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Effect of Irrigation Intervals and Foliar Spray of Micronutrients on Growth, Yield and Essential Oil Production of *Rosmarinus officinalis* l. Plant.

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ABSTRACT

The present study was carried out at Mansoura Horticulture Research Station, Dakahlia Governorate, Hort. Res. Institute, Agric. Res. Center, Ministry of Agric., during the two successive seasons (2011/2012) and (2012/2013) to study the effects of irrigation intervals and micronutrients on growth, herb yield, leaves yield, essential oil production and its components of rosemary (*Rosmarinus officinalis* L.) plant. The results showed that: irrigation interval every 7 days resulted in significant increase in vegetative growth characters as well as essential oil content per plant, but irrigation interval every 21 days increased essential oil percentage in the two cuts during the both seasons. Foliar spray with micro elements Fe, Zn, Mn individually and mixture between them recorded significant increase in vegetative growth, as well as the highest essential oil content per plant in the first and second cuts of the two seasons compared to the control. In addition, the previous values of characters were increased by using (Mn) to reach their maximum values by using the mixture of (Fe+Zn+Mn) at 150 ppm in both cuts of the two seasons. The interaction between irrigation interval every 7 days with foliar spray of a mixture, followed by Mn at 150 ppm gave significant increase in vegetative growth, as well as the highest essential oil content per plant in the first and second cut of the two seasons. In addition, the irrigation intervals every 21 days with same spraying treatments gave the highest essential oil percentage compared to other ones or the control plants. The irrigation interval every 21days gave the highest main components of essential oil (camphor, 1.8-cineole and α-pinene) which recorded (50.04 %), while the interaction between irrigation interval every 21days with foliar spray (Mn) at 150 ppm gave the highest main components (65.53 %) followed the mixture of the microelements (60.85 %) of the rosemary essential oil.

Keywords: *Rosmarinus officinalis* L. plant, irrigation intervals, foliar spray, vegetative growth, essential oil production.

INTRODUCTION

Rosemary "*Rosmarinus officinalis* L." Fam. Lamiaceae (Labiateae) is one of the important medicinal plants. The main product of rosemary is the leaves and essential oil which has a strong analgesic, antimicrobial, antioxidant, antiseptic, carminative, fungicidal, nerving, stomachic and tonic. It has been used in the treatment of cancer. In addition, rosemary improves liver functions and is thought to act as a stimulant to the kidneys.

Essential oil of rosemary constituents are mainly pinene, cineol, camphor, bornylacetate, camphene, linalool, limonene, borneol, myrcene, terpineol, and caryophyllene, (Beddows *et al*., 2000).

Water stress in plant influences much metabolic process, and the extent of its effects depend on drought severity. The optimization of irrigation for the production of fresh herbs and essential oil is important since water is a major component of the fresh produce and affects both weight and quality, (Jones and Tardien, 1998). Kandeel (2001) revealed that, irrigation every 14 days significantly increased *Rosmarinus officinalis* plant height, fresh and dry herbs per plant, in addition to the highest oil yield attain 100 % field capacity. The irrigation intervals 21 days increased cineole, borneol and linalool percentages and reduced p-cymene percentage compared with the other two intervals.Leithy *et al*. (2006) indicated that, irrigation every three weeks reduced each of plant height, number of branches, fresh and dry weights/ plant, but increased oil content in *Rosmarinus officinalis* plants was happened under water stress. Some components of the essential oil were influenced by prorogating irrigation water intervals to three weeks, such as α, β-pinene, Limonene,1,8–cineole, Linalool, camphor, β-terpineol, borneol, linalylacetate, geranylacetate, β-caryophyllene.El-Mekawy (2009) showed that the short irrigation interval every 10 days was the best for producing taller plants with more number of branches/plant, heavier fresh and dry weights of *Thymus capitatus* herb, while the higher volatile oil yield gave from the long intervals every 20 and 30 days. Khalil *et al*. (2010) showed that plant height, number of branches, fresh and dry weights showed significant increases with increasing soil moisture levels. Hassan *et al*. (2013) showed that the irrigation levels significantly affected the growth, yield of rosemary plant. Water deficit decreased plant height, branch number and both fresh and dry weights compared to control which applied of 100 % FC, and the volatile oil composition were affected by irrigation levels. Deficit irrigation increased α-pinene, 1,8cineol and borneol especially when 60 % of FC was applied. On the other hand, linalool and camphor were decreased by deficit irrigation.

Micronutrients are needed in too small quantities involving physiological process and metabolism, enhancement of plant resistance, involvement in the centers of enzymes and vitamins, and are necessary for plant growth and oil yield as well as oil composition (Shoala, 2000), Ramadan (2001) found that foliar application with mixture of Fe, Mn and Zn significantly increased each of plant height, number of main branches, fresh and dry weights of whole herb/ plant. The highest level of 100 ppm Fe + 100 ppm Mn + 200 ppm Zn was more effectives in this respect, and increasing the trace-elements level increased the essential oil percentage and oil yield as well as the major oxygenated compounds (thymol and borneol %), while it decreased the major hydrocarbons (P-cymene, terpinene and umonene %) on thyme (*Thymus vulgaris* L.) plant. Refaat and Balbaa (2001) revealed that, foliar application of micronutrients mixture (Zn, Mn and Fe) significantly increased lemongrass fresh weight and dry mass, and significantly increased lemon grass essential oil yield and myrcene content. Abd El- Wahab (2008) reported that increasing plant height, number of branches /plant, plant fresh and dry weights was significantly increased with Fe, Zn and Mn application at 50 or 100 ppm compared with untreated *Trachyspermum ammi* plants. Zehtab-Salmasi *et al*. (2008) showed that essential oil percentage and yield of *Mentha peperita* L. increased with spraying of microelements as mixture of iron + zinc. Ibrahim (2010) found that spraying lemon verbena plants with mixture of Fe, Zn and Mn produced the tallest plants, highest number of branches, heaviest fresh and dry yield of leaves and gave the highest essential oil % and yield, main constituents than unsprayed control plants.

Therefore, the present work aimed to improve rosemary plant productivity of herb, leaves and essential oil by using the best treatments of micronutrients foliar spray and proper water irrigation intervals as well as their interaction of rosemary (*Rosmarinus officinalis* L.) plant.

MATERIALS AND METHODS

The present work was carried out at the Experimental Station of Mansoura Horticulture Research Station, Dakahlia Governorate Hort. Res. Institute, Agric. Res. Center, Egypt, during the two successive seasons of (2011/2012 and 2012/2013). The present work aimed to improve rosemary plant productivity of herb, leaves and essential oil by using the best treatments of irrigation intervals and micronutrient fertilization as well as their interactions. The seedlings were planted in the nursery bed on 1st November in green house in the two seasons (2011-2012). The plants transplant in 15 January of plastic pots (one plant/ pot) with a diameter of 50 cm and filled with 15 kg of dry soil mixture clay and sand (2: 1 v / v) and compost was added at 1.5 kg/ pot to soil mixture in the two seasons. The plants were held under natural conditions and irrigated with water as needed for 4 weeks from transplanting date in both seasons. The mechanical and chemical properties of the used soil are shown in Table (A) according to Chapman and Pratt (1971).

Table (A): Chemical and physical analysis of experimental soil.

