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MINIMIZING THE EFFECT OF SOIL SALINITY ON FENNEL PLANT USING CYANOBACTERIA AND COMPOST

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ABSTRACT

This study was carried out during the two successive growing seasons of 2013/ 14 and 2014/15 at the Farm of Soils, Water and Environ. Res. Inst., Agric., Res. Center in Sahal El-Tina (Por-saied Governorate), to investigate effects of cyanobacteria at rates of 0, 6 or 9 g/L and compost at rates of 0, 6, 8 and 10 ton /fad on growth, fruits yield, essential oil %, essential oil yield/ plant and its components and chemical composition of Fennel (Foeniculum vulgare Mill.) under soil salinity conditions.

Gradual and significant increase in plant height, numbers of branches and number of umbels/ plant, fresh and dry weights of plant, fruit yield per plant, essential oil percentage in fruits, and essential oil yield per plant were recorded with increasing the tested cyanobacteria concentration from zero up to 9 g/L. Maximum percentages of α- Pinene, β- Pinene, fenchone and anethole in the resulted essential oil also, was recorded with 9 g/L cyanobacteria while the maximum anise aldehyde % was resulted with 6 g/L cyanobacteria. Cyanobacteria at all tested concentrations reduced straggle percent.

Compost treatments especially (8 ton /fad) enhanced all growth characteristics of fennel plants. Also, maximum fenchone and anethole content and minimum estragole content was resulted with 8 ton/ fad.

Significant increase in growth characteristics was obtained with combination between 8 ton compost/fed and 9 g/L cyanobacteria.

***Conclusively,** it could be recommend that using* cyanobacteria *(CB) at 9 g/L with 8 ton /fad, compost enhanced fennel growth as well as fruit and essential oil yield and its composition.*

Keywords: Foeniculum vulgare, cyanobacteria, compost, fenchone, anethole, anise aldehyde, estragole, proline, carbohydrates nents, soil salinity. .

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INTRODUCTION

Fennel (*Foeniculum vulgare* Mill.,) belonging to *Apiaceae* Family is an important medicinal and aromatic plant due to its estrogenic activities and uses as a carminative, diuretic, anti-inflammatory, antimicrobial, and galactogogue, (Morelli *et al.*, 1983). Mature fennel fruits (seeds) contain essential oil and are used as flavoring agents in food products such as liqueurs, bread, pickles, pastries, and cheese. They are also used as a constituent of cosmetic and pharmaceutical products. (Telci *et al*., 2009). The essential oil has antioxidant, antimicrobial and hepatoprotective activity (Lucinewton *et al.,* 2005). The essential oil of fennel is used to flavor different food preparations and in perfumery industries.

Salinity is one of the major factors reducing plant growth in the most parts of the world (Jafari, 1994). Salinity stress also decrease photosynthetic capacity due to the osmotic stress and partial closure of stomata. Plants can suffer from membrane destabilization and general nutrient imbalance (Parida and Das, 2005). Salt stressed plants accumulate various molecules found in organic matter such as Proline, glucose, glycin betaine etc, in the cell membrane for osmoregulation to occur thereby protecting enzyme activity (Esfandiari, *et al.,* 2007).

Blue-green algae (Cyanobacteria) are distributed world-wide and contribute to the fertility of many agricultural ecosystems, either as free-living organisms or in symbiotic association with the water-fern Azolla (Fay, 1983). Azolla, a dichotomously branched free floating aquatic fern, is naturally available mostly in the tropical belt of India. A blue green algae *Anabaena azollae*. Abundant growth of Azolla not only makes a useful addition of combined nitrogen to the ecosystem but can also provide a 'green manure'. Cyanobacteria *Anabaena azallea* from the symbiosis have also been isolated and cultured independently of the fern (Abd el-aal, 2013). *Spirulina platensis* produced a great variety of secondary metabolites such as, polyketides, lipopeptides, cyclic peptides and others (Gervick *et al.,* 2001).

Cyanobacteria are photosynthetic prokaryotes and colonizing microorganisms that are found throughout the world and they are exceptionally well adapted to a wide array of environmental conditions. They can enhance the plant growth directly and/or indirectly. The direct ways include the production of various plant growth promoting biologically active substances including phytohormones, such as auxin, gibberellins and cytokinins (Mazhar and Hasnain, 2011).

Organic farming as compost is one of the practices to make the production system more sustainable without adverse effects on the natural resources and the environment (Ram, *et al,*. 2014). It not only maintains soil fertility but also conserves soil moisture (Yadav, *et al.,* 2014). Organic fertilizers increases the availability and absorption of the essential nutrient elements, such as Fe_2^+, Mg_2^+ and NH_4^+ cat ions, which are necessary for enzyme activation and chloroplast and chlorophyll formation. Increased seed germination, growth and yield are response to plant hormones, micro- and macronutrients exist in compost (Jamal and Ozra, 2014)**.**

Salinity problem as a one of the major external factors that influence the various metabolic activities of plant is now receiving much attention. However, according to the available literature there is no information about the effect of cyanobacteria alone or in combination with compost on growth characteristics of fennel plant under salinity soil stress.

Thus, the objective of this research was to evaluate to what extent cyanobacteria, compost applications and their interactions can enhance fennel plant growth, fruit yield, and essential oil production growing under soil salinity.

MATERIALS AND METHDOS

This study was carried out at the clay soil of Sahl El-Tina Agric. Res. Station, (Por-Saied Governorate.), during the two successive seasons of 2013/2014 and 2014/2015.

Fennel (*Foeniculum vulgare*, Mill) fruits were obtained from Medicinal and Aromatic Plants Research Department, Dokki, Giza. The fruits of fennel were sown on 4 November for the two seasons 30 cm between hills (2-3 fruits /hill), 60 cm between rows. After germination seedlings were thinned leaving one plant per hill. Soil samples were obtained from a depth of 30 cm from the soil surface and analyzed at laboratories of the Agricultural Research Center, Ministry of Agriculture, Giza. The physical and chemical characteristics of the soil and irrigation water are shown in Table (A&B), according to (Chapman and Pratt, 1961).

Table (A): The main physical and chemical properties analyses of experimental soil

<table>
<tr><td>Course sand</td><td>Fine sand</td><td>Silt</td><td>Clay</td><td colspan="2" rowspan="2">Soil Texture</td><td colspan="2">OM</td><td>$CaCO_3$</td></tr>
<tr><td colspan="4">(%)</td><td colspan="3">(%)</td></tr>
<tr><td>12.85</td><td>71.5</td><td>13.8</td><td>14.7</td><td colspan="2">Loamy sand</td><td colspan="2">0.48</td><td>7.9</td></tr>
<tr><td rowspan="2">pH (1:2.5)</td><td rowspan="2">EC*(dSm^{-1})</td><td colspan="4">Cations (meq/L)</td><td colspan="3">Anions (meq/L)</td></tr>
<tr><td>Ca^{++}</td><td>Mg^{++}</td><td>Na^+</td><td>K^+</td><td>HCO^-_3</td><td>Cl^-</td><td>SO^{--}_4</td></tr>
<tr><td>8.45</td><td>8.26</td><td>7.85</td><td>12.63</td><td>44.00</td><td>1.40</td><td>20.0</td><td>33.0</td><td>29.2</td></tr>
</table>

Cyanobacteria source and levels:

Anabaena azollae and *Spirulina platensis* strains were obtained from the Microbiology Department, Soils Water and Environment Res. Inst., ARC, Giza, Egypt.

