USING MORINGA LEAF EXTRACT AS BIOSTIMULANT AND GIBERRELLIC ACID FOR ENHANCING FENNEL (*Foeniculum vulgare* var. *azoricum* Mill.) GROWTH AND OIL YIELD

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ABSTRACT

The field work was carried out at the experimental farm "Demo" in faculty of Agriculture, Fayoum university, during two successive seasons of 2013/2014 and 2014/2015. The present study aimed to investigate the effect of Giberrellic acid (GA_3) and Moringa leaf aqueous extract (ML_e) as individual and interaction on the growth, seed (fruit) yield, oil production and its main components and chemical constituents of Fennel plants. The results showed that spraying fennel plants at 150ppm (GA_3) plus 20% of (ML_e) gave the highest vegetative growth attributes; plant height, branches number plant^{-1} and fresh and dry weight plant^{-1}. Using 50 ppm of GA_3 along with 10% of ML_e concentration recorded the highest fruit yield plant^{-1}, fruit yield feddan^{-1}, oil yield plant^{-1} and feddan^{-1}, also the highest percentages of oil constituents; α-Pinene, Limonene, Eucalyptol, Fenchone and trans-Anethole but it gave the lowest content of Estragole, (which is undesirable component), compared to other treatments. While, the foliar application of 50ppm with 30% of ML_e concentration has resulted in the highest values in terms of number of umbels plant^{-1} and root length. The highest content of chlorophyll (a), (b) and carotenoids has been given from the interaction between 150ppm (GA_3) with 30% of (ML_e) concentrations. The highest contents of total carbohydrates percentage and the greatest essential oil percentage plant^{-1} were obtained from the moderate concentration of GA_3, (100ppm) combined with 20% of ML_e.

Hence, it can be recommended that for obtaining higher fruit yield plant^{-1} and feddan^{-1} and oil yield plant^{-1} and feddan^{-1}, Fennel plants should be sprayed with 50ppm of GA_3 plus 10% of ML_e concentration.

Keywords*: Fennel, Foeniculum vulgare, azoricum, Moringa oleifera extract, Gibberllic acid and essential oil*

INTRODUCTION

Fennel *Foeniculum vulgare,* Mill, which belongs to the family of Apiaceae is one of the most important medicinal and aromatic plants. Essential oil of fennel is used as flavouring agents 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). Traditionally in Europe and Mediterranean areas fennel is used as antispasmodic, diuretic, anti-inflammatory, analgesic, secretomotor, secretolytic, eye lotion, and antioxidant remedy and integrator (Gori

et al., 2012). Moreover, fennel fruits possess anticancer activity (Anand *et al*., 2008). Recently it was shown that fennel essential oil possesses emmenagogue and galactagogue properties (Babu *et al*., 2010). In addition, the volatile oils (1-3%) of fennel are used to control flatulent dyspepsia and colic in children (Mahfouz and Sharaf-Eldin, 2007). Antioxidant and antimicrobial activity of fennel has also been reported (Ruberto *et al*., 2000).

Giberrellic acid is one of the most important growth stimulating substances which is used in agriculture and occurs naturally in many plants. It regulates various important functions such as elongation of stems, creation of proteins and germination of seed plants (Yahaya and Gaya 2012). Gibberellins (GA_3) have been used in increasing stalk length and vegetative growth, flowers initiation, increasing fruit size, hastening maturity, improving fruit quality and controlling fruit cracking in horticultural crops. Earlier studies have reported that GA application (at 50, 100, and 500 g m^{-3}) as foliar spray on transplanted cuttings increased plant height (Sadowska *et al*., 1984). GA_3 play an important role in enhancing the growth and yield in fenugreek (Bagde *et al*., 1993). In some recent researches, GA_3 have been shown to improve herb yield in fenugreek (Deore and Bharud 1990), basil (Arularasu and Sambandamurthi 1999) and coriander (Badgujar and Warhal 1988, Verma and Sen 2008). Similarly, the positive effects of GA_3 on plant growth and development have been again reported by (Santos *et al.,* 1998) in *Ocimum* spp. Furthermore, Zeid *et al.,* 2001 stated that GA_3 treatment at 50 mgl^{-1} concentration resulted in the maximum seed production, essential oil yield, as well as the best quality of Fennel oil because of its high content of the flavor compounds, e.g. trance-anethole and fenchone. Singh, 2010 assured that the application of GA at 50 ppm gave significant effect on fenugreek vegetative and yield attributing characters as compared to water spraying. (Stella *et al.,* 2013), on tomato, reported that some combined applications of GA_3 promoted significant increases in the dry matter accumulation of roots and fresh and dry matter of fruit compared to the control. (Danesh-Talab *et al.,* 2014) stated that application of GA significantly increased shoot dry weight, 1000-seeds weight, number of seeds per pod, plant height, number of pods per plant, and root, stem, leaf and pod dry weight.