Mechanical analysis (%)		Chemical analysis (ppm)		Soluble cations and anions (meq/ 100 g soil)	
Coarse sand	8.2	Available N	30.3	Ca ++	2.73
Fine sand	30.6	Available P	12.4	Mg ++	2.41
Silt	27.7	Available K	239	Na+	0.98
Clay	33.5	pH**	7.60	K+	0.36
Organic matter	1.34	CaCO3 %	2.4	Cl -	2.15
Soil texture	Clay loamy	EC* %	0.34	SO4 =	3.46
				HCO3 -	0.87

The treatments of irrigation intervals were 7, 14 and 21 days, while micro elements treatments used in the rates of 0, 50,100,150 ppm on 1st march, the second spray was after month than first spraying and third spray was after month the first cut in the two seasons and it was Edta-mixfert Fe, Zn and Mn (12:12:12) in the form of individual and mixture, obtained from the center of Egyptian Fertilizers Development, Delta Company for Fertilizers and Chemical Industries. The experimental design was a factorial experiment in a randomized complete block design with three replicates, where each replicate containing 39 treatment, each treatment includes five plants

The following data were recorded:

1. **Vegetative growth characters**: A random sample of four plants from each replicate was taken at the first cut 1st July and the second cut was done 4months after the first cut, (Kandeel, 2001) and El-Weshahy (2007). The following data were recorded - plant height (cm), number of branches/ plant, herb and leaves dry weights (g / plant).
2. **Essential oil production**: was determined in the fresh leaves samples (100g) for each cut. Distillation and determination of the essential oil was carried out according to the method described by the Egyptian Pharmacopoeia (1984). The oil content ml per plant was calculated by multiplying the oil % by average of leaves yield per plant
3. **Essential oil constituents:** was analyzed using DsChrom Gas Chromatograph equipped with a flame ionization detector for separation of essential oil constituents. It was conducted Medicinal and Aromatic Plants Department at the Institute of Horticulture Research, Agricultural Research Center. The analysis conditions were as follows: - The chromatograph apparatus was fitted with capillary column BPX-5.5% phenyl (equiv.) polysillphenylene-siloxane 30cm × 0.25mm ID × 0.25µ film. Temperature program ramp increase with a rate of 10ºC/min from 70º to 200ºC. Flow rates of gases were nitrogen at 1ml/min, hydrogen at 30ml/min and 330 ml/min for air. Detector and injector temperatures were 300ºC and 250ºC, respectively. The obtained chromatogram and report of GC analysis for each sample were analyzed to calculate the percentage of main components according to Guenther and Joseph (1978).

Statistical analysis:

Data of present study were statistically analyzed and the differences between the means of the treatments were considered significant when they were more than least significant differences (L.S.D) at the 5% level according to Steel and Torrie (1980).

RESULTS

Vegetative growth characters

1-Plant height and number of branches

Effect of irrigation intervals:-

Data in Tables (1) shows that plant height, number of branches, were influenced by irrigation intervals at different rates. Moreover, the irrigation interval every 7 days recorded highly significant increase in plant highest, number of branches on rosemary in comparison with other irrigation intervals (14 and 21 days). Moreover, the highest values of plant height was (66.6, 56.3 and 62.8, 57.7 cm), number of branches (26.9, 38.1 and 39.8, 44.7 per plant),in the both cuts of the two seasons, respectively obtained from 7 days irrigation interval treatment then decreased gradually with 14 days and the least values was from 21 days irrigation interval treatment. Furthermore, there was significant decrease observed between 14 days and 21 days irrigation intervals treatments. This increase in the vegetative growth characters might be due to that the short irrigation intervals increased the growth of roots system, consequently, increased the nutrients uptake which needed for plant growth. Hence, enhancement of the assimilated food and increase the cell elongation and division consequently. Besides, enhancing the rates of physiological processes and increasing the hydrostatic pressure on the cell wall which is necessary for the enlargement of cell. These results agreed with those obtained by Kandeel (2001) and Leithy et al. (2006) on *Rosmarinus officinalis* plant, Aziz et al. (2008) and El-Mekawy (2009) on *Thymus vulgaris* plant, Khalil et al. (2010) and Van-Houtte (2012) on *Ocimum basilicum* plant and Massoud et al. (2010) on marjoram.

Table (1): Effect of irrigation intervals and foliar spray of microelements on plant height (cm) and number of branches/ plant of *Rosmarinus officinalis* L. plant in the two cuts during 2011/2012 and 2012/2013 seasons.

Foliar fertilization (ppm) (B)		Plant height (cm)								Number of branches/ plant							
		Irrigation intervals (A)															
		1st cut				2nd cut				1st cut				2nd cut			
		7 day	14 Day	21 Day	Mean of B)	7 day	14 Day	21 Day	Mean of (B)	7 day	14 day	21 day	Mean of (B)	7 day	14 day	21 Day	Mean of (B)
First season																	
Control		44.0	41.0	34.0	39.7	43.0	39.0	29.3	37.1	12.3	9.7	8.0	10.0	21.3	18.0	14.7	18.0
Fe	50	49.7	45.3	41.3	45.4	45.7	42.3	31.7	39.9	17.7	12.7	10.7	13.7	26.7	22.3	18.3	22.4
	100	55.7	51.7	47.6	517	50.7	50.3	43.0	48.0	22.3	17.3	14.7	18.1	33.3	28.3	21.3	27.7
	150	63.0	59.7	55.3	59.3	59.0	54.3	47.7	53.7	26.3	22.7	19.0	22.7	40.0	32.3	23.0	31.8
Zn	50	59.7	50.0	44.0	51.2	47.3	43.3	35.7	42.1	21.3	14.3	12.7	16.1	32.3	25.0	17.0	24.8
	100	64.7	55.7	50.6	57.0	54.3	52.3	45.0	50.6	25.0	20.0	17.3	20.8	38.0	32.3	21.3	30.6
	150	70.7	63.7	58.0	64.1	62.3	59.0	51.7	57.7	29.3	24.3	18.3	24.0	44.7	37.3	24.7	35.6
Mn	50	64.3	52.3	42.7	53.1	50.7	47.0	38.3	45.3	25.3	16.7	14.0	18.7	34.7	27.0	20.3	27.3
	100	71.3	59.0	52.7	61.0	58.0	54.3	45.3	52.6	31.3	22.0	18.7	24.0	40.0	33.7	23.3	32.3
	150	79.0	65.3	60.3	68.2	65.3	62.3	54.3	60.6	36.3	27.0	23.3	28.9	46.7	40.3	29.0	38.7
Mix	50	70.7	58.3	50.7	59.9	57.0	52.7	46.3	52.0	28.0	20.3	18.3	22.2	40.0	31.7	21.7	31.1
	100	78.7	63.7	57.3	66.6	64.3	60.7	54.3	59.7	34.3	25.7	22.7	27.6	46.3	37.7	25.7	36.6
	150	81.0	74.0	67.7	74.6	73.7	68.0	56.3	66.0	41.0	32.3	28.7	34.0	51.7	42.3	32.3	42.1
Mean of A)		61.8	56.8	50.9		56.3	52.7	44.5		26.9	20.4	17.4		38.1	31.4	22.5	
L.S.D. at		A		B	AxB	A	B		AxB	A	B		AxB	A	B		AxB
(5%)		(0.41)		(0.96)	(1.86)	(0.41)	(0.94)		(1.93)	(0.35)	(0.73)		(1.46)	(0.69)	(1.43)		(2.87)
Second season																	
Control		42.0	38.0	34.7	38.2	41.3	33.7	30.0	35.0	28.3	21.3	14.7	21.4	31.3	24.3	21.7	25.8
Fe	50	46.0	43.0	38.7	42.6	45.3	41.0	37.3	41.2	32.3	24.3	19.3	25.3	35.0	29.0	25.3	29.8
	100	52.0	46.7	44.7	47.8	51.0	44.3	41.3	45.6	35.3	28.0	23.0	28.8	41.0	32.3	30.0	34.4
	150	61.0	56.0	51.0	56.0	56.7	51.0	48.7	52.1	37.0	31.7	26.3	31.7	44.3	38.0	33.0	38.3
Zn	50	55.3	51.0	46.3	50.9	52.3	46.3	43.0	47.2	37.3	28.0	18.0	27.8	41.0	34.0	24.3	33.1
	100	61.3	56.7	52.3	56.8	57.0	53.0	50.0	53.3	39.3	31.3	21.7	30.8	44.0	37.7	30.7	37.4
	150	69.7	64.0	58.0	63.9	62.7	59.0	53.7	58.4	43.0	35.7	27.7	35.4	47.3	41.3	35.3	41.3
Mn	50	59.3	52.0	50.0	53.8	56.7	48.3	46.0	50.3	39.3	30.3	21.0	30.2	42.7	37.3	28.0	36.0
	100	65.7	59.3	54.7	59.9	60.0	54.7	52.0	55.6	43.0	34.7	26.0	34.6	46.3	41.0	35.0	40.8
	150	74.7	67.0	61.3	67.7	68.0	62.3	58.3	62.9	45.3	38.0	32.0	38.4	51.0	44.0	39.3	44.8
Mix	50	65.0	60.3	53.3	59.6	60.3	54.3	50.7	55.1	42.3	32.3	22.7	32.4	47.0	38.7	31.3	39.0
	100	72.7	64.3	58.7	65.2	67.0	60.3	57.3	61.6	46.0	36.3	28.0	36.8	51.7	45.0	38.3	45.1
	150	82.0	72.7	64.3	73.0	72.0	65.3	62.3	66.6	49.7	41.3	35.0	42.0	58.0	49.7	42.3	50.0
Mean of (A)		62.8	56.2	51.4		57.7	51.8	48.5		39.8	31.8	24.3		44.7	37.9	31.9	
L.S.D. at		A	B		AxB	A	B		AxB	A	B		AxB	A	B		AxB
(5%)		(0.33)	(0.78)		(1.55)	(0.31)	(0.71)		(1.43)	(0.53)	(1.11)		(2.22)	(0.53)	(1.09)		(2.19)

Effect of foliar fertilization:-

From data presented in Tables (1), results shows that the foliar spray of Fe, Zn, Mn individually or as a mixture gave a highly significant increase in plant height, number of branches in all levels of foliar spray of microelements compared to control plants. Moreover, the highest values of plant height (78.6, 66.0 and 73.0, 66.6 cm), number of branches (34.0, 42.1 and 42.0, 50.0 per plant), produced from sprayed plant with the mixture of (Mn, Fe and Zn) at 150 ppm, followed by plants treated with the mixture at 100 ppm, and then with Mn treatment at 150 ppm in the 1st and 2nd cuts of the both seasons respectively, compared to the other microelements treatments. The favorable effect of foliar-spraying might be ascribed to its important role in fixing atmospheric N as well as increasing the secretion of natural hormones namely and possibly raising availability of various nutrients. These results are in harmony with those found by Ramadan (2001) on thyme, Hendawy and Khalid (2005) on sage, Ibrahim (2010) on *lemon verbena* plants.

Effect of the interaction treatments:-

Data recorded in Tables (1) reveal that, the interaction treatments between all irrigation intervals every 7, 14 and 21 days with all concentration of microelements (Fe, Zn and Mn) individually or as a mixture caused significant increase in plant height, number of branches compared to the treatment of un-sprayed plants in the first and second cuts in the two seasons.

The effective treatment in this concern was the plants irrigated every 7 days and sprayed with the mixture of microelements (Fe+Zn+Mn) at 150 ppm which gave the highest plant height (94.0, 73.7 and 82.0, 72.0 cm), number of branches (41.0, 51.7 and 49.7, 58.0 per plant) respectively, in the both cuts in the two seasons.

2-Fresh and dry weights of herb and leaves per plant

Effect of irrigation intervals

Data in Tables (2 and 3) shows that fresh and dry weights of herb and leaves per plant were influenced by irrigation intervals at different rates. Moreover, the irrigation interval every 7 days recorded highly significant increase in herb fresh weight (143.9, 238.9 and 367.6, 422.1 g/ plant), herb dry weight (61.9, 135.5, 158.9 and 178.4 g/ plant), leaves fresh weight (73.9, 134.7 and186.6, 212.7 g/ plant) and leaves dry weight (30.6, 55.3 and 77.3, 85.8 g/ plant) in the both cuts of the two seasons, respectively obtained from 7 days irrigation interval treatment then decreased gradually with 14 days and the least values was from 21 days irrigation interval treatment. Furthermore, there was significant decrease observed between 14 days and 21 days irrigation intervals treatments. This increase in the vegetative growth characters might be due to that the short irrigation intervals increased the growth of roots system, consequently, increased the nutrients uptake which needed for plant growth. Hence, enhancement of the assimilated food and increase the cell elongation and division consequently. Besides, enhancing the rates of physiological processes and increasing the hydrostatic pressure on the cell wall which is necessary for the enlargement of cell. These results agreed with those obtained by Kandeel (2001) and Leithy et al. (2006) on *Rosmarinus officinalis* plant, Aziz et al. (2008) and El-Mekawy (2009) on *Thymus vulgaris* plant, Khalil et al. (2010) and Van-Houtte (2012) on *Ocimum basilicum* plant and Massoud et al. (2010) on marjoram.

Effect of foliar fertilization

From data presented in Tables (2 and 3), results shows that the foliar spray of Fe, Zn and Mn individually or as a mixture gave a highly significant increase in fresh and dry weights of herb and leaves per plant in all levels of foliar spray of microelements compared to control plants. Moreover, herb fresh weight (199.2, 379.6 and 466.3, 518.4 g/ plant), herb dry weight (97.0, 191.5 and 198.5, 222.1 g/ plant), leaves fresh weight (100.7, 194.2 and 233.9, 260.2 g/ plant) and leaves dry weight (42.4, 82.7 and 98.1, 109.1 g/ plant) produced from sprayed plant with the mixture of (Mn, Fe and Zn) at 150 ppm, followed by plants treated with the mixture at 100 ppm, and then with Mn treatment at 150 ppm in the 1st and 2nd cuts of the both seasons respectively, compared to the other microelements treatments. These results are in harmony with those found by Ramadan (2001) on thyme, Hendawy and Khalid (2005) on sage, Ibrahim (2010) on *lemon verbena* plants.

Effect of the interaction treatments

Data recorded in Tables (2 and 3) reveal that, the interaction treatments between all irrigation intervals every 7, 14 and 21 days with all concentrations of microelements (Fe, Zn and Mn) individually or as a mixture caused significant increase in fresh and dry weights of herb and leaves compared to the treatment of un-spraying plants in the first and second cuts of the two seasons.

The effective treatment in this concern was the plants irrigated every 7 days and sprayed with the mixture of microelements (Fe+Zn+Mn) at 150 ppm which gave increase in herb fresh weight (213.8, 425.2 and 515.7, 590.2 g/ plant), herb dry weight (111.2, 210.0 and 216.3, 252.5 g/ plant) leaves fresh weight (108.5, 213.9 and 258.5, 296.2 g/ plant) and leaves dry weight (45.7, 89.9 and 108.4, 124.2 g/ plant) respectively, in the both cuts of the two seasons.

Table (2): Effect of irrigation intervals and foliar spray of microelements on herb fresh and dry weights (g/ plant) of *Rosmarinus officinalis* L. plant in the two cuts during (2011/2012 and 2012/2013) seasons.

Foliar fertilization (ppm) (B)		Herb fresh weight (g/ plant)								Herb dry weight (g/ plant)							
		Irrigation intervals (A)															
		1st cut				2nd cut				1st cut				2nd cut			
		7 Day	14 Day	21 Day	Mean of B)	7 day	14 day	21 day	Mean of (B)	7 Day	14 day	21 Day	Mean of (B)	7 day	14 day	21 day	Mean of (B)
First season																	
Control		69.4	61.7	53.4	61.5	147.5	١١٧.٦	١٠٨.٨	124.6	29.8	26.5	25.4	27.3	82.3	50.2	42.9	42.9
Fe	50	94.5	81.7	69.0	81.7	178.0	146.6	121.3	148.7	40.2	34.3	32.7	35.7	92.8	72.3	61.9	75.7
	100	112.1	102.3	86.9	100.5	189.2	186.2	162.3	179.2	49.7	42.9	34.8	42.5	98.3	93.1	75.0	88.8
	150	134.1	119.5	111.7	121.7	227.8	220.2	197.6	215.2	66.3	57.5	44.0	55.9	108.3	102.1	99.9	103.4
Zn	50	115.6	93.3	73.9	94.3	209.4	192.3	160.4	187.3	55.7	41.2	34.7	43.8	100.7	86.1	81.5	89.4
	100	152.4	131.7	106.7	130.3	235.2	220.7	190.4	217.1	70.1	50.4	49.4	56.7	121.7	101.1	99.8	107.5
	150	175.7	141.7	140.0	152.5	260.9	251.6	243.9	254.2	87.7	49.0	59.0	70.0	132.5	122.2	120.3	125.0
Mn	50	110.5	97.3	87.9	98.6	252.5	213.2	201.9	222.5	52.3	39.5	39.5	45.6	137.0	101.7	96.3	111.7
	100	133.7	121.0	118.3	124.3	301.2	245.6	215.3	254.0	70.6	48.4	48.4	58.6	162.3	120.0	115.2	132.5
	150	206.9	176.5	161.7	181.7	331.3	284.3	269.6	295.1	100.1	73.8	73.8	84.7	173.9	153.5	139.6	155.7
Mix	50	164.2	140.2	135.0	146.5	325.9	236.2	241.6	267.9	77.3	58.2	58.2	68.3	165.6	126.8	117.8	136.7
	100	187.7	169.8	163.5	173.7	353.7	320.1	292.3	322.0	91.6	69.7	69.7	79.4	176.2	164.9	143.4	161.5
	150	213.8	198.9	185.0	199.2	425.2	365.9	347.8	379.6	111.2	83.3	83.3	97.0	210.0	196.5	167.6	191.4
Mean of A)		143.9	125.8	114.9		238.9	230.8	٢١١.٨		61.9	57.6	50.0		135.5	114.7	104.7	
L.S.D. at (5%)		A (٢.٠٢)	B (4.10)		AxB (8.16)	A (2.42)	B (4.60)		AxB (9.21)	A (0.54)	B (2.07)		AxB (4.19)	A (1.14)	B (2.63)		AxB (5.25)
Second season																	
Control		283.8	٢٠٨.٢	١٢٧.٩	٢٠٦.٦	297.4	٢٦٩.٤	١٩٦.٣	٢٥٤.٤	121.3	87.2	56.0	88.2	124.9	113.1	82.8	106.9
Fe	50	308.1	240.7	182.9	243.89	314.7	296.2	217.3	276.1	130.8	101.2	76.9	103.0	132.6	124.4	92.4	116.5
	100	316.3	287.3	211.6	271.74	375.9	320.1	284.8	326.9	134.5	122.1	91.4	116.0	159.3	134.8	120.7	138.3
	150	358.9	309.9	272.2	313.69	414.6	364.5	305.7	361.6	160.4	130.2	116.6	135.7	176.5	154.7	130.9	154.0
Zn	50	331.0	257.4	208.6	265.68	354.3	318.9	265.3	312.3	138.0	108.2	92.8	113.0	151.7	136.3	114.1	134.0
	100	385.1	309.9	270.4	321.80	405.2	392.8	316.0	371.3	161.6	130.1	113.7	135.1	173.1	167.0	134.7	158.3
	150	409.2	354.0	307.3	356.83	452.0	420.6	341.0	404.6	171.8	149.9	131.0	150.9	194.3	180.4	146.2	173.7
Mn	50	333.3	290.8	231.9	285.37	401.4	372.3	292.9	355.5	138.6	123.5	98.6	120.2	170.8	159.4	124.6	151.6
	100	393.5	351.9	306.7	350.72	431.8	407.9	335.3	391.7	165.5	148.0	131.0	148.2	183.5	172.4	141.6	165.8
	150	432.9	406.5	332.5	390.66	493.5	459.2	386.9	446.6	181.8	171.1	142.4	165.1	209.3	195.6	163.9	189.6
Mix	50	380.3	321.9	277.8	326.69	433.5	387.3	327.1	382.6	158.3	135.5	119.6	137.8	186.1	165.2	141.5	164.3
	100	447.8	387.8	326.7	387.45	482.8	427.5	405.4	438.6	186.3	163.0	140.5	163.2	207.0	181.6	171.6	186.7
	150	515.7	463.8	419.5	466.32	590.2	511.7	453.1	518.4	216.3	198.4	180.7	198.5	252.5	218.9	194.8	222.1
Mean of (A)		376.3	٣٢٢.٣	٢٦٧.٤		422.1	٣٨٠.٦	٣١٧.٥		158.9	136.0	114.7		178.4	164.1	125.8	
L.S.D. at (5%)		A (2.32)	B (5.36)		AxB (10.70)	A (2.26)	B (5.21)		AxB (10.40)	A (1.10)	B (2.55)		AxB (5.21)	A (0.94)	B (2.16)		AxB (4.25)

Table (3): Effect of irrigation intervals and foliar spray of microelements on leaves fresh and dry weights (g/plant) of *Rosmarinus officinalis* L. plant in the two cuts during (2011/2012 and 2012/2013) seasons.

Foliar fertilization (ppm) (B)		Leaves fresh weight (g/ plant)								Leaves dry weight (g/ plant)							
		Irrigation intervals (A)															
		1st cut				2nd cut				1st cut				2nd cut			
		7 Day	14 Day	21 Day	Mean of B)	7 Day	14 day	21 Day	Mean of (B)	7 day	14 day	21 Day	Mean of (B)	7 day	14 day	21 day	Mean of (B)
First season																	
Control		35.5	٣٢.٦	26.4	30.8	٧٤.٧	٦٣.٩	٥٥.٢	٦٤.٦	14.7	١٣.٣	١١.٢	١٣.١	٣٠.٤	٢٤.٢	٢٢.٢	٢٥.٦
Fe	50	٤٧.٩	٤٢.٦	٣٥.٦	٤٢.٠	٩٠.٥	٧٤.٦	٦١.٧	٧٥.٦	١٩.٣	١٧.٢	١٧.٩	١٧.٢	٣٦.٨	٣٠.٠	٢٥.١	٣٠.٦
	100	٥٨.١	٥١.٩	٤٤٦	٥١.٥	٩٧.٧	٨٦.٥	٨٢.٣	٨٨.٨	٢٣.٩	٢١.٢	١٨.٢	٢١.١	٤٠.٤	٣٩.٠	٣٣.٦	٣٧.٧
	150	٦٨.٨	٦٠.٢	56.7	٦١.٦	١٢١.٩	١٠٨.٦	٩٥.٩	١٠٨.٨	٢٨.٦	٢٥.٣	٢٤.١	٢٦.٠	٤٨.٤	٤٦.٩	٤١.٧	٤٥.٧
Zn	50	٥٥.٦	٤٧.٩	٣٨.٢	٤٧.٣	١٠٧.٨	٩٥.٤	٨١.٦	٩٥.٦	٢٣.٢	١٩.٦	١٥.٤	١٩.٤	٤٢.٢	٣٩.١	٣٥.٦	٣٨.٩
	100	٧٠.١	٦٠.٩	٥٤.٣	٦١.٨	١٢٠.٩	١١٠.٨	٩٦.٤	١٠٩.٨	٣٠.١	٢٥.٠	٢٢.٣	٢٥.٨	٤٩.٤	٤٨.٩	٤٦.٨	٤٨.٤
	150	٩٠.٩	٧٧.٤	٦٩.٧	٧٩.٣	١٣٥.٦	١٢٠.٩	١١٠.١	١٢٢.٢	٣٨.٤	٢٩.٩	٢٩.٧	٣٢.٧	٥٥.٤	٥٤.٥	٥١.٥	٥٣.٨
Mn	50	٥٩.٥	٤٩.٩	٤٤.٨	٥١.٤	١٢٧.٨	١٠٧.٨	١٠١.٩	١١٢.٥	٢٤.٤	٢٠.٣	١٧.٩	٢٠.٩	٥١.٢	٤٣.٠	٤١.١	٤٥.١
	100	٧٨.٢	٦٧.٠	٦٠.٠	٦٨.٤	١٥١.٥	١٢٨.٩	١٠٨.٣	١٢٩.٦	٣٢.٨	٢٧.٥	٢٤.٦	٢٨.٣	٦٢.٢	٥٢.٨	٤٤.٤	٥٣.١
	150	١٠٣.٣	٨٨.٩	٨٣.٣	٩١.٩	١٦٦.٦	١٤٣.٣	١٣٥.٤	١٤٨.٥	٤٣.٦	٣٧.١	٣٤.٩	٣٨.٥	٧٣.٢	٦٠.٣	٥٢.٤	٦١.٨
Mix	50	٨٤.٠	٧٣.١	٦٩.٠	٧٥.٤	١٦٤.٢	١٣١.١	١١٩.٤	١٣٨.٢	34.2	٢٩.٣	٢٧.٣	٣٠.٣	٦٥.٨	٤٨.٥	٤٧.٥	٥٣.٩
	100	٩٦.٢	٨٦.٢	٨٣.٢	٨٨.٥	١٧٨.٠	١٦٠.١	١٤٦.٨	١٦١.٩	٣٨.٨	٣٤.٢	٣٣.٥	٣٥.٥	٧٣.١	٦٠.٤	٦٠.٠	٦٤.٥
	150	١٠٨.٥	١٠٠.٦	٩٣.٠	١٠٠.٧	٢١٣.٩	١٩٤.١	١٧٤.٧	١٩٤.٢	٤٥.٧	٤٢.١	٣٩.٥	٤٢.٤	٨٩.٩	٨١.٣	٧٧.٠	٨٢.٧
Mean of A)		73.٩	٦٤.٤	٥٨.٢		13٤.٧	١١٧.٧	١٠٥.٧		30.6	26.3	24.4		55.3	48.4	44.5	
L.S.D. at (5%)		A (1.25)	B (2.89)		AxB (5.71)	A (2.07)	B (2.79)		AxB (٥.٤٦)	A (0.54)	B (1.25)		AxB (2.66)	A (1.52)	B (3.52)		AxB (7.00)
Second season																	
Control		138.3	104.0	64.9	102.4	155.4	135.4	99.3	130.4	55.3	42.1	25.9	41.1	59.4	54.1	39.9	51.1
Fe	50	154.7	121.2	92.1	122.7	165.9	158.2	110.1	144.7	62.1	48.5	36.7	49.1	63.6	66.3	44.2	58.0
	100	158.5	144.5	106.6	136.5	188.9	161.1	141.1	173.7	64.8	59.1	43.6	55.8	77.4	65.9	58.5	67.3
	150	180.1	155.7	136.9	157.6	207.9	186.5	150.7	181.5	75.5	65.3	57.4	66.0	87.1	76.8	64.5	76.1
Zn	50	165.9	129.6	105.2	133.6	178.5	160.3	134.6	157.8	66.3	51.9	42.2	53.5	71.2	64.2	53.6	63.0
	100	167.6	155.6	136.1	153.1	203.7	197.5	158.4	186.5	79.6	63.7	55.5	66.3	83.4	80.1	64.8	76.1
	150	205.1	177.7	154.5	179.1	228.3	200.9	172.8	200.6	86.0	74.5	64.6	75.0	95.8	88.5	72.2	85.5
Mn	50	167.5	146.1	116.6	143.4	203.4	180.7	147.3	177.1	66.9	58.4	46.5	57.3	81.4	75.5	59.3	72.1
	100	197.4	176.7	154.1	176.1	220.9	204.9	168.6	198.2	80.4	72.3	63.1	71.9	88.8	83.8	69.0	80.5
	150	217.1	204.0	167.0	196.1	248.0	220.9	194.9	221.3	91.0	85.3	69.9	82.1	100.7	96.6	81.7	92.9
Mix	50	190.7	161.6	139.5	163.9	216.9	190.6	165.3	190.9	76.2	64.8	55.6	65.5	86.9	77.6	66.1	76.9
	100	224.7	194.8	164.1	194.5	250.4	215.2	204.3	223.3	91.9	79.5	67.1	79.5	95.7	88.0	83.5	89.1
	150	258.5	232.8	210.4	233.9	296.2	257.0	227.5	260.2	108.4	97.7	88.2	98.1	124.2	107.8	95.6	109.2
Mean of (A)		186.6	161.9	134.5		212.7	176.4	159.6		77.3	66.4	55.1		85.8	78.9	65.6	
L.S.D. at (5%)		A (1.٨١)	B (٤.١٨)		AxB (8.34)	A (1.89)	B (4.37)		AxB (8.78)	A (1.11)	B (2.55)		AxB (5.22)	A (1.03)	B (2.38)		AxB (4.62)

Essential oil production

1. Effect of irrigation intervals:-

Essential oil percentage and content per plant of rosemary affected by different irrigation intervals was shown in Table (4). The results shown that the essential oil percentage and content per plant tended to increase by increasing irrigation intervals from 7 to 21 days. Furthermore, the highest value in this regard was (0.37, 0.34 and 0.39, 0.37 %) respectively, in the two cuts during the both seasons, obtained from irrigation interval every 21 days. Data indicated that the irrigation interval at 7 days recorded the lowest values of essential oil percentage was (0.31, 0.29 and 0.34, 0.30 %) respectively, in the two cuts during the both seasons. Khalid (2006) mentioned that the essential oil production was significantly affected by changes water stress, but increased the essential oil percentage and the main constituents of *Ocimum sp.* plant.

