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EFFECT OF IRRIGATION INTERVALS AND BIOFERTILIZATION ON GROWTH, YIELD, OIL PRODUCTION AND CHEMICAL CONSTITUENTS OF ROSEMARY (*Rosmarinus officinalis*,L.) PLANTS.

A. S. El-Leithy* ; Salem, M. A.*; El-Ghadban, E. A.** and Abd El- Ghani, N.M.**
** Ornamental Hort. Department, Fac. Agric., Cairo Univ., Egypt.*
***Med. and Arom. Plant Research Dept., Hort. Research Instit., Agric. Research Center, Dokki, Giza, Egypt.*

ABSTRACT

This investigation was carried out aiming to study the effect of irrigation intervals (every 7 , 11 and 15 days) and Biofertilization (nitrobien and phosphorein each at 0 , 3 and 6 g /pot) on growth, yield, oil production and chemical composition of rosemary (Rosmarinus officinalis, L.), during two successive seasons of 2004 and 2005.

The results showed that irrigation every 7 days gave the tallest plant, the highest oil percentage and oil yield/ plant in the first cut of both two seasons, the highest number of branches/ plant, fresh and dry weights/plant, total carbohydrates , N, P and K percentage in the first and second cut of both seasons and gave the highest linalool and P-cymene percentages in the essential oil. Whereas irrigation every 11 days gave the tallest plant, the highest oil percentage and oil yield/ plant in the second cut of both seasons and the highest α-pinene, β-pinene, limonene, 1,8 cineol and camphor percentages compared to irrigation every 15 days which gave the lowest values.

Nitrobien and phosphorein at 3 and 6 gm/ pot significantly increased plant height, number of branches/ plant, fresh and dry weights/ plant and oil yield/ plant, and increased the main constituents of the essential oil (γ-Terpenene, 1,8 cineol, linalool , camphor, P-cymene, bornyl acetate and β caryophyllene percentages), total carbohydrates, N, P and K contents in the first and second cut of both two seasons compared to unfertilized control.

Interaction between irrigation intervals and bio-fertilization had a significant effect on vegetative growth characteristics and oil percentage and oil yield. Irrigation every 7 days and phosphorein at 6 g /pot gave the highest values of plant height (in the first cut), number of branches /plant (second cut), fresh and dry weights /plant (in the first cut, oil yield /plant (in the first cut), total carbohydrates, N and P contents in the first and second cut of both seasons. Whereas irrigation every 11 days and phosphorein application at 6 g /pot gave the highest dry weight/ plant, oil percentage and oil yield/ plant in the second cut of both two seasons. irrigation every 11 days and nitrobien application at 3 g /pot gave the highest β-pinene, 1,8 cineol, camphor and bornyl acetate percentages in the essential oil. Whereas irrigation every 11

days and phosphorein at 3 gm/pot gave the highest linalool and P- cymene percentages in the essential oil.

Keywords: Irrigation intervals, biofertilization, growth, yield, oil production, chemical constituents, rosemary (*rosmarinus officinalis*,l.) plants.

INTRODUCTION

Rosemary (*Rosmarinus officinalis*, L.) belongs to family *Lamiaceae* (*Labiatae*) is a shrubby evergreen bush up to 2 meters high with silvery- green, needle shaped leaves and pale blue flowers. The whole plant is strongly aromatic. It is one of the earliest plants to be used for food and medicine. It has been used for a wide range of complaints including respiratory and circulatory disorders, liver congestion, digestive and nervous complaints, muscular and rheumatic pain, skin and hair problems (Lawless, 1992).

The effect of irrigation treatments on growth and yield of many aromatic and medicinal plants were studied by several researchers; Yassen *et al.* (2003) on *Ocimum basilicum*; Aly (2004) on *Senna occidentalis* and Singh (2004) on rosemary.

The effect of bio-fertilizers on growth and yield of many aromatic and medicinal plants were studied by several researchers; Salman (2004) on basil; Youssef *et al.* (2004) on sage; Zayed *et al.* (2004) on borage ; Migahed *et al.* (2004) celery; Shalan (2005) on borage; Heikal (2005) on thyme and Sakr (2005) on senna plants.

MATERIALS AND METHODS

This investigation was carried out at the Experimental Farm of Ornamental Horticulture Department, Faculty of Agriculture, Cairo University and Medicinal and Aromatic Plant Research Department, Horticulture Research Institute, Agricultural Research Center, Dokki, Giza, in two successive seasons of 2004 and 2005. The aim of this study was to investigate the effect of irrigation intervals and Bio-fertilization on growth, yield, oil production and chemical composition of rosemary (*Rosmarinus officinalis,* L.).

Rooted cuttings (15-20 cm long) of *Rosmarinus officinalis*, L. plants were planted on 28th February in the two seasons of 2004 and 2005 into 30 cm (diameter) clay pots filled with sandy loam soil. Physical and chemical characters of the soil are shown in Table (A).

Bio-fertilizers (nitrobien and phosphorein) were inserted in the soil surface at the rates of 0 , 3 and 6 g /pot when the rooted cuttings were transplanted.

The experiment included 3 irrigation intervals every 7, 11 and 15 days after two weeks from transplanting.

Table A: Chemical and physical properties of the experimental soil.

Physical properties			
Sample	**Sand %**	**Clay %**	**Silt %**
Sandy loam	55.2	18.5	26.3

Chemical properties												
pH	**EC mmhos cm/25° C**	**Soluble cations and anions (meq/L)**								**Available (ppm)**		
		CO_3^{--}	**HCO_3^-**	**CL**	**$SO4^{--}$**	**Ca^{++}**	**Mg^{++}**	**Na^+**	**K^+**	**N**	**P**	**K**
7.5	4.45	--	2.0	17.14	33.48	18.76	14.4	12.7	6.76	24.3	208	340.7

The experimental layout was factorial experiment design. The main plots were irrigation intervals and the sub- plots were bio-fertilizer treatments, including15 treatments. Each treatment was replicated 3 times and each replicate consisted of 6 plants.

The plants were harvested twice /season (first and second cuts) on August 9th and November 15th in both seasons, by cutting the herb of the plants at 10 cm above the soil surface.

The following data were recorded in the first and second cuts, in both seasons. Plant height , number of branches /plant, plant fresh weight (g), plant dry weight (g), essential oil percentage in fresh herb, oil yield of fresh herb /plant. Essential oil percentage in the fresh herb was determined according to the British Pharmacopoeia (1963). Gas Liquid Chromatography (GLC) analysis of the essential oil in the first cut of the first season was performed using Ds- Chrom. 6200 Gas Chromatography equipped with flame ionization detector (FID) under the conditions of : Column with a coating film of 3% OV-17 (Methyl phenyl Silicone) on chromosorb - WHP.(1.5 X 4.0 mm and 100-120 mesh), and injector temperature of 250°C. Nitrogen flow rate at 30 ml/ min, hydrogen flow rate at 30ml / min and air flow rate at 330 ml/ min with an initial temperature of 70°C –P.R.8°C and final temperature of 200°C, chart speed was 2 min./cm., Range 32 as described by Bunzen *et al.* (1969). The following chemical composition were determined in the dry matter of the plants in both cuts of the first and second seasons ; Total carbohydrates contents were determined using the method described by (Herbert *et al.,*1971). Nitrogen percentage determined according to Koch and Mc-Meeking (1924). Phosphorus percentage determined as recommended by King (1951). Potassium percentage determined using atomic absorption spectrophotometer (Perkin Elemer, Model 3300).

Data recorded on growth parameters, volatile oil percentage and oil yield/ plant were statistically analyzed, and separation of means was performed using the

Least Significant Difference (L.S.D.) test at the 5% level, as described by Snedecor and Cochran (1980).

RESULTS AND DISCUSSION

Plant height (cm):

Data presented in Table 1 showed that irrigation intervals had a significant effect on plant height in both seasons. In the first cut, in the first season, irrigation every 7 days was the most effective treatment, which gave the tallest plant followed by irrigation every 11 days compared with for plants irrigated every 15 days. In the second cut the highest value was obtained from plants irrigated every 15 days compared to plants irrigated every 11 days. In the second season, first cut, similar results were obtained as in the first one, i.e., prolonging irrigation intervals gradually decreased plant height. Irrigation every 7 days was the most effective treatment, which gave the tallest plants compared to for plants irrigated every 15 days , while in the second cut the highest value was obtained from plants irrigated every 15 days compared to for plants irrigated every 7 days.

Generally, it could be concluded that irrigation at short interval increased plant height especially in the first cut of both seasons. These results are in agreement with those obtained by Hammoda (2001) on moghat and Hammam (2002) on *Cassia acutifolia.* They showed that prolonging irrigation intervals decreased plant height.

Regarding the effect of bio-fertilization, both nitrobien and phosphorein at the rates of 3 and 6 g /pot significantly increased plant height in both two cuts of both seasons. In the first cut of both first and second seasons the highest values were obtained from plants fertilized with phosphorein and nitrobien at 3 g /pot, respectively compared to un fertilized plants. In the second cut of both first and second seasons, the highest values were produced from plants fertilized with phosphorein at the highest rate(6 g /pot) compared to for control plants. These results are in harmony with the findings obtained by. Mahfoz (2003) on marjoram plant, showed that application of bio-fertilizers increased plant height. Shalan (2005) on borage plants, reported that bio-fertilizers application increased plant height.

Interaction between irrigation intervals and bio-fertilizers had a significant effect on plant height in both seasons. In the first cut of the first season, plants treated with nitrobien at 3 g /pot (N_1) or phosphorein at 6 g /pot (P_2) plus irrigation every 7 days gave the tallest plants compared with control plants(without bio-fertilizer) and irrigated every 15 days which gave the shortest plants. In the second cut of the first season the tallest plants were obtained from irrigation every 15 days with phosphorein at 6 g /pot compared to the lowest value for plants treated with irrigation intervals every 11 days with phosphorein at 6 gm/ pot. In the second season, in first cut, the treatment of irrigation intervals every 7 days and fertilized with nitrobien at 3 g/ pot gave the tallest plants compared to for control plants(without bio-fertilizer) and irrigation every 15 days . In the second cut the highest value was obtained from

Table 1 : Effect of irrigation intervals and bio-fertilizers on plant height (cm) of rosemary (*Rosmarinus officinalis*, L.) plants during 2004 and 2005 seasons.

Irrigation Intervals	7days	11days	15days	Mean	7days	11days	15days	Mean
Bio-fertilizers	First cut				Second cut			
				2004				
Control	19.17	13.44	12.50	15.04	13.22	11.33	11.50	12.02
N1	21.67	18.39	17.00	19.02	13.17	14.17	14.50	13.94
N2	19.33	18.33	16.00	17.89	11.83	13.67	12.67	12.72
P1	21.33	20.17	17.67	19.72	15.33	12.50	11.67	13.17
P2	21.67	20.17	15.67	19.17	14.00	10.33	18.33	14.22
Means	**20.63**	**18.10**	**15.77**		**13.51**	**12.40**	**13.73**	
L.S.D. at 0.05 for :								
Irrigation (A)				0.80				1.32
Bio-fertilizer (B)				1.04				1.70
A x B				1.79				2.94
				2005				
Control	20.50	16.33	16.17	17.67	14.44	13.00	12.33	13.26
N1	25.50	21.89	20.33	22.57	14.67	16.17	17.50	16.11
N2	21.00	19.22	20.33	20.18	13.50	17.50	17.17	16.06
P1	23.83	20.44	20.50	21.59	17.33	16.00	14.83	16.06
P2	23.83	22.84	19.83	22.17	14.50	14.33	20.17	16.33
Means	**22.93**	**20.15**	**19.43**		**14.89**	**15.40**	**16.40**	
L.S.D. at 0.05 for :								
Irrigation (A)				0.77				0.77
Bio-fertilizer (B)				0.99				1.00
A x B				1.72				1.73

N1= Nitrobien at 3 g/ pot P1= Phosphorein at 3 g/ pot
N2 = Nitrobien at 6 g/ pot P2 =Phosphorein at 6 g/ pot

plants irrigated every 15 days and fertilized with phosphorein at 6 g /pot. While the lowest value was produced from control plants and irrigated every 15 days.

Number of branches per plant:

The results in Table 2 indicate that irrigation intervals had a significant effect on number of branches/ plant in both two seasons. In general prolonging irrigation intervals significantly decreased the number of branches per plant. The highest number of branches per plant in the first and second cuts of both first and second seasons were obtained from plants irrigated at the shortest irrigation interval (7 days)

Table(2): Effect of irrigation intervals and bio-fertilizers on number of branches of rosemary (*Rosmarinus officinalis*, L.) plants during 2004 and 2005 seasons

Irrigation Intervals	7days	11days	15days	Mean	7days	11days	15days	Means
Bio-fertilizers	First cut				Second cut			
2004								
Control	2.33	1.61	1.50	1.81	10.28	5.83	6.17	7.43
N1	5.67	3.61	3.00	4.09	10.67	9.33	8.00	9.33
N2	4.17	3.50	3.83	3.83	5.67	10.17	8.17	8.00
P1	5.33	2.78	3.50	3.87	12.17	8.83	7.00	9.33
P2	4.83	2.56	3.17	3.52	12.33	9.00	8.33	9.89
Means	**4.47**	**2.81**	**3.00**		**10.22**	**8.63**	**7.53**	
L.S.D. at 0.05 for :								
Irrigation (A)				0.45				0.68
Bio-fertilizer (B)				0.58				0.88
A x B				1.01				1.53
2005								
Control	3.67	2.83	2.67	3.06	12.22	6.67	8.17	9.02
N1	7.50	5.00	3.33	5.28	12.17	11.67	10.17	11.33
N2	6.17	4.50	4.83	5.17	10.17	12.00	12.17	11.44
P1	7.06	4.17	3.83	5.02	16.33	9.67	8.83	11.61
P2	7.00	3.61	5.00	5.20	16.00	11.50	11.50	13.00
Means	6.28	4.02	3.93		13.38	10.30	10.17	
L.S.D. at 0.05 for :				0.50				0.58
Irrigation (A)				0.65				0.75
Biofertilizer (B)				1.12				1.31
A x B				0.50				0.58

N1= Nitrobien at 3 g/ pot
N2 = Nitrobien at 6 g/ pot
P1= Phosphorein at 3 g/ pot
P2 =Phosphorein at 6 g/ pot

compared to irrigation every 15 days which gave the lowest values. These results are in agreement with those obtained by Hammam (2002) on *Cassia acutifolia*. They showed that irrigation intervals at long time decreased number of branches/ plant.

