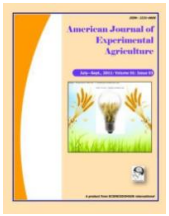

American Journal of Experimental Agriculture
6(4): 251-257, 2015, Article no.AJEA.2015.084
ISSN: 2231-0606

SCIENCEDOMAIN *international*
www.sciencedomain.org

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

Z. Sheykholeslami[1], M. Qasempour Almdari[1*], S. Qanbari[1] and M. Akbarzadeh[2]

[1]Department of Agronomy, Qaemshahr Branch, Islamic Azad University, Qaemshahr, Iran.
[2]Department of Botany, Mazandaran Agricultural and Natural Resources Research Center, Sari, Iran.

Authors' contributions

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

Article Information

DOI: 10.9734/AJEA/2015/14953
Editor(s):
(1) Vladimir K. Mukhomorov, Agrophysical Institute, 14 Grazhdanskiy Ave., Russia.
Reviewers:
(1) Changbing Yu, Oil Crops Research Institute, Chinese Academic of Agricultural Science, China.
(2) Raúl Leonel Grijalva Contreras, Instituto Nacional de Investigaciones Forestales Agrícolas y Pecuarias. Mexico.
Complete Peer review History: http://www.sciencedomain.org/review-history.php?iid=866&id=2&aid=7459

Original Research Article

Received 29th October 2014
Accepted 25th November 2014
Published 26th December 2014

ABSTRACT

The current study examined the effect of chemical and organic fertilizers on yield components and essence content of peppermint (*Mentha piperita* L.). The experiment was carried out in randomized complete design with 7 treatments and 4 replications in Sari Agricultural Research Center, Iran, in 2013. Treatments were: 1-control, 2-sheep manure, 3-vermicompost, and basic chemical fertilizers at different contents as 4-N60,P50,K60 kg ha^{-1} which equals 0.24, 0.2 and 0.24 g per pot, respectively), 5-N60,P80,K60, 6-N90,P50,K80 and 7-N90,P80,K80. There were 28 pots that 10 kg soil was added to each of those and chemical fertilizer (at determined rates), sheep manure and vermicompost fertilizers (both at the content of 20 ton ha^{-1} equal 80 g per pot) were also added in per selected pot as treatment. The results showed that the effect of all treatments was very significant on the all agronomic properties and yield of peppermint. Some agronomic and quantitative traits of peppermint like plant height, number of chain, stem wet and dry weight, leaves wet weight and total wet and dry weight were obtained at the maximum values when basic chemical fertilizers was applied at the rate of 90-80-80. The maximum number of stems, number of flowers, number of suckers, leaves dry weight and essence content were also attained by sheep manure. Thus, to prevent soil, plant and finally environment pollution by using chemical fertilizers

**Corresponding author: E-mail: ghasempour3m@yahoo.com;*

and also to achieve the maximum leaves dry weight and essence content of peppermint, application of sheep manure as organic fertilizers is recommended.

Keywords: Vermicompost; sheep manure; chemical fertilizer; yield; essence; peppermint.

1. INTRODUCTION

Medicinal plants are included most sources of secondary metabolites which provides effective material of some drugs. Biosynthesis of secondary metabolites will be controlled by genetics and also climate factors [1]. An effective material of peppermint plant is included essence as essential oil (1-2%), Tanon, Flavonoid, Colien and bitter materials. Medicine effects of this plant is concerned to chemical compounds of essence in leaves which is more than 20 types such as Menthol (40-60%), Menthofuran, Menthone, Piperitone, Pulygone and Cineole. So, the factors which affect on the essence content of the plant; must be attended as growth restricted factors like warm or cool stresses, nutrient deficiency into the soil, water deficiency and the other factors. [1] Investigation of the plant nutrition is one of the most important programs in the management of crop plant cultivation especially medicinal plants. An adequate nutrient and water supply into the soil is needed to healthy growth and produce more effective materials for medicine plant especially aromatic and essence-bearing plants like peppermint. 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 [2]. Among the essential elements macro and also micronutrients such as N, P, K, S, Fe and Zn are necessary to suitable growth and increase essence content and wet or dry yield of medicine plants. To provide these essential elements, not only chemical fertilizer but also the use of manure fertilizers is recommended which are included macro and also micro nutrients [2]. Patrui and Tabara [3] reported that the manure fertilizer (as organic) increased the yield of peppermint compared to the chemical fertilizer (as inorganic). Dalvand et al. [4] and Mehr-afarin et al. [5] have investigated the effect of bio and manure fertilizers on morphological traits and essence content of peppermint and resulted that these fertilizers increased dry yield and the percentage of essence which is due to existence of more microelements at the compounds of these organic fertilizers. This fertilizer will be decomposed and released microelements gradually during the harvesting time that will be more taken up by plant and will be increased essence content of the leaves. Daramol [6] expressed that biomass yield and dry weight of peppermint increased by using compost and manure fertilizer at the content of 1-2 kg and 250-500 g per pot, respectively. But, Mahmod et al. [7] reported that nitrogen fertilizer as urea and phosphorous as Triple super phosphate increased dry matter and essence yield of this plant. Niyakan et al. [8] reported that wet and dry yield and also the content of essence as qualitative trait were increased using nitrogen and potassium elements at more content compared to the less content. The reason of the effect of nitrogen on wet and dry weight is existence of it in the chemical compound of some molecules like Protein, amino acid and nucleic acid [9,10]. Regarding to the effects of chemical and manure fertilizers on the qualitative and quantitative characteristics of medicinal plants, the present research is devoted more to the comparative study of chemical and manure fertilizers on yield, yield components and essence content of peppermint plant.

