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Comparison of the Effect of Organic and Chemical Fertilizers on Yield and Essence of Peppermint (*Mentha piperita* L.)

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

This study compared organic and chemical fertilizers on qualitative yield and essence content of peppermint. The experiment was carried out as Randomized Complete Design in Agricultural Farm Center, Sari, Iran, in 2013. The treatments were as control, vermicompost, composed sheep manure and basic chemical fertilizers at N60, P50, K60; N60, P80, K60; N90, P50, K80 and N90, P80, K80, and replicated four times. The results showed that all the measured characteristics were significantly ($p<0.05$) influenced by both organic and chemical fertilizers at the two harvest times. The values of the quantitative (wet and dry yield) and qualitative characteristics (essence content and essence yield) were also more at the first harvest than the second harvest. At the first harvest, the maximum value for dry and wet yield, and the maximum essence value and its yield were attained by using both sheep manure and chemical fertilizers at the rate of N90, P80, K80. The highest value for dry (96 kg ha^{-1}) and wet (207 kg ha^{-1}) yield, and yield (0.46 lit ha^{-1}) and content of essence (0.48 g/100 g) were obtained with vermicompost. The values obtained for vermicompost and sheep manure were not significantly different. Application of sheep manure and vermicompost as organic fertilizer was recommended for production of peppermint. Whereas essence content and yield for first harvest were significantly higher than other treatments and control.

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1. INTRODUCTION

Peppermint is one of the restricted medicinal plants for the human healthy. Essence is an essential oil found in peppermint as (1-2%), Tannin, Flavonoid, Colien and bitter materials. Chemical compounds of essence in peppermint leaves is more than 20 types which include Menthol (40-60%), Menthofuran, Menthone, Piperitone, Pulegone and Cinneole. The chemical composition of essence is controlled by growth restrict factors such as warm or cool stresses, soil nutrients deficiency, water deficiency among other factors [1]. An adequate nutrient and water supply into the soil is needed for healthy growth and production of effective materials for medicinal plant especially aromatic and essence-bearing plants like peppermint. Some of macro and microelements such as N, P, K, S, Fe and Zn are necessary for suitable growth and increase essence content and wet or dry yield of medicinal plants. Use of chemical fertilizer and manure organic fertilizers is recommended for supply of adequate and balanced macro- and micro-nutrients [2]. About 30% of the agricultural soils of the world face micro-elements deficiency [2]. In addition to the frequent use of superphosphate fertilizers the plantation at short intervals also causes a decrease in the density of micronutrients in arable soils. The plant growth is also affected in soils deficient in micronutrients even the use of N, P and K fertilizers cannot help in increasing the plant yield. By observing the plant growth one can evaluate the micronutrient deficiency. Each element has a role in the plant nourishment and certain types of crop plants are susceptible to stunted growth if the required micronutrients are not made available. Mehrafarin [3] reported that the maximum wet and dry yield of peppermint was attained when nitrogen fertilizer as bio-fertilizer applied at the rate of 8 kg ha^{-1}. Niyakan [4] observed that the use of both nitrogen and phosphorous fertilizers increase essence content and also leaf surface of the peppermint plant. Mahmod [5] reported that the use of nitrogen fertilizer as urea and phosphorous as superphosphate triple increased dry matter and essence yield of peppermint. Daramol [6] expressed that biomass yield and dry weight of peppermint increased by using compost and manure fertilizer at the rate of 1-2 kg and 250-500 g per pot with 20 kg soil, respectively. The use of chemical fertilizers in the arable soils of the world is imbalanced and does not take into account the actual necessary need of the crop plant or the nature of the soil. The study determines the effects of organic and inorganic fertilizers on essence content and yield of peppermint plant.

2. MATERIALS AND METHOD

The experiment was carried out in Sari Agricultural Farm, Dodangeh Region (long. 52^0 15' E. to lat. 36^0 15' N), in northern part of Iran in 2013, where the general altitude is 700 m above the sea level. The mean precipitation and daily mean temperature during growth season of peppermint plant in the studied region was 94.5 mm and 31.19 ^{0}C, respectively. The experiment was carried out as randomized complete design with 7 treatments and 4 replications. Treatment were as control, vermicompost, composed sheep manure and basic chemical fertilizers which were N60,P50,K60; N60,P80,K60; N90,P50,K80and N90,P80,K80. Nitrogen, phosphorous and potassium fertilizers had been chosen as urea (equals 46% net N), triple superphosphate (equals 45% P_2O_5) and potassium sulfate (equals 48% K_2O), respectively. Soil physical and chemical properties were determined. Nutrient contents of sheep manure and vermicompost were also determined (Table 1).

