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Effect of Compost, Ascorbic Acid and Salicylic Acid Treatments on Growth, Yield and Oil Production of Fennel Plant

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Abstract

The present work was conducted during the two successive seasons of 2012/2013 and 2013/2014 to determine the effect of organic fertilization, foliar spray with ascorbic acid and salicylic acid as well as their interactions on growth, yield and oil production of fennel. Organic fertilizer was plant compost at 0, 8, 16 and 24 m^3/fed. The plants were sprayed with ascorbic acid and salicylic acid each at 0, 50, 100 and 200 ppm. The revealed results indicated that utilizing organic manure increased herb dry weight/plant, number of umbels/plant, fruit yield/plant and yield/fed. Volatile oil % and volatile oil yield/plant and per fed. The highest values of such parameters were obtained by adding compost at the high level (24 m^3/fed.). In most cases, spraying fennel plants with ascorbic acid or salicylic acid improved plant growth, fruit yield and oil production. Foliar spray with ascorbic acid at 100 ppm gave the maximum values of herb dry weight, fruit yield and volatile oil yield. The highest values of umbel number/plant were occurred by using ascorbic acid at 200 ppm in the first season and salicylic acid at 100 ppm in the second one. The application of ascorbic acid at 200 ppm registered the maximum values of volatile oil %. With regard to the interaction, the most of combined treatments showed a significant increase in all examined characters. The addition of compost at the high level (24 m^3/fed.) plus 100 ppm ascorbic acid gave the highest values of herb dry weight, number of umbels/plant, fruit yield and volatile oil yield. While, the use of compost at the high level in combination with 200 ppm ascorbic acid recorded the maximum values of volatile oil %. From the obtained results, it could be recommended, to supply fennel plants with plant compost at 24 m^3/fed in combination with foliar spray with ascorbic acid at 100 ppm to obtain better growth, high yield of fruit and volatile oil under this investigation conditions.

Introduction

Fennel (*Foeniculum vulgare* Mill) is an annual, biennial or perennial aromatic herb, depending on the variety, it belongs to Apiaceae Family (Farrell,K.T. (1988) and Wichtl and Bissel, 1994). It is widely cultivated as medicinal and aromatic plants in many countries including Egypt particularly in Middle Egypt such as El-Minia and Assiut governorates. The fruits contain essential oil which is utilized as carminative, flavoring agents and laxative preparations (Lawless, 1997). The fennel has been used in medicinal folklore as carminative, sedative stimulant and diuretic (Charles *et al*., 1993) and galactogogic, expectorant, emmenagogic and antispasmodic (Chiej, R. 1984). The oil contains a main compound namely fenchone that plays an important role in pharmaceutical, in-

dustries and confectionery (Abdallah *et al*., 1978).

Abou El-Fadl *et al*. (1990) reported that in order to augmenting the quality of crops especially medicinal and aromatic plants, the application of organic fertilization is more acceptable than mineral fertilization and organic farming have been quality standard to be matched well by small farmers in Egypt. The positive role of organic fertilization in increasing herb dry weight, umbels number, seed yield, volatile oil % and volatile oil yield were obtained by several investigators such as Badran and Safwat (2004), Mohamed and Ahmed (2003), Abdou and Mohamed (2003), Sharaf and Khatab (2004) and Azzaz *et al*. (2009) on fennel, Abou-Aly and Gomaa (2002), and Radwan and Farahat (2002), Abd El-Gawad (2007) and Rekaby (2013) on coriander, Shaalan (2005) and Somida *et al*. (2001) on *Nigella sativa*, Ali *et al*. (2014) on *Cassia acutifolia* and Hassan *et al*. (2015) on rosemary.

The efficiency of antioxidant such as salicylic acid and ascorbic acid in enhancing herb dry weight, umbels number, seed yield, volatile oil % and yield was studied by many authors, concerning salicylic acid applciatoin, Ali (2004) on *Tagetes minuta*, Hassan *et al.* (2010), Badran *et al*. (2011 and 2013) and Rekaby (2013) on coriander, Al-Shareif (2006), Abd El-Naeem (2008) and Eshak (2013) on caraway, Abdou *et al*. (2012) on cumin, Tanious (2008) on fennel and Hemdan (2008) on anise.