2. MATERIALS AND METHODS

The present experiment was done in Sari Agricultural Farm, Dodangeh region (Long. 52º15' E. to Lat. 36º15' N), in northern part of Iran in 2013, where the general altitude is about 700 m above the sea level. The mean precipitation and daily mean temperature during growth season of peppermint plant in the studied region is 94.5 mm and 31.19ºC, 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. Initially, the studied soil and sheep and vermicompost (from plant sources) fertilizers were tested at laboratory to determine the element contents and other their chemical and physical properties which are shown in Tables 1A and 1B.

All studied plants as seedling were cultivated into the pots (size 30*40cm^2) on May 2013 which located on the farm (outdoor condition). Each pot was filled 10 kg soil and chemical fertilizer (were

chosen as treatments) and sheep and vermicompost fertilizers (both at the content of 20 ton ha^{-1} equals 80 g per pot) were also added in per selected pot as treatment. Then, all the pots were irrigated two times per week and were also weeded out during growth period. First and second harvesting times were done at August and November, 2013. Essential oil content was determined by hydro distillation method by submitting aerial part of dried plants (100 g) 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 in the current study were plant height, the total number of stem, the number of flowers, the number of suckers, the number of chain, leaves wet weight, stem wet weight, total wet weight (wet yield), leaves dry weight, stem dry weight, total dry weight (dry yield) and the content of essence. Data were analyzed following the analysis of variance technique (ANOVA) by using Microsoft-MSTAT-C and the mean differences were adjudged by Duncans' multiple range tests (DMRT) at the level of 5%, probability [11].

3. RESULTS AND DISCUSSION

The results showed that the effect of all used treatments was very significant on all the measured characteristics, statistically (Table 2). According to analysis of variation of data, the essence content and also all agronomic characteristics of peppermint were very significantly influenced by both organic and chemical fertilizers. Coefficient of variation of all the measured characteristics is less than 10% at the present study which is showed the experiment was carefully done at suitable conditions.

As it can be seen at Table 3, the maximum values of the number of flowers, the number of stem, the number of suckers, leaves dry weight and essence content of peppermint were attained when organic fertilizers (sheep manure) was applied. Using sheep manure fertilizers, the number of chain per pot 212%, leaves wet weight 29%, stem wet weight 52%, wet yield 39%, leaves dry weight 84%, stem dry weight 97%, dry yield 90% and essence content 70% increased compared to the control pot. The maximum values of plant height, the number of chains, leaves and stem wet weight, total wet weight, stem dry weight and total dry weight were also attained when chemical fertilizers applied at the ratio of 90-80-80 and then 90-50-80. Comparison between the control pot and the use of organic and chemical fertilizers showed that using sheep manure fertilizer dry yield and essence content increased 90 and 70% compared to the control pot, respectively. Essence content increased 23% when sheep manure was applied compared to chemical fertilizer at the ratio of 90-80-80. Table 4 shows that all the agronomic characteristics, quantitative yield and essence content of peppermint were influenced by both organic and chemical fertilizers which had significant difference compared to control pot. But, organic fertilizers group (sheep and vermicompost fertilizers) affected significantly on the number of flowers, the number of stem, the number of suckers, leaves dry weight and essence content of peppermint and increased those traits compared to chemical fertilizers group, statistically. Other measured traits were more influenced by chemical fertilizers group.

