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## Influence of Soil Type on the Growth Parameters, Essential Oil Yield and Biochemical Contents of *Mentha arvensis* L.

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**Abstract:** *Mentha arvensis* is a rich source of menthol that is used in pharmaceutical, flavouring and cosmetic industries. Environmental conditions including soil type are important factors affecting plant growth and yield. Although mentha is adapted to various habitats but to get the maximum yield it is important to find out the requisite soil type. Therefore, the present study was conducted in pots to find out the soil type which favours maximum growth and oil yield of *M. arvensis*. Significant difference in plant growth parameters were observed between the plants grown in different soil types ( $P \leq 0.01$ ). The plants grown in sandy clay soil showed maximum plant growth and biochemical content. The highest oil yield was recorded in plants grown in sandy clay soil (0.78 ml/100g fresh herb). There was a significant difference ( $P \leq 0.01$ ) in oil yield per plant between the plants grown in sandy clay (1.18 ml), sandy clay loam (1.20 ml) and sandy loam soil (0.85 ml), whereas non-significant difference was observed between sandy loam and loamy sand (0.81 ml). The present study indicates that among all tested soils, sandy clay soil supports the highest growth and oil yield of *M. arvensis*. This information will be helpful for farmers in selecting soil for the cultivation of *M. arvensis*.

**Key words:** *Mentha arvensis*, Japanese mint, soil types, oil yield, biochemical content.

### Introduction

Mints (*Mentha* spp., family Lamiaceae) have been grown and utilised since ancient times and are believed to have originated in the Mediterranean basin. They eventually spread throughout the world. *Mentha* have been cultivated on a large scale in many tropical countries of the world including Brazil, China, India, Japan and U.S.A. *Mentha arvensis* L. (Japanese mint) yields essential oil on hydro-distillation of fresh herbs. Mint oil is a rich source of menthol and considered as an outstanding stomachic, stimulant, anti-spasmodic and carminative. Menthol containing oil has great demand in pharmaceutical, flavoring and cosmetic industries. Due to this demand, the cultivation of mint has risen tremendously, at present mint is grown on an area of around 300,000

ha<sup>1,2,3</sup>.

Some of the soil properties which affect plant growth are soil texture, aggregate size, porosity, aeration (permeability), and water holding capacity<sup>4</sup>. The amounts of clay and organic matter present in the soil directly influence its fertility. Generally, higher content of clay and organic matter leads to greater soil fertility<sup>4</sup>. Species of the *Mentha* grow in different habitats, so they are adapted to a variety of environmental conditions. Environmental conditions are important factors affecting plant growth and yield<sup>5</sup>. Several studies have reported the influence of mineral nutrients, drought, light intensity and altitude on plants growth and essential oil content<sup>6,7,8</sup>. Flecher *et al.*<sup>9</sup> reported that the accumulation of rosmarinic acid was affected by soil type in spearmint and

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peppermint. Several reports are available on the effects of altitude, to pography, soil type and other factors on mint <sup>2,10,11</sup>. Although *Mentha* is adapted to various habitats, getting the maximum yield is dependent on knowledge of best-suited soil types. Therefore, the present study was conducted to findout the soil type which supports highest growth and oil yield of *M. arvensis*. Soil with different ratio of clay and sand were selected which represent four different types of soil ranging from heavier to lighter soil type. This will help the mint growers select the suitable soil type for the cultivation of *Mentha* for the extraction of essential oils.