The world has become aware of environmental issue in recent years. Synthetic compounds are highly polluting, hazardous and much more costly. Researchers are working in the field of natural products extensively as they are less hazardous, low cost and easily available. The dependency on the use of inorganic fertilizers as a source of plant nutrients by farmers and their high cost is further associated with land and soil degradation and environmental pollution. *Moringa oleifera* (family: Moringaceae) is one of such alternatives, being investigated to ascertain its effect on growth and yield of crops and thus can be promoted among farmers as a possible supplement or substitute to inorganic fertilizers (Phiri, 2010). Thus, there is a continuous need to search for alternative safe natural sources of plant nutrients and natural growth regulators even for protecting against disease and insects. Moringa leaves gathered from various parts of the world were found to have high zeatin concentrations (up to 200 mcg/g) of leaves (Fuglie, 2000). Zeatin is one form of the most common forms which is naturally occurring cytokinin in plants not only plays an important role in cell

division and cell elongation that led to promote the growth of plants but also has anti-aging potential and protective effects in plants (Siddhuraju and Becker, 2003; Marcu, 2005; Nagar *et al*., 2006 and Anwar *et al*., 2007). In addition, fresh *Moringa oleifera* content of proteins, vitamins (such as A, B1, B2, B3, ascorbic acid and E), β carotene, amino acids phenolic compounds, sugars, and minerals (such as calcium, magnesium, sodium, iron, phosphorus and potassium) and several flavonoid pigments. Furthermore, ascorbic acid and foliar application have been reported to be growth and yield improving tools in various crops (Jyotsna and Srivastava 1998; Fuglie 2000; Foidl *et al*., 2001 and Nagar *et al*., 2006). So it is a good source of natural antioxidants (Anwar *et al*., 2007; Jacob and Shenbagaraman, 2011). Moreover, Moringia leaf extract has the potential to promote plant growth; hence, it is used as a natural plant growth enhancer. Moringa leaf extract was sprayed onto leaves (25ml.) of onions, bell pepper, soya beans, sorghum, coffee, tea, chili, melon and maize and was shown to increase yields of these crops. Also, the leaf extract of *M. oleifera* accelerated growth of young plants, strengthened plants, increased number of roots, produced more and larger fruits and generally increased yield by 20 and 35% (Fuglie, 2000). As well as, spraying wheat, peas and tomato with *M. oleifera* extract at 3.5% increased all growth parameters, productivity and crop characteristics (Azra, 2011). In addition, spraying rocket (*Eruca vesicaria* subsp. sativa) plants with the aqueous extracts of leaves and twigs of *M. oleifera* at rates of 1, 2 and 3% increased all measured growth criteria (plant height), the amounts of each of chlorophyll a and b, total sugars, ascorbic acid and N, P and K (Mona, 2013). The aqueous extract of moringa and N rates with interactions showed significant effects on the parameters; plant height, plant dry weight and fruit yield (Muhamman, 2013). Based on the result it was concluded that aqueous extract of moringa can compliment N on the production of tomato. Moreover, it was noticed that moringa extract at (4%) improved yield/ tree, number of fruits /tree and fruit weight of Pear (Sheren and Eman 2015).

MATERIALS AND METHODS

The present investigation was carried out at the Experimental Farm "Demo" in Faculty of Agriculture, Fayoum University, during two successive seasons of 2013/2014 and 2014/2015. This investigation aimed to study the effect of Moringa leaf aqueous extract and Gibberellic acid (GA_3) as individual and interaction effect on the growth, seed (fruit) yield, oil production and its main components and chemical constituents of Fennel plants.

Seeds of Fennel were obtained from Research Center of Medicinal and Aromatic Plants, Ministry of Agriculture, Egypt. Seeds were sown on 15th and 17th of Oct. (for two seasons, respectively). Five seeds were sown in each hill at 35cm apart and then were thinned (at the age of 30 days) to two plants. Plants received the normal agricultural practices as needed.

The layout of the experiment used was "factorial experimental" in complete randomized block design system with three replicates. Each replicate contained 3 plots each plot contained five rows. The plot area was 2.1× 3 m and included 5

rows each row was 60 cm apart and 2.1m in length. All the plants received recommended agriculture practices.

Moringa leaf extract and Gibberellic acid were added as foliar application at 0, 10, 20, 30% and 0, 50, 100, 150ppm respectively. Triton B at 0.1 % as a wetting agent was used. These applications were added three times /season. The first one was sprayed after 50 days from sowing, followed by the second and the third ones after 3 and 6 weeks from the first one, respectively.

The 10, 20 and 30% moringa aqueous extract was prepared by blending 100, 200, and 300g of young moringa leaves with 675 ml of 80% ethanol as suggested by (Makker and Becker 1996). The obtained suspension homogenized and filtered by wringing using a mutton cloth. Finally, the solution re-filtered using No. 2 Whatman filter paper and rose to one liter (Fuglie, 2000).

