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GROWTH, YIELD AND CHEMICAL COMPOSITION OF *ROSEMARINUS OFFICINALIS L.* PLANT AS AFFECTED WITH SULPHUR, NITROGEN AND PHOSPHORUS FERTILIZATION UNDER SALINE WATER IRRIGATION

Eman E.Aziz and A.A. Youssef
Cultivation and Production of Medicinal and Aromatic Plant Department National Research Centre Dokki Cairo Egypt

ABSTRACT

The objective of this study was to evaluate the effect of using sulphur, nitrogen and phosphorus fertilization on plant growth and chemical composition of *Rosmarinus officinalis L.* grown under saline irrigation water. Obtained results showed that rosemary have been affected significantly with all fertilizer treatments. This reflected on increasing plant growth, nutrient contents as well as increasing total carbohydrates, total soluble sugars, reducing sugars and sucrose. The essential oil percent was particularly high with different fertilizer treatment as compared with control (saline water at 4000 ppm. NaCl only). The application of sulphur, nitrogen and phosphorus fertilization showed a marked quantitative difference in chemical composition of oil and the principal component 1,8-cineole reached the greatest amount (60.15%) with applying the medium rate (N2) of nitrogen; followed by champhor (30.56%) resulted from adding the low level (P1)of phosphorus, then β-pinene (15.32, 15.31 and 12.29%) and limonene (16.78, 17.87 and 15.91%) recorded the greatest increase with application of sulpher at medium rate (S2) and high rate of nitrogen and phosphorus (N3 and P3) fertilizers respectively.

INTRODUCTION

Rosemary, *Rosmarinus officinalis L*. is an evergreen, perennial shrub native to chalky, calcareous hills along the Mediterranean Sea. Reaching a height of up 1.8 meters, the plant is characterized by linear, narrow leaves. Leading areas of rosemary production are the Mediterranean countries, the United States and England (Rol and Jacamon, 1968). Oil glands are found in the leaves and flowers; however, the most important rosemary oil is obtained from leaves only by stem distillation (Flamini et al, 1992). The major components in rosemary oil were 1,8-cineole (23.5%), camphor (17.7%), α-pinene (12.8%), limonene (9.5%), α-terpineol (7.8%) followed by camphene (3.7%), β-pinene (3.5%), β-caryophyllen (2.8%), terpinen 4-ol (2.5%), caryophyllen oxide (2.0%), linalool (1.1%) and bornyl acetate (1.1%) (Arnold et al, 1997). Alexandre et. al, 2000, reported that the major constituents of *Rosmarinus officinalis* oil from Brazil were camphor (26%), 1,8-cineole (22.1%), myrcene (12.4%) and α-pinene (11.5%), followed by β-pinene (5%), camphene (4.3%), limonene (2.9%) and linalool (1.1%).

The oil is used in certain medicinal proportional as an ingredient in rubefacient lineaments (Guenther, 1949). Rosemary extract is known for its anti-oxidative and anti-microbial activity (Collens and Charles, 1987). Also rosemary has been used as an external stimulant and as relaxant for nevousnear, muscle spasms and headaches, and it is thought to act as stimulant to the kidneys. Rosemary has been used as an expectorant and as a folk remedy against asthma, eczema, rheumatism and wounds. It has been used in the treatment of cancer and is categorized today as a therapeutic emmenagogue. The plant is used as an insect repellent (Simon et al 1984).

In Egypt increasing aromatic plant production is dependent upon irrigated agricultural because the rainfall is insufficient to grow crops. Unfortunately the quantity of good quality of water supplies available to agriculture, is limited. It has to be use saline water for irrigation. Salinity is an environmental problem usually associated with decreases in crop growth and yield through restriction of the water uptake by plant roots, ion toxicity and ionic imbalance (Bernstein et al. 1969). Salinity generally inhibits the growth of plants, through reduced water absorption, reduced metabolic activities due to Na^+ and Cl^- toxicity and nutrient deficiency caused by ionic interference (Yeo 1983). Salinity and soil nutrient deficiencies are the main factors which reduce plant production in the arid and semi-arid areas around the world (Mc William 1986) and (Shannon et al 1994). For this reason, improving soil, water and crop management is vital to obtain sustainable production under such conditions.

With the goals outlined in our previous paper on rosemary, we have begun to evaluate of using sulphur, nitrogen and phosphorus on plant growth and chemical composition of rosemary grown under irrigation with saline water.