Isolated *Ananbaena azollae* strain from *Azolla pinnata* (Abd El-Aal, 2013) was grown on BG11 medium (Rippka *et al.*, 1979), while the mesophilic alga of *Spirulina platensis* was cultured on Zarrouk medium (Zarrouk, 1966). Cultures were incubated under continuous illumination (2000 lux) and under 25˚C ± 2˚C for *Anabaena azollae* and 35˚C ± 2˚C for *Spirulina platensis*. Then, growth of the two strains of cyanobacteria and their media was put in an electric mixer, then filtered and kept at 4^{o}C till field application.

Three cyanobacteria concentrations*: i.e.* 0, 6 or 9 g/ L, were tested in this experiment. Plants were treated five times with cyanobacteria. The first time was as seed soaking for 30 minute just before seed sowing and the other four times were as monthly foliar spray.

Compost fertilizer:

Compost *was* obtained from the Egyptian company for Waste Recycling. It was applied as one dose during soil preparation on 1^{st} November in both tested seasons. It was used at rates of 0, 6, 8 or 10 Ton/ *fad*. Physical and chemical characteristics of the used compost were determined according to Brunner and Wasmer (1978). Such characteristics are shown in Table B.

Table B: Physical and chemical characteristics of the used Compost fertilizer

The character	1^{st} Season	2^{ed} Season
Weight of 1 m^3 (kg)	375	385
Moisture content (%)	25	30
Organic Matter (%)	55.62	45.21
Organic Carbon (%)	35.88	33.26
Total N (%)	1.8	2.08
C:N ratio	19.7:1	17.2:1
Total P (%)	1.47	1.24
Total K (%)	1.26	1.12
Fe (ppm)	1080	1051
Mn (ppm)	114	110
Zn (ppm)	54.9	38.3
EC	3.2	4.4
pH	6.7	7.2

The experimental design was factorial between cyanobacteria treatments (three concentrations) and compost (four levels) in completely randomized block design with three replicates (blocks). The three cyanobacteria (CB) concentrations were 0, 6 and 9 g/ L while the four compost rates were 0, 6, 8 and 10 ton/ fad, as follows:

1-	cyanobacteria	0 g/L,	X 0 ton	compost/fad	as a (Control)
2-	"'	"	X 6 "'	"'	".
3-	"'	"	X 8."'	"'	"
4-	"'	"	X10."'	"'	"
5-	"'	6 g/L	X 0 "'	"'	"
6-	"'	"	X 6 "'	"'	"
7-	"'	"	X 8 "'	"'	"
8-	"'	"	X 10 "'	"'	"
9-	"'	9 g/L	X 0 "'	"'	"
10-	"'	"	X 6 "'	"'	"
11-	"'	"	X 8 "'	"'	"
12-	"'	"	X 10 "'	"'	"

Cyanobacteria source and growth conditions: *Anabaena azollae* and *Spirulina platensis* were obtained from the Microbiology Department, Soils Water and Environment Res. Inst., ARC, Giza. *Ananbaena azollae* strain which isolated from Azolla pinnata (Abd El-Aal, 2013) was grown on BG11 medium (Rippka *et al.*, 1979), while *Spirulina platensis* was cultured on Zarrouk medium (Zarrouk, 1966).

Cultures were incubated in a growth chamber under continuous illumination (2000 lux) and temperatures of 25˚C ± 2˚C for Anabaena azollae while the mesophilic alga *Spirulina platensis* (35˚C ± 2˚C). After propagation, the growth of the two strains of cyanobacteria and their media was put in an electric mixer, then filtered and kept at 4^{o}C till field application. Plants were treated five times with alga. The first time was used as soaking for seeds for 30 minute before sown. The other times were sprayed monthly.

The compost fertilizer was obtained from the Egyptian company for Waste Recycling was added in one dose; at rates of 0, 6, 8 or 10 Ton/fad. Which was incorporated into the soil to a depth of 15-20 cm, during soil preparations on 1st November in both seasons? The physical and chemical characteristics of the compost fertilizer are presented in Table (B) described by (Brunner and Wasmer, 1978).

Recorded data:

Fennel plant responses to the tested cyanobacteria and compost applications were recorded at the two experimental seasons as follows:

1. ***Growth characteristics:***

On completion of the vegetative growth, just before flowering, vegetative growth responses were recorded as plant height (cm), number of branches/ plant, fresh and dry weights per plant (g).

At harvesting on May 15th during the two tested seasons, number of umbels/ plant, seed index represented as weight of 100 fruits (g) and fruit yield per plant (g) were recorded.

2. ***Essential oil content and yield:***

Essential oil was extracted from fruit samples of each treatment by distillation according to the method of (British Pharmacopoeia, 1963) and oil percentages were recorded. Then, oil yield per plant was calculated. Essential oil composition was determined by GLC as described by (Bunzen *et al.,* 1969).

3. ***Chemical analysis:***

Chemical determinations included assay: total carbohydrates % in fruits, and N, P, K and Na in dry leaves as well as antioxidant enzyme activities of catalase and peroxidase in fresh leaves. Additionally, Prolien content was determinad in fresh leaves (µmol/g f.w.). Leaves samples were taken just before flowering, while fruits samples were taken after harvesting during the two experimental seasons.

Total nitrogen, P, K, Ca and Na were determined according to the methods described by (Herbert *et al.*, 1971), (Pregl, 1945), (Allen, *et al.*, 1974), respectively.

The antioxidant enzyme activity of catalase (CAT) was assayed by measuring the decrease in absorbance due to disappearance of H_2O_2 at 240 nm according to (Chance and Maely, 1955). Peroxidase (POD) activity was recorded according to (Amako, *et al.,* 1994). Enzymes activities were expressed as units / g fresh weight (µ.M/g. fresh weight/min).

Statistical analysis

Collected data were subjected to statistical analysis according to (Little and Hills, 1978). Mean separation was done using least significant difference test at 5% level (LSD 0.05).

