, 10.66 ; 11.33, respectively).

These results were in harmony with those found by El-Jawary (2002) on sweet pepper, Fayad (2005) on cucumber, Jibouri *et al.* (2005) on sweet pepper, Husain and El-Rekaby (2006) on cucumber, Kamal and Ghanem (2012) on snap bean, Nasser *et al.* (2014) on fenugreek and Hassan and Abd El-Samee (2015) on roselle. They reported that foliar spraying with licorice extract has a favorable biological effect on fresh and dry weights of plants, flowering, total yield and fruits quality of above mentioned crops.

This increase may be because of AMF can benefit plants by stimulating the production of growth regulating substances, increasing photosynthesis, improving osmotic adjustment under drought and salinity stresses and increasing resistance to pests and soil borne diseases (Al-Karaki, 2006).

Effect of AM Fungi Inoculation Combined with Foliar Spray of Licorice and Moringa Aqueous Extracts on Yield Parameters of Fennel Plant

Data presented in Table 3 show the effect of AM Fungi inoculation combined with spraying of licorice and moringa aqueous extracts on yield parameters of fennel plants during 2013/14 and 2014/15 seasons. Data clear that inoculating fennel plants with AM Fungi combined with L3 aqueous extract of licorice roots resulted in a significant increase in fruit No./umbel, fruit yield / plant and fruit yield/fad., (12.66, 17.51g and 490.28 kg, respectively) during the first season. The same trend was observed in the second season (13.00, 18.46 g and 516.88 kg, respectively).

The role of licorice aqueous extract as foliar spray may be due to that licorice roots extraction contains mainly glycyrrhizin, flavonoids, reducing and non-reducing sugars, plant gums, resins, essential oils, inorganic salts and low levels of nitrogenous constituents such as proteins, individual amino acids and nucleic acids (Isbrucker and Burdock, 2006).

On the other hand, volatile oil percentage data clear that there were no significant differences between AM fungi inoculation and un- inoculated on this regard.

Effect of AM Fungi Inoculation Combined with Foliar Spray Licorice and Moringa Aqueous Extracts on Chemical Constituents of Fennel Plant

Data in Table 4 show that nitrogen, phosphorus and potassium contents of the fennel herb were significantly affected by all treatments in both seasons. Fennel plants inoculated with AM Fungi combined with M3 aqueous extract of moringa leaves gave the highest herb contents of nitrogen (0.374 ppm in the first season and 0.385 ppm in the second season), phosphorus (0.275 ppm in the first and 0.283 ppm in the second season) and potassium (148.49 ppm in the first and 156.13 ppm in the second season).

The increase of herb content of nitrogen, phosphorus and potassium may be due to moringa leaf extract is a rich source of amino acids, potassium, calcium, iron, vitamin E, ascorbates, phenolic compounds and growth regulating hormones like zeatin (Makkar and Becker, 1996 ; Nagar *et al.*, 2006). Also, AM fungi Improved productivity of plants, that was attributed to enhanced uptake of immobile nutrients such as phosphorus, zinc, nitrogen and copper. AM fungi can be integrated in soil management to achieve low-cost sustainable agricultural systems (Hooker and Blackke, 1995).

Table 3. Effect of AM Fungi inoculation combined with foliar spray with licorice and moringa aqueous extracts on yield parameters of fennel plant during 2013/14 and 2014/15 seasons