MATERIALS AND METHODS

The present investigation was carried out during two successive seasons of 1999-2000 and 2000-2001 under green house conditions at National Research Centre, Dokki, Cairo, Egypt.

The lay out of the experiment was in complete randomized design of three replicates. On the 15^{ed} August for each season, vegetative uniformal cuttings (15-20 cm. Length) were taken from *Rosmarinus officinalis* plants grown at the experimental farm of cultivation and production of Medicinal and Aromatic plants Department Giza. These cuttings were planted in clay pots (30 cm.in diameter) filled with 12-kg soil. The physical and chemical characteristics of the used soil were determined according to Black et al 1965 and presented in Table (A)

The pots were kept outdoor under natural environmental conditions and all pots were irrigated with tap water for three month, during which, the success of roots formation on the cuttings occurred, then the irrigation with saline water started using sodium chloride salt (Na Cl) at rate of 4000 ppm.

Fertilizers used in these experiments were as follows.

1-Control treatment, plants were irrigated with saline water only (4000 ppm. Na Cl).

2-All treated plants irrigated with saline water at 4000 ppm Na Cl and combined with fertilizer treatments as follow.

2.1- Sulphur fertilizer was added to the soil, after rooting of the cuttings at three different concentrations as follows 23.7, 47.4 and 71.1 kg S/fed. in the form of magnesium sulphate(26.6% S) i.e. (S1) 1.5, (S2) 3 and (S3) 4.5 gm/pot.

2.2- Nitrogen fertilizer as calcium nitrate (15.5%N) were added at the rate of 36.8, 55.2 and 73.6 kg N/fed. i.e. (N1)4.16, (N2) 6.33 and (N3) 8.43 gm/pot.

2.3- Three levels of phosphorus fertilizer were added, 22.8, 45.6 and 68.4 kg P_2O_5/fed. i.e. (P1)2.4, (P2)4.8 and (P3) 7.2 g/pot calcium super phosphate (16 % P_2O_5) after rooting of the cuttings.

Table (A): Some physicochemical properties of the soil.

<table>
<tr><th rowspan="2">Seasons</th><th colspan="10">Physical properties</th></tr>
<tr><th colspan="2">Soil texture</th><th colspan="2">Sand %</th><th>Silt %</th><th>Clay %</th><th colspan="2">pH</th><th colspan="2">E.C. mmoh/c</th></tr>
<tr><td>1st season</td><td colspan="2">Sand loamy</td><td colspan="2">38.8</td><td>43.3</td><td>18.0</td><td colspan="2">8.19</td><td colspan="2">0.84</td></tr>
<tr><td>2nd season</td><td colspan="2">Sand loamy</td><td colspan="2">46.8</td><td>33.2</td><td>20.0</td><td colspan="2">8.42</td><td colspan="2">0.76</td></tr>
<tr><th rowspan="2">Seasons</th><th colspan="10">Chemical properties</th></tr>
<tr><th colspan="4">Soluble cations meq/100 g soil</th><th colspan="3">Soluble anions meq/100 g soil</th><th colspan="2">Available P (ppm)</th><th>Ttotal N %</th></tr>
<tr><td rowspan="2">1st season</td><td>Na^+</td><td>K^+</td><td>Ca^{++}</td><td>Mg^{++}</td><td>HCO_3</td><td>Cl</td><td>SO_4</td><td colspan="2"></td><td></td></tr>
<tr><td>3.2</td><td>1.78</td><td>2.00</td><td>1.45</td><td>2.96</td><td>3.35</td><td>2.45</td><td colspan="2">8.40</td><td>0.07</td></tr>
<tr><td>2nd season</td><td>2.8</td><td>1.86</td><td>1.88</td><td>1.14</td><td>1.99</td><td>3.77</td><td>1.59</td><td colspan="2">7.77</td><td>0.09</td></tr>
</table>

The plants were harvested two times in April and August during the two successive seasons. At each harvest plant height, number of branches per plant, fresh and dry weight of herb per plant were recorded.

Total carbohydrate percent and total soluble sugars in the dried material were determined according to Dubois et al., (1956). Reducing sugars were determined according to Nelson's calorimetric method (1944), and sucrose was calculated according to the following equation mentioned by Singh et al., (1972) as follows

Sucrose = (total soluble sugars – total reducing sugars) x 0.95

Total nitrogen, Potassium and phosphorus were determined (on a dry matter basis) according to (Jackson, 1985). Sulphur was determined according to Dewis and Freitas (1970). Fe and Zn content in plant were determined using acid digestion technique (Jackson, 1985) and measured in an atomic absorption spectrophotometer.