The mechanical and chemical analysis of soil used was carried out according to Klute (1986) and Page *et al.* (1982).

Table 1. *Some Mechanical and chemical analysis of used soil samples obtained from the experimental locations of Demo*

Years	Mechanical analysis									
	Sand %		Silt %		Clay %		Texture class			
2013/2014	78.29		14.93		9.81		Sandy loam			
2014/2015	77.97		15.95		8.68		Sandy loam			
Years	Available nutrients (mg/kg)									
	Soil pH	ECe	N	P	K	Fe	Mn	Zn	Mg	$CaCo_3$ %
2013/2014	7.81	3.71	17.53	9.77	1.67	2.27	4.83	0.33	8.77	10.3
2014/2015	7.83	3.73	18.67	8.81	1.60	2.25	5.91	0.35	8.71	9.9

Data recorded:

1- Vegetative growth:

At the age of 160 days (during vegetative stage), the outer two rows (1st and 5th) of each plot were chosen from each experimental unit and cut off at ground level and submitted to the following determinations:**-**

Plant height (cm), number of branches plant^{-1}, fresh and dry weight plant^{-1} (gm), root weight plant^{-1} (gm), root length (cm) plant^{-1}

2- Yield characters and Oil production:

At full maturity fruit stage (190 days), the central ridges were chosen from each experimental unit, to estimation the following yield characters:-

Number of umbels plant^{-1}, fruit yield plant^{-1} (gm), fruit yield feddan^{-1} (kg), essential oil (%) was determined in the fruits (seeds) using water distillation methods according to (British Pharmacopoeia, 1963)**,** Essential oil yield plant^{-1} (ml) was calculated in proportion to fruit weight,

$$\text{Oil yield} = \frac{\text{Fruit yield x Oil content (\%)}}{100} = \text{plant}^{-1}\text{(ml)}$$

Essential oil yield feddan^{-1} (L) and essential oil constituents: Gas chromatography-mass spectrometry analysis of essential oil (GC-MS): The

separation, identification and quantification of the main constituents of the essential oil were performed with a Shimadzu GC-17A gas chromatograph (Shimadzu Corp., Kyoto, Japan), coupled with a Shimadzu mass spectrometer detector (GC-MS QP-5050A). The separated components of the essential oil were identified by matching with the National Institute of Standards and Technology (NIST) mass spectral library data, comparison with those of authentic components and with published data (Adams, 2001). The quantitative determination was carried out based on peak area integration.

3- Chemical analysis:

In fresh leaves at the age of 160 days, Chlorophyll a,b and carotenoids contents were determined according to (Arnon 1949) and total carbohydrates content (%) in powedered dry matter of herb determined color-metrically according to Herbert *et al*. (1971).

4- Statistical analysis:

Results were statistically analysis using the LSD at probability level of 5 % for comparison (Gomez and Gomez 1983).

RESULTS AND DISCUSSION

I. Effect of Giberrelic acid (GA_3) of fennel plants:

1- Vegetative growth characters:

Data presented in Table (2) show that Giberrelic acid caused a gradual significant increase in plant height, the number of branches plant$^{-1,}$ fresh and dry weight plant^{-1} namely; the more the concentration was increased the more the highest values of these parameters were obtained. Treating the plants with 150 ppm concentration was the most effective treatment in this respect as it gave the highest results in both seasons. The approximate increase mean in plant height, the number of branches plant^{-1}, fresh and dry weight plant^{-1} for this treatment was 61.5, 75, 179.5 and 96.5% in both seasons, respectively than the control. On the other hand, the lowest concentration of GA_3 (50 ppm) gave the highest value of root length plant^{-1}. This treatment resulted in an increase of 20% than the control in both seasons.

While, treating Fennel plants with the moderate GA_3 concentration (100ppm) resulted in the highest root fresh weight plant^{-1} in both seasons. The application of this treatment recorded an increase of 72% in both seasons than the control.

Differences between values of all vegetative growth characters treatments are significant in both seasons.

These results are in agreement with those reported by (Sadowska *et al*., 1984), (Yahaya *et al*., 2012), (Badge *et al*., 1993), (Santos *et al.,* 1998), (ELNaggar *et al.,* 2009), (Singh 2010), (Stella *et al.,* 2013) and (Danesh-Talab *et al.,* 2014)

2- Yield characters and oil yield components:

Table (2) also, reveals that the use of the lowest concentration of GA_3 (50 ppm) recorded the highest results of umbels number plant^{-1}, fruit weight plant$^{-1,}$

fruit yield feddan^{-1}, essential oil yield plant^{-1} and essential oil yield feddan^{-1}. Such a treatment gave an increase of 25.5, 23, 23, 21.5 and 18.5% in both seasons, respectively compared to the control.