The results of this study showed that not only organic fertilizers but also basic chemical fertilizers such as nitrogen, phosphorus and potassium increased plant height, wet and dry weight of stem and leaves, total wet and dry weight and the content of leaves essence of peppermint significantly compared to control pot. The obtained results are in agreement with the observations by Mahmod et al. [7]. They investigated the effect of nitrogen fertilizer on the growth and essence yield of peppermint and announced that dry matter and essence yield was significantly increased when nitrogen fertilizer applied. Not only the nitrogen element does not exist into the essence compound, but also it is involved in the chemical compound of some molecules like Protein, amino acid and nucleic acid [9]. The use of this element causes increasing extraction gland of essence at the leaves of peppermint [12]. It is because of producing and consuming simple glucoses, increasing vegetative growth and developing leaves surface [13].

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

Table 2. Square mean of the effect of organic and chemical fertilizers on yield and yield components of peppermint

S.O.V	Df	Plant height (cm)	Number of stem	Number of chain	Number of flowers	Number of suckers	Leaves wet weight (g pot^{-1})	Stem wet weight (g pot^{-1})	Wet yield (kg ha^{-1})	Leaves dry weight (gpot^{-1})	Stem dry weight (gpot^{-1})	Dry yield (kgha^{-1})	Essence content (g $100g^{1}$)
Treatment	6	95.25**	1.5767**	63.774**	2.3748**	1.5767**	62.187**	113.1**	2747722**	0.67**	2.2014**	33161**	0.715**
Error	21	0.6548	0.0129	0.3724	0.0196	0.0129	0.7395	0.5692	16507.6	0.0129	0.0571	723.21	0.039
C.V(%)	-	1.50	5.039	5.72	8.15	9.07	8.69	7.63	7.22	4.82	10.20	6.36	7.840

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

Table 3. Mean comparison of the effect of chemical and organic fertilizers on yield and yield components and essence content of peppermint

Treatments	Plant height(cm)	Number of stem	Number of chain	Number of flowers	Number of suckers	Leaves wet weight (g pot^{-1})	Stem wet weight (g pot^{-1})	Wet yield(kg ha^{-1})	Leaves dry weight (g pot^{-1})	Stem dry weight (g pot^{-1})	Dry yield (kg ha^{-1})	Essence content (g $100g^{-1}$)
Control pot	45.8^{f}	2.75^{c}	3.08^{f}	1.65^{c}	1.75^{c}	4.58^{g}	3.25^{g}	704^{g}	1.48^{f}	1.13^{g}	234^{g}	1.85^{g}
Vermicompost	55.3^{c}	2.93^{ab}	8.85^{de}	2.43^{b}	1.93^{ab}	6.68^{e}	4.9^{ef}	1042^{e}	2.6^{ab}	2.1^{cdef}	423^{cde}	2.2^{f}
Sheep manure	51.3^{e}	2.98^{a}	9.63^{d}	3.1^{a}	1.98^{a}	5.95^{ef}	4.95^{e}	981^{ef}	2.73^{a}	2.23^{cd}	446^{bc}	3.15^{a}
Mean manure	53.3	2.95	9.24	2.76	1.95	6.31	4.92	1011.5	2.66	2.16	434.5	2.67
N60-P80-K60	51.3^{e}	1.8^{e}	13.6^{b}	1.35^{de}	0.8^{e}	12.8^{abc}	12.1^{d}	2241^{bcd}	2.5^{bc}	2.15^{cde}	419^{cdef}	2.65^{bc}
N60-P50-K60	54.8^{cd}	1.45^{g}	11.2^{c}	1.03^{fg}	0.45^{g}	13.3^{ab}	13.5^{bc}	2410^{bc}	2.43^{cd}	2.38^{c}	432^{cd}	2.5^{cde}
N90-P50-K80	57^{b}	1.73^{ef}	13.6^{b}	1.05^{f}	0.73^{ef}	12.6^{abcd}	14.3^{b}	2414^{b}	2.43^{cd}	2.9^{b}	479^{b}	2.85^{b}
N90-P80-K80	61^{a}	2.13^{d}	14.7^{a}	1.43^{d}	1.13^{d}	13.4^{a}	16.2^{a}	2657^{a}	2.3^{de}	3.53^{a}	524^{a}	2.55^{bcd}
Mean chemical	56.02	1.77	13.27	1.21	0.77	13.02	14.02	2430.5	2.41	2.74	463.5	2.63

