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ESSENTIAL OIL AND CHEMICAL CONESTITUENTS OF FENNEL PLANTS AS AFFECTED BY COMPOST/NPK AND BIOFERTILIZATION TREATMENTS

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ABSTRACT: A field experiment was conducted during the two successive seasons of 2012/2013 and 2013/2014 to explore the effect of compost/NPK and biofertilization treatments on essential oil, photosynthetic pigments and herb NPK content of fennel plants.

Obtained results revealed that the best three essential oil characteristics (essential oil %, essential oil yield per plant and per feddan), photosynthetic pigments (chlorophylls a, b and carotenoids) and herb content of N, P and K values were obtained due to the use of the full dose of mineral NPK, ¼ compost + ¾ NPK dose or ½ compost + ½ NPK dose with no significant differences being detected between such three fertilization treatments. Concerning biofertilization treatments, all of the prementioned essential oil determinations, photosynthetic pigments and herb NPK content traits were considerably augmented due to the dual treatment (Minia Azotein + phosphorein) followed by Minia Azotein, while phosphorein gave the least values. In regard to the interaction gave between the, two involved factors, the highest volatile oil determinations and chemical compositions values were given by fertilizing fennel plants with the full dose of mineral NPK, 25% compost + 75% NPK or 50% compost + 50% NPK in combination with dual biofertilizer treatments (Minia Azotein + phosphorein).

It is recommended, to supply fennel plants with 50% compost + 50% NPK in combination with the dual biofertilization treatment (Minia Azotein + phosphorein), from the environmental and economical point of view, in order to maximize the fruit essential oil productivity.

Key words: *Foeniculum vulgare*, compost, NPK, biofertilization, essential oil, chemical constituents.

INTRODUCTION

One of the widely cultivate aromatic and medicinal plants in Egypt is *Foeniculum vulgare*, Miller (fennel) plant. It is a common winter annual herbaceous plant grown successfully in middle Egypt region and belonging to Fam. Apiaceae and considered as one of the ancient Egyptian herbs. Its fruits are used in medicinal folklore, bakery and food industry and the essential oil (2.5-5.0% of the fruits) is involved in different pharmaceutical purposes.

Many investigators revealed the effective role of organic fertilization treatments, from different sources, on promoting essential oil parameters, photosynthetic pigments and/or N, P and K contents of various aromatic seed plants. Examples are Khater (2001) and Abd El-Naeem (2008) on caraway; Rashed (2002) on three aromatic seed crops; Younis *et al.* (2004) on Khella; Abd El-Gawad (2007) and Abdalla (2009) on coriander; Hemdan (2008) and Ali *et al.* (2010) on anise and Helmy (2008) and Al-Shareif (2012) on *Nigella sativa*. In regard to mineral NPK fertilization, it was found that these treatments caused considerable augmentation in essential oil aspects, photosynthetic pigments and/ or N, P and K contents (Abd El-Kader and Ghaly, 2003 and Badran *et al.*, 2013 on coriander; Badran *et al*, 2003 on anise; Salah-Eldeen, 2005 and Badran *et al.*, 2007 on fennel and Badran *et al.*, 2009 and Al-Shareif, 2012 on *Nigella sativa*). Similarly, positive effects due to N-fixing and/or P-dissolving bacteria were found by Rashed (2002) on three aromatic seed plants; Safwat and Badran (2002) and Shalateet (2006) on cumin; Mahfouz and Sharaf-Eldin (2007) and Tanious (2008) on fennel; Abd El-Naeem (2008) on caraway and Badran *et al.* (2009) and Badran *et al.* (2012) on *Nigella sativa.* So, the present investigation aimed to reach the most proper compost/NPK treatment in combination with biofertilizer treatment for producing the highest essential oil of fennel plants.

MATERIALS AND METHODS

This trial was carried out during the two successive seasons of 2012/2013 and 2013/2014 at Mattay, Minia Governorate, Egypt to investigate the effect of compost/NPK and biofertilizer treatments on essential oil parameters and some chemical constituents of fennel plants.

Fruits of fennel were sown on the last week of Oct. of both seasons in 3×3.60 meter plots with 60 cm distance between the rows and 50 cm between hills within each row. So, each plot contained 6 rows and 36 hills (2 plants/hill). Plants were thinned twice, 3 weeks from planting date and 2 weeks followed as usual. Physical and chemical properties of the soil are shown in Table (a).

A complete randomized block design following the split-plot arrangement, in three replicates, was executed in this experiment with six compost/NPK treatments in the main plots (A) i.e. control, compost (7.5 ton/fed), ¾ compost + ¼ NPK, ½ compost + ½ NPK, ¼ compost + ¾ NPK and full dose of NPK. The full dose of mineral NPK was added at the rate of 200 kg/fed ammonium nitrate, 33.5% N; 150 kg/fed calcium superphosphate, 15.5% P_2O_5 and 100 kg/ fed potassium sulphate, 48.55 K_2O. While the full dose of compost (Compost El-Neel) was added at the rate of 7.5 ton/fed, with physical and chemical properties shown in Table (b).

The sub-plots (B) were control, Minia Azotein, phosphorein and Minia Azotein plus phosphorein. The mineral N and K fertilizer amounts, for each treatment were divided into 3 batches and added after the last thinning and every three weeks thereafter.

Table a. Physical and chemical analysis of the soil.

Characters	Value	Characters		Value
Soil type	Clay loam	**Total N (%)**		0.06
Sand (%)	31.70	**Avail. P (%)**		8.90
Silt (%)	25.60	**Exch. K (mg/100 g)**		1.46
Clay (%)	42.70	**DTPA Extr. (ppm)**	**Fe**	5.10
Org. Matt. (%)	1.08		**Cu**	1.29
Ca CO_3 (%)	4.18		**Zn**	1.85
pH (1 : 2.5)	7.86		**Mn**	11.52
E.C. (mmhos/cm)	1.08			

Table b. Physical and chemical properties of the used compost.

Properties	Value	Properties	Value
Dry weight of 1 m^3	450 kg	**C/N ratio**	18.5-14.1
Fresh weight of 1 m^3	650-700kg	**NaCl (%)**	1.1- 1.75
Moisture (%)	25-30	**Total P (%)**	0.5- 0.75
pH (1:10)	7.5- 8	**Total K (%)**	0.8-1.0
E.C. (mmhos/cm)	2 - 4	**Fe (ppm)**	150-200
Total N (%)	1-1.4	**Mn (ppm)**	25-56
Org. matter (%)	32-34	**Cu (ppm)**	75-150
Org. carbon %	18.5-19.7	**Zn ppm**	150-225

While compost and phosphorus fertilizer were added during soil preparation. The two biofertilizers, Minia Azotein and phosphorein were applied to the soil twice, after 6 and 10 weeks from planting date, at the rate of 50 ml/plant of each biofertilizer, and then plants were irrigated immediately.

Data were recorded for the three essential oil parameters, percent and yield per plant and per fed. according to the method of Gad *et al.* (1963) the three photosynthetic pigments, chlorophylls a, chlorophyll b and carotenoids contents were estimated using the method of Fadl and Seri-Eldeen (1978). Also the herb contents of nitrogen, phosphorus and potassium were determined, according to Wilde *et al.* (1985), Chapman and Prat (1975) and Cottenie *et al.* (1982) respectively, by multiplying the percent of each nutrient by the corresponding herb dry weight. All obtained data were statically analyzed following the L.S.D. method at 5% according to MSTAT-C (1986).

RESULTS

Essential oil parameters:

Obtained data in Table (1) show that the five compost/NPK treatments, namely, full dose of compost (7.5 ton/ fed), ¾ compost + ¼ NPK, ½ compost + ½ NPK, ¼ compost + ¾ NPK and full dose of NPK caused noticeable and great increase in essential oil percent and yield per plant and per fed, in the two seasons, over those of control unfertilized plants. Such increase was significant due to all these five treatments for the essential oil yield per plant and per fed, but not significant only for full dose of compost in regard to essential oil percent in both seasons. Among the five examined compost/NPK treatments, each of the three essential oil parameters, was gradually increased, in ascending order, due to full dose of compost, ¾ compost + ¼ NPK, ½ compost + ½ NPK, ¼ compost + ¾ NPK and full dose of NPK. These results were almost identical in the two seasons as illustrated in Table (1).

The increase in essential oil yield per fed due to the use of the previously mentioned five treatments, in comparison with control treatment, reached 52.7, 86.4, 113.0, 147.3 and 195.1% in the first season; and 66.9, 97.1, 140.6, 191.4 and 228.6% respectively in the second season. The role of organic fertilization in augmenting essential oil parameters was reported by Abd El-Naeem (2008) on caraway; Hemdan (2008) on anise; Helmy (2008) and Al-Shareif (2012) on black cumin and Abdalla (2009) on coriander. While that of ¾ compost + ¼ NPK, ½ compost + ½ NPK, ¼ compost + ¾ NPK and full dose of NPK was insured by Badran *et al.* (2003) on anise; Adb El-Kader and Ghaly (2003) and Badran *et al.* (2013) on coriander and Badran *et al.* (2009) and Al-Shareif (2012) on *Nigilla sativa*.

Concerning biofertilization treatments, the three used ones, Minia Azotein, phosphorein and dual Minia Azotein/ phosphorein treatments caused an increase in essential oil percent and yield per plant and per fed, in both seasons, over those of control plants as shown in Table (1). The differences were significant only for the yield per plant and per fed with the highest values being given by the dual treatment (Minia Azotein + phosphorein) followed by Minia Azotein, while phosphorein gave the least values. The dual treatment increased essential oil yield/ fed by 19.4% in the first season, and by 18.4% in the second one in comparison with those of control plants as shown in Table (1). The increase in essential oil was also found on cumin (Safwat and Badran, 2002 and Shalateet, 2006); caraway (Abd El-Naeem, 2008); fennel (Tanious, 2008) and black cumin (Badran *et al.*, 2012).

The interaction between compost / NPK treatments and biofertilization treatments was significant, in both seasons, for the three fennel essential oil parameters, percent and yield per plant and per fed, as clearly shown in Table (1). The highest overall value for the three parameters was obtained when fennel plants were fertilized with the full dose of NPK in combination with the dual

Table 1. Effect of compost/ NPK and biofertilization treatments on essential oil determinations of fennel plants during 2012/2013 and 2013/2014 seasons.