Whereas, essential oil percentage, was resluted from the moderate concentration (100ppm) of GA_3 increase than the control with 9% in both seasons.

Values mean differences were significant in all above mentioned yield characters and oil yield components in both seasons except for umbles number plant^{-1}.

Results mentioned above are correspondent to those detected by (Badge *et al*., 1993), (Deore and Bharud 1990), (Arularasu and Sambandamurthi 1999), (Badgujar and Warhal 1988, Verma and Sen 2008), (Zeid *et al*., 2001), (Masroor 2006), (Singh 2010), (Stella *et al*., 2013) and (Danesh-Talab *et al*., 2014).

3- Chemical constituents:

Presented data in Table (2) clarifies that untreated plants (0ppm) resulted in the highest values of Chlorophyll a,b and carotenoids contents in the fresh leaves mgg^{-1}

Table 2. *Effect of foliar application of (GA_3) and (Ml_e) of fennel plants*

GA_3 \ ML_e	Plant height plant^{-1} (cm) 1st season (2013\2014)					Plant height plant^{-1} (cm) 2nd season (2014\2015)				
	0 ppm	**50ppm**	**100ppm**	**150ppm**	**Mean**	**0ppm**	**50ppm**	**100ppm**	**150ppm**	**Mean**
0%	73.67	95.00	113.33	116.67	**99.67**	71.00	95.37	105.82	117.77	**98.76**
10%	83.42	104.00	103.33	110.00	**100.19**	76.80	96.08	103.21	109.95	**96.51**
20%	86.00	87.51	115.00	123.29	**102.95**	83.89	88.06	116.31	122.84	**102.25**
30%	92.55	92.51	115.23	116.67	**104.24**	91.76	97.28	115.11	120.75	**105.48**
Mean	**83.91**	**94.76**	**111.72**	**116.66**		**80.86**	**94.2**	**110.11**	**117.83**	
L.S.D 5%	**(a)= 7.44 (b) = n.s. (axb)=n.s.**					**(a)= 4.**73 **(b) = n.s. (axb)=n.s.**				
Number of branches plant^{-1}										
0%	4.00	4.67	**4.67**	6.33	**4.92**	3.30	3.59	3.59	5.37	**3.96**
10%	**4.00**	5.00	6.00	6.33	**5.33**	3.36	3.86	4.69	5.69	**4.40**
20%	4.33	4.33	5.67	7.33	**5.42**	3.46	3.41	4.72	6.52	**4.53**
30%	4.67	4.67	5.67	7.33	**5.59**	4.14	4.07	5.12	6.23	**4.89**
Mean	**4.25**	**4.67**	**5.50**	**6.83**		**3.57**	**3.73**	**4.53**	**5.95**	
L.S.D 5%	**(a)=0.53 (b) = n.s. (axb)=1.06**					**(a)= 0.37 (b) =n.s. (axb)=0.75**				
Fresh weight plant^{-1} (gm)										
0%	36.90	46.77	74.92	79.47	**59.52**	31.61	41.00	73.27	84.50	**57.60**
10%	55.23	87.77	83.07	88.20	**78.57**	56.90	81.93	86.08	86.12	**77.76**
20%	53.44	87.28	79.73	109.43	**82.47**	46.72	90.21	97.47	106.92	**85.33**
30%	86.64	96.90	107.20	108.07	**99.70**	76.26	97.46	98.10	99.55	**92.84**
Mean	**58.05**	**79.68**	**86.23**	**96.29**		**52.87**	**77.65**	**88.73**	**94.27**	
L.S.D 5%	**(a)= 14.67 (b)= 14.**89 **(axb)=29.35**					**(a)= 2.44 (b)=2.**25 **(axb)=4.87**				
Dry weight plant^{-1} (gm)										
0%	9.45	12.58	20.07	20.38	**15.62**	7.68	10.01	16.00	20.88	**13.64**
10%	12.76	18.87	20.33	23.47	**18.86**	12.73	17.97	18.78	23.33	**18.20**
20%	12.26	27.28	23.38	**35.75**	**24.67**	11.09	20.89	24.55	26.85	**20.85**
30%	21.85	21.46	25.65	31.42	**25.10**	18.14	21.07	25.20	26.38	**22.70**
Mean	**14.08**	**20.05**	**22.36**	**27.76**		**12.41**	**17.49**	**21.13**	**24.36**	
L.S.D 5%	**(a)= 4.**28 **(b)= 4.01 (axb)= 8.03**					**(a)= 1.**56 **(b)= 1.34 (axb)= 2.69**				
Root length plant^{-1} (cm)										
0%	10.33	16.00	12.00	15.33	**13.42**	8.48	15.82	10.30	13.99	**12.15**
10%	15.00	17.33	13.67	12.33	**14.58**	12.87	15.95	10.97	11.55	**12.84**

