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Comparative examination of the effect of manure and chemical fertilizers on yield and yield components of rosemary *(Rosemarinus officinalis L.)*

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Key words: Rosemary, Manure and chemical fertilizer, Yield and Essence.

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Abstract

In order to examine the effect of manure and chemical fertilizers on the some agronomic characteristics, yield and the amount of essence of rosemary, the experiment was carried out as randomized complete design with 9 treatments at 4 replications at in Sari city at 2013. Treatments were included witness (control), sheep and vermicompost fertilizers and chemical fertilizers of nitrogen and phosphorus at 6 different amounts which are N150-P150, N150-P200, N150-P250, N200-P150, N200-P200 and N200-P250. The results showed that the all agronomic traits were very significantly affected by the manure and chemical fertilizers compared to the control. The effect of the manure fertilizer was statistically more that chemical fertilizers on the all characteristics. The maximum plant height, leaf wet and dry weight, wet yield, dry yield and the amount of the essence of the plant were attained when manure fertilizers applied and the maximum stem wet and dry weight and the total number of the chain stems were also attained by chemical fertilizers. It showed that to increase the quality properties and the amount of the essence of the rosemary plant, the use of manure fertilizers is more effective than chemical fertilizers, statistically. Sheep fertilizers as the manure fertilizers increased all the traits and also the rate of essence significantly compared to vermin-compost fertilizers. Thus, sheep fertilizer can be recommended as the best treatment at the present study.

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Introduction

Medicinal plants due to the influence of physiologically active substances on organisms are given special status (Shrikumar and Ravi, 2007). In the meantime, the oil plants as part of medicinal plants due to aromatic compounds, are differentiated from other species (Bagheri *et al.,* 2006). Rosemary is one of the most valuable medicinal plants. Rosemary (*Rosmarinus officinalis*) of the family Labiate is evergreen woody aromatic herb with a characteristic aroma and lavender-like leaves. The plant is native of Mediterranean regions of Europe, Asia minor and North Africa. The leaves of Rosemary are also used for culinary purpose and are reported to possess antioxidant properties. It has been described as a medicinal plant and wonder-drug in various medieval drug monographs and literature. (Haji-Sharifi, 2005).

One of the most important needs in agricultural planning to achieve high yield and good quality, especially in the case of medicinal plants, plant nutrition evaluation of various systems. Researches show that excessive use of chemical fertilizers decreases crop yield that this decline is due to soil acidification, loss of biological activity in the soil, changes in soil physical properties and lack of micronutrients in agricultural land (Adediran *et al*., 2004). To reduce these risks, resources and inputs must be used that in addition to the current needs of the plant, followed sustainability of agricultural systems in the long term (Murty and Ladha, 1988). In this regard, consumption of organic fertilizers as input replaced chemical fertilizers and used in all agricultural land. Sheep manure as an important source of manure fertilizer, also, vermicompost is an important source of organic fertilizer, used it as nutrient, soil conditioner in sustainable soil management systems are common (Thomsen, 2001). Research on the effect of manure and vermicompost fertilizers has been increasing in recent years. An experiment was conducted on the use of organic fertilizers in Peppermint (*Mentha piperita* L.), yield in organic farming was about 80 percent more than the yield of conventional farming (Kalra, 2003). Various studies on some medicinal plants such as sweet basil (*Ocimum bacilicum*) and yarrow (*Achillea millefolium* L.) have shown that organic fertilizers compared to chemical fertilizers has a significant effect on yield and essential oil (*Scheffer* and *Koehler, 1993; El-Gendy et al., 2001).* Vermicompost soil has more nitrogen, phosphorus and potassium than surrounding soil. Add vermicompost to soil and substrates, increases plant growth (Atiyeh *et al*., 2000). Lotfi *et al*, (2008) reported that adding manure to the soil significantly increased the biomass of medicinal plants Psyllium (*Plantago ovata* Forssk.). *Also,* it was observed that the application of manure improved the essence of the herb salvia (*Silybum marianum* L.) (Kaplan *et al.,* 2009). The results of research on Roman chamomile (*Anthemis nobilis*) showed that the application of vermicompost improved the quality of essential oil (Luic and Pank, 2005). In another trial, presence of organic matter and micronutrients in the manure improved soil fertility and increased performance and physicochemical properties of Carum copticum (*Pimpinella anisum* L.) (Akbarinia *et al.,* 2003).