Peppermint seedlings were raised in pots (size 30*40cm^2) in May 2013. Each pot was filled 10 kg soil and chemical fertilizer (were chosen as treatments), sheep and vermicompost fertilizers (both at the rate of 20 ton ha^{-1} equals 80 g per pot) were also added in per selected pot as treatment. Pots were irrigated two times per week and were also weeded out during growth period. First and second harvest times were carried out in August and November, respectively. Essential oil content was determined by hydro distillation method by submitting aerial part of dried plants (100g) in modified a British-type Clevenger's apparatus system model 7890 A. After 3 hours distillation was stopped so essential oil ratio was measured by using dry yield (biomass yield) of peppermint. The measured characteristics was included wet yield, dry yield, the content of essence and essence yield at two harvest times. Data were subjected to analysis of variance technique (ANOVA) by using Microsoft-MSTAT-C (word 2010) and the mean differences were separated by Duncans' multiple range tests (DMRT) at the level of 5% probability [7].

Table 1a. Elements content and chemical and physical properties of the studied soil

Properties	Depth (cm)	Base saturation (%)	E.C (ds m-1)	pH	Organic matter (%)	Organic carbon (%)	P (mg kg -1)	K (mg kg -1)	N (%)	Ca (%)	Mg (%)	Fe (mg kg -1)	Mn (mg kg -1)	Zn (mg kg -1)	Cu (mg kg -1)	Soil texture
	0-30	40	3.5	7.4	2.2	1.28	14.3	137	0.128	-	0.04	15.1	11.3	2.6	0.7	Sand-Loam*

**,Clay 10%, Sand 60% and Silt 30%*

Table 1b. Elements content and chemical and physical properties of the sheep and compost fertilizers

Properties	E.C (ds m-1)	pH	Organic matter (%)	Organic Carbon (%)	P (mg kg -1)	K (mg kg -1)	N (%)	Ca (%)	Mg (%)	Fe (mg kg -1)	Mn (mg kg -1)	Zn (mg kg -1)	Cu (mg kg -1)
Vermicompost	5.25	7.42	24.42	14.2	0.44	0.28	1.1	2.32	0.41	12.5	428	43	21
Sheep	25.3	7.56	48.5	28.2	0.46	2.79	2.1	1.32	0.36	1110	290	25	19

3. RESULTS AND DISCUSSION

The results showed that treatments had significant effects on all the measured characteristics of peppermint at first and second harvest (Table 2). It means that all organic and chemical fertilizers increased wet and dry yield and the content and yield of essence significantly at two harvest times. Coefficient of variation was less than 14% at all the measured characteristics which is that the experiment was carried out carefully.

Inorganic fertilizers affected on all the measured characteristics significantly at the level of 5% compared to the control pot. The effect of nitrogen fertilizer on these properties was more than other element which exists in the fertilizers. The result of the current study was in agreement with observations by Mahmod [5]. They investigated the effect of nitrogen fertilizer on the growth and essence yield of peppermint and observed that dry matter and essence yield were significantly increased when nitrogen fertilizer was applied. Nitrogen element is absent in the essence composition, but the use of this element causes increasing extraction gland of essence in the leaves of peppermint [8]. This was attributed to increased production and consumption of simple glucoses for vegetative growth and leaf production [9].

Comparison of the qualitative and quantitative characteristics of peppermint at second harvest, were lower than first harvest time, statistically (Table 3). It was due to less vegetative growth period, less sunlight and temperature content and less photosynthesis and gross production at second harvest time. The maximum wet (2657 kg ha-1) and dry (524 kg ha-1) yield were obtained by chemical fertilizer at 90-80-90 for first harvest time. Increasing quantitative yield of peppermint by chemical fertilizer was because of readily availability of nitrogen, which increases vegetative growth, leaf surface and the number of extraction gland. The maximum percentage of essence (3.15) and essence yield (14 liter ha^{-1}) was observed with sheep manure at first harvest time which could be due to higher E.C, O.M, O.C, N, P, K and Fe content in sheep manure compound compared to other in Table 1. Microelements are involved in chemical compound of essence. As shown in Table 3, all the measured characteristics such as wet and dry yield, and the content of essence and yield were influenced when manure fertilizers were applied. The highest value for dry (96 kg ha^{-1}) and wet (207 kg ha^{-1}) yield, and yield (0.46 lit ha^{-1}) and content of essence (0.48 g/100 g) were obtained with vermicompost, but had no significantly difference with the values obtained by sheep manure. Manure fertilizer would have decomposed and released microelements gradually during first harvest might have been more available uptake before the second harvest. On the other hand, decomposing and releasing nutrient elements of vermicompost fertilizer take more time compared to chemical

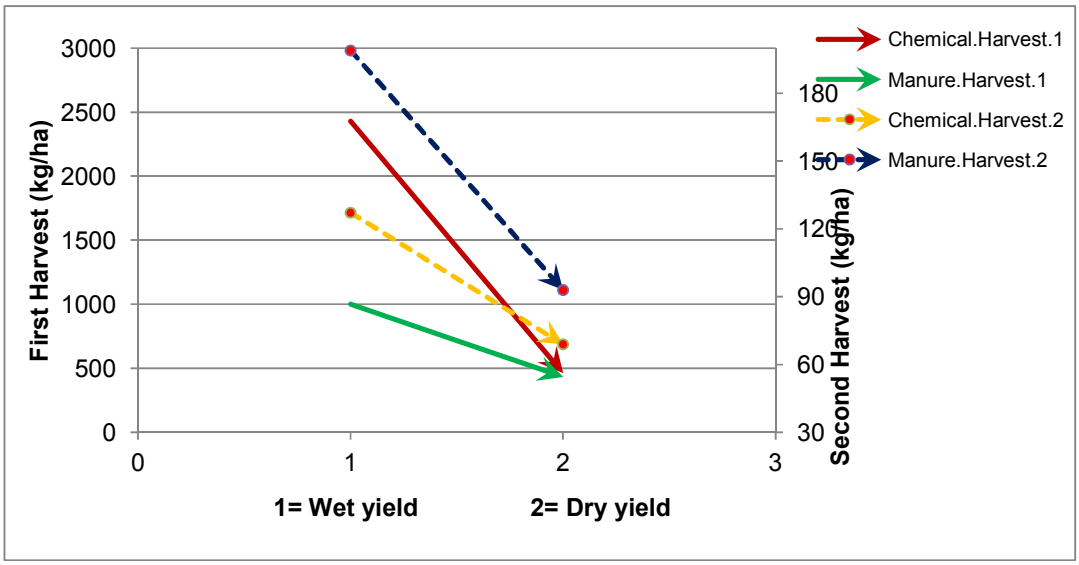

Fig. 1. Mean wet and dry yield of peppermint under the effect of chemical and organic fertilizers at first and second harvest times

Table 2. Square mean of the effect of chemical and organic fertilizers on wet and dry yield and the content and yield of essence of peppermint at different harvest times

S.O.V	Df	Wet yield (first harvest)	Wet yield (second harvest)	Dry yield (first harvest)	Dry yield (second harvest)	Essence content (first harvest)	Essence content (second harvest)	Essence yield (first harvest)	Essence (yield second harvest)
Treatment	6	2747722**	6740.3**	33161**	1060.9**	0.7157**	0.0124**	44.365**	0.045**
Error	21	6.16507	23.774	723.21	23.464	0.0395	0.0029	0.9787	0.001
C.V(%)	0	7.22	3.39	6.36	6.61	7.84	13.85	9.11	13.65

***: very significant at the level of 1%*

Table 3. Mean comparison of wet and dry yield and the content and yield of essence of peppermint at different harvest times under the influence of chemical and organic fertilizers measured traits

Treatments	Wet yield first harvest(kg ha-1)	Wet yield second harvest (kg ha-1)	Dry yield first harvest (kg ha-1)	Dry yield second harvest (kg ha-1)	Essence content first harvest(g/100g)	Essence content second harvest(g/100 g)	Essence yield first harvest (lit ha-1)	Essence yield second harvest (lit ha-1)
Control pot	704g$^{}$	99^{g}	234^{g}	49.5^{g}	1.85^{g}	0.33^{cde}	4.32^{g}	0.16^{fg}
Vermicompost	1042^{e}	207^{a}	423^{cde}	96.8^{a}	2.2^{f}	0.48^{a}	9.29^{f}	0.46^{a}
Sheep manure	981^{ef}	191^{b}	446^{bc}	90a^{b}	3.15^{a}	0.45^{ab}	14^{a}	0.41^{ab}
Mean Manure	1002.5	199	434.5	93.4	2.67	0.46	11.64	0.34
N60-P80-K60	2241^{bcd}	113^{ef}	419^{cdef}	60.8^{f}	2.65^{bc}	0.35^{cd}	11.1^{d}	0.21^{def}
N60-P50-K60	2410^{ba}	136^{d}	432^{cd}	68.8^{de}	2.5^{cde}	0.35^{cd}	10.8^{de}	0.24^{cde}
N80-P50-K90	2414^{b}	145^{c}	479^{b}	76.3^{c}	2.85^{b}	0.38^{bc}	13.6^{ab}	0.28^{c}
N80-P80-K90	2657^{a}	115^{e}	524^{a}	70.3^{cd}	2.55^{bcd}	0.38^{bc}	12.8^{abc}	0.26^{cd}
Mean Chemical	2430.5	127.25	463.5	69.05	2.63	0.36	12.07	0.24

Mean along column with the same letter are not significantly different ($p < 0.05$).

and sheep manure fertilizers consequently. Vermicompost affected on peppermint at second harvest time and increased quantitative and qualitative yield and essence percentage and its yield. Dalvand [10] and Mehrafarin [3] have investigated the effect of bio and manure fertilizers on morphological traits and essence content of peppermint and observed that these fertilizers increased dry yield and the percentage of essence, which was in agreement with the results obtained for the current study. The maximum essence percentage was chemical fertilizer as 90-50-80 compared to the other chemical fertilizers was cause of existence of more nitrogen and potassium elements in this treatment. These findings are in agreement with those reported by Niyakan [4], who reported that wet and dry yield and also the content of essence were increased using nitrogen and potassium elements. The positive effect of nitrogen on wet and dry weight was attributed to its chemical compound of some molecules like Protein, amino acid and nucleic acid [11,12]. So at the first harvest time, quantitative yield (wet and dry yield) was influenced by chemical fertilizers due to existent of more nitrogen (organic carbon= 28%) and potassium content in this fertilizer, and qualitative yield (the content and yield of essence) was affected when organic fertilizer especially sheep fertilizer was applied due to high in the fertilizer compared to other ones. Some researchers such as Clark [13], Singh [14], Fernander [15], Gerder [16] and Arabasi [17] observed that nitrogen fertilizer increased the content essence of some medicinal plants which was in agreement with the result of the present research. Considering the mean comparison (Table 3), the content of essence of peppermint chemical fertilizer than manure fertilizer for was lower for the second harvest with. The content of essence at second harvest time was less than first with chemical fertilizer. For example, the content of attained essence by vermi-compost and chemical fertilizer (as 60-80-60) at second was decreased 1.7% and 2.2% compared to first harvest time, respectively. Mean wet yield of peppermint affected by chemical fertilizer was 2.5 times higher than organic fertilizer (1002 kg ha^{-1}) at first harvest (Fig. 1). Mean dry yield of peppermint affected by chemical fertilizer (463.5 kg ha^{-1}) was slightly higher with than affected by organic fertilizer (434.5 kg ha^{-1}) at first harvest. On the other hand, mean dry yield by chemical fertilizer was 20% of mean wet yield while it was 50% for organic which the required amount for agronomic and medicinal plants. It can be concluded that great part of wet weight of peppermint plant which was influenced by chemical fertilizer is included water and dry yield content will be much lowered after drying. Mean wet and dry was affected by organic fertilizer was more than chemical fertilizer at second harvest time.

4. CONCLUSION

The study concluded that wet and dry weight of peppermint plant was influenced by chemical fertilizer at first harvest while it was increased by organic fertilizers at second harvest. Essence content and yield were improved by sheep manure at first harvest compare to the second harvest. The second harvest was significantly lower than the first harvest. Mean dry yield by chemical fertilizer was 20%of wet yield at first harvest while it was 50% for organic. It was 50% of wet yield with both organic and chemical fertilizers at second harvest.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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