20%	17.17	17.33	16.00	12.33	**15.71**	14.09	14.77	13.80	12.64	**13.83**
30%	16.50	**18.00**	15.33	17.33	**16.79**	15.20	**16.17**	13.69	15.44	**15.13**
Mean	**14.75**	**17.17**	**14.25**	**14.33**		**12.66**	**15.68**	**12.19**	**13.41**	
L.S.D 5%	**(a)= 1.56 (b)= 1.**49 **(axb)=3.12**					**(a)= 0.8**2 **(b)=0.87 (axb)=1.74**				
Root fresh weight plant^{-1} (gm)										
0%	2.43	4.30	6.40	6.23	**4.84**	2.31	3.19	5.42	5.04	**3.99**
10%	3.11	6.83	8.60	6.93	**6.37**	2.85	5.57	5.13	5.41	**4.74**
20%	4.45	6.91	9.33	7.23	**6.98**	4.12	7.88	7.99	6.01	**6.50**
30%	8.93	7.77	**9.53**	8.90	**8.78**	6.95	6.32	**8.17**	7.43	**7.22**
Mean	**4.73**	**6.45**	**8.47**	**7.32**		**4.06**	**5.74**	**6.68**	**5.97**	
L.S.D 5%	**(a)= 1.**66 **(b)= 1.95 (axb)=n.s.**					**(a)= 0.**38 **(b)=0.49 (axb)= n.s.**				
Umbels number plant^{-1}										
0%	9.00	12.33	14.67	12.00	**12.00**	6.70	8.82	11.64	8.77	**8.98**
10%	14.00	14.00	13.33	14.67	**14.00**	9.92	11.20	11.20	10.75	**10.77**
20%	13.00	18.00	14.33	17.67	**15.75**	9.36	14.55	10.07	14.55	**12.13**
30%	18.33	**21.67**	15.33	15.67	**17.75**	14.40	**17.65**	12.01	11.98	**14.01**
Mean	**13.58**	**16.50**	**14.42**	**15.00**		**10.10**	**13.06**	**11.23**	**11.51**	
L.S.D 5%	**(a)=n.s. (b)=2.03 (axb)=4.06**					**(a)=n.s. (b)=1.69 (axb)=3.38**				
Fruit weight plant^{-1} (gm)										
0%	12.53	23.39	22.9	15.79	**18.65**	15.55	20.15	17.63	15.59	**17.23**
10%	14.88	**25.80**	21.65	23.83	**21.54**	14.94	**25.03**	23.02	22.94	**21.48**
20%	23.28	23.59	15.13	22.86	**21.22**	21.00	21.23	15.22	23.81	**20.32**
30%	22.23	20.43	18.43	21.73	**20.71**	21.63	19.97	18.23	23.19	**20.76**
Mean	**18.23**	**23.30**	**19.53**	**21.05**		**18.28**	**21.60**	**18.53**	**21.38**	
L.S.D 5%	**(a)=3.23 (b) =n.s. (axb)=6.45**					**(a)=2.**21 **(b) =n.s. (axb)=4.60**				
Fruit yield feddan^{-1} (kg)										
0%	751.80	1403.40	1374.00	947.40	**1119.15**	933.00	1209.00	1057.80	935.40	**1033.80**
10%	892.80	**1548.00**	1299.00	1429.80	**1292.40**	896.40	**1501.80**	1381.20	1376.40	**1288.95**
20%	1396.80	1415.40	907.80	1371.60	**1272.90**	1260.00	1273.80	913.20	1428.60	**1218.90**
30%	1333.80	1225.80	1105.80	1303.80	**1242.30**	1297.80	1198.20	1093.80	1391.40	**1245.30**
Mean	**1093.80**	**1398.15**	**1171.65**	**1263.15**		**1096.80**	**1295.70**	**1111.50**	**1282.95**	
L.S.D 5%	**(a)=194 (b) =n.s. (axb)=387**					**(a)=138 (b) =n.s. (axb)=276**				
Oil percentage plant^{-1} (%)										
0%	0.91	0.91	1.04	1.03	**0.97**	0.89	0.97	0.89	0.98	**0.93**
10%	1.26	0.97	1.03	1.01	**1.07**	1.12	1.03	1.02	0.99	**1.04**
20%	0.98	0.99	**1.34**	1.03	**1.09**	0.99	1.00	**1.27**	1.01	**1.07**
30%	1.03	1.03	1.27	1.01	**1.09**	1.03	1.00	1.13	1.02	**1.05**
Mean	**1.05**	**0.98**	**1.17**	**1.02**		**1.01**	**1.00**	**1.08**	**1.00**	
L.S.D 5%	**(a)=0.0**7 **(b)=0.05 (axb)=0.10**					**(a)=0.09 (b)=0.0**8 **(axb)=0.17**				
oil yield plant^{-1} (ml)										
0%	0.11	0.21	0.24	0.16	**0.18**	0.14	0.20	0.16	0.15	**0.16**
10%	0.19	**0.25**	0.22	0.24	**0.23**	0.17	**0.26**	0.23	0.23	**0.22**
20%	0.23	0.23	0.20	0.24	**0.22**	0.21	0.21	0.19	0.24	**0.21**
30%	0.23	0.21	0.23	0.22	**0.22**	0.22	0.20	0.21	0.24	**0.22**
Mean	**0.19**	**0.23**	**0.22**	**0.21**		**0.18**	**0.22**	**0.20**	**0.21**	
L.S.D 5%	**(a)=0.0**3 **(b)=0.0**2 **(axb)=0.06**					**(a)=0.03 (b)=0.0**2 **(axb)=0.06**				
oil yield feddan^{-1} (L)										
0%	6.84	12.77	14.29	9.76	**10.92**	8.30	11.73	9.41	9.17	**9.65**
10%	11.25	**15.02**	13.38	14.44	**13.52**	10.04	**15.47**	14.09	13.63	**13.31**
20%	13.69	14.01	12.16	14.13	**13.50**	12.47	12.74	11.60	14.43	**12.81**
30%	13.74	12.63	14.04	13.17	**13.39**	13.37	11.98	12.36	14.19	**12.98**
Mean	**11.38**	**13.61**	**13.47**	**12.87**		**11.05**	**12.98**	**11.87**	**12.85**	
L.S.D 5%	**(a)=1.73 (b)=1.53 (axb)=3.36**					**(a)=1.70 (b)=1.8**7 **(axb)=3.59**				

