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Effect of Irrigation Intervals and Bentonite on Productivity of Rosemary Plants under Sinai Conditions

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ABSTRACT

Two field experiments were carried out at El-Maghara, Experimental Station of Desert Research Center (DRC), during two successive seasons 2014 and 2015, to study the effects of irrigation intervals (every two, four and six days) and bentonite at (1% and 2%) and untreated control on the growth and essential oil contents of *Rosmarinus officinalis* L. plants grown in sandy soil under Sinai conditions. The obtained results revealed that, the best growth parameters (plant height, number of branches, fresh and dry weights (g/plant), dry weight (kg/fed.), oil percentage, oil yield (L/fed.) total nitrogen and total carbohydrate content were obtained by irrigation every four days before first cut and irrigation every two days before the second cut combined by added bentonite at 1% / feddan. The main compounds of essential oil GC-MS resulted from some treatment in the first cut in second season, irrigation every two days led to the major component was Camphor followed by Borneol, α-Pinene, 1,8-Cineole , Camphene and L-Linalool. As far as, irrigation every four days gave the major component was Camphor followed by α-Pinene, Borneol, 1,8-Cineole, terpinene 4-L, Camphene and L-Linalool. While, irrigation every six days led to the major component was α-Pinene followed by Camphor, Borneol, 1,8-Cineole, Camphene, terpinene 4 – L and L-Linalool.

Key words: *Rosmarinus officinalis* L., irrigation intervals, bentonite, growth, essential oil and GC-MS.

Introduction

Rosemary (*Rosmarinus officinalis* L.) plant belongs to family Lamiaceae, it is an evergreen plant typical of Mediterranean region. Rosemary was long been considered an important plant for its essential oil used in perfumes and medicine (Khare, 2007). The plant was reported to possess several medicinal properties like antimicrobial, antioxidant, antiseptic, carminative, fungicidal, nerving and stomachic. Volatile oil of rosemary constituents are mainly α-pinene, camphene, limonene, cineole, camphor and linalool (Tamara, 1998)

Water is the most influential factor affecting crop yield particularly in irrigated agriculture in arid and semi-arid regions. It is the most important factors affecting plant growth and production of secondary metabolites, (Randhawa *et al.,* 1992). Also, Singh *et al.* (2001) mentioned that the positive effect of limited water supply in year growth, play an important role in the biosynthesis of secondary metabolites and enzyme activities. Many authors discuss the effect of irrigation limited to production *Rosmarinus officinalis* L., (Sardans *et al.,*2005 &Hassan *et al.,* 2013 and Khalil and Khalil, 2015) results that deficit irrigation significantly reduced growth parameters and relative water content of *Rosmarinus officinalis* L.

Most soils in Egypt are sandy soil; these soils are characterized by low organic matter content, low water holding capacity. Thus, productivity of these soils is limited by these constraints. Several management practices such as the application of synthetic soil conditioners were carried out to improve some physical properties of sandy soil (Al-Harbi *et al.,* 1996). The application of synthetic soil on larger scale in agricultural land could be unfeasible because of their high cost. Thus, using the natural compounds might be a good idea to increase soil productivity. So that, (Al-omran *et al.,* 2002 and Selinus and Alloway, 2005) reported that, clays contain large amounts of trace minerals, addition of clay deposits (bentonite) to the sandy soil increased the retention and the availability of soil moisture content.

The aim of this study is to investigate the effect of irrigation intervals and bentonite on productivity of Rosemary plants grown under sandy soil conditions of El-Maghara Research Station. Desert Research Center, Egypt.

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Material and Methods

A field experiment was carried out at El-Maghara, Experimental Station of Desert Research Center (DRC), during two successive seasons 2014 and 2015, to study the effect of irrigation intervals and bentonite on the growth of rosemary plants grown in sandy soil under Sinai conditions.

On 12th and 15th February (in both seasons), seedlings of *Rosmarinus officinalis* L. were obtained from the Experimental Farm of Medicinal and Aromatic Plants, Faculty of Pharmacy, Cairo University, Giza. Soil preparation, Compost manure 15m^3/feddan with addition calcium superphosphate at a rate of 30 kg (P_2O_5)/fed. were mixed with the soil before transplanting. N and K fertilizers were added at a rate of 70 kg N/fed. as NH_4NO_3 and 50 kg K_2O/fed. divided in two equal doses. The first addition was after one month from transplanting, while the second was applied after the first cut. Experimental plots were irrigated using drip irrigation 4L/h in two added/day in the morning and afternoon. The seedlings were transplanting at 50 cm between hills on rows and 100cm between rows. Physical and chemical analysis of soil, irrigation water and compost manure were presented in Table (A, B,C and D) according to Chapman and Pratt (1961). Chemical analysis of bentonite application contained presented in Table (E) 84% clay.

Table A: Particles size distribution of the experimental soil.

Very coarse sand (%) (2:1 mm)	Coarse sand (%) (1:0.5mm)	Medium sand (%) (0.5:0.25mm)	Fine sand (%) (0.25:0.1mm)	Very fine sand (%) (0.1:0.063mm)	Silt and clay (%) (<0.063mm)	Soil texture
1.27	5.90	15.30	61.28	12.82	3.43	Sandy

Table B: Chemical properties of the experimental soil.

pH	E.C. (dSm^{-1})	O.M. (%)	Soluble cations (meq./l)				Soluble anions (meq./l)			
			K^+	Na^+	Mg^{++}	Ca^{++}	CO_3^{--}	HCO_3^-	Cl^-	SO_4^{--}
7.70	0.76	0.41	0.09	2.43	0.80	3.20	-	3.00	1.38	2.14

Table C: Irrigation water analysis.

pH	E.C. (dSm^{-1})	Soluble cations (meq./l)				Soluble anions (meq./l)			
		K^+	Na^+	Mg^{++}	Ca^{++}	CO_3^{--}	HCO_3^-	Cl^-	SO_4^{--}
7.6	4.06	0.69	24.60	3.48	11.40	-	4.40	32.20	3.57

Table D: Compost manure analysis

pH	O.C. %	O.M. (%)	N %	C/N ratio
7.6	12.15	24.56	1.17	10.38

Table E: Bentonite analysis

Bentonite texture	Mineral contents					
	SiO_2%	CaO	Fe_2O_3 %	K_2O %	Na_2O %	MgO %
Clay	66.20	0.90	2.50	0.80	3.54	2.21

Irrigation intervals and Bentonite treatment:

This experiment contained nine treatments in three replicates with split plot design. Irrigation intervals in mean plot with three treatments, irrigation after two day, every four day and every six day.

The sub plot was added of Bentonite obtained from "International Co. For Mining and Investment" into the hill around root with three treatment Without Bentonite, Bentonite 1% fed. (about 10 ten /fed.) and Bentonite 2% fed.(about 20 ten / fed.)

Plant growth parameters:

Two harvested cuts were taken in June and October in both seasons. Meanwhile, plant height, number of branches, fresh and dry weight (g/plant), dry weight (kg/fed.) oil yield (L/fed.) were recorded at each cut.

Chemical analysis:

The chemical analysis included essential oil percentage, oil yield (L/fed.), oil composition at some treatments in the first cut in second season with GC-Ms analysis, a TRACE GC Ultra Gas Chromatographs

(THERMO Scientific Corp., USA), coupled with a THERMO mass spectrometer detector (ISQ Single Quadrupole Mass Spectrometer). Total nitrogen determined according to (James, 1995) Total carbohydrate analyzed according to (Chaplin and Kennedy 1994)

Statistical analysis:

Data were analysis according to the procedure analysis of variance "ANOVA" described by Steel and Torrie (1980). Treatment means were compared by the LSD at 5% level of probability.

Results and Discussion

Vegetative growth:

Plant height:

Regarding the effect of irrigation intervals and bentonite on plant height for rosemary plants, the data in Table (1) showed that, the plants irrigated every four days gave the taller plant following by irrigation every two days without significantly between them, in the first season in both cuts. Also, in the second season, it was clearly show that, the plant height was decreased affected by irrigation days in the first and second cuts, the tallest plants were result by irrigation every two days following by every four days without significant between them. The shortest plant recorded by irrigation every six days in both seasons and cuts.

Data presented in Table (1) showed that the plant height of rosemary plants was significantly affected by using the bintonite in the soil. In both seasons, add bintonite at 1% led to a significant increase in plant height following by 2% in most cases. While, the lowest values were obtained from the control plant (without bintonite).

As far as, the interaction between irrigation intervals and bentonite indicated that, in both seasons, increasing in the irrigation intervals from two to six days under 0% bentonite led to decrease in plant height. While, using bintonite with any irrigation was significant affect of plant height. The best results were obtained by irrigation under four days with add bentonite at 1%. The obtained results are in agreement with the Sardans *et al*. 2005 and Hassan *et al.* 2013 found that deficit irrigation significantly reduced growth parameters and relative water content of rosemary plants as compared to the control.

Table 1: Effect of irrigation intervals and bentonite on plant height (cm) of *Rosmarinus officinalis* L.

	First season 2014							
	First cut				Second cut			
Bento. / Irrig.	Bento.0%	Bento.1%	Bento.2%	mean	Bento 0%	Bento.1%	Bento.2%	mean
Two d.	29.67	34.67	34.33	32.89	24.67	27.67	25.00	25.78
Four d.	28.00	37.00	34.00	33.00	22.00	31.00	27.67	26.89
Six d.	26.00	31.00	30.67	29.22	20.33	27.67	25.67	24.56
Mean	27.89	34.22	33.00		22.33	28.78	26.11	
L.S.D. at 5%	Irrig. 3.06 Bento. 1.43 I.X B. 2.46				Irrig. 1.76 Bento. 1.51 I.X B. 2.61			
	Second season 2015							
Bento. / Irrig.	First cut				Second cut			
	Bento.0%	Bento.1%	Bento.2%	mean	Bento.0%	Bento.1%	Bento.2%	mean
Two d.	41.67	43.00	42.33	42.33	24.33	28.67	28.00	27.00
Four d.	40.00	44.67	41.33	42.00	23.00	29.00	26.00	26.00
Six d.	29.00	39.00	35.67	34.56	20.00	27.67	25.00	24.22
mean	36.89	42.22	39.78		22.44	28.45	26.33	
L.S.D. at 5%	Irrig. 1.47 Bento. 1.90 I.X B. 3.30				Irrig. 1.53 Bento. 1.20 I.X B. 2.08			
Irrig. = irrigation, Bento. = bentonite , d. =day								

Number of branches/ plant:

The data shown in Table (2) revealed that, in both seasons, increasing in irrigation intervals form two to six days had negative affected on number of branches/plant. The highest number of branches/plant resulted from irrigation every two days, there was a significant affect between them and other treatments. In the same trend, applying the bentonite caused significant increase on number of branches compared to the control plants. Interactions had a significant effect on number of branches, the highest values were obtained by irrigation every four days and using bentonite at 1% in both seasons and cuts. The present findings are in harmony with those reported by Leithy *et al.* 2006 and Hassan *et al.* 2013 on *Rosmarinus officinalis* L. they found that the growth were also affected by deficit irrigation.

Table 2: Effect of irrigation intervals and bentonite on number of branches of *Rosmarinus officinalis* L.

	First season 2014							
Bento. / Irrig.	First cut				Second cut			
	Bento.0%	Bento.1%	Bento.2%	Mean	Bento 0%	Bento.1%	Bento.2%	Mean
Two d.	35.00	49.00	47.33	43.78	45.00	84.67	80.67	70.11
Four d.	26.33	39.00	38.00	34.44	41.33	72.33	62.00	58.55
Six d.	16.33	29.67	29.33	25.11	36.33	56.00	59.00	50.44
Mean	25.89	39.22	38.22		40.89	71.00	67.22	
L.S.D. at 5%	Irrig. 3.05 Bento. 1.80 I.X B. 3.12				Irrig. 2.68 Bento. 2.82 I.X B. 4.89			
	Second season 2015							
Bento. / Irrig.	First cut				Second cut			
	Bento.0%	Bento.1%	Bento.2%	Mean	Bento.0%	Bento.1%	Bento.2%	Mean
Two d.	41.00	61.00	56.67	52.89	40.00	69.00	66.67	58.56
Four d.	33.67	43.33	40.67	39.22	38.33	66.33	59.00	54.55
Six d.	20.67	30.00	25.00	25.22	30.33	51.00	53.67	45.00
mean	31.78	44.78	40.78		36.22	62.11	59.78	
L.S.D. at 5%	Irrig. 3.43 Bento. 2.67 I.X B. 4.64				Irrig. 2.17 Bento. 1.29 I.X B. 2.23			
Irrig. = irrigation, Bento. = bentonite, d.= day								

Fresh weight / plant:

The data shown in table (3) revealed that, in both seasons, irrigation treatment every four days increased the herb fresh weight followed by irrigation every two days without significant, in the first cut. While, in the second cut, irrigation intervals every two days gave the best results followed by four days without significant. The light weight was obtained by irrigation every six days. Regarding, applied bentonite treatment significantly increased the herb fresh weight/plant compared to the control plants. The highest fresh herb /plant was achieved by using bentonite at 1%.

It was worth mentioning that, the interaction between irrigation intervals and add bentonite in soil had a significant effect on fresh weight/plant. In table (3) showed that, using bentonite at all level had no significant effect in fresh weight under irrigation every two day in the first cut in both seasons. While, in the second cut, using bentonite at 1% gave the best weight. These results may be related to growth of plant under different temperature from first cut compared to the second cut. In most cases, applied bentonite at 1% gave the best result of fresh weight compared to 2%. These results revealed that, applied bentonite at 1% may be supported to stabilized the level of water around root system this result may be related to the good equilibrium of nutrients in the root medium (Abdelaziz *et al.* 2007).

Herd dry weight (g/plant) and yield of dry weight (kg/fed.):

As regard to herb dry weight (g/plant) and yield of dry weight (kg/fed.) it could be noticed from the data presented in Table (4 & 5) that herb dry weight/plant and yield of plant were decreased by increasing

the level of irrigation to six days. While, using bentonite led to significant increasing in the recoded data. The effect of irrigation on plant dry weight and yield may be explained by role of moisture soil limited can alter the content and yield of secondary metabolites in plant (Gershenzon, 1984). Charles *et al.* (1990), reported that dry matter increased with higher levels of irrigation and that the timing of irrigation was an important factor to obtained the best yield of plant. The role of bintonite to increase plant herb can be explained by El-Sherif and El-hady (1986), revealed that mixing sandy soil with local bentonite improved soil mechanical, hydrophysical, chemical properties and consequently increasing water use efficiency.

Table 3: Effect of irrigation intervals and bentonite on fresh weight (g/plant) of *Rosmarinus officinalis* L.

	First season 2014							
Bento. / Irrig.	First cut				Second cut			
	Bento.0%	Bento.1%	Bento.2%	mean	Bento 0%	Bento.1%	Bento.2%	mean
Two d.	60.73	60.53	61.17	60.81	135.00	167.00	128.33	143.44
Four d.	44.53	75.12	65.62	61.76	115.33	178.33	133.73	142.46
Six d.	32.50	59.63	58.25	50.13	107.33	147.25	117.03	123.87
Mean	45.92	65.09	61.68		119.22	164.19	126.36	
L.S.D. at 5%	Irrig. 4.72 Bento. 3.03 I.X B. 5.25				Irrig. 2.70 Bento. 3.34 I.X B. 5.78			
	Second season 2015							
Bento. / Irrig.	First cut				Second cut			
	Bento.0%	Bento.1%	Bento.2%	mean	Bento.0%	Bento.1%	Bento.2%	Mean
Two d.	60.78	75.38	73.17	69.78	116.33	145.67	113.70	125.23
Four d.	50.00	85.82	79.45	71.76	100.90	157.23	114.00	124.04
Six d.	45.67	68.63	50.90	55.07	95.33	132.27	105.77	111.12
mean	52.15	75.28	67.17		104.19	145.06	111.16	
L.S.D. at 5%	Irrig. 2.04 Bento. 2.55 I.X B. 4.42				Irrig. 3.86 Bento. 3.56 I.X B. 6.18			
Irrig. = irrigation, Bento. = bentonite , d. =day								

Table 4: Effect of irrigation intervals and bentonite on herb air dry weight (g/plant) of *Rosmarinus officinalis* L.

	First season 2014							
Bento. / Irrig.	First cut				Second cut			
	Bento.0%	Bento.1%	Bento.2%	mean	Bento 0%	Bento.1%	Bento.2%	mean
Two d.	22.16	21.65	21.78	21.86	46.55	55.66	42.77	48.33
Four d.	15.91	23.57	21.41	20.29	38.44	61.49	46.59	48.84
Six d.	13.54	20.55	20.24	18.11	38.16	49.08	42.40	43.21
Mean	17.20	21.92	20.81		41.05	55.41	43.92	
L.S.D. at 5%	Irrig. 1.34 Bento. 1.02 I.X B. 1.76				Irrig. 1.06 Bento. 1.20 I.X B. 2.08			
	Second season 2015							
Bento. / Irrig.	First cut				Second cut			
	Bento.0%	Bento.1%	Bento.2%	mean	Bento.0%	Bento.1%	Bento.2%	mean
Two d.	22.11	25.98	25.63	24.57	40.12	48.55	45.62	44.76
Four d.	18.27	28.60	25.38	24.08	33.63	54.21	48.99	45.61
Six d.	18.15	23.75	18.31	20.07	33.89	44.09	38.32	38.77
mean	19.51	26.11	23.11		35.88	48.95	42.31	
L.S.D.at 5%	Irrig. 0.86 Bento. 0.84 I.X B. 1.45				Irrig. 1.32 Bento. 1.20 I.X B. 2.09			
Irrig. = irrigation, Bento. = bentonite, d. =day								

Table 5: Effect of irrigation intervals and bentonite on yield of air dry weight (kg/fed.) of *Rosmarinus officinalis* L.

	First season 2014							
Bento. / Irrig.	First cut				Second cut			
	Bento.0%	Bento.1%	Bento.2%	Mean	Bento 0%	Bento.1%	Bento.2%	Mean
Two d.	186.14	181.86	182.95	183.65	391.02	467.54	359.27	405.94
Four d.	133.64	197.99	179.84	170.49	322.90	516.52	391.36	410.26
Six d.	113.74	172.62	170.02	152.13	320.54	412.27	356.16	362.99
Mean	144.51	184.16	177.60		344.82	465.44	368.93	
L.S.D. at 5%	Irrig. 11.27 Bento. 8.55 I.X B. 14.82				Irrig. 8.97 Bento. 10.08 I.X B. 17.42			
	Second season 2015							
Bento. / Irrig.	First cut				Second cut			
	Bento.0%	Bento.1%	Bento.2%	Mean	Bento.0%	Bento.1%	Bento.2%	Mean
Two d.	185.72	218.23	215.29	206.41	337.01	407.82	383.21	376.01
Four d.	153.47	240.24	213.19	202.30	282.49	455.36	411.52	383.12
Six d.	152.46	199.50	153.80	168.59	284.68	370.36	321.89	325.64
mean	163.88	219.32	194.09		301.39	411.18	372.21	
L.S.D. at 5%	Irrig. 7.26 Bento. 7.06 I.X B. 12.23				Irrig. 18.56 Bento.12.05 I.X B. 20.88			
Irrig. = irrigation, Bento. = bentonite , d. =day								

Essential oil percentage:

Data in Table (6) noticed that, in both seasons, increasing in irrigation intervals from two days to six days led to significant increment in volatile oil percentage in the first cut. While, in the second cut, decreasing within the period intervals of irrigation resulted the best volatile oil. In this respect, the different essential oil in two cut may be attributed to the balance between day length, photon flux density, night and day temperatures combined with moisture soil limited play a role in volatile oil percentage (Voirin *et al.* 1990 and Charles *et al.* 1990). In the same trend, Noques *et al.* (2015) found that, drought stress considerably reduced photosynthetic rates, stomata conductance in rosemary plants, a negative relationship of oxygenated monoterpene with photosynthesis were observed. As far as, added bentonite increased the percentage of essential oil as compared to the control plants. The highest values obtained from application bentonite at 1% following by 2%. Interaction between irrigation intervals and bentonite had a significant effect on volatile oil percentage, in both seasons and cuts. In most cases, irrigation the plant every four days combined with bentonite at 1% gave the best volatile oil following by irrigation every six days combined with 2% bentonite without significant between them.

Table 6: Effect of irrigation intervals and bentonite on essential oil percentage of air dry herb of *Rosmarinus officinalis* L. .

	First season 2014							
Bento. / Irrig.	First cut				Second cut			
	Bento.0%	Bento.1%	Bento.2%	Mean	Bento 0%	Bento.1%	Bento.2%	Mean
Two d.	0.72	0.93	0.68	0.78	0.50	0.80	0.60	0.63
Four d.	0.74	0.94	0.84	0.84	0.55	0.70	0.51	0.59
Six d.	0.84	0.87	0.83	0.85	0.44	0.70	0.57	0.57
mean	0.77	0.91	0.78		0.50	0.73	0.56	
L.S.D. at 5%	Irrig. 0.027 Bento. 0.014 I.X B. 0.124				Irrig. 0.030 Bento. 0.015 I.X B. 0.323			
	Second season 2015							
Bento. / Irrig.	First cut				Second cut			
	Bento.0%	Bento.1%	Bento.2%	Mean	Bento.0%	Bento.1%	Bento.2%	Mean
Two d.	0.62	0.87	0.60	0.70	0.38	0.69	0.49	0.52
Four d.	0.70	0.89	0.80	0.80	0.43	0.59	0.39	0.47
Six d.	0.78	0.80	0.79	0.79	0.33	0.59	0.47	0.46
mean	0.70	0.85	0.73		0.38	0.62	0.45	
L.S.D. at 5%	Irrig. 0.010 Bento. 0.009 I.X B. 0.373				Irrig. 0.012 Bento. 0.006 I.X B. 0.0768			
Irrig. = irrigation, Bento. = bentonite , d. =day								

Essential oil yield dry herb (L/fed.):

Data in Table (7) showed that, in both seasons in the first cut, the highest oil yield/fed. were resulted from irrigation the plant every four days. While, in the second cut irrigation the plant every two days led to the beast resulted. Concerning, added bentonite increased the percentage of essential oil compared to control plants. The highest values obtained from application bentonite at 1% following by 2%. In the same trend, in both seasons interaction between irrigation intervals and bentonite showing, irrigation the plant every four days with 1% bentonite led to the best oil yield in the first cut. But, in the second cut irrigation every two day and 1% bentonite gave the best results. The effect of irrigation intervals and bentonite can be attributed to the direct effects of soil moisture content on root growth and carbohydrate content. The present findings are in harmony with (Flexas and Medrano 2002) reported that, the reduction in essential oil content may be due to disturbance in photosynthesis and carbohydrate production under water stress condition and suppression of the plant growth.

Table 7: Effect of irrigation intervals and bentonite on essential oil yield dry herb (L/fed.) of *Rosmarinus officinalis* L.

	First season 2014							
Bento. / Irrig.	First cut				Second cut			
	Bento.0%	Bento.1%	Bento.2%	Mean	Bento 0%	Bento.1%	Bento.2%	Mean
Two d.	1.34	1.69	1.24	1.42	1.96	3.74	2.16	2.62
Four d.	0.99	1.86	1.51	1.45	1.78	3.62	2.00	2.47
Six d.	0.96	1.50	1.41	1.29	1.41	2.89	2.03	2.11
Mean	1.10	1.68	1.39		1.72	3.42	2.06	
L.S.D. at 5%	Irrig. 0.12 Bento. 0.07 I.X B. ns				Irrig. 0.27 Bento. 0.18 I.X B. ns			
	Second season 2015							
Bento. / Irrig.	First cut				Second cut			
	Bento.0%	Bento.1%	Bento.2%	Mean	Bento.0%	Bento.1%	Bento.2%	Mean
Two d.	1.15	1.90	1.29	1.45	1.28	2.81	1.88	1.99
Four d.	1.07	2.14	1.71	1.64	1.21	2.69	1.60	1.83
Six d.	1.19	1.60	1.22	1.34	0.94	2.19	1.51	1.55
mean	1.14	1.88	1.41		1.14	2.56	1.66	
L.S.D. at 5%	Irrig. 0.04 Bento. 0.06 I.X B. ns				Irrig. 0.03 Bento. 0.04 I.X B. ns			
Irrig. = irrigation, Bento. = bentonite , d. =day								

Analysis of Rosmarinus officinalis essential oil components by GC-MS:

Concerning the effect of irrigation intervals and bentonite of some treatments on the essential oil GC-MS, the data presented in table (8) showed that 33 compounds were identified; the major component was different under different irrigation intervals with using bentonite at 1%.

As for, irrigation every two days led to the major component was Camphor followed by Borneol, α-Pinene, 1,8-Cineole, Camphene and L-Linalool (28.29, 23.90, 17.69, 16.16, 4.91 and 2.00 %, respectively). As far as, irrigation every four days gave the major component was Camphor followed by α-Pinene, Borneol, 1,8-Cineole, Terpinene 4-L, Camphene and L-Linalool (23.00, 20.34, 15.99, 12.72, 10.15, 4.38 and 2.92 %, respectively). While, irrigation every six days led to the major component was α-Pinene followed by Camphor, Borneol, 1,8-Cineole, Camphene, Terpinene 4–L and L-Linalool (22.00, 19.79, 14.91, 12.17, 4.76, 3.16 and 3.90 % respectively).

Regarding the effect of irrigation intervals under same bentonite concentration showed that, increasing irrigation from two days for six days led to continuous decreased in the percentage of Camphor (28.29, 23.00 and 19.79%) and Borneol percentage (23.90, 15.99 and 14.91 %). Meanwhile, it can be showed that, irrigation intervals had be effected on the major component, Camphor was the major when the plant irrigation every two or four days while, α-Pinene was the major if plant irrigated every six days. The obtained results are in agreement with the Hassan *et al.* (2013) on *Rosmarinus officinalis* L. found

that, the main component were α-Pinene, 1,8-Cineole, Linalool, Camphor and Borneol were affected by deficit irrigation. Also, Khalil and Khalil (2015). In the same plant, indicated that, the mean component of volatile oil was affected by irrigation intervals.

Table 8: Effect of irrigation intervals and bentonite on essential oil GC-MS of some treatments in the first cut in second season of *Rosmarinus officinalis* L.

NO	Num. of compound	Bentonite at 1%		
		Irrigation two days	Irrigation four days	Irrigation six days
1	Hexane	0.23	-	-
2	Pentane, 3Methyl	0.22	-	-
3	Cis-Verbenol	0.60	0.28	0.29
4	α-Pinene	17.69	20.34	22.00
5	Camphene	4.91	4.38	4.76
6	Thujenol	0.62	0.63	0.74
7	α -Myrcene	0.23	0.10	0.18
8	o-Cymene	0.22	0.08	0.30
9	D-Limonene	0.81	0.32	1.14
10	1,8-Cineole	16.16	12.72	12.17
11	α -Thujone	0.33	0.12	0.19
12	L-LINALOOL	2.00	2.92	3.90
13	Camphor	28.29	23.00	19.79
14	CIS-SABINENE HYDRATE	-	1.20	0.13
15	BORNEOL	23.90	15.99	14.91
16	Pinocarvone	-	-	0.24
17	Camphenol,	-	0.14	0.17
18	Terpinene 4-1	0.47	10.15	3.16
19	Trans-Caryophyllene	1.21	1.12	--
20	Bornyl acetate	-	-	8.68
21	á-ELEMENE	0.29	-	-
22	p-Menth	-	-	1.99
23	Iso-Borneol	0.21	0.48	-
24	Carveol, dihydro,cis	-	1.38	-
25	7 ETHYL3METHYL2NITRO4OX O4,7DIHYDROTHIENO[2,3B]PYR IDINE5CARBOXYLIC ACID	0.27	-	-
26	Terpene	-	2.31	2.44
27	CYCLOPENTANE, 1ACETOXYMETHYL3ISOPROPE	0.26	0.93	1.2
28	Propyne	0.18		
29	Caryophyllene	-		1.23
30	Humulene	0.19	0.17	0.17
31	1,2Propadiene	0.18	-	-
32	Iso-Propyl	-	0.13	0.14
33	Caryophyllene Oxide	-	0.13	0.13

Nitrogen (%) and total carbohydrates (%) content:

Data presented in table (9) revealed that, in both seasons, increasing in irrigation intervals from two days to six days led to a line decreasing in nitrogen and total carbohydrates in the dry herb of rosemary plant. Concerning, added bentonite increased the percentage of nitrogen and total carbohydrates. To obtain the best content of nitrogen and carbohydrates, must be irrigation the plant every four days with 1% bentonite in the first cut, and in the second cut irrigation every two day under same bentonite concentration. This resulted may be attributed to the soil water deficiency which markedly reduces the flow rates of element in soil and decrease the uptake of several vital nutrients, such as nitrogen from soil (Metin *et al.* 2006 and Hassan *et al.* 2013).

Table 9: Effect of irrigation intervals and bentonite on nitrogen percentage and total carbohydrates contents of *Rosmarinus officinalis* L.

Irrig. \ Bento.	Nitrogen %											
	First season 2014						Second season 2015					
	First cut			Second cut			First cut			Second cut		
	Bento. 0%	Bento. 1%	Bento. 2%	Bento. 0%	Bento. 1%	Bento. 2%	Bento. 0%	Bento. 1%	Bento. 2%	Bento0 %	Bento. 1%	Bento. 2%
Two d.	2.14	2.54	2.33	3.03	3.59	3.22	2.21	2.67	2.26	3.73	3.60	3.98
Four d.	2.11	2.64	2.55	2.95	3.45	3.12	2.54	2.74	2.38	3.46	3.12	3.38
Six d.	1.99	2.11	2.04	2.31	2.66	2.54	2.08	2.54	2.34	2.62	2.75	2.37
	Total carbohydrates %											
Irrig. \ Bento.	First season 2014						Second season 2015					
	First cut			Second cut			First cut			Second cut		
	Bento. 0%	Bento. 1%	Bento. 2%	Bento. 0%	Bento. 1%	Bento. 2%	Bento. 0%	Bento. 1%	Bento. 2%	Bento. 0%	Bento. 1%	Bento. 2%
Two d.	17.19	18.18	18.19	14.70	17.46	15.79	18.00	19.77	19.19	15.57	17.27	17.17
Four d.	16.41	19.28	18.23	15.09	16.40	15.75	17.78	20.50	20.43	15.49	16.85	16.81
Six d.	16.09	19.14	17.88	14.86	15.42	15.17	17.09	18.87	18.46	14.58	16.68	16.26

Irrig. = irrigation, Bento. = bentonite , d. =day

Conclusion

From the above mentioned results, it could concluded that, irrigation plants every four days before first cut and every two days before the second cut combined with bentonite at 1% fed. gave the best growth parameters (plant height, number of branches, fresh and dry weight (g/plant), dry weight (kg/fed.), oil percentage, oil yield (L/fed.) total nitrogen and total carbohydrate content.

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