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Effect of Compost and some Biofertilizers on Growth, Yield, Essential Oil Productivity and Chemical Composition of *Rosmarinus officinalis*, L. Plants

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Abstract: This investigation was carried out at the experimental farm of Medicinal and Aromatic plants Research Department, Horticulture Research, Dokki, Giza during two successive seasons of 2009/2010 and 2010/2011.The research aimed to study the effect of compost rates (2,4and 8 ton/fed) and some biofertilizers *(Azotobacter Chroococcum*, *Bacillus megaterium, Bacillus circulanse*) alone or all strains in a mixture with or without compost on growth, yield, essential oil productivity and chemical composition of *Rosmarinus officinalis,* L. plants. The results showed that, in both seasons, the highest plant height; number of branches; plant fresh and dry weights, oil percentage and yield in fresh herb and total carbohydrates were given by adding compost at 8 ton/ fed compared to other compost treatments; *Azotobacter Chroococcum* (AZ) + *Bacillus megaterium* (B1) +*Bacillus circulanse* (B2) compared to other biofertilizers treatments; compost at 8 ton / fed + Az+B1+B2 compared to other combination treatments.

Key words: *Rosmarnus offcinalis* · Compost · Biofertilization · Growth · Essential oil percentage · Oil yield

INTRODUCTION

Medicinal and aromatic plants represent an important source of income in agriculture section of national economy in many countries. Medicinal and aromatic plants are an essential oil source of the well known drugs.Rosemary (*Rosmarinus officinalis* L.) is one of the important medicinal and aromatic perennial plants used externally as parasiticide and cicatrisant for muscular pains and rheumatism, dermatitis, dandruff and eczema. It serves as a natural antioxidant, it promotes hair growth and stimulates scalp. Internally, it is used for asthma, bronchitis whooping cough to stimulate poor circulation. It is employed for palpitation, debility, headache, neuralgia, rental fatigue, nervous exhaustion and stress-related disorders, dyspepsia, flatulence, hepatic disorders, hypercholesterolemia and jaundice [1, 2]. Rosemary oil is extensively used in soap, detergents, cosmetics, house-hold sprays and perfumes industry. Also, it is extensively used in most major food categories especially meat products and drinks. [2].

MATERIALS AND METHODS

This investigation was carried out at the Experimental Farm of Medicinal and Aromatic Plants, Research Department, Horticulture Research Institute, Agricultural Research Center, Dokki, Giza in two successive seasons of 2009/2010 and 2010/2011.The aim of this study was to investigate the effect of using different levels of compost and some biofertilizers on growth, yield, essential oil productivity and chemical composition of rosemary (Rosmarinus officinalis, L.) plants.
The bacterial strains used in the experiment were:

- *Azotobacter Chroococcum* (Az).
- *Bacillus megatherium* (B1).
- *Bacillus circulanse* (B2).
- Mixture of the three used strains (A+B1+B2). All the strains were kindly obtained from Agic. Microbiology Res. Dept., A R C, Giza, Egypt. They were grown on nutrient broth medium [3] incubated for 24 hr at 28°C to ensure population density of 5*10 cfu /ml culture and injected into sterilized cattier.

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Table 1: Physical and chemical characters of the soil

Physical analysis											
Sand%			Clay%			Silt%					Texture class
72.3			6.4			13.6					Sandy loam
Chemical analysis											
		Soluble cations and anions (meq/L)					Available elements (ppm)				
pH	EC dS/m	HCO_3^-	Cl^-	SO_4^{--}	Ca^{++}	Mg^{++}	Na^+	K^+	N	P	K
8.1	125	3.00	3.5	7.20	5.10	2.20	4.20	0.40	2.00	27.00	7.00

Table 2: Chemical analysis of compost used in this investigation

Chemical analysis	pH	E.C.mM	N%	P%	K%	C/Nratio	Feppm	Mnppm	Cuppm	znppm
Compost	7.5	6.4	1.16	1.47	1.23	17	1021	111	180	28

They were added one month after transplanting and repeated after each cut as soil drench. Compost El-Nile was obtained from the company Engineering Tasks Group(ENTAG). Rosemary seedlings used in this study (average height of 20-25cm) were obtained from the farm of El-Kanater El- Khaireya, Kalyoubeya Governorate and planted on 15thMarch in both seasons in clay pots (30 cm diameter) filled with sandy loam soil. The physical and chemical characters of the soil as well as the chemical analysis of compost used in this investigation are shown in Tables 1 and 2, respectively.

The plants received the following levels of compost and biofertilizer:

- Compost at 2ton/feddan
- Compost at 2ton/feddan+*Azotobacter Chroococcum* (AZ)
- Compost at 2ton/feddan+*Bacillus megaterium* (B1*)*
- Compost at 2ton/feddan+*Bacillus circulanse*(B2)
- Compost at 2ton/feddan+ *Azotobacter Chroococcum*+ *Bacillus megaterium* +*Bacillus circulanse(*AZ+B1+B2)
- compost at 4ton/feddan
- compost at 4ton/feddan+*Azotobacter Chroococcum*(AZ)
- compost at 4ton/feddan+*Bacillus megaterium* (B1*)*
- compost at 4ton/feddan+*Bacillus circulanse*(B2)
- compost at 4ton/feddan+ *Azotobacter Chroococcum*+ *Bacillus megaterium* +*Bacillus* circulans (AZ+B1+B2)
- compost at 8ton/feddan
- compost at 8 ton/feddan+*Azotobacter Chroococcum* (AZ)
- compost at 8ton/feddan+*Bacillus megaterium* (B1)
- compost at 8ton/feddan+*Bacillus* circulanse (B2)
- compost at 8ton/feddan+ *Azotobacter Chroococcum*+ *Bacillus megaterium* +*Bacillus circulanse*(AZ+B1+B2)

Layout of the Experiment: The data from the three cuts were statistically analyzed as out lined by Gomez and Gomez [4] using the least significant difference (LSD) at 5 level to differentiate between means.