RESULTS AND DISCUSSION

Growth and herb yield:

1. Plant height

The results presented in Table (1) show that there is a directly increase in the plant height with increase in cyanobacteria. The highest plant was obtained with 9 g/L (139.64 and 145.82 cm in the first and second season, respectively) These results are in harmony with those reported by Ahmed et al. (2011) on grape vines, significant increase in fennel plant height was also resulted with the increase in compost rate. Maximum plant height was obtained with 8 ton/ fad (138.50 and 144.33 cm in the first and second season, respectively). These data are in a agreement with the conclusions reached by (Hossein. 2014) on *Foeniculum vulgare*

Regarding the interaction between the effects of cyanobacteria and compost treatments on height of fennel plants, it is clear from the data in the Table (1) that in the first season, plants receiving most of the cyanobacteria and compost treatment combinations were significantly taller than untreated control plants. The tallest plants in the first season were those supplied with cyanobacteria at the rate of 9 g/L, combined with compost at 8 Ton/fad. (155.16 cm), followed by plants fertilized using a combination of cyanobacteria at 6 g/L and compost at 10 Ton /fad. (Giving values 150.43cm). On the other hand, the shortest plants were those receiving no cyanobacteria and compost treatments, whereas the shortest plants (120.50 cm) were those supplied with 6 g cyanobacteria /L. and no compost. The results recorded in the second season (Table 1) confirmed those obtained in the first season. Combining the rate of cyanobacteria (9 g/L) with compost at 8 Ton/fad. gave the tallest plants (with height of 162.17 cm), followed by plants receiving cyanobacteria at 6 g/L. combined with compost at 10 Ton /fad. (Giving plant height of 158.64 cm) The recorded values were generally decreased by reducing the application rates of cyanobacteria and/or compost.

Thus, the shortest plants (107.31 cm) were those receiving no cyanobacteria or compost treatment.

2. Number of branches and umbels/plant

The data in Table (1) show that increasing the concentration of cyanobacteria from 0 to 9 g/L resulted in a significant increase in the number of branches and umbels /plant. The highest number of branches and umbels/plant was obtained in plants fertilized with cyanobacteria at the rate of 9 g/L (with 7.06, and 8.70 branches/ plant and 56.39 and 65.34 umbels/plant in the first and second season, respectively). The positive effect of combining cyanobacteria in accordance with the results obtained by Ahmed *et al.* (2011) on grape vines.

Also, the data in Table (1) show that the highest number of branches and umbels (7.00 and 8.40 branches/plant and 56.40 and 63.37 umbels/ plant in the first and second season respectively), were obtained on plants which received compost at 8 ton /fad. This effect of compost on branching is in harmony with the findings of many authors, including (Darzi, *et al.*, 2008) on fennel.

Data in the Table (1) found that The combination cyanobacteria at the rate of 9 g/L. with compost at 8 ton/fad., resulted in the highest number of branches and umbels/plant (with 9.54 and 10.15 branches/plant and 78.44 and 83.30 umbels/plant in the first and second season, respectively.

3. *Weight of 100 fruit (g)*

The results presented in Table (1) also show that, in general, raising the rate of cyanobacteria (CB) from 0 to 9 g/L resulted in steady increases in the weight of 100 fruit, with cyanobacteria (CB) being most effective when applied at the rate of 9 g/L (giving values of 1.26 and 1.34 g. in the first and second seasons, respectively).

The data in Table (1) also show that in the both seasons, plants receiving the different compost (Com) treatments gave significantly higher weight of 100 fruit than the control. Accordingly, compost (Com) was most effective when applied at the rate (8 ton/ fad), giving weight of 100 fruit of (1.22 and 1.30 g. in the first and second seasons, respectively). These values were significantly higher than those recorded with compost (Com) at the rate of 10 ton/ fad. (1.20 and 1.28 g. in the first and second seasons, respectively). These conclusions are in agreement with the findings of Hossein (2014) on *Foeniculum Vulgare*.

The data presented in Table (1) show that the highest values recorded (1.48 and 1.58 g in the first and second seasons, respectively) were obtained from plants fertilized with cyanobacteria (CB) at the rate of 9 g/L combined with compost (Com) at 8 ton/fad. The application cyanobacteria (CB) at the rate of 6 g/L combined with compost (Com) at 10 ton/fad, gave insignificantly higher weight of 100 fruit, (with the values of 1.40 and 1.50 g. in the first and second seasons, respectively) than combining cyanobacteria (CB) at the rate of 6 g/L with compost (Com) at 6 ton/fad, (giving values of 1.15 and 1.20 g in the first and second seasons, respectively).

Table (1). Influence of cyanobacteria (CB), compost (Com) and their interaction on plant parameters of fennel plants in two seasons.

Cyanobacteria (CB) (g/L)	1st season					2nd season				
	Compost (Com) (Ton/fad).									
	0	6	8	10	Mean	0	6	8	10	Mean
Plant height (cm)										
0	100.75	109.64	113.13	116.45	**109.99**	107.31	112.70	118.45	123.11	**115.39**
6	120.50	130.05	147.20	150.43	**137.05**	127.50	137.02	152.37	158.64	**143.88**
9	125.34	136.30	155.16	141.75	**139.64**	133.35	141.72	162.17	146.04	**145.82**
Mean	**115.53**	**125.33**	**138.50**	**136.21**		**122.72**	**130.48**	**144.33**	**142.60**	
LSD.5% CB	2.04					2.14				
LSD.5%Com	2.51					4.30				
Interaction	3.61					4.54				
No. of branches/plant										
0	3.00	3.12	3.70	4.01	**3.46**	4.43	5.21	5.64	6.14	**5.36**
6	4.70	6.00	7.76	8.33	**6.70**	6.52	7.75	9.41	9.82	**8.38**
9	5.25	6.43	9.54	7.02	**7.06**	7.43	8.36	10.15	8.86	**8.70**
Mean	**4.32**	**5.18**	**7.00**	**6.45**		**6.13**	**7.11**	**8.40**	**8.27**	
LSD.5% CB	2.11					2.67				
LSD.5%Com	1.77					2.00				
Interaction	2.53					3.13				
No. of umbels/plant										
0	20.82	23.16	26.45	29.15	**24.90**	23.52	27.28	33.92	40.11	**31.21**
6	33.61	44.56	64.30	70.12	**53.15**	46.04	57.45	72.89	77.14	**63.38**
9	37.97	50.19	78.44	58.97	**56.39**	50.19	61.40	83.30	66.47	**65.34**
Mean	**30.80**	**39.30**	**56.40**	**52.75**		**39.92**	**48.71**	**63.37**	**61.24**	
LSD.5% CB	3.21					3.74				
LSD.5%Com	3.55					4.21				
Interaction	5.24					5.87				
Weight of 100 fruit (g)										
0	0.54	0.71	0.84	0.92	**0.75**	0.61	0.76	0.89	0.98	**0.81**
6	1.00	1.15	1.35	1.40	**1.23**	1.05	1.20	1.43	1.50	**1.30**
9	1.08	1.21	1.48	1.27	**1.26**	1.12	1.28	1.58	1.36	**1.34**
Mean	**0.87**	**1.02**	**1.22**	**1.20**		**0.93**	**1.08**	**1.30**	**1.28**	
LSD.5% CB	0.22					0.34				
LSD.5%Com	0.21					0.24				
Interaction	0.35					0.41				

Fresh and dry weights of plant (g.):

In (Table 2), the highest increments in fresh and dry weights were recorded under the effect of 9 g/L cyanobacteria. The maximum values represented cyanobacteria effect recorded 400.95 and 411.16 g., for fresh weight and 153.96

and 162.23 g for dry weight during 1st and 2nd seasons, respectively with 9 g/L cyanobacteria concentrate. These results are in accordance with those reported by Ahmed *et al.* (2011) on grape vines and Aly and Esawy (2008) on *Spirulina platensis*.