Regarding the effect of bio-fertilizers, both nitrobien and phosphorein at 3 and 6 g /pot significantly increased number of branched /plant in both two seasons. In the first cut, in first and second seasons, nitrobien at 3 gm/ pot gave the highest values of number of branches per plant compared to control treatment. Whereas in the second cut in both first and second seasons, phosphorein at 6 gm/ pot gave the highest values of number of branches per plant compared to unfertilized control, which gave the

lowest values. Heikal (2005) on thyme and Sakr (2005) on senna plants. They showed that bio-fertilization treatments increased number of branches /plant.

Concerning the effect of interaction on branching, the data in Table 2 showed a significant effect for the interaction between irrigation intervals and bio-fertilization treatments. Irrigation intervals at 7 days and bio-fertilization with nitrobien at 3 g /pot (N_1) gave the highest number of branches per plant in the first cut of the first and second seasons compared to control plants(without bio-fertilizer) and irrigated every 15 days . Whereas in the second cut of the first season, the highest value of number of branches per plant was obtained from plants irrigated every 7 days and fertilized with phosphorein at 6 g /pot (P_2) compared to plants irrigated every 7 days and fertilized with nitrobien at 6 g /pot. In the second cut, in second season plants irrigated every 7 days and fertilized with phosphorein at 3 and 6 g /pot gave the highest number of branches per plant compared to control plants irrigated every 11 days .

Fresh weight (g) per plant:

The data in Table 3 show that irrigation intervals treatments had a significant effect on the fresh weight/ plant. The shortest irrigation interval (7 days) gave the highest fresh weight of herb in the first and second cuts in both first and second seasons . Whereas the lowest values were obtained from plants irrigated every 15 days. Prolonging irrigation intervals gradually decreased fresh weight / plant in the two cuts of both two seasons. The differences between 11 and 15 days were statistically significant in the first cut of both two seasons only. These results are in agreement with the findings obtained by Toima *et al*.(1984) on caraway, Hammoda (2001) on moghat and Hammam (2002) on *Cassia acutifolia*. They found that short irrigation intervals increased plant fresh weight.

Regarding the effect of bio-fertilization on the fresh weight of rosemary plants, the data in Table 3 show that both nitrobien and phosphorein at 3 or 6 g /pot significantly increased herb fresh weight in both two seasons. Nitrobien at 3 g /pot (N_1) gave the highest fresh weight of herb in the first cut of both first and second seasons. While in the second cut of the first and second seasons, phosphorein at 6 g /pot (P_2) gave the highest fresh weight of herb per plant compared to control (unfertilized plants) in both two cuts of the two seasons. Similar results were obtained by Heikal (2005) on thyme plant and Sakr (2005) on senna plants. They showed that bio-fertilization treatments increased plant fresh weight.

Interaction between irrigation intervals and bio-fertilizers had a significant effect on fresh weight of herb. Irrigation interval every 7 days and bio-fertilization with phosphorein at 6 gm/ pot gave the highest fresh weight of herb per plant in the first cut of both first and second seasons .While in the second cut of the first season, the highest fresh weight of herb per plant was obtained from plants irrigated every 15 days and fertilized with phosphorein at 6 g /pot. In the second cut of the second season, irrigation intervals at 7 days and phosphorein application at 6 g /pot gave the highest values of fresh weight of herb per plant , compared to control plants and irrigation every 15 days which gave the lowest values in the first and second cuts of the two seasons.

Table 3 :Effect of irrigation intervals and bio-fertilizers on fresh weight (g)/ plant of rosemary (*Rosmarinus officinalis*, L.) plants during 2004 and 2005 seasons.

Irrigation Intervals / Bio-fertilizers	7days	11days	15days	Means	7days	11days	15days	Means
	First cut				Second cut			
2004								
Control	13.60	7.57	5.47	8.88	32.95	23.87	21.10	25.97
N1	22.97	20.17	12.10	18.41	38.93	37.75	36.77	37.82
N2	16.73	18.28	10.33	15.12	39.00	39.67	39.30	39.32
P1	20.88	11.23	9.03	13.72	40.48	35.40	29.03	34.97
P2	23.37	12.00	12.25	15.87	41.90	35.67	48.33	41.97
Means	**19.51**	**13.85**	**9.84**		**38.65**	**34.47**	**34.91**	
L.S.D. at 0.05 for :								
Irrigation (A)				1.79				3.39
Bio-fertilizer (B)				2.31				4.37
A x B				4.00				7.58
2005								
Control	20.50	8.82	6.97	12.09	36.97	27.37	23.80	29.38
N1	30.10	24.57	16.23	23.63	52.07	41.97	40.27	44.77
N2	23.20	23.00	16.20	20.80	52.67	48.20	49.27	50.04
P1	29.80	16.32	14.95	20.36	55.10	47.90	42.45	48.48
P2	30.63	19.75	16.70	22.36	56.67	48.00	53.47	52.71
Means	**26.85**	**18.49**	**14.21**		**50.69**	**42.69**	**41.85**	
L.S.D. at 0.05 for :				2.16				2.95
Irrigation (A)				2.79				3.80
Bio-fertilizer (B)				4.83				6.59
A x B				2.16				2.95

N1= Nitrobien at 3 g/ pot P1= Phosphorein at 3 g/ pot
N2 = Nitrobien at 6 g/ pot P2 =Phosphorein at 6 g/ pot

Dry weight (g) per plant:

The data in Table 4 show that in the first cut, in first and second seasons, the shortest irrigation intervals 7 days gave the highest values of dry weight of herb per plant, while in the second cut, in the first season, irrigation every 11 days gave the highest value of dry weight per plant. In the second cut of the second season, the highest value was obtained from plants irrigated every 7 days compared to plants irrigated every 15 days in the first and second cuts of both seasons. These results agree with those obtained by Hammoda (2001) on moghat and Hammam (2002) on senna plants. They found that short irrigation intervals increased plant dry weight.

Table 4 :Effect of irrigation intervals and bio-fertilizers on dry weight (g)/ plant of rosemary (*Rosmarinus officinalis*, L.) plants during 2004 and 2005 seasons.

Irrigation Intervals / Bio-fertilizers	7days	11days	15days	Means	7days	11days	15days	Means
	First cut				Second cut			
2004								
Control	5.67	3.05	2.35	3.69	9.69	7.53	6.90	8.04
N1	8.30	8.49	4.62	7.14	15.00	12.25	11.61	12.95
N2	7.18	6.73	4.45	6.12	14.61	13.80	11.34	13.25
P1	7.00	4.66	3.62	5.09	12.20	11.43	9.97	11.20
P2	8.89	4.83	4.64	6.12	14.66	12.00	15.14	13.94
Means	**7.41**	**5.55**	**3.93**		**13.23**	**11.40**	**10.99**	
L.S.D. at 0.05 for :								
Irrigation (A)				0.45				1.58
Bio-fertilizer (B)				0.58				2.04
A x B				1.00				3.53
2005								
Control	7.45	4.10	2.70	4.75	11.06	8.53	7.97	9.19
N1	12.27	10.66	7.92	10.29	17.93	13.69	12.83	14.81
N2	10.44	10.45	7.87	9.59	19.00	16.29	15.20	16.83
P1	12.10	9.00	8.05	9.72	19.56	15.57	14.66	16.59
P2	12.49	15.19	8.08	11.92	19.66	16.98	15.05	17.23
Means	10.95	9.88	6.92		17.44	14.21	13.14	
L.S.D. at 0.05 for :				0.41				0.99
Irrigation (A)				0.52				1.28
Bio-fertilizer (B)				0.91				2.22
A x B				0.41				0.99

N1= Nitrobien at 3 g/ pot P1= Phosphorein at 3 g/ pot
N2 = Nitrobien at 6 g/ pot P2 =Phosphorein at 6 g/ pot

Regarding the effect of bio-fertilization the data in Table 4 show that most of bio-fertilization treatments significantly increased the dry weight of herb compared to the control in the first and second cuts of the first and second seasons. In the first cut of the first season, nitrobien fertilization at 3 g /pot (N1) gave the highest value of dry weight per plant, while in the second cut, the highest level of Nitrobein (N_2) gave the highest dry weight/ plant. In the second season, the highest values of dry weight/plant were obtained from plants fertilized with phosphorein at 6 g /pot ($P_{2)}$ in the first and second cuts. Similar results were obtained by Shalan *et. al.,* (2001) on chamomile; Heikal (2005) on thyme plant and Sakr (2005) on senna plants. They showed that bio-fertilization treatments increased plant dry weight.

In the first cut of the first season, irrigation every 7 days and fertilization with phosphorein at 6 g /pot (P_2) gave the highest value of dry weight, while in the second cut of the first season the highest value was produced from plants irrigated every 15 days and fertilized with phosphorein at 6 g /pot (P2). In the first cut of the second season, irrigation every 11 days and fertilization with phosphorein at 6 g /pot (P2) gave the highest value of dry weight of herb, while in the second cut of the second season, the highest value was obtained from plants irrigated every 7 days and fertilized with phosphorein at 6 g /pot (P2), compared to plants irrigated every 15 days and unfertilized in the first and second cuts in first and second seasons.

Essential oil percentage in fresh herb:

The oil percentage in fresh herb as affected by irrigation intervals and bio-fertilization are shown in Table 5.Irrigation intervals had a significant effect on oil percentage in both two seasons. In first cut of the first season, irrigation every 7 days gave the highest value of oil percentage in fresh herb compared to plants irrigated every 15 days, while in the second cut of the first season, the highest value of oil percentage was obtained from plants irrigated every 11 days compared to plants irrigated every 7 days. In the first cut of the second season, the treatment of irrigation interval every 7 days gave the highest value compared to plants irrigated every 11 days, while in the second cut of the second season, the highest value was obtained from plants irrigated every 11 days compared to plants irrigated every 15 days. Also, Yassen *et al.* (2003) on *Ocimum basilicum* and Singh (2004) on rosemary. They found that irrigation at short intervals increased essential oil percentage.

Regarding the effect of bio-fertilization, the treatment of nitrobien at 6 g /pot (N2) gave the highest essential oil percentages in the first and second cuts of the first and second seasons compared control plants. Phosphorein at 3 and 6 gm/pot significantly decreased essential oil percentages in the first cut of both two seasons , while significantly increased it in the second cut of both two seasons as compared with the control plants. These results are confirmed with those obtained by Migahed *et al.* (2004) on celery; Salman (2004) on basil and Heikal (2005) on thyme plants. They showed that bio-fertilization treatments increased essential oil contents.

Interaction between irrigation intervals and bio-fertilization had a significant effect on oil percentage in both two seasons. In the first cut of the first and second seasons the treatment of irrigation every 7days and nitrobien at 6 g /pot (N2) gave the highest values of oil percentage. While in the second cut of the first and second seasons, the highest oil percentages in fresh herb were produced from plants irrigated every 11 days and fertilized with phosphorein at 6 gm/ pot (P2) compared to unfertilized plants and irrigated every 15 days which gave the lowest essential oil percentage.

Essential oil yield (ml/plant):

The oil yield of fresh herb as affected by irrigation intervals and bio-fertilization are shown in Table 6. In the first cut of the first and second seasons, irrigation every 7 days significantly increased oil yield/ plant, which gave the highest

Table 5 :Effect of irrigation intervals and bio-fertilizers on oil percentage(%) in fresh herb of rosemary (*Rosmarinus officinalis*, L.) plants during 2004 and 2005.

Irrigation Intervals / Bio-fertilizers	7days	11days	15days	Means	7days	11days	15days	Means
	First cut				Second cut			
2004								
Control	0.220	0.246	0.216	0.227	0.100	0.150	0.079	0.110
N1	0.222	0.220	0.217	0.219	0.157	0.230	0.097	0.161
N2	0.260	0.223	0.231	0.238	0.173	0.227	0.171	0.190
P1	0.223	0.227	0.155	0.202	0.120	0.151	0.169	0.147
P2	0.240	0.152	0.160	0.184	0.120	0.255	0.167	0.181
Means	**0.233**	**0.214**	**0.196**		**0.134**	**0.203**	**0.137**	
L.S.D. at 0.05 for :								
Irrigation (A)				0.007				0.008
Bio-fertilizer (B)				0.010				0.010
A x B				0.017				0.017
2005								
Control	0.240	0.266	0.220	0.242	0.130	0.143	0.073	0.116
N1	0.240	0.220	0.240	0.233	0.147	0.227	0.107	0.160
N2	0.280	0.260	0.251	0.264	0.170	0.210	0.160	0.180
P1	0.240	0.227	0.220	0.229	0.133	0.152	0.150	0.145
P2	0.260	0.171	0.226	0.219	0.127	0.240	0.143	0.170
Means	**0.252**	**0.229**	**0.231**		**0.141**	**0.194**	**0.127**	
L.S.D. at 0.05 for :				0.011				0.007
Irrigation (A)				0.014				0.010
Bio-fertilizer (B)				0.024				0.017
A x B				0.011				0.007

N1= Nitrobien at 3 g/ pot P1= Phosphorein at 3 g/ pot
N2 = Nitrobien at 6 g/ pot P2 =Phosphorein at 6 g/ pot

oil yield of fresh herb/ plant compared to plants irrigated every 15 days. While in the second cut of the first and second seasons, the highest values of oil yield of fresh herb/ plant were obtained from plants irrigated every 11days compared to plants irrigated every 15 days. The differences between irrigation every 7 days and other irrigation intervals were statistically significant in both seasons. The increment in the essential oil yield/ plant may be due to the effect of irrigation at short intervals on increasing both herbage yield and essential oil percentage. Similar results were obtained by, Yassen *et. al.,* (2003) on *Ocimum basilicum* and Singh (2004) on rosemary. They found that irrigation at short intervals increased essential oil yield.

Table 6 :Effect of irrigation intervals and biofertilizers on oil yield of fresh herb (ml/plant) of rosemary (*Rosmarinus officinalis*, L.) plants during 2004 and 2005 seasons.

