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EFFECT OF FOLIAR SPRAY WITH ZINC, BORON AND MOLYBDENUM ON THE GROWTH, YIELD, ESSENTIAL OIL PRODUCTIVITY AND CHEMICAL COMPOSITION OF ROSEMARY (*ROSMARINUS OFFICINALIS*, L.) PLANT.

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ABSTRACT

This experiment was carried out in Medicinal and Aromatic Plants Research Station at EL-Kanater EL-Khayria, Horticultural Research Institute, Agricultural Research Center, in two successive seasons; 1998 and 1999. The trace elements used in this experiment were Zn, B and Mo. Zn or B used at the rates of 0, 25, 50 or 100 ppm, while Mo at 0, 5, 10 or 20 ppm. The plants were treated with the microelements as foliar spray on April 22nd, July 7th and October 23rd. The obtained results can be summarized as follows: Spraying the plants with B at 100 ppm resulted in the greatest plant height and number of branches/plant as well as oil percentage in herb and leaves and N, K and B content in the herb. It increased herb and leaves fresh and dry weight/plant, oil yield of herb and leaves/plant as well as total carbohydrates, chlorophylls (a, b and total), carotenoids, P, Zn and Mo contents in the herb. Treating the plants with B at 50 ppm increased the vegetative growth, leaves and herb oil % and oil yield/plant, chlorophylls a, b and total, carotenoids, total carbohydrates content, N, Zn, B and Mo in the herb. Using B at 25 ppm led to an increase in the vegetative growth, oil% and yield in leaves and herb/plant, chlorophylls a, b and total, carotenoids, total carbohydrates content, Zn, B and Mo in the herb. However, it decreased P% in both seasons, compared to control plants.

Supplying the plants with Zn at 50 ppm resulted in the highest P% in the herb. It increased the vegetative growth as well as oil% and oil yield in herb and leaves/plant. It increased chlorophylls a, b and total, carotenoids, total carbohydrates content, N, P, Zn, B and Mo in the herb, compared to control plants. Application of Zn at 25 ppm resulted in an increase in plant height, oil% in the leaves, oil yield in leaves and herb/plant, total carbohydrates, chlorophylls a, b and total, K%, Zn, B and Mo content in the herb. However, it decreased herb and leaves fresh and dry weight/plant in comparison *with untreated plants. Application of Zn at 100 ppm led to an increment in number of branches/plant, total carbohydrates, chlorophylls (a, b and total), carotenoids, N, Zn and B contents. While, it decreased plant height, leaves and herb fresh and dry weight/plant, oil% in leaves, oil yield of leaves and herb/plant and P % compared to control plants. Application of Mo at 10 ppm led to the greatest fresh and dry weights of leaves and herb/plant as well as oil yield of herb and leaves/plant, also total carbohydrates content in the herb. It increased plant height, number of branches/plant, oil percentage in both herb and leaves, N, K, Zn, B and Mo in the herb, chlorophylls (a, b and total), carotenoids content. It decreased P content in the herb, compared to untreated plants.*

Spraying the plants with Mo at 5 ppm caused an increase in plant height, leaves and herb fresh and dry weights/plant, as well as oil% and yield of leaves and herb/plant, chlorophylls (a, b and total), carotenoids, Zn and B contents. However, P and K% in both seasons were decreased compared with control plants. Treating the plants with Mo at 20 ppm decreased all vegetative characteristics and the chemical determinations, except chlorophylls (a, b and total), carotenoids, Zn, B, and Mo contents which were increased compared to untreated plants.

Key words: Foliar spray, zinc, boron, molybdenum, growth, essential oil productivity, chemical composition, rosemary plant.

INTRODUCTION

Rosemary plant belongs to family *Lamiaceae* (Labiatae) used for oil production, analgesic, antimicrobial, antioxidant, antirheumatic, antiseptic, antispasmodic, aphrodisiac, astringent, carminative and cephalic (Lawless, 1992). One from problems that facing the cultivation of field or horticultural crops in Egypt is the deficiency of trace elements in the soil specially the new reclaimed soil. Thus the aim of this study was to investigate the effect of foliar spray with zinc, boron and molybdenum on the growth, yield, essential oil productivity and chemical composition of rosemary plant.

Foliar spray with zinc on some plants caused an increase in the growth, plant fresh and dry weights, this conclusion reported by Naguib *et al.* (1998) on number of branches of dill plant and Abd EL-Salam (1999) on plant height of *Foeniculum vulgare.* Using Zn as foliar spray lead to an increase in essential oil, oil yield, chlorophylls, carbohydrates and menerals content in some plants, these results were reported by Late and Sedowska (1996) on N, P, K contents in *Catharanthus roseus*, Soliman (1997) on total carbohydrates content in black cumin and Shoala (2000) on essential oil percentage in *Lavandula multifida* plant.

Boron had a clear effect on increasing growth and plant fresh and dry weights in some plants; this conclusion was stated by Duraisamy *et al.,* (1990) on plant height and herbage yield of *Mentha citrata* and Atteia (1995) on number of branches of *Pelargonium graveolens.* Spraying some plants with boron caused an increase in essential oil, oil yield, chlorophylls, carbohydrates, menerals content; these results were reported by EL-Sherbeiny and Abou Zied (1986) on volatile oil of fennel plant, Gupta and Shah (1989) on essential oil of *Ocimum basilicum,* and Aly *et al.* (1995) on total carbohydrates in fenugreek plant.

Spraying some plants by molybdenum increased growth and plant fresh and dry weights, this conclusion was reported by Atteia (1995) on number of branches of *Pelargonium graveolens* and Jethra and Kothari (1999) on fenugreek plant fresh and dry weight.

Molybdenum had a clear effect on increasing essential oil, oil yield, chlorophylls, carbohydrates and menerals content in some plants. These results were stated by Aly *et al.*(1994) on N, P, K, Zn, B and Mo contents in *Nigella sativa,* Atteia (1995) on total carbohydrates in *Pelargonium graveolens* and EL-Mansi *et al.*(2000) on chlorophyll a, b, total chlorophylls and carotenoids in pea plant.

MATERIALS AND METHODS

This experiment aimed to study the effect of foliar spray with zinc, boron and molybdenum on growth, yield, essential oil productivity and chemical composition of rosemary (*Rosmarinus officinalis,* L.) plant.

This research was carried out in two successive seasons of 1998 and 1999 in the Experimental Field of Medicinal and Aromatic Plants Research Section, Horticultural Research Institute, Agricultural Research Center, Ministry of Agriculture, El-Kanater El-Khayria, Egypt. Soil of the experiment is clay sand which contained 40.74% clay, 25.72% silt, 30.33% fine sand, 3.21% coarse sand, 7.20 pH value, 5.25 ppm Zn, 2.50 ppm B, 0.93 ppm Mo and available N, P, K were 22.4, 109 and 180 ppm, respectively. Rooted cuttings (15-20 cm long) of *Rosmarinus officinalis,* L. plants were used. The cuttings were planted on 28th January in the two seasons of 1998 and 1999.

