



## The Response of Dragon head (*Dracocephalum moldavica* L.) plant to Sowing Date and Planting Density

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**ABSTRACT:** Dragonhead (*Dracocephalum moldavica* L.) is an annual, herbaceous plant belongs the family Lamiaceae. In order to study the effects of sowing date and density on essential oil content and some morphological characteristics of dragonhead, a field experiment was conducted in Sari Agricultural Sciences and Natural Resources university by using of split-plot design in the base of randomized complete blocks with three replications in 2011. Which has been in three sowing dates (12 of June, 5 of July and 17 of July) as main factors and three planting density levels (30 × 10, 30 × 20 and 30 × 30cm). The results of the analysis of variance indicated that sowing date had significant effect on plant height, oil percentage and oil yield but planting density had significant effect only on the fresh herbage and dry herbage. Results of mean comparisons revealed that the highest fresh herbage weight (7374.7 kg) and the highest oil yield (1.197 kg) were obtained at the second sowing date (July 5). The highest dry herbage weight (2007 kg) was obtained at the third sowing date (July 17) and the highest oil content (0.065 %) was obtained at the first sowing date (June 12). Results of mean comparisons revealed that the highest fresh herbage weight (8260.2 kg), the highest dry herbage weight (2787.5 kg) and the highest oil yield (1.53 kg) were obtained at the 10 cm planting density but the highest oil content (0.058 %) was obtained at the 30 cm planting density.

**Key words:** (*Dracocephalum moldavica* L.), Sowing date, planting density, essential oil.

### INTRODUCTION

Dragonhead with scientific name (*Dracocephalum moldavica* L.) is an annual herbaceous, some times biennial, which is aromatic, with achromo some number of  $2n = 2x = 10$ , and belonging to the mint family (Lamiaceae). There are 45 species of herbaceous and shrub's dragonhead in the world and there are 8 species of annual and perennial herbaceous and fragrant in Iran which 3 of them are endemic in Iran (Mirheidar, 1994; Mozafarian, 1996). The origin of this plant is reported from southern Siberia and the Himalaya (Omidbeigi, 2005; Galambosi *et al.*, 1989) and naturally grows in temperate Zones of Europe & Asia (Galambosi & Holmes, 1989; Domokos *et al.*, 1994). In the study of Abd-El-Baky & El-Baroty (2007) on the dragonhead they found that 44 combination of essential oils was obtained which consist 97.18% of essential oil and 90% of them was combined with oxygenated monoterpenes and consisted less than one percent of the weight of the plant which include compounds such as: geranyl acetate, neryl acetate, geranyl, geraniol, neral, nerol, linalool. Dragonhead has some therapeutic properties such as sedative, tonic, antimicrobial, and wound healer (El-Gengaihi & Wahba, 1995).

Environmental factors have an important effect on the product yield and its components derived from herbs. However, it was not possible to fully control these factors but can managed environmental impact with a certain methods, which plant under those conditions appear its potential, among them, factors such as sowing date and density play an essential role in achieving the proper conditions during the period of growth to achieve maximum performance in medicinal plants (Hassani, 2006; Abedi *et al.*, 2015). In addition to sowing time and planting density is also an important factor in determining productivity. So that, if the rate of planting density is greater than optimal level, environmental factors will not be enough for the plant, conversely, if the planting density is less than optimal level so available environmental facilities are not used effectively, and leading to a decrease in the product. (Galambosi & Holm, 1991). Davazdahmami *et al.* (2008) in a study on the essential oil of dragonhead conducted cultivation in autumn, spring and summer in Isfahan, and three treatments of winter crop, sown in spring and summer were compared together, and they found that the growth of dragonhead in spring sowing is more than summer sowing, and autumn sowing was not successful at all.

A report by Bourna *et al.* (2007) performed an experiment as different sowing time effects on growth, yield and essential oil content from (*Dracocephalum moldavica* L.). The results showed that the highest plant (82.5 cm) and the largest number of branches per plant (18.14) was obtained from the plants which were sown on 19 of March and essential oil content (199.0 Kg) was obtained from the plants which were sown on 4 of April. Haj Seyyedhadi *et al.* (2002) according to a survey reported that with sowing chamomile in sowing pattern (20 × 50cm) the maximum essential oil yield and performance of kamazolen is achieved. Mohammadpour *et al.* (2013) reported that on (*Satureja hortensis* L.) the highest plant height (52.3 cm), lateral shoot (23.22 N/P), number of nod (17.81), shoot diameter (8.8 mm), root diameter (9.12 mm) and dry weight of root (2.76 g/p) were recorded for first sowing date (11 April). The highest dry shoot yield (3023.1 and 2663.9 kg/ha) was obtained at third and second sowing time (22 April and 3 May). The highest plant height (53.03 and 51.09 cm), lateral stem (21.94 and 21.79 N/P), number of nod (17.06 and 16.32) and shoot diameter (7.92 and 7.4 mm) were obtained at third and second densities (25 × 35 and 35×35cm) in Sari condition. Ahmed and Haque (1986) studied the effect of row spacing (15, 20, 25 and 30 cm) and time of sowing (November 1, November 20, December 10 and December 30) on the yield of black cumin (*Nigella sativa*) in Bangladesh, they found that closer row spacing (15 cm) and early sowing (November 1) was the best for higher seed yield of black cumin. The aim of this study was to evaluate effects of sowing date and planting density on essential oil percentage and some morphological characteristics of dragonhead herb in the weather condition of Sari.

## MATERIAL AND METHODS

### A. Plant material

In order to study the effects of sowing date and density on essential oil content and some morphological characteristics of dragonhead, a field experiment was conducted in Sari Agricultural Sciences and Natural Resources university by using of split-plot design in the base of randomized complete blocks with three replications in 2011. Which has been in three sowing dates (12 of June, 5 of July and 17 of July) as main factors and three planting density levels (30 × 10, 30 × 20 and 30 × 30cm). Location of test implementation has the (latitude. 36°, 39' N, longitude. 53°, 4' E, altitude 16 m above sea level). After land preparation which was including plowing, disking and rotivator than classification of farm plots based on the scheme is investigating. The experimental plots size was 1.25 × 2.75meter. The dragonhead seeds was prepared from Karaj city. For fast germination of dragon head seeds, was used from stalk and stover mulch that have very much effect on dragonhead seeds germination and protect of planting bed humidity. Texture of soil's location has been loam and fight against weeds was performed mechanically (twist hand weeding). In order to investigate the physical and chemical properties of field soil, one sample of that was transferred to the laboratory and was analyzed. The results of the soil analysis are shown in Table 1. In every experimental units, attributes such as: Plant height (cm), fresh and dry weight yield of plants per hectare, percentage and yield of essential oil per hectare was measured. Harvest in full bloom was performed at the middle of line plots.

**Table 1. Some physical and chemical properties of soil test in the field experiment.**

Sand (%)	Silt (%)	Clay (%)	PH	EC	Organic carbon (C %)	Organic matters (%)	Annihilate matters (%)	Total Nitrogen (%)	P (ppm)	K (ppm)	Fe (ppm)	Mn (ppm)
32	45	23	8.1	0.63	0.44	0.77	28.5	0.05	9	234	3.7	5.7

### B. Extraction of essential oil

In this method, the essential oil was extracted from the amount of 80 g of inflorescences, stems and dried leaves of dragon head in 2 treatments (sowing date and plant density) in 1 L of water contained in a 2 L flask and heated by heating jacket at 100°C for 4h in a Clevenger-type apparatus, according to producers outlined British Pharmacopoeia.

### C. Statistical analysis

All data obtained based on two split-plot design in randomized complete block design was analyzed, Means of the traits were compared by Duncan's multiple range test at p < 0.05 level. Analytical data for hierarchical cluster analysis were treated by means of the SPSS statistical software.

## RESULT AND DISCUSSION

The results of the analysis of variance (Table 2) indicated that sowing date factor had a significant effect on plant height and planting density had no significant effect on plant height. Results of mean comparisons, plant height revealed that the highest plant height (52.88 cm) was obtained at the sowing date (June 12) and the highest plant height (52.90 cm) was obtained at the 10 cm planting density (Table 3).

According to Fig.1, interaction effects sowing date and planting density on plant height revealed that the highest plant height (56.26 cm) was obtained at the second sowing date (July 5) and 30 cm planting density.

### A. Fresh and dry herbage

The results of the analysis of variance (Table 2) indicated that sowing date factor had no significant effect on the fresh and dry weight of plant, but the plant density had a significant effect on it. Also the interaction of sowing date and planting density had no significant effect on the fresh and dry weight of plant. Results of mean comparisons, fresh herbage revealed that the highest fresh herbage weight (7374.7 kg) was obtained at the second sowing date (July 5) and the highest fresh herbage weight (8260.2 kg) was obtained at the 10 cm plant density (Table 3).

According to Fig. 2, interaction effects sowing date and planting density on fresh herbage revealed that the highest fresh herbage weight (10413.3 kg) was obtained at the second sowing date (July 5) and 30 cm planting density. Results of mean comparisons, dry herbage revealed that the highest dry herbage weight (2007 kg) was obtained at the third sowing date (July 17) and the highest dry herbage weight (2787.5 kg) was obtained at the 10 cm plant density (Table 3). According to Fig. 3, interaction effects sowing date and plant density on dry herbage revealed that the highest dry herbage weight (2959.5 kg) was obtained at the third sowing date (July 17) and 30 cm planting density.

The results of the analysis of variance (Table 2) indicated that sowing date factor had a significant effect on essential oil percentage and yield but planting density had no significant effect on essential oil percentage and yield. Also the interaction of sowing date and planting density had significant effect on essential oil yield.

Results of mean comparisons, oil content revealed that the highest oil content (0.065 %) was obtained at the first sowing date (June 12) and the highest oil content (0.058 %) was obtained at the 30 cm planting density (Table 3).

**Table 2. Analysis of variance for different parameters of (*Dracocephalum moldavica* L.)**

S.V	Df	Mean of square				
		Plant height	Fresh weight	Dryweight	Essential oil	Essential oil yield
Replication	2	41.1974463 <sup>ns</sup>	22807123.88 <sup>**</sup>	542185.27 <sup>ns</sup>	0.00281734 <sup>**</sup>	442.540578 <sup>**</sup>
Sowing date (A)	2	222.2422352 <sup>*</sup>	5840668.01 <sup>ns</sup>	447612.8 <sup>ns</sup>	0.00169378 <sup>*</sup>	613.202685 <sup>**</sup>
Error (A)	4	20.8098407	7540352.51	434300.97	0.00059592	58.189141
Plant density (B)	2	155.3994296 <sup>ns</sup>	34337757.47 <sup>**</sup>	9581765.90 <sup>**</sup>	0.00005957 <sup>ns</sup>	49.319436 <sup>ns</sup>
A B	4	127.5258074 <sup>ns</sup>	15717516.32 <sup>**</sup>	243119.56 <sup>ns</sup>	0.00071358 <sup>ns</sup>	133.763218 <sup>**</sup>
Error (B)	12	30.9989704	1911481.90	376712.81	0.00032969	50.797573
C.V	-	10.71	18.21	34.12	28.17	24.51

n.s., \*, \*\*: non-significant, Significant at 0.05 and 0.01 probability levels, respectively.

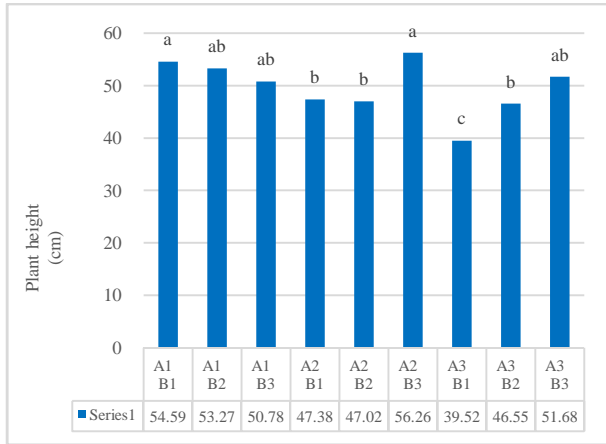
**Table 3: Mean comparison effects of sowing date and plant density on different parameters of (*Dracocephalum moldavica* L.) in Sari climatic condition.**

Treatments	Mean of characters				
	Plant height (cm)	Fresh weight (Kg/ha)	Dry weight (Kg/ha)	Essential oil (%)	Essential oil yield (Kg/ha)
Sowing date					
2011/6/12	52.88 <sub>a</sub>	6259.5 <sub>b</sub>	1766.9 <sub>a</sub>	0.065 <sub>a</sub>	1.148 <sub>a</sub>
2011/7/5	50.22 <sub>a</sub>	7374.7 <sub>a</sub>	2064 <sub>a</sub>	0.058 <sub>a</sub>	1.197 <sub>a</sub>
2011/7/17	45.92 <sub>b</sub>	6615.7 <sub>ab</sub>	2007 <sub>a</sub>	0.046 <sub>b</sub>	0.91 <sub>b</sub>
Plant density					
30 cm	47.16 <sub>b</sub>	5550.9 <sub>c</sub>	1490.1 <sub>b</sub>	0.058 <sub>a</sub>	0.86 <sub>a</sub>
20 cm	48.95 <sub>b</sub>	6438.8 <sub>b</sub>	1560.3 <sub>b</sub>	0.054 <sub>a</sub>	0.83 <sub>a</sub>
10 cm	52.90 <sub>a</sub>	8260.2 <sub>a</sub>	2787.5 <sub>a</sub>	0.055 <sub>a</sub>	1.53 <sub>a</sub>

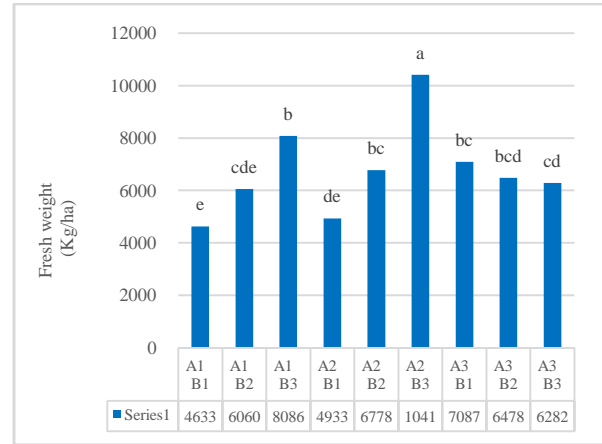
Means in each column followed by the same letter are not significantly different (P <0.05).

According to Fig. 4, interaction effects sowing date and planting density on oil content revealed that the highest oil content (0.07 %) was obtained at the first sowing date (June 12) and 10 cm planting density. Results of mean comparisons, oil yield revealed that the highest oil yield (1.197 kg) was obtained at the second sowing date (July 5) and the highest oil yield (1.53 kg) was obtained at the 10 cm planting density (Table 3).

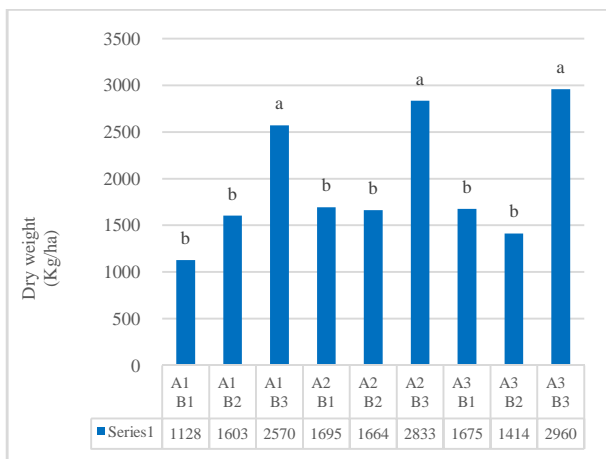
According to Fig. 5, interaction effects sowing date and planting density on oil yield revealed that the highest oil yield (1.77 kg) was obtained at the first sowing date (June 12) and 30 cm planting density. Growth and production of medicinal plants like other plants is influenced by genetic and agronomic factors. Choosing the most suitable sowing date and plant density is one of the most important factors of success in agriculture.



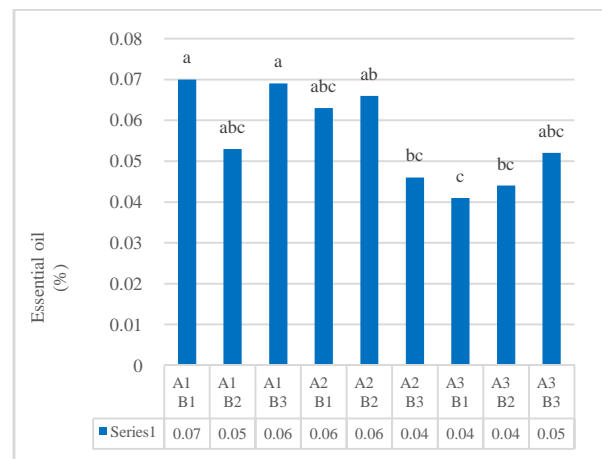
**Fig. 1.** Comparison of interaction effects of sowing date and plant density on plant height. A<sub>1</sub>: first sowing date, A<sub>2</sub>: second sowing date, A<sub>3</sub>: third sowing date; B<sub>1</sub>: 10 cm density, B<sub>2</sub>: 20 cm density, B<sub>3</sub>: 30 cm density.



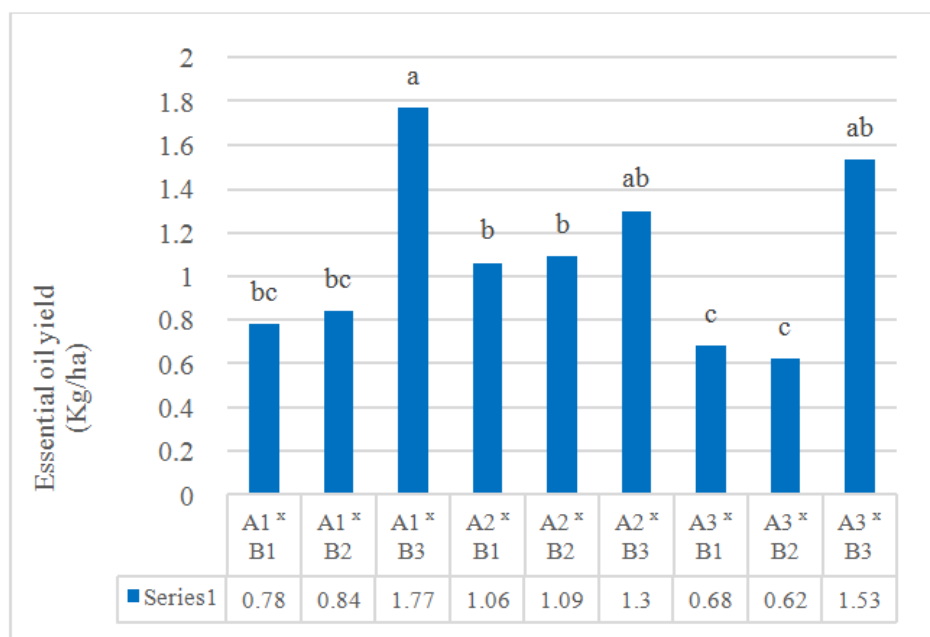
**Fig. 2.** Comparison of interaction effects of sowing date and plant density on fresh weight. A<sub>1</sub>: first sowing date, A<sub>2</sub>: second sowing date, A<sub>3</sub>: third sowing date; B<sub>1</sub>: 10 cm density, B<sub>2</sub>: 20 cm density, B<sub>3</sub>: 30 cm density.



**Fig. 3.** Comparison of interaction effects of sowing date and plant density on dry weight. A<sub>1</sub>: first sowing date, A<sub>2</sub>: second sowing date, A<sub>3</sub>: third sowing date; B<sub>1</sub>: 10 cm density, B<sub>2</sub>: 20 cm density, B<sub>3</sub>: 30 cm density.



**Fig. 4.** Comparison of interaction effects of sowing date and plant density on essential oil. A<sub>1</sub>: first sowing date, A<sub>2</sub>: second sowing date, A<sub>3</sub>: third sowing date; B<sub>1</sub>: 10 cm density, B<sub>2</sub>: 20 cm density, B<sub>3</sub>: 30 cm density.



**Fig. 5.** Comparison of interaction effects of sowing date and plant density on essential oil yield. A1: first sowing date, A2: second sowing date, A3: third sowing date; B1: 10 cm density, B2: 20 cm density, B3: 30 cm density.

It appears that the increase in plant height following the increase in plant density was brought about by the increase in the inter-plant competition over light and the disruption of the balance of growth regulators. In other words, the decrease in light penetration into middle and lower layers of canopy decreases auxin decomposition and thus, plant height increases and under these conditions, plant height increases if other environmental parameters such as moisture and soil fertility, do not limit the growth of plants (Imam and Ranjbar, 2000).

For each product there is an optimum sowing date which its delay can usually reduce the yield. Agriculture experts believed that the establishment of an appropriate density of healthy plants at the farm levels, is the foundation of a successful system of agronomic. At densities less than optimum use of available environmental factors such as light, moisture and nutrients was not maximum, and also at densities higher than optimal the existence of intense competition would reduce the yield of the final product (Sarmadnia and Kochaki, 1990). About the effect of sowing date on the dragonhead medicinal plant, various researchers have been tested on the best time to sowing which considering the climatic conditions of test location, different results have been achieved, so that Halaszelnik *et al.* (1988) suggested late march/early April as the best time for sowing, and Suchorska *et al.*

(1994) have introduced may month has the best time for that.

harvesting of dragonhead in summer sowing (during 61 days) more than spring sowing (during 22 days) allows sowing after grain autumn harvest and provides adequate opportunity to prepare the land for the next autumn sowing (Davazdahemami *et al.*, 2008). Arabaci and Bayram (2004) with sowing basil at 3 different densities (20, 40 and 60 plants per square meter) in two cases of fertilization with nitrogen and without fertilization, reported that the highest fresh and dry yield, percentage and yield of active ingredients were achieved in the density of 20 plants per square meter with the mode of fertilization.

Also the highest yield of fresh weight plant (8260.2 kg) and dry weight plant (2787.5 kg/ha) was obtained from a of 10 cm density (Table 3). From the above results it comes onto gain much dry weight of the plant, should create less density. Growth and production of medicinal plants like other plants is influenced by genetic and agronomic factors. Choosing the most suitable sowing date and plant density is one of the most important factors of success in agriculture. Because seed set depends on sufficient nutrients they provide and environmental conditions while shift from vegetative to reproductive stage, increased planting densities result in limited availability of nutrients, light and water so the number of reproductive units decrease; at last seed number reproduction decreases.

Shalaby and Razin (1992) were cultured thyme in rows of 60cm and plant distance (15, 30 and 45cm). Results showed that the distance of 45cm support plant growth and that yield. But the maximum essential oil yield was obtained at a distance of 15cm. Close distance causes a significant progress in yield and essential oil content. But the percentage of essential oil of the dried plant was not affected by distance.

Daadkhaah *et al.* (2009) with evaluate the effect of sowing dates and plant density on growth and yield and quality of chamomile have concluded that crop season significantly affected on the growth characteristics and yield of chamomile, so that in the autumn sowing the plant height, number of main stem and sub, flowering period, number of flowers per plant and flowers yield per unit area was higher than spring sowing. The highest yield of flowers were achieved from a rows of 20 cm at a density of 100,000plants per hectare. At higher densities due to the large number of plants per unit area wet and dry performance increasing. Morteza *et al.* (2009) with evaluating of sowing date and plant density on essential oils and combinations of valerian reported that the highest essential oils and its major combinations were achieved from sowing date of 30 August and a density of 40,000 plants per hectare. Mohammad Alipour *et al.* (2010) with evaluating the effects of density and nitrogen fertilization on yield and composition of thyme essential oils showed that the plant density on dry matter yield and essential oil and thymol have significant impact on the unit. Maximum dry matter yield, essential oil and thymol were achieved of a 15cm distance and using 100kg nitrogen per hectare.

According to study of Davazdahemami *et al.* (2008) dragonhead height reduced from 93cm to 58cm in summer sowing. Also study of Burna *et al.* (2007) on the dragonhead showed that spring sowing in terms of higher essential oil combinations has the advantage than summer sowing. In the spring and summer sowing amount of granyalacetate was measured respectively: 35.3 and 14.1 %, and geraniol 15 % and 19.7 %, and geraniol 20.1 and 15 %. Resaam *et al.* (2007) to investigate the effect of sowing date and sowing density on yield and grain yield components of anise showed that the sowing dates, density levels and their interaction had a significant effect on the most studied traits. Totally the highest grain yield of anise was obtained in the first sowing date (10 March) with a density of 40 plants square meter. Azizi (1998) in a similar survey mentioned late February as the best time to anise sowing and noted that postponing of cultivation after this date will result in the loss of 40-30 percent of yield. Akbarinia *et al.* (2005) have been reported that

fennel plant's yield in autumn sowing is more than spring sowing and stated that cultivation in autumn has higher grain yield for this reasons; better establishment, cold tolerance, early onset, spring growth, and consequently higher foliage and seed weight.

Ebadi *et al.* (2010) reported that on (*Matricaria recutita* L.) the highest essential oil content (0.72 percent w/w), essential oil yield (0.26 g/m<sup>2</sup>) and -bisabolol yield (0.2375 g/m<sup>2</sup>) were obtained from the second harvest of March and the most chamazulene yield (0.0473 g/m<sup>2</sup>) was obtained from the third harvest of March sowing date in Mashhad condition. Qualitative and quantitative changes in the essential oil of thyme in Iran, over a period of growth and various density was examined and showed that plant density and harvest time has a significant effect on the quality and quantity of thyme performance. So that the maximum dry yield of plant, the performance of essential oils and thymol yield was observed at the beginning of flowering and a density of 15cm (Naghdibaadi *et al.*, 2004).

## CONCLUSION

Evaluate the quantity outcomes of the essential oil showed that to achieve the highest level of essential oils, its better to use this plant in summer cultivation, weather conditions of Sari city of Mazandaran province in north of Iran, at the first sowing date, and a planting density of 30cm. For achieve to better quantity and quality of the essential oil of dragonhead, the sowing of *Dracocephalum moldavica* L. plant in early times will be better than these dates that used in this investigation.

## REFERENCES

- Abd-El-Baky HH, El-Baroty GS.(2007). Chemical and biological evaluation of the essential oil of *Dracocephalum moldavian* L. Chemical and biological evaluation of the essential oil. *International journal of integrative biology*, 2(2), 74-80.
- Abedi R, Golparvar AR, Hadipanah A. (2015). Identification of the essential oils composition from four ecotypes of *Mentha longifolia* (L.) Huds. growing wild in Isfahan province, Iran. *Journal of Bio Science and Biotechnology*, 4(2), 117-121.
- Ahmed NU, Haque KR.(1986). Effect of row spacing and time of sowing on the yield of black cumin (*Nigella sativa* L.). *Bangladesh. J. Agric*, 1, 21-4.
- Akbarinia A, Khosravifard M, Rezaee MB, Sharifi Ashoorabadi E. (2005). Comparison of fall and spring cultivation of fennel, caraway, anise and black cumin under irrigation and no-irrigation conditions. *Iranian journal of medicinal and aromatic plants research*, 21(3), 319-334.

- Arabaci O, Bayram E. (2004). The effect of nitrogen fertilization and different plant densities on some agronomic and technologic characteristic of basil (*Ocimum basilicum* L.). *Journal of Agronomy*, **3**(4), 255-256.
- Aziai S. (1998). The effect of sowing date and nitrogen fertilizer on growth and development, yield and essential oil of anise medicinal plant. Islamic Azad University of Science and Research of Tehran Branch. 87-95.
- Borna F, Omidbaigi R, Sefidkon F.(2007). The effect of sowing dates on growth, yield and essential oil content of (*Dracocephalum moldavica* L.). *Iranian journal of medicinal and aromatic plants research*, **23**(3), 307-334.
- Dadkhah A, Kafi M, Rasam GH. (2009). The effect of sowing date and plