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RESPONSE OF ROSEMARY PLANTS *(Rosmarinus officinalis* L.) TO ORGANIC AND BIOFERTILIZERS IN REPLACEMENT OF CHEMICAL FERTILIZATION

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By
E. M . Z. Harb and N. G. Eltatawy

Branch of Plant Physiology, Agricultural Botany Department, Faculty of Agriculture, Cairo University, Giza, Egypt

ABSTRACT

Pot experiment was carried out during two successive seasons 2008 and 2009 to investigate the effect of organic fertilizer (compost) ,with or without biofertilizer inoculation (*Azotobacter chroococcum* and *Bacillus megaterium*) in comparison with the recommended dose of NPK as control on growth, yield and chemical composition of rosemary plants. Data obtained clearly revealed that plants received the compost in combination with a mixture of biofertilizers recorded a considerable increments with regard to growth characters, macronutrients, phytohormones (IAA, GA_3 and CK) and essential oil components (1,8-Cineol, Camphor, α-Pinene, β– Pienene, Bornyl acetate and Borneol). In addition, the significant increases were recorded on fresh weight (g/plant) and herb dry weight (g/plant) in both seasons, as well as essential oil percentage and oil yield/plant in the fresh herb in the combined of compost and mixture of biofertilizers as compared to the control treatment. These findings clearly indicated that organic fertilizer (compost) and biofertilizers mixture could replace the application of mineral fertilizers and consequently minimize the pollution of the agricultural environment.

Key words : *biofertilizer, organic fertilizer, rosemary.*

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1. INTRODUCTION

Medicinal plants occupy a prominent position because of the increasing demand of the local industry and export. In order to cover such increase, an increasing interest in the cultivation of medicinal and aromatic plants has been settled in Egypt. Recently, a considerable attention has been directed in the newly reclaimed lands to improve the growth and the yield of various aromatic and medicinal plants.

According to Anjara (1996), UNESCO (1996), Bhat (1997), and World Bank (1997) rosemary plants (*Rosmarinus officinalis* L.) are considered as an important aromatic and medicinal crop in Egypt with high production and great applications. It is used extremely as anti-spasmodic, analgesic, anti-cancer, anti-diarrhea, anti-gout, anti-influenza, whooping cough and neuralgia, bile stones, increase urine flow, diaphoretic and appetizer, urinary system stones and improves blood circulation as well as emmenagogue, diuretic and anti-congestion. In addition, it can be used for edema, knocks, bruises, sprains and pulls. It speeds up the healing of wounds and eases mouth infection when used as a gargle. It is also used in the treatment of female genital disorders when used as vaginal douche. It can be used also as antimicrobial, antioxidant, antiseptic. aphrodisiac, astringent, carminative, parasiticide and insect repellent. Moreover, the oil is extensively used in detergents, cosmetics, household sprays and perfumes. The herb and its oil are largely employed in most major food categories, especially meat products as well as soft drinks.

In the recent years, safe agriculture is one of the main attitudes in the world (El-Kouny, 2002). Also, recently there has been an increasing awareness of the undesirable impact of mineral fertilizers on the environment, as well as the potentially dangerous effects of chemical residues in plant tissues on the health of human and animal consumers. As a result of this awareness, strict regulations and restrictions have been imposed in several countries (especially in the European markets) prohibiting the impact of “Chemically–grown” products. This has led growers of medicinal and aromatic plants in many countries to adopt organic and biological agricultural methods for fertilization, pest controls, etc.

Composting of agricultural residues by supplying the natural microbial flora present on them with their requirements of inorganic nutrients such as nitrogen and phosphorous and by applying a proper moistening and turning, resulted in a final product with high ability to improve soils and enhanced plant growth . This was reported by Lampkin (1990), Mohamed and Matter (2001), Badran (2002) and Ghallab and El-Gahdban (2004). Moreover, compost with its content of humic substances and microbial materials, has been shown to improve soil physical, chemical and microbiological conditions, moisture content, and reduce leaching of nutrients, water run-off and soil erosion (Amin *et al.*, 1999).