The trace elements used were Zn, B or Mo at the rates of 0, 25, 50 or 100 ppm for Zn or B, while Mo used at the rate of 0, 5, 10 or 20 ppm. The sources used for Zn, B and Mo were Zinc sulphate, borax and sodium molybdate, respectively. The plants were treated with the microelements as foliar spray on April 22nd, July 7th and October 23rd. The all plants of the experiment were fertilized with nitrogen (N) at 150 kg, phosphorus (P_2O_5) at 50 kg and potassium (K_2O) at 30 kg/ fed. Nitrogen was added in the form of ammonium nitrate (33.5%N), while phosphorus was applied as calcium superphosphate (15.5% P_2O_5) and potassium as potassium sulphate (48% K_2O). The experimental area consisted of plots (2.0 X 2.5 m) having 6 rows with a distance of 30 cm between rows and 30 cm between the plants, each treatments contained 165 plants in three replicates (55 plants per replicate). The treatments were: 1- Control (tap water), 2- Zn (25 ppm), 3- Zn (50 ppm), 4- Zn (100 ppm), 5- B (25 ppm), 6- B (50 ppm), 7- B (100 ppm), 8- Mo (5 ppm), 9- Mo (10 ppm), 10- Mo (20 ppm). The layout of this experiment was a randomized complete blocks design including 10 treatments with 3 replicates. The plants were harvested twice/ season (first and second cuts) on August 5th and November 28th in both seasons by cutting the herb of the plants at 10 cm above the soil surface. The following parameters were recorded in the first and second cuts in both seasons:

1- Plant height (cm.).
2- Number of branches/plant.
3- Herb fresh weight (g/plant).
4- Herb dry weight (g/plant).
5- Leaves fresh weight (g/plant).
6- Leaves dry weight (g/plant).
7- Essential oil percentage in fresh herb.
8- Essential oil percentage in fresh leaves.
9- Essential oil yield of fresh herb/plant.
10- Essential oil yield of fresh leaves/plant. The essential oil percentage in the fresh herb and leaves was determined according to the British Pharmacopoeia (1963).
11- Chlorophylls and carotenoids were determined in fresh leaves according to Saric *et al.* (1967).
12- Total carbohydrates percentages were determined in the dry herb according to Herbert *et al.* (1971).
13- N, P contents. Total nitrogen contents in the dry herb were determined by modified micro-Kjeldahl methods according to the procedure described by Pregl (1945) and Piper (1947). Phosphorus content in dry herb was determined according to Troug and Meyer (1939). Also potassium, Zinc, Boron and Molybdenum contents were determined in the dry herb by using Atomic Absorption/Flame Spectrophotometer AA-646 according to Allen *et al.* (1997).

The all parameters recorded on the growth, yield and chemical composition were statistically analyzed by using the method described by Steel and Torre (1980).

RESULTS AND DISCUSSION

1. Plant height (cm.):

Data shown in Table 1 revealed that application of micronutrients affected significantly, plant height, in both seasons. In the first season, the height of the plants of the first cut ranged from 51.20 to 69.27 cm. The tallest plants (69.27 cm) were those received B at the rate of 100 ppm followed by the plants treated with Zn at the rate of 50 ppm and Mo at the rate of 5 ppm (67.63 and 66.47 cm, respectively). The shortest plants (51.20 cm) were those supplied with Mo at the rate of 20 ppm even less than control plants (60.27 cm). In the second cut, a similar trend was found as shown in first cut.

In the second season, the plants supplied with B at the rate of 100 ppm in the first cut, were the tallest ones (68.80 cm). They were followed by those sprayed with Mo at 5 ppm or Zn at 50 ppm (67.50 and 67.47 cm, respectively). While, the shortest plants (53.10 cm) were those received Mo at the rate of 20 ppm even less than control plants (60.80 cm).

In the second cut, spraying the plants with B at the rate of 100 ppm led to the tallest plants (66.57 cm). While, using Mo at the rate of 20 ppm caused the production of the shortest plants (51.60 cm), even shorter than the control plants (58.00 cm).

Table 1. Effect of some trace elements on plant height (cm) of *Rosmarinus officinalis,* L., at 1998 and 1999 seasons.

Trace elements concentrations (ppm)		1998		1999	
		1st Cut	2nd Cut	1st Cut	2nd Cut
Control.		60.27	59.77	60.80	58.00
	25	62.80	62.80	66.47	61.67
	50	67.63	68.73	67.47	64.90
Zn	**100**	55.80	58.60	59.30	59.37
	25	62.33	62.20	65.03	63.00
	50	60.77	62.57	65.27	63.67
B	**100**	69.27	69.47	68.80	66.57
	5	66.47	67.13	67.50	65.53
	10	63.07	65.20	64.50	65.27
Mo	**20**	51.20	49.23	53.10	51.60
L.S.D at 0.05		**5.28**	**5.53**	**5.61**	**4.70**

It is clear that all concentrations of Zn, all concentrations of B and all concentrations of Mo increased plant height except Zn at the rate of 100 ppm and Mo at the rate of 20 ppm as compared with the control plants in both seasons. These results are in harmony with those obtained by Abd El-Salam (1999) mentioned that Zn applied as foliar spray at 50 or 100 ppm increased the plant height of *Foeniculum vulgare* and El-Keltawy (1981) on *Mentha spicata*, demonstrated that 25 ppm boron significantly increased plant height.

2. Number of branches/plant:

The data in Table 2 show that spraying the plants with boron at 100 ppm resulted in the formation of the greatest number of branches/plant in both seasons. However supplying the plants with Mo at 20 ppm decreased the number of branches/plant than control plants, except in the second cut of first season.

Table 2. Effect of some trace elements on number of branches/plant of *Rosmarinus officinalis,* L., at 1998 and 1999 seasons.

Trace elements concentrations(ppm)		1998		1999	
		1st Cut	2nd Cut	1st Cut	2nd Cut
Control.		18.60	19.50	16.47	19.27
	25	19.47	20.57	19.07	20.83
	50	24.20	25.97	23.80	24.00
Zn	100	21.70	23.50	23.23	22.40
	25	24.00	24.10	22.00	24.23
	50	19.97	20.40	19.03	23.57
B	100	27.00	28.73	26.60	26.90
	5	18.50	20.10	17.97	20.40
	10	24.60	27.57	24.00	26.37
Mo	20	14.17	19.70	13.73	17.77
L.S.D at 0.05		5.78	4.31	6.28	4.76

In the first cut of the first season, the highest value (27.00 branches/ plant) resulted from spraying the plants with 100 ppm B. This was followed by the plants treated with Mo at 10 ppm, Zn at 50 ppm or B at 25 ppm (24.60, 24.20 and 24.00 branches/plant, respectively, without significant difference between them). The least number of branches was formed on the plants supplied with Mo at 20 ppm (14.17 branches/ plant). This was less than control plants (18.60 branches/ plant). In the second cut of the first season, a similar trend was found as in the first cut.