Data were statistically analyzed according to Sndecor and Cochran ,(1967).

Samples from the fresh herbage of each treatment at each cutting in both seasons were separately subjected to hydro-distillation in order to determine the percentage of essential oil (V/W) according to the Egyptian Pharmacopoeia (1984). The resultant essential oil from each treatment was dehydrated over anhydrous sodium sulfate.

GC-MS analysis of volatile oil of each treatment was performed separately with a Hewlett-Packard model 5890. A fused silica capillary column carbowax 20 M measuring 25 m x 0.32 mm internal diameter, film thickness of 0.17 μm. The temperature program adopted was maintained at

75 ^{0}C for 5 min with an increase of 4 ^{0}C /min until 220 ^{0}C (10 min); mass spectra were recorded at 70 eV. The carrier gas was helium and the working flow rate was 1.0 mL/min, detector was 9144 HP. Compounds were identified by matching of their mass spectra with those recorded in the MS Library and further confirmed by comparison of the mass spectra with those of reference compounds or with published data. The identification of these compounds was achieved by matching their retention times with those of authentic samples injected under the same conditions.

RESULTS AND DISCUSSION

Data in table (1) represented the effect of adding different levels of sulphur, nitrogen and phosphorus on rosemary grown under saline condition. The result showed that all fertilizer treatments significantly increased plant height, number of branches, fresh and dry weight of herb compared with control (plants irrigated with saline water at 4000 ppm NaCl only), however the response of the plants to fertilizers under saline condition is dependent on the type of the added fertilizer, according to its basic chemical properties.

Sulphur fertilization as magnesium sulphate was the most effective for increasing plant height, number of branches, fresh and dry weight of herb compared with other treatments and control, and the extent of enhancement was dependent on the applied level of Mg SO_4. The addition of sulphur at the highest level recorded the greatest increase; i.e. 65%, 54%, 77% and 82% for plant height, number of branches, fresh and dry weight of herb, respectively in the first cut at the first season over the control, i.e. it had favorable effect on the whole parameters of the vegetative growth, and this hold for both cuts in the two investigated seasons. In this respect, Stuiver et. al, 1981 suggested a direct involvement of S in salt transport and salt tolerance. Supporting this view is the sulpholipid content of plant roots and their positively correlated to salt tolerance. Hilal and Korkor 1990 discussed the potential role of sulphur application to soil and proper irrigation scheduling as promising means of salinity control. In a calcareous soil at south Sinai that is irrigated with saline water 4500 ppm. Sulphur at the rate of 100 kg /fed. has succeeded to reduce soil salinity in root zone and prevent salt accumulation around plant roots and sustained the yield of both cucumber and onion under all management condition. Salem et. al, 1990, showed that elemental sulphur had a significant increase on stem diameter, leaf area and fresh and dry weight of wheat plant grown under irrigation with saline water. These results are in agreement with that obtained by Aziz (1999) showed that all phosphorus and sulphur treatments on *Sinapis alba* grown in calcareous soil (30.7 CaCO3) increased plant height, number of branches, fresh and dry weight of leaves, stem and root as well as number of pods, pod yield and seed yield. Moreover sulphur at high level applied alone or mixed with phosphorus at either low or high level were the most effective treatments. This effect might be due to a decrease in soil pH and consequently an increase of the availability of mineral nutrients.

Table1

Concerning, the effect of nitrogen, it was found that plant height, number of branches as well as fresh and dry weight of herb increased significantly with increasing levels of calcium nitrate from 4.16 to 6.33 or 8.43 g /pot. in the first and second cut during the two seasons. This effect might be due to calcium nitrate, and this was fairly effective in improving plant growth because its calcium content which is strongly competitive with sodium ion present in saline soils, and also its chemical effect slightly decreased EC. value, when it combined with saline water.