Chlorophyll A (mg g^{-1})										
0%	1.63	1.42	1.17	0.86	**1.27**	1.64	1.44	1.24	0.81	**1.28**
10%	1.15	1.23	0.98	0.61	**0.99**	1.30	1.22	1.01	0.64	**1.04**
20%	0.73	1.13	1.09	0.91	**0.97**	0.77	1.20	1.06	1.03	**1.02**
30%	1.48	1.18	0.87	**1.65**	**1.30**	1.49	1.25	0.81	**1.70**	**1.31**
Mean	**1.25**	**1.24**	**1.03**	**1.01**		**1.30**	**1.28**	**1.03**	**1.05**	
L.S.D 5%	**(a)=0.07 (b)=0.08 (axb)=0.16**					**(a)=0.08 (b)=0.09 (axb)=0.19**				
Chlorophyll B (mg g^{-1})										
0%	1.06	0.88	0.37	0.48	**0.70**	1.07	0.82	0.55	0.46	**0.73**
10%	0.78	0.78	0.63	0.40	**0.65**	0.75	0.76	0.65	0.48	**0.66**
20%	0.48	0.63	0.84	0.72	**0.67**	0.53	0.67	0.85	0.76	**0.70**
30%	0.98	0.77	0.46	**1.11**	**0.83**	0.92	0.73	0.43	**1.34**	**0.86**
Mean	**0.82**	**0.76**	**0.58**	**0.68**		**0.82**	**0.75**	**0.62**	**0.76**	
L.S.D 5%	**(a)=0.03 (b)=0.02 (axb)=0.05**					**(a)=0.03 (b)=0.03 (axb)=0.06**				
Chlorophyll C (mg g^{-1})										
0%	0.65	0.59	0.35	0.34	**0.48**	0.63	0.61	0.38	0.34	**0.49**
10%	0.41	0.5	0.45	0.34	**0.43**	0.43	0.54	0.45	0.34	**0.44**
20%	0.41	0.45	0.55	0.34	**0.44**	0.43	0.45	0.55	0.34	**0.44**
30%	0.56	0.49	0.46	**0.69**	**0.55**	0.57	0.49	0.47	**0.69**	**0.56**
Mean	**0.51**	**0.51**	**0.45**	**0.43**		**0.52**	**0.52**	**0.46**	**0.43**	
L.S.D 5%	**(a)=0.02 (b)=0.03 (axb)=0.04**					**(a)=0.02 (b)=0.03 (axb)=0.04**				
Total Carbohydrates content of herb (%)										
0%	10.22	12.82	10.17	14.15	**11.84**	9.11	10.91	11.25	10.73	**10.50**
10%	11.27	15.11	14.73	13.47	**13.65**	10.57	11.55	14.78	13.55	**12.61**
20%	12.73	13.95	**17.51**	12.11	**13.71**	11.82	12.57	**17.82**	13.55	**13.94**
30%	13.66	12.67	16.17	11.51	**12.91**	13.35	11.97	16.33	11.11	**13.19**
Mean	**11.02**	**13.64**	**14.65**	**12.81**		**11.21**	**11.75**	**15.05**	**12.24**	
L.S.D 5%	**(a)=1.12 (b)=1.02 (axb)=2.25**					**(a)=1.23 (b)=1.01 (axb)=2.31**				

followed by the lowest concentration (50ppm) of GA_3. The highest increase in vegetative growth and increase in cells size especially the elongation of cells resulted from the use of high Giberrellin concentrations consequently low content of Chlorophyll a,b and carotenoids was obtained.