### Materials and methods

#### Collection and mechanical analysis of soil

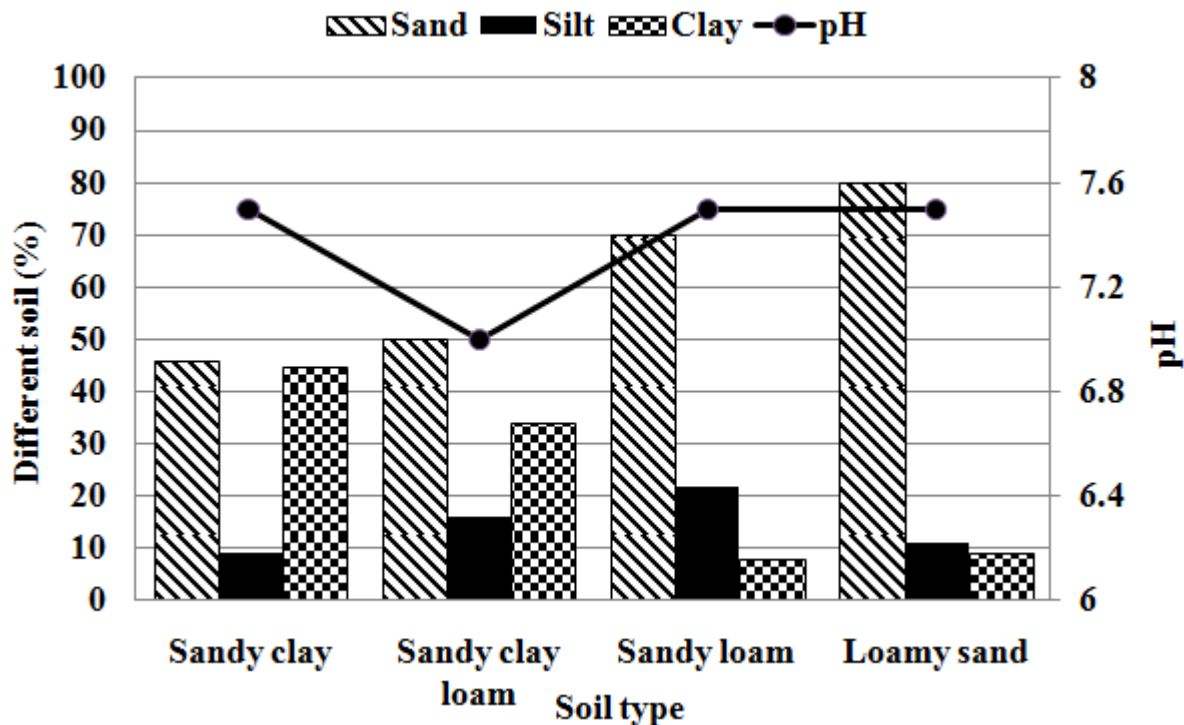
Different soil samples of 50 kg each were collected from various fields. Mechanical analysis of soil samples was carried out to determine the soil type <sup>12</sup>. After the analysis, four soil types, namely sandy clay, sandy clay loam, sandy loam and loamy sand were selected for the experiment (Figure 1). The experiment was planned to observe the influence of soil type (excluding the role of

soil micro flora) on the plant growth, biochemical parameters and oil yield under pot condition. Therefore, all four soil types selected for study were autoclaved and 5 kg soil was filled in 30 cm diameter and 27 cm height sterilized clay pots.

#### Transplanting, inoculation and recording of data

In each sterilized soil filled pot, a single surface sterilized sucker was transplanted. There were four replicates for each treatment. The pots were placed on a bench in a green house. The pots were irrigated with sterilized water as and when required. The experiment was laidout as a completely randomized block design.

After the completion of one hundred days, plants were carefully uprooted from pots and roots/suckers were washed in running tap water to remove the adhering soil particles. Excess water was removed with blotting paper. Plant growth was determined by measuring shoot height and the dry weight of shoot and roots/suckers. For determining dry weight, the shoot and roots/suckers wrapped in blotting paper sheet were dried at 60°C for 24 hours.



**Figure 1.** Soil components and pH of the different soil types selected for the experiment  
Mechanical analysis of soils was done by the International pipette method<sup>10</sup>.