Considering the importance of rosemary plant in the pharmaceutical industry, medicine, cosmetics, health and antibacterial properties of rosemary on Escherichia coli and since there is few studies on the effect of chemical fertilizers and organic compounds on rosemary plant .This study aimed to evaluate use of chemical fertilizers (nitrogen and phosphorus), manure (from sheep) and vermicompost organic fertilizer on yield and its components and quantity of the active ingredients in the herb rosemary.

Material and methods

Description of experimental site and design

This research was carried out at spring of 2013 in Sari (38N, 53 E and 705m above sea level), Iran. Experimental field has Caspian mild and wet climate, average rainfall during the growing season (spring and summer), 94.5 mm and the average daily temperature is 31.19°C. At first, the soil of experimental field with sheep manure and vermicompost samples analysed to determine the amount of nutrients and physical and chemical

properties (table 1). The experiment was carried out as randomized complete design with 9 treatments at 4 replications. Treatments were included witness (control), sheep and vermicompost fertilizers and chemical fertilizers of nitrogen and phosphorus at 6 different amounts which are N150-P150, N150-P200, N150-P250, N200-P150, N200-P200 and N200-P250. Nitrogen was chosen as Urea (45% pure nitrogen) and phosphorus was also chosen as triple superphosphate fertilizer (46% phosphorus as P_2O_5). The amount of chemical fertilizers, sheep manure and vermicompost were determined regarding to Rosemary plant fertilizer needs (Each one 10t/ha) (Zargari, 1990).

Table 1. Nutrients amount and physical and chemical properties of vermicompost, sheep manure and experimental soil.

Soil texture	Cu (ppm)	Zn (ppm)	Mn (ppm)	Fe (ppm)	Mg (%)	Ca (%)	N (%)	K (ppm)	P (ppm)	O.C (%)	O.M (%)	pH	Electrical conductivity EC*10 (ds m-2)	Base percentage	Depth (cm)	Characteristics
Silty loam	0.7	2.6	11.3	15.1	400	-	0.128	137	14.3	1.28	2.20	7.4	3.5	40	0-30	Soil
-	21	43	428	1205	0.41	2.32	1.10	0.28	0.44	14.2	-	7.42	5.25	-	-	Vermicompost
-	19	25	290	1110	0.36	1.32	2.10	2.79	0.46	28.2	-	7.56	25.3	-	-	Sheep manure

Fertilization practices

About a month before transferring seedlings in plastic pots (15 of April 2013), the manure and vermicompost mixed with the soil in each pot to convert vermicompost organic matter and manure into absorbable mineral during a month before transferring seedling. Reticulated around pot to increase root growth by air conditioner, increase decomposition of organic matter by microorganisms in fertilizers and increased efficiency of uptake by plant roots. Due to the sudden absorption of minerals, nutritional shocks caused burn young seedling. On 15 May before planting rosemary seedlings, chemical fertilizers mixed with soil in pot, such as urea in 3 stages (early planted, early vegetative and early reproductive growth) and phosphorus fertilizer at planting time added to all pots soil. After fertilization, the seedlings were planted in each pot. Then all pots were placed outdoors in a field experimental. Growing stage such as irrigation and weed control was carried in the pots during the growing season.

Measurement parameters

Traits including plant height, number of sub-branches, leaf wet weight, stem wet weight, wet yield, dry yield, leaf dry weight, stem dry weight, and essential oil. Plant height, number of sub-branches were measured after the growth of the plant and flowering time. On 20 September, the plant was harvested 10 cm above soil surface of the pot, separated the leaves from the stems and leaves and wet weight and yield were calculated. To maintain the quantity and quality of plant, the samples were dried in shade at room temperature in 7 days. Leaf and stem dry weigh were measured separately and dry yield was determined. 100 gr of dried leaf powder of each sample was transported to the laboratory to determine essential oil. In order to extract the essential oil from the dried vegetative organs, steam distillation by Clevenger apparatus was used.

Statistical analysis

The obtained data were analyzed by MSTAT-C program. Data means were compared by Duncan's Multiple Range Test at P=0.05. The EXCEL Microsoft word was used for drawing of diagram.

Results

The results showed that all manure and chemical fertilizers treatments significantly affected on all traits compared to control pot. Both organic and chemical fertilizer (at various levels) increased morphological trait and essential oil content of Rosemary compared to control significantly (Table 1).

Comparison of the data showed that organic fertilizers significantly influenced on traits such as plant height, leaf wet weight, dry weight, leaf yield, dry yield and essential oil of rosemary compared to control and chemical fertilizer. The maximum plant height was observed in Sheep manure (44.5 cm) and vermicompost (41.5 cm) treatments respectively and minimum height (30.75 cm) was recorded in control treatment (Table 3). Other traits such as leaf weight (7.46 g), leaf dry weight (23.6 gr), wet yield (25.2587 kg), dry yield (1344 kg) and essence content (3.72 %) were reached in sheep manure treatments. However, all of the above traits in organic fertilizers (sheep manure and vermicompost), on average more than the chemical fertilizers treatments in the test. Among the chemical fertilizer treatments, (N = 150, P = 150) treatment had significant effected on most agronomic traits, yield and essential oil compared to the others.

Table 2. Mean square of the effect of used treatment on yield, yield components and essence content.

essential oil	dry yield	wet yield	leaf wet weight	leaf dry weight	stem wet weight	stem dry weight	number of sub-branches	plant height	df	Sources of variation
1.738**	197820**	570462.8**	261.029**	117.019**	91.267**	17.644**	19.625**	85.562**	8	Treatment
0.047	2503.491	1932.176	2.052	1.125	0.45	0.370	0.287	1.166	27	Error
8.671	4.927	2.043	4.298	7.360	3.280	5.526	3.230	2.817	-	coefficient of variation

‘**High significant at 1%.

Table 3. Mean comparison of the effect of used treatment on yield, yield components and essence content.

Essen-tial oil (%)	Dry yield (kg/ha)	Wet yield (kg/ha)	Stem dry weight (gr per plant)	Stem wet weight (gr per plant)	Leaf dry weight (gr per plant)	Leaf wet weight (gr per plant)	Number of sub-branches (Per plant)	Plant height (cm)	Treatment
1.55^{hi}	673.25^{hi}	1422.75^{i}	8.8^{h}	13.9^{i}	8.32^{ghi}	20.57^{i}	13.25^{h}	30.75^{gh}	Control
									Organic Fertilizer
3.02^{b}	1188^{b}	2366.5^{b}	9.77^{fg}	17.12^{fg}	19.92^{b}	42.01^{b}	14.5^{f}	41.5^{b}	Vermicompost
3.72^{a}	1344^{a}	2587.25^{a}	10^{ef}	18^{f}	23.6^{a}	46.7^{a}	16.5^{de}	44.5^{a}	Sheep manure
3.37	1266	2476.87	9.88	17.56	21.76	44.35	15.5	43	Total Average
									Chemical Fertilizer
2.9^{bc}	1164.25^{bc}	2362.25^{bc}	11.07^{d}	21.9^{d}	18.03^{c}	37.12^{c}	17.5^{bc}	41^{bc}	N150+P150
2.45^{de}	1074^{de}	2292.25^{d}	12.87^{b}	25.87^{b}	14.02^{e}	31.4^{e}	18.25^{b}	39^{d}	N150+P200
2.2^{efg}	977^{f}	2216^{efg}	15.02^{a}	26.95^{a}	9.42^{g}	28.42^{g}	20.25^{a}	37.25^{ef}	N150+P250
2.57^{d}	107^{6d}	2276^{de}	10.7^{de}	20.42^{e}	16.2^{d}	36.47^{cd}	17.25^{cd}	41.5^{b}	N200+P150
2.37^{def}	952^{fg}	2222^{ef}	12.35^{bc}	24.85^{c}	11.45^{f}	30.7^{ef}	17.5^{bc}	38^{de}	N200+P200
1.77^{h}	689.75^{h}	1617.75^{h}	8.47^{hi}	15.02^{h}	8.75^{gh}	26.55^{gh}	14.25^{fg}	31.5^{g}	N200+P250
2.37	988.83	2164.37	11.74	22.50	12.97	31.77	17.5	38.04	Total Average

* Numbers with at least one common letter are statistically significant at the 5% level, no significant differences.

Discussion

Ghasempour-Alamdari (2005) stated that the micronutrients and base fertilizers had significant effect on some characteristics such as height, biomass and yield. Significant differences in organic fertilizer compared to chemical fertilizer on the agronomic traits such as height, leaf wet weight, dry weight, leaf wet yield, dry yield and essential oil in Rosemary plant is because of high concentration of nutrients in organic fertilizer (Table 1). The total average of electrical conductivity, total nitrogen, organic carbon content, percentage of potassium and micronutrients (Fe, Zn, Cu, Mn) in organic fertilizers is more than chemical fertilizers that increased quantity of agronomic traits.The results showed that all of the measured characteristics were significantly

influenced by organic fertilizer with the use of sheep manure, which is of high levels of electrical conductivity, organic carbon and potassium in it. Organic treatments with gradual supply of nutrients increased plant height. Due to high levels of nutrients, especially nitrogen in manure fertilizer than other treatments in this experiment, due to stimulate vegetative growth, plant height in these treatments (manure fertilizer) increased. Yadav *et al* (2003) reported that manure fertilizer increased height of medicinal plant *Plantago Psyllium*. Also Norman and Arancon (2006) stated manure fertilizer increased vegetative growth and plant height in strawberries plant. Azizi *et al* (2007) reported that different levels of vermicompost had a significant effect on *Ocimum basilicum* plant height. Nutrient deficiency is one of the main factors in determining plant height (Sing and Chauhan, 1994), it seems that lower growth in control treatment due to lack of nutrient. While organic treatments stimulate plant growth and nutrient supply that increase height of Rosemary plant. Thus it can be stated that chemical and physical properties of humic acid in an organic fertilizer (vermicompost) by increasing the capacity of nutrients, regulating growth hormones and activity of microorganisms enhanced accumulation of nitrogen in plant (Arancon *et al.*, 2005; Arancon *et al.*, 2004). Also our results on the effects of vermicompost with the results obtained by Atie (2002) corresponded.

Adding manure in soil improve soil physical and biological conditions. Also, by creating a more favorable environment for root growth and nutrient availability, increased plant growth and dry matter (Kaplan *et al.*, 2009; *Scheffer* and *Koehler, 1993*; Biasi *et al*, 2009). Manure improved soil physical properties, finally, better root growth, better plant growth and biological yield. On the other hand, the growth of shoots with increasing manure fertilizer could be due of microorganisms activity in soil (Gryndler *et al.*, 2008). Development of mineral nutrients in the manure increased root growth, absorption and nutrients, ultimately leading to increased plant yield (Tinca *et al.*, 2007). Lotfi *et al* (2008), reported that 40 tons of manure per ha significantly increased the biomass of *Plantago Psyllium*. Vermicompost and organic fertilizer by making positive changes in physical and chemical properties of soil, supply nutrients of plants during the growing seasons, can provide optimal conditions for plant weight. Research on the pepper plant showed that vermicompost increased shoot dry weight (Leithy *et al.*, 2006; Arancon *et al.*, 2004). High levels of organic matter, increase soil water capacity, improvement activities of auxin and generally improve the chemical and physical structure of the seed bed, among the reasons to increase plant yield due to vermicompost fertilizer (Bachman and Metzger, 1998).

According to results, yield and essential oil of rosemary in manure fertilizer treatments were more than vermicompost, because electrical conductivity, carbon and potassium were higher. Thus it can be stated that the amount of potassium and nitrogen in manure fertilizer are able to increase the amount of essential oil. Also in manure fertilizer nutrients decomposes rapidly and absorbed by plant roots easily but the nutrients in vermicompost needs more time to decompose and absorb by roots. Khaled and Shafei (2005) in a research about effect of manure fertilizer on essential oil of (*Anethum graveolens*) reported that 30 tons of manure fertilizer improved the amount of oil about 30%. In other research, 20 tons of manure fertilizer increased essential oil content and yield of *Coriandrum sativum* plant (Salem and Awad, 2005). Santos (2008) stated that increasing amounts of manure fertilizer improved essential oil content and yield of *Melissa officinalis* plant. Also vermicompost fertilizer and chemical treatment (N_{220}-P_{200}) increased essential oil after manure treatment significantly. In accordance with our results, Ajay *et al* (2005) stated 10 tons of manure fertilizer with 20 kg N improved essential oil of *Withania somnifera* plant. Also Kaplan *et al* (2009) reported improvement in Salvia officinalis essential oil by manure treatment. These results also reported by Kocabas *et al.*, (2010) and Azzaz *et al.*, (2009) in other plants. Letchamo and Marquard (1993) experiments showed, increased levels of nitrogen can

