The effect of sowing date and sowing method on quantity characteristics and essential oil content on Moldavian balm (*Dracocephalum moldavica L.*)

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ABSTRACT: In order to study the effect of sowing date and the methods of sowing on quantity characteristics and essential oil content on Moldavian balm, an experiment was carried out in research field of agronomy factuality of Urmia university in 2011. This research was conducted as factorial based on randomized complete block design with four replications. The first factor was including four sowing dates (April 9, 19 and 9, 29 May) and the second factor was two sowing method (direct planting at main field and sowing in the nursery and then transplanting). The results of analysis of variance showed that sowing date had significant effect on quantity characteristics and essential oil content and yield. The method of sowing factor had significantly affected on essential oil content and all of quantity characteristics. Also, interaction effect between sowing date and sowing method in term of quantity characteristics and essential oil content was significant at the 0.05 probability level. Maximum biological yield and essential oil content were obtained from combination treatments namely first sowing date and transplanting method. However, compare means showed that this combination treatment had no significant difference with combination treatment of second sowing date and transplanting method.

Keywords: sowing date, sowing method, Moldavian balm, quantity characteristics and essential oil content

Introduction

Moldavian balm with scientific name (*Dracocephalum moldavica L.*) is known Badrshby, Badrshbo and Savory-Shatra names in Iran (Mozafarian, 2003). It is a perennial herb native to central Asia and naturalized in eastern and central Europe (Dastmalchi et al., 2007). In Moldavian balm 62 compounds were identified by capillary GC and GC/MS. Geranyl Acetate, Geranial, Neral and Geraniol were found in Moldavian balm (Venskutisons et al., 1995). Neral and geraniol have anti-viral and anti-bacterial properties. The extract of Moldavian balm principally contained polar compounds including Hydroxycinnamic acids and Flavonoids, with Caffeic and Ferulic acids, luteolin-7-O-glucoside, Rosmarinic acid, Luteolin and Apigenin being identified from their chromatographic behavior and spectral characteristics. The Moldavian balm extracts demonstrated activity in all the antioxidant assays (Dastmalchi et al., 2007b). Combinations of antioxidants and flavonoids from Moldavian balm are playing an important role in preventing injuries such as heart infarct size (Najafi et al., 2007). The essential oils of Moldavian balm have been investigated previously.
in Hungarian, Iran, Magnolia and Finland (Rechinger, 1986; Galambosi et al., 2002). The use of essential oils is important not only in preservation of food but also in control of human and plant diseases of microbial origin (Baratta et al., 1998). Aziz et al (2010) reported that the seasonal changes in plant height, fresh and dry weight of plant as well as fresh and dry yield of herb are significant. It is clear that essential oil content increase with increasing plant age to reach the maximum values at post flowering stage. The yield of plant fresh herb, the essential oil content and its composition can be influenced by growth stages, ecological and climatically condition. Researches show that the components of essential oil yields affected by genotype, growth and development stages and also agronomy practice and environmental conditions (Marotti et al., 1995). The significantly effects of different water regimes (Safikhani et al., 2007) and nutrients (Rahbarian et al., 2009) on growth characteristics, essential oil content and yield of Moldavian balm pervious have been reported. Shifting planting date caused to change of day length, minimum and maximum temperatures, relative humidity and other environmental conditions during the plant growing season and affects on biological yield, phenological, quality and quantity of essential oil of plant. Among various factors which can increase the yield on per unit area basis, sowing date and sowing methods are considered to be the most important. Leto et al (1996) reported that early planting produced higher seed yield but oil contents remained similar. Transplanting method of fennel gave 38% higher seed yield than direct seeding (Yadav & Khurana, 1999). Borna et al (2007) reported that planting dates has significant effect on growth and development of Dragonhead. The highest essential oil content obtained from the early planting date was sown on 4 of April. In studying by Davazdah-Emami et al (2008) the majority of seedlings of Moldavian balm were injured in autumn planting date (November), but Fresh and dry biological yields, essential oil quality per m$^2$ had significant differences and in spring (March) were 12.7 kg, 10.3cc and 4.1kg and in summer (June) were 4.1, 1 kg and 4.1cc, respectively. Essential oil quantity was significantly higher than summer planting date (June). With Weather conditions in growing regions of Moldavian balm, there are different results in values of essential oil yield and content, so that halasz-zelnik et al (1988) suggested the best sowing time in Late March or early April and Suchorska et al (1994) have introduced May month best time for sowing Moldavian balm. A little is known about the impacts of planting date and especially the methods of planting on improving essential oil and its yield in D. Moldavia. Therefore, the present study was conducted to evaluate the simple and interaction effects of these factors in quantity characteristics and essential oil of Moldavian balm as important medicinal plant.