RESULTS AND DISCUSSION

Effect of compost and biofertilization on vegetative growth

1. Plant height

Data in Table 3 showed that increasing the rates of compost per feddan significantly increased the plant height of the plant. The highest rate of compost (8ton/fed) significantly produced the tallest plants (32.64 and 30.36 cm) in the first and second seasons, respectively. Concerning the effect of the interaction between compost treatments and cuts, it is very clear that the tallest plants(36.53 and 36.37cm) were produced with compost at 8ton/fed in the second cut and the first cut in the first and second seasons, respectively. Regarding the use of biofertilization, it was clear that the tallest plants (32.10 and 30.33 cm) were obtained with adding *Azotobacter Chroococcum* + *Bacillus* megaterium and *Bacillus circulanse* in the first and second seasons, respectively. These results are in agreement with these obtained by El-Hindi and EL-Boraie [5] on Majoram plants observing that Nitrobein improved the plant height. Balathand *et al*. [6] found that the combination between Azotobacter, Bacillus and Pseudomonas significantly increased plant height.

Table 3: Effect of compost, biofertilizers and the interaction between them on plant height during 2009/2010 and 2010/2011 seasons

Treatments								
Bio	First season				Second season			
Comp	Cuts			Compost means	Cuts			Compost means
Comp	1st	2nd	3rd		1st	2nd	3rd	
2 ton/fed	32.07	32.20	19.23	27.83	33.46	25.53	21.69	26.89
4 ton/fed	34.07	35.13	24.33	31.18	34.67	27.61	23.68	28.65
8 ton/fed	36.20	36.53	25.20	32.64	36.37	30.68	24.04	30.36
	Cuts * Biofertilizer interaction			Biofertilizer means	Cuts * Biofertilizer interaction			Biofertilizer mean
nonbiofertilizer	32.78	33.11	22.82	29.57	34.00	26.33	21.83	27.39
(Az)	34.33	35.89	23.24	31.16	35.50	28.02	23.48	29.00
(B1)	33.00	34.33	23.19	30.18	35.02	28.22	23.52	28.92
(B2)	34.00	34.11	21.16	29.76	33.56	26.78	22.30	27.54
Az+B1+B2	36.44	35.67	24.18	32.10	36.07	30.36	24.56	30.33
	C*COMP*BIO			Compost * Biofertilizer interaction	C*COMP*BIO			Compost *Biofertilizer interaction
Comp 2 ton								
Comp	31.00	28.33	18.13	25.82	32.33	24.33	21.33	26.00
(Az)	32.33	33.33	19.40	28.36	34.40	26.33	21.88	27.54
(B1)	31.33	31.33	19.92	27.53	33.67	26.00	21.22	26.96
(B2)	31.67	32.33	17.80	27.27	32.67	24.00	21.67	26.11
Az+B1+B2	34.00	35.67	20.89	30.18	34.22	27.00	22.33	27.85
Comp 4 ton								
Comp	33.33	35.00	26.00	31.44	34.55	26.67	21.50	27.57
(Az)	33.33	36.67	23.67	31.22	34.78	27.33	24.22	28.78
(B1)	32.67	35.00	24.67	30.78	34.67	28.00	24.00	28.89
(B2)	34.00	33.33	22.67	30.00	34.00	27.33	23.00	28.11
Az+B1+B2	37.00	35.67	24.67	32.44	35.33	28.73	25.67	29.91
Comp 8 ton								
Comp	34.00	36.00	24.33	31.44	35.11	28.00	22.67	28.59
(Az)	37.33	37.67	26.67	33.89	37.33	30.40	24.33	30.69
(B1)	35.00	36.67	25.00	32.22	36.73	30.67	25.33	30.91
(B2)	36.33	36.67	23.00	32.00	34.00	29.00	22.22	28.41
Az+B1+B2	38.33	35.67	27.00	33.67	38.67	35.33	25.67	33.22
Cut means	34.11	34.62	22.92		34.83	27.94	23.14	
LSD at			5%				5%	
Cuts (c)			0.891				0.676	
Compost (Comp)			0.891				0.676	
Biofertilizer (Bio)			1.150				0.872	
C * Comp			NS				1.170	
C * Bio			NS				NS	
Comp * Bio			NS				NS	
C * Comp * Bio			NS				NS	

Comp*compost, *Azotobacter Chroococcum* (AZ), *Bacillus megaterium* (B1) *Bacillus circulanse* (B2), *Azotobacter Chroococcum*+ *Bacillus megaterium* +*Bacillus circulanse(*AZ+B1+B2)

Table 4: Effect of compost, biofertilizers and the interaction between them on number of branches during 2009/2010 and 2010/2011 seasons

Treatments								
Bio	First season				Second season			
Comp	Cuts			Compost means	Cuts			Compost means
2 ton/fed	5.720	12.600	7.907	8.742	5.47	11.00	9.70	8.72
4 ton/fed	7.493	16.987	9.173	11.218	7.67	13.00	11.58	10.75
8 ton/fed	8.067	19.760	15.700	14.509	8.73	17.20	18.47	14.80
	Cuts * Biofertilizer interaction			Biofertilizer means	Cuts * Biofertilizer interaction			Biofertilizer mean
nonbiofertilizer	6.489	15.311	9.322	10.374	6.44	12.11	10.96	9.84
(Az)	7.311	17.267	11.889	12.156	7.33	14.00	14.67	12.00
(B1)	7.000	15.667	10.667	11.111	7.22	14.11	14.52	11.95
(B2)	6.556	15.333	9.089	10.326	7.00	13.33	10.39	10.24
Az+B1+B2	8.111	18.667	13.667	13.481	8.44	15.11	15.70	13.09
	C*COMP*BIO			Compost * Biofertilizer interaction	C*COMP*BIO			Compost * Biofertilizer interaction
Comp 2 ton								
Comp	5.267	10.667	7.733	7.889	4.33	7.67	7.89	6.63
(Az)	5.667	13.333	8.000	9.000	5.67	11.67	11.33	9.56
(B1)	5.667	12.667	8.000	8.778	5.33	11.67	9.67	8.89
(B2)	5.333	11.000	6.467	7.600	5.33	11.33	8.17	8.28
Az+B1+B2	6.667	15.333	9.333	10.444	6.67	12.67	11.44	10.26
Comp 4 ton								
Comp	6.867	17.267	8.333	10.822	7.00	12.67	9.00	9.56
(Az)	7.933	17.000	9.333	11.422	7.67	12.67	11.33	10.56
(B1)	7.333	16.000	9.000	10.778	8.00	13.00	12.89	11.30
(B2)	7.000	16.667	8.467	10.711	7.33	12.33	11.00	10.22
Az+B1+B2	8.333	18.000	10.733	12.356	8.33	14.33	13.67	12.11
Comp 8 ton								
Comp	7.333	18.000	11.900	12.411	8.00	16.00	16.00	13.33
(Az)	8.333	21.467	18.333	16.044	8.67	17.67	21.33	15.89
(B1)	8.000	18.333	15.000	13.778	8.33	17.67	21.00	15.67
(B2)	7.333	18.333	12.333	12.667	8.33	16.33	12.00	12.22
Az+B1+B2	9.333	22.667	20.933	17.644	10.33	18.33	22.00	16.89
Cut means	10.92	16.449	7.093		7.29	13.73	13.25	
LSD at			5%				5%	
Cuts (c)			0.569				0.568	
Compost (Comp)			0.569				0.568	
Biofertilizer (Bio)			0.735				0.733	
C * Comp			0.986				0.983	
C * Bio			1.273				1.270	
Comp * Bio			1.273				1.270	
C * Comp * Bio			NS				2.199	

Comp*compost, *Azotobacter Chroococcum* (AZ), *Bacillus megaterium* (B1) *Bacillus circulanse* (B2), *Azotobacter Chroococcum+ Bacillus megaterium +Bacillus circulanse(*AZ+B1+B2)

Concerning the effect of the interaction between biofertilization treatments and cuts, it is clear that the tallest plants (36.44and 36..07cm)were produced form adding (*Azotobacter Chroococcum* + *Bacillus* megaterium and *Bacillus circulanse*) together in the first and second seasons, respectively. Concerning the effect of different cuts on plant height, different cuts had a significant effect on plant height. The maximum plant height was 34.62cm in the second cut of the first season and 34.83cm in the first cut of the second season.

Number of Branches / Plant: Data in Table 4 indicated that increasing compost doses gradually increased number of branches /plant. The best results were obtained with compost at 8 ton/fed (14.50 and 14.80 branches per plant) in the first and second seasons, respectively. In the second cut in the first season, the best results were obtained with compost at 8ton /fed (19.76 branches per plant).whereas in the second season, the best results were obtained in the third cut followed by the second cut due to using compost at 8ton/fed (18.47 and 17.20 branches per plant, respectively). These results were in agreement with these obtained by Abd E1-Raoof [7] who studied the effect of different rates of compost on growth and yield of basil (*Ocimum basilium*) plant. Regarding using biofertilization, *Azotobacter Chroococcum* + *Bacillus megaterium* and *Bacillus circulanse* had significant effect on number of branches /plant (13.48 and 13.09 branches per plant in the first and second seasons, respectively). For first seasons, the best results were obtained in the second cut with *Azotobacter Chroococcum* + *Bacillus megaterium* and *Bacillus circulanse* followed by the third and the first cuts (18.66 and 13.66 branches per plant). Meanwhile in the second season, the best results were obtained with the treatment *Azotobacter Chroococcum* + *Bacillus* megaterium and *Bacillus circulanse* in the third cut followed by the second cut (15.70 and 15.11 branches per plant). These results agreed with these obtained by Ahmed [8].

The interaction between compost and biofertilization significantly increased the number of branches in the first and second seasons. The best results were obtained with compost at 8ton plus *Azotobacter Chroococcum*; *Bacillus megaterium* and *Bacillus circulanse* recording 17.64 and 16.89 branches per plant

The first seasons had no significant effect on number of branches, whereas the second seasons had a significant effect on number of branches /plant. It was clear that the highest number of branches /plant resulted in the third cut followed by the second cut (22.and 18.13 branches per plant).

The different cuts had a significant effect on number of branches /plant, it was clear that the highest number of branches /plant was resulted from the second cut in the first and second seasons, respectively (16.44 and 13.73 branches per plant).The lowest values of number of branches /plant were produced in third cut in the first season, (7.09 branches per plant) while the second season gave the lowest value of number of branches /plant produced in the first cut (7.29 branches per plant).

Herb Fresh Weight /Plant: Data in Table 5 showed that in the two seasons, the three used rates of compost treatment increased significantly herb fresh weight especially the higher rate (8ton/fed) recording 45.67 and 31.95 g/plant in the first and second seasons, respectively. The best results were obtained in the second cut of the first and second seasons (72.83 and 43.29 g/plant, respectively).

Regarding using biofertilizers of *Azotobacter Chroococcum* + *Bacillus* megaterium and *Bacillus circulanse* in the first and second seasons, there was significant increase in herb fresh weight / plant giving 44.17 and 30.53 g/plant in the second cut in the first and second seasons, respectively. Concerning the interaction between biofertilization and cuts, biofertilization significantly increased herb fresh weight in the second cut of both seasons recording 68.86 and 36.82 g/plant, respectively.

The interaction between compost and biofertilization, compost at 8 ton/fed plus biofertilization (*Azotobacter Chroococcum* + *Bacillus* megaterium and *Bacillus circulanse*) significantly increased herb fresh weight in the first season (55.89 g/plant) whereas the same treatment gave the best results in the second cut of the first season giving 88.95 g/plant. Whereas the interaction in the second season had no significant effect on herb fresh weigh. Results agreed with these obtained by Ali *et al.* [9] on garlic and EL-Ghadban *et al*. [10] on marjoram.

The different cuts had a significant effect on herb fresh weight it was clear that the highest herb fresh and weight were resulted from the second cut in first season (52.13 g/plant) whereas in the second seasons, the highest value of herb fresh weight was recorded in the third cut (32.78 g/plant).

Herb Dry Weight /Plant: Data in Table 6 showed that,in both seasons, all compost treatments increased herb dry weight / plant. in both seasons. Using the higher rate of compost (8ton/fed) significantly increased herb dry weigh

Table 5: Effect of compost, biofertilizers and the interaction between them on herb fresh weight / plant during 2009/2010 and 2010/2011 season

Treatments								
Bio	First season			Second season				
				Compost				Compost
Comp	Cuts			means	Cuts			means
2 ton/fed	19.10	37.05	23.87	26.67	11.92	24.61	19.59	22.23
4 ton/fed	22.70	46.50	29.89	33.03	15.97	30.44	24.35	26.63
8 ton/fed	28.46	72.83	35.73	45.67	18.99	43.29	31.41	31.95
				Biofertilizer				Biofertilizer
	Cuts * Biofertilizer interaction			means	Cuts * Biofertilizer interaction			mean
Non biofertilizer	21.14	45.02	27.20	31.12	13.13	29.16	22.00	23.70
(Az)	25.34	52.67	29.94	35.99	17.34	33.43	26.00	27.22
(B1)	21.29	46.94	30.52	32.92	14.53	33.19	25.29	28.13
(B2)	20.74	47.15	26.40	31.43	13.80	31.31	23.40	25.10
Az+B1+B2	28.59	68.86	35.08	44.17	19.34	36.82	28.90	30.53
				Compost * Biofertilizer				Compost * Biofertilizer
	C*COMP*BIO			interaction	C*COMP*BIO			interaction
Compost 2 ton								
Comp	16.24	35.45	20.20	23.96	9.87	23.33	17.57	19.50
(Az)	19.96	32.62	22.27	24.95	12.93	25.63	20.36	22.50
(B1)	17.77	37.63	23.33	26.24	11.43	25.37	19.93	23.00
(B2)	17.75	38.64	25.70	27.36	10.76	22.50	18.36	21.83
Az+B1+B2	23.80	40.91	27.83	30.85	14.63	26.23	21.73	24.33
Compost 4 ton								
Comp	23.25	38.00	27.40	29.55	14.37	28.80	21.93	22.63
(Az)	23.06	43.15	29.50	31.90	16.19	30.93	24.47	26.30
(B1)	21.00	36.00	31.70	29.57	15.27	29.40	24.38	28.47
(B2)	20.55	38.65	25.83	28.34	14.87	29.27	23.09	25.13
Az+B1+B2	25.62	76.72	35.03	45.79	19.17	33.80	27.87	30.63
Compost8 ton								
Comp	23.92	61.60	34.01	39.84	15.17	35.33	26.49	28.97
(Az)	33.00	82.25	38.07	51.11	22.90	43.73	33.17	32.87
(B1)	25.10	67.20	36.53	42.94	16.90	44.80	31.54	32.93
(B2)	23.92	64.15	27.67	38.58	15.77	42.17	28.76	28.33
Az+B1+B2	36.35	88.95	42.37	55.89	24.23	50.43	37.10	36.63
Cut means	23.42	52.13	29.83		15.63	26.94	32.78	
LSD at			5%				5%	
Cuts (c)			1.070				5%	
Compost (Comp)			1.070				1.68	
Biofertilizer (Bio)			1.381				1.68	
C * Comp			1.853				2.18	
C * Bio			2.392				2.92	
Comp * Bio			2.392				NS	
C * Comp * Bio			4.144				NS	

Comp*compost, *Azotobacter Chroococcum* (AZ), *Bacillus megaterium* (B1) *Bacillus circulanse* (B2), *Azotobacter Chroococcum+ Bacillus megaterium +Bacillus circulanse(*AZ+B1+B2)

Table 6: Effect of compost, biofertilizers and the interaction between them on herb dry weight/ plant during 2009/2010 and 2010/2011 seasons

Treatments								
Bio	First season			Second season				
				Compost				Compost
Comp	Cuts			means	Cuts			means
2 ton/fed	6.22	15.16	6.27	9.22	3.96	8.73	5.48	6.06
4 ton/fed	8.29	18.89	7.89	11.69	5.70	10.85	6.54	7.70
8 ton/fed	10.20	29.85	13.85	17.97	6.78	15.76	7.91	10.15
				Biofertilizer				Biofertilizer
	Cuts * Biofertilizer interaction			means	Cuts * Biofertilizer interaction			mean
nonbiofertilizer	7.67	17.81	7.28	10.92	4.80	9.74	5.78	6.77
(Az)	9.13	21.57	7.92	12.88	6.14	12.10	6.76	8.33
(B1)	7.48	18.32	7.69	11.17	5.11	11.38	7.22	7.91
(B2)	6.57	19.19	14.49	13.42	4.56	9.84	6.41	6.93
Az+B1+B2	10.32	29.61	9.30	16.41	6.81	15.85	7.04	9.90
				Compost * Biofertilizer				Compost * Biofertilizer
	C*COMP*BIO			interaction	C*COMP*BIO			interaction
Compost 2 ton								
Comp	5.03	13.70	4.91	7.88	3.19	7.60	4.87	5.22
(Az)	7.06	13.93	6.95	9.31	4.30	9.02	5.62	6.31
(B1)	5.74	14.06	5.48	8.43	3.93	7.60	5.74	5.76
(B2)	5.80	16.56	6.42	9.59	3.48	9.03	5.86	6.12
Az+B1+B2	7.46	17.57	7.60	10.88	4.93	10.40	5.29	6.87
Compost 4 ton								
Comp	9.46	14.71	7.66	10.61	5.79	9.20	5.66	6.88
(Az)	8.26	17.85	7.89	11.33	5.72	9.91	7.00	7.54
(B1)	7.58	13.61	8.16	9.78	5.50	9.65	7.08	7.41
(B2)	6.33	15.83	6.29	9.48	4.98	9.83	6.28	7.03
Az+B1+B2	9.82	32.43	9.43	17.23	6.53	15.69	6.68	9.63
Compost8 ton								
Comp	8.53	25.01	9.26	14.27	5.41	12.41	6.81	8.21
(Az)	12.09	32.93	8.93	17.98	8.39	17.38	7.65	11.14
(B1)	9.12	27.31	9.44	15.29	5.92	16.90	8.85	10.56
(B2)	7.58	25.20	30.75	21.12	5.21	10.65	7.08	7.65
Az+B1+B2	13.68	38.82	10.87	21.17	8.96	21.48	9.16	13.20
Cut means	8.24	21.30	9.33		6.64	11.78	5.48	
LSD at			5%				5%	
Cuts (c)			2.623				0.577	
Compost (Comp)			2.623				0.577	
Biofertilizer (Bio)			3.386				0.745	
C * Comp			4.544				0.999	
C * Bio			5.865				1.290	
Comp * Bio			NS				1.290	
C * Comp * Bio			NS				2.234	

Comp*compost, *Azotobacter Chroococcum* (AZ), *Bacillus megaterium* (B1) *Bacillus circulanse* (B2), *Azotobacter Chroococcum+ Bacillus megaterium +Bacillus circulanse(*AZ+B1+B2)

Table 7: Effect of compost, biofertilizers and the interaction between them on oil percentage (%) in fresh herb during2009/2010 and 2010/2011 seasons

Treatments								
Bio	First season				Second season			
Comp	Cuts			Compost means	Cuts			Compost means
2 ton/fed	0.13	0.15	0.14	0.14	0.12	0.14	0.14	0.13
4 ton/fed	0.19	0.18	0.17	0.18	0.16	0.21	0.17	0.18
8 ton/fed	0.23	0.24	0.21	0.22	0.21	0.29	0.20	0.23
	Cuts * Biofertilizer interaction			Biofertilizer means	Cuts * Biofertilizer interaction			Biofertilizer mean
nonbiofertilizer	0.16	0.17	0.16	0.16	0.15	0.18	0.15	0.16
(Az)	0.18	0.20	0.18	0.18	0.16	0.21	0.18	0.18
(B1)	0.19	0.20	0.18	0.19	0.17	0.22	0.18	0.19
(B2)	0.17	0.18	0.17	0.17	0.16	0.21	0.16	0.18
Az+B1+B2	0.21	0.22	0.19	0.21	0.18	0.25	0.19	0.21
	C*COMP*BIO			Compost * Biofertilizer interaction	C*COMP*BIO			Compost * Biofertilizer interaction
Compost 2 ton								
Comp	0.11	0.15	0.14	0.13	0.11	0.13	0.10	0.11
(Az)	0.11	0.15	0.14	0.13	0.12	0.14	0.16	0.14
(B1)	0.15	0.16	0.14	0.15	0.13	0.15	0.15	0.14
(B2)	0.11	0.14	0.14	0.13	0.12	0.14	0.12	0.13
Az+B1+B2	0.16	0.16	0.15	0.16	0.13	0.16	0.17	0.15
Compost 4 ton								
Comp l	0.18	0.17	0.16	0.17	0.15	0.15	0.16	0.16
(Az)	0.19	0.19	0.18	0.18	0.16	0.22	0.18	0.19
(B1)	0.19	0.19	0.17	0.18	0.16	0.22	0.17	0.18
(B2)	0.19	0.16	0.17	0.17	0.16	0.23	0.16	0.18
Az+B1+B2	0.21	0.21	0.19	0.20	0.17	0.23	0.18	0.20
Compost8 ton								
Comp	0.18	0.19	0.18	0.18	0.18	0.26	0.19	0.21
(Az)	0.23	0.25	0.22	0.23	0.21	0.27	0.20	0.23
(B1)	0.24	0.24	0.21	0.23	0.21	0.29	0.21	0.24
(B2)	0.21	0.23	0.20	0.22	0.19	0.27	0.19	0.22
Az+B1+B2	0.26	0.28	0.23	0.26	0.25	0.35	0.22	0.27
Cut means	0.18	0.19	0.17		0.16	0.21	0.17	
LSD at			5%				5%	
Cuts (c)			0.007				0.006	
Compost (Comp)			0.007				0.006	
Biofertilizer (Bio)			0.009				0.008	
C * Comp			0.011				0.011	
C * Bio			NS				0.014	
Comp * Bio			0.015				0.014	
C * Comp * Bio			NS				0.025	

Comp*compost, *Azotobacter Chroococcum* (AZ), *Bacillus megaterium* (B1) *Bacillus circulanse* (B2), *Azotobacter Chroococcum+ Bacillus megaterium +Bacillus circulanse(*AZ+B1+B2)

(17.97 and10. 1 g/plant in the first and second seasons, respectively). The best results were obtained in the second cut of the first and second seasons (29.85 and 15.76 g/plant, respectively).

Regarding using biofertilization (*Azotobacter Chroococcum* + *Bacillus megaterium* and *Bacillus circulanse*), there were significant increase in herb dry weight / plant in the first and second seasons (16.41and 9.90 g/plant, respectively). In the second cut in both seasons, biofertilization significantly increased herb dry weight (29.61 and 15.85 gm/plant in the first and second seasons, respectively).