In general, gradual significant increases in both fresh and dry weights of plant were noticed by applying compost (Com) at (8 ton/fad.). The greatest values recorded 395.29, 412.34 g., in fresh weight) during 1st and 2nd seasons, respectively. While, they were recorded 155.82, 166.63 g., in herb dry weight of plant (8 ton/ fad) during 1st and 2nd seasons, respectively.

Data of Table 2 revealed that the heaviest herb fresh and dry weights/ plant were noticed in plants received 9 g/L cyanobacteria and treated with (8 ton/fad.) compost This was repeated during the 2 tested seasons.

Fruit yield/ plant (g.):

The data recorded on the fruit yield/plant (Table 2) indicate that the highest cyanobacteria (CB) concentration (9 g/L) was the most effective rate for increasing the fruit yield/plant (giving values of 63.32, g/plant), The same trend was found in the second season. Accordingly, the highest values of fruit yield/plant (68.76 g/plant) were obtained on plants treated with cyanobacteria (CB) at (9 g/L).

Data in Table (2) show that, compost (Com) was most effective when it was applied at the rate of 8 ton/fed., giving the highest fruit yield/plant (62.45and 67.42 g/plant) during 1st and 2nd seasons, respectively.

The increase that was recorded in the fruit yield/plant that was fertilized with compost (Com) is in agreement with the findings of Hossein (2014) on *Foeniculum Vulgare*.

Plants receiving cyanobacteria at 9 g/L plus compost at 8 ton/fed gave the highest fruit yield/plant (with values of 78.64 and 84.21g/plant in the first and second season, respectively).

Essential oil determinations:

Recorded data represented essential oil determinations are in Tables 3 and 4.

1. ***Effect of cyanobacteria (CB) treatments:***

Results in Table 3 indicate that fertilized of cyanobacteria (CB) at 6 or 9 g/L significantly increased percentage of essential oil in fruits comparing to control plants during the 2 seasons. No significant differences were noticed in this respect between the two cyanobacteria concentrations. The fruit essential oil % mean was reached 2.704% and 2.723% comparing to 2.331% in control in the 1st season and 2.767% and 2.786% comparing to 2.398% in control plants in the 2nd season for 6 and 9 g/L cyanobacteria

Table (2). Influence of cyanobacteria (CB), compost (Com) and their interaction on plant parameters of fennel plants in two seasons.

Cyanobacteria (CB) (g/l)	1st season					2nd season				
	Compost (Com) (Ton/fad).									
	0	6	8	10	Mean	0	6	8	10	Mean
Fresh weight of plant (g.)										
0	204.33	253.04	287.10	311.51	**264.00**	220.08	275.15	309.45	321.84	**281.63**
6	322.12	352.74	432.33	455.14	**390.58**	334.65	370.71	442.51	460.72	**402.15**
9	346.16	380.55	466.45	410.64	**400.95**	351.22	391.12	485.07	417.24	**411.16**
Mean	**290.87**	**328.78**	**395.29**	**392.43**		**301.98**	**345.66**	**412.34**	**399.93**	
LSD.5% CB	**4.44**					**6.37**				
LSD.5%Com	**6.47**					**7.53**				
Interaction	**7.89**					**9.24**				
Dry weight of plant (g.)										
0	54.53	69.64	80.86	93.42	**74.62**	62.28	77.76	91.50	100.76	**83.08**
6	103.12	120.80	171.45	196.42	**147.95**	111.34	132.43	186.07	210.45	**160.07**
9	112.72	137.30	215.14	150.67	**153.96**	120.02	144.50	222.31	162.10	**162.23**
Mean	**90.12**	**109.25**	**155.82**	**146.84**		**97.88**	**118.23**	**166.63**	**157.77**	
LSD.5% CB	**3.54**					**4.72**				
LSD.5%Com	**4.68**					**6.21**				
Interaction	**8.32**					**10.47**				
Fruit yield (g.)/plant										
0	33.32	37.12	40.17	43.50	**38.53**	36.77	40.30	43.42	47.66	**42.04**
6	46.48	55.67	68.53	73.12	**60.95**	50.38	61.05	74.59	79.42	**66.36**
9	50.53	59.48	78.64	64.64	**63.32**	54.96	65.68	84.21	70.18	**68.76**
Mean	**43.44**	**50.76**	**62.45**	**60.42**		**47.37**	**55.68**	**67.41**	**65.75**	
LSD.5% CB	**2.47**					**3.35**				
LSD.5%Com	**3.14**					**4.05**				
Interaction	**5.32**					**5.88**				

concentrations, respectively. It could be noticed that from the previous discussed results of such research that cyanobacteria treatments which improved plant height, branches No/ plant, umbels No/ plant and Fruit yield per plant and per *fed* also increased fruits essential oil percentage.

For essential oil yield/ plant (cc), data of Table 3 show that of the two seasons, the different cyanobacteria concentrations increased the oil yield/plant significantly, compared to the control. Cyanobacteria had significant effect on oil yield/plant during the both seasons. The highest cyanobacteria concentrate (9g/L) gave the highest oil yield/plant (1.735 and 1.930 ml/plant in the first and second season respectively), while unfertilized (control) plants gave significantly lower oil yields (0.903 and 0.1012 ml/plant in the first and second season respectively).

Data of Table 4 showed cyanobacteria concentrations effect on the main components of the resulted essential oil. It is clear that fertilized fennel plants with 9g/L cyanobacteria resulted in the highest percentages of the main

Table 3. Influence of cyanobacteria (CB), compost (Com) and their interaction on oil determinations of fennel plants in two seasons.

1st season	1nd season					2nd season				
	Compost (Com) (Ton/fed).									
	0	6	8	10	Mean	0	6	8	10	Mean
Essential oil (%)										
0	2.150	2.221	2.443	2.508	**2.331**	2.206	2.388	2.472	2.525	**2.398**
6	2.564	2.621	2.784	2.845	**2.704**	2.572	2.684	2.870	2.942	**2.767**
9	2.581	2.678	2.888	2.743	**2.723**	2.609	2.735	2.991	2.810	**2.786**
Mean	**2.432**	**2.507**	**2.705**	**2.699**		**2.462**	**2.602**	**2.778**	**2.759**	
LSD.5% CB	**0.15**					**0.18**				
LSD.5% Com	**0.23**					**0.25**				
Interaction	**0.37**					**0.41**				
Essential oil yield/plant (mL)										
0	0.716	0.824	0.981	1.091	**0.903**	0.811	0.962	1.073	1.203	**1.012**
6	1.192	1.459	1.908	2.080	**1.660**	1.296	1.639	2.141	2.337	**1.853**
9	1.304	1.593	2.271	1.773	**1.735**	1.434	1.796	2.519	1.972	**1.930**
Mean	**1.071**	**1.292**	**1.720**	**1.648**		**1.180**	**1.466**	**1.911**	**1.837**	
LSD.5% CB	**0.44**					**0.54**				
LSD.5% Com	**0.30**					**0.36**				
Interaction	**0.50**					**0.59**				

determined essential oil ingredients comparing to control plants or those treated with other tested cyanobacteria concentrations cyanobacteria concentrations. However, resulted essential oil under the effect of 9 g/L cyanobacteria contained 3.07% α- Pinene, 3.96% β- Pinene, 22.05% fenchone and 19.90% anethole. While the highest percentages of anise aldehyde resulted under the effect of 6 g/L cyanobacteria. On the opposite, the estragole gave lowest percentages 30.02% compare 41.71% of control plants.

Effect of compost treatments:

All compost tested treatments, generally, had significant effects on essential oil % as compare to control during the both seasons (Table 3). The highest oil % was resulted from fruits of plants supplied with 8 ton compost/ *fad* (2.705% and 2.778% in the first and second seasons, respectively). Whereas, the lowest compost rate of 6 ton/*fed* was the least effective treatment (giving values of 2.507% and 2.602% in the first and second seasons, respectively).

As for essential oil yield per plant as affected by compost application treatments (Table 3), the results show that fertilizing by compost, generally, had significant effect on the resulted oil yield per plant (cc) comparing to

Table 4. Influence of cyanobacteria (CB), compost (Com) and their interaction on the components (%) of essential oil of fennel plants in the second season.

Cyanobacteria (CB) (g/l)	Compost (Com) (Ton/fed).				
	0	**6**	**8**	**10**	**Mean**
α-Pinene					
0	0.71	1.36	2.19	1.80	**1.52**
6	0.86	4.20	2.03	2.67	**2.44**
9	0.98	3.17	3.51	4.62	**3.07**
Mean	**0.85**	**2.91**	**2.58**	**3.03**	
B- pinene					
0	1.22	1.74	2.00	2.50	**1.87**
6	2.21	3.88	4.44	3.86	**3.60**
9	2.88	5.07	3.05	4.83	**3.96**
Mean	**2.10**	**3.56**	**3.16**	**3.73**	
Anise aldehyde					
0	4.36	4.72	5.48	5.82	**5.10**
6	6.30	8.03	9.56	10.12	**8.50**
9	6.65	7.10	9.18	8.47	**7.85**
Mean	**5.77**	**6.62**	**8.07**	**8.14**	
Fenchone					
0	10.40	11.35	12.52	14.45	**12.18**
6	15.60	18.15	25.30	27.35	**21.60**
9	16.07	19.27	31.11	21.75	**22.05**
Mean	**14.02**	**16.26**	**22.98**	**21.18**	
Anethole					
0	12.35	12.69	13.20	13.52	**12.94**
6	14.02	16.13	20.70	24.35	**18.80**
9	15.37	17.40	27.55	19.27	**19.90**
Mean	**13.91**	**15.41**	**20.48**	**19.05**	
Estragole					
0	46.17	43.50	39.44	37.72	**41.71**
6	36.16	32.04	28.64	27.70	**31.14**
9	34.70	30.23	25.54	29.60	**30.02**
Mean	**39.01**	**35.26**	**31.21**	**31.67**	

untreated control during the two seasons. Treated plants with 8 ton/*fad* compost resulted in the highest significant values of essential oil yield per plant comparing to control or applying 6 ton/*fad*. Such results were corroborative in the two seasons.

Data represented the main components of the resulted essential oil as affected with compost application treatments (Table 4) revealed that the highest percentages of α- Pinene, β- Pinene and anise aldehyde (3.03 %, 3.73 % and 8.14 %, respectively) were recorded in essential oil extracted from plants treated with compost at the rate of 10 ton/fad, comparing to control. While the highest percentages of fenchone and anethole (22.98% and 20.48%, respectively) were obtained in the plants which treated by 8 ton compost/fad. On the other hand, the same rate of compost resulted the lowest percentages of estragole 31.21% compare 39.01% of untreated plants. These data are in a agreement with the conclusions reached by Hossein (2014) on *Foeniculum Vulgare*.

Effect of interaction treatments between cyanobacteria and compost:

It is evident that the interaction treatments between cyanobacteria and compost had significant effects on oil % in fruits of fennel during both seasons (Table 3). Plants which received 9 g/L cyanobacteria combined with compost at 8 ton/*fad* had the highest essential oil percentages in their fruits comparing to all other interaction treatments during the both seasons.

The mean in this respect recorded 2.888% and 2.991% in 1st and 2nd seasons, respectively, followed by plants fertilized with cyanobacteria at 6 g/L X compost at 10 ton/*fad*. (giving values of 2.845% and 2.942% in the first and second seasons, respectively). The least effective combination treatment was cyanobacteria at 6 g/L X compost at 6 ton/ *fad*.

The combination treatments of cyanobacteria concentrations X compost application treatments caused considerable effects on essential oil yield per plant (Table 3). In general, the above 2 mentioned interaction treatments which caused significant increases in essential oil %; *i. e.,* 9 g/L cyanobacteria X 8 ton compost/ *fad* or 6 g/L cyanobacteria X 10 ton compost/ *fad*, also caused significant increases in essential oil yield per plant as compare to control and most of the other interaction treatments.

Data in Table 4 state that the combination between 9 g/L cyanobacteria and compost at 8 ton/*fad* gave the highest fenchone and anethole contents (31.11% and 27.55%, respectively) compared to the control. While, the combination between 6 g/L cyanobacteria and compost at 10 ton/*fad* show the highest values of the anise aldehyde contents (10.12%). Additionally, interaction treatments between the cyanobacteria and compost gave lower values of the estragole content, compared to the unfertilized control plants which gave the highest value of estragole content (46.17%). Plants received cyanobacteria at 9 g/L combined with compost at 8 ton/*fad* resulted in the lowest value of estragole content (with 25.54%).

The increase in volatile oil content was probably due to the increment in the metabolic activities, Ibrahim et al (2006).

Chemical determinations:

Total carbohydrates (%) in fruits:

Data of Table 5 show gradual increases in total carbohydrates % in herb with increasing the applied cyanobacteria concentration from 0.00 up to 9 g/L. Results of the two seasons, respectively, recorded the highest percentages of carbohydrates (23.06 and 25.26%) under the effect of 9 g/L. cyanobacteria followed by 22.54 and 24.91% with 6 g/L. cyanobacteria applied. Control treatment recorded the least total carbohydrates.

For the effect of compost application treatments, results in Table 5 show that the highest values of carbohydrates percentages were achieved during the both of seasons by adding compost at 8 ton/fad. While, the least carbohydrates percentages were occurred with control treatment. The mean of total carbohydrates recorded 22.79 and 25.23% for compost at 8 ton/ fad during 1st and 2nd seasons, respectively. These conclusions are in agreement with the findings of Hossein (2014) on *Foeniculum Vulgare*.