In the second season, the plants in the first cut had the greatest number of branches/plant (26.60) when they were sprayed with B at 100 ppm. They were followed by the plants treated with Mo at 10 ppm or Zn at 50 ppm (24.00 and 23.80 branches/ plant respectively, without significant difference between them). The plants formed the least number of branches (13.73) as a result of a foliar spray with Mo at 20 ppm, even less than control plants (16.47). In the second cut, similar trend was found as that of the first cut.

These results conceded with those obtained by Atteia (1995) on *Pelargonium graveolens* showed that B or Mo application increased number of branches/ plant. Naguib *et al.,* (1998) on dill plants showed that spraying Zinc at two doses (50 and 75 ppm) increased the number of branches per plant.

3. Herb fresh weight (g)/plant:

The data in Table 3 revealed that spraying the plants with Mo at 10 ppm had a favorable effect on herb fresh weight in both seasons. While, increasing its concentration to the highest level used (20 ppm) caused the production of the lightest fresh herb, even less than the control plants, in both seasons.

Table 3. Effect of some trace elements on herb fresh weight (g)/plant of *Rosmarinus officinalis,* L., at 1998 and 1999 seasons.

Trace elements concentrations (ppm)		1998		1999	
		1st Cut	2nd Cut	1st Cut	2nd Cut
Control.		185.03	166.13	187.93	175.77
	25	181.40	160.90	182.13	169.67
	50	228.23	210.80	232.07	219.03
Zn	100	168.70	152.00	168.17	159.83
	25	198.60	179.30	201.10	197.57
	50	189.20	176.30	192.80	195.00
B	100	234.23	221.07	233.00	229.57
	5	217.57	219.97	214.97	227.60
	10	284.90	270.20	285.53	281.33
Mo	20	164.70	142.83	164.27	154.33
L.S.D at 0.05		**22.73**	**28.78**	**30.81**	**35.80**

In the first season, the plants of the first cut had the maximum fresh weight (284.90 g) when they were sprayed with Mo at 10 ppm. The difference between this treatment and the control (185.03 g) was 99.87 g (53.98 %). They were followed by the plants treated with B at 100 ppm (234.23 g), and Zn at 50 ppm (228.23 g). Increasing the concentration of foliar spray of B from 25 to 100 ppm led to a significant increase in herb fresh weights.

Increasing the level of Zn from Zn at 25 ppm to Zn at 50 ppm increased significantly herb fresh weight from 181.40 to 228.23 (46.83 g i.e. 25.82 %). Raising its concentration to the highest level (100 ppm) led to a significant decrease in herb fresh weight.

Concerning to Mo spray, using 5 ppm led to a significant increase in herb fresh weight compared to the control. More increment in Mo concentration to 10 ppm caused the production of the heaviest fresh herb. The difference between this treatment and the control reached 99.87 g (53.98%). But, increasing Mo concentration to 20 ppm resulted in the minimum value of herb fresh weight (164.70 g). In the second cut of first season, a similar trend, as that of the first cut, was observed.

In the second season, spraying the plants with trace elements Zn, B or Mo caused an increase in herb fresh weight compared with control plants, except Zn at 25 and 100 ppm and Mo at 20 ppm, which decreased this parameter less than the control.

4. Herb dry weight (g)/plant:

Data shown in Table 4 revealed that herb dry weight (g) was affected by spraying the plants with trace elements. All elements used increased herb dry weight over control, except Zn at 100 ppm and Mo at 20 ppm as well as Zn at 25 ppm in the first cut in both seasons.

Table 4. Effect of some trace elements on herb dry weight (g)/ plant of *Rosmarinus officinalis,* L., at 1998 and 1999 seasons.

Trace elements concentrations(ppm)		1998		1999	
		1st Cut	2nd Cut	1st Cut	2nd Cut
Control.		117.60	107.80	119.53	113.67
	25	115.47	106.33	116.20	112.47
	50	134.10	139.10	135.97	144.57
Zn	**100**	103.43	85.70	101.03	92.60
	25	124.00	114.57	125.70	126.77
	50	120.20	111.13	122.23	122.43
B	**100**	140.50	145.90	139.80	151.50
	5	128.43	132.00	126.83	136.57
	10	176.73	183.77	177.00	191.30
Mo	**20**	97.10	85.13	99.37	89.30
L.S.D at 0.05		**21.64**	**32.51**	**35.55**	**39.50**

In the first season, the dry weight of the herb ranged from 97.10 to 176.73 g for the treatments of Mo at 20 ppm and Mo at 10 ppm, respectively, in the first cut. In this cut, a similar trend, same as herb fresh weight, was observed. Treating the plants with B at all concentrations, increased herb dry weight, compared to control plants.

In the second cut of this season, the least value of herb dry weight was 85.13 g for the plants sprayed with Mo at 20 ppm, even less than the control (107.80 g). The heaviest dry herb (183.77 g) was that received Mo at 10 ppm. The data of herb dry weight per plant in the second season followed the same trend of the first one.

Generally, it may be concluded from these results that to obtain the heaviest dry herb, the plants might be sprayed with Mo at 10 ppm.

5. Leaves fresh weight (g)/ plant:

Data in the Table 5 show that spraying the plants with Mo at 10 ppm led to the heaviest leaves fresh weight, in both seasons. This was followed by applying B at 100 ppm.

Table 5. Effect of some trace elements on leaves fresh weight (g)/ plant of *Rosmarinus officinalis,* L., at 1998 and 1999 seasons.

Trace elements concentrations (ppm)		1998		1999	
		1st Cut	2nd Cut	1st Cut	2nd Cut
Control.		130.80	125.73	134.33	137.00
	25	125.07	123.03	128.57	132.63
	50	168.63	138.33	171.90	181.60
Zn	**100**	119.50	117.13	123.57	122.80
	25	150.80	130.80	153.83	160.40
	50	146.43	128.43	149.43	158.23
B	**100**	171.20	173.80	174.30	196.03
	5	150.63	170.73	153.83	193.00
	10	191.97	220.30	196.67	249.47
Mo	**20**	129.13	92.37	132.90	122.20
L.S.D at 0.05		**33.64**	**36.86**	**29.77**	**36.33**

In the first season, the plants of the first cut had the heaviest fresh leaves (191.97 g) when they were treated with Mo at 10 ppm, compared to control plants (130.80 g). The difference between them (61.17 g) was significant (46.77%). However, the least value of leaves fresh weight (119.50 g) was recorded on the plants received Zn at 100 ppm, even less than the control.

In the second cut of the first season, the leaves fresh weight ranged from 92.37 to 220.30 g for the plants treated with Mo at 20 and 10 ppm respectively. Control plants had fresh leaves of 125.73 g.

Supplying the plants with B at 100 ppm caused the production of fresh leaves having 173.80 g while Zn at 50 ppm resulted in fresh leaves of 138.33g.

The data of leaves fresh weight per plant in the second season followed the same trend of the first one. Thus, it may be concluded that to obtain the heaviest fresh leaves/plant, the plants might be sprayed with Mo at 10 ppm.

6. Leaves dry weight (g)/ plant:

Data shown in Table 6 revealed that spraying rosemary plants with trace elements had significant effects on leaves dry weight/ plant in both seasons, depending on the element and its concentration.

Some of them such as boron at all concentrations used, Zn at 50 ppm and Mo at 10 ppm increased leaves dry weight, compared to control. Others like Zn at 100 ppm and Mo at 20 ppm caused a decrease in leaves dry weight compared with the control.

Table 6. Effect of some trace elements on leaves dry weight (g)/ plant of *Rosmarinus officinalis,* L., at 1998 and 1999 seasons.

Trace elements concentrations (ppm)		1998		1999	
		1st Cut	2nd Cut	1st Cut	2nd Cut
Control.		70.10	67.90	72.00	73.97
	25	67.40	70.17	69.27	75.60
	50	84.33	77.90	84.73	101.70
Zn	**100**	61.53	54.03	63.70	56.50
	25	79.20	68.00	80.73	83.43
	50	78.20	70.63	79.80	87.03
B	**100**	84.33	97.33	85.97	108.10
	5	73.80	85.40	75.40	98.03
	10	99.80	127.77	102.23	144.70
Mo	**20**	63.40	46.20	65.27	61.13
L.S.D at 0.05		**13.33**	**25.76**	**22.42**	**35.30**

In the first season, the plants sprayed with Mo at 10 ppm produced the heaviest dry leaves/plant, in both cuts. The values were 99.80 and 127.77 g/ plant for the first and second cuts, respectively. While, control plants had 70.10 and 67.90 g/plant in both cuts, respectively. However, the least dry weight of leaves was obtained from supplying the plants with Zn at 100 ppm in the first cut and Mo at 20 ppm in the second cut. The values were 61.53 and 46.20 g/ plant, respectively. In the second season, a similar trend was found, as in the first one.

Thus, from the above-mentioned results it may be concluded that supplying rosemary plants with Mo at 10 ppm was the most favorable treatment to increase both fresh and dry weights of leaves/plant.

These results of effect of trace elements on herb and leaves fresh and dry weights were in agreement with those obtained by Gupta and Shah (1989) treated *Ocimum basilicum* plants with B at 0.1, 0.2 or 0.3% or Mo at 0.3, 0.6 or 0.9%. They found that the highest fresh leaf yield was obtained with B at 0.2%. Duraisamy *et al.,* (1990) sprayed *Mentha citrata* plants with Zn, B and Mo. They found that application of Zn at 0.25% gave the greatest plant height and herbage yield. Whereas, plants receiving B at 0.20% or Mo at 0.10% resulted in 107.07 and 97.90 q/ ha, respectively compared with 87.23 q/ ha for the control. Cheng (1994) on strawberry and mulberry, showed a promotive effect of Mo on their growth. Jacoub (1995) on *Ocimum basilicum* plants found that the application of Zn at 50 and 100 ppm produced the highest fresh and dry weights of plants. Soliman (1997) on *Nigella sativa* plants claimed that spraying plants with zinc at 50 ppm gave the best dry weight of plants. Jethra and Kothari (1999) on fenugreek mentioned that Mo had a beneficial effect on its productivity.

7. Essential oil percentage in fresh herb:

Data in Table 7 show that, in the first cut of the first season, the oil percentages ranged from 0.13% for the plants treated with Mo at 20 ppm to 0.25% in the plants received B at 50 or 100 ppm or Mo at 10 ppm. Control plants and those sprayed with Zn at 25 ppm had 0.19 % oil in their herb.

Table 7. Effect of some trace elements on essential oil percentage in fresh herb of *Rosmarinus officinalis*, L., at 1998 and 1999 seasons.

Trace elements concentrations(ppm)		1998		1999	
		1st Cut	2nd Cut	1st Cut	2nd Cut
Control.		0.19	0.18	0.16	0.16
Zn	25	0.19	0.20	0.24	0.19
	50	0.22	0.20	0.16	0.20
	100	0.15	0.20	0.16	0.18
B	25	0.24	0.22	0.20	0.19
	50	0.25	0.25	0.26	0.20
	100	0.25	0.26	0.26	0.26
Mo	5	0.21	0.22	0.20	0.18
	10	0.25	0.24	0.24	0.22
	20	0.13	0.16	0.14	0.12
L.S.D at 0.05		0.08	0.03	0.08	0.05

In the second cut of the same season, the highest oil percentages (0.26 and 0.25 %) were determined in the herb of the plants sprayed with B at 100 or 50 ppm. While, the plants treated with Mo at 20 ppm contained the least oil percentage (0.16 %).

In the second season, the herb of the plants of the first cut had the highest oil percentage (0.26 %) when they were supplied with B at 50 or 100 ppm. They were followed by the plants received Zn at 25 ppm or Mo at 10 ppm (0.24 %). Treating the plants with Mo at 20 ppm resulted in the lowest oil percentage (0.14 %), even less than the control plants (0.16 %).

In the second cut of the second season, spraying the plants with B at 100 ppm caused the formation of the highest oil content (0.26 %). Also, Mo at 10 ppm led to a high oil percentage in the herb (0.22 %). The least oil percentage (0.12 %) was detected in the herb of the plants treated with Mo at 20 ppm, even less than the control plants (0.16%).

Generally, it can be noticed that in both seasons, spraying the plants with B at 100 ppm or Mo at 10 ppm enhanced the synthesis of essential oil in the herb of rosemary.

8. Essential oil percentage in fresh leaves:

Data shown in Table 8 revealed that, in the first season, the plants of the first cut had the highest oil percentage (0.33 %) when they were sprayed with B at 25 or 100 ppm. The use of Mo at 5 or 10 ppm caused the synthesis of high percentage of essential oil compared to control (0.29, 0.30 and 0.24% respectively). But increasing its level to 20 ppm decreased oil percentage to its minimum (0.23%) even less than the control (0.24%).

Table 8. Effect of some trace elements on essential oil % in fresh leaves of *Rosmarinus officinalis,* L., at 1998 and 1999 seasons.