As for the total carbohydrates content of herb, the highest records were obtained due to the application of 100ppm concentration of GA_3. Differences between values of these treatments were significant in both seasons.

II. Effect of Moringa leaf aqueous extract (Ml_e) of fennel plants:

1- Vegetative growth characters:

The show results in Table (2) state that (Ml_e) caused a gradual increase in all vegetative growth characters i.e., plant height, number of branches plant^{-1}, fresh and dry weight plant^{-1}, root fresh weight plant^{-1} and root length plant^{-1}. It is revealed that spraying the plants with (30%) concentration of (Ml_e) recorded the highest results in both seasons. The obtained values of this treatment in all parameters (30%) increase than the control with 6, 18.5, 64.5, 63.5, 25 and 81% in both seasons, respectively.

Differences between values of all vegetative growth characters treatments are significant while it was insignificant with plant height and number of branches plant^{-1} in both seasons. (Ml_e) has the potential to promote plant growth; hence, it used as a natural plant growth enhancer.

The given results are close to those declared by (Jyotsna and Srivastava 1998; Fuglie 2000; Foidl *et al*., 2001 and Nagar *et al*., 2006), (Fuglie, 2000), (Azra, 2011), (Muhamman, 2013) and (Mona, 2013).

2- Yield characters and oil yield components:

It is clarified from Table (2) as well, that spraying Fennel plants with the highest concentration of (Ml_e), 30%, resulted significantly in the highest records of umbels number plant^{-1} in both seasons. The increase occured by applying this treatment was of 52% than the control in both seasons.

On the other hand, using the lowest concentration (10%) gave the highest fruit weight plant^{-1} and fruit yield feddan^{-1} with insignificant differences between values in both seasons. Such treatments gave an increase of 20 and 20% in both seasons, respectively compared to the control treatment. The same concentration (10%) resulted also in the highest essential oil yield plant^{-1} and essential oil yield feddan^{-1} but with significant differences between values and an increase of 33 and 31% respectively in both seasons than the control.

Whereas, essential oil percentage was obtained from the moderate concentration (20%) of Ml_e in both seasons. Values of this treatment show significant differences between them in both seasons. The highest records obtained from using such a treatment increase than the control with 13.5% in both seasons.

These results are similar to those reported by (Jyotsna and Srivastava 1998; Fuglie 2000; Foidl *et al*., 2001 and Nagar *et al*., 2006), (Fuglie, 2000), (Azra, 2011) and (Muhamman, 2013).

3- Chemical constituents:

Results involved in Table (2) reveal that the 30% concentration of Ml_e caused the highest significant values of Chlorophyll a, b and carotenoids, contents in both seasons. While, the highest records of total carbohydrates content were produced from the 20% concentration of Ml_e in both seasons with significant differences between mean values.

These results are confirmed by authors like (Mona, 2013).

III. Effect of the interaction between (GA_3) and (Ml_e) of fennel plants:

1- Vegetative growth characters:

As indicated in Table (2), the interaction between 150ppm of GA_3 and 20% of Ml_e gave the highest significant values for the number of branches plant^{-1}, fresh and dry weight plant^{-1} and also the highest but insignificant records of plant height in both seasons.

Using 50 or 100ppm of GA_3 plus 30% of Ml_e concentration produced the significant or insignificant highest values of root length plant^{-1} and root fresh weight plant^{-1}, in both seasons, respectively.

The approximate increase mean in plant height, number of branches plant^{-1}, fresh and dry weight plant^{-1}, root fresh weight plant^{-1} and root length plant^{-1} for this treatments were 70, 90.5, 217.5, 264, 82.5 and 273% in both seasons, respectively than the control treatment.

2- Yield characters and oil yield components:

It is clarified from Table (2) as well, that spraying Fennel plants with 50 ppm of GA_3 with 30 or 10%, the concentration of (Ml_e), resulted significantly in the highest records of umbels number plant^{-1}, fruit weight plant^{-1}, fruit yield feddan^{-1}, essential oil yield plant^{-1} and essential oil yield feddan^{-1} in both seasons. Such a treatment gave an increase of 152, 83.5, 83.5, 106.5 and 103% in both seasons, respectively compared to the control treatment.

In this respect, also, using the moderate concentrations of GA_3 with (Ml_e) (100ppm + 20%) gave the highest essential oil percentage, in both seasons. Values of this treatment show significant differences between them in both seasons. The highest records obtained from using such a treatment in this character increase than the control with 45% in both seasons.