As for ascorbic acid, Ali *et al*. (2003), Badran *et al*. (2011 and 2013) and Rekaby (2013) on coriander, Ali *et al*. (2006) on anise, Al-Shareif (2006), Abd El-Naeem (2008) and Eshak (2013) on caraway, Gahory (2012) on *Nigella ativa*, Tanious (2008) on fennel and Kenawy (2010) on *Ammi visnaga*.

The aim of this work was to study the influence of organic fertilization and some antioxidants (salicylic acid and ascorbic acid) and their interactions on grotw, fruit yield and oil production of fennel.

Materials and Methods

The present study was conducted at the Experimental Farm, Fac. of Agric., Al-Azhar Univ., Assiut, during the two successive seasons of 2012/2013 and 2013/2014 to determine the influence of organic fertilization and some antioxidants namely, ascorbic acid and salicylic acid as well as their interactions on fennel (*Foeniculum vulgare* Mill) plant.

The experiment was arranged in split plot design with three replications, the main plots included compost (plant residues) as organic fertilizer levels whereas, and ascorbic acid and salicylic acid concentrations considered the sub-plots. Fennel seeds were obtained from Medicinal and Aromatic Plants Department, Agricultural Research Center, Egypt. The seeds were sown on Nov. 5th for the two seasons in 2x1.8 m plot containing 3 rows, 40 cm apart in hills, 60 cm apart on one side of the ridge. The growing seedlings were thinned to two plants/hill after 45 days from the planting date. Accordingly, the experimental unit contained 30 plants. Physical and chemical properties of the experimental soil are shown in Table (1). The utilized compost were

obtained from Pharaohs Factory for the production of compost, Wasti, Beni Suef, Egypt, and the chemical analysis of it was illustrated in Table (2). The used materials (ascorbic acid and salicylic acid) were obtained from Gomhoria company, Egypt. Such organic manure was added during preparing the soil for sowing in both seasons at four levels as follows:

1- control. 2- 8 m^3/fed. 3- 16 m^3/fed. 4- 24 m^3/fed. The plants were foliar sprayed with ascorbic acid and salicylic acid each at concentrations of 0, 50, 100 and 200 ppm three times at two week intervals starting January 10th of the two experimental seasons, one day period was allowed between the spraying of the two materials. All agricultural practices were performed as usual. At the harvesting time on the first week of May in both seasons, the following data were recorded: herb dry weight (g/plant), number of umbels/plant, fruit yield (g/plant), fruit yield (kg/fed.), essential oil % in the fruits, then essential oil yield (ml/plant) and liter/fed. were calculated. The essential oil in the fruits of fennel plant was extracted and determined according to the method described by Guenther (1961). All obtained data were statistically analyzed according to Little and Hills (1978).

Table 1. The physical and chemical properties of the used Soil (Average the two seasons).

Texture	PH (1:2.5)	E.C. (m.mohs/cm)	$CaCo_3$ %	O.M %	Total N %	Available		Water soluble Ions (meq/L) in the soil paste				
						P ppm	K (mg/100g soil)	Ca	Mg	$Co_3 + Hco_3$	CL	SO_4
Loamy	7.5	2.2	2.53	0.50	0.12	0.14	3.5	3.4	1.9	2.9	2.2	6.6

Table 2. The chemical analysis of the used compost. (Average the two seasons).

Content	Compost (plant residues)
$_P$H	7.0
E.C.(m.mhos/cm.)	1.94
Organic matter %	37.0
Organic carbon %	18.9
C : N Ratio	12 : 1
Total nitrogen %	1.20
Total phosphorus %	1.25
Total potassium%	1.05
Fe ppm	2397
Mn ppm	241
Zn ppm	46
Cu ppm	13

Results and Discussion

Herb dry weight (g)/plant:

The present data in Table (3) revealed that supplying fennel plants with organic manure as compost at all levels in the two experimental seasons, except the low and the medium ones in the second season led to a significant augment in herb dry weight compared to untreated plants. It is obvious that the high level of compost (24 m^3/fed.) registered the heaviest herb dry weight which increased it by 16.8% and by 11.8% over the check treatment in the first and second seasons, respectively. The positive effect of organic fertilization on enhancing the herb weight was obtained by Badran and Safwat (2004) Mohamed and Ahmed (2003) and Tanious (2008) and Abdou *et al.* (2012) on fennel and Rekaby (2013) on coriander.

with regard to antioxidant treatments, the listed data in Table (3) declared that spraying the plants with ascorbic acid and salicylic acid at all concentrations, except, 50 ppm salicylic acid in both seasons caused a significant increase in herb dry weight/plant in comparison with unsprayed plants in both seasons. From the obtained results, it is clear that the medium concentration of ascorbic acid (100 ppm) gave the maximum value of this trait as ranged 25.2% and 27.4% over control in the first and the second seasons, respectively.

The capability of ascorbic acid on increasing herb dry weight was detected by Tanious (2008) on fennel, Ali *et al*. (2003) and Badran *et al*. (2011 and 2013) and Rekaby (2013) on coriander and Ali *et al*. (2006) on anise.

The role of salicylic acid on augmenting herb dry weight was noticed by Tanious (2008) on fennel, Hemdan (2008) on anise and Abd El-Naeem (2008) and Eshak (2013) on caraway.

The interaction effect between the two studied factors on herb dry weight of fennel was significant in both seasons (Table3). The most combined treatments significantly increased herb dry weight compared to untreated ones in the two seasons. Obviously, the heaviest herb dry weight/plant was observed by using 24 m^3/fed compost plus foliar sprays with ascorbic acid at 100 ppm comparing to the other combination treatments in the two seasons.

Table 3. The influence of compost levels and treatments of ascorbic and salicylic acids on herb dry weight (g)/plant of fennel during 2012/2013 and 2013/2014 seasons.

First season						
Antioxidant concentrations (B) ppm		**compost levels (A)**				**Mean (B)**
		Control	**8 m^3**	**16 m^3**	**24 m^3**	
Control	**0**	84.3	91.5	97.0	106.3	94.8
Ascorbic acid	50	100.3	103.8	107.3	109.8	105.3
	100	111.6	122.3	114.0	127.0	118.7
	200	109.3	114.0	117.6	126.0	116.7
Salicylic acid	50	83.3	94.3	98.0	109.3	96.2
	100	90.6	98.6	102.0	111.6	100.7
	200	94.6	102.6	104.0	97.3	99.6
Mean (A)		96.3	103.9	105.7	112.5	
L.S.D $_{(0.05)}$		**A= 2.4**		**B= 3.7**		**AB= 7.4**
Second season						
Antioxidant concentrations (B)		**compost levels (A)**				**Mean (B)**
		Control	**8 m^3**	**16 m^3**	**24 m^3**	
Control	**0**	96.0	98.6	103.6	112.5	102.7
Ascorbic acid	50	114.1	104.0	108.5	115.0	110.4
	100	127.2	135.3	126.5	134.4	130.9
	200	119.6	123.0	127.2	129.8	124.9
Salicylic acid	50	96.6	96.6	104.0	114.2	102.9
	100	99.0	105.0	107.0	117.9	107.2
	200	103.3	108.0	112.3	121.0	111.2
Mean (A)		108.0	110.1	112.7	120.7	
L.S.D $_{(0.05)}$		**A= 5.1**		**B= 4.4**		**AB= 8.8**

Number of umbels/plant:

Data in Table (4) showed that number of umbels/plant of fennel was significantly increased compared to control in both seasons due to fertilizing the plants with compost at all levels, except the low one (8 m^3/fed) in the first season compared to the check treatment. It seems that the application of higher level of compost gave the highest value of umbels number/plant reached 28.3% and 25.7% over unfertilized plants in the firest and second seasons, respectively. The increment of umbels number/plant as result of utilizing organic manure was reported by Badran

and Safwat (2004), Tanious (2008) and Azzaz, *et al.* (2009) on fennel.

Concerning ascorbic acid and salicylic acid treatments, data reveals that all concentrations of both substances, except 200 ppm salicylic acid in the first season and 50 ppm ascorbic acid in the second one led to a significant augment in number of umbels/plant. Compared to unsprayed plants in the two seasons. It was found that foliar sprays with ascorbic acid at 200 ppm in the first season recorded the highest number of umbels/plant comparing to the other treatments.

In the second season, the use of 100 ppm salicylic acid gave the highest value of umbels number/plant comparing to other treatments. These superior treatments increased umbels number/plant by 28.8% and 20.6% over the check treatment in the first and second seasons, respectively (Table 4). The efficiency of ascorbic acid on enhancing number of umbels was insured by Tanious (2008) on fennel, Kenawy (2010) on *Ammi risvaga* and Rekaby (2013) on coriander. The positive effect of salicylic acid in augmenting number of ambles was studied by Tanious (2008) on fennel, Hemdan (2008) on anise and Rekaby (2013) on coriander.