In this respect, as salt concentration is increased, these effects disappeared, and the osmotic effects of excess salts in solution inhibit microbial activity (Johnson and Guenzi 1963). Weasterman and Tucker 1979, found that dilute salt concentrations and added nitrogen enhance mineralization of soil nitrogen. This is hypothesized to be either through increase solubility of organic and hence easier mineralization of soil and / or nitrogen through the stimulatory effect of added nitrogen on microbial decomposition of soil organic matter. Steppuhn *et. al,* 1994 found that, increasing N rate (0, 56, 112 and 168 kg N/ha) progressively increased the production of kochia forage. Balak *et. al,* (1999) stated that plant height, plant spread and number of branches, dry weight of shoots and yield of flowering heads of *Chammomilla recutita* decreased with increasing sodicity but increased with increasing fertility. Katiyar *et. al,* (1999) conducted that vegetative growth of plants grown under intercropping system with poplar on sodic soils were promoted by increasing N rates and the highest yield was obtained at the rates of 90 kg N and 60 kg P /ha. Desai et. al, (2000), revealed that the maximum growth, dry matter and green yield of Coriander was obtained from the residual effect of 120 kg N/ha.

In case of phosphorus treatments; significant increases in plant height number of branches, fresh and dry weight of herb as compared with untreated plants were obtained. Phosphorus fertilization has the effect of reducing soil salinity, as insoluble Ca and Mg phosphates will be formed, resulting in removing these ions from soil solution, which decrease the total dissolved salts, causing reduction of the EC. These results agreed with that reported by Singh *et. al*, (1990) they found that, application of phosphorus at the rate of 12.9-kg P/ ha gave the largest yield of grain and straw of wheat plant grown on saline soil. Hussein and El-Ziny 1990 stated that P application increased growth, seed weight /plant and 100 seed weight of *Lupinus termis L.* plants grown under salinity conditions. Mor and Manchanda (1992), demonstrated that, there were significant interaction in the effect of P and salinity on seed yields of peas, in more saline soil, all levels of phosphorus (20, 40 and 80 mg P_2O_5/ kg soil) increase yield. Pal and Singh (1993), reported that increasing the level of P (50-150 kg P_2O_5 /ha) at higher salinity level resulted in higher dry matter production of *Trifolium alexandrinum.* Zaiter and Saade (1993) stated that increasing P improved the tolerance of *Phasolus vulgaris* to salinity significantly increased shoot and root growth and reducing foliar injuries. Malik *et .al,* (1999) found that, increasing P rate from 0 to 30, 60 and 90 mg/ kg^{-1}soil increased growth at all salinity levels (4, 8 or 12 dsm^{-1}) of sunflowers. Increasing P rates up to 60 kg P_2O_5/ fed. significantly increased the yield of fenugreek (Sheoran *et. al*, 1999). The plants grown at high NaCl produced less dry matter and chlorophyll than those at normal nutrient solution for three cultivars of *Lycopersicon esculentum*. Supplementary P and K as a foliar spray can significantly improve the parameters affected by salinity e. g. plant growth, water use, and membrane permeability (Cengiz *et.al*, 2001).

The nutrient contents of the plant is one of the most important productivity parameters for evaluation the treatments under investigation. Data presented in table (2) clearly revealed that, the percentages of N, P, K and S were affected favorably with different fertilizers treatment as compared with untreated plants, this effect varied in accordance to the type and rate of the fertilizers. The concentration of N, P, K and S recorded remarkable increase with sulpher fertilizer treatment compared with other treatments and control. Fe and Zn content in plant were also affected by different fertilizer treatments and the highest contents were obtained from application of $MgSO_4$ at higher level (S3). The physiological role of sulphur may be shown, that it is a component of proteins, which is the main product of nitrogen metabolism, thus, the ability of plants to utilize nitrogen depend on their sulphur supply of special interest to desert agriculture ; depending on the role of sulphur in N_2 fixation and the S requirements of N_2-Fixing systems. Helal and Schnug (1995) reported that the application of S might improve nutrient utilization of Fe, Zn, Mn and Cu as well as P and N on calcareous soil. On the other hand Hu and Schmidhalter (2001) suggested that the micronutrient concentration in the plants were probably not much affected by salinity. They added that the change in the micronutrients concentration in the plant under saline conditions depended upon the levels of macronutrients and salinity and the organs of plant. Steppuhn *et.al,* (1994), found that, increasing N rate from 0 to 56, 112 and 168 kg N/ ha enhanced the N concentration of Kochia forage plant by increasing both protein and NO_3N. The total accumulation of N in the biomass increased linearly with fertilizer N dosage, moreover, application of phosphorus at the rate of 0, 12.9, 25.8 kg P/ ha. considerably improved P concentration and uptake by wheat plant, the effect being more pronounced at high soil salinity (singh *et. al*, 1990). Gunes *et. al*, (1999) found that phosphorus concentration in the leaf of *Capsicum annum L*. tended to increase with increasing P rate (200-500 mg/ kg), and to a greater extent under saline conditions. Concentrations of P and K were at deficient ranges in the *Lycopersicon esculentum* plants grown at high NaCl levels and these deficiencies were corrected by supplementary K and P application via leaves (Cengiz *et. al*, 2001).

Data in table (3) revealed that, total carbohydrate, total soluble sugars, reducing sugar and sucrose percentages in Rosemary plant were increased significantly with increasing sulphur, nitrogen and phosphorus fertilization treatment and the greatest increases were recorded with applying the highest dose of sulphur (S3) as compared with control (plant irrigated with saline water at 4000 ppm. NaCl only) which gave the lowest values. These results were in agreement with those of Hussein *et. al,* (1990) on geranium. They obtained that reduction in soluble, non soluble and total carbohydrate contents as salinity levels were increased. Aziz (1992) showed that total carbohydrates, soluble sugars and sucrose content in calyces and

Table2

table3

epicalyces of roselle plant gradually decreased with increasing salinity level from 4000 to 6000 ppm. NaCl. Also, Fiad (1999) revealed that using soil salinity treatments at all levels decreased total carbohydrate percentage of *Nigella sativa* leaves compared to control. While the rate of 3000 or 5000 ppm gave the minimum values of total carbohydrate percentage.

Data in Table (3) indicated that oil percentage of *Rosmarinus officinalis* grown under irrigation with saline water was greatly influenced by application of sulphur, nitrogen and phosphorus fertilization. The highest values of essential oil percentage (0.19, 0.21 and 0.22 % in the first cut during the two seasons, were recorded from applying the highest level of sulphur (S3), nitrogen (N3) and phosphorus (P3) fertilization treatment, respectively compared with untreated plants, which gave the lowest value (0.12 %). In this respect, Fiad (1997) on *Nigella sativa* showed that soil salinity treatments decreased seeds oil percentage and yield compared to controls. Nikolova *et. al,* (1999) reported that nitrogen and potassium increased the yields, while phosphorus increased the essential oil content of *Chamomilla recutita*. and added that sulphur and phosphorus increased inflorescence weight and essential oil content.

Data in table (4) showed that adding different levels of sulphur, nitrogen and phosphorus on rosemary grown under saline conditions gave marked quantitative differences among the oils. Generally, the application of sulphur, nitrogen and phosphorus showed increase the amount of monoterpene hydrocarbon coincided with low amount of sesquiterpen hydrocarbons, as well as a generally low concentration of mono and sesquiterpen alcohol's and the greatest values of β-pinene, limonene and terpinolene were obtained with applying medium rate of sulphur (S2) and high rate of nitrogen(N3) and phosphorus (P3). This effect was compound with decreasing the relative content of α-pinene. Moreover, the highest oxides content i.e. 1-8-cineole (44.99 and 60.15 %) was occurred with application of N1 and N2. Oxygenated sesquiterpens increased with adding sulphur at high rate (S3). The application of sulphur increased the phenols compound, while nitrogen and phosphorus decreased its concentration. The addition of sulphur, nitrogen and phosphorus increased the concentration of ketones, and the greatest increase of camphor resulted from adding P1, while the monoterpene esters were decreased as compared with control. In this respect, Youssef and Radi (2000) showed that 1,8-cineole and camphor, which were found as major compounds in intact plants and callus tissue grown in salt-free medium was decreased when grown under saline condition.

It has been demonstrated that *Rosemarinus officinalis* plants grown under irrigation with saline water and fertilized with sulphur, nitrogen and phosphorus gave the principal component of 1,8- cineole (60.15 %), followed by camphor (30.56%), limonene (17.47 %), β-pinene (15.32%), α-pinene (12.94 %), and linalool (11.44%) compared with control.

Table(4): Effect of Sulphur, Nitrogen and Phosphorus fertilization on essential oil composition of *Rosmarinus officinalis L.* plant grown under saline water irrigation.