Biofertilization is used in order to compensate a part of the mineral fertilizer doses, taking in consideration the complementary or synergistic effects of such combination between bio-and mineral fertilization. This could be of economic value from the applied point of view of minimizing the used doses of the mineral fertilizers and consequently reduce agricultural costs as well as soil pollution.

Over the last two decades, the biofertilizers are increasingly used in modern agriculture due to the extensive knowledge in rihzospheric biology and the discovery of the promotive function of special groups of microorganisms such as *Azospirillum, Azotobacter, Acetobacter, Bacillus, Serratia* and *Pseudomonas* which are known as plant growth promoting rhizobacteria (PGPR). They appear to be frequent colonizers of important medicinal crops including *Ammi visnaga*, Lemongrass, Palmarorsa and Marjoram (Masheshwari *et al.*, 1995, El-Sawy *et al.*, 1998, Harridy *et al.*, 2001 and Ghallab and El-Gahdban, 2004). Such beneficial effects of these plant growth promoting rhizobacteria (PGPR) could be attributed to the biological nitrogen fixation and production of phytohormones (gibberellins and cytokinins like substances as well as auxins) that promote root development and proliferation, resulting in efficient uptake of water and nutrients (Hartmann *et al.*, 1983 and Haahtela *et al.*, 1990).

The beneficial effects of rhizobiacteria on aromatic and medicinal crops are recently increased due to their potential use as biofertilizers (Okon and Labandera – Gonzalez, 1994 and Kumar *et al.*, 1998). Thus, the extensive researches in this field strongly indicate that application of bacterial inoculants as biofertilizers resulted in improvement of growth and productivity of aromatic and medicinal crops, in addition to the reduction of their N-requirements to 50% of the recommended dose (Harridy *et al.* 1998).

The aim of the present study was to investigate the effects of compost solely or combined with inoculation mixture of biofertilizers, *i.e.*, *Azotobacter chroococcum and Bacillus megaterium* on the growth, oil yield and chemical composition of rosemary plants and to compare this effect with that of recommended NPK fertilization.

2. MATERIALS AND METHODS

The present work was conducted in pot experimental farmyard, Ramsis region, Cairo, Egypt during the two successive seasons; 2008 and 2009. The total area of the farmyard was 175 m^2 . Plastic pots diameter was 40 cm and 30 cm in depth. Some physical and chemical analyses (Table 1) of the experimental soil used were carried out as described by Page *et al.* (1982) before planting.

Terminal cuttings (15 – 20 cm. in length) of rosemary (*Rosmarinus officinalis* L.) were transplanted on the 15^{th} of March 2008, on 9 th November 2008; the plants were cut 15 cm above the soil surface at the first season, and on the 25^{th} of April 2009 at the second season. The seedlings of rosemary plant were supplied from the Experimental Farm of Medicinal and Aromatic Plants, Faculty of Pharmacy, Cairo Univ., Giza, Egypt. The seedlings were given the recommended agronomic managements except the fertilization.

Pot experiment during the two seasons included four treatments as follows:

1- The recommended quantities of NPK fertilizers which are 200 kg N/ fed.
 as ammonium nitrate (33.5% N), 100 kg., P_2O_5/ fed. as calcium superphosphate (15.5% P_2O_5) and 100 kg K_2O/ fed. as potassium sulfate (48% K_2O) (control)
2- Mixture of Biofertilizers *Azotobacter chroococcum* + *Bacillus megaterium* .
3- Compost
4-Mixture of biofertilizers + Compost

Pots were laid out in a completely randomized design with five replications according to Gomez and Gomez (1984), with enough space between them to keep the plants from shading each other.

Biofertilizers are represented by Nitrobin and Phosphorin as commercial names containing $1x10^8$ CFU/ml from *Bacillus megaterium* and *Azotobacter chroococcum* individually in Biofertilizer unit, Soils Water and Environ. Res. Inst., Dept. of Microbiology (A. R. C.), Giza, Egypt. Both biofertilizers were mixed well together in a liquid at equal portions. Roots of rosemary seedling were dipped into the mixture of biofertilizers immediately before planting. Also, this mixture was added to plant rihzosphere through a view holes (2 and 4) already made in soil surface for inoculated treatments at 30 and 60 days after transplanting.