Table 4. The influence of compost levels, and treatments of ascorbic and salicylic acids on number umbels/plant of fennel during 2012/2013 and 2013/2014 seasons.

First season						
antioxidant concentrations (B) ppm		**compost levels (A)**				**Mean (B)**
		Control	**8 m^3**	**16 m^3**	**24 m^3**	
Control 0		32.5	33.5	35.1	41.7	**35.7**
Ascorbic acid	50	33.4	34.3	41.2	51.0	**40.0**
	100	40.9	39.8	44.6	54.0	**44.8**
	200	44.5	44.1	47.5	48.0	**46.0**
Salicylic acid	50	31.8	37.2	38.3	41.5	**37.2**
	100	38.4	41.1	45.0	50.8	**43.8**
	200	33.1	34.0	37.3	40.2	**36.2**
Mean (A)		36.4	37.7	41.3	46.7	
L.S.D $_{(0.05)}$		**A= 1.5**		**B= 1.4**		**AB= 2.9**
Second season						
antioxidant concentrations (B) ppm		**compost levels (A)**				**Mean (B)**
		Control	**8 m^3**	**16 m^3**	**24 m^3**	
Control 0		33.6	38.1	40.0	51.0	**40.7**
Ascorbic acid	50	36.0	39.6	40.8	50.0	**41.6**
	100	41.7	42.3	44.8	53.2	**45.5**
	200	39.2	46.7	47.1	46.5	**44.9**
Salicylic acid	50	44.9	45.4	46.3	52.6	**47.3**
	100	46.0	49.3	49.1	52.0	**49.1**
	200	41.3	44.3	44.9	50.0	**45.1**
Mean (A)		**40.4**	**43.7**	**44.7**	**50.8**	
L.S.D $_{(0.05)}$		**A= 2.2**		**B= 2.0**		**AB= 4.0**

The combined effect between the two factors on umbels number plant of fennel was statistically significant in both seasons. (Table 4). The most effective treatment was detected due to receiving the plants the high level of compost + 100 ppm ascorbic acid in comparison with those obtained by other combination treatments in both seasons.

Fruit yield/plant and per fed:

The obtained data in Tables (5 and 6) indicated that with increasing the level of compost significantly increased fruit yield/plant and/fed. of fennel in the two seasons. Obviously, the addition of compost at the high level (24 m^3/fed) produced the maximum value of fruit yield/plant and per fed. sa recorded it by 31.8% and 35.8% over the check treatment in the firest and second seasons, respectively.

The positive effect of organic manure on augmenting fruit yield was reported by Sharaf and Khattab (2004) and Azzaz *et al*. (2009) on fennel and Abou-Aly and Gomma (2002) and Radwan and Farahat (2002) on coriander.

As for ascorbic acid and salicylic acid treatments, the recorded data in Tables (5 and 6) shows that fruit yield/plant and per fed. of fennel was significantly increased resulting from a foliar spray with the two examined materials at all concentrations in both seasons, comparing to untreated ones, except salicylic acid at the low concentration (50 ppm) and the high one (200 ppm) in the first season. In this concern, utilizing the medium concentration of ascorbic acid (100 ppm) registered the heaviest fruit yield/plant and per fed. as recorded 25% and 25.8% over control in the first and second seasons, respectively.

The increase in fruit yield due to applying ascorbic acid was detected by Tanious (2008) on fennel, Kenawy (2010) on *Ammi visnaga* and Ghahory (2012) on *Nigella sativa*. The stimulating effect of salicylic acid on enhancing fruit yield was studied by Tanious (2008) on fennel, Badran *et al*. (2011 and 2013) and Rekaby (2013) on coriander and Hemdan (2008) on anise.

Table 5. The influence of compost levels and treatments of ascorbic and salicylic acids on fruit yield (g)/plant of fennel during 2012/2013 and 2013/2014 seasons.