### Materials and Methods

This research was conducted in research field of Agronomy Factuality of Uremia University located on Nazlou Campus in 2011. This region situated at a latitude of 37°32’ N and longitude 45°2’ E and at about 1320 m above sea level. Annual rainfall of region based on long-term Average 365.5 mm with narrow variation rainfall from year to year. Soil texture of experimental site was clay loam which as characteristic by pH=7.8 and electricity conductivity (EC=1.2 dS/m). Experimental treatments were arranged as factorial in a randomized complete block design with four replications. The first factor was including four sowing dates (April 9, 19 and 9, 29 May) and the second factor was two methods sowing (direct planting at main field and sowing in the nursery and then transplanting). To prepare field soil, moldboards plow tillage carried out in the autumn and after favorable climate conditions in spring, Secondary tillage operations for the final seed bed preparation was done by cultivator. Then, 30 ton quite rotten manure was added to field. Plots were 8 meter square and within each plot created furrow as distance between planting rows and two plants (within rows) were 60 and 20 centimeter, respectively. For control weeds used agronomy practice by Hand weeding in three times and didn’t use any herbicide. Field irrigation was carried due to weather conditions and plant phenological stages during the growing season on appropriate time. Harvest time was different in regard to sowing dates, However all of harvesting carried out at 50% flowering. Fresh and dry weight plants were determined with digital weighing scales. Samples of plants were dried in the shade and for extracting essential oils were used distillation with water practice and Clevenger device. The data were statistically analyzed using statistical program SAS. Analysis of variance was employed to test the overall significance of the data, while the Duncan's multiple range (Duncan) test at $P=0.05$ was used to compare the differences among treatment means.
Results and discussion

**Plant height:** Plant height character influenced significantly by sowing date, sowing method and interaction effects of these factors (Table 1). So that based on comparing means, the maximum plant height (97.2 cm) was obtained from first date of sowing (9 April) and with delay of date sowing decreased and reach to 50.9 cm in fourth date of sowing (9 May). Transplanting method was better in compared with direct planting method in plant height character (17.98 percent increasing with 105.1 cm) (Table 2). Also, in interaction effects, compound treatments first sowing date (9 April) by transplanting method was better than others treatments and in final date sowing (9 may) with compound direct planting method was obtained the lowest plant height (110.17 and 70.51 cm, respectively). In direct planting method, there was no significant difference between first and second time of sowing (Fig 1).

![Fig 1. Interaction effects between sowing date and sowing method on plant height](image1.png)

**Branch numbers:** Sowing date and sowing method had significant effect on branches number per plant, also the interaction effects of these factors were significant (Table 1). Maximum and minimum branches was observed on first and fourth sowing date (16.15 and 12.15, respectively), although there was no significant difference between third and fourth time of sowing (Table 2). Transplanting in compared to direct planting was increased branches of Moldavian 13.47 percentage (Table 2). The highest branches was obtained from first sowing date by transplanting method compound treatment and followed second date sowing with transplanting method was located, but third and fourth date sowing on this sowing method weren’t significant differences together (Fig 2). In direct planting method, first and second times didn’t have significant differential effects; similar result was observed in third and fourth times on this method of sowing (Fig 2).

![Fig 2. Interaction effects between sowing date and sowing method on Branches number per plant](image2.png)
**Fresh weight:** Fresh weight of Moldavian balm significantly was changed by variance sources such as sowing date, sowing method and interaction effects (Table 1). In compared means it was cleared that maximum fresh weight (3892.3 Kg/ha) was obtained from first sowing date (9 April) and with delaying in sowing dates it was decreased, also transplanting method was better than direct planting, statistically (Table 2). First and second times of sowing date by transplanting method without significant difference had the highest fresh weight (4115.3 Kg/ha) among combination treatment. In opposition to fourth time sowing with direct planting had the lowest fresh weight (2765.6 Kg/ha) (Fig 3).

**Dry weight:** Dry weight character affected by both sowing date and sowing method, also interaction effects of these factors had significant difference on this character (Table 1). Based on compared means, early sowing caused to up the dry weight and it decreased with delaying in sowing date as the maximum and minimum dry weight (778.5 and 593.5 Kg/ha) were belonged to first and fourth sowing dates (9 April and 9 May). Also transplanting method increased dry weight in compared with direct planting (up 8.09 percent) (Table 2). Sowing Moldavian seeds in 9 and 19 April on transplanting method hadn’t difference significant, also there was not significant different between third and fourth sowing date on this method. All of sowing dates in direct planting method followed by these compound treatments and placed in different groups in term of this character; however the lowest dry weight was obtained with fourth sowing date (9 May) by direct sowing method (Fig 4).
### Table 1: Analysis variance of measured quantity characteristics and essential oil on Moldavian

<table>
<thead>
<tr>
<th>S.O.V</th>
<th>d.f</th>
<th>MS</th>
<th>Plant height</th>
<th>Branches No.</th>
<th>Fresh weight</th>
<th>Dry weight</th>
<th>Biologic yield</th>
<th>Essential oil yield</th>
<th>Essential oil content</th>
<th>Harvest index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Replication</td>
<td>3</td>
<td>100.7</td>
<td></td>
<td>17.55</td>
<td>3876.8</td>
<td>824.61</td>
<td>4352.8</td>
<td>8.12</td>
<td>0.91</td>
<td>24.45</td>
</tr>
<tr>
<td>S.D</td>
<td>3</td>
<td>103.9</td>
<td></td>
<td>19.53</td>
<td>4549.7**</td>
<td>909.94*</td>
<td>5120.6*</td>
<td>9.71*</td>
<td>1.02*</td>
<td>27.43*</td>
</tr>
<tr>
<td>S.M</td>
<td>1</td>
<td>182.2*</td>
<td></td>
<td>27.92*</td>
<td>8064.5**</td>
<td>1607.9*</td>
<td>8634.2*</td>
<td>13.8*</td>
<td>1.41*</td>
<td>46.02*</td>
</tr>
<tr>
<td>SD*SM</td>
<td>3</td>
<td>97.49*</td>
<td></td>
<td>14.58*</td>
<td>3204.7**</td>
<td>739.28*</td>
<td>3584.9*</td>
<td>7.82*</td>
<td>0.81*</td>
<td>21.48*</td>
</tr>
<tr>
<td>Error</td>
<td>21</td>
<td>18.27</td>
<td></td>
<td>3.01</td>
<td>753.3</td>
<td>155.10</td>
<td>825.7</td>
<td>1.49</td>
<td>0.15</td>
<td>4.52</td>
</tr>
<tr>
<td>CV (%)</td>
<td>-</td>
<td>12.3</td>
<td></td>
<td>12.6</td>
<td>14.5</td>
<td>16.4</td>
<td>11.46</td>
<td>12.1</td>
<td>11.8</td>
<td>12.9</td>
</tr>
</tbody>
</table>

*: Significant at 0.05 level, **: Significant at 0.01 level.