Table (1). Some mechanical and chemical properties of the used soil.

Property	Value	Property	Value
Clay %	34	Ca^{+2} (meq/l)	7.00
Silt %	21	Mg^{+2} (meq/l)	2.39
Coarse sand %	7	Na^{+} (meq/l)	0.24
Fine sand %	38	K^{+} (meq /l)	0.85
Soil texture class	Clay loam	CO_3^{-} (meq/l)	0.00
Organic matter %	1.5	HCO_3^{-} (meq/l)	2.00
pH	7.4	SO_4^{-2} (meq/l)	12.50
E_C (ds/m)	0.30	Cl^{-} (meq/l)	0.61
		Total N %	0.35

The compost was obtained from the Soil Department, A.R.C. Various properties of the compost is shown in Table (2). Chemical analysis of the compost was conducted according to Page *et al.* (1982).

Table(2):Means value of various properties of compost in both seasons

Property	Value
pH (1:5)	7.5
Ec (1: 5 extract) ds/m	3.1
Organic-C %	33.11
Organic matter %	70
Total-N %	1.82
Total-K %	1.25
C/N ratio	18.19
Total-P %	1.29
Fe-ppm	1019
Mn-ppm	111
Cu-ppm	180
Zn-ppm	280
NH^{+}_{4} - N (ppm)	274.7
NO^{-}_{3} - N (ppm)	33.1
Ashes %	30
Total content of Bacteria	2.5×10^{7}
Total content of Fungi	7×10^{5}
Weed seeds	0
Nematode	0
Phosphate dissolving Bacteria	2.5×10^{6}
Dehydrogenase activity (mg TPF/100g)	32.5
Nitrogenase activity (N mol C_2H_4/g/hr)	123.5
Humidity (%)	25

The compost (5 ton/fed.) and NPK fertilization treatments were incorporated with the potting medium, two weeks before transplanting.

In both seasons, plant height, number of branches/plant and herb fresh and dry weight/plant were recorded.

The mean values of growth were determined in the two seasons, statistically analyzed and the means were compared using L. S. D. values at 5% level (Gomez and Gomez, 1984).

2.1.Chemical analysis

The shoot was chemically analyzed in order to determine their chemical constituents. For the determination of total nitrogen, the modified Micro Kjeldhl apparatus of Parnas and Wanger as described by Jones *et al.*, (1991) was used. For total P and K determinations, the wet digestion of the plant material was carried out as recommended by Piper (1950). Phosphorus was determined colorimetrically using the stannous chloride reduced molybdophosphoric blue color method in sulphoric acid as described by Jackson (1973). Potassium was determined by the Atomic Absorption Spectrophotometer (GBC, 932 AA).

For determination of plant phytohormones freeze-dried rosemary leaves (equivalent 6 g F.W.) were ground to a fine powder with mortar and pestle. The powdered material was extracted three times (1x3 h. 2x1 h) with methanol (80% v/v, 15 ml./g F. W.), supplemented with butylated hydroxy toluene (2, (6) –Di-tret-Butyl-P-crosol) as an antioxidant, at 4^{o}C in darkness. The extract was centrifuged at 4000 rpm. The supernatant was transferred into flasks wrapped with aluminum foil and the residue was again twice extracted. The supernatants were combined and the volume was reduced to 10 ml at 35^{o} C under vacuum. The aqueous extract was adjusted to pH 8.6 and extracted three times with an equal volume of pure ethyl acetate. The combined alkaline ethyl acetate extract was dehydrated over anhydrous sodium sulphate then filtered. The filtrate was evaporated to dryness under vacuum at 35°C and redissolved in 1 ml absolute methanol. The methanol extract was used after methylation according to Palmer *et al.* (1981) for the determination of cytokinins. The remaining aqueous extract was acidified to pH 2.6 and extracted as previously described by ethyl acetate. The methanol extract was used after methylation according to Fales and Jaouni (1973) for determination of gibberlic acid (GA) and indole-acetic acid (IAA). The quantification of the endogenous phytohormones was carried out with Ati-Unicum gas-liquid chromatography, 610 Series, equipped with flame ionization detector according to the method described by Vogel (1975). The fractionation of phytohormones was conducted using a coiled glass column (1.5 m x 4 mm.) packed with 1% OV-17. Gases flow rates were 30, 30, 330 ml/min., for nitrogen, hydrogen and air, respectively. For cytokinins fractionation, the temperatures were for injector 260°C, detector 300 °C and column initially for 3 min. at 220 °C then programmed at 20 °C /min. for 220 °C to 240 °C. then isothermally at 240 °C for 8 min. For IAA and GA, the initial column temperature was 200 °C for 3 min. then programmed at 20 °C /min. for 200 °C to 220 °C, then isothermally at 220 °C for 4 min, then programmed at 20 °C /min. for 220 °C to 240 °C, then isothermally at 240 °C for 6 min. The peaks identification and quantification of phytohormones were performed by using external authentic hormones and a Microsoft program to calculate the concentrations of the identified peaks.