increase the amount of essential oil in *Matricaria chamomilla* plant. These results in agreement with Meawad *et al.,* (1984) stated high or low nitrogen content reduced significantly of *Carum carvi* seeds yield. In addition, the high nitrogen content reduced essential oil. In a study on *Artemisia* absinthium Ozgoven *et al.,* (2008) concluded, increase levels of nitrogen fertilizer increased essential oil and maximum amount of essential oil obtained by 80 and 120 kg nitrogen. Also other research results showed improvement of oil essential of *Ocimum basilicum* (Azizi *et al.,* 2004) and *Roman chamomile* plant (Liuc and Pank, 2005).

Some characteristics, as number of branches, shoot wet weight and shoot dry weight were affected significantly by chemical fertilizers compared to manure fertilizer and control treatment. These results are because of rapid effects of chemical fertilizers, especially phosphorus fertilizer on stem and branch number. In this experiment, the maximum number of branches obtained (25.20) in chemical fertilizer (N150-P250) and lowest number achieved in the control treatment (25.13) that had significant differences with other treatments. Borghei *et al.,* (2011) reported that 25% of manure fertilizer with 75% of chemical fertilizer treatments had the highest number of lateral branches, 100% manure fertilizer, had the lowest number of lateral branches. Since phosphorus element had maximum absorption during early plant growth, had effected on number of stems and branches and in some plants such as bean on tillering stage. Also because of the heat and light in summer (stem elongation stage in plants), nutrients in fertilizers were used to produce more stems and stalks weight. On the other hand, the presence of light and heat, auxin in the shoot apex decomposed and transported to the lower stem caused growth, produced branches and increased production of wet and dry weight of stem (Havlin *et al.*, 2003 and Ewulo, 2005). Absorption and rapid transfer of nutrients in chemical fertilizers treatment in this experiment increased root growth in early growth and ultimately increased the number of lateral branches. Also, other researchers stated nitrogen increased levels of green photosynthetic, this caused more production and transfer of photosynthesis, growth hormone stimulator to apex and lateral. As a result, all these factors increased stimulation of apex and lateral branches and increased production of nitrogen in higher levels (Fathi *et al.,* 2002 and Hassani Malayeri, 2004). Also, the number of lateral branches in organic fertilizers treatments reduced because of slow decomposition, food plants need persists so suitable substrate could not provide for root growth and number of lateral branches.

Among chemical fertilizer treatments, (N_{150}-P_{150}) treatment had a significant effect on characteristics such as plant height, leaf dry weight, wet and dry yield and amount of rosemary essential oil compared to other treatments, so that at the highest levels than organic fertilizer. In an experiment on *Dracocephalum moldavica* plant highest leaf dry matter yield obtained in chemical fertilizer treatment (Rahimzadeh *et al.,* 2011). In a study *Hypericum perforatum* dry matter yield increased significantly by chemical fertilizer (Mallanagouda, 1995). Thus it can be concluded that 150 kg of nitrogen and phosphorus fertilizers compared to other fertilizer treatments better to increase the yield and essential oil of rosemary plant. When amount of nitrogen and phosphorus increased yield and essential oil reduced. So that, taking 200 kg N and 250 kg phosphorus (N200-P250), all characteristics reached their lowest level. The amount of nitrogen and phosphorus for rosemary plant according to the soil nutrients was at critical levels. In the research on *Tanacetum parthenium* plant (Tanacetum parthenium), results showed that low level of chemical fertilizer produced more biomass and increased the amount of chemical fertilizer reduced biomass to 23% (Tindal *et al.*, 2002). *Matricaria recutita* had good response to NPK fertilizers in large quantities, but was sensitive to P (Pourohit and Vyas , 2004).

In general results showed, most agronomic traits such as plant height, leaf wet weight, dry weight, leaf wet yield, dry yield and essential oil of rosemary plant influenced by organic fertilizers, especially sheep

manure that had significant differences compared to control and chemical fertilizers. Among chemical fertilizer,(N_{150}-P_{150}) treatment had significant difference on most agronomic traits and essential oil yield compared to other chemical treatment. Since the maximum dry weight, yield and essential oil of rosemary achieved thus, the use of sheep manure, (10 tons per hectare) can be conclouded as the best treatment in the current study.

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