First season						
Antioxidant concentrations (B) ppm		Compost levels (A)				Mean (B)
		Control	8 m^3	16 m^3	24 m^3	
Control 0		45.7	54.7	58.0	60.0	**54.6**
Ascorbic acid	50	50.8	58.5	74.6	78.3	**65.6**
	100	53.8	60.5	77.2	81.6	**68.3**
	200	57.2	61.5	70.2	74.0	**65.7**
Salicylic acid	50	50.0	54.3	56.4	58.5	**54.8**
	100	52.5	55.6	58.0	61.9	**57.0**
	200	50.5	51.9	57.3	60.9	**55.2**
Mean (A)		**51.5**	**56.7**	**64.5**	**67.9**	
L.S.D (0.05)		A= 1.5		B= 1.5		AB= 3.0
Second season						
Antioxidant concentrations (B) ppm		Compost levels (A)				Mean (B)
		Control	8 m^3	16 m^3	24 m^3	
Control 0		53.3	58.5	61.3	79.1	**63.1**
Ascorbic acid	50	61.2	66.0	64.0	87.8	**69.8**
	100	72.5	72.8	78.2	94.0	**79.4**
	200	59.5	72.6	85.6	90.5	**77.1**
Salicylic acid	50	62.3	67.5	74.3	86.0	**72.5**
	100	66.6	73.4	79.3	79.8	**74.8**
	200	62.2	60.8	63.3	77.0	**65.8**
Mean (A)		**62.5**	**67.4**	**72.3**	**84.9**	
L.S.D (0.05)		A= 1.4		B= 1.0		AB= 2.0

Table 6. The influence of compost levels and treatments of ascorbic and salicylic acids on fruit yield ton/feddan of fennel during 2012/2013 and 2013/2014 seasons.

First season						
Antioxidant concentrations (B) ppm		Compost levels (A)				Mean (B)
		Control	8 m^3	16 m^3	24 m^3	
Control		1.523	1.823	1.933	2.000	**1.820**
Ascorbic acid	50	1.693	1.950	2.487	2.610	**2.185**
	100	1.793	2.017	2.573	2.720	**2.276**
	200	1.907	2.050	2.340	2.447	**2.186**
Salicylic acid	50	1.667	1.810	1.880	1.950	**1.827**
	100	1.750	1.854	1.933	2.062	**1.900**
	200	1.683	1.730	1.910	2.030	**1.838**
Mean (A)		**1.717**	**1.891**	**2.151**	**2.260**	
L.S.D (0.05)		A= 0.044		B= 0.055		AB= 0.110
Second season						
Antioxidant concentrations (B) ppm		Compost levels (A)				Mean (B)
		Control	8 m^3	16 m^3	24 m^3	
Control 0		1.777	1.950	2.043	2.636	**2.102**
Ascorbic acid	50	2.040	2.200	2.133	2.927	**2.325**
	100	2.417	2.409	2.607	3.133	**2.642**
	200	1.983	2.420	2.853	3.017	**2.568**
Salicylic acid	50	2.077	2.250	2.477	2.867	**2.418**
	100	2.210	2.447	2.643	2.660	**2.490**
	200	2.073	2.026	2.110	2.567	**2.194**
Mean (A)		**2.082**	**2.243**	**2.409**	**2.830**	
L.S.D (0.05)		A= 0.044		B=0.032		AB= 0.064

According to the interacting between the two examined factors, data in Tables (5 and 6) appeared significant effects on fruit yield/plant and per fed. of fennel in both seasons. Obviously, fertilizing fennel plants with the most combined treatments caused a significant increase in fruit yield/plant and per fed. as compared to untreated plants in the two experimental seasons. Supplying the plants with compost at the high level (24 m^3/fed) + 100 ppm ascorbic acid was the most effective treatment in comparison with that obtained by other combination treatments in the two consecutive seasons.

Volatile oil production:

Volatile oil %:

The listed data in Table (7) clearly that the application of organic manure (compost) at all levels in both seasons except the low level in the two seasons, significantly increased volatile oil % in fennel fruits as composed to no sprayed control. The maximum value of volatile oil % was obtained by using compost at the high level (24 m^3/fed) which increased it by 36.6% and by 15% over ones in the first and the second seasons, respectively. The role of organic manure in augmenting volatile oil % was insured by Shaalan (2005) and Somida *et al*. (2001) on *Nigella sativa*, Ali *et al*. (2014) on *Cassia acutifolia* and Rekaby (2013) on coriander.

