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INFLUENCE OF COMPOST, MICROORGANISMS AND NPK FERTILIZER UPON GROWTH, CHEMICAL COMPOSITION AND ESSENTIAL OIL PRODUCTION OF *ROSMARINUS OFFICINALIS* L.

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Abstract. The performance of compost and microorganisms was compared with standard, commercial rates of NPK fertilizers with respect to the growth, chemical composition and essential oil production of *Rosmarinus officinalis* L. In two successive seasons, plants treated by a mixture of compost and microorganisms showed a significant increase in vegetative growth, total N, P and carbohydrate content and essential oil production. The findings clearly indicate that compost and microorganisms could replace conventional NPK fertilizers in the cultivation of rosemary, and consequently minimize environmental pollution by these compounds.

Key words: *Rosmarinus officinalis*, compost, microorganisms, growth, chemical composition

INTRODUCTION

Many researchers have started to give attention to the negative effects of using NPK chemical fertilizers in agriculture, both in agriculture itself and on human beings.

The intensive use of chemical fertilizers has side effects in polluting underground water, destroying microorganisms and insects, making plants more susceptible to the attack of diseases and reducing soil fertility. Therefore, the development of satisfactory alternatives for supplying the nutrients needed by crops (so-called "green agriculture") could decrease the problems associated with conventional NPK chemical fertilizers and thereby protect both the environment and human health. *Rosmarinus officinalis* L. has both medicinal and aromatic properties.

Herbs play an important role in maintaining human health and their extracted oils are used for many medical products (Al-Sereitia et al., 1999). This study was designed to study the effect of using compost and microorganisms, both separately and in a mixture, on the growth characteristics, chemical composition and essential oil yield of rosemary plants, and to assess their potential as alternatives to conventional NPK fertilizers.

MATERIALS AND METHODS

This study was conducted during the two successive seasons, 2002 and 2003, on the Experimental farm of the Agricultural Research Centre, Ismailia, Egypt.

Cuttings of *Rosmarinus officinalis* L. were planted on 25th March 2002 and arranged in five rows using complete randomized block design with four replicates. Each treatment

contained 50 plants with plant spacing was 0.3 m^2. Plants were cut 0.15 m above the soil surface on 9th November 2002 in the first season, and on 25th April 2003 in the second. The following treatments were applied:

1. Chemical fertilizer N, P, K (control): The manufacturer's recommended rate of nitrogen for sandy soils was applied at a rate of 100 kg N / ha using ammonium nitrate (33.5 % N). Phosphorus was applied at a rate of 50 kg P / ha using calcium super phosphate (15.5 % P). Potassium was applied at a rate of 50 kg / ha using potassium sulphate (48 % K_2O).

2. Microorganisms: Nitrogen-fixing bacteria, *Azotobacter chroococcum*, and phosphate-solubilising bacteria, *Bacillus megaterium*, were used. Cuttings of *Rosmarinus officinalis* L. were dipped in a solution of these microorganisms for 5 min using a liquid culture from each strain at a rate of 5 ml/litre before planting (1 ml contain 10^9 cells of bacteria) as recommended by Omar, El-Katan (2003).

3. Compost: a rate of 35 t/ha of compost was applied in the bottom of the rows as recommended by Egyptian Ministry of Agriculture.

4. A mixture of the same microorganisms and the same compost was applied at the same rates as above.

Table 1

Chemical and physical properties of the soil

Sand %	Silt %	Clay %	Soil Texture	pH	EC	Organic-C (%)	N %	P %	K %	Ca ppm	Mg ppm
89.7	6.8	4.7	Sandy	7.8	0.38	0.32	0.03	0.01	0.02	92	43

Table 2

Chemical properties of the compost

Content of bacteria	Organic matter %	pH	EC	Organic -C (%)	N %	P %	K %	Fe ppm	Mn ppm	Cu ppm	Zn ppm
2.5×10^7	70	7.5	3.1	33.11	1.82	1.29	1.25	1019	111	180	280

In the two seasons, plant height, number of branches per plant, number of flowers and plant fresh and dry weight were measured. Determination of N, P and K was done on the dry herb. Total nitrogen was determined using the micro-Kjeldahl method as described by Jackson (1973).

Phosphorus was estimated calorimetrically using the chlorostannous reduced molybdophosphoric blue colour method as described by Chapman and Pratt (1961). Potassium was determined using a flame photometer as described by Jackson (1965). The concentration of total carbohydrate was determined in the dried herb and root system using the phenolsulphuric acid method according to Dubois et al. (1956).

The oil percentage was determined according to the British Pharmacopeia (1963) and the yield of oil produced per plant was calculated by multiplying the average of herb fresh weight per plant by the average oil percentage. All data were statistically analyzed using LSD 0.05.

RESULTS AND DISCUSSION

In general, plants treated with the mixture of compost and microorganisms showed significant increases in plant height, number of branches, fresh and dry weights, and number of flowers, compared to those treated with mineral NPK, especially in the second season (Table 3).

Table 3

Effect of NPK, microorganisms and compost on growth characters of rosemary plants

Growth characters	Plant height (mm)		Number of branches		Fresh weight (g)		Dry weight (g)		Number of flowers	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
NPK (control)	790	841	40	51	521	561	100	118	20	18
Microorganisms	521	600	22	26	327	365	71	80	7	12
Compost	680	660	34	30	436	496	90	97	13	17
Compost+Microorganisms	810	880	41	60	550	600	115	123	22	25
L. S. D. 0.05	10.30	9.50	3.77	5.16	22.85	25.68	8.16	9.33	2.60	3.11

These results are in agreement with those obtained by Haridy et al. (2001) on lemongrass and El-Ghadban et al. (2002) on *Origanum majora*. In this respect, it is possible that the favourable effect of compost and microorganisms on growth characteristics may be due to their ability to enhance the physical, chemical and biological properties of the soil. A similar suggestion was made by Hanafy Ahmed et al. (2002) on rocket plants. Furthermore, this stimulative effect may be related to the good equilibrium of nutrients and water in the root medium (Abdelaziz et al., 2007) or to the beneficial effects of bacteria on vital enzymes and hormonal, stimulating effects on plant growth (Bashan et al., 1989).

As regard to the effect of treatments on plant chemical composition, a small but significant increase was found in N, K and total carbohydrate content in plants treated with the mixture of compost and microorganisms, while no significant differences were observed in the P content between treatments (Table 4). Similar results were obtained by Zaied et al. **(**2003) on wheat and Haroun and Hussein (2003) on *Lupinus termis*. On the other hand, the control plants had higher levels of all chemicals compared to plants treated by microorganisms or compost alone. Furthermore, both Hammoda (2001), studying *Glossostemon bruguieri*, and El-Ghadban et al. **(**2002), studying marjoram, mentioned that both compost and biofertilizer led to an increase in carbohydrate percentage and some macro-nutrients. These increases might be related to the positive effect of compost and microorganisms in increasing the root surface area per unit of soil volume, water-use efficiency and photosynthetic activity, which directly affects the physiological processes and utilization of carbohydrates. These suggestions are confirmed by the data in Tables (1 and 2), which illustrate the higher levels of nutrients and organic matter in compost.

Table 4

Effect of NPK, microorganisms and compost on N, P, K and total carbohydrates of rosemary plants

Growth characters	N %		P %		K %		Total carbohydrates $mg.g^{-1}DW$	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd
NPK (control)	1.8	2.2	0.53	0.55	3.9	4.2	48	52
Microorganisms	1.1	1.4	0.49	0.50	2.8	3.1	46	43
Compost	1.6	1.9	0.51	0.52	3.1	3.2	49	50
Compost + Microorganisms	2.1	2.3	0.52	0.55	4.0	4.5	52	54
L. S. D. 0.05	0.05	0.07	NS	NS	0.31	1.22	3.18	4.35