Components	Cont.	S1	S2	S3	N1	N2	N3	P1	P2	P3
α-Pinene	8.22	0.67	0.40	7.94	12.94	0.14	0.20	0.03	0.05	0.15
Camphene	0.01	0.29	0.04	0.01	0.15	0.07	0.00	0.14	0.31	0.06
β-Pinene	3.96	3.92	15.32	4.00	2.16	9.63	15.31	2.95	2.31	12.29
Myrcene	0.60	1.11	2.78	1.17	15.54	0.86	3.05	1.05	0.52	2.08
Limonene	8.27	9.08	16.78	9.73	12.04	15.89	17.47	9.22	6.07	15.91
β-Ocimene	1.58	0.01	2.19	3.51	0.26	0.14	3.62	0.01	0.03	0.02
P-Cymene	1.74	8.29	0.04	4.30	0.00	0.04	3.31	0.01	0.02	0.03
Terpinolene	1.59	4.65	2.12	6.38	0.28	3.04	2.91	8.08	10.03	15.99
Monoterpene Hydrocarbons	**25.97**	**28.02**	**39.67**	**37.04**	**43.37**	**29.81**	**45.87**	**21.49**	**19.34**	**46.53**
β-Caryophyllene	9.90	10.01	0.14	0.10	2.12	0.28	2.23	8.95	9.30	4.92
α-humulene	0.01	0.29	0.01	0.27	0.04	0.01	0.00	0.01	0.28	0.01
Sesquiterpene Hydrocarbons	**9.91**	**10.30**	**0.15**	**0.37**	**2.16**	**0.29**	**2.23**	**8.96**	**9.58**	**4.93**
1,8-cineol	24.94	15.96	24.68	25.50	44.95	60.15	24.66	29.53	21.78	28.86
Oxides	**24.94**	**15.96**	**24.68**	**25.50**	**44.95**	**60.15**	**24.66**	**29.53**	**21.78**	**28.86**
Linalool	4.19	11.44	5.11	8.59	0.68	0.54	5.99	0.00	0.00	0.01
Terpinen-4-ol	1.69	2.18	0.77	0.07	0.34	0.02	0.13	1.30	1.75	0.32
Borneol	8.14	2.82	0.94	1.03	0.79	0.56	0.79	1.30	3.89	4.28
α-Terpineol	0.04	0.14	0.84	0.04	0.25	0.02	0.62	0.96	1.10	0.02
Myrtenol	0.04	0.82	0.04	0.08	0.01	0.09	0.00	1.06	1.26	0.01
α-bisabolol	0.17	0.33	0.34	0.01	0.04	0.06	1.97	0.23	3.32	0.05
Mono-and Sesquiterpene alcohols	**14.27**	**17.73**	**8.04**	**9.82**	**2.11**	**1.29**	**9.5**	**4.85**	**11.32**	**4.69**
Caryophyllene oxide	0.03	0.22	0.02	1.30	0.01	0.02	0.00	0.17	0.06	0.02
Oxygenated Sesquiterpenes	**0.03**	**0.22**	**0.02**	**1.30**	**0.01**	**0.02**	**0.00**	**0.17**	**0.06**	**0.02**
Thymol	0.10	0.49	0.02	1.19	0.01	0.02	0.00	0.03	0.26	0.03
Carvacrol	0.14	0.28	0.23	0.05	0.03	0.01	0.00	0.00	0.40	0.09
Phenols	**0.24**	**0.77**	**0.25**	**1.24**	**0.04**	**0.03**	**0.00**	**0.03**	**0.66**	**0.12**
Camphor	3.23	7.10	20.13	17.73	1.63	4.19	11.39	30.56	4.56	11.81
Verbenone	0.04	2.60	0.64	0.48	0.95	0.79	0.89	1.38	1.61	0.01
Carvone	0.01	0.47	0.14	0.34	0.03	0.17	0.67	1.16	3.66	0.02
Ketones	**3.28**	**10.17**	**20.91**	**18.55**	**2.61**	**5.15**	**12.95**	**33.1**	**9.83**	**11.84**
Linalyl acetate	0.52	0.01	0.10	1.21	0.00	0.31	0.05	0.00	0.00	0.17
Bornyl acetate	14.05	11.38	2.44	2.79	3.83	1.01	1.22	0.07	12.80	1.44
Geranyl acetate	0.14	0.63	2.59	1.45	0.04	0.04	1.88	1.34	3.98	0.03
Monoterpene Esters	**14.71**	**12.02**	**5.13**	**5.45**	**3.87**	**1.36**	**3.15**	**1.41**	**16.78**	**1.64**
T. identification	93.39	95.19	98.84	99.28	99.11	98.12	98.36	99.56	88.34	98.67

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تـأثير التسـميد الكبريتـى و النيتروجينـى و الفوسـفورى علـى النمـو و المحصـول و المكونات الكيميائيه لنبات حصالبان المنزرع تحت ظروف الرى بالماء المالح

إيمان إبراهيم عزيز –عبد الغنى عبدة يوسف
قسم زراعة وإنتاج النباتات الطبية – المركز القومى للبحوث- الدقى - مصر

تم إجراء هذه التجربة خلال موسمين متتاليين (١٩٩٩-٢٠٠٠ و ٢٠٠٠-٢٠٠١) في صوبة المركز القومي للبحوث وذلك لدراسة تأثير استخدام التسميد الكبريتي والنيتروجينى وكذلك الفوسفورى علي النمو والمكونات الكيميائية لنبات الحصالبان المنزرع تحت ظروف الري بالماء المالح(٤٠٠٠ جزا في المليون) وقد أوضحت الدراسة النتائج التالية:-

1- جميع الأسمدة المستخدمة أدت إلى زيادة معنوية في طول النبات وعدد الأفرع والوزن الطازج والجاف للنبات. واكثر المعاملات تأثيرا كانت عند إضافة المستوى المرتفع من الكبريت
2- أدت هذه المعاملات إلى زيادة معنوية في محتوى النبات من العناصر والكربوهيدرات الكلية والسكريات الذائبة وكذلك السكريات المختزلة والسكروز مقارنة بالكنترول
3- أوضحت النتائج زيادة معنوية في محتوي النبات من الزيوت الطيارة مقارنة بالكنترول مع وجود اختلافات واضحة في تركيز المكونات الكيميائية للزيوت الطيارة.
4- أظهرت نتائج التحليل أن مركب 1,8-cineole هو المركب الرئيسي في عينات الزيوت الطيارة تحت الدراسة وقد أدى التسميد النيتروجيني بالمستوي الثاني (N2)إلى ارتفاع نسبة هذا المركب إلى ١٥و٦٠%
5- أدي استخدام المستوي المنخفض من التسميد الفوسفوري (P1)إلى ارتفاع نسبة ألCamphor في الزيت العطري إلى ٥٦و٣٠% .
6- أدى المستوى الثاني (S2)من التسميد الكبريتي وكذلك المستوي المرتفع من التسميد النيتروجيني والفوسفوري (P3 , N3) إلى زيادة تركيز كلا من β-pinene(٣٢و١٥ - ٣١و١٥- ٢٩و١٢) وأل limonene (٧٨و١٦-٨٧و١٧- ٩١و١٥)

Table (1): Effect of Sulphur, Nitrogen and Phosphorus fertilization on some growth characteristics of *Rosmarinus officinalis L.* plant grown under saline water irrigation.

Seasons	First season (1999-2000)								Second season (2000-2001)							
Parameters	Plant height cm. /plant		No. of branches /plant		Fresh weight gm. /plant		Dry weight gm./plant		Plant height cm. /plant		No. of branches /plant		Fresh weight gm. /plant		Dry weight gm./plant	
Treatments	1st cut	2nd cut	1stcut	2nd cut	1stcut	2nd cut	1stcut	2nd cut	1stcut	2nd cut	1stcut	2nd cut	1stcut	2nd cut	1stcut	2nd cut
Control	38.67	18.33	16.67	10.67	38.47	18.87	13.78	6.30	41.33	20.00	18.33	11.67	43.33	21.50	16.41	8.31
S1	53.33	23.00	19.33	13.67	52.37	26.08	20.32	9.37	54.33	27.33	22.67	14.67	55.78	29.93	21.48	11.26
S2	58.33	29.33	22.67	16.00	59.63	30.59	23.01	11.40	60.33	31.33	25.33	17.67	63.49	33.44	24.10	12.59
S3	63.67	33.67	25.67	19.67	67.97	35.19	25.13	12.53	66.33	35.33	27.00	21.00	69.41	36.90	26.01	14.00
N1	43.33	22.33	18.67	13.00	45.63	21.28	17.80	7.86	45.00	25.33	21.33	13.00	47.13	26.05	19.03	9.71
N2	46.33	27.00	21.00	15.33	49.13	27.02	19.85	9.20	50.67	29.00	24.00	15.67	53.00	28.37	21.08	10.85
N3	51.00	34.00	23.00	19.33	57.37	29.65	22.97	10.93	54.67	30.33	26.00	19.33	59.18	31.28	23.59	11.85
P1	48.00	23.67	19.67	13.00	51.37	24.70	19.79	9.09	49.33	25.67	20.33	15.00	50.11	28.37	19.67	10.37
P2	52.67	33.00	23.33	19.67	60.30	31.31	23.44	11.44	55.67	30.33	24.33	17.67	59.71	30.59	23.80	11.83
P3	50.33	30.00	20.67	17.00	54.37	27.25	21.98	10.09	52.67	28.00	21.67	16.00	55.77	28.36	21.60	10.73
LSD 5%	4.21	3.30	1.98	2.20	3.40	2.56	1.42	0.77	3.86	2.15	1.42	1.19	3.30	2.16	1.65	0.83