Treatment		Fruit No. / umbel	Fruit yield / plant (g)	Fruit yield / fad. (kg)	Volatile oil (%)
AMF inoculation	Foliar spray (g l ⁻¹)				
First season 2013/14					
Inoculated	Control	8.66 ef	10.32 ef	288.96 ef	1.30 cd
	L1	10.00 cd	12.29 c	344.12 c	1.40 b-d
	L2	11.66 bc	13.53 b	378.84 b	1.60 a-c
	L3	12.66 a	17.51 a	490.28 a	1.80 a
	M1	9.66 c-e	11.32 d	316.96 d	1.30 cd
	M2	10.00 cd	12.41 c	347.48 c	1.50 a-d
	M3	10.66 cd	13.41 b	375.48 b	1.60 a-c
Un-inoculated	Control	7.33 g	8.83 g	247.24 f	1.20 d
	L1	8.40 e-g	10.14 f	283.92 f	1.30 cd
	L2	9.33 d-f	11.15 de	312.20 de	1.50 a-d
	L3	10.00 cd	12.57 bc	351.96 bc	1.72 a
	M1	8.33 fg	9.32 fg	260.96 f	1.20 d
	M2	8.66 ef	9.99 f	279.72 f	1.40 b-d
	M3	8.70 ef	10.20 ef	285.60 ef	1.60 a-c
Second season 2014/15					
Inoculated	Control	9.00 e-g	11.63 d-f	325.64 f	1.40 bc
	L1	10.33 b-e	13.05 cd	365.40 d	1.50 a-c
	L2	11.66 b	13.73 bc	384.44 c	1.70 ab
	L3	13.00 a	18.46 a	516.88 a	1.83 a
	M1	10.66 b-d	12.76 c-e	357.28 e	1.40 bc
	M2	11.00 b-d	13.03 cd	364.84 d	1.60 a-c
	M3	11.33 bc	14.74 b	412.72 b	1.80 a
Un-inoculated	Control	7.33 h	9.25 g	259.00 j	1.33 bc
	L1	8.66 fg	10.90 f	305.20 h	1.40 bc
	L2	9.66 d-g	12.85 cd	359.80 e	1.60 a-c
	L3	10.00 c-f	13.12 cd	367.36 d	1.80 a
	M1	8.33 gh	10.67 f	298.76 i	1.30 c
	M2	9.66 d-g	11.35 ef	317.80 g	1.50 a-c
	M3	9.80 d-f	11.56 d-f	323.68 f	1.70 ab

Means having the same letter (s) within the same column are not significantly different according to Duncan's multiple range tests at 5% level of probability.

Table 4. Effect of AM Fungi inoculation combined with licorice and moringa aqueous extracts on chemical constituents of fennel herb during 2013/14 and 2014/15 seasons

Treatment		N	P	K
AMF inoculation	Foliar spray (g l ⁻¹)	(ppm)	(ppm)	(ppm)
First season (2013-2014)				
Inoculated	Control	0.110 m	0.112 i	98.08 j
	L1	0.201 h	0.122 h	101.75 i
	L2	0.225 f	0.133 g	119.17 f
	L3	0.234 e	0.156 f	127.42 d
	M1	0.249 d	0.203 d	136.58 c
	M2	0.338 b	0.242 b	140.25 b
	M3	0.374 a	0.275 a	148.49 a
Un-inoculated	Control	0.105 n	0.102 j	62.33 n
	L1	0.166 l	0.107 ij	71.33 m
	L2	0.178 k	0.120 h	87.45 l
	L3	0.187 j	0.187 e	93.13 k
	M1	0.195 i	0.190 e	108.17 h
	M2	0.211 g	0.203 d	111.33 g
	M3	0.287 c	0.210 c	119.31 e
Second season (2014-2015)				
Inoculated	Control	0.125 l	0.121 i	102.22 j
	L1	0.211 h	0.130 h	112.33 i
	L2	0.233 f	0.141 g	130.33 e
	L3	0.242 e	0.164 f	136.44 d
	M1	0.260 d	0.212 d	145.12 c
	M2	0.342 b	0.250 b	151.33 b
	M3	0.385 a	0.283 a	156.13 a
Un-inoculated	Control	0.112 m	0.110 j	72.22 n
	L1	0.174 k	0.118 i	82.13 m
	L2	0.190 j	0.121 i	95.30 l
	L3	0.199 i	0.199 e	101.20 k
	M1	0.201 i	0.203 e	116.33 i
	M2	0.220 g	0.210 d	120.45 g
	M3	0.295 c	0.221 c	129.55 f

Means having the same letter (s) within the same column are not significantly different according to Duncan's multiple range test at 5% level of probability.

REFERENCES

- Abbas, R.N., A. Tanveer, A. Khaliq, A. Iqbal, A.R. Ghaffari, A. Matloob and Q. Maqsood (2013). Maize (*Zea mays* L.) germination, growth and yield response to foliar application of *Moringa oleifera* Lam. Leaf extracts. *Crop Environ.*, 4: 39-45.
- Al-Karaki, G.N. (2006). Nursery inoculation of tomato with arbuscular mycorrhizal fungi and subsequent performance under irrigation with saline water. *Scientia Hort.*, 109:1-7.
- Allen, M.F. (2011). Linking water and nutrients through the vadose zone: a fungal interface between the soil and plant systems. *J. Arid Land.*, 3: 155-163.
- Arystanova, T., M. Irismetov and A. Sophekova (2001). Chromatographic determination of glycyrrhizic acid in *Glycyrrhiza glabra* preparation. *Chem. Nat. Com.*, 37: 89-91.
- AOAC (1975). Association of Official Analytical Chemists. Official Methods of Analysis 12th Ed. Washington, D.C.
- Auge, R.M. (2001). Water relations, drought and vesicular-arbuscular mycorrhizal symbiosis. *Mycorrhiza*, 11: 3-42.
- Azcón, R., M.C. Perálvarez, B. Biró, A. Roldán and J.M. Ruiz-Lozano (2009). Antioxidant activities and metal acquisition in mycorrhizal plants growing in a heavy-metal multicontaminated soil amended with treated lingo cellulosic agrowaste. *Appl. Soil Ecol.*, 41: 168-177.
- Clevenger, J.F. (1928). Apparatus for the determination of volatile oil. *J. Ame. Assoc.*, 17: 346.
- Culver, M., T. Fanuell and A.Z. Chiteka (2012). Effect of moringa extract on growth and yield of tomato. *Greener J. Agric. Sci.*, 2 (5): 207-211.
- Dayananda, B., A.K. Raghavan, F. Khanum and B.A. Singh (2010). *In vitro* antioxidant and free radical scavenging activity of *Glycyrrhiza glabra* root extracts. *J. Herbal Med. and Toxicol.*, 4 (1): 97-102.
- Duncan, B.D. (1955). Multiple Ranges and Multiple F. test. *Biometrics*, 11:1- 42.
- El-Jawary, A.K. (2002). Effect of deferent foliar nutritions on growth and yield of sweet pepper. M.Sc. Thesis, Fac. Agric., Baghdad Univ., Iraq.
- Entry, J.A., P.T. Rygielwicz, L.S. Watrud and P.K. Donnelly (2002). Influence of adverse soil conditions on the formation and function of Arbuscular mycorrhizas. *Adv. Environ. Res.*, 7 (1): 123-138.
- Estaun, V., A. Camprubi and E.J. Joner (2002). Selecting Arbuscular Mycorrhizal Fungi for Field Application. In: *Mycorrhizal Technology in Agriculture* (Gianinazzi S., Schuepp H., Barea J.M., Haselwandter K., Eds.). Birkhauser Verlag, Berlin., 249-259.
- Fayad, M.H. (2005). Effect of foliar spraying with some plant growth regulators and plant extracts on growth and yield of cucumber plants. Ph.D. Thesis, Fac., Agric. Basra Univ., Iraq.
- Gerdemann, J.W. and T.H. Nicholson (1963). Spore of mycorrhizal endogone species extracted from soil by wet sieving and decanting. *Trans. Brit. Mycol. Soc.*, 5: 235-244.
- Gerdemann, J.W. and J.M. Trappe (1974). The Endogonaceae in the Pacific North West. *Mycologia* 5: 1-76.
- Hassan, H.M.S. and M.A.S. Abd El-Samee (2015). Growth, yield and nutritional value of *Hibiscus sabdariffa* L. as influenced by licorice and moringa aqueous extracts under North Sinai conditions. *Zagazig J. Agric. Res.*, 42 (5): 1069-1079.
- Hooker, J.E. and E. Blackke (1995). Arbuscular mycorrhizal fungi as components of sustainable soil-plant systems. *Crit. Rev. Biotechnol.*, 15: 201-212.
- Husain, W.A. and F.H. El-Rekaby (2006). Response of cucumber plants to foliar spray with garlic, licorice extract and urea on growth and yield. *Iraq. J. Agric. Sci.*, 37(4): 33-38.
- Isbrucker, R.A. and G.A. Burdock (2006). Risk and safety assessment on the consumption of licorice roots, its extract and powder as a food ingredient, with emphasis on the