The highest total carbohydrates percentages were recorded in plants which received the interaction treatment of 9 g/L. of cyanobacteria and compost at 8 ton/fad, then 6 g/l. of cyanobacteria and compost at 10 ton/fad. This was confirmed during the two seasons (Table 5).

This general increase in the total carbohydrates content of fertilized plants (compared to the control) that was recorded can be easily explained, since the nitrogen supplied by fertilization is essential in the structure of prophyrines, which are found in the cytochrome enzymes essential in photosynthesis. This increase in the cytochrome enzymes results in an increase in the rate of photosynthesis, and a promotion in carbohydrate synthesis and accumulation. Moreover, the potassium added by fertilization acts as an activator for several enzymes involved in carbohydrate metabolism (Devlin, 1975).

Prolien content in fresh herb:

The results presented in Table (5) show that, the content of prolien was decrease when the tested of cyanobacteria treatments increased. However, the highest content of prolien in the both seasons was obtained in the unfertilized plants (with values of 45.16 and 43.34 µmol/g in the first and second seasons, respectively). Otherwise, plants receiving cyanobacteria at 9 g/L had lowest prolien contents (with values of 36.04 and 25.33 µmol/g in the first and second seasons, respectively).

Table 5. Effect of cyanobacteria (CB), compost (Com) and their interaction on the total carbohydrates (%) of dry weight in fruits Prolien, Peroxidase and Catalase content in fresh herb of fennel plants in both seasons.

Cyanobacteria (CB) (g/L)	1st season					2nd season				
	Compost (Com) (Ton/fed).									
	0	6	8	10	Mean	0	6	8	10	Mean
carbohydrates (%)										
0	16.35	17.42	19.18	20.06	**18.25**	18.50	19.62	20.34	21.05	**19.88**
6	20.73	21.60	23.48	24.33	**22.54**	21.88	23.40	26.70	27.65	**24.91**
9	21.24	22.18	25.70	23.10	**23.06**	22.61	24.21	28.66	25.55	**25.26**
Mean	**19.44**	**20.40**	**22.79**	**22.50**		**21.00**	**22.41**	**25.23**	**24.75**	
Prolien (µmol/g f.w.)										
0	46.03	45.24	44.96	44.42	**45.16**	43.34	41.39	38.14	34.94	**39.45**
6	43.79	41.40	32.39	29.53	**36.78**	32.19	28.17	22.68	21.44	**26.12**
9	43.19	39.58	25.21	36.17	**36.04**	30.77	26.53	18.75	25.25	**25.33**
Mean	**44.34**	**42.07**	**34.19**	**36.71**		**35.43**	**32.03**	**26.52**	**27.21**	
Peroxidase (POX), µ.M/g. fresh weight/min										
0	6.9	6.0	5.9	5.9	**6.18**	6.8	5.9	5.8	5.7	**6.05**
6	7.1	5.4	4.5	4.6	**5.40**	6.8	4.0	3.9	4.0	**4.68**
9	7.2	5.9	5.6	5.9	**6.15**	6.3	5.1	4.1	4.3	**4.95**
Mean	**7.07**	**5.77**	**5.33**	**5.47**		**6.63**	**5.00**	**4.60**	**4.67**	
Catalase (CAT), µ.M/g. fresh weight/min										
0	0.14	0.14	0.09	0.10	**0.12**	0.14	0.13	0.10	0.10	**0.12**
6	0.11	0.07	0.06	0.06	**0.08**	0.12	0.07	0.05	0.06	**0.08**
9	0.13	0.10	0.07	0.08	**0.10**	0.11	0.08	0.06	0.06	**0.08**
Mean	**0.127**	**0.103**	**0.073**	**0.08**		**0.123**	**0.093**	**0.070**	**0.073**	

The data presented in Table (5) also show that the effectiveness of the different compost treatments for decreasing the prolien content, compared to the control, in the both season, the control plants having The highest prolien content (with values of 44.34 and 35.43 µmol/g in the first and second seasons, respectively). The lowest prolien contents (with values of 34.19 and 26.52 µmol/g in the first and second seasons, respectively). were found in plants fertilized with compost at 8 ton/fad.

Concerning, the effect of the interaction treatments between cyanobacteria and compost on the prolien content. The data in Table (5) state that, the control show great effect during the two seasons compared to the combined treatments. the unfertilized plants gave the highest values of the prolien content (with values of 46.03 and 43.34 µmol/g in the first and second seasons, respectively). The lowest values of the prolien content obtained when using 9 g/L. of cyanobacteria combined with compost at 8 ton/fad., (with values of 25.21 and 18.75 µmol/g in the first and second seasons, respectively).

Activity of antioxidant enzymes:

The results are present in (Table 5) show the effect of cyanobacteria and compost and their interactions on the antioxidants activity content in shoots during two seasons under salinity stress.

Results in (Table 5) indicate that application of cyanobacteria at 6 or 9 g/L significantly decreased antioxidants activity content comparing to control plants during two seasons. No significant differences were noticed in this respect between the two cyanobacteria concentrations. The lowest values were recorded in the plants which treated by 6 g/L.

For the effect of compost, results in (Table 5) show that the values of peroxidase (POX) and catalase (CAT) contents were achieved during the both of seasons by untreated plants compared to the other. While, the least POX, CAT contents were occurred with compost at rate 8 ton/ fad, followed by compost at rate 10 ton/fad.

Concerning the interaction between cyanobacteria (CB) and compost (Com) treatments significantly reduce POX, CAT activity content compared to control. The control plants recorded the highest increased antioxidant activity compared to the treated plants during two seasons. 6 g/L. of cyanobacteria and compost at 8 ton/fad gave the highest reduction in POX which recorded 4.5 and 3.9 (µM /g F wt min-1), where recorded in CAT 0.06 and 0.05 (µM /g F wt min-1) in first seasons and second seasons respectively, followed by 6 g/L of cyanobacteria and compost at 10 ton/fad.

Mineral contents:

Data showed in (Figure 1-2) represent the effects of cyanobacteria (CB) and compost (Com) and their interaction during the two successive seasons on mineral contents as nitrogen (N), phosphorus (P), potassium (K), calcium (Ca) and sodium (Na) of fennel plants.

Results from (Figure 1-2) indicated that the treatment by different cyanobacteria (CB) concentrations had considerable effects on the different mineral contents of fennel especially N, P, K, Ca and Na. In the most cases, the different cyanobacteria concentrations resulted in significant increases in the values of N, P, K and Ca but the amounts of sodium decreased compared to the control plants. Gradual increases in the above mentioned traits were noticed with the plants which received cyanobacteria (9 g/L) followed by that the treatment by (6 g/L).

All compost (Com) tested application treatments had significant effects on different mineral contents of fennel especially N, P, K, Ca and Na as compare to control during the both seasons (Figure 1-2). However, the control plants had significantly lower N, P, K and Ca contents in the dry herb in the both seasons compared to plants receiving the different compost treatments. The highest N, P, K

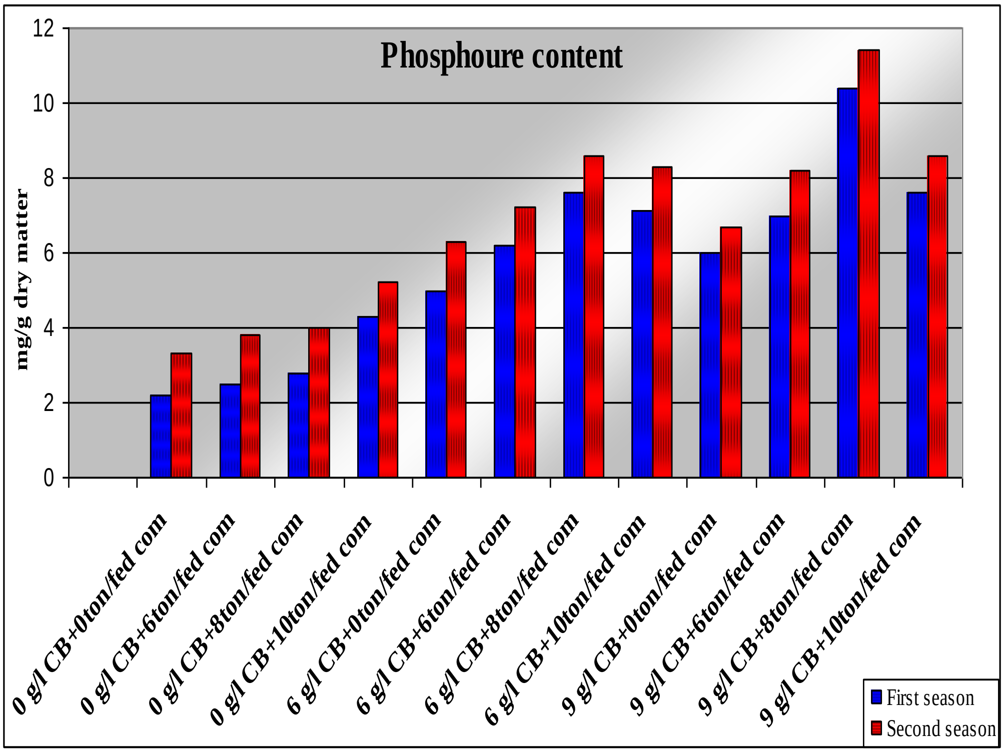

Figure 1: Effect cyanobacteria (CB), compost (Com) and their interaction on the nitrogen and phosphoure contents in dry herb of fennel plants in both seasons.

and Ca contents were obtained from plants supplied with 8 ton/fad of compost. Whereas the treatment which 6 ton/fed gave the least effective compost treatments. On the other hand, the different compost treatments gave the lowest Na contents compared to control during the both seasons.

Concerning, the effect of the interaction treatments between cyanobacteria (CB) and compost (Com) on the mineral contents. The data in (fig 1-2) state that, the combined treatments show great effect during the two seasons compared to the control. The unfertilized plants gave lower values of the N, P, K and Ca contents. While, the highest values of the N, P, K and Ca contents obtained when using 9 g/L of cyanobacteria combined with compost at 8 ton/fad. While, The Na accumulation was significantly lower compared to control plants. Followed by the treatment amended with cyanobacteria at 6 g/L plus compost at 10 ton/ fad. However, the plants treated by 6g/L of cyanobacteria combined with compost at 6 ton/fad gave the lowest values of N, P, K and Ca contents and highest values of Na contents.

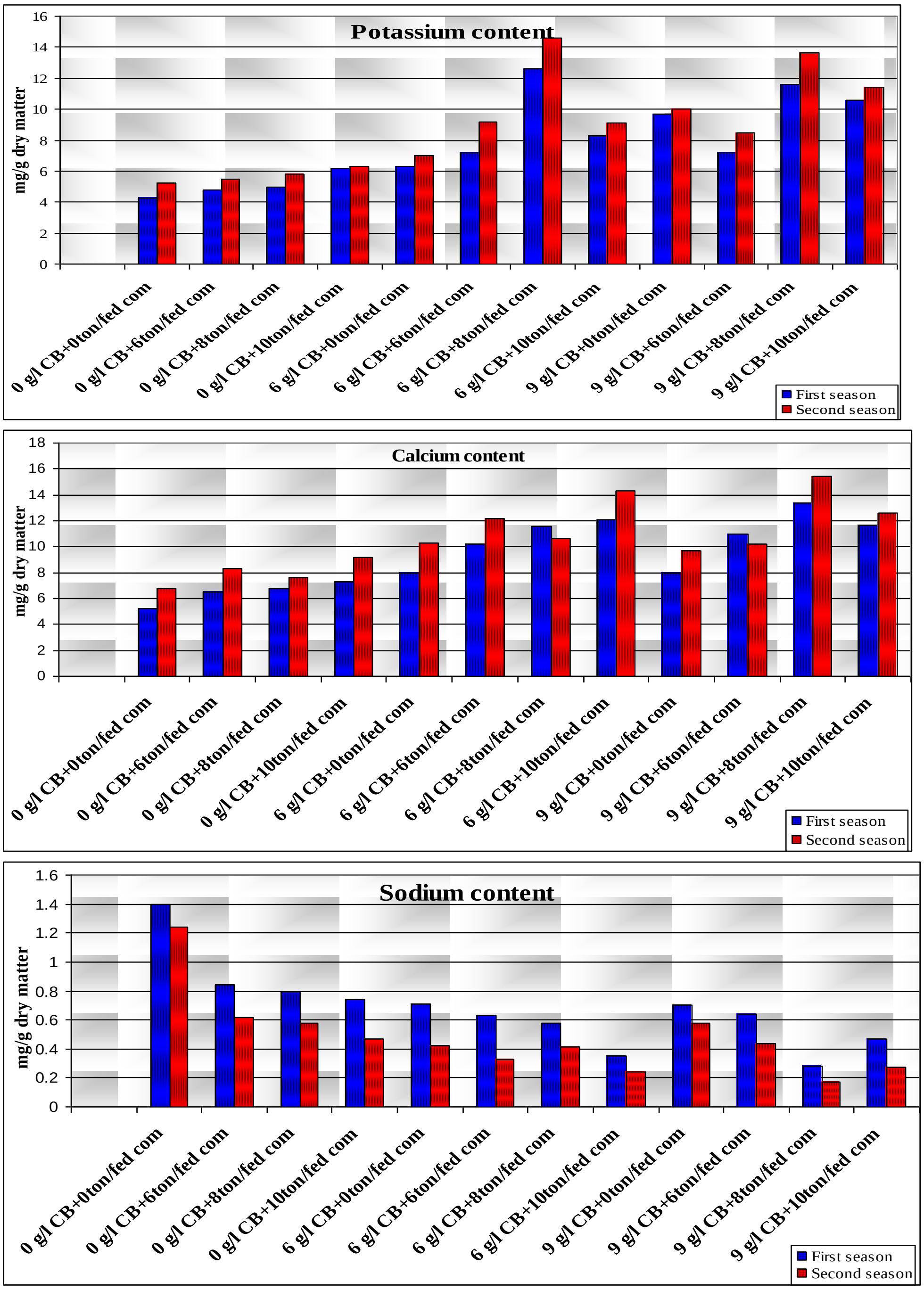

Figure (2): Effect cyanobacteria (CB), compost (Com) and their interaction on the potassium, calcium and sodium contents in dry herb of fennel plants in both seasons