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

Table 4. Comparison of average of yield and yield components of peppermint by the effect of organic and chemical fertilizers

Properties	Plant height (cm)	Number of stem per pot	Number of chain per pot	Number of flowers per pot	Number of suckers per pot	Leaves wet weight (g pot^{-1})	Stem wet weight (g pot^{-1})	Wet yield (kg ha^{-1})	Leaves dry weight (g pot^{-1})	Stem dry weight (g pot^{-1})	Dry yield (kg ha^{-1})	Essence content (g $100g^{-1}$)
Control	45.8^{f}	2.75^{c}	3.08^{f}	1.65^{c}	1.75^{c}	4.58^{g}	3.25^{g}	704^{g}	1.48^{f}	1.13^{g}	234^{g}	1.85^{g}
Organic mean	53.3	2.95	9.24	2.76	1.95	6.31	4.92	1011.5	2.66	2.16	434.5	2.67
Chemical mean	56.02	1.77	13.27	1.21	0.77	13.02	14.02	2430.5	2.41	2.74	463.5	2.63

The effect of sheep manure fertilizer on the some agronomic characteristic like the number of flowers, the number of stem, the number of suckers, leaves dry weight and essence content of peppermint was significant compared to vermicompost fertilizer, statistically. The values of electrical conductivity, total nitrogen, organic carbon, organic matter, total potassium and iron concentration existing sheep fertilizer are 5, 2, 2, 2, 10 and 88 times more than vermicompost fertilizer, respectively (Table 1). It seems that high nutrient values of sheep fertilizer could be increased vegetative growth content, leaves surface developing, photosynthesis content, some agronomic properties and finally the content of leaves essence. Existence of some macronutrients like nitrogen and potassium and also micronutrients especially iron into the sheep manure fertilizer increased essence content as qualitative trait which is in agreement with some observations by Dalvand et al. [4] and Mehrafarin et al. [5]. The effect of chemical fertilizer as 90-80-80 and then 90-50-80 on the some measured properties like plant height, the number of chains, leaves, stem and total wet weight, stem and total dry weight are more than other chemical fertilizer treatments, statistically; which is because of high nitrogen and potassium content at these types of chemical fertilizers. It can be concluded that quantitative properties of peppermint will be increased by increasing N and K elements up to 90 and 80 kg ha^{-1}, respectively. The same results were attained by Niyakan et al. [8]. They reported that some quantitative characteristics like total wet and dry weight and also the content of essence of peppermint increased significantly using high N and K content compared to the low content ones. Zhao [10] expressed that the reason of the effect of nitrogen on increasing wet and dry weight of peppermint is due to exist of this element into the big molecules composition like protein, amino acid and nucleic acids. Thus it may be resulted that there is an interaction effects (positive correlation) between N and K elements into the plant body. Therefore, increasing quantitative and qualitative traits of peppermint by both chemical and sheep fertilizers can be raised due to high content of N and K elements in both these fertilizers. The results of the present study are in agreement with the observations by Clark and Menary [14], Singh et al. [15], Fernander [16] and Gerder et al. [17] and Arabasi and Bayram [18] who reported that essence content increases using nitrogen fertilizer.

The content of some measured quantitative traits is more using chemical fertilizers than organic fertilizers. Chemical fertilizers especially nitrogen will be rapidly decomposed into the soil by micro-organisms and will be changed to absorbable inorganic materials (mineralization period). These absorbable nutrients will be taken up by plants as soon as possible and will increase vegetative growth of plant. While, organic fertilizers will be decomposed into the soil by micro-organism gradually and released their nutrients slowly [9]. Thus, the content and content of nitrogen uptake by the plant at organic fertilizers is less than chemical fertilizers. Accordingly, organic fertilizers may be affected on the plant growth at the end of growth stages or at the second or third harvesting times. On the other hand, the content of some measured quantitative traits is also more using organic fertilizers than chemical fertilizers. It is because of high microelement concentration in organic fertilizers which can be increased the number of stem, the number of suckers, the number of flowers, leaves dry weight and the content of essence. This finding is in agreement with those reported by Tahami et al. [19]. They reported that the maximum sub-stem per plant was attained when sheep manure fertilizer applied compared to chemical, vermicompost and chicken fertilizers.

4. CONCLUSION

Some agronomic and quantitative traits of peppermint like plant height, number of chain, stem wet and dry weight, leaves wet weight and total wet and dry weight were obtained at the maximum values when basic chemical fertilizers was applied at the rate of 90-80-80. The maximum number of stems, number of flowers, number of suckers, leaves dry weight and essence content were also obtained by sheep manure. Thus, to prevent soil, plant and finally environment pollution by using chemical fertilizers and also to achieve the maximum leaves dry weight and essence content of peppermint, application of sheep manure as organic fertilizers is recommended.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Omid Beygi R. Production and processing of medical plants. 2nd valium. 5th ed. Qods razavi publication. Mash-had, iran (in persian); 2000.
2. Qasempour Alamdari M. The effect of macro and micronutrients on the growth and yield of rice (*Oryza sative* L.). Ph.D thesis, Pune University, India; 2004.
3. Patrui O, Tabara V. Research on the quality yield of herbal mint (*Mentha piperita* L.) under the influence of mineral and organic fertilization in climate condition n S.C.D.A.LOVRIN, Buletinul AGIR nr; 2011.
4. Dalvand Y, Sadeqi A, Asadi Gh, Karimi A. Effect of *Streptomyse* and different content of vermicompost on yield and essence of peppermint (*Mentha piperita*) under farm condition. Iranian 7th congress of horticulture sciences; 2011. Available:http://www.civilica.com/Paper-BAGHBANI07-BAGHBANI07_890.html
5. Mehrafarin A, Naqdi Badi H, Pour Hadi M, Hadavi A, Qavami N, Kadkhoda Z. Response of photochemistry and agronomy of peppermint to use of bio-fertilizer and urea fertilizer. Medical Plant Journal. 2010;2(1):63-74
6. Daramol OS. Effects of organic fertilizers on growth and yield of MINT (*Mentha piperita*). Department of Horticulture Trans. By-Mycol, Soci. 2011;55:158-61.
7. Mahmod S, AsafarY, Al-Hassan M. Effect of nitrogen and phosphorus fertilizers on growth and oil yield of indigenous Mint (*Mentha longifolia* L.). Biotechnology. 2009;3:380-384.
8. Niyakan M, Khavarinezhad R, Rezaee M. Effect of different proportion of basic fertilizers N, P and K on wet and dry weight and leaves surface and essence content of peppermint (Mentha piperita). Iranian Aromatic and Medical Plants Research Journal. 2004;20(2):131-148.
9. Kolata E, Beresniiewicz A, Krezel J, Nowosielshi L, Slow O. Slow release fertlizers on organic carriers as the source of N for vegetab cops production in the open field. Acta- Horticaulhtre. 1992;339:241-249.
10. Zhao J. The effect of nitrogen fertilization on spearmint. Journal of Essential Oil Research. 2006;18:452-455.
11. Gomez KA, Gomez AA. Statistical procedures for agricultural research (2nd ed). Gohn wiley sons, New York, Chichester, Bribane, Toronto, Singapor; 1984.
12. Marotti M, Piccaglia R, Crout W, Craufutd K, Deans S. Effect of planting time and mineral fertilization on peppermint (*Mentha piperita* L.) essential oil composition and its biological activity. Flavor and Fragrance Journal. 2004;9(3):125-129.
13. Brown B. Mint soil fertility research in the PNW. Western Nutrient management Conf. 2003;5(3):54-60.
14. Clark RJ, Menary R. The effect of irrigation and nitrogen on yield and composition of peppermint oil (*Mentha piperita* L.). Applied-Plant Science. 1999;62(2):68-71.
15. Singh VP, Chatterjee BN, Singh P. Response of mint species to nitrogen fertilization. Journal of Agricultural Science. 2003;113(2):267-271.
16. Fernander CH. Nitrogen and water management for medicinal and aromatic plants. Acta Horticulture. 2006;132(2):203-215.
17. Gerder HV, Vangelder H, Mucciarelli N. Influence of nitrogen fertilizer application level on oil production and quality in *Mentha spp*. Applied Plant Science. 1993;92(2):68-71.
18. Arabasi D, Bayram E. The effect of nitrogen fertilization and different plant densities on some agronomic and technologic characteristic of (*Ocimum basilicum* L.). Essential Oil Research. 2005;17:203-205.
19. Tahami Zarandi S, Rezvani P, Jahani M. Compression of the effect of chemical and organic fertilizers on yield and essence percentage of *Ocimum basilicum* L. Agro-Ecology Journal. 2010;2(1):63-74.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sciencedomain.org/review-history.php?iid=866&id=2&aid=7459