Fig. 1 shows that the highest essential oil yields were obtained from plants treated by the mixture of microorganisms and compost (59, 72 kg. ha^{-1}), followed by plants treated by NPK chemical fertilizers (54, 64 $kg.ha^{-1}$) in both seasons, respectively. In this respect, it can be suggested that the stimulative effect of the mixture of compost and microorganisms on increasing essential oil yield might be attributed to their enhancing effect on vegetative

growth characteristics and plant chemical composition. In addition, this favourable effect could be related to increasing the number of glands. However, in this respect, Zaurolav (1978) found that the physiological activity of the glands had a greater effect on essential oil levels than simply their number. Similar results have been reported by Ram, Kumar (1997) on *Mentha arvensis*, Jacoub (1999) on thyme and El-Ghadban et al. (2002) on marjoram.

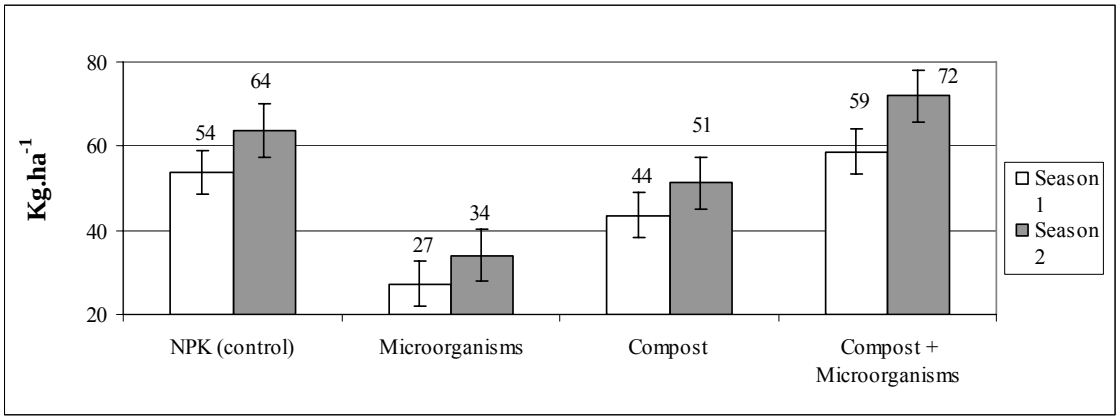

Figure 1. Effect of NPK, microorganisms and compost on essential oil production of rosemary plants*
*Intervals represent LSD 0.05

CONCLUSIONS

The results point to the beneficial effects of a compost and microorganisms mixture as alternative nutrition systems on the growth characteristics, total N, P and carbohydrate content, and essential oil yields of rosemary. Alternative nutrition systems could have environmental advantages when compared to conventional NPK fertilizers.

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REZUMAT

INFLUENȚA COMPOSTULUI, MICROORGANISMELOR ŞI FERTILIZĂRII CU NPK ASUPRA CREȘTERII, COMPOZIȚIEI CHIMICE ȘI PRODUCȚIEI DE ULEIURI ESENȚIALE LA *ROSMARINUS OFFICINALIS* L.

Efectul compostului şi microorganismelor a fost comparat cu efectul fertilizării standard, la o doză comercială de fertilizant NPK, în scopul urmăririi creşterii, compoziției chimice şi producției esențiale de ulei la *Rosmarinus officinalis* L. In două sezoane succesive, plantele tratate cu o mixtură de compost şi microorganisme au prezentat creşteri vegetative semnificative, constatându-se şi sporirea conținutului în N şi P total, carbohidrați şi uleiuri esențiale. Cercetările au demonstrat în mod clar faptul că este posibilă înlocuirea fertilizării convenționale cu NPK de către compost şi microorganisme; în acest fel, în cultura rozmarinului pot fi evitate consecințele poluării mediului cu diferiți componenți nocivi din îngrăşăminte chimice.