Trace elements concentrations (ppm)		1998		1999	
		1st Cut	2nd Cut	1st Cut	2nd Cut
Control.		0.24	0.24	0.23	0.24
	25	0.28	0.26	0.27	0.26
	50	0.26	0.31	0.25	0.30
Zn	**100**	0.24	0.24	0.22	0.23
	25	0.33	0.28	0.30	0.26
	50	0.28	0.33	0.27	0.30
B	**100**	0.33	0.33	0.32	0.32
	5	0.29	0.26	0.28	0.24
	10	0.30	0.33	0.29	0.32
Mo	**20**	0.23	0.20	0.22	0.19
L.S.D at 0.05		**0.04**	**0.03**	**0.05**	**0.06**

In the second cut of this season, the leaves of rosemary plant had the highest oil percentage (0.33 %) when they received B at 50 and 100 ppm or Mo at 10 ppm. Zn at 50 ppm also increased essential oil percentage in the leaves to reach 0.31 %, while control plants contained 0.24 % oil. The use of Mo at 20 ppm was determined as it decreased oil content to the least value (0.20%) even lower than in control plants. In the second season, a similar trend found as in the first one.

Generally, the use of B at 100 or 50 ppm and Mo at 10 ppm had a beneficial effect on essential oil synthesis and accumulation in the leaves of rosemary plants.

9. Essential oil yield of fresh herb (ml/ plant):

The data exhibited in Table (9) revealed that in the first season, the plants of the first cut produced the highest oil yield/plant (0.712 ml) when they were treated with Mo at 10 ppm. The difference between this treatment and the control (0.352 ml/ plant) was significant. Also, B at all concentrations used, Zn at 50 ppm and Mo at 5 ppm resulted in significant increases compared to control. However, Zn at 25 and 100 ppm, as well as, Mo at 20 ppm decreased significantly herb oil yield/ plant when compared with the control.

The least herb oil yield/ plant (0.214 ml) was obtained from the plants sprayed with Mo at 20 ppm, even less than the control (0.352 ml/ plant). In the second cut of the first season, a similar trend was observed as the same in the first cut. In the second season a similar trend was observed as the same in the first season.

Table 9. Effect of some trace elements on fresh herb essential oil yield (ml)/ plant of *Rosmarinus officinalis,* L., at 1998 and 1999 seasons.

Trace elements Concentrations (ppm)		1998		1999	
		1st Cut	2nd Cut	1st Cut	2nd Cut
Control.		0.352	0.299	0.301	0.281
	25	0.345	0.322	0.437	0.322
	50	0.502	0.422	0.371	0.438
Zn	**100**	0.253	0.304	0.269	0.288
	25	0.477	0.394	0.402	0.375
	50	0.473	0.441	0.501	0.390
B	**100**	0.586	0.575	0.606	0.597
	5	0.457	0.484	0.430	0.410
	10	0.712	0.648	0.685	0.619
Mo	**20**	0.214	0.229	0.230	0.185
L.S.D at 0.05		**0.001**	**0.002**	**0.001**	**0.002**

10. Essential oil yield of fresh leaves (ml/ plant)

The data in Table 10 show that spraying the plants of rosemary by trace elements affected significantly the oil yield of leaves.

In the first season, the plants of the first cut produced the highest oil yield (0.576 ml/ plant) with Mo at 10 ppm. But, spraying them with 20 ppm Mo led to the least oil yield (0.297 ml/ plant) even less than the control plants (0.314 ml/ plant). Applying B at 100 ppm, Zn at 50 ppm or Mo at 5 ppm increased significantly leaves oil yield/ plant compared with control. The values were 0.565, 0.438 and 0.437 ml/ plant, respectively. In the second cut of this season, almost similar trend was observed.

In the second season, the highest leaves essential oil yield/ plant was obtained, in the first cut, from the plants received Mo at 10 ppm (0.570 ml) followed by B at 100 ppm (0.558 ml). Whereas, those treated with Mo at 20 ppm or Zn at 100 ppm produced the least oil yield (0.292 and 0.272 ml/ plant, respectively), even less than the control (0.309 ml/ plant). Meanwhile, B at 25 ppm, Mo at 5 ppm and Zn at 50 ppm resulted in significant increases in oil yield / plant compared with control plants. The values recorded were 0.461, 0.431, 0.430 and 0.309 ml/ plant, respectively. In the second cut, same as in the first one. From these results, it may be concluded that Mo at 10 ppm was the best treatment for producing the greatest essential oil yield of the leaves of rosemary plants. This was followed by B at 100 ppm. But, increasing Mo concentration to 20 ppm had an injurious effect on the production of leaves oil.

Table 10. Effect of some trace elements on fresh leaves essential oil yield (ml)/ plant of *Rosmarinus officinalis,* L., at 1998 and 1999 seasons.

Trace elements concentrations (ppm)		1998		1999	
		1st Cut	2nd Cut	1st Cut	2nd Cut
Control.		0.314	0.302	0.309	0.329
	25	0.350	0.320	0.347	0.345
	50	0.438	0.429	0.430	0.545
Zn	**100**	0.287	0.281	0.272	0.282
	25	0.498	0.366	0.461	0.417
	50	0.410	0.424	0.403	0.476
B	**100**	0.565	0.574	0.558	0.627
	5	0.437	0.444	0.431	0.463
	10	0.576	0.727	0.570	0.798
Mo	**20**	0.297	0.185	0.292	0.232
L.S.D at 0.05		**0.002**	**0.002**	**0.004**	**0.001**

These results of effect of trace elements on essential oil percentage and oil yield agreed with those obtained by Chaudhury *et al.,* (1986) on *Ocimum gratissimum*, showed that the maximum essential oil content (0.46%) was obtained with Zn application at 50 ppm. El-Sherbeiny and Abou Zied (1986) found that the volatile oil of fennel was increased by micronutrient foliar fertilizers containing Cu, Zn, B and Mn. Gupta and Shah (1989) on *Ocimum basilicum*, mentioned that the highest content of essential oil (0.612 – 0.615) was obtained with B at 0.20%. Hussein *et al.,* (1990) found that Mo at 0.5% increased oil content of basil plant. Jacoub (1995) on sweet basil mentioned that the application of zinc at the rate of 50 and 100 ppm gave the highest oil content. Shoala (2000) indicated that spraying the plants of *Lavandula multifida* with Zn at 25 or 100 ppm resulted in an increment in oil percentage in leaves.

11. Photosynthetic pigments:

As shown in Table 11 photosynthetic pigments content was affected by microelements treatments. Chlorophyll a content was highest, in the first season, (0.98 mg/ g) as a result of spraying the plants with Zn at 100 ppm. This was followed by Zn at 50 and 25 ppm (0.91 and 0.87 mg/ g, respectively). Also, using Mo at 10 ppm caused an increment in chlorophyll a content than the control plants which contained the least amount (0.70 and

0.41 mg/ g, respectively). All concentrations of B increased chlorophyll a content as compared with the control. In the second season, a similar trend was observed.

Concerning to chlorophyll b content, the data in Table (11) revealed that in the first season the plants treated with Zn at 100 ppm had the highest amount (0.75 mg/ g). This was followed by the plants sprayed with Zn at 50 or 25 ppm and B at 100 ppm (0.61, 0.51 and 0.51 mg/ g, respectively). Control plants had the least chlorophyll b content (0.31 mg/ g).

In the second season, it can be observed that using Zn at all concentrations increased chlorophyll b content compared with the control. The values were 0.70, 0.67 and 0.64 mg/ g for Zn at 100, 50 and 25 ppm, while control plants had the least amount (0.23 mg/ g). Also, Mo at 5 ppm led to an increment of chlorophyll b content (0.61 mg/ g) compared with control. Regarding total chlorophylls (a + b) content, the same trend of both chlorophylls a and b was observed.

Concerning to carotenoids content, in both seasons Zn at 100 and 50 ppm resulted in the highest content. This was followed by B at 50 ppm whereas the control plants had the least values in the two seasons.

Table 11. Effect of some trace elements on photosynthetic pigments (mg/g) in fresh leaves of *Rosmarinus officinalis,* L., in the first cut at 1998 and 1999 seasons.

Trace elements concentrations (ppm)		Chl. a		Chl. b		Chls. a+b		Carotenoids	
		1998	1999	1998	1999	1998	1999	1998	1999
Control.		0.41	0.51	0.31	0.23	0.72	0.74	0.31	0.29
	25	0.87	0.97	0.51	0.64	1.38	1.61	0.33	0.32
	50	0.91	0.98	0.61	0.67	1.52	1.65	0.47	0.50
Zn	**100**	0.98	1.05	0.75	0.70	1.73	1.75	0.48	0.61
	25	0.67	0.71	0.43	0.51	1.10	1.22	0.38	0.30
	50	0.64	0.67	0.38	0.39	1.02	1.06	0.41	0.45
B	**100**	0.60	0.73	0.51	0.50	1.11	1.23	0.38	0.39
	5	0.52	0.80	0.43	0.61	0.95	1.41	0.33	0.39
	10	0.70	0.97	0.48	0.39	1.18	1.36	0.36	0.34
Mo	**20**	0.63	0.53	0.40	0.30	1.03	0.83	0.33	0.39
L.S.D at 0.05		**0.11**	**0.21**	**0.17**	**0.23**	**0.30**	**0.21**	**0.11**	**0.14**

The results obtained from the present study were in agreement with those obtained by El-Ghadban (1994) on *Mentha viridis* concluded that chlorophylls a, b, (a+b) and carotenoids contents were increased by Zn at 50 or 100 ppm. Atteia (1995) on *Pelargonium graveolens*, showed that B application increased chlorophyll a, b, total chlorophylls and carotenoids contents in the leaves. El-Mansi *et al.* (2000) mentioned that the concentrations of chlorophyll (a), (b) and total chlorophylls as well as carotenoids were highest in leaves of pea plants sprayed with Mo (40 ppm).

12. Total carbohydrates percentage:

Data in Table 12 show that treating the plants in both seasons with Mo at 10 ppm increased total carbohydrates content to its maximum, but increasing Mo concentration to 20 ppm decreased total carbohydrates percentage to its minimum value.

In the first season, when the plants were supplied with Mo at 10 ppm they had the highest total carbohydrates percentage in both cuts (51.23 and 48.94 %, respectively). Doubling the concentration of Mo to 20 ppm led to the least amount of total carbohydrates in the herb of rosemary plants in both cuts (28.51 and 29.18 %, respectively) even less than the control (33.80 and 34.18 %) in the first and second cuts, respectively.

Concerning to Zn application, it may be noticed that spraying the plants with 25 ppm increased total carbohydrates content in both cuts (39.40 and 43.35 %, respectively) compared with the control. Supplying the plants with Zn at 50 ppm caused the synthesis of more carbohydrates than using Zn at 25 ppm. The values were 44.43 and 48.36 % in both cuts, respectively.

Table 12. Effect of some trace elements on total carbohydrates percentage in herb of *Rosmarinus officinalis,* L., at 1998 and 1999 seasons.

Trace elements Concentrations (ppm)		1998		1999	
		1st Cut	2nd Cut	1st Cut	2nd Cut
Control.		33.80	34.18	36.40	33.36
	25	39.40	43.35	49.12	44.30
	50	44.43	48.36	50.10	47.50
Zn	**100**	42.13	40.32	45.10	45.20
	25	37.54	39.14	40.06	41.13
	50	35.15	37.26	38.28	39.20
B	**100**	42.46	40.32	45.17	46.26
	5	40.10	41.06	38.46	32.50
	10	51.23	48.94	51.28	49.86
Mo	**20**	28.51	29.18	33.41	28.29
L.S.D at 0.05		**14.70**	**11.06**	**11.90**	**13.15**

However, more increase in Zn concentration to 100 ppm decreased total carbohydrates content to 42.13 and 40.32 % in the two cuts, respectively.

Concerning to the effect of B, it can be observed that the highest concentration (100 ppm) led to higher carbohydrates percentage than the low and medium concentrations. The values were 42.46, 37.54 and 35.15 %, respectively for the first cut and 40.32, 39.14 and 37.26 % for the second one.

In the second season, it was observed that the total carbohydrates content had a similar trend to the first one.

These results were in line with those obtained by Aly *et al.,* (1995) on fenugreek (*Trigonella foenum-graecum*), reported that foliar application of boron increased total carbohydrates, Atteia (1995) on *Pelargonium graveolens*, found that application of Mo increased soluble, non-soluble and total carbohydrates content in the leaves and stems of the plants, and Soliman (1997) showed that the total carbohydrates content in herb of black cumin plants was increased by application of zinc at the concentration of 50 ppm.

13. Nitrogen percentage:

The data in Table 13 show that in the first season, the plants of the first cut had the greatest percentage of N (3.91 %) in their herb when they were supplied with boron at 100 ppm. This was followed by the plants sprayed with Zn at 50 ppm. The percentage of N was 3.50 %. The least content of N (1.30 %) was determined in the herb of the plants received Mo at 20 ppm, even less than the control plants (2.10%). It can also observe from these results that the moderate concentration of both Zn and Mo was more efficient in increasing N content than the low and high concentrations. In the second cut of the first season, a similar trend was observed. In the second season, the plants of the first cut contained the highest percentage of N (3.95 %) as a result of spraying them with B at 100 ppm. While, using the highest concentration of Mo led to the least N percentage (1.30 %), even less than the control. Also, increasing Zn concentration in the foliar spray from 25 to 50 ppm led to an increase in N percentage in the herb, but more increase of its concentration caused a decrease in N percentage. The values were 2.36, 3.23 and 2.67 %, respectively. In the second cut of this season, a similar trend was observed.