Compost/NPK Treatments (A)	Biofertilizer (B)									
	Control (zero)	M.A.	Phos.	M.A.+ Phos.	Mean (A)	Control (zero)	M.A.	Phos.	M.A.+ Phos.	Mean (A)
	First season (2012/2013)					Second season (2013/2014)				
	Essential oil %									
Control (zero)	2.25	2.58	2.53	2.80	2.54	2.27	2.62	2.47	2.75	2.53
Compost 7.5ton/fed	2.92	3.18	3.00	3.22	3.08	3.00	3.12	3.05	3.17	3.09
¾ Compost + ¼ NPK	3.25	3.30	3.27	3.32	3.28	3.13	3.27	3.20	3.32	3.23
½ Compost + ½ NPK	3.33	3.38	3.35	3.45	3.38	3.35	3.45	3.43	3.63	3.47
¼ Compost + ¾ NPK	3.50	3.58	3.52	3.75	3.59	3.70	3.77	3.72	3.80	3.75
Full dose of NPK	3.87	4.05	4.02	4.17	4.03	3.87	4.10	4.05	4.22	4.06
Mean (B)	3.19	3.35	3.28	3.45		3.22	3.39	3.32	3.48	
L.S.D. at 5%	A: 0.69		B: N.S	AB: 0.71		A: 0.63		B: N.S	AB: 0.68	
	Essential oil yield (ml/plant)									
Control (zero)	0.48	0.63	0.59	0.74	0.61	0.45	0.63	0.58	0.68	0.58
Compost 7.5ton/fed	0.82	0.99	0.91	1.02	0.94	0.87	1.01	0.95	1.06	0.97
¾ Compost + ¼ NPK	1.04	1.18	1.14	1.22	1.15	1.08	1.18	1.11	1.24	1.15
½ Compost + ½ NPK	1.23	1.31	1.26	1.43	1.31	1.26	1.40	1.38	1.58	1.40
¼ Compost + ¾ NPK	1.44	1.53	1.46	1.65	1.52	1.63	1.72	1.68	1.78	1.70
Full dose of NPK	1.68	1.84	1.79	1.93	1.81	1.80	1.93	1.90	2.02	1.91
Mean (B)	1.12	1.25	1.19	1.33		1.18	1.31	1.26	1.39	
L.S.D. at 5%	A: 0.18		B: 0.12	AB: 0.29		A: 0.21		B: 0.11	AB: 0.27	
	Essential oil yield (l/feddan)									
Control (zero)	14.5	19.0	17.9	22.2	18.4	13.4	18.8	17.5	20.4	17.5
Compost 7.5ton/fed	24.7	29.7	27.3	30.7	28.1	26.2	30.2	28.4	31.9	29.2
¾ Compost + ¼ NPK	31.2	35.3	34.3	36.6	34.3	32.3	35.4	33.2	37.2	34.5
½ Compost + ½ NPK	36.9	39.2	37.8	42.8	39.2	37.8	42.0	41.3	47.3	42.1
¼ Compost + ¾ NPK	43.2	45.8	43.8	49.4	45.5	48.8	51.7	50.3	53.5	51.0
Full dose of NPK	50.5	55.3	53.6	58.0	54.3	54.0	57.9	57.1	60.8	57.5
Mean (B)	33.5	37.4	35.8	40.0		35.4	39.3	38.0	41.9	
L.S.D. at 5%	A: 5.8		B: 4.1	AB: 10.0		A: 6.1		B: 3.8	AB: 9.3	

biofertilization treatment. However, from the practical, economical and environmental point of view, no significant differences were existed, in both seasons for the three essential oil parameters, between solely NPK traditional treatment and that of ½ compost + ½ NPK plus dual biofertilization treatment as clearly indicated in Table (1).

Photosynthetic pigments:

The three photosynthetic pigments, chlorophyll a, chlorophyll b and carotenoids contents in the leaves of fennel plants were greatly promoted in the two seasons due to the use of all five compost and/or mineral NPK fertilization treatments in comparison with those of control treatment as shown in Table (2). Most of these fertilization treatments resulted in significant differences, for control treatment. The highest values in this concern were obtained from the three treatments of all NPK dose, ¼ compost + ¾ NPK and ½ compost + ½ NPK with no significant being obtained between such three treatments. These results were similar in the two experimental seasons as illustrated in Table (2). In agreement with these results, in regard to organic fertilization, were the findings of Abd El-Gawad (2007) and Abdalla (2009) on coriander; Abd El-Naeem (2008) on caraway; Hemdan (2008) on anise and Al-Shareif (2012) on *Nigella sativa*. In relation to mineral NPK fertilization were those found by Badran *et al.* (2003) on anise; Salah-Eldeen (2005) and Badran *et al*. (2007) on fennel and Badran *et al.* (2009) and Al-Shareif (2012) on *Nigella sativa.*

In regard to biofertilization treatments, the obtained results in Table (2) showed that these treatments seemed to have slight influence on inducing the contents of chlorophyll a, chlorophyll b and carotenoids. Significant differences were detected only for chlorophyll a in the first season. Among the three biofertilization treatments, the dual one (Minia Azotein + phosphorein) surpassed the other two treatments in producing higher values of chlorophyll a and b and carotenoids contents in both seasons as shown in Table (2). In accordance with these findings were the results of Rashed (2002) on three aromatic seed plants; Shalateet (2006) on cumin; Abd El-Naeem (2008) on caraway; Tanious (2008) on fennel and Badran *et al.* (2009) on *Nigella sativa*.

The interaction between compost/ NPK and biofertilization treatments was significant for chlorophyll a and carotenoids contents in the two experimental seasons. However, the highest overall values for the three photosynthetic pigments were obtaind due to the full NPK, followed by ¼ compost + ¾ NPK and ½ compost + ½ NPK in combination with the dual Minia Azotein/phosphorein treatment as shown in Table (2).

Herb Contents of N, P and K:

Data in Table (3) showed that all five tested compost and/or NPK fertilization treatments caused significant promotion, in both first and second seasons, in each of nitrogen, phosphorus and potassium contents in the herb of fennel plants, in comparison with those of control plants. The highest increase, among these five treatments, for each one of three nutrients contents in the two seasons was attained by the full dose of NPK treatment, while the lowest increase was due to the full dose of compost treatment. Meanwhile, the three combined compost/NPK treatments gave intermediate increase as clearly illustrated in Table (3). The increase in herb N, P and K contents due to 100% compost and 100% NPK treatments, respectively, came to 14.3 and 68.6% for nitrogen; 33.7 and 132.7% for phosphorus and 24.0 and 66.1% for potassium in the first season. The corresponding increase in the second season reached 17.1 and 74.2% for nitrogen; 36.5 and 138.5% for phosphorus, and 13.7 and 55.0% for potassium.

The role of organic fertilization in promoting N, P and k contents was found by Khater (2001), Rashed (2002), Younis *et al.* (2004), Abd El-Gawad (2007) and Ali *et al.* (2010) on caraway, 3 aromatic plants, Khella, coriander and anise respectively.

Table 2. Effect of compost/ NPK and biofertilization treatments on photosynthetic pigments of fennel plants during 2012/2013 and 2013/2014 seasons.

Compost/NPK Treatments (A)	Biofertilizer (B)									
	Control (zero)	M.A.	Phos.	M.A.+ Phos.	Mean (A)	Control (zero)	M.A.	Phos.	M.A.+ Phos.	Mean (A)
	First season (2012/2013)					Second season (2013/2014)				
	Chlorophyll a content (mg/g F.W.)									
Control (zero)	1.429	1.522	1.499	1.572	1.505	1.483	1.521	1.503	1.535	1.511
Compost 7.5ton/fed	1.606	1.633	1.611	1.643	1.623	1.577	1.620	1.613	1.637	1.612
¾ Compost + ¼ NPK	1.652	1.673	1.669	1.687	1.670	1.659	1.687	1.675	1.699	1.680
½ Compost + ½ NPK	1.701	1.728	1.716	1.761	1.727	1.710	1.734	1.725	1.745	1.729
¼ Compost + ¾ NPK	1.759	1.790	1.783	1.798	1.782	1.748	1.775	1.760	1.810	1.773
Full dose of NPK	1.804	1.817	1.810	1.827	1.814	1.826	1.841	1.838	1.859	1.841
Mean (B)	1.658	1.694	1.681	1.715		1.667	1.696	1.686	1.714	
L.S.D. at 5%	A: 0.106	B: 0.051		AB: 0.125		A: 0.121	B: N.S		AB: 0.135	
	Chlorophyll b content (mg/g F.W.)									
Control (zero)	0.522	0.554	0.544	0.567	0.547	0.524	0.540	0.539	0.557	0.540
Compost 7.5ton/fed	0.571	0.586	0.581	0.593	0.583	0.570	0.581	0.577	0.585	0.579
¾ Compost + ¼ NPK	0.597	0.619	0.615	0.625	0.614	0.592	0.613	0.611	0.637	0.613
½ Compost + ½ NPK	0.636	0.642	0.640	0.665	0.646	0.646	0.656	0.650	0.688	0.660
¼ Compost + ¾ NPK	0.666	0.677	0.671	0.697	0.678	0.692	0.703	0.694	0.717	0.701
Full dose of NPK	0.704	0.727	0.715	0.742	0.722	0.719	0.733	0.724	0.768	0.736
Mean (B)	0.616	0.634	0.628	0.648		0.624	0.637	0.632	0.659	
L.S.D. at 5%	A: 0.092	B: N.S		AB: N.S		A: 0.086	B: N.S		AB: N.S	
	Carotenoids content (mg/g F.W.)									
Control (zero)	0.636	0.654	0.659	0.679	0.657	0.641	0.651	0.660	0.672	0.656
Compost 7.5ton/fed	0.683	0.694	0.696	0.710	0.696	0.697	0.713	0.717	0.729	0.714
¾ Compost + ¼ NPK	0.722	0.736	0.742	0.759	0.740	0.748	0.760	0.773	0.780	0.765
½ Compost + ½ NPK	0.766	0.774	0.779	0.798	0.779	0.792	0.798	0.813	0.826	0.807
¼ Compost + ¾ NPK	0.842	0.855	0.868	0.893	0.865	0.849	0.856	0.868	0.875	0.862
Full dose of NPK	0.900	0.923	0.922	0.940	0.921	0.915	0.934	0.949	0.964	0.940
Mean (B)	0.758	0.773	0.778	0.797		0.774	0.785	0.797	0.808	
L.S.D. at 5%	A: 0.165	B: N.S		AB: 0.208		A: 0.152	B: N.S		AB: 0.172	

Table 3. Effect of compost/ NPK and biofertilization treatments on NPK contents of fennel plants during 2012/2013 and 2013/2014 seasons.

Compost/NPK Treatments (A)	Biofertilizer (B)									
	Control (zero)	M.A.	Phos.	M.A.+ Phos.	Mean (A)	Control (zero)	M.A.	Phos.	M.A.+ Phos.	Mean (A)
	First season (2012/2013)					Second season (2013/2014)				
	Herb nitrogen content (mg/g D.W.)									
Control (zero)	44.6	51.0	50.1	55.6	50.3	44.5	51.4	50.0	55.5	50.4
Compost 7.5ton/fed	55.6	58.0	57.3	59.2	57.5	56.1	59.7	58.9	61.2	59.0
¾ Compost + ¼ NPK	57.9	62.4	61.1	66.2	61.9	61.7	63.4	62.4	68.1	63.9
½ Compost + ½ NPK	65.7	69.0	67.3	71.4	68.4	69.3	72.1	70.6	73.6	71.4
¼ Compost + ¾ NPK	74.4	78.5	77.0	81.1	77.8	75.5	81.4	79.1	82.1	79.5
Full dose of NPK	81.9	85.8	83.5	87.8	84.8	84.7	87.8	87.1	91.6	87.8
Mean (B)	63.4	67.5	66.0	70.2		65.3	69.3	68.0	72.0	
L.S.D. at 5%	A: 6.2	B: 6.6		AB: 16.2		A: 7.3	B: 6.2		AB: 15.2	
	Herb phosphorus content (mg/g D.W.)									
Control (zero)	8.4	10.1	10.2	11.6	10.1	8.3	9.5	9.8	10.9	9.6
Compost 7.5ton/fed	12.7	13.2	13.6	14.4	13.5	11.8	12.6	13.7	14.2	13.1
¾ Compost + ¼ NPK	14.4	15.4	15.3	16.7	15.4	14.5	14.9	15.0	15.9	15.2
½ Compost + ½ NPK	16.6	17.3	17.2	18.9	17.5	16.2	17.0	16.8	18.2	17.1
¼ Compost + ¾ NPK	19.3	20.4	20.5	22.0	20.6	18.6	19.9	19.8	20.4	19.7
Full dose of NPK	22.0	23.4	23.5	25.0	23.5	21.7	22.7	23.0	24.2	22.9
Mean (B)	15.6	16.6	16.7	18.1		15.2	16.1	16.3	17.3	
L.S.D. at 5%	A: 3.1	B: N.S		AB: 10.3		A: 2.8	B: N.S		AB: 9.3	
	Herb potassium content (mg/g D.W.)									
Control (zero)	70.1	77.5	74.5	86.8	77.2	77.6	86.9	85.0	92.8	85.6
Compost 7.5ton/fed	93.3	96.0	95.0	98.5	95.7	93.7	98.4	97.9	99.1	97.3
¾ Compost + ¼ NPK	96.7	102.0	100.1	106.7	101.4	100.1	101.7	100.2	106.3	102.4
½ Compost + ½ NPK	106.3	110.0	107.3	112.6	109.1	108.3	112.4	110.2	114.1	111.3
¼ Compost + ¾ NPK	116.8	121.7	119.6	123.3	120.4	116.4	123.5	121.1	125.0	121.5
Full dose of NPK	124.6	128.7	127.0	132.3	128.2	128.1	132.7	131.9	137.9	132.7
Mean (B)	101.3	106.0	103.9	110.0		104.0	109.3	107.9	112.5	
L.S.D. at 5%	A: 10.3	B: 7.6		AB: 18.6		A: 10.8	B: 8.1		AB: 19.8	