### Essential oil extraction by Clevenger apparatus

To get the essential oil of *M. arvensis*, hydro-distillation of fresh herb was carried out by using Clevenger apparatus<sup>13</sup>. Hundred gram aerial parts, including leaves and stems, of each replicate were cut into 2-3 cm long pieces and placed with 400 ml water into the round bottom flask of the apparatus. The flask was kept on a heating mantel at 90°C. As water started to boil, oil from herb evaporated, passed through a condenser, and drops of oil were accumulated on the water filled in the measuring tube of the apparatus. The process was run for one hour and the volume of oil was measured in ml and percent oil yield was calculated on fresh herb basis.

### Estimation of total chlorophyll

For the estimation of chlorophyll content, fresh leaf (0.2 g) sample was homogenized in 80 % acetone and the homogenate was filtered through Whatman filter paper no. 1 into a volumetric flask. The process was repeated thrice and the final volume (v) of extract was brought to 25 ml by adding required amount of acetone. The absorbance (A) of the extract was measured at 645 and 633 nm. The chlorophyll a, chlorophyll b and total chlorophyll content of *M. arvensis* leaves was calculated by using the following formula<sup>14</sup>

Total chlorophyll =  $(20.2 \times A_{645}) + (8.02 \times A_{663}) \times \text{factor}$

Chlorophyll a =  $(12.3 \times A_{663}) - (0.86 \times A_{645}) \times \text{factor}$

Chlorophyll b =  $(19.3 \times A_{645}) - (3.60 \times A_{663}) \times \text{factor} / \text{Volume (v)}$

Factor =  $1000 \times \text{leaf weight (g)}$

### Estimation of total sugar

Total sugar content of the third leaf from the apex was estimated by using the Anthrone reagent method<sup>15</sup>. Briefly, 500 mg fresh leaves were transferred to 10 ml of boiling 80 % ethanol and boiled further for 15 minutes. The solution so obtained was filtered and final volume was made up to 50 ml with 80 % ethanol. In 1 ml of filtrate, 5 ml of anthrone reagent was added and tubes were kept in boiling water bath for 15 min. After that the test tubes were kept for 20 min at room temperature (25°C). Optical density (OD) was

read at 620 nm. The soluble sugars were calculated from a standard curve developed using glucose<sup>15</sup>.

### Estimation of total phenol

To estimate the total phenol content, 500 mg fresh leaves were extracted with 30 ml methanol and the process repeated thrice each time decanting supernatant. The extract was pooled and evaporated to dryness. The residue so obtained was dissolved in 0.5 ml methanol and distilled water was added to make the final volume 25 ml. One ml of extract distilled water (6 ml) and 0.5 ml Folin & Ciocalteu phenol reagent (1:1) was added. After 3 min, 1 ml of sodium carbonate (35 %) was added to the reaction mixture and final volume was made 10 ml. The tubes were kept incubated in darkness for 30 min and OD was recorded at 600 nm. The phenol content was calculated from a standard curve of gallic acid and reported as gallic acid equivalents<sup>13</sup>.

### Statistical analysis

Duncan Multiple Range Test was used to evaluate the significant differences between treatments ( $P \leq 0.01$ ). Analysis of variance (ANOVA) analysis was done with the IBM SPSS statistics (version 21.0) software.

### Results

Present investigation was carried out to determine the effect of different soil types on the shoot height, shoot-root dry weight, essential oil yield, chlorophyll, total sugar and total phenol content of *M. arvensis*. The data presented in Table 1 shows the effect of different soil types on the plant growth and oil yield. The significant influence of soil types was observed on the various plant growth parameters of *M. arvensis*. The significant difference in plant shoot height, shoot and root dry weight was observed between the plants grown in different soil types ( $P \leq 0.01$ ). The plants grown in sandy clay soil showed maximum shoot height (72.5 cm), shoot dry weight (45.2 g) and root dry weight (27.0 g). The next best plant growth was observed in plants grown in sandy clay loam soil, followed by sandy loam and loamy sand soil respectively. The essential oil obtained by hydro-distillation of fresh herb of Japanese mint grown in different soil types showed that oil yield varies