Irrigation Intervals	7days	11days	15days	Means	7days	11days	15days	Means
Bio-fertilizers	First cut				Second cut			
2004								
Control	0.030	0.019	0.012	0.020	0.033	0.036	0.017	0.028
N1	0.051	0.044	0.026	0.040	0.062	0.087	0.035	0.062
N2	0.044	0.041	0.024	0.036	0.068	0.090	0.067	0.075
P1	0.047	0.025	0.014	0.029	0.048	0.054	0.049	0.050
P2	0.056	0.018	0.020	0.031	0.050	0.091	0.081	0.074
Means	**0.045**	**0.030**	**0.019**		**0.052**	**0.071**	**0.050**	
L.S.D. at 0.05 for :								
Irrigation (A)				0.008				0.008
Bio-fertilizer (B)				0.010				0.010
A x B				0.017				0.017
2005								
Control	0.049	0.023	0.015	0.029	0.048	0.039	0.017	0.035
N1	0.072	0.054	0.039	0.055	0.076	0.095	0.043	0.071
N2	0.065	0.060	0.041	0.055	0.090	0.101	0.079	0.090
P1	0.072	0.037	0.033	0.047	0.073	0.073	0.064	0.070
P2	0.079	0.033	0.038	0.050	0.072	0.115	0.077	0.088
Means	**0.067**	**0.042**	**0.033**		**0.072**	**0.085**	**0.056**	
L.S.D. at 0.05 for :				0.013				0.013
Irrigation (A)				0.017				0.017
Bio-fertilizer (B)				0.029				0.029
A x B				0.013				0.013

N1= Nitrobien at 3 g/ pot P1= Phosphorein at 3 g/ pot
N2 = Nitrobien at 6 g/ pot P2 =Phosphorein at 6 g/ pot

Concerning bio-fertilization treatments, both nitrobien and phosphorein at 3 and 6 gm/ pot significantly increased oil yield /plant in both two cuts of the two seasons compared with unfertilized control. In the first cut of the first and second seasons, nitrobien at 3 g /pot(N1) gave the highest oil yield of fresh herb/ plant compared control plants. In the second cut of the first and second seasons, the highest values were obtained from plants fertilized with nitrobien at 6 g/ pot (N2) compared to unfertilized plants. These results agree with those obtained by Mahfoz (2003) on marjoram; Salman (2004) on basil and Heikal (2005) on thyme plants. They showed that bio-fertilization treatments increased essential oil yield.

Interaction between irrigation intervals and bio-fertilization had a significant effect on oil yield/ plant in both two seasons. In the first cut of the first and second seasons, irrigation every 7 days and bio-fertilization with phosphorein at 6 g/ pot (P2) gave the highest oil yield of fresh herb/ plant compared to irrigation at long intervals and unfertilized control. While in the second cut, in first and second seasons, irrigation interval every 11 days and phosphorein at 6 g/ pot (P2) gave the highest oil yield of fresh herb/plant compared to unfertilized plants which irrigated every 15 days. The increment in the essential oil yield/ plant may be due to the effect of irrigation at short intervals and both nitrobien and phosphorein on increasing both herbage yield and essential oil percentage.

GLC analysis of the essential oil:

Data on GLC analysis of the essential oil in the first cut of the first season are presented in Table 7 and Figures (1 , 2 and 3).The data show that, irrigation every 7 days gave the highest linalool and P-cymene percentages in the essential oil, while irrigation every 11 days gave the highest α-pinene, β-pinene, limonene, 1,8 cineol and camphor percentages. Whereas irrigation at long intervals (every 15 days) gave the highest γ- Terpenene, bornyl acetate, borneol and β caryophyllene percentages in the essential oil.

Concerning bio-fertilization treatments, both nitrobien and phosphorein at 3 and 6 g/ pot increased the main constituents of the essential oil (γ- Terpenene, 1,8 cineol, linalool, camphor, P-cymene, bornyl acetate and β caryophyllene percentages compared to unfertilized control.

Regarding interaction between irrigation intervals and irrigation intervals, the data show that irrigation every 11 days and nitrobien application at 3 g/ pot gave the highest β-pinene, 1,8 cineol, camphor and bornyl acetate percentages in the essential oil. Whereas irrigation every 11 days and phosphorein at 3 g/pot gave the highest linalool and P- cymene percentages in the essential oil.

Total carbohydrates content in herb:

The total carbohydrates contents in herb as affected by irrigation intervals and bio-fertilization are shown in Table 8.These data indicate that, in the first and second cuts of both first and second seasons, irrigation every 7 days gave the highest total carbohydrates contents in herb compared to the lowest values which obtained from plants irrigated at longer intervals(every 15 days). These results are in agreement with those obtained by; Hammoda (2001) on moghat, they showed that prolonging irrigation intervals decreased total carbohydrates contents.

Concerning bio-fertilization, the data indicate that, in the first cut of the first and second seasons, both nitrobien and phosphorein at 3 and 6 gm/pot increased total carbohydrates contents in herb compared to unfertilized control. Phosphorein application at 6 g / pot (P2) gave the highest values of total carbohydrates contents in herb. While in the second cut of the first and second seasons, the highest values were obtained from plants fertilized with nitrobien at 6 g / pot (N2) compared with the lowest values of total carbohydrates content which obtained from unfertilized plants.

Table 7 : GLC analysis of the essential oil of rosemary (*Rosmarinus officinalis*, L.) plants in the first cut of the first season.

Treatments		α - Pinene	β - Pinene	Limonene	γ- Terpinene	1 , 8 Cineol	Linalool	Camphor	P - Cymene	Bronyl acetate	Borneol	B - Caryophyllene
7 - Days	--	7.63	4.25	10.95	8.20	17.45	15.61	3.47	8.53	5.29	6.78	2.03
	N1	1.48	1.16	7.16	10.59	19.26	18.69	5.63	13.15	3.73	3.77	2.12
	N2	14.34	3.91	13.06	6.55	15.14	12.68	2.71	6.12	4.33	6.04	1.99
	P1	1.15	0.53	3.08	9.20	16.30	25.31	7.65	7.28	3.69	7.32	2.52
	P2	0.69	0.48	4.96	9.96	18.07	22.90	6.84	12.69	7.69	3.17	1.91
Means		**5.06**	**2.07**	**7.84**	**8.90**	**17.24**	**19.04**	**5.26**	**9.55**	**4.95**	**5.42**	**2.11**
11 - Days	--	16.90	4.45	15.72	5.36	13.99	10.67	2.11	5.09	3.39	6.46	2.06
	N1	0.69	8.23	10.58	2.14	26.01	8.21	13.14	3.61	7.23	4.12	1.79
	N2	7.05	4.03	9.54	8.06	15.74	15.64	3.49	7.97	5.78	7.16	2.92
	P1	0.60	2.89	3.95	8.89	16.83	23.71	7.33	14.35	4.68	2.74	2.46
	P2	1.07	1.04	7.46	9.82	20.18	19.93	6.88	13.78	5.12	4.57	1.49
Means		**5.26**	**4.13**	**9.45**	**6.85**	**18.55**	**15.63**	**6.59**	**8.96**	**5.24**	**5.01**	**2.14**
15 - Days	--.	7.57	4.16	10.05	8.39	16.88	16.34	3.56	8.52	5.59	6.75	2.24
	N1	3.22	3.13	8.47	9.55	17.85	18.53	4.09	8.11	7.15	6.48	3.59
	N2	6.23	3.48	8.91	8.99	16.60	16.84	3.99	9.37	6.38	6.11	1.80
	P1	6.22	3.82	9.97	8.59	16.84	16.52	3.84	8.23	5.96	6.58	2.38
	P2	1.65	1.48	8.87	9.59	20.98	19.35	6.54	12.03	7.27	3.50	1.40
Means		**4.98**	**3.21**	**9.26**	**9.02**	**17.83**	**17.52**	**4.40**	**9.25**	**6.47**	**5.88**	**2.28**
Mean of --		**10.70**	**4.29**	**12.24**	**7.32**	**16.11**	**14.21**	**3.05**	**7.38**	**4.76**	**6.66**	**2.11**
Mean of N1		**1.80**	**4.17**	**8.74**	**7.43**	**21.04**	**15.14**	**7.62**	**8.29**	**6.04**	**4.79**	**2.50**
Mean of N2		**9.20**	**3.81**	**10.50**	**7.87**	**15.83**	**15.05**	**3.40**	**7.82**	**5.50**	**6.44**	**2.24**
Mean of P1		**2.66**	**2.41**	**5.67**	**8.89**	**16.65**	**21.85**	**6.27**	**9.95**	**4.78**	**5.55**	**2.46**
Mean of P2		**1.14**	**1.00**	**7.10**	**9.79**	**19.74**	**20.73**	**6.75**	**12.83**	**6.70**	**3.74**	**1.60**

N1= Nitrobien at 3 g/ pot
N2= Nitrobien at 6 g/ pot
P1= Phosphorein at 3 g/ pot
P2= Phosphorein at 6 g/ pot --= Control

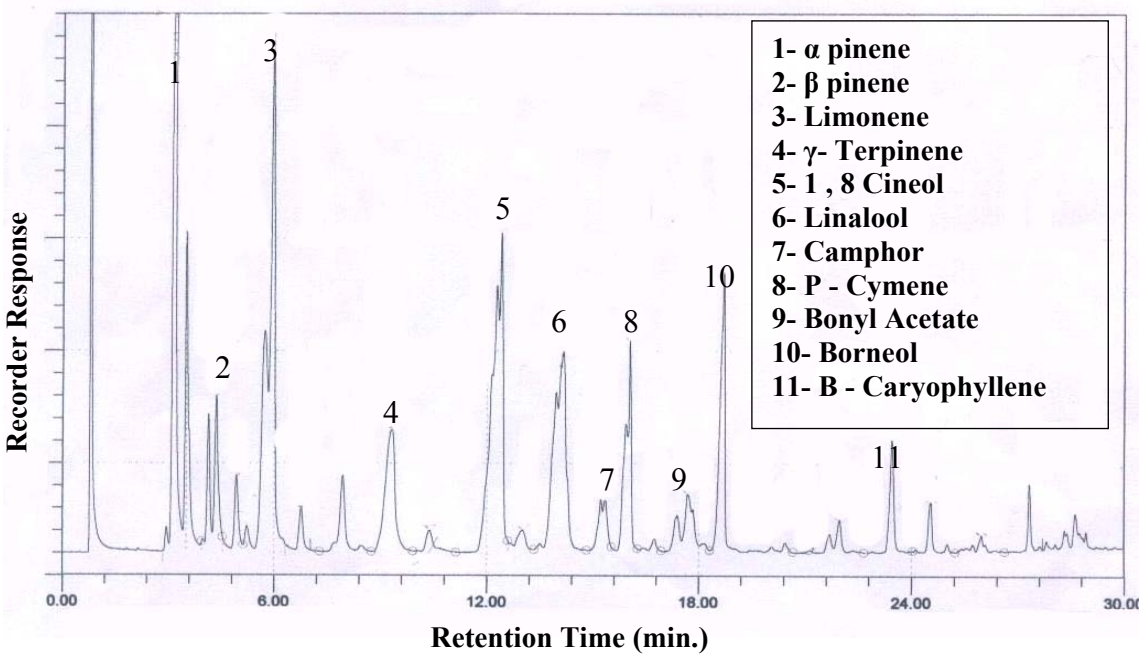

Fig. 1 : Chromatogram of rosemary (*Rosmarinus officinalis*, L.) essential oil distilled from control plants irrigated every 11 days in the first cut of the first season.

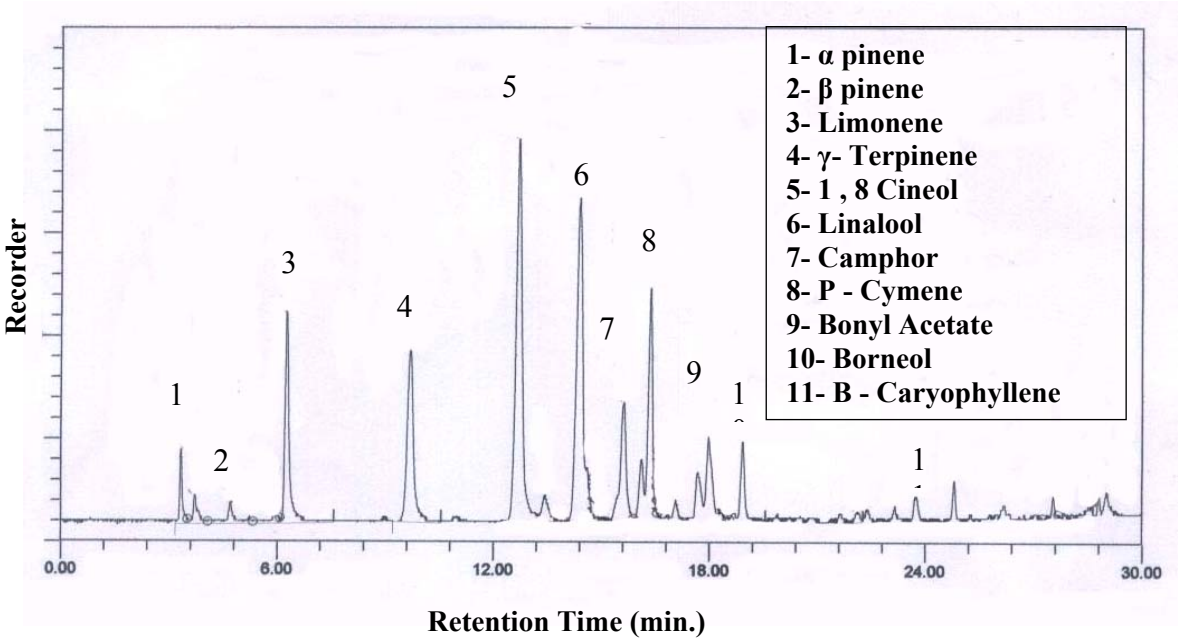

Fig. 2 : Chromatogram of rosemary (*Rosmarinus officinalis*, L.) essential oil distilled from plants irrigated every 11 days and treated with nitrobien at 3 gm/ pot in the first cut of the first season.