While that of NPK fertilization was recognized on anise (Badran *et al.*, 2003); fennel (Salah-Eldeen, 2005) and (Badran *et al.*, 2007); black cumin (Badran *et al.*, 2009) and coriander (Badran *et al.*, 2013).

Herb nitrogen and potassium contents were significantly increased, in the two seasons, due to the use of dual biofertilization treatment (Minia Azotein + phosphorein) as shown in Table (3). Similar observation was found for phosphorus content but with no significant differences. In addition, each of Minia Azotein and phosphorein treatments caused an increase in N, P and K contents over those of control plants in both seasons, but the differences did not reach the level of significancy as indicated in Table (3). Some authors pointed out the role of biofertilization treatments in augmenting N, P and K contents such as Rashed (2002) on 3 aromatic plants; Mahfouz and Sharaf-Eldeen (2007) on fennel and Badran *et al.* (2012) on *Nigella sativa*.

The interaction between compost/NPK treatments and biofertilization treatments was significant for nitrogen, phosphorus and potassium contents in the two seasons as shown in Table (3). The highest overall values were those given by the full dose of NPK treatment in combination with any one of the three biofertilization treatments. In the second place came the treatment of ¼ compost + ¾ NPK in combination with the dual biofertilization treatment, (Table, 3).

DISCUSSION

The recommended dose of mineral NPK was applied to fennel plants to be compared with some organic and (N-fixing and/or P-dissolving bacteria) commercial products (Minia Azotein and/or phosphorein). It was found that NPK treatment overcame such compost and biofertilization treatments in essential oil yield and some chemical composition. The superiority of mineral NPK fertilization could be attributed to the unique biological and physiological roles of each one of such three essential elements in plant growth and development explained by Yagodin (1984).

Nitrogen is a constituent of most organic compounds i.e. amino acids, nucleic acids (RNA and DNA) enzymes, alkaloids, vitamins, phosphatides, purine, and many energy transfer materials such as chlorophylls, ADP and ATP, Bidwall (1974) . Phosphorus which have been called the key to life is essential for cell division and for development of meristimatic tissue and it is very important for carbohydrate transformation duo to multitude of phosphorylation reaction and to energy rich phosphate bond, (Lambers *et al.*, 2000). Potassium is important for growth and elongation probably due to its function as an osmoticum and may react synergistically with IAA; moreover, it promotes CO2 as simulation and translocation of carbohydrates from the leaves to storage tissues (Mengel and Kirkby, 1987).

