The Effect of Plant Density and Harvesting Time on Growth and Essential Oil of Peppermint (Mentha Piperita L.)

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Abstract—**Peppermint is a therapeutic and aromatic herb. In order to determine the effect of plant density and harvesting time on growth and oil production of peppermint a field experiment was carried out at Sari Agricultural Science and Natural Resources University, in Iran, during 2010-2011. A split plot experiment was performed in a randomized complete block design with four replications. The main plots were four levels of density (8, 12, 16 and 20 plat $^{1}m^{-2}$) and the sub plots were two levels of harvesting time (25th may and10th September. Fresh biomass yield, plant height, dry biomass yield and fresh leaf weight, increased significantly with the decreasing plant density. The value of fresh biomass and essential oil yield were significantly ($p< 0.01$) increased by increasing plant density from 8 (plant m^{-2}) to 20 (plant m^{-2}). Maximum oil yield and dry matter was obtained in the first harvesting.**

Index Terms—***Mentha piperita*, Plant density, Harvesting time, Essential oil, peppermint.**

I. Introduction

Mints comprise a group of species of the genus Mentha belong to the family Lamiaceae [1]. Mint is grown primarily for the oil produced from its leaves. Mint plants are one of the most interesting research plants; they are between medicinal and aromatic plants [2]. There is a numerous research on mint, however, only few reports are available on environment conditions [3]. Several mint species, origins and cultivars are cultivated around the world. The two major species of mint grown for commercial uses are peppermint and spearmint. Peppermint is grown more widely in the world because its taste is preferred to that of spearmint [4]. A climate with adequate and regular rainfall and good sunshine during its growing period ensures a good yield [5]. Peppermint oil is one of the most important essential oils; it is used in pharmaceuticals, cosmetics and flavoring all over the world [6]. In addition, yield and the essential oil composition of mint species were influenced by interaction between the genotype and environment, method of distillation, kind of storage, crop age, time of harvest and season [7]. However, its economic cultivation has not grown to a sizable area in Iran, perhaps due to several factors, including the lack of information of the agronomic aspects of this crop. Among the various factors which affect, harvesting time and plant density are important [8]. Yields of fresh material and essential oil were enhanced by planting density. Plant density is an important factor in determining the micro environment in the mint field [9]. The optimization of this factor can lead to a higher yield in the mint. The effect of plant density on growth and development is largely due to change in the interception of radiant energy, the higher plant density leads to higher interception and consequently to the greater growth of peppermint [10]. Composition of essential oil is strongly dependent on developmental stage of the plant (ontogeny), and therefore harvesting time is one of the most important factors influencing mint oil [11]. Keeping the above in view, studies were undertaken to know the effect of planting time and plant density on the growth and yield of peppermint under Iran condition.

II. Material and Method

The experiment was conducted at Sari Agricultural Sciences and Natural resources university compose, Sari, Iran (lat, 53 ·13 °; long 36 ·42 °; Alt 40cm). The annual mean rainfall of the area is about 800 mm. The soil was clay loam (clay 30%, sand 39% and silt 31%) with 1.74% Organic matter, 7.1 pH, 9 and 210 ppm available phosphorous (p) and potassium (k), respectively. Soil samples were taken for analysis before land preparation and were fertilized on the basis of a soil test recommendation. The effects of plant density and harvesting time on growth and oil production of peppermint was studied in a split plot experiment based on randomized complete block design with four replications, during 2010-2011. The main plots were four levels of density (8, 12, 16 and 20 plat m^{-2}) and the sub plots were two levels of harvesting time (25th may and 10th September). Plowing operations were done by chisel to a depth of 20 to 25 cm flowed by rotary harrow to level soil surface. Each plots was consisted of four rows, the outer ones considered as a border lines. Each plot received 20 kg p ha^{-1} as triple superphosphate and 40 kg k ha^{-1} as kcl. A uniform amount of 60 kg N/ha was applied in the form of urea. All fertilizers were broadcast on soil surface before seeding, and then incorporate into

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the top 20 cm soil. Uniform weeding, watering and hoeing were made whenever required. Transplanting was carried out to the experiment plots on 15 October. Seedling with an average height of 10- 15 cm were used, cutting height was around 7 cm above soil surface. All plants samples were oven dried at 40 ° for 72 h. The parameters recorded during the course of experiment were, fresh biomass yield, Plant height, dry biomass yield, fresh leaf weight, essential oil content (%) and oil yield (lit ha^{-1}) were measured at each harvest. Essential oils were extracted from at dried leaf samples for 2:30 hrs distillation time by hydro distillation in Clevenger apparatus [12]. All statically analysis was performed by analysis of variance (ANOVA) procedures using MSTAT-C software.

III. Result and Discussion

A. Fresh Biomass Yield

Mint total fresh yield is an important indicator required by growers to judge the economic value of its cultivation. Main effects of plant density and harvesting time significantly affected fresh biomass yield (Table I).

TABLE I. Analysis of Variance for Effect of Plant Density and Harvesting Time on Major Parameters of Peppermint (*Mentha piperita* L.).

SOV	Df	Fresh biomass yield	Height	Dry biomass yield
Rep	3	1678250.0	30.8	13241.4
Pd	3	2356990.2**	40.2**	12436.1**
Err (a)	9	547321.4	6.5	15647.7
Ht	1	3247685.4**	498.8*	8674321.1**
Rep ×Ht	3	453281.7	6.90	8654317.3
Pd ×Ht	3	642101.5 ns	4.3 ns	437690.8 ns
Err (b)	6	31245.3	5.2	3583151.2
CV (%)		21.1	9.4	18.7

There was a highly significant fresh biomass yield reduction with reducing plant density (Table II) which might have led to competition for space, light inefficient, utilization of nutrient etc, resulting into less plant growth characters and lower fresh biomass yield. Planting patterns is an agronomic management that optimizes the available natural and unnatural resources. The adjustment of plant density is done to improve the effect of planting patterns on crop development [13].

The value of fresh biomass yield was ranged between 2563.6 (kg ha^{-1}) for plant density of 8 (plant m^{-2}) to 3210.6 (kg ha^{-1}) for plant density of 20 (plant m^{-2}). Similar result of increase fresh biomass with increasing peppermint density was reported [14].

TABLE II. Effect of Plant Density (Plant M^{-2}) on Biological Parameter of Peppermint *(Mentha piperita*)

Plant density	Fresh biomass yield (kg ha^{-1})	Height (cm)	Dry biomass yield (kg ha^{-1})	Fresh leaf weight
8	2563.6	59.5	841.4	501.56
12	2987.8	68.1	976.5	513.93
16	3011.4	68.3	996.7	621.87
20	3210.6	69.7	1012.4	802.32

Means with the same letter with in a column are not significant at 1% level of probability.

Fresh biomass yield significantly increased in first harvest time.. At the first harvest (25^{th} may), plants were established, produced good canopy and thus increase in yield was obtained, at the second harvest (**(**10^{th} September) biomass was decreased, this is attributed to the shorter photoperiod during autumn [15].

B. Dry Biomass Yield

Result of the experiments showed that plant density and harvesting time (Table III) had significant effect on dry biomass yield. Similar to fresh biomass yield, the value of dry biomass yield was reduced with decreasing plant density. At high density vegetative growth of peppermint was extended, more number of leaves per plant were produced that increased light interception at the high density, as a result more assimilates were produced by plant, that increased plant dry biomass yield. This result is in close agreement with those of [16]. The maximum dry biomass yield (1123.4 kg ha^{-1}) was obtained at first harvesting.

TABLE III. Analysis of Variance for Effect of Plant Density and Harvesting Time on Major Parameters of Peppermint (*Mentha piperita* L.).

SOV	df	Fresh leaf weight	Essential oil content	Essential oil Yield
Rep	3	154231.2	0.012	14.67
Pd	3	23418.3**	0.045ns	213.67*
Err (a)	9	65432.4	0.018	56.30
Ht	1	42671.3**	0.123**	0.873**
Rep ×Ht	3	505321.9	0.006	8.817
Pd ×Ht	3	68903.6 ns	0.015 **	61.78**
Err (b)	6	231464.8	0.009	12.02
CV (%)		14.8	19.3	16.2

* and** significant at 1 and 5% levels respectively; ns , non significant at 1 and 5% level of probability.

Rep, replication; Err, error; Pd, plant density; Ht, Harvesting time

C. Plant Height

The plant height was affected significantly by different plant density and harvesting time (Table IV). 20 (plant m^{-2}) plant Idensity (69.7 cm) and first harvesting time (69.3 cm) recorded the maximum plant height which was significantly higher to other plant density and harvesting time. Less planting per unit area resulted in lower height, It is well known that many herbaceous plants enhance elongation of stems when the stand density or the leaf area index (LAI) is high [17]

TABLE IV. Effect of Plant Density (Plant M^{-2}) on Biological Parameter of Peppermint *(Mentha Piperita*)

Plant density	Fresh biomass yield (kg ha^{-1})	Height (cm)	Dry biomass yield (kg ha^{-1})	Fresh leaf weight
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Means with the same letter with in a column are not significant at 1% level of probability.