Therefore, the reduction in water supply usually inhibited the physiological activity that might result in less oil content. Water deficiency decreased the leaf size and gland counts but resulted in a slight increase in the gland density. The variance in essential oil content was due to different degrees of filling of oil glands. The highest values of essential oil content per plant obtained by using the irrigation every 7 days was (0.25, 0.41 and 0.64, 0.67 ml/ plant) followed by the moderate irrigation interval every 14 days (0.23, 0.38 and 0.60, 0.63 ml/ plant) and the lowest values every 21 days irrigation interval (0.22, 0.37 and 0.54, 0.60 ml/ plant) in the two cuts during the both seasons, respectively.

These results were in the same line by Hendawy and Khalid (2005) on *Salvia officinalis* plant, Leithy *et al*. (2006) on *Rosmarinus officinalis* plants, Aziz *et al.* (2008) on *Thymus vulgaris* plant, Said-Al Ahl *et al*. (2009) and Massoud *et al*. (2010) on *Origanum vulgare* L. plant and Ekren *et al*. (2012) on *Ocimum sp*. plant.

2. Effect of foliar fertilization:-

From data presented in Table (4) show that essential oil percentage and content per plant was increased gradually by using foliar application with the mixture of microelements followed by Mn, Zn and Fe treatments compared to control. The maximum oil percentage and content was (0.42, 0.40 and 0.44, 0.42 %) and (0.42, 0.77 and 1.04, 1.08 ml/ plant) respectively, in the two cuts during the both seasons obtained from plants sprayed with the microelements mixture at 150 ppm followed by the plants treated with microelements mixture (Fe, Zn and Mn) from 100ppm gave a significant increase in essential oil percentage (0.40, 0.37 and 0.42, 0.39%) and oil content per plant (0.35, 0.57 and 0.81,0.86 ml / plant) compared to the other treatments and the control plants.

Table (4): Effect of irrigation intervals and foliar spray of microelements on essential oil (%) and content (ml/ plant) of *Rosmarinus officinalis* L. plant in the two cuts during (2011/2012 and 2012/2013) seasons.

Foliar fertilization (ppm) (B)		Essential oil percentage (%)								Essential oil content (ml/ plant)							
		Irrigation intervals (A)															
		1st cut				2nd cut				1st cut				2nd cut			
		7 Day	14 day	21 day	Mean Of (B)	7 day	14 day	21 Day	Mean of (B)	7 Day	14 day	21 day	Mean of (B)	7 Day	14 day	21 day	Mean of (B)
First season																	
Control		0.20	0.23	0.26	0.23	0.18	0.21	0.24	0.21	0.07	0.07	0.06	0.07	0.14	0.13	0.12	0.13
Fe	50	0.24	0.27	0.29	0.27	0.22	0.25	0.27	0.24	0.11	0.11	0.10	0.11	0.20	0.19	0.17	0.19
	100	0.29	0.31	0.35	0.32	0.27	0.30	0.32	0.30	0.17	0.16	0.16	0.16	0.26	0.25	0.25	0.25
	150	0.31	0.35	0.39	0.35	0.29	0.32	0.36	0.33	0.22	0.21	0.20	0.21	0.36	0.35	0.34	0.35
Zn	50	0.27	0.29	0.31	0.29	0.25	0.28	0.29	0.27	0.15	0.14	0.12	0.14	0.27	0.26	0.24	0.26
	100	0.31	0.33	0.37	0.34	0.29	0.31	0.34	0.31	0.22	0.20	0.19	0.20	0.35	0.34	0.33	0.34
	150	0.33	0.37	0.41	0.37	0.31	0.34	0.38	0.34	0.30	0.29	0.29	0.29	0.42	0.42	0.41	0.42
Mn	50	0.29	0.33	0.35	0.32	0.27	0.30	0.32	0.30	0.17	0.17	0.16	0.17	0.35	0.32	0.31	0.33
	100	0.33	0.35	0.39	0.36	0.31	0.33	0.36	0.33	0.26	0.23	0.23	0.24	0.47	0.43	0.39	0.43
	150	0.37	0.39	0.42	0.39	0.33	0.38	0.39	0.37	0.38	0.35	0.33	0.35	0.55	0.54	0.52	0.54
Mix	50	0.33	0.37	0.39	0.36	0.31	0.34	0.37	0.34	0.28	0.27	0.27	0.27	0.51	0.45	0.44	0.47
	100	0.37	0.41	0.42	0.40	0.34	0.34	0.40	0.37	0.36	0.35	0.35	0.35	0.61	0.55	0.54	0.57
	150	0.40	0.42	0.45	0.42	0.37	0.40	0.43	0.40	0.43	0.42	0.42	0.42	0.79	0.78	0.75	0.77
Mean of A)		0.31	0.34	0.37		0.29	0.29	0.43		0.25	0.23	0.22		0.41	0.38	0.37	
L.S.D. at (5%)		A (0.003)	B (0.004)	AxB (0.009)		A (0.002)	B (0.005)	AxB (0.010)		A (0.051)	B (0.012)	AxB (0.02)		A (0.071)	B (0.016)	AxB (0.03)	
Second season																	
Control		0.23	0.26	0.28	0.26	0.21	0.24	0.27	0.24	0.32	٠.٢٨	0.18	٠.٢٦	0.33	0.32	0.27	0.31
Fe	50	0.27	0.29	0.31	0.29	0.23	0.27	0.29	0.26	٠.٤٢	٠.٣٥	0.29	٠.٣٥	0.45	0.36	0.32	0.38
	100	0.31	0.34	0.37	0.34	0.29	0.30	0.34	0.31	٠.٤٩	٠.٤٨	0.39	٠.٤٥	0.55	0.48	0.47	0.50
	150	0.34	0.37	0.41	0.37	0.31	0.32	0.39	0.34	٠.٦١	٠.٥٨	0.56	٠.٥٨	0.64	0.59	0.58	0.60
Zn	50	0.29	0.31	0.34	0.31	0.27	0.28	0.31	0.29	٠.٤٨	٠.٤٠	0.31	٠.٤٠	0.48	0.45	0.44	0.46
	100	0.33	0.36	0.39	0.36	0.30	0.32	0.36	0.33	٠.٥٥	٠.٥٤	0.53	٠.٥٤	0.61	0.63	0.57	0.60
	150	0.36	0.38	0.43	0.39	0.32	0.36	0.40	0.36	٠.٧٤	٠.٦٨	0.66	٠.٦٩	0.73	0.72	0.69	0.71
Mn	50	0.32	0.35	0.38	0.35	0.29	0.32	0.35	0.32	٠.٥٤	٠.٥١	0.44	٠.٥٠	0.59	0.57	0.52	0.56
	100	0.35	0.38	0.41	0.38	0.32	0.34	0.38	0.35	٠.٦٩	٠.٦٧	0.63	٠.٦٦	0.71	0.69	0.64	0.68
	150	0.40	0.42	0.44	0.42	0.35	0.39	0.41	0.38	٠.٨٧	٠.٨٥	0.74	٠.٨٢	0.87	0.86	0.80	0.84
Mix	50	0.35	0.39	0.41	0.38	0.32	0.36	0.39	0.36	٠.٦٧	٠.٦٣	0.57	٠.٦٢	0.69	0.68	0.64	0.67
	100	0.39	0.42	0.44	0.42	0.35	0.40	0.41	0.39	٠.٨٨	٠.٨٢	0.72	٠.٨١	0.88	0.86	0.84	0.86
	150	0.43	0.44	0.47	0.44	0.39	0.41	0.45	0.42	١.١١	١.٠٢	0.99	١.٠٤	1.16	1.05	1.02	1.08
Mean of A)		0.34	0.36	0.39		0.30	0.33	0.37		0.64	٠.٦٠	0.54		0.67	0.63	0.60	
L.S.D. at (5%)		A (0.003)	B (0.006)	AxB (0.011)		A (0.003)	B (0.007)	AxB (0.013)		A (0.073)	B (0.017)	AxB (0.03)		A (0.094)	B (0.011)	AxB (0.02)	

In the sometimes, the foliar spray with Mn treatment at 150 ppm produced higher essential oil content was (0.39, 0.37 and 0.42, 0.38%) and (0.35, 0.54 and 0.80, 0.84 ml/ plant) respectively, in the two cuts during the both seasons compared to the other foliar spray treatments and the control plants. The stimulatory effect of the treatments of foliar application of microelements on essential oil percentage may be due to the positive role of microelements on plant growth Similar findings were previously recorded by Ramadan (2001) on thyme, Refaat and Balbaa (2001) on lemongrass, Zehtab-Salmasi *et al*. (2008) on *Mentha peperita* plant and Said-Al Ahl and Abeer (2010) on *Ocimum basilicum* plants.

3. Effect of the interaction treatments:-

The data described in Table (4) reveal that, the interaction between irrigation intervals and all micro-spray as a mixture or individually gave an increase in essential oil production of rosemary plant in comparison with the treatment of unsprayed plants in the two cuts of the both seasons.

The effective treatment in this concern was the plants irrigated every 21 days and sprayed with the mixture of micro elements at 150 ppm which gave the maximum oil percentage was (0.45, 0.43 and 0.47, 0.45 %) respectively, in the both cuts of the two seasons.

Such data indicated that the irrigation intervals treatment (7 days) and spray microelement mixture at 150 ppm recorded the highest values of essential oil content (0.43, 0.79 and 1.11, 1.16 ml/ plant) respectively, followed by the plants irrigated every 21 days with microelements mixture (Fe, Zn and Mn ,at 100ppm) gave a significant increase in essential oil percentage (0.42, 0.40 and 0.44, 0.41%), while, plants irrigated every 7 days and sprayed microelements mixture at 100 ppm gave higher oil content (0.36, 0.61 and 0.88, 0.88 ml / plant) compared to the other treatments and the control plants, in the both cuts of the two seasons. In the same time, irrigation every 7 days with spray Mn at 150 ppm produced higher oil content (0.38, 0.55 and 0.85, 0.87 ml / plant), followed by plants sprayed with Zn (0.30, 0.42 and 0.74, 0.73 ml / plant) and with Fe (0.22, 0.36 and 0.61, 0.64 ml/ plant) but the lowest values in this respect (0.07,0.14 and 0.32, 0.33 ml / plant) were obtained from plants irrigated every 21days without microelements in the two cuts during both seasons.

Essential oil components of rosemary:-

GLC analysis of essential oil samples of the first cut at the second season for plants irrigated every 7, 14 and 21 days and receiving foliar spray treatments of individually microelements or their mixture at the rate of 150 ppm was illustrated in Table (5) and Fig. (1). Results identified 11 components divided into 5 oxygenated compounds (1.8-cineole, α-terpineole, borneole, bornyl-acetate and eugenole) and 6 hydrocarbon compounds (α and β-pinene, camphene, limonene, camphor and β-caryophyllene).

The identified compounds constituted 68.70 to 96.83 % of the essential oil of rosemary herb. Moreover, the highest components of rosemary oil were champhore, 1.8-cineole and α-pinene. In this concern the irrigation every 21 days gave the highest main components (23.86, 13.86 and 12.78 %) which calculated (50.50 %), followed by irrigation every 14 days gave main components (22.13, 11.88 and 12.71%) which calculated (46.72%), but the lowest value (40.63 %) from 7 days irrigation interval. The results obtained indicate that with the increase of irrigation periods of 7 to 21 days have increased the percentage of some oil components such as (α –pinene, 1.8-cineole, Camphor, α –Terpineole, Borneol, Bornyl-acetate, Eugenol and Caryophyllene), while led to a few percentage of some other oil components the second spray was after month than first spraying such as (β-pinene, Camphene, Limonene).These results were in the same line by Hassan et al. (2013) indicated that the volatile oil composition of rosemary was affected by irrigation levels.

Table (5): Essential oil components (%) as affected by irrigation intervals and the interaction treatments between irrigation every 21 days and foliar spray of microelements at 150 ppm of *Rosmarinus officinalis* L. plant in the 1st cut during the second season.

Components (%)	Irrigation intervals			Microelements spray at 150 ppm with irrigation every 21 days			
	7 Days	14 days	21 days	Fe	Zn	Mn	Mixture
α –pinene	11.19	12.71	12.78	13.53	18.07	20.14	20.84
β-pinene	7.30	3.39	3.59	2.91	4.49	3.54	7.82
Camphene	2.83	2.42	2.58	1.49	2.26	2.18	4.14
Limonene	6.02	3.79	3.25	3.24	4.35	3.48	5.77
1.8-cineole	12.36	11.88	13.40	13.23	14.20	19.95	14.54
Camphor	17.08	22.13	23.86	23.97	24.12	25.44	25.47
α –Terpineole	1.41	2.03	2.04	2.14	1.97	2.08	2.03
Borneol	1.01	1.96	2.00	2.07	0.85	2.02	----
Bornyl-acetate	6.71	7.67	8.34	15.01	13.10	5.81	7.83
Eugenol	2.25	6.43	5.74	6.99	5.79	6.53	7.37
β- Caryophyllene	0.54	3.13	4.23	5.32	1.64	4.23	1.02
Total components	68.70	79.56	81.81	89.90	90.84	94.11	96.83

In the same Table (5) the interaction between irrigation interval every 21 days and foliar spray with the microelement (Mn) at 150 ppm recorded the highest main components of champhore, 1.8-cineole and α-pinene (25.44, 19.95 and 20.14 %) which calculated (65.53 %), followed by microelements mixture at 150ppm was (25.47, 14.54 and 20.84 %) which calculated (60.85 %) of the main components, Then followed by foliar spraying using zinc in the 150 ppm as given (24.12, 14.20 and 18.07%), which is calculated (56.39%) of the main components compared to the control with irrigation every 21 days. Changes in the components by using various fertilization treatments may be due to its effect on metabolism and this is responsible for the installation of the components of the enzyme. Also, some differences may be due to the different climatic factors, and dealing with a group and ripening times. Said-Al Ahl and Abeer (2010) indicate that iron treatment gave the highest content of (methylchavicol, germacrene D, α-pinene and αthujene); zinc treatment gave the highest content of (1, 8-cineol, β-pinene, camphor, nerolidole and camphene) as well as iron + zinc treatment gave the highest content of (linalool, sabinene, nerol, eugenol, selinene and cadinole). Similar findings were previously recorded by Kandeel (2001) and Leithy *et al*. (2006) on *Rosmarinus officinalis* plants, Ramadan (2001) and Aziz *et al*. (2008) on thyme and Ibrahim (2010) on *Lemon verbena.*