3. GC mass (analysis of the volatile oil constituents):

The GC-MS chemical analysis done on some treatments (Table 3) which have the highest effect upon vegetative growth and fruit and oil yield characters, show that 50ppm of GA_3 plus 10% of Ml_e recorded the highest percentages of α-Pinene (1.78%), Limonene (14.08%), Eucalyptol (4.18%), Fenchone (8.76%) and *trans*-Anethole (61.27%) but it gave the lowest content of Estragole (6.85 %), which is undesirable component, compared to other treatments. These constituents are found to have the highest concentrations among all Fennel essential oil components.

Table 3. *Chemical constituents (%) of the essential oils of fennel as affected by different treatments*

Treatments / **Compounds (%)**	**50ppm + 10%**	**100ppm + 10%**	**50ppm +10%**	**50ppm +20%**	**100ppm + 20%**	**150ppm + 20%**	**50ppm+ 30%**	**150ppm +30%**
***trans*-Anethole**	61.27	58.11	60.17	58.82	55.88	59.11	58.39	58.47
Limonene	14.08	13.21	9.99	11.82	11.53	13.11	11.99	10.94
Fenchone	8.76	6.11	8.21	6.45	5.99	7.97	7.82	6.73
Eucalyptol	4.18	3.01	3.11	3.74	2.05	2.22	2.55	3.47
α-Pinene	1.78	1.66	1.57	1.49	1.45	1.24	1.63	1.33
Estragole	6.85	13.21	12.37	12.82	18.19	11.94	12.99	13.98
β-Pinene	0.06	0.11	0.10	0.09	0.12	0.07	0.09	0.14
Myrcene	0.11	0.17	0.16	0.16	0.18	0.14	0.13	0.20
αPhellandrene	0.06	0.11	0.10	0.09	0.11	0.07	0.09	0.14
o-Cymene	0.19	0.39	0.27	0.36	0.46	0.25	0.33	0.51
γ Terpinene	0.11	0.19	0.31	0.40	0.24	0.24	0.29	0.27
Linalool	0.14	0.41	0.22	0.23	0.29	0.25	0.26	0.28
Camphor	0.08	0.11	0.10	0.09	0.13	0.07	0.09	0.14
Fenchyl acetate	0.08	0.11	0.10	0.09	0.13	0.07	0.09	0.14
Cumic aldehyde	0.09	0.17	0.16	0.16	0.18	0.14	0.13	0.20
p-Anisaldehyde	0. 11	0.41	0.29	0.42	0.40	0.43	0.42	0.34

4- Chemical constituents:

Results involved in table (2) reveal that the 30% concentration of Ml_e caused the highest significant values of Chlorophyll a, b and carotenoids, contents in both seasons. While, the highest records of total carbohydrates content were produced from the 20% concentration of Ml_e in both seasons with significant differences between mean values.

Concerning the interaction between (GA_3) and (Ml_e), revealed in Table (2), show that the highest levels of Chlorophyll a, b and carotenoids, contents were given from the interaction between the highest (GA_3) and (Ml_e), concentrations (150ppm with 30%), in the two seasons respectively, of study. Differences between all values were significant.From Table (2) it can be noticed that in both seasons of study the medium (GA_3) folair application (100ppm) and (Ml_e) (20%) produced the highest values of total carbohydrates (17.51 and 17.82%) for the first and second seasons, respectively, compared to other treatments of the duel interaction between (GA_3) and (Ml_e). The percentage of total carbohydrate obtained from the medium concentration of Giberrellin (100ppm) with the medium concentration of Moringa leaf extract at (20%) increases with approximately 71 and 96% than the control in the both seasons, respectively.

CONCLUSION

It can be summarized that, all concentrations led to a highly significant increase in all studied characters, namely; vegetative growth, fruit and oil yield and the chemical constituents. Among all concentrations of Giberrellin and Moringa leaf extract, the highest ones resulted in obtaining the optimum records of vegetative growth characters while the highest values of fruit and oil yield were resulted from the lowest concentrations. Giberrellic and Moringa's effect on Fennel plants completes and companies each other, that is to say, Giberrellin leads to increasing the cells size and elongation and consequently increasing the plant vegetative growth which affect the fruit and oil yield i.e., having the lowest amount of them, the thing which is compensed by using the highest concentrations of Moringa leaf extract because Moringa leaf extract is rich in proteins, vitamins (such as A, B1, B2, B3, ascorbic acid and E), β carotene, amino acids phenolic compounds, sugars, and minerals (such as calcium, magnesium, sodium, iron, phosphorus and potassium) and several flavonoid pigments. Furthermore, ascorbic acid and foliar application have been reported to be growth and yield improving tools in various crops which enhances and increases fruit and oil yield.

Of all treatments, the sole and the interaction, the interaction between Moringa and Giberrellin was of the most significant values in all studied characters compared to the sole treatments.

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