With respect to ascorbic acid and salicylic acid treatments, the revealed data in Table (7) emphasized that all of them, in both seasons, except salicylic acid at 100 and 200 ppm in the first season led to a significant augment in volatile oil % as compared to the check treatment. The use of ascorbic acid at the high concentration (200 ppm) gave the maximum value of volatile oil % as ranged 23% and 25.4% over control in the two experimental seasons respectively. The positive effect of ascorbic acid on augmenting volatile oil % was studied by Tanious (2008) and Eshak (2013) on caraway. The promoting effect of salicylic acid on enhancing volatile oil % was reported by Abdou *et al*. (2012) on cumin, Tanious (2008) on fennel and Hassan *et al.* (2010) on coriander.

Table 7. The influence of compost levels, ascorbic acid and salicylic acid treatments on volatile oil (%) in the fruit of fennel during 2012/2013 and 2013/2014 seasons.

First season						
Antioxidant concentrations (B) ppm		Compost levels (A)				Mean (B)
		Control	8 m^3	16 m^3	24 m^3	
Control 0		1.88	1.73	2.48	2.63	2.18
Ascorbic acid	50	1.93	2.20	2.60	2.77	2.37
	100	2.15	2.49	2.78	2.93	2.59
	200	2.17	2.60	2.87	3.07	2.68
Salicylic acid	50	1.93	1.93	2.85	2.91	٢,٤١
	100	1.95	2.03	2.30	2.40	2.17
	200	1.90	1.83	2.05	2.33	2.03
Mean (A)		1.99	2.12	2.56	2.72	
L.S.D (0.05)		A= 0.25		B= 0.15		AB= 0.2٩
Second season						
Antioxidant concentrations (B) ppm		Compost levels (A)				Mean (B)
		Control	8 m^3	16 m^3	24 m^3	
Control 0		2.10	2.33	2.25	2.42	2.28
Ascorbic acid	50	2.45	2.68	2.73	2.88	2.69
	100	2.47	2.83	2.90	2.95	2.79
	200	2.72	2.63	3.00	3.10	2.86
Salicylic acid	50	2.43	2.52	2.68	2.86	2.62
	100	2.36	2.76	2.72	2.60	2.61
	200	2.34	2.50	2.92	2.55	2.58
Mean (A)		2.41	2.61	2.74	2.77	
L.S.D (0.05)		A= 0.31		B= 0.22		AB= 0.45

The interaction between the two studied factors was statistically significant on volatile oil % of fennel fruits in the two experimental seasons. However, it is clear that the most of combined treatments caused a significant augment in volatile oil % as compared to untreated plants in the two seasons. Treating fennel plants with 24 m^3/fed compost in combination with 200 ppm ascorbic acid registered the maximum value of this trait in comparison with that obtained by other combination treatments in both seasons, as clearly declared in Table (7) Essential oil yield/plant and/fed:

The registered data in Tables (8 and 9) postulated that supplying fennel plants with compost at all levels, in both seasons, led to a significant increase in volatile oil yield/plant and/fed. comparing to the check treatment. The maximum values of volatile oil yield/plant was obtained due to applying the high level of compost which augmented it by 80% and 62.7% over unfertilized ones in the first and the second seasons, respectively. The positive effect of organic manure on augmenting volatile oil yield was reported by Abdou and Mahmoud (2003) and Sharaf and Khattab (2004) on fennel.

Table 8. The influence of compost levels and treatments of ascorbic and salicylic acids on volatile oil (ml)/plant of fennel during 2012/2013 and 2013/2014 seasons.

First season						
antioxidant Concentrations (B) ppm		compost levels (A)				Mean (B)
		Control	8 m^3	16 m^3	24 m^3	
Control 0		0.86	0.95	1.44	1.58	1.21
Ascorbic acid	50	0.98	1.28	1.94	2.16	1.59
	100	1.16	1.50	2.14	2.40	1.80
	200	1.24	1.60	2.01	2.27	1.78
Salicylic acid	50	0.97	1.05	1.61	1.70	1.33
	100	1.02	1.13	1.33	1.48	1.24
	200	0.96	0.95	1.17	1.42	1.13
Mean (A)		1.03	1.21	1.66	1.86	
L.S.D (0.05)		A= 0.15		B= 0.10		AB= 0.19
Second season						
antioxidant concentrations (B) ppm		compost levels (A)				Mean (B)
		Control	8 m^3	16 m^3	24 m^3	
Control 0		1.12	1.37	1.38	1.91	1.45
Ascorbic acid	50	1.50	1.77	1.75	2.53	1.89
	100	1.79	2.06	2.27	2.77	2.22
	200	1.62	1.91	2.57	2.80	2.23
Salicylic acid	50	1.52	1.70	1.99	2.46	1.92
	100	1.57	2.02	2.15	2.08	1.96
	200	1.45	1.52	1.85	1.97	1.70
Mean (A)		1.45	1.77	1.٩٩	2.36	
L.S.D (0.05)		A= 0.08		B= 0.17		AB= 0.34

Table 9. The influence of Compost levels and treatments of Ascorbic and Salicylic acids on volatile oil (L) per feddan of fennel during 2012/2013 and 2013/2014 seasons.