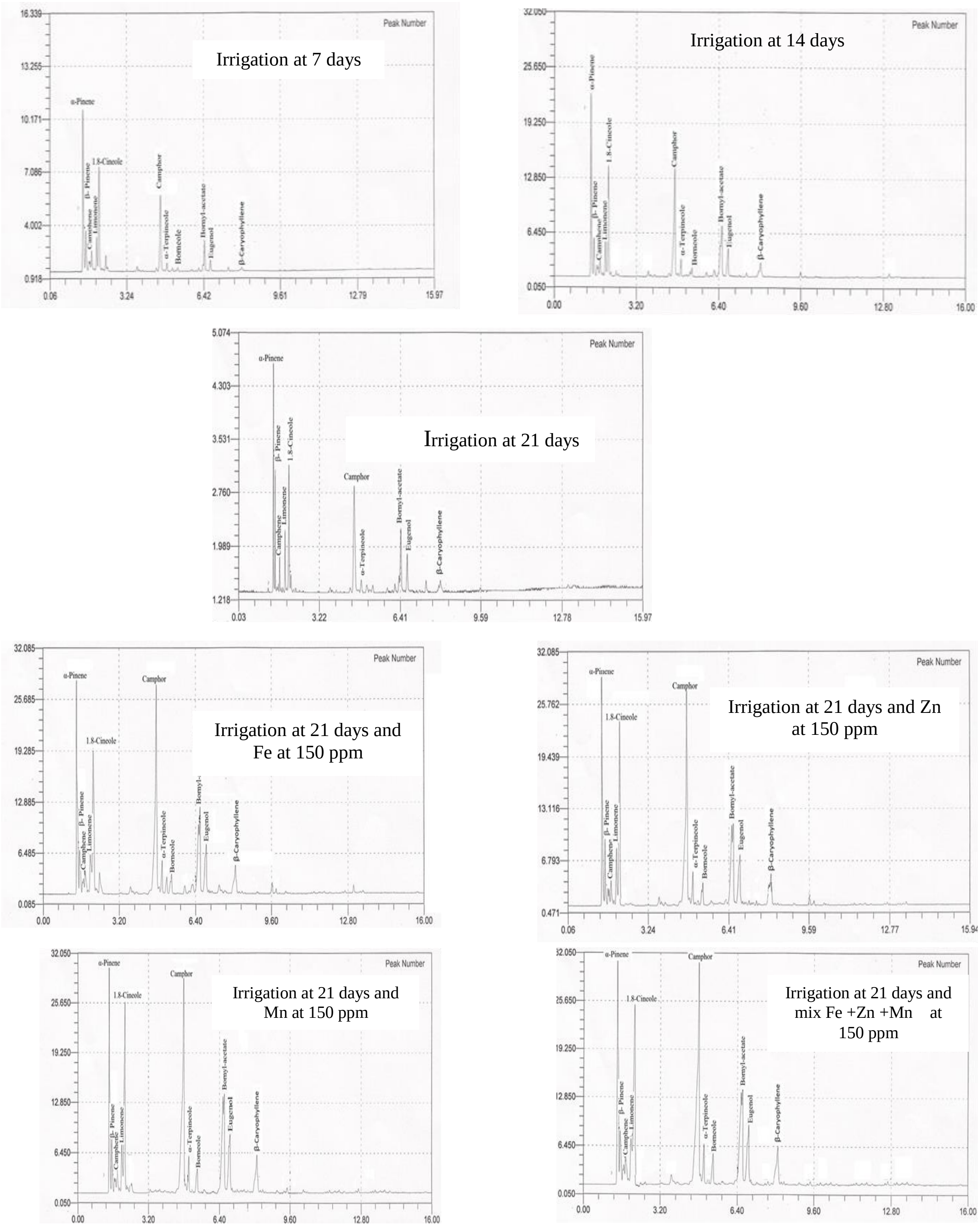

Fig (1): G.L.C. of Rosemary essential oil components (%) as affected by irrigation intervals and the interaction treatments between irrigation every 21 days and foliar spray of microelements at 150 ppm in the 1st cut during the second season.

It could be concluded that the highest productivity of herb, leaves and essential oil was obtained from the interaction between irrigation interval every 7 days and foliar spraying with a mixture of

(Fe+Zn+Mn) or individual of Fe, Zn and Mn at 150 ppm of each. While, the highest essential oil percentage was recorded irrigation interval every 21 days under the same foliar spray treatments of rosemary (*Rosmarinus officinalis* L.) plants.

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تأثير فترات الرى والرش بالعناصر الصغرى على النمو والمحصول وانتاج الزيت الطيار لنبات الحصالبان

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تم اجراء هذه التجربة خلال موسميين متتالية من (٢٠١٢/٢٠١١ و٢٠١٣/٢٠١٢) في محطة بحوث البساتين بالمنصورة محافظة الدقهلية، تهدف التجربة إلى دراسة تأثير ثلاث فترات ري ومستويات مختلفة من الرش الورقي للمغذيات الدقيقة من الحديد والزنك والمنجنيز في شكل فردى، وايضا بصورة خليط والتفاعل بينهما على النمو الخضري والمحصول وإنتاج الزيت ومكوناته لنبات حصالبان. وكانت النتائج المتحصل عليها كالآتى:- ادى الري كل ٧ أيام الى زيادة معنوية فى صفات النمو الخضري (طول النبات، وعدد الأفرع، الوزن الجاف للعشب والاوراق/ نبات) وايضا زيادة محصول الزيت الطيار/ نبات. بينما أدى الري كل ٢١ يوما إلى زيادة النسبة المئوية للزيت الطيار مقارنة مع فترات الري الأخرى. ادت معاملة الرش بالعناصر الصغرى (الحديد والزنك والمنجنيز) سواء خليط أوفردى بتركيز ١٥٠ جزء في المليون الى زيادة معنوية في قياسات صفات النمو الخضري وايضا إنتاج الزيت الطيار فى الحشة الاولى والثانية خلال كلا الموسميين مقارنتا بمعاملة الكنترول. بالاضافة الى ان القيم السابقة زادت باستخدام معاملة الرش بالعناصر الصغرى (الحديد والزنك والمنجنيز) سواء خليط أوفردى بتركيز ١٥٠ جزء في المليون مع معاملة الري كل ٧ أيام وكذلك أعلى نسبة مئوية من الزيت الطيار عند نفس معاملة التسميد مع الرى كل ٢١ يوما مقارنة مع المعاملات الأخرى ومعاملة الكنترول. أعطت معاملة الرى كل ٢١ يوم أعلى نسبة مئوية من المركبات الرئيسية (كامفور، ١.٨ سينول، الفا بينيين) باجمالى ٥٠.٠٤ % بينما أعطت معاملة التفاعل بين الرش بالعناصر الصغرى (المنجنيز) والري كل ٢١ يوم أعلى نسبة مئوية للمركبات الرئيسية وكانت ٦٥.٥٣ % يليها خليط العناصر بنسبة ٦٠.٨٥ % من الزيت الطيار لنبات حصالبان. يمكن التوصية بأن أفضل مقاييس النمو الخضري لنبات حصالبان عند معاملة التفاعل بين الري كل ٧ أيام والرش الورقى بخليط أو فردى من الحديد والزنك والمنجنيز بمعدل ١٥٠ جزء في المليون لكل منهما وايضا أعلى إنتاجية للزيت الطيار. ولكن كانت أعلى نسبة مئوية من الزيت الطيار عند الرى كل ٢١ يوما مع نفس معاملة الرش.