**Table 1. Effect of different soil types on the plant growth and oil yield of *Mentha arvensis***

Soil type	Shoot height (cm)	Shoot dry weight (g)	Root dry weight (g)	Fresh herb per plant (g)	Oil yield (ml/100g fresh herb)	Oil yield/plant (ml)
Sandy clay	72.5 <sup>a</sup>	45.2 <sup>a</sup>	27.0 <sup>a</sup>	194.9 <sup>a</sup>	0.78 <sup>b</sup>	1.18 <sup>a</sup>
Sandy clay loam	68.4 <sup>b</sup>	38.0 <sup>b</sup>	24.0 <sup>b</sup>	165.0 <sup>b</sup>	0.74 <sup>ab</sup>	1.02 <sup>b</sup>
Sandy loam	64.5 <sup>c</sup>	30.0 <sup>c</sup>	22.5 <sup>c</sup>	132.8 <sup>c</sup>	0.72 <sup>a</sup>	0.85 <sup>c</sup>
Loamy sand	58.4 <sup>d</sup>	28.0 <sup>d</sup>	20.7 <sup>d</sup>	120.5 <sup>d</sup>	0.70 <sup>a</sup>	0.81 <sup>c</sup>

Each value is an average of four replicates

Data followed by different letters in the column are significantly different ( $P \leq 0.01$ ) according to Duncan's multiple range test.

from 0.78 to 0.70 %. Oil yield was observed highest in the plants grown in sandy clay soil (0.78 ml/100 g fresh herb), followed by sandy clay loam, sandy loam and loamy sand soil. The non-significant difference ( $P \leq 0.01$ ) in oil yield was observed between plants grown in sandy clay and sandy clay loam soil and also between sandy loam, sandy clay loam and loamy sand soil. However, fresh herb weight of plant grown in sandy clay soil was significantly higher as compared to plants grown in other tested soil. Therefore, the oil yield/plant was also observed significantly more in sandy clay soil grown plants (1.18 ml) than other tested plants. Similar trends were also observed in the biochemical content of plants grown in different soil types (Table 2). Chlorophyll (a, b and total), total sugar and total phenol contents of the leaves were maximum in plants grown in sandy clay soil (1.24, 0.71, 1.95, 12, 17 mg/g respectively),

followed by sandy clay loam soil, sandy loam soil and loamy sand soil respectively. Analyses of data indicated the significant difference ( $P \leq 0.01$ ) in chlorophyll b, total sugar and total phenol content of plants grown in different soil types. However, several non-significant differences were observed in chlorophyll a and total chlorophyll content of leaves of plants grown in different soil types.

### Discussion

Plant growth and development is highly affected by the type of soil that gives support, nutrients and space to roots. Soil environment is quite complex and several factors are involved in providing suitable environment to plants. Soil type is one of the most important factors responsible for affecting plant growth, yield and biochemical contents. For growing any plant, it is important to find out the suitable soil type which favours its

**Table 2. Effect of different soil types on the chlorophyll, total phenol and total sugar content of *Mentha arvensis***

Soil type	Chlorophyll content (mg/g fresh leaves)			Total Phenol (mg/g fresh leaves)	Total sugar (mg/g fresh leaves)
	Chlorophyll a	Chlorophyll b	Total Chlorophyll		
Sandy clay	1.24 <sup>b</sup>	0.71 <sup>d</sup>	1.95 <sup>b</sup>	12.0 <sup>d</sup>	17.0 <sup>d</sup>
Sandy clay loam	1.22 <sup>ab</sup>	0.69 <sup>c</sup>	1.90 <sup>b</sup>	11.2 <sup>c</sup>	16.25 <sup>c</sup>
Sandy loam	1.20 <sup>ab</sup>	0.66 <sup>b</sup>	1.86 <sup>b</sup>	10.4 <sup>b</sup>	15.6 <sup>b</sup>
Loamy sand	1.10 <sup>a</sup>	0.58 <sup>a</sup>	1.68 <sup>a</sup>	10.0 <sup>a</sup>	15.0 <sup>a</sup>