Follet *et al.* (1981) summarized the positive roles of organic fertilization in the following points:

- Increasing total nitrogen, organic matters and humus in soil.
- Improving soil properties and water holding capacity.
- Faster release of essential nutrients by microbial decomposition.

Different authors such as Hedge *et al.* (1999) and Hauwaka (2000) explained the roles of N- fixing bacteria in:

- Fixation of the atmospheric N which caused an increment of available N which increase, by sequence, the formation of many metabolites.
- Protecting their host plant against plant pathogens through the production of antibacterial and antifungal substances.

The enhancing effects of P-dissolving bacteria, on the other hand, were suggested by Abdou-Elnour *et al*. (1996) and Hauaka (2000) and could be summarized in:

- Producing growth hormones which promote plant growth and development.
- Establishment of strong root system is related to the level of available phosphate in the soil.

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تأثير معاملات التسميد بالكمبوست/المعدني والحيوي على الزيت الطيار والمكونات الكيماوية لنباتات الشمر

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تم إجراء تجربة حقلية بهدف معرفة تاثير التسميد بالكمبوست/المعدني و التسميد الحيوي في خلال موسمين ٢٠١٢/٢٠١٣ و ٢٠١٣/٢٠١٤ على الزيت الطيار والصبغات الضوئية ومحتوى العشب الجاف لنبات الشمر من النيتروجين والفوسفور والبوتاسيوم .

افضل النتائج المتحصل عليها لصفات الزيت الطيار (النسبة المئوية لزيت الثمار الطيار، محصول النبات والفدان من زيت الثمار الطيار) وصفات الصبغات الضوئية الثلاثة (كلوروفيل أ ، ب والكاروتينيدات) وكذلك محتوى العشب الجاف من النيتروجين والفوسفور والبوتاسيوم كانت نتيجة استخدام كل من المعدل الكامل من التسميد المعدني وكذلك (٣/٤ معدل السماد المعدني + ١/٤ معدل الكمبوست) و (١/٢ معدل المعدني + ١/٢ معدل الكمبوست) كما انه لا يوجد اختلاف معنوي في نتائج الثلاث معاملات . اما بالنسبة لمعاملات التسميد الحيوي فان افضل النتائج المتحصل عليها كانت نتيجة استخدام المعاملة المزدوجة من (منيا أزوتين + الفوسفورين) تليها المعاملة ب (منيا أزوتين) وأقلهم كان نتيجة التسميد بالفوسفورين. اما بالنسبة لمعاملات التفاعل بين التسميد بالكمبوست/المعدني والسماد الحيوي فقد نتجت افضل صفات الزيت الطيار والصفات الكيماوية عند تسميد نباتات الشمر بالمعدل الكامل من NPK او٧٥% معدني + ٢٥% كمبوست او ٥٠% معدل التسميد المعدني + ٥٠% معدل الكمبوست بالاضافة الى التسميد الحيوي (منيا أزوتين + الفوسفورين).

لذلك يمكن أن نوصي من وجهة النظر البيئية والاقتصادية بامداد نباتات الشمر بـ ١/٢ الكمبوست (٣.٥ طن/ف) + ١/٢ NPK (١٠٠ كجم/ف نترات نشادر + ٧٥ كجم/ف سوبر فوسفات + ٥٠كجم/ف سلفات بوتاسيوم) بالاضافة الي المعاملة الحيوية الثنائية (منيا أزوتين ٥٠ مل للنبات + فوسفورين ٥٠ مل للنبات) وذلك بغرض تعظيم محصول الزيت الطيار لثمار نباتات الشمر.