### Table 2: Mean comparisons of the main effects

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Plant height (cm)</th>
<th>Branches No.</th>
<th>Fresh Weight (Kg/ha)</th>
<th>Dry Weight (Kg/ha)</th>
<th>Biologic Yield (Kg/ha)</th>
<th>Essential oil yield (Kg/ha)</th>
<th>Essential Oil content (%)</th>
<th>Harvest Index (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sowing date</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9 April</td>
<td>97.2</td>
<td>16.2</td>
<td>3892.3</td>
<td>778.5</td>
<td>4712.9</td>
<td>8.46</td>
<td>0.83</td>
<td>23.1</td>
</tr>
<tr>
<td>19 April</td>
<td>93.4</td>
<td>14.7</td>
<td>3578.3</td>
<td>715.6</td>
<td>4011.3</td>
<td>7.79</td>
<td>0.81</td>
<td>21.8</td>
</tr>
<tr>
<td>29 April</td>
<td>70.4</td>
<td>12.6</td>
<td>32112</td>
<td>642.2</td>
<td>3623.6</td>
<td>6.82</td>
<td>0.75</td>
<td>19.4</td>
</tr>
<tr>
<td>9 May</td>
<td>50.9</td>
<td>12.2</td>
<td>2967.4</td>
<td>593.5</td>
<td>3014.7</td>
<td>6.04</td>
<td>0.68</td>
<td>17.9</td>
</tr>
<tr>
<td>Sowing method</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Direct planting</td>
<td>86.2</td>
<td>13.4</td>
<td>3869.4</td>
<td>773.9</td>
<td>3912.6</td>
<td>5.94</td>
<td>0.51</td>
<td>22.8</td>
</tr>
<tr>
<td>Transplanting</td>
<td>105.1</td>
<td>15.5</td>
<td>4210.5</td>
<td>842.1</td>
<td>4732.6</td>
<td>8.74</td>
<td>0.81</td>
<td>24.2</td>
</tr>
</tbody>
</table>

S.D: Sowing date, S.M: Sowing method, and CV: Coefficient variance
Mean which have at least once common letter are not significant different at the 5% level probability using Duncan's test.
Fig 4. Interaction effects between sowing date and sowing method on dry weight

**Biological yield:** The effects of sowing date and sowing method on Biological yield character was significant, also this character influenced by interaction effects from these treatments (Table 1). Comparing means showed that maximum biological yield (4712.2 Kg/ha) was obtained from early dates of sowing and delayed in sowing date, biologic yield of Moldavian decreased (Table 2). Transplanting method was better than that direct sowing in producing biological yield, significantly (with increasing 17.33 percent) (Table 2). There was significant difference between first and second time of sowing by transplanting method, but in third and fourth time of sowing didn’t have any different significantly in this method. In direct sowing method, sowing plant of Moldavian in 9 and 19 April showed similar result, but were different from 29 April and 9 May (Fig 5).

Fig 5. Interaction effects between sowing date and sowing method on Biological yield

**Essential oil yield:** oil essential yield significantly were affected by sowing date and sowing method (Table 1). Mean comparison was cleared that sowing Moldavian seeds on 9 and 19 April without different significant had similar result (8.46 and 7.79, respectively), but decreased in 29 April and 9 May dates. It was cleared that transplanting can be caused higher value of essential oil yield in compared to direct planting method (with increasing 32.04 percent). In compound treatments, the highest and lowest essential oil yield were obtained with first sowing date by transplanting method and fourth sowing date by direct sowing method (8.99 and 4.38 Kg/ha, respectively). Although there was no significant difference between third and fourth sowing dates in direct sowing method (Fig 6)
**Essential oil content:** The effects of sowing date, sowing method and interaction effect of these factors on Essential oil content of Moldavian were significant (Table 1). The essential oil content was highest (0.83%) when Moldavian seeds sown on earliest sowing date (9 April), however didn't have significant difference with second sowing date (19 April) (Table 2). It became clear that transplanting can produce greater quantities of essential oil in compared with direct sowing method (Table 2). Sowing dates and sowing methods combination had significant effect on essential oil content. The highest essential oil content was produced from first sowing date by transplanting method, while lowest essential oil content was obtained from fourth sowing date by direct sowing method (8.99 and 4.38 percentage, respectively), (Fig 7).