Each value is an average of four replicates

Data followed by different letters in the column are significantly different ( $P \leq 0.01$ ) according to Duncan's multiple range test



growth and yield. In the present investigation, four different types of soil were studied to determine the effect of soil types on the plant growth, oil yield, and biochemical content of *M. arvensis* under pot condition.

Present study depicted that the maximum plant growth and oil yield was supported by sandy clay soil. Oil yield was also found highest in the sandy clay soil however non-significant difference in oil yield of *Mentha* was observed between sandy clay soil and sandy clay loam soil. It may be noted that the weight of plants grown in sandy clay soil was significantly higher as compared to plants grown in other tested soil. Thus, the oil yield per plant was significantly more in plants grown in sandy clay soil as compared to those plants grown in other tested soils. This would significantly increase total essential oil yield production. The oil yield of *M. arvensis* grown in sandy clay loam and sandy loam soils falls in the reported range i.e. 0.75-0.90 %<sup>1</sup>. In the other two soil types, the oil yield of mint was less than the reported range of oil yield. Generally, heavier soils i.e. containing more clay and loam has more water retention capacity, more adhesion and cohesion to retain nutrients and more organic matter than do light soils<sup>4</sup>. Collectively, these factors favor plant growth and development<sup>14</sup>. Flecher *et al.*<sup>7</sup> reported that the accumulation of rosmarinic acid was affected by soil type in spearmint and peppermint. They indicated that retention of moisture in heavy soil favours the rosmarinic acid production.

Recently, Mahmoodabad *et al.*<sup>11</sup> observed that application of vermicompost enhanced the peppermint plant growth as well as oil yield. These factors may be responsible for higher growth and oil yield of *M. arvensis* in sandy clay than the other soil types. Shukla *et al.*<sup>17</sup> determined the growth of *M. citrata* in the presence and absence of *P. thornei*. They observed that in absence of nematodes, the greatest plant growth and oil yields were in sandy loam soil followed by sandy clay loam and loamy sand. The maize plants growing in pots filled with the smallest of the aggregates obtained from the loam soil grew substantially

better than plants grown in the larger aggregates<sup>18,19</sup>.

Chlorophyll (a, b and total), total sugar and total phenol contents of the *M. arvensis* leaves were observed maximum in plants grown in sandy clay soil (Table 2). Sharma *et al.*<sup>20</sup> observed the maximum growth of *Cassia* species in black soil followed by sandy and humus soils; the leaf pigments were also observed more in black soil. The present results also showed the directly proportional relationship between plant growth and chlorophyll content. It has been suggested that photosynthesis influences production of carbohydrate and plant growth<sup>21</sup>. Passioura<sup>16</sup> suggested that when roots are growing in soil which does not favour growth they send inhibitory signals to the leaves. Effects of the signals on the leaves are of many types. Probably, a network of hormonal and other responses is involved in attuning the growth and development of a plant to its environment. The reduction in chlorophyll content may create disturbance in photosynthesis and carbohydrate production which may lead to less plant growth and oil yield, which is in complete agreement with observed reduction in oil yield of peppermint due to disturbance in photosynthesis which occurred under stress condition<sup>22</sup>.

## Conclusions

Japanese mint is an oil-yielding crop and therefore, the soil which supports maximum oil yield along with plant growth will be considered as the best soil. The present study indicates sandy clay soil to be the best soil for the growth of *M. arvensis*. Results show the importance of soil types as a factor affecting the yield of *M. arvensis* and this information will be helpful for farmers/gardeners in selecting soil for the cultivation of *M. arvensis*.

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