The oil percentage was determined in the fresh herb using the method described by the Egyptian Pharmacopoeia (1984), and the essential oil yield per plant was calculated in proportion to the herb fresh weight (Oil yield/plant = plant fresh weight x oil percentage).

Chemical analysis for essential oil was conducted by using Ati-Unicum gas liquid chromatography (GLC) 610 series, to determine their main constituents as described by Gunther and Joseph (1978).

3. RESULTS AND DISCUSSION

3.1. Growth characters

Growth characters of both seasons of rosemary plants as influenced by compost or biofertilizer treatment either alone or in combination are presented in Table (3).

In general, the results indicated that the compost associated with the inoculation of biofertilizer mixture significantly increased growth as compared to the control (plants receiving the recommended NPK dose) characters; *i.e*., plant height, number of branches / plant and both of herb fresh and dry weight (g/plant) in both seasons. Concerning this, it is notable that compost treatment without inoculation also gave results similar to the results of the control plants in most morphological parameters. In addition, it was mentioned that the positive effects of the other treatments on all studied growth characters failed to reach the 0.05 level of significance.

The favorable effects of the combination between compost fertilizer and biofertilizers might be explained based on the beneficial effects of bacteria on the nutrient availability, vital enzymes, hormonal stimulating effects on plant growth or the increasing of photosynthetic activity. supportive evidence. This was reported by Bashan *et al.* (1989) who found that *Azospirillum* and *Pseudomonas* improved wheat growth through the significant increase in dry matter accumulated in

Table (3): Growth characters of rosemary plants as affected by compost, biofertilizers and their combination during 2008 and 2009 seasons.

Growth character	Plant height (cm)		No. of branches / plant		Herb fresh weight (g/plant)		Herb dry weight (g/plant)	
Season / Treatment	1st Season 2008	2nd Season 2009	1st Season 2008	2nd Season 2009	1st Season 2008	2nd Season 2009	1st Season 2008	2nd Season 2009
Control (NPK)	80.5	85.7	42	61	525.7	565.6	105.4	128.5
Biofertilizers	53.7	61.3	24	27	332.5	370.3	75.8	85.5
Compost	74.6	81.4	36	46	440.7	499.7	100.5	114.2
Compost + Biofertilizers	96.4	105.6	49	76	634.8	706.8	125.8	160.8
L. S. D 0.05	1.34	1.5	1.25	1.14	24.90	26.86	8.19	9.36

both roots and shoots of the treated plants.

Also, Bashan and Levanony (1990) proposed several possible modes of action of *Azospirillum* on plant growth and N_2 fixation, which contributes N to the plant. Hormonal effects, alter plant metabolism and growth. Moreover General growth improvement in the entire root system, result in enhanced mineral and water uptake. Moreover, Valssak and Reyndres (1980) found that *Azospirillum* produced Indole lactic acid (IAA) and gibberllins and the degree of sensitivity of plants to phytohormones are being suggested as the main reason for this phenomenon (Jlik, 1995). Furthermore, Ghallab and Salem (2001) found that wheat inoculated with *Azospirillum* spp. improved grain yield and total dry matter accumulation. Recently, Salem *et al.* (2006) found that flax cultivars inoculated with nitrobien or phosphorien increased most of the studied growth and yield characters .

