Comparative of the effect of organic and chemical fertilizers on yield and essence of peppermint (*Mentha piperita* L.)

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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 the all measured characteristics were significantly (at the level of 5%) influenced by both organic and chemical fertilizers at the two harvest times. The values of the quantitative (wet and dry yield) and qualitative (essence content and essence yield) characteristics 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. Some characteristics like dry (96 kg ha^{-1}) and wet (207 kg ha^{-1}) yield and the content of the essence (0.48 g/100g) and essence yield (o.46 lit ha^{-1}) were increased at the maximum values by vermicompost at the second harvest. Thus, regarding to the maximum achieved values for dry and wet yield and also essence content and its yield by vermicompost, the use of it can be recommended for peppermint as organic fertilizer.

Key words: Organic and chemical fertilizer, Yield, Essence, Peppermint.

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 [14]. An adequate nutrient and water supply into the soil is needed for healthy growth and produce more effective materials for medicinal plant especially aromatic and essence-bearing plants like peppermint. Among the essential elements macro and also micronutrients such as N, P, K, S, Fe and Zn are necessary for suitable growth and increase essence content and wet or dry yield of medicine plants. Use of chemical fertilizer and manure organic fertilizers is recommended for supply of adequate and balanced macro- and micro-nutrients [15]. About 30% of the agricultural soils of the world face micro-elements deficiency [15]. 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 [12] reported that the maximum wet and dry yield of peppermint was attained when nitroxin fertilizer as bio-fertilizer applied at the rate of 8 kg ha^{-1}. Niyakan [13] observed that the use of both nitrogen and phosphorous fertilizers increase essence content and also leaf surface of the peppermint plant. Mahmod [10] reported that the use of nitrogen fertilizer as urea and phosphorous as superphosphate triple increased dry matter and essence yield of peppermint. Daramol [5] 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. Thus, regarding to the effects of different fertilizers on qualitative and quantitative characteristics of medicinal plants, the present research is devoted more to the study of chemical and manure fertilizers on quantitative yield (wet leaves and stems weight, dry leaves and stems weight) and essence content of peppermint plant.

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 are N60,P50,K60; N60,P80,K60; N90,P50,K80 and 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. Initially, the studied soil and sheep and vermicompost (as plant sources) fertilizers were tested at laboratory to determine the element contents and other their chemical and physical properties which are shown in Table 1.

Table 1 a. 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 1 b. 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

All studied plants as seedling were cultivated into the pots (size 30*40cm^2) in May 2013 was located on the farm (outdoor condition). 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, 2013. 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 analyzed as the analysis of variance technique (ANOVA) by using Microsoft-MSTAT-C (word 2010) and the mean differences were adjudged by Dancans' multiple range tests (DMRT) at the level of 5% probability [8].

RESULT AND DISCUSSION

The results showed that treatments had significant effects on all the measured characteristics of peppermint was very significant at the 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 showed the experiment was carried out carefully.

The results showed that nitrogen element existing chemical and 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 is more than other element which exists in the fertilizers. The result of the current study was in agreement with observations by Mahmod [10]. They investigated the effect of nitrogen fertilizer on the growth and essence yield of peppermint and announced that dry matter and essence yield were significantly

increased when nitrogen fertilizer was applied. There is not nitrogen element into the essence composition, but the use of this element causes increasing extraction gland of essence at the leaves of peppermint [11]. It is because of producing and consuming of simple glucoses and increase vegetative growth and developing leaf surface [2].

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%.

Comparative of the qualitative and quantitative characteristics of peppermint at second harvest time 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 of peppermint obtained by chemical fertilizer at 90-80-90 for first harvest time. Increasing quantitative yield of peppermint by chemical fertilizer was because of readily available of nitrogen, which increase 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 attained by sheep manure at first harvest time that is because of existence of more E.C, O.M, O.C, N, P, K and Fe content in sheep manure compound compared to other fertilizers. Microelements are involved in chemical compound of essence. As it can be seen 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 maximum values of these characteristics are related to vermicompost fertilizer due to existence of more microelements at its compound. This fertilizer would have decomposed and released microelements gradually during first harvest might have been more available uptake before the second harvest. On the other word, decomposing and releasing nutrient elements of vermicompost fertilizer take more time compared to chemical 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 [4] and Mehrafarin [12] 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, 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 [13]. They reported that wet and dry yield and also the content of essence were increased using nitrogen and potassium elements at more content compared to the less content. 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 [9,17]. 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 which is because presence of more microelements fertilizer compared to other ones. Some researchers such as Clark [3], Singh [16], Fernander [6], Gerder [7] and Arabasi [1] 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 harvest chemical fertilizer. For example, the content of attained essence by vermi-compost and chemical fertilizer (as 60-80-60) at second harvest decreased 1.7% and 2.2% compared to first harvest time, respectively. As can be seen in Fig.1, mean wet yield of peppermint affected by chemical fertilizer (2430 kg ha^{-1}) 2.5 times more than organic fertilizer (1002 kg ha^{-1}) at first harvest time. Mean dry yield of peppermint affected by chemical fertilizer (463.5 kg ha^{-1}) was a little more than affected by organic fertilizer (434.5 kg ha^{-1}) at first harvest time. On the other word, mean dry yield by chemical fertilizer was 20% of mean wet yield; while it was 50% for organic fertilizer 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 yield affected by organic

fertilizer is more than chemical fertilizer at second harvest times, but attained mean dry yield by both organic and chemical fertilizers are about 50% of wet yield.