14. Phosphorus percentage:

Data in Table 14 show that in the first and second seasons, the plants of both cuts had the greatest P percentage when they were sprayed with Zn at 50 ppm. The values were 0.95 and 0.85% for the first and second cuts, respectively in the first season and 0.72 and 0.75% in the second season respectively. However, the least P percentage was determined in the herb of the plants received the highest dose of Mo (20 ppm). The values in the first season were 0.23 and 0.31%, 0.25 and 0.22% in the second season, respectively, even less than the control (0.36 and 0.46%) in the first season and 0.35 and 0.36% in the second season, respectively. Supplying the plants with B resulted in a steady increase in P percentage as B level increased, in both cuts of the two seasons.

Table 13. Effect of some trace elements on nitrogen percentage in herb of *Rosmarinus officinalis,* L., at 1998 and 1999 seasons.

Trace elements concentrations (ppm)		1998		1999	
		1st Cut	2nd Cut	1st Cut	2nd Cut
Control.		2.10	2.31	1.86	2.44
	25	1.40	2.46	2.36	2.66
	50	3.50	3.47	3.23	3.81
Zn	**100**	2.17	3.15	2.67	2.82
	25	2.10	2.14	2.56	2.74
	50	3.15	2.83	2.91	2.90
B	**100**	3.91	4.26	3.95	4.15
	5	1.41	1.96	2.41	2.10
	10	3.21	2.43	2.56	2.58
Mo	**20**	1.30	0.98	1.30	1.94
L.S.D at 0.05		**1.14**	**1.30**	**1.47**	**1.25**

Table 14. Effect of some trace elements on phosphorus percentage in herb of *Rosmarinus officinalis,* L., at 1998 and 1999 seasons.

Trace elements concentrations (ppm)		1998		1999	
		1st Cut	2nd Cut	1st Cut	2nd Cut
Control.		0.36	0.46	0.35	0.36
	25	0.32	0.43	0.31	0.38
	50	0.95	0.85	0.72	0.75
Zn	**100**	0.32	0.35	0.23	0.37
	25	0.25	0.31	0.32	0.31
	50	0.38	0.41	0.36	0.37
B	**100**	0.42	0.49	0.38	0.39
	5	0.32	0.37	0.31	0.29
	10	0.39	0.45	0.32	0.33
Mo	**20**	0.23	0.31	0.25	0.22
L.S.D at 0.05		**0.24**	**0.31**	**0.20**	**0.29**

15. Potassium percentage:

Data in Table 15 show that the highest K percentage was detected in the herb of the plants treated with B at 100 ppm, in both seasons.

In the first season, the plants in the first cut contained 4.15 % as a result of spraying with B at 100 ppm they were followed by those supplied with Zn at 25 ppm (3.81% K). The least K percentage was found in the plants received Mo at 5 ppm (1.78 %), even less than the control (2.23 %).

In the second cut, the same trend was observed. Also, increasing Zn concentration in the foliar spray led to a continuous decrease in K percentage, in both cuts. In the second season, in both cuts, the use of B at 100 ppm resulted in the highest K percentage in the herb. The values were 3.83 and 3.16 %, respectively.

Table 15. Effect of some trace elements on potassium percentage in herb of *Rosmarinus officinalis,* L., at 1998 and 1999 seasons.

Trace elements concentrations (ppm)		1998		1999	
		1st Cut	2nd Cut	1st Cut	2nd Cut
Control.		2.23	2.53	2.18	2.73
	25	3.81	3.25	3.18	3.00
	50	3.51	2.48	2.34	2.38
Zn	**100**	2.41	2.11	2.19	2.21
	25	2.48	2.51	2.13	2.57
	50	2.81	2.95	2.41	1.96
B	**100**	4.15	3.99	3.83	3.16
	5	1.78	2.10	1.81	1.74
	10	3.15	3.17	2.83	2.71
Mo	**20**	2.81	2.36	2.38	2.25
L.S.D at 0.05		**0.90**	**0.66**	**0.95**	**0.89**

They were followed by the treatment Zn at 25 ppm which resulted in 3.18 and 3.00 % K, respectively. The least K percentage was found in the herb of the plants treated with Mo at 5 ppm. However, increasing Mo level to 10 ppm increased K percentage in the herb. But, more increase of Mo concentration decreased K percentage, in both cuts.

16. Zinc content (ppm) in the herb:

The data on Zn content in the herb of rosemary are shown in Table 16. They revealed that when the plants were sprayed with Zn, at all concentrations used, the herb contained more Zn compared to untreated ones.

It may be remarked that the content of Zn in the herb was greater in the second season than in the first one.

In both seasons, the highest amount of Zn was determined in the plants supplied with Zn at 100 ppm (18.08 and 18.15 ppm, respectively). The least content of Zn was found in control plants (4.08 and 4.26 ppm, respectively). Moreover, the increase in B level resulted in a steady increment in Zn content to reach its maximum 12.35 ppm in the first season and l3.48 ppm in the second one. However, increasing Mo concentration in the solution sprayed on the plants caused a continuous decrease in Zn content, in both seasons.

17. Boron content (ppm) in the herb:

In Table 16 the determined quantities of B in the herb are shown. It may be noticed that in both seasons, the increment in B in the foliar spray caused a steady increase in B content in the herb of rosemary plants. The greatest amount was 31.05 ppm in the first season and 32.23 ppm in the second one.

Table 16. Effect of some trace elements on zinc, boron and molybdenum (ppm) in herb of *Rosmarinus officinalis,* L., at 1998 and 1999 seasons.

Trace elements concentrations(ppm)		Zinc		Boron		Molybdenum	
		1998	1999	1998	1999	1998	1999
Control.		4.08	4.26	9.00	9.13	1.01	1.70
	25	8.12	8.38	12.08	13.70	3.23	3.36
	50	12.43	12.88	18.50	20.00	2.35	2.45
Zn	**100**	18.08	18.15	16.30	18.60	1.27	1.45
	25	9.45	9.75	19.05	20.40	1.51	1.99
	50	11.28	12.65	21.53	23.75	2.67	2.86
B	**100**	12.35	13.48	31.05	32.23	3.08	3.24
	5	11.83	12.05	12.70	13.73	1.57	1.68
	10	10.28	11.55	14.38	15.10	2.70	3.13
Mo	**20**	7.90	8.73	20.20	21.45	3.38	3.96
L.S.D at 0.05		**6.77**	**8.10**	**10.22**	**9.17**	**1.14**	**0.97**

The same effect was observed with Mo, i.e. increasing Mo concentration increased B content. The values were 12.70, 14.38 and 20.20 ppm for Mo at 5, 10 and 20 ppm, respectively in the first season. In the second one the values recorded were 13.73, 15.10 and 21.45 ppm, respectively. Spraying the plants with Zn increased B content in the herb, compared with the control. The values of B increased, in both seasons, when Zn was increased to Zn at 50 ppm but more increase in Zn concentration decreased the amount of B in the herb of rosemary plants.