Moreover, the significant positive effect of compost fertilizer on vegetative growth characters might be due to the improvement in soil physical and biological properties and also, the chemical characteristics resulting in more release of available nutrient elements to be absorbed by plant root and its effect on the physiological processes such as photosynthesis activity as well as the utilization of carbohydrates, in addition to water use efficiency by different plants (Abd El-Moez *et al.*, 1999; Hussein, 2003 and Ghallab and El-Gahdban, 2004).

It is worth to mention that compost combined with biofertilizer mixture, lead to a high increase in dry weight of rosemary plants.

3.2. Chemical analysis

The effects of different treatments on the essential oil percentage (ml/100g.F. W. herb.); oil yield/plant; N, P, K, IAA, GA_3 and CK concentrations in the shoots of rosemary plants grown in both seasons (Table 4) were similar to those recorded for growth characters. The data clearly showed the significant increases in both essential oil percentage (22.6 and 26.5 % in both seasons, respectively) and oil yield/ plant (48.4 and 57.6 % in both seasons, respectively) in the fresh herb at the combination of compost and biofertilizer mixture as compared to the control. On the other hand, insignificant differences were detected among the other treatments (compost and biofertilizer mixture) and the control.

These results are in agreement with those obtained by Jacoub (1999) on *Ocimum basillicum* L. and *Thymus vulgaris* L. plants ; Mansour *et al.*,

Table (4): Essential oil %, oil yield, concentrations of N, P, K (mg/g D.W.), indole-3-acetic acid (IAA), gibberellic acid (GA_3) and cytokinins (CK) (µg/gF.W.) in shoots of rosemary plants as affected by biofertilizer, compost and their combination during 2008 and 2009 seasons.

Chemical composition / Treatments	Essential oil% (ml./100 g.F.W.)	Oil yield (ml./plant)	N	P	K	IAA	GA_3	CK
	First cut (2008)							
Control	0.31	1.61	27.74	3.82	28.58	9.96	8.53	7.21
Biofertilizers	0.25	0.82	24.58	2.63	25.43	6.74	7.16	6.16
Compost	0.28	1.22	25.39	3.14	26.84	7.11	7.21	6.33
Compost+ Biofertilizers	0.38	2.39	36.65	4.52	31.68	11.85	9.89	8.98
L. S. D. 0.05	0.06	0.59						
	Second cut (2009)							
Control	0.34	1.91	28.94	3.87	29.68	10.85	8.89	7.57
MB	0.28	1.02	26.88	2.92	27.59	9.76	7.57	6.34
Compost	0.31	1.54	27.38	3.56	28.97	9.96	7.86	6.52
Compost+ MB	0.43	3.01	38.94	4.96	34.21	12.37	10.57	9.34
L. S. D. 0.05	0.05	0.66						

(1999) on spearmint and marjoram plants ; Badran and Safwat (2004) on fennel plants and Ghallab and El-Gahdban (2004) on marjoram plants. The effect of compost on increasing the volatile oil percentage of shoots might be attributed to their enhancing effect on vegetative growth, in terms of the fresh yield and increasing the uptake of nutrient by roots. Similar results were recorded by Mohamed and Matter (2001) on marigold plants.

The effects of different treatments on the mean values of macro-nutrient concentrations in the shoots of rosemary plants in both growing seasons (Table 4) were similar to those recorded for growth characters (Table 3).

The data show the superiority of the combined treatment including compost and biofertilizers mixture which resulted in the highest promotive effects on the macronutrients accumulation which surpassed both other treatments. However, the positive effect of both other treatments on the values of macronutrient concentrations was insignificant.