First season						
antioxidant concentration (B) ppm		compost levels (A)				Mean (B)
		Control	8 m^3	16 m^3	24 m^3	
Control 0		28.719	31.531	47.967	52.742	**40.240**
Ascorbic acid	50	32.683	42.810	64.525	72.099	**53.029**
	100	38.550	50.129	71.486	79.848	**60.003**
	200	41.344	53.338	67.047	75.607	**59.334**
Salicylic acid	50	32.261	34.948	53.666	56.696	**44.393**
	100	34.103	37.617	44.249	49.482	**41.363**
	200	31.991	31.708	39.071	47.416	**37.546**
Mean (A)		**34.236**	**40.297**	**55.430**	**61.984**	**47.987**
L.S.D (0.05)		A= 6.595		B= 4.373		AB= 8.900
Second season						
Antioxidant Concentration (B) ppm		Compost levels (A)				Mean (B)
		Control	8 m^3	16 m^3	24 m^3	
Control 0		37.278	45.651	45.989	63.801	**48.180**
Ascorbic acid	50	50.004	59.029	58.283	84.266	**62.896**
	100	59.633	68.781	75.646	92.457	**74.129**
	200	53.889	63.812	85.607	93.432	**74.185**
Salicylic acid	50	50.572	56.543	66.381	82.083	**63.895**
	100	52.382	67.457	71.795	69.243	**65.219**
	200	48.466	50.668	61.666	65.606	**56.602**
Mean (A)		**50.318**	**58.849**	**66.481**	**78.698**	**63.587**
L.S.D (0.05)		A= 6.478		B= 5.548		AB= 10.927

It worthy mention that a foliar spray with ascorbic acid and salicylic acid at all concentrations, in the two seasons, except 100 and 200 ppm salicylic acid in the first season led to a significant increase in volatile oil yield/plant and/fed. of fennel in comparison with no sprayed plants. Obviously, it could be noticed that utilizing 100 ppm ascorbic acid produced the best result of volatile oil yield/plant and fed. reached 48.7% and 53% over untreated ones in the two growing seasons, respectively, as clearly indicated in Tables (8 and 9). The positive effect of ascorbic acid on augmenting volatile oil yield was studied by Tanious (2008) on fennel and Abd El-Naeem (2008) and Eshak (2013) on caraway. The promoting effect of salicylic acid on enhancing volatile oil yield was reported by Abdou *et al*. (2012) on cumin, and Tanious (2008) on fennel. As far as the combined effect on volatile oil yield/plant and/fed. of fennel, the listed data in Tables (8 and 9) revealed that there were statistically significant differences in the two experimental seasons. It is obvious that these traits were significantly augmented as a result of using the most combined treatments in comparison with untreated plants in the two seasons. However, the treatment with compost at the high level plus ascorbic acid at 100 ppm produced the better values of volatile oil yield/plant and/fed. as compared to these obtained by other combination treatments in both seasons.

From the obtained results, it could be discussed as follows: The promoting effect of organic manure on growth, fruit yield and oil production of fennel plants may be attributed to the role of organic fertilizer in physiological and biological process whereas, Bohn *et al*. (1985) emphasized that organic matter as a source of N, P, S and contains high content of B and Mo. In addition organic matter has source of energy for *Azotobacter* growth. Follet *et al*. (1981) demonstrated that some of beneficial effect of organic manure for example: enhancing soil properties, water holding capacity and increasing total N, organic matter and humus in soil as well as releasing essential nutrients by microbial decomposition and also making frost micronutrients more readily available at a wide range of pH. Taiwo *et al*. (2002) reported that microbial activities in root zone was increased by the application of organic manure. Humic substances have to be direct influence on growth which assuming a hormonal action of humic substances (Varanini and Pinton, 1995). The same previous authors showed that soil organic matter supplies nutrients, it is a buffer against pH change it protects against salt toxicity and heavy metal, it prevents leaching of nutrients and it supports microorganisms which recycle nutrients and the formation of soil. The enhancement of growth, fruit yield and oil production of fennel due to applying ascorbic acid and salicylic acid might be attributed to the positive, biological and physiological roles of these substances, where that ascorbic acid is considered as an antioxidant that protect the plant against damage as a result of aerobic metabolism and pollutants range. It is involved in establishing the local and systemic disease resistance response of plants after pathogen attack (Alvarez, 2000). It induce flowering retard senescence and augment the rate of cell metabolic and the sustained level of salicylic acid may be a prerequisite for auxin