18. Molybdenum content (ppm) in the herb:

The data in Table 16 revealed that treating the plants of rosemary with trace elements increased its content in the herb more than the control. The amount of Mo determined in the second season was more than that in the first one. Increasing Zn concentration in the foliar spray resulted in a steady decrease in Mo content in the herb. The values were 3.23, 2.35 and 1.27 ppm for Zn at 25, 50 and 100 ppm, respectively, in the first season. While, in the second one, the values were 3.36, 2.45 and 1.45, respectively. On the other hand, the increment in B concentration in the solution sprayed on the plants caused a continuous increase in Mo content in the herb. The determined amounts were 1.51, 2.67 and 3.08 ppm for B at 25, 50 and 100 ppm, respectively, in the first season. The values detected in the second one were 1.99, 2.86 and 3.24 ppm, respectively.

The increase in Mo concentration in the foliar spray led to a steady increment in Mo content in the herb, to reach its maximum with Mo at 20 ppm (3.38 and 3.96 ppm in the first and second seasons, respectively).

These results of effect of trace elements on N, P, K, Zn, B and Mo contents were in harmony with those obtained by Prasad and Dey (1979) treated tea plants with B. They noticed that B uptake increased with increasing B application rates, Bishr and Makarim (1984) on Ammi plants, found that zinc application increased N, P, K and Zn content in fruits and herb, Aly *et al.,* (1994) on *Nigella sativa* observed that using Mo as foliar spray increased N, P, K, Zn, B and Mo content in the herb and capsules, Jacoub (1995) reported that spraying *Ocimum basilicum* with Zn at 50 and 100 ppm increased the nitrogen and potassium contents, Late and Sedowska (1996) on *Catharanthus roseus*, stated that spraying the plants with ZnSO4 (0.2%) gave the highest minerals content (N, P and K) in leaves and Chiwan *et al.* (1996) on geranium, showed that applying elevated levels of B and Mo caused an increment in macro- and micro-elements content of the plant.

Conclusively, the results of this investigation may lead to the following conclusions: To obtain the greatest yield of herb and leaves fresh and dry weights/ plant, as well as the heightest essential oil %, oil yield, total carbohydrates, chlorophylls, caroteniodes, N, K, B and Mo contents, the plants might be sprayed with either B at 100 ppm or Mo at 10 ppm.

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تأثير الرش الورقي بالزنك والبورون والموليبدنيوم على النمو والمحصول وإنتاجية الزيت الطيار والتركيب الكيماوي في نبات الحصا لبان

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هذه التجربة نفذت في مزرعة قسم بحوث النباتات الطبية والعطرية بالقناطر الخيرية، معهد بحوث البساتين- مركز البحوث الزراعية، في عامين متتالين ١٩٩٨-١٩٩٩. تم رش نباتات التجربة بالعناصر الصغرى (زنك، بورون، موليبدنيوم) بتركيزات صفر، ٢٥، ٥٠، ١٠٠ جزء في المليون بالنسبة للزنك والبورون وصفر، ٥، ١٠، ٢٠ جزء في المليون بالنسبة للموليبدنيوم وتم الرش في ٢٢ أبريل، ٧ يوليو، ٢٣ أكتوبر في كلا الموسمين وكانت أهم النتائج التي تم التوصل اليها كالآتي:-

استخدام البورون بتركيز ١٠٠ جزء في المليون أدى إلى الحصول على أكبر ارتفاع للنبات وأكبر عدد للأفرع/نبات وأعلى نسبة مئوية للزيت الطيار في العشب والأوراق وأعلى

استعمال الزنك رشاً بتركيز ٢٥ جزء في المليون أدى الى زيادة في ارتفاع النبات ونسبة الزيت الطيار في الأوراق ومحصول الزيت من العشب أو الأوراق/نبات، كما أنها أدت الى زيادة محتوى النبات من الكربوهيدرات الكلية والكلوروفيلات أ، ب والكلية (أ+ب) والنسبة المئوية للبوتاسيوم والمحتوى من الزنك والبورون والمولبدنيوم في العشب الا أنها أدت الى نقص الوزن الطازج والجاف في الأوراق أو العشب/نبات.

استخدام الزنك بتركيز ١٠٠ جزء في المليون أدى الى زيادة عدد الأفرع/نبات والكربوهيدرات الكلية ومحتوى النبات من الكلوروفيلات (أ، ب والكلية (أ+ب)) والكاروتينات والنيتروجين والزنك والبورون، بينما أدت هذه المعاملة الى نقص في ارتفاع النبات والوزن الطازج والجاف للأوراق أو العشب/نبات والنسبة المئوية للزيت الطيار في الأوراق ومحصول الزيت في الأوراق أو العشب/نبات والنسبة المئوية للفوسفور مقارنة بالكنترول. استخدام المولبدنيوم بتركيز ١٠ جزء في المليون أدى الى الحصول على أكبر وزن طازج و جاف للأوراق أو العشب/نبات وأكبر محصول للزيت الطيار في العشب أو الأوراق/نبات وكذلك أكبر محتوى للكربوهيدرات الكلية في العشب، كما أدت هذه المعاملة الى زيادة في ارتفاع النبات وعدد الأفرع لكل نبات والنسبة المئوية للزيت الطيار في العشب أو الأوراق والمحتوى من النيتروجين والبوتاسيوم والزنك والبورون والمولبدنيوم في العشب والمحتوى من الكلوروفيلات أ، ب والكلية (أ+ب) والكاروتينات الا أنها أدت الى نقص في المحتوى من الفوسفور في العشب. استخدام المولبدنيوم بتركيز ٥ جزء في المليون أدى الى زيادة في ارتفاع النبات والوزن الطازج والجاف للأوراق أو العشب/نبات والنسبة المئوية للزيت الطيار ومحصوله في الأوراق أو العشب/نبات والمحتوى من الكلوروفيلات أ، ب والكلية (أ+ب) والكاروتينات والزنك والبورون الا أنها أدت الى النقص في النسبة المئوية للفوسفور والبوتاسيوم في كلا الموسمين.

معاملة النباتات بالمولبدنيوم بتركيز ٢٠ جزء في المليون أدت الى نقص في كل الصفات الخضرية التي درست وكذلك في التقديرات الكيماوية و لكنها أدت الى زيادة في محتوى النبات من الكلوروفيلات (أ، ب والكلية (أ+ب)) والكاروتينات والزنك والبورون والمولبدنيوم.