The promotive effects of the bioferilization on macronutrients accumulation could be attributed to that the inoculation of rosemary plants resulted in a promotive effect on root development and consequently their function in the uptake of both water and nutrients. Similar results were reported by Harridy *et al.*(2001) on lemongrass. More supportive evidences for the obtained results were found in the work of Ghallab and Salem (2001) on wheat who found that a mixture of *Azospirllium* and *Serratia* inoculation greatly enhanced the uptake of N, P, K, Fe, Mn , Zn and Cu as well as the accumulation of these minerals in wheat plants. Moreover, Faragl and Ali (2004) found that using 75 % NPK + Biofertilizers [HALEX2] + organic fertilizers caused increasing N, P and K percentage in the leaves of tomato plants. Also, Bashan *et al.,* (1989) attributed the increase of mineral uptake by inoculated roots to the enhancement in proton efflux activity of wheat root inoculated with *Azospirllium*. Moreover, Omar *et al.* (1991) reported that inoculation with *Azospirllium* cultures stimulated the uptake and accumulation of the nutrients from the soil. Furthermore, Dashti *et al.,* (1997) suggested that the promotive mechanism of growth and nitrogen fixation induced by plant growth promoting rhizobacteria (PGPR) included both direct and indirect effects. The direct effects included an increase in the mobilization of insoluble nutrients followed by enhancement uptake by the plants (Lifshitz *et al.,* 1987) and production of plant growth regulators that stimulated plant growth (Gaskins *et al.,* 1985). The indirect effects included positive effects on symbiotic nitrogen fixation by enhancement of root nodules number or mass as reported by Yahalom and Okanad (1987).

Increasing N, P and K concentrations by compost fertilization might be due to the increase in root surface per unit of soil volume as well as the high capacity of the plants supplied with compost fertilizer in building metabolites, which in turn contributed much to the increase in nutrients uptake. In this respect, Abd El-Moez *et al.*, (1999) on fennel and coriander plants and Ghallab and El-Gahdban (2004) on marjoram plants, found that the macro -nutrients uptake by plant roots increased significantly by the addition of organic composts to prepared soil. They attributed the results to the effect of organic fertilizer on improving not only soil physical and biological properties but also soil chemical characteristics resulting in more release of available nutrient elements to be absorbed by plant roots and the water efficiency by different plants.

Concerning the phytohormones , the results of the hormonal analysis [IAA, GA_3 and CK] in the leaves of the rosemary plants in both seasons as affected by different treatments are presented in Table (4) confirmed the previous results obtained in Table (3) as well as essential oil percentage, oil yield(ml./plant) and macro-nutrients concentration.

The results obtained (Table 4) showed the positive response in the hormonal concentrations which reached their maximum when the compost was combined with biofertilizer mixture. However, the positive effects of the other treatments on hormonal concentrations failed to reach the 0.05 level of significant.

The promotive effects of the biofertilization mixture with the compost on phytohormons might be attributed to the production of growth promotive substances from rihzospheric microorganisms such as IAA and GA_3 (Gulam *et al.*, 1998). In this respect. *Azospirllium* produced several plant hormones in liquid culture, mainly IAA. Other hormones were detected at much lower concentration, indole-3 butyric acid (IBA) (Fallik *et al.*, 1989), indole –3 ethanol and indole –3– methanol (Crozier *et al.*, 1988). Several gibberllins (Bottini *et al.*, 1989), abscisic acid (ABA) (Kolp and Martin ,1989), and cytokinins (Horemans *et al.*, 1986).

It is well established that biofertilizers could lower the amount of the added inorganic nitrogen fertilizer to the soil and consequently reduced soil pollution.

3.3. Chemical composition of the essential oil

Table (5) showed that the highest content of 1,8-Cineol (the main component), as well as that of some other important components; *i.e.* Camphor, α-Pinene, β– Pienene, Bornyl acetate and Borneol were obtained from plants fertilized with compost in combination with biofertilizers mixture compared to the control. This finding strongly confirmed the previous conclusion drawn about essential oil percentage, oil yield/plant and concentrations of macronutrients and phytohormones (Table 4). In this respect, Bajaj (1999) and Nagata and Ebizuka (2002) indicated that all oil components of rosemary plants have medical useful effect; in the sense that any components having high concentration in oil and high medical effect if well purified and used alone, does not give the required medical effect unless it is found together with other oil components even with less percentage. This indicated the fact that all oil components together could induce the medical effect. Therefore, the treatment of compost combined with biofertilizer mixture could help to increase the quality of rosemary essential oil. Also, these results in the increase of its use as stimulating in use as anti-spasmodic, anti-cancer, anti-diarrhea, anti-gout, edema, knocks, bruises, sprains, pulls, anti-microbial, detergents, household sprays and perfumes.