D. Leaves Fresh Weight

Leaves are a good indicator on plant productivity [17]. Main effects of plant density and harvesting time significantly affected leaves fresh weight (Table V).

Maximum leaves fresh weight was obtained in 20 (plant m^{-2}) plant densities and 25th may harvesting time.

TABLE V. EFFECT OF HARVESTING TIME ON BIOLOGICAL PARAMETER OF PEPPERMINT *(MENTHA PIPERITA*)

Harvesting time	Fresh biomass yield(kg ha^{-1})	Height (cm)	Dry biomass yield (kg ha^{-1})	Fresh leaf weight
25th may	3422.4	69.3	1123.4	801.87
10th September	3084.6	60.3	9901.3	613.45

Means with the same letter with in a column are not significant at 1% level of probability.

The higher herbage yield under this plant density and harvesting time might be due to optimum plant population, proper utilization of moisture and nutrition by the plants which resulted in more leaf growth per plant leading to higher herbage yield (802.32 kg ha^{-1}). Researchers have also reported similar results [18].

E. Essential Oil Content

Main effects of plant density and its interaction with harvesting time significantly affected essential oil content of peppermint (Table VI).

TABLE VI. INTERACTION EFFECT OF PLANT DENSITY AND HARVESTING TIME ON ESSENTIAL OIL CONTENT (%) OF PEPPERMINT *(MENTHA PIPERITA*).

Harvesting Time		Plant density plant m^{-2}		
	8	12	16	20
25th may	0.50	0.55	0.62	1.02
10th September	0.40	0.46	0.57	0.9

Means with the same letter with in a column are not significant at 1% level of probability.

Maximum oil content was obtained in the first harvesting and 20 (plant m^{-2}) plant densities (Table VI). Harvesting time had a significant effect on essential oil content and maximum oil content was obtained in first harvesting, because of better growth conditions [19], [20].

F. Essential Oil Yield

The main effect of plant density and harvesting time and their interaction have shown a highly significant ($p< 0.01$) effect on essential oil yield of peppermint (Table VII). In both harvesting time essential oil was increased when plant density was increased. This result was in consistence with reported by other researches [21].

TABLE VII. INTERACTION EFFECT OF PLANT DENSITY AND HARVESTING TIME ON ESSENTIAL OIL YIELD (LIT HA^{-1}) OF PEPPERMINT *(MENTHA PIPERITA*).

Harvesting		Plant density plant m^{-2}		
	8	12	16	20
25th may	17.90[a]	17.07[a]	18.49[a]	21.06[a]
10th September	12.45	15.2	16.7	19.3

Means with the same letter with in a column are not significant at 1% level of probability.

IV. DISCUSSION

There were no interaction between plant density and harvesting time on fresh biomass yield (kg ha^{-1}), plant height (cm), dry biomass yield (kg ha^{-1}) and fresh leaf weight (kg ha^{-1}), indicating that the two factors act independently from each other. Main effect of plant density had affected significantly all parameters measured except essential oil content (%) and higher plant densities produced higher fresh biomass yield, plant height (cm), dry biomass yield (kg ha^{-1}) and leaves fresh weight (kg ha^{-1}). Harvesting time however had affected significantly all parameters. Comparing the first and second harvests with harvesting time, a higher value was obtained in all agronomic parameters during the first harvest. This study provided basic information with respect to some agronomy of peppermint useful for further investigation. Although the present study contains some new information and gives a significant amount of information about the peppermint much still remains to be studied.

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REFERENCES

[1] S. M. Beetmnet, "Row spacing and harvesting age affect agronomic characteristics and essential oil yield of Japanese mint (Mentha arvensis L.)," *Medicinal and Aromatic plant Scie and biotech.*, vol. 5, pp. 74-76, 2011.

[2] A. Aflatuni, "The yield and essential oil content of mint (Mentha spp.) in Northern Ostrobothnia," Academic dissertation to be presented with the assent of the faculty of science of the University of Oulu for public defense in Op-Sali. 592 p. June 2005.

[3] S. Drazic and S. Pavlovic, "Effects of vegetation space on productive traits of peppermint (Mentha piperita L.)," Institute for Medicinal Plants, Belgrade, vol. 31, pp. 1-4. 2005.

[4] J. M. Hart. N. W. Christensen. M. E. Mellbye, and G. A. Gingrich, "Nutrient and biomass accumulation of peppermint," in *Proc. Western Nutrient Management Conference*, 2003, pp. 63-70.

[5] S. Sharma, "Effect of dates of transplanting on the growth and oil yield of *Mentha arvensis L.*," *Scholarly Journal of Agri Sci.*, vol. 2, no. 7, pp. 130-132, 2012.

[6] A. E. Edris. A. S. Shalaby. M. A. Fadel, and A. Wahab, "Evaluation of a chemo type of spearmint (*Mentha spicata* L.) grown in Siwa Oasis, Egypt," *Euro. Food. Technol*, vol. 218, pp. 74-78. 2003.

[7] M. S. Alsafar and Y. M. Al-Hassan, "Effect of nitrogen and phosphorus fertilizer on growth and oil yield on indigenous mint (Mentha longifolia L.)," *Biotech.*, vol. 8, pp. 380-384, 2009.

[8] J. Rohloff. S. Dragland. R. Mordal, and I. Tor-Henning, "Effect of harvest time and drying method on biomass production, essential oil yield and quality of peppermint (*Mentha piperita* L.)," *J. Agr. Food Chem.*, vol. 53. pp. 4143-4148, 2005.

[9] O. Arabci and E. Bayram, "The effect of nitrogen fertilization and different plant densities on some agronomic and technologic characteristic of basil (*Ocimum basilicum* L.)," *J. Agron.*, vol. 3. pp. 255-256, 2004.

[10] A. R. Dedham. M. Kafi, and G. H. Rasam, "The effect of planting date and plant density on growth traits, yield quality and quantiy of matricaria (*Matricaria Chamomilla*)," *J. Hort. Sci.*, vol. 23. pp. 100-107, 2009,
[11] R. J. Clar and R. C. Menary, "The effect of two harvests per year on the yield and composition of Tasmanian peppermint oil (Mentha piperita L.)," *J. Sci. Food Agr.*, vol. 35. pp. 191-1195, 2006.
[12] A. A. Jahangir, K. Nada. F. Begum, F. Hossain, M. A Srker, and M. Moniruzzaman, "Influence of nitrogen-phosphorous fertilization and time of harvest on the growth, yield and oil content of (*Mentha spicata* L.)," *J. Scientific and industrial Res.*, vol. 43, pp. 47-54, 2008.
[13] U. Niinemets, "Photosynthesis and resource distributionthrough plant canopies," *Plant Cell Environ*., vol. 30, pp. 1052-1071. 2007.
[14] V. D. Zheljazkov1 and V. Cerven, "Effect of Nitrogen, Location and harvesting stage on peppermint productivity, oil content and oil composition," *J. Amer. Soc. Hort. Sci*., vol. 44, pp. 1267-1270, 2009.
[15] R. L. Yadav, R. Mohan, M. A. Ram, A. Naqut, and D. V. Singh, "Response of (*Mentha piperita* L.) to nitrogen and row spacing in semi-arid central," *J. Agri Sci.*, vol. 55, no. 1, pp. 59-60, 2000.
[16] B abbaszade, H. A. Farhadi, A. S. A. Valeabadi, and P. Moaveni, "Investigation of variations of the morphological values and flowering shoot yield in different mint species at Iran," *J. Hort and Forest*, vol. 1, pp. 107-112, 2009.
[17] W. Aftab. H. Abid. A. Ashfaq. R. Muhammad, A. R. Goheer, and I. Muhammad, "Effect of sowing date and plant density on growth, light interception and yield of wheat under semi arid conditions," *Int. J. Agric. Biol.*, vol. 6, pp. 1119-1123. 2004
[18] M. D. Ram. S. Ram. S. Sing. K. Roy, and S. Kumar, "Effect of planting time on the growth and essential oil yield in different varieties of menthol mint Mentha arvensis," *I. J. Med. Arom. Pl. Sci*., vol. 22, pp. 400–403. 2001.
[19] Katzer, G, Modification. (July 2004). Peppermint (*Mentha piperita* L.). [Online]. Available: http://www.uni-graz.at/~katzer/engl/Ment_pip.html
[20] N. Mimica-Dukic, B. Bozin, M. Sokovic, B. Mihailovic, and M. Matavulj, "Antimicrobial and antioxidant activities of three *Mentha* species essential oils," *Planta Medica*, vol. 69, pp. 413-419, 2003.
[21] M. G. Miguel, F. Duarte, F. Venancio, and R. Tavares, "Composition of the essential oils from ortuguese *Thymus albicans* collected at different regions of Ria formasa (Algarve)," *J. Essential oil Res.*, vol. 1, pp. 308-311, 2004.

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3- I. Mansoori. M. T. Bararpour. N. Babaeian Jelodar, "Effect of tillage, row spacing and weeding on soybean [Glycine max (L.) Merr.] growth and yield potential and weed management ", J. Agric. Sci. Natur. Resour, vol.8, pp. 73-83.

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