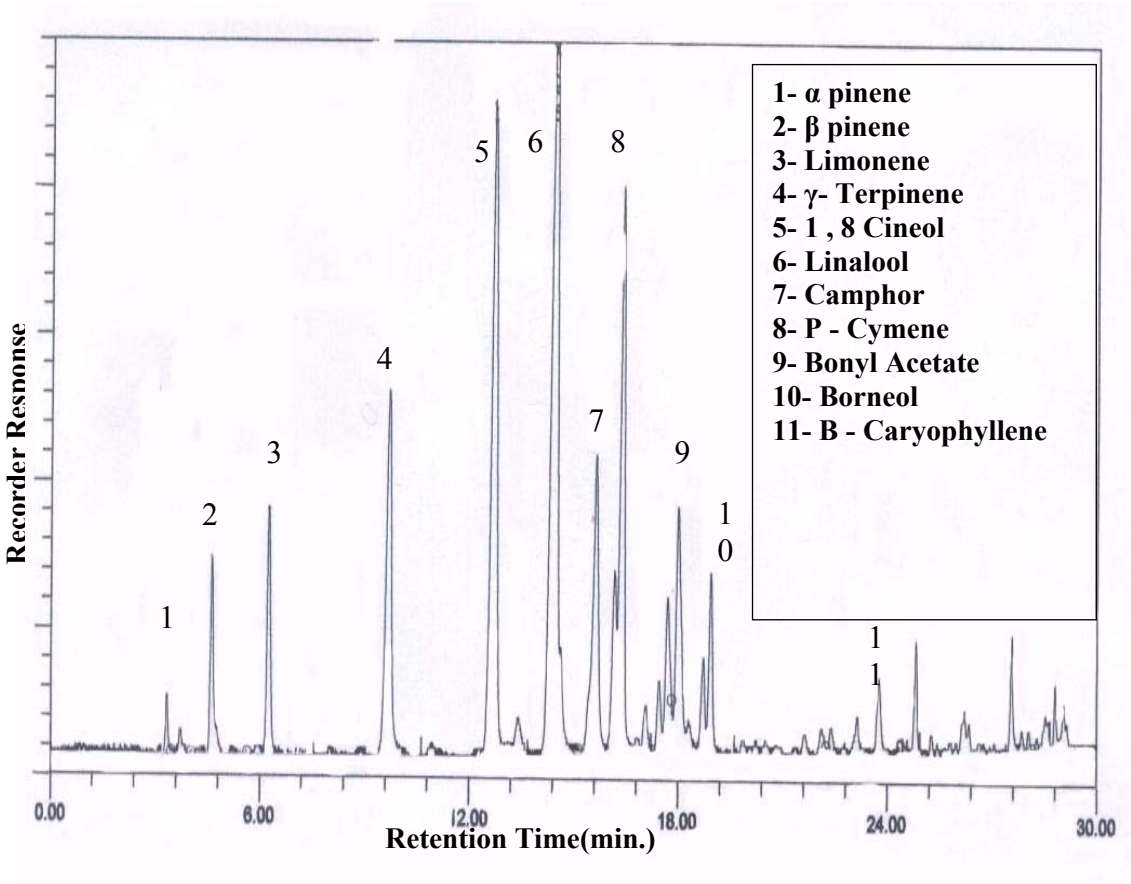

Fig. 3 : Chromatogram of rosemary (*Rosmarinus officinalis*, L.) essential oil distilled from plants irrigated every 11 days and treated with phosphorein at 3 gm/ pot in the first cut of the first season.

The increment in total carbohydrates contents as affected by bio-fertilizers were obtained by Mahfouz (2003) on marjoram; Heikal (2005) on thyme plant, Sakr (2005) on senna plants.

Regarding to interaction between irrigation intervals and bio-fertilization, the data indicate that, in the first and second cuts of the first and second seasons, irrigation every 7 days and bio-fertilization with phosphorein at 6 g/pot (P2) gave the highest values of total carbohydrates contents in herb compared to irrigation at long interval (every 15 days) which gave the lowest total carbohydrates contents in unfertilized plants.

Table 8:Effect of irrigation intervals and bio-fertilizers on carbohydrate percentages (%) of rosemary (*Rosmarinus officinalis* L.) plants during 2004 and 2005 seasons.

Irrigation Intervals / Bio-fertilizers	7days	11days	15days	Means	7days	11days	15days	Means
	First cut				Second cut			
				2004				
Control	7.01	6.91	6.02	6.65	6.41	6.33	6.23	6.32
N1	7.22	7.21	7.51	7.31	6.68	6.72	6.81	6.74
N2	7.62	7.80	7.58	7.67	7.33	7.37	7.72	7.47
P1	6.96	6.92	6.11	6.66	6.24	6.69	6.91	6.61
P2	8.29	8.18	7.06	7.84	7.87	7.25	6.64	7.25
Means	7.42	7.40	6.86	------	6.916	6.87	6.86	------
				2005				
Control	6.66	6.75	5.84	6.42	6.55	6.14	6.06	6.25
N1	6.75	7.10	7.10	6.98	6.33	6.66	6.71	6.57
N2	7.15	7.33	7.57	7.35	6.66	6.71	6.80	6.72
P1	6.36	6.00	6.85	6.40	6.55	6.25	6.12	6.31
P2	7.90	7.50	7.00	7.47	6.76	6.33	6.30	6.46
Means	**6.96**	**6.94**	**6.87**	------	**6.57**	**6.42**	**6.40**	------

N1= Nitrobien at 3 g/ pot P1= Phosphorein at 3 g/ pot
N2 = Nitrobien at 6 g/ pot P2 =Phosphorein at 6 g/ pot

Elements percentage:

Elements percentage in herb are shown in Tables (9 , 10 and 11). In the first and second cuts of both first and second seasons, irrigation interval every 7 days gave the highest N, P and K percentage in herb compared to irrigation every 15 days which gave the lowest values. Similar results were obtained by Hammoda (2001) on moghat and Alee (2004) on *Senna occidentalis*, reported that irrigation at short intervals increased N, P and K percentage in herb.

Regarding to bio-fertilization, the data indicate that, both nitrobien and phosphorein at 3 or 6 g/pot increased N, P and K percentage in herb compared to control in the first and second cuts of the first and second seasons. Phosphorein at 6 or 3 g/pot (P2) gave the highest N and P percentage in herb, respectively. Nirobien application at 6 g/ pot (N2) gave the highest K percentage in herb. whereas the lowest N, P and K percentage in herb were obtained from unfertilized plants. Migahed *et. al.,* (2004)on celery; Zayed *et. al.,* (2004) on borage; Heikal (2005) on thyme plant and Sakr (2005) on senna plants.

Table(9):Effect of irrigation intervals and biofertilizers on nitrogen percentages (%) in herb of rosemary(*Rosmarinus officinalis* L.)plants during 2004 and 2005 seasons.