- pharmacology and toxicity of glycyrrhizin", Regul. Toxicol. Pharmacol., 46 : 167-192.
- Jackson, M.L. (1973). Soil Chemical Analysis. Prentice-Hall. India Private Limited, New Delhi.
- Javaid, A. (2007). Allelopathic interactions in mycorrhizal associations. Allelopathy J., 20: 29-42.
- Javaid, A. (2009) Arbuscular mycorrhizal mediated nutrition in plants. J. Plant Nutr., 32: 1595-1618.
- Javaid, A. and T. Riaz (2008). Mycorrhizal colonization in different varieties of Gladiolus and its relation with plant vegetative and reproductive growth. Int. J. Agric. Biol., 10: 278-282.
- Javaid, A., K. Jabeen and A. Javaid (2007). Effect of NPK fertilizers and two types of green manures on growth and mycorrhizal colonization of wheat. Pak. J. Phytopathol., 19 (2):132-138.
- Jibouri, A.M., A.K. Al-Jawary and F.H. Al-Sahaf (2005). Effect of foliar fertilizer and liquid extract on TSS and vitamin C of sweet pepper fruits. The 6th Arabian Conf. for Hort., Ismailia, Egypt.
- Kamal, A.M. and K.M. Ghanem (2012). Impact of some bio-stimulants on organically cultivated snap bean plants. Egypt. J. Appl. Sci., 27(2): 89-104.
- Khaosaad, T., J.M. Garcia-Garrido, S. Steinkellner and H. Vierheilig (2007). Take-all disease is systemically reduced in roots of mycorrhizal barley plants. Soil Biol. Biochem., 39: 727-734.
- Makkar, H.P.S. and K. Becker (1996). Nutritional value and antinutritional components of whole and ethanol extracted *Moringa oleifera* leaves. Animal Feed Sci. and Technol., 63: 211-288.
- Menge, J.A. and L.W. Timmer (1982). Procedure for inoculation of plants with vesicular arbuscular mycorrhizae in the laboratory. Green house and field. In: Methods and principles of mycorrhizal research, St. Paul: American Phytopathol. Soc., 59.
- Michigan State University (1983). MSTAT-C Micro Computer Statistical Program, Version 2. Michigan State Univ., East Lansing.
- Morsi, M.K., B. El-Magoli, N.T. Saleh, E.M. El-Hadidy and H.A. Barakat (2008). Study of antioxidants and anticancer activity licorice *Glycyrrhiza glabra* extracts. Egyptian J. Nutr. and Feeds, 2 (33): 177-203.
- Nagar, P.K., R.I. Iyer and P.K. Sircar (2006). Cytokinins in developing fruits of *Moringa pterigosperma* Gaertn. Physiol. Plant, 55:45-50.
- Nasser, N.S., M.W. Mahdi and S.S. Abdullah (2014). The effect of spraying with licorice extract and organic fertilization of poultry in the growth of fenugreek plant (*Trigonella foenum-gracum* L.). Swedish J. Scien. Res., 1 (6): 36-42.
- Philips, J.M. and D.S. Hayman (1970). Improved procedures for clearing roots and staining parasitic and vesicular-arbuscular mycorrhizal fungi for rapid assessment of infection. Trans. Brit. Myco. Soc., 55: 158-161.
- Phiri, C. (2010). Influence of *Moringa oleifera* leaf extracts on germination and early seedling development of major cereals. Agric. Biol. J. North Ame., 1:774-777.
- Piccaglia, R. and M. Marotti (2001). Characterization of some italian types of wild fennel (*Foeniculum vulgare* Mill.) J. Agric. Food Chem., 49: 239-244.
- Plenchette, C., C. Clermont-Dauphenc, J.M. Meynard and J.A. Fortin (2005). Managing arbuscular mycorrhizal fungi in cropping systems. Can. J. Plant Sci., 85 (1): 31-40.
- Rady, M.M. and G.F. Mohamed (2015). Modulation of salt stress effects on the growth, physio-chemical attributes and yields of *Phaseolus vulgaris* L. plants by the combined application of salicylic acid and *Moringa oleifera* leaf extract. Scientia Hort., 193:105-113.
- Ravolanirina, F., V. Gianinazzi-Pearson and S. Gianinazzi (1987). Preliminary studies *in vitro* endomycorrhizal inoculation of micropropagated tree species of nutritional value, In: FSP. Trees and mycorrhizae. Proc. Asian Seminar, 91-101.

- Rossi, I. (1999). Medicinal Plants of the World. Chemical Constituents, Traditional and Modern Medicinal Uses. Human Press, Ottawa, USA., 2.
- Ruberto, G., M.B. Barattata, S.G. Deans and H.D.I. Dorman (2000). Antioxidant and antimicrobial activity of *Foeniculum vulgare* and *Crithmum maritimum* essential oils. Plant Medico., (66): 687-693.
- Smith, S.E. and D.J. Read (2008). Mycorrhizal Symbiosis. 3rd Ed. Academic Press, London, UK.
- Stary, F. and V. Jirasck (1975). A Coise Guide in Colour Herbs. Hamlyn; London, New York, Sydney, Toronto.
- Van der Heijden, M.G.A., R. Streitwolf-Engel and R. Riedl (2006). The mycorrhizal contribution to plant productivity, plant nutrition and soil structure in experimental grassland. New Phytologist. 172: 739-752.