S= sulphur fertilizer N= nitrogen fertilizer P= phosphorus fertilizer

Table (2): Effect of Sulphur, Nitrogen and Phosphorus fertilization on nutrient content of *Rosmarinus officinalis L.* plant grown under saline water irrigation (Mean of two seasons).

Parameters / Treatments	N %		P %		K %		S %		Fe mg/g		Zn µg/g	
	1stcut	2nd cut	1stcut	2nd cut	1stcut	2nd cut	1stcut	2nd cut	1stcut	2nd cut	1stcut	2nd cut
Control	1.80	0.86	0.61	0.34	1.76	0.74	0.24	0.11	1.33	0.71	96.63	58.98
S1	2.43	1.08	0.69	0.53	1.90	0.90	0.35	0.18	2.04	0.99	101.17	81.62
S2	2.66	1.25	0.89	0.62	2.08	1.04	0.46	0.24	2.14	1.11	129.90	91.08
S3	3.51	2.16	0.97	0.73	2.45	1.57	0.70	0.35	2.40	1.38	132.10	99.05
N1	2.07	0.96	0.64	0.39	1.89	0.88	0.30	0.17	1.39	0.84	99.40	72.02
N2	2.30	1.22	0.67	0.44	2.11	0.99	0.38	0.20	1.54	0.98	99.70	79.70
N3	2.97	1.51	0.68	0.50	2.37	1.08	0.61	0.30	1.74	1.16	102.83	89.03
P1	2.03	0.94	0.66	0.45	1.96	0.99	0.33	0.16	1.71	0.88	110.57	70.26
P2	2.26	1.16	0.71	0.51	2.11	1.11	0.35	0.20	1.79	1.00	113.17	78.46
P3	2.54	1.23	0.83	0.60	2.37	1.26	0.53	0.25	1.89	1.17	114.37	87.31
LSD 5%	0.22	0.06	0.02	0.05	0.14	0.07	0.07	0.04	0.05	0.13	1.24	6.20

S= sulphur fertilizer N= nitrogen fertilizer P= phosphorus fertilizer

J. Agric. Sci. Mansoura Univ., 26 (11): 7221 - 7235, 2001.

Table (3): Effect of Sulphur, Nitrogen and Phosphorus fertilization on some chemical composition of *Rosmarinus officinalis L.* plant grown under saline water irrigation (Mean of two seasons).

Parameters / Treatments	Total carbohydrate %		Total soluble sugar %		Reducing sugar %		Sucrose %		Oil %	
	1stcut	2nd cut	1stcut	2nd cut	1stcut	2nd cut	1stcut	2nd cut	1stcut	2nd cut
Control	11.33	8.76	1.23	0.95	0.23	0.17	0.95	0.74	0.12	0.08
S1	13.54	10.20	2.10	1.65	0.36	0.28	1.66	1.31	0.14	0.11
S2	15.14	11.57	3.15	2.13	0.56	0.38	2.46	1.66	0.18	0.12
S3	18.66	14.28	3.85	2.95	0.63	0.51	3.06	2.33	0.19	0.15
N1	12.48	9.58	1.70	1.30	0.27	0.23	1.36	1.02	0.17	0.11
N2	12.56	10.77	2.37	1.67	0.40	0.29	1.88	1.31	0.19	0.13
N3	13.74	11.81	2.88	2.03	0.49	0.37	2.27	1.58	0.21	0.15
P1	12.63	9.91	1.81	1.44	0.30	0.24	1.44	1.13	0.14	0.11
P2	13.67	10.57	2.54	2.07	0.43	0.37	2.00	1.62	0.19	0.15
P3	14.10	10.88	3.03	2.40	0.50	0.41	2.40	1.89	0.22	0.17
LSD 5%	0.81	0.67	0.35	0.21	0.02	0.03	0.34	0.21	0.02	0.02

S= sulphur fertilizer N= nitrogen fertilizer P= phosphorus fertilizer