Table (5): Effect of biofertilizer, compost and their combination on the essential oil components of rosemary plant during 2008 season.

Treatments / Oil components	NPK	Biofertilizer	Compost	Compost+Biofertilizer
α-Pinene	4.22	2.54	3.32	6.79
Camphene	2.71	1.52	2.12	2.76
Camphor	11.92	7.32	9.96	14.76
β-Pinene	7.02	7.64	6.96	10.45
Limonene	2.09	1.52	1.06	1.95
P-cymene	5.46	3.43	4.35	5.54
1,8-Cineol	15.26	11.96	13.21	18.31
Linalool	9.97	3.1	8.22	8.88
Bornyl acetate	5.73	6.62	4.36	7.52
Borneol	7.68	8.55	6.74	10.89
γ -Terpinene	1.12	0.07	1.11	1.01
Thymol	0.18	0.02	0.08	0.11

Conclusion

The obtained data emphasized the efficiency of treatment including combined compost and biofertilizers mixture in inducing increase in the studied morphological characters, different chemical constituents in the shoots of rosemary plants (essential oil percentage, oil yield/plant, percentage of oil components, macronutrients and hormones concentrations of rosemary leaves). This treatment resulted in considerable and even significant increases in all studied parameters, over the control (plants receiving only the recommended dose of NPK fertilizers).

Economic value taking into consideration the production of safe plants without using chemical fertilizers which in turn minimize the agricultural costs as well as the pollution of the Egyptian environment. Therefore, such effects will surely minimize the costs in terms of potential benefits to be derived from using compost combined with inoculation with biofertilizers mixture for the various plant species to approach its optimal productivity, taking into consideration the economic point of view to attain the minimum level of agricultural costs.

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إستجابة نباتات حصالبان للتسميد العضوى والحيوى كبديل لإستخدام التسميد الكيميائى

إجلال زكى حرب – نوران جميل التطاوى

فرع فسيولوجيا النبات – قسم النبات الزراعى – كلية الزراعة – جامعة القاهرة – الجيزة -مصر

ملخص

تم إجراء هذه التجربة خلال موسمين زراعيين متتالين: 2008 و 2009 بهدف دراسة تأثير كلا من السماد العضوى(الكمبوست) والاسمدة الحيوية (الأزوتوباكتر *chroococcumAzotobacter* *والباسلس* *Bacillus megaterium)* أو خليط منهما مقارنة بالتسميد الكيميائى الموصى به من NPK على النمو والمحصول والتركيب الكيميائى لنبات حصالبان. أظهرت البيانات المتحصل عليها بوضوح أن إستخدام خليط من السماد العضوى والأسمدة الحيوية سجلت زيادة ملحوظة فى قياسات النمو للنبات، الهرمونات النباتية (الأوكسينات والجبريللينات والسيتوكينينات)، مكونات الزيت الطيار (1,8-Cineol, Camphor, α-Pinene, β– Pinene Bornyl acetate and Borneol) وبالإضافة إلى ذلك سجلت زيادة كبيرة في كلا من الوزن الغض والجاف فضلا عن زيادة فى محصول الزيت الطيار في النبات والتى تم فيها الجمع بين الأسمدة العضوية والحيوية مقارنة بالتسميد الكيميائى الموصى به .

تؤكد هذه النتائج بوضوح إلى أن خلط السماد العضوى(الكمبوست) بالأسمدة الحيوية يمكن أن تستخدم كبديل لإستخدام الأسمدة الكيميائية والتى تؤدى إلى زيادة جودة محصول نبات حصالبان كما ونوعا وبالتالي تقليل تلوث البيئة الزراعية.

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