Table-3. Mean comparison of wet and dry yield and the content and yield of essence of peppermint at different harvest times under the effect 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/100g)	Essence yield first harvest(lit ha^{-1})	Essence yield second harvest(lit ha^{-1})
Control pot	704^{g*}	99^{g}	234g	49.5^{g}	1.85^{g}	0.33^{cde}	4.32g	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}	90^{ab}	**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**

A given means per each column with the same letters, have not significant difference, statistically ($p<0.05$).

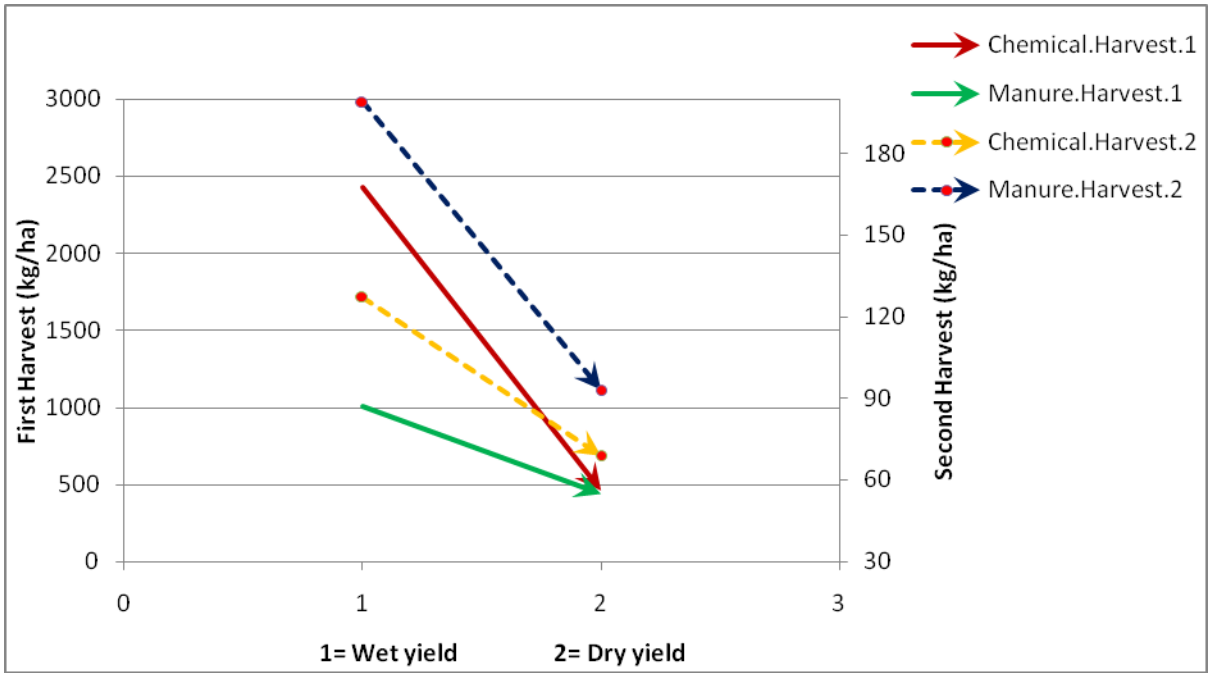

Fig.1 Mean wet and dry yield of peppermint under the effect of chemical and organic fertilizers at first and second harvest times

CONCLUSSION

Basic chemical fertilizers means N, P and K and increased significantly wet and dry yield and the content of essence and its yield of peppermint compared to the control pot at both two harvest times. It is because of continuing vegetative growth, leaves surface developing, increasing extraction gland of essence and finally increasing essence production by N, P and K elements. Organic fertilizers means vermicompost and sheep manure also increased significantly all the measured characteristics of peppermint

compared to the control pot at both two harvest times. The maximum wet and dry yield and maximum essence content and its yield of peppermint was obtained by chemical fertilizer as 90-80-80 and organic fertilizer as sheep manure at first harvest time, respectively. All the measured characteristics were also attained when vermicompost fertilizer applied at second harvest time that is because of gradual composition and release the nutrients of vermicompost at this time. Thus, to obtain the maximum content of the essence and its yield for peppermint as medical plant, the use of vermin-compost is recommended as organic fertilizer.

ACKNPWLEDGMENT

The authors are thankful from all person or institutes who helped them to do the present study.

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