GENERAL DISCUSSION

Salinity is one of the major abiotic stresses that adversely constitute a problem everywhere in the world. More than 6% of the world's total land area is salt-affected; most of this salt-affected land has arisen from natural causes and the accumulation of salts over long periods of time in arid and semiarid zones (Bui, 2013). Soils that have excessive amounts of salts; *i.e.*, electrical conductivity (EC) > 4 dS/m are classified as saline soils (Pierzynski, *et al.*, 2005). Soil salinity stresses plants in two ways: high concentrations of salts in the soil make it harder for roots to extract water and high concentrations of salts within the plant can be toxic. Salts on the outside of the roots have an immediate effect on cell growth and associated metabolism; toxic concentrations of salts take time to accumulate inside plants before they affect plant function (Munns and Tester, 2008).

Cyanobacteria play an important role in maintenance and building up the soil fertility. The acts of these cyanobacteria include: (1) Excretion of growth – promoting substances such as hormones, vitamins, amino acids as organic matter (Rodriguez *et al.,* 2006), (2) increase in soil biomass after their death and decomposition. Also, under salt stress condition, application of cyanobacteria to the soil lead to increase the soil organic matter, which is consequently, increased the soil biological activity by increasing the soil CO_2 evolution leading to increase the soil fertility (Nanjappan *et al.,* 2008). Cyanobacteria that excrete a great number of substances have been reported to benefit plants by producing growth-promoting regulators (PGPR), vitamins, amino acids, polypeptides, antibacterial and antifungal substances that exert phytopathogen biocontrol, and polymers, especially exopolysaccharides, that improve soil structure and exoenzyme activity Zaccaro *et al.* (2001).

The compost used in this study was a good ameliorating agent to the soil and a potential plant growth medium similarly. Fathy (2010) found that the biological amelioration methods using living or dead organic matter (crops, stems, straw, compost and sewage sludge) have two principals' beneficial effects on reclamation of saline soils: improvement of soil structure and permeability thus enhancing salt leaching, reducing surface evaporation and inhibiting salt accumulation in surface soil. Organic farming is one of the practices to make the production system more sustainable without adverse effects on the natural resources and the environment (Kochakinezhad, *et al.,* 2014). It not only maintains soil fertility but also conserves soil moisture (Yadav, *et al.*, 2014).

Organic fertilizers and their extracts enhance soil fertility via improved nutrient retention and cycling and also plays an essential role in growth and yield and it increases the availability and absorption of the essential nutrient elements, such as Fe_2^+, Mg_2^+ and NH_4^+ cations, which are necessary for enzyme activation and chloroplast and chlorophyll formation (Adholeya and Prakash , 2004). Also, Sajal, *et al.* (2014) found that the increased growth and nutrient content of plant suggest the positive effects of organic manures in amelioration of saline soils by enhancing soil fertility through the release of essential macro and micro elements. Eleter, *et. al.* (2013) found that organic substances in saline soils can function as ion binding agents and detoxify the toxic ions, particularly Na^+ and Cl^-. Also, an organic matter application to saline soil is a useful remediation method, in terms of physical, chemical and biological properties of the soil. A suitable concentration of organic material in soil is essential for supporting an active bacterial pool and hence, high microbiological activity in soil**.**

According to the results of the present study, proline content of shoots and roots significantly increased under salinity stress. Non inoculated plants accumulated much proline than inoculated ones. Proline is known as the main important osmolyte accumulated under salt stress. These osmolytes play a great role for facilitating water retention in the cytoplasm and to activate water up take in growing tissues (Ashraf and Foaad, 2007). Proline acts as cytocompostpatible solute in response to Na^+ accumulation and the compost partmentation should be balanced (Wang *et al.,* 2004).

Conclusively, although all the applied treatments improved growth and yield parameters of fennel plant under salinity soil conditions, the combination treatment of cyanobacteria at the rate of 9 g/l. plus compost at 8 ton/*fed* proved to be the best in increasing herb fresh and dry weights/ plant, as well as oil percentage and oil yield/ plant, followed by combining cyanobacteria at 6 g/l. with compost at 10 ton/*fed*.

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تقليل تاثير ملوحة التربة علي الشمر باستخدام السيانوبكتريا والكومبوست"

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أجريت هذه الدراسة خلال الموسمين المتتاليين ٢٠١٣/ ١٤ ، ٢٠١٤/ ١٥ فى مزرعة معهد بحوث المياه والتربة والبيئة بمركز البحوث الزراعية فى سهل الطينه بمحافظة بورسعيد لدراسة تأثيرات السيانوبكتريا بمعدلات صفر ، ٦ ، ٩ جم والكومبوست بمعدلات صفر ، ٦ ، ٨ طن/ فدان على النمو ، محصول الثمار ، نسبة الزيت العطرى ، محصول الزيت العطرى للنبات ومكوناته ، والتركيب الكيمياوى لنبات الشمر تحت ظروف الأراضى الملحية.

سُجلت زيادات معنوية تدريجية فى كل من إرتفاع النبات ، عدد الأفرع والنورات للنبات ، محصول الثمار للنبات ، النسبة المئوية للزيت العطرى فى الثمار ، ومحصول الزيت العطرى للنبات بزيادة التركيز المختبر من السيانوبكتريا من صفر حتى ٩ جم/ لتر ، سُجلت أعلى النسب المئوية لكل من *α- Pinene* ، *β- Pinene* ، *fenchone* ، *anethole* فى الزيت العطرى الناتج باستخدام ٩ جم سيانوبكتريا / للتر بينما أعلى نسبة

مئوية لـ *anise aldehyde* نتجت تحت تـأثير ٦ جم/ لتر سيانوبكتريا ، كل التركيزات المختبرة من السيانوبكتريا أدت إلى تقليل نسبة الـ *estragole* فى الزيت العطرى.

دفعت معـاملات الكومبوست خصوصـا بتركيـز ٨ طـن/ فـدان كـل قياسـات النمـو لنباتــات الشــمر الناميــة تحــت ظــروف الملوحــة ، أعلــى نســب كــل مــن *fenchone* ، *anethole* وأقل نسبة لـــ *estragole* فـى الزيـت العطـرى نتجت أيضـا باستخدام ٨ طـن كمبوست/ فدان.

نتجت زيادات معنوية فى كل من قياسات النمو ومحصول الثمار والزيت العطرى تحت تأثير معاملة التفاعل بين ٨ طن كمبوست/ فدان مع ٩ جم/ لتر سيانوبكتريا.

التوصية: باستخدام السيانوبكتريا بتركيز ٩ جم/ لتر متفاعلاً مع ٨ طن كمبوست/ فدان لدفع نمو ومحصول الثمار