تأثير التلقيح بالميكروهيذا والرشد الورقي بمستخلصات بعض النباتات على نمو وإنتاجية نبات الشمر

سونيا عطية شحاته عبدالله^١ - هاني محمد سامي حسن^١ - محمد أحمد إبراهيم أحمد منصور^٢

١- قسم الإنتاج النباتي - كلية العلوم الزراعية البيئية بالعريش - جامعة قناة السويس - مصر

٢- قسم علم النبات والميكروبيولوجي - كلية العلوم بالعريش - جامعة قناة السويس - مصر

أجريت هذه الدراسة بالمزرعة التجريبية لكلية العلوم الزراعية البيئية بالعريش - جامعة قناة السويس خلال الموسمين المتتاليين ٢٠١٤/٢٠١٣ و ٢٠١٥/٢٠١٤ لدراسة تأثير التلقيح بالميكروهيذا والرشد الورقي بالمستخلصات المائية لبعض النباتات على نمو وإنتاجية نبات الشمر، حيث تم الرش بالمستخلص المائي لكل من جذور العرقسوس بتركيزات صفر، ٢٠، ٤٠، ٦٠ جم/لتر وأوراق المورينجا بتركيزات صفر، ٢٠، ٤٠، ٦٠ جم/لتر وذلك برشها مرتين: الأولى بعد شهر من الزراعة، والثانية بعد اسبوعين من الأولى، وقد أظهرت النتائج المتحصل عليها أن نباتات الشمر التي تم تلقيحها بالميكروهيذا ورشها بتركيز ٤٠ أو ٦٠ جم/لتر بالمستخلص المائي لجذور العرقسوس سجلت أعلى القيم المعنوية لصفات النمو والتزهير بدون أي اختلافات معنوية بين تلك المعاملتين في معظم الحالات في الموسم الأول، وقد سجل نفس الاتجاه في الموسم الثاني فيما عدا النباتات الملقحة بالميكروهيذا والمعاملة بالرش بالمستخلص المائي لجذور العرقسوس بتركيز ٦٠ جم/لتر والتي أعطت أعلى القيم المعنوية لصفات النمو والتزهير على الترتيب التالي (ارتفاع النبات (سم)، وعدد الأفرع، الوزن الطازج والجاف للعشب (جرام)، وعدد النورات لكل نبات، وعدد النيرات لكل نورة) (١٠٠.٠٣ سم، ٩.٧٠، ٦٧.٧٤ جم، ٢٤.٨٨ جم، ١٠.٦٦ و ١١.٣٣ على التوالي)، أيضا أدى التلقيح بالميكروهيذا مع الرش بالمستخلص المائي لجذور العرقسوس بتركيز ٦٠ جم/لتر إلى زيادة معنوية في عدد الثمار/نورة، ومحصول الثمار/نبات (جم)، ومحصول الثمار/ فدان (كجم) (١٢.٦٦، ١٧.٥ جم، ٤٩٠.٢٨ كجم على التوالي) في الموسم الأول و(١٣، ١٨.٤٦ جم، ٥١٦.٨٨ كجم على التوالي) في الموسم الثاني، في حين أدى تلقيح نبات الشمر بالميكروهيذا مع الرش بالمستخلص المائي لأوراق المورينجا بتركيز ٦٠ جم/لتر إلى الحصول على أعلى محتوى للعشب من النيتروجين (٠.٣٧٤، ٠.٣٨٥ جزء في المليون)، والفسفور (٠.٢٧٥ جزء في المليون و ٠.٢٨٣ جزء في المليون) والبوتاسيوم (١٤٨.٤٩ و ١٥٦.١٣ جزء في المليون) لكلا الموسمين على التوالي.

المحكمون :

- ١- أ.د. محمد أحمد محمود علي أستاذ الزينة والنباتات الطبية والعطرية - كلية العلوم الزراعية البيئية بالعريش - جامعة قناة السويس.
- ٢- أ.د. هشام عبدالعال الشامي أستاذ الزينة والنباتات الطبية والعطرية - كلية الزراعة - جامعة الزقازيق.