and/or it plays an important role as coenzyme. Also, it is a significant resistance against many plant pathogens i.e. bacteria, fungi, nematode and parasitic plants (Oertil, 1987 and Mahdy, 1994). As for salicylic acid, it is classified as a plant hormone (Raskin, 1992). It plays regulatory role in plant metabolism (Popova *et al*., 1997). Romani *et al*. (1989) proved that salicylic acid affects the biosynthesis of ethylene, stomatal movement and reserves the influence of ABA on leaf abscission.

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تأثير معاملات الكمبوست وحامض الأسكوربيك وحامض السالسيليك علي النمو والمحصول وانتاج الزيت لنبات الشمر

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الملخص

أجريت هذه التجربة خلال موسمين متتاليين ٢٠١٢/٢٠١٣ و ٢٠١٣/٢٠١٤ لدراسة تأثير التسميد العضوي والرش بحامض الأسكوربيك وحامض السالسيليك والتداخل بينهما علي النمو والمحصول وإنتاج الزيت لنبات الشمر. ولقد أضيف السماد العضوي علي صورة سماد الكمبوست بمعدلات صفر ، ٨ ، ١٦ ، ٢٤ م^{٣}. وتم رش النباتات بكلا الحامضين بتركيز صفر ، ٥٠ ، ١٠٠، ٢٠٠ جزء في المليون لكل منهما. وكانت أهم النتائج المتحصل عليها كالتالي:

أدي التسميد العضوي إلي تحسين الوزن الجاف للعشب/نبات وعدد النورات/نبات ومحصول الثمار/نبات ومحصول الثمار/فدان والنسبة المئوية للزيت الطيار ومحصول الزيت الطيار للنبات وللفدان. ولقد سجل المعدل العالي من سماد الكمبوست أعلي القيم بالنسبة لهذه الصفات السابقة. في معظم الحالات أدي الرش بكل من حامض الأسكوربيك وحامض السالسيليك إلي تحسين النمو والمحصول وإنتاج الزيت. أتضح ايضاأن أعلي القيم بالنسبة للوزن الجاف للعشب ومحصول الثمار ومحصول الزيت الطيار تم الحصول عليها عند الرش بحامض الأسكوربيك بتركيز ١٠٠ جزء في المليون. أما بالنسبة لعدد النورات/نبات فإن أعلي القيم تم الحصول عليها عند استعمال حامض الأسكوربيك بتركيز ٢٠٠ جزء في المليون في الموسم الأول، وحامض السالسيليك بتركيز ١٠٠ جزء في المليون في الموسم الثاني. أدي الرش بحامض الأسكوربيك بتركيز ٢٠٠ جزء في المليون إلي الحصول علي أعلي القيم بالنسبة للنسبة المئوية للزيت الطيار. أدت معظم معاملات التداخل إلي زيادة معنوية في الصفات تحت الدراسة. وأكثر المعاملات تأثيراً كانت عند إضافة الكمبوست بالمعدل العالي (٢٤ متر مكعب/فدان) + الرش بحامض الأسكوربيك بتركيز ١٠٠ جزء في المليون وذلك للحصول علي أعلي القيم الخاصة بالوزن الجاف للعشب وعدد النورات ومحصول الثمار ومحصول الزيت الطيار، ولقد تبين أن أعلي القيم للنسبة المئوية للزيت الطيارنتجت عند استعمال المعدل العالي من الكمبوست + حامض الأسكوربيك بتركيز ٢٠٠ جزء في المليون. ويمكن التوصية بإمداد نباتات الشمر بسماد الكمبوست بمعدل ٢٤ م^{٣}/ فدان مع الرش بحامض الأسكوربيك بتركيز ١٠٠ جزء في المليون للحصول علي أفضل نمو ومحصول عال من الثمار والزيت الطيار تحت ظروف هذا البحث.