**Harvest index:** The results showed that harvest index was significantly affected by sowing dates and sowing methods (Table 1). Maximum harvest index (23.12 %) was obtained at 9 April sowing, while minimum HI (17.89 %) was obtained from fourth sowing date (9 May), (Table 2). Also, transplanting method was better than direct sowing method in this character because HI significantly increased. Interaction effect between sowing date and sowing method was significant on this character (Table 1), so that the maximum and minimum HI were obtained from compound treatments first sowing date by Transplanting and fourth date by direct sowing method (26.37 and 17.85 percentage, respectively), however there was no significant differences among first, second and third sowing dates by transplanting method on this character (Fig 8).
In plant height character, the difference between first and final sowing date (Apr 9 and May 29) was 47.6 percent, in other words with early sowing Moldavian with regard to weather conditions, can be increased plant height because of the positive effect of this character in increase essential oil on Moldavian. Borna et al (2007) showed that sowing dates has significant effect on plant height and with delaying sowing date this character decreased significantly. In plant height character, the difference between first and final sowing date (9 Apr and 29 May) was 47.6 percent, in other words with early sowing Moldavian with regard to weather conditions, plant height can be increased because of the positive effect of this character in increase essential oil on Moldavian. Also, sowing in the nursery not only protects seedlings from cold stress, but also it provides an earlier sowing because seedling is more resistance to unfavorable condition. Due to extended periods of plant growth and higher plant height, it is possible creating branch plant and increasing the number of branches. Similar the result of this experiment, the largest number of branches per plant (18.14) was obtained from the plants which were sown on 19 of March in study by borna et al (2007). Fresh weight increased about 23.8 percentages at first sowing date in compared with final sowing date (9 May). Increased growing season with early planting or transplanting allows the plant to the desired use of water, nutrients and light raised Photosynthesis process rate and increased its fresh weight. In agreement with our results, Aziz et al (2010) reported that the seasonal changes in fresh and dry weight of plant are significant. First sowing date (9 Apr) increased biological yield about 36 percent in compared to final sowing date (9 May), also it increased about 17 percent in transplanting compared with direct plant method. Shifting planting date caused to change of day length, minimum and maximum temperatures, relative humidity and other environmental conditions during the plant growing season and affects on biological yield. So transplanting Moldavian balm seedling at first sowing date showed the best results in terms of biological yield in our study. Davazdah-Emami et al (2008) reported that the majority of seedlings of Moldavian balm were injured in autumn planting date (November), but fresh and dry biological yields had significant differences in spring and summer sown. Sowing date especially the method of sowing had significantly effects on essential oil yield, so that there was visible 28 percent difference between the first and last sowing date and this difference between sowing methods was about 32 percent. Marotti et al (1995) Expressed that essential oil yields affected by genotype, growth and development stages and also agronomy practice such as different water regimes (Safikhani1 et al., 2007), nutrients (Rahbarian et al., 2009) and other environmental conditions such as sowing dates or sowing method as was observed in this experiment. Transplanting method of fennel gave 38% higher seed yield than direct seeding (Yadav & Khurana, 1999). First sowing date was caused to increased 2.4, 9.6 and 18.1% essential oil content in compared to second, third and fourth sowing dates, respectively which shows the importance of sowing plant on the essential oil content in Maldivian balm. Based on results it can be said that earlier sowing date, if it is associated with transplantation seedling, especially it can be an important role in increasing essential oil content of Moldavian balm. Inconsistent with the results of this experiment, Leto et al (1996) reported that although early sowing produced higher seed yield, but oil contents remained similar. Although
other researchers (Halasz-Zelnik et al., 1988; Suchorska et al., 1994) reported significant effects on sowing dates on produce of essential oil content of Moldavian balm.

Reference