The interaction between compost and biofertilization revealed that compost at 8 ton/fed plus biofertilization (*Azotobacter Chroococcum* + *Bacillus megaterium* and *Bacillus circulanse*) had no significant effect on herb dry weight in the first season. In the second season, the best treatment was 8 ton/fed compost plus biofertilization (*Azotobacter Chroococcum* + *Bacillus* megaterium and *Bacillus circulanse*) (13.20 g/plant) and the best result was obtained with compost 8 ton/fed plus biofertilization (*Azotobacter Chroococcum* + *Bacillus* megaterium and *Bacillus circulanse*) in the second cut (21.48 g/plant). In this respect, Hendawy and El-Gengaihi [11] stated that *Borago officinalis* and *Echium vulgare* plants which were fertilized with compost mixed with the biofertilizers phosphorine or rhizobacterine produced higher yield, comparing with that fertilized by compost only.

The different cuts had a significant effect on herb dry weight. It was clear that the highest herb dry weight were resulted from the second cut in first and second seasons.

Effect of Compost and Biofertilization on Oil Production

Essential Oil Percentage: Data in Table 7 indicated that increasing organic fertilizer compost doses gradually increased oil percentage. The best results were obtained with compost at rate 8 ton/fed (0.22 and0. 23% in the first and second seasons, respectively).

Concerning biofertilization, data showed that *Azotobacter Chroococcum* + *Bacillus megaterium* + *Bacillus circulanse* treatment significantly decreased oil percentage recording a mean of 0.21% in both the first and second seasons. Highest percentage (0.25%) was obtained in the second season at the second cut. The best result were obtained from *Azotobacter Chroococcum* + *Bacillus megaterium* and *Bacillus circulanse* (0.29%) due to the interaction between compost at 8 ton/fed and biofertilization biofertilization (*Azotobacter Chroococcum* + *Bacillus* megaterium and *Bacillus circulanse*) (0.26 and0.27% in the first and second seasons, respectively). whereas the first season had no significant effect on oil percentage. The second cut in the second season gave the best results with adding compost at 8 ton/fed plus biofertilization (*Azotobacter Chroococcum* + *Bacillus megaterium* and *Bacillus circulanse*) resulting in 0.35 %. These results agreed with these obtained by Hemdan [12]. Different cuts had a significant effect on oil percentage, the best results were obtained from in the second cut of the first and second seasons (0.21and 0.19%) these results agreed with these obtained by Hemdan [12].

Essential Oil Yield (ml/plant): Data in Table 8 indicated that increasing organic fertilizer, represented as compost, doses gradually increased oil yield. The best results were obtained with compost at rate of 8 ton/fed (0.11 and 0.08 ml/plant in the first and second seasons, respectively). The best results were obtained in the second cut of the first and second seasons (0.18and 0.13 ml/plant, respectively).

Concerning biofertilization (*Azotobacter Chroococcum* + *Bacillus megaterium* and *Bacillus circulanse*), the data showed that it significantly decreased oil yield (0.10and 0.07 ml/plant in the first and second seasons, respectively). In the first season at the second cut, the best results were obtained from *Azotobacter Chroococcum* + *Bacillus megaterium* + *Bacillus circulanse* combination (0.16 ml/plant) wheares the second season had no significant effect on oil yield. The interaction between compost and biofertilization indicated that compost at 8 ton/fed plus biofertilization (*Azotobacter Chroococcum* + *Bacillus megaterium* and *Bacillus circulanse*) significantly increased oil yield in the first and second seasons were obtained form(0.15 and0.11 ml/plant respectively) wheares the first season had asignificant effect on oil yield the best results were obtained with compost 8 ton/fed plus biofertilization (*Azotobacter Chroococcum* + *Bacillus megaterium* and *Bacillus circulanse*) recording 0.25 ml/plant in the second cut of the first season. Whereas the second season had no significant effect on oil yield. These results agreed with these obtained by Mazrou [13] on *Cymbopogon citratus*.

The different cuts had a significant effect on oil yield. The best results were obtained in the second cut of the first and second seasons (0.11and 0.08 ml/plant, respectively). These results agreed with these obtained by Hemdan [12].

Table 8: Effect of compost, biofertilizers and the interaction between them on oil yield in fresh herb (ml/plant) during 2009/2010 and 2010/2011 seasons

Treatments								
Bio	First season				Second season			
Comp	Cuts			Compost means	Cuts			Compost means
2 ton/fed	0.02	0.05	0.03	0.04	0.01	0.04	0.03	0.03
4 ton/fed	0.04	0.09	0.05	0.06	0.03	0.07	0.05	0.05
8 ton/fed	0.07	0.18	0.07	0.11	0.04	0.13	0.06	0.08
	Cuts * Biofertilizer interaction			Biofertilizer means	Cuts * Biofertilizer interaction			Biofertilizer mean
nonbiofertilizer	0.03	0.08	0.04	0.05	0.02	0.06	0.03	0.04
(Az)	0.05	0.11	0.05	0.07	0.03	0.07	0.05	0.05
(B1)	0.04	0.10	0.06	0.06	0.02	0.08	0.05	0.05
(B2)	0.04	0.09	0.04	0.06	0.02	0.07	0.04	0.04
Az+B1+B2	0.06	0.16	0.07	0.10	0.04	0.10	0.06	0.07
	C*COMP*BIO			Compost * Biofertilizer interaction	C*COMP*BIO			Compost * Biofertilizer interaction
Compost 2 ton								
Comp	0.02	0.05	0.03	0.03	0.01	0.03	0.02	0.02
(Az)	0.02	0.05	0.03	0.03	0.02	0.04	0.04	0.03
(B1)	0.03	0.06	0.03	0.04	0.01	0.04	0.04	0.03
(B2)	0.02	0.05	0.04	0.03	0.01	0.03	0.03	0.02
Az+B1+B2	0.04	0.06	0.04	0.05	0.02	0.04	0.04	0.03
Compost 4 ton								
Comp	0.04	0.06	0.04	0.05	0.02	0.05	0.03	0.03
(Az)	0.04	0.08	0.05	0.06	0.03	0.07	0.05	0.05
(B1)	0.04	0.07	0.05	0.05	0.02	0.07	0.05	0.05
(B2)	0.04	0.06	0.04	0.05	0.02	0.07	0.04	0.04
Az+B1+B2	0.05	0.16	0.07	0.09	0.03	0.08	0.06	0.06
Compost8 ton								
Comp	0.04	0.12	0.06	0.07	0.03	0.09	0.05	0.06
(Az)	0.08	0.21	0.08	0.12	0.05	0.12	0.06	0.08
(B1)	0.06	0.16	0.08	0.10	0.03	0.13	0.07	0.08
(B2)	0.05	0.15	0.05	0.09	0.03	0.11	0.05	0.07
Az+B1+B2	0.10	0.25	0.09	0.15	0.06	0.18	0.08	0.11
Cut means	0.04	0.11	0.05		0.03	0.08	0.05	
LSD at			5%				5%	
Cuts (c)			0.003				0.01	
Compost (Comp)			0.003				0.01	
Biofertilizer (Bio)			0.004				0.01	
C * Comp			0.005				0.01	
C * Bio			0.007				NS	
Comp * Bio			0.007				0.01	
C * Comp * Bio			0.012				NS	

Comp*compost, *Azotobacter Chroococcum* (AZ), *Bacillus megaterium* (B1) *Bacillus circulanse* (B2), *Azotobacter Chroococcum+ Bacillus megaterium +Bacillus circulanse(*AZ+B1+B2)

Table 9: Effect of compost, biofertilizers and the interaction between them on oil yield /feddan during 2009/2010 and 2010/2011 seasons

Treatments								
Bio	First season				Second season			
Comp	Cuts			Compost means	Cuts			Compost means
2 ton/fed	0.62	1.39	0.84	0.95	0.37	0.88	0.78	0.68
4 ton/fed	1.08	2.18	1.31	1.52	0.64	1.62	1.14	1.14
8 ton/fed	1.64	4.42	1.87	2.64	1.01	3.17	1.61	1.93
	Cuts * Biofertilizer interaction			Biofertilizer means	Cuts * Biofertilizer interaction			Biofertilizer mean
nonbiofertilizer l	1.30	1.12	1.92	0.86	0.50	1.39	0.91	0.93
(Az)	1.79	1.38	2.80	1.19	0.74	1.85	1.22	1.27
(B1)	1.62	1.38	2.42	1.06	0.62	1.96	1.26	1.28
(B2)	1.42	1.12	2.22	0.90	0.56	1.77	1.01	1.12
Az+B1+B2	2.41	1.17	3.96	1.56	0.94	2.49	1.47	1.63
	C*COMP*BIO			Compost * Biofertilizer interaction	C*COMP*BIO			Compost * Biofertilizer interaction
Compost 2 ton								
Comp	0.46	1.30	0.69	0.82	0.28	0.75	0.47	0.50
(Az)	0.57	1.17	0.76	0.83	0.38	0.88	0.88	0.71
(B1)	0.68	1.51	0.83	1.01	0.36	0.93	0.86	0.72
(B2)	0.48	1.35	0.88	0.90	0.33	0.79	0.67	0.60
Az+B1+B2	0.94	1.63	1.05	1.21	0.49	1.05	1.01	0.85
Compost 4 ton								
Comp	1.04	1.59	1.09	1.24	0.55	1.11	0.91	0.85
(Az)	1.07	2.01	1.33	1.47	0.65	1.71	1.16	1.17
(B1)	1.00	1.71	1.37	1.36	0.59	1.65	1.24	1.16
(B2)	0.95	1.58	1.08	1.20	0.60	1.66	1.03	1.10
Az+B1+B2	1.35	4.02	1.67	2.35	0.83	1.97	1.38	1.40
Compost8 ton								
Comp	1.08	2.87	1.56	1.84	0.68	2.31	1.35	1.45
(Az)	1.93	5.20	2.06	3.06	1.18	2.96	1.62	1.92
(B1)	1.50	4.04	1.95	2.50	0.91	3.29	1.70	1.96
(B2)	1.28	3.74	1.41	2.14	0.76	2.86	1.34	1.65
Az+B1+B2	2.39	6.23	2.39	3.67	1.49	4.44	2.03	2.65
Cut means	1.11	2.66	1.34		0.67	1.89	1.18	
LSD at			5%				5%	
Cuts (c)			0.076				0.130	
Compost (Comp)			0.076				0.130	
Biofertilizer (Bio)			0.098				0.169	
C * Comp			0.131				0.226	
C * Bio			0.170				NS	
Comp * Bio			0.170				0.292	
C * Comp * Bio			0.294				NS	

Comp*compost, *Azotobacter Chroococcum* (AZ), *Bacillus megaterium* (B1) *Bacillus circulanse* (B2), *Azotobacter Chroococcum+ Bacillus megaterium +Bacillus circulanse(*AZ+B1+B2)

Table 10: Effect of compost, biofertilizers and the interaction between them on total carbohydrates during 2009/2010 and 2010/2011 seasons

Treatments								
Bio	First season			Second season				
Comp	Cuts			Compost means	Cuts			Compost means
2 ton/fed	3.50	3.17	3.62	3.43	3.26	2.42	2.95	2.88
4 ton/fed	6.03	4.13	6.03	5.40	6.21	5.10	4.78	5.36
8 ton/fed	7.60	5.85	6.57	6.67	7.61	6.35	6.38	6.78
Cuts * Biofertilizer interaction			Biofertilizer means	Cuts * Biofertilizer interaction			Biofertilizer mean	
nonbiofertilizer	4.75	3.93	4.83	4.50	4.55	4.26	4.01	4.28
(Az)	5.87	4.10	5.15	5.04	5.91	4.65	4.40	4.99
(B1)	5.74	4.49	5.48	5.24	5.81	4.33	4.74	4.96
(B2)	5.31	3.87	5.58	4.92	5.80	4.49	5.02	5.11
Az+B1+B2	6.87	5.52	5.99	6.13	6.39	5.37	5.35	5.70
C*COMP*BIO			Compost * Biofertilizer interaction	C*COMP*BIO			Compost * Biofertilizer interaction	
Compost 2 ton								
Comp	2.02	3.10	2.10	2.41	1.73	2.00	2.64	2.12
(Az)	3.66	3.47	2.33	3.15	3.41	2.60	2.72	2.91
(B1)	3.62	2.83	3.83	3.43	4.24	2.17	2.62	3.01
(B2)	3.06	2.83	4.93	3.61	2.66	2.46	3.42	2.85
Az+B1+B2	5.13	3.61	4.93	4.56	4.27	2.86	3.36	3.50
Compost 4 ton								
Comp	5.64	4.04	5.57	5.08	4.55	4.78	3.61	4.31
(Az)	6.22	4.10	6.65	5.66	6.80	5.22	3.80	5.27
(B1)	5.94	4.19	6.36	5.50	5.15	4.22	5.49	4.95
(B2)	6.07	4.07	5.45	5.20	6.87	4.86	5.20	5.64
Az+B1+B2	6.29	4.26	6.10	5.55	7.67	6.44	5.80	6.63
Compost8 ton								
Comp	6.58	4.66	6.82	6.02	7.38	6.00	5.80	6.39
(Az)	7.74	4.73	6.46	6.31	7.52	6.15	6.67	6.78
(B1)	7.67	6.44	6.25	6.78	8.03	6.61	6.10	6.91
(B2)	6.80	4.70	6.36	5.95	7.88	6.15	6.45	6.83
Az+B1+B2	9.20	8.70	6.94	8.28	7.23	6.83	6.88	6.98
Cut means	5.71	4.38	5.40		5.69	4.62	4.70	
LSD at			5%				5%	
Cuts (c)			0.408				0.408	
Compost (Comp)			0.408				0.408	
Biofertilizer (Bio)			0.527				0.527	
C * Comp			0.707				0.707	
C * Bio			0.912				0.939	
Comp * Bio			0.912				0.912	
C * Comp * Bio			1.580				1.580	

Comp*compost, *Azotobacter Chroococcum* (AZ), *Bacillus megaterium* (B1) *Bacillus circulanse* (B2), *Azotobacter Chroococcum+ Bacillus megaterium +Bacillus circulanse(*AZ+B1+B2)

Essential Oil Yield (liter /feddan): The oil yield of fresh herb/ feddan is shown in Table 9. Best results were obtained with compost at 8 ton/fed (2.64 and 1.93 liter/ fed in the first and second seasons, respectively). The best results were obtained in the second cut of the first and second seasons (4.42 and 3.17 liter/ fed, respectively).

Concerning biofertilization, treatment including *Azotobacter Chroococcum* + *Bacillus megaterium* + *Bacillus* circulanse significantly decreased oil yield of fresh herb/ feddan (2.41and 1.6 liter/ fed in the first and second seasons, respectively). In the first season, the best results were obtained at the second cut from *Azotobacter Chroococcum* + *Bacillus megaterium* + *Bacillus circulanse* treatment (3.96 liter/ fed). Whereas the second season had no significant effect on oil yield of fresh herb/ feddan. The interaction between compost and biofertilization indicated that compost 8 ton/fed plus biofertilization (*Azotobacter Chroococcum* + *Bacillus megaterium* and *Bacillus circulanse*) significantly increased yield of fresh herb/ feddan in the first and second seasons (3.67 and2.65 liter/ fed), whereas the first season had a significant effect on oil yield of fresh herb/ feddan. The best results were obtained with compost 8 ton/fed plus biofertilization (*Azotobacter Chroococcum* + *Bacillus megaterium* + *Bacillus* circulanse) recording 6.23 liter/ fed in the second cut of the first season. The second season had no significant effect on oil yield of fresh herb/ feddan.

The different cuts had a significant effect on oil yield of fresh herb/ feddan. The best results were obtained in the second cut of the first and second seasons (2.66and 1.89 liter/ fed, respectively) followed by the third cut (1.34 and 1.18 in the first and second seasons, respectively). These results agreed with these obtained by Hemdan [12] on anise plants.

Total Carbohydrates Content in Herb: Data in Table 10 indicated that increasing organic fertilizer compost doses gradually increased the total carbohydrates content in herb. The best results were obtained with compost at rate 8 ton/fed (6.67 and 6.78 % in the in the first cut of first and second seasons, respectively). The best results were obtained with compost at 8ton /fed recording 7.60 and7.61 % in the first cut of the first and second seasons, respectively, followed by the third cut of the first and second seasons giving 6.57 and 6.38 %, respectively). These results were in agreement with these obtained by Abd E1-Raoof [7].

Regarding the usage of biofertilization (*Azotobacter Chroococcum* + *Bacillus megaterium* + *Bacillus* circulanse), it had a significant effect on total carbohydrates content in herb (6.13 and 5.70% in the first and second seasons, respectively). At the first cut of the first and second seasons the best results were obtained with *Azotobacter Chroococcum* + *Bacillus megaterium* + *Bacillus* circulanse (6.87 and 6.39 %, respectively).

The interaction between compost and biofertilization significantly increased the total carbohydrates content in herb in the first and second seasons, the best results were obtained with compost at 8ton/fed plus *Azotobacter Chroococcum* + *Bacillus megaterium* + *Bacillus circulanse* (8.28 and 6.98 % in the first and second seasons, respectively).

The different cuts had a significant effect on number of branches /plant. It was clear that the highest total carbohydrates content in herb were resulted from the first cut in the first and second seasons recording 5.71and 5.69%, respectively.

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