Irrigation Intervals	7days	11days	15days	Means	7days	11days	15days	Means
Bio-fertilizers	First cut				Second cut			
2004								
Control	1.69	1.57	1.00	1.42	1.88	1.65	1.22	1.58
N1	2.08	1.86	1.49	1.81	2.25	1.77	1.39	1.80
N2	2.26	2.21	1.74	2.07	2.44	1.91	1.62	1.99
P1	2.69	2.17	1.29	2.05	2.71	1.83	1.48	2.01
P2	2.96	2.18	2.15	2.43	2.89	2.01	1.93	2.28
Means	**2.34**	**2.00**	**1.53**	**----**	**2.43**	**1.83**	**1.53**	**----**
2005								
Control	1.51	1.48	1.25	1.41	1.49	1.35	1.31	1.38
N1	1.83	1.77	1.52	1.71	1.75	1.71	1.40	1.62
N2	1.96	1.91	1.80	1.89	1.88	1.75	1.69	1.77
P1	2.10	2.05	2.00	2.05	1.95	1.84	1.73	1.84
P2	2.22	2.19	2.11	2.17	2.00	1.92	1.81	1.91
Means	**1.92**	**1.88**	**1.74**	**----**	**1.81**	**1.71**	**1.59**	**----**

N1= Nitrobien at 3 g/ pot P1= Phosphorein at 3 g/ pot
N2 = Nitrobien at 6 g/ pot P2 =Phosphorein at 6 g/ pot

Concerning interaction between irrigation intervals and bio-fertilization, the data indicate that, in the first and second cuts of the first and second seasons, irrigation every 7 days and bio-fertilization with phosphorein at 6 g/ pot (P2) gave the highest N percentage in herb, while irrigation every 7 days and bio-fertilization with phosphorein at 3 g/ pot (P1) gave the highest values of P percentage in herb**.** Whereas irrigation interval every 7 days and bio-fertilization with nitrobien application at 6 g/ pot (N2) gave the highest K percentage in herb compared to unfertilized control and irrigation at long intervals (every 15 days) which gave the lowest N, P and K percentage in herb.

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Table10: Effect of irrigation intervals and bio-fertilizers on phosphorus percentages (%) in herb of rosemary (*Rosmarinus officinalis* L.) plants during 2004 and 2005 seasons.

Irrigation Intervals	7days	11days	15days	Mean	7days	11days	15days	Means
Bio-fertilizers	First cut				Second cut			
				2004				
Control	0.16	0.15	0.12	0.14	0.18	0.16	0.12	0.15
N1	0.29	0.18	0.18	0.22	0.30	0.20	0.17	0.22
N2	0.19	0.14	0.13	0.15	0.20	0.14	0.13	0.16
P1	0.35	0.24	0.15	0.25	0.36	0.32	0.16	0.28
P2	0.29	0.22	0.15	0.22	0.21	0.22	0.18	0.20
Means	**0.26**	**0.19**	**0.15**	-----	**0.25**	**0.21**	**0.15**	-----
				2005				
Control	0.13	0.13	0.12	0.13	0.12	0.11	0.10	0.11
N1	0.19	0.17	0.16	0.17	0.16	0.15	0.15	0.15
N2	0.17	0.15	0.14	0.15	0.14	0.13	0.12	0.13
P1	0.22	0.20	0.16	0.19	0.18	0.16	0.15	0.16
P2	0.20	0.19	0.17	0.19	0.16	0.14	0.14	0.15
Means	**0.18**	**0.17**	**0.15**	-----	**0.15**	**0.14**	**0.13**	----

N1= Nitrobien at 3 g/ pot P1= Phosphorein at 3 g/ pot
N2 = Nitrobien at 6 g/ pot P2 =Phosphorein at 6 g/ pot

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تأثير فترات الري والتسميد الحيوي علي النمو والمحصول وإنتاج الزيت والتركيب الكيماوي لنباتات حصالبان

احمد الليثى

اجري هذا البحث في قسم بساتين الزينة – كلية الزراعة – جامعة القاهرة ومركز بحوث النباتات الطبية والعطرية- معهد بحوث البساتين- الدقي – الجيزة خلال موسمين متتاليين ٢٠٠٤ ، ٢٠٠٥ بهدف دراسة تأثير فترات الري (كل ٧ ،١١ ، ١٥ يوم) والتسميد الحيوي (النتروبين والفوسفورين بمعدل صفر ، ٣ ، ٦ جرام/ أصيص) علي النمو والمحصول وإنتاج الزيت والتركيب الكيماوي لنباتات حصالبان. وأوضحت النتائج مايلي: أعطي الري كل ٧ أيام أطول النباتات وأعلي نسبة مئوية للزيت ومحصول الزيت/ نبات في الحشة الأولي في كلا الموسمين ، وأعلي عدد من الفروع/ نبات، والوزن الطازج والجاف/ نبات، ومحتوي العشب من الكربوهيدرات والنتروجين والفوسفور والبوتاسيوم خلال الحشة الأولي والثانية في كلا الموسمين. وأعطي أعلي نسبة مئوية من الليناالول والبارا سيمين في الزيت العطري. بينما أعطي الري كل ١١ يوم أطول النباتات وأعلي نسبة مئوية للزيت ومحصول الزيت/ نبات خلال الحشة الثانية في كلا الموسمين، وأعلي نسبة مئوية من الفا بينين ، الليمونين، ١و٨ سنيول والكامفور في الزيت مقارنة بالري كل ١٥ يوم والتي أعطت أقل القيم.

أدي التسميد بالنتروبين والفوسفورين بمعدل ٣ ، ٦ جرام/ أصيص إلي زيادة معنوية في ارتفاع النبات ، عدد الفروع/ نبات ، الوزن الطازج والجاف/ نبات، محصول الزيت/ نبات، وزيادة المكونات الرئيسية للزيت العطري (تربينين ، ١و٨ سنيول ، الليناالول ، الكامفور ، الباراسيمين ، خلات البورنيول ، البيتا كاريوفللين)، وزيادة محتوي العشب من الكربوهيدرات والنتروجين والفوسفور والبوتاسيوم خلال الحشة الأولي والثانية في كلا الموسمين مقارنة بالنباتات غير المعاملة(معاملة المقارنة).

أدي التفاعل بين فترات الري والتسميد الحيوي إلي تأثير معنوي علي الصفات الخضرية ونسبة الزيت ومحصول الزيت/ نبات؛حيث أعطي الري كل ٧ أيام مع إضافة الفوسفورين بمعدل ٦ جرام/ أصيص أعلي ارتفاع للنبات (في الحشة الأولي)، وأكبر عدد فروع/ نبات (في الحشة الثانية) ، والوزن الطازج والجاف/ نبات (في الحشة الأولي) ومحصول الزيت / نبات (في الحشة الأولي) في كلا الموسمين وأعلي محتوي للعشب من الكربوهيدرات والنتروجين والفوسفور في الحشة الأولي والثانية في كلا الموسمين. بينما أعطي التفاعل بين الري كل ١١ يوم والتسميد بالفوسفورين بمعدل ٦ جرام/ أصيص أعلي وزن جاف/ نبات والنسبة المئوية للزيت ومحصول الزيت/ نبات في الحشة الثانية في كلا الموسمين.أعطي الري كل ١١ يوم مع إضافة النتروبين بمعدل ٣ جرام/ أصيص أعلي نسبة مئوية من البيتا بينين ، ١و٨ سنيول ، الكامفور وخلات البورنيول في الزيت العطري. بينما أعطي الري كل ١١ يوم مع إضافة الفوسفورين بمعدل ٣ جرام/ أصيص أعلي نسبة مئوية من الليناالول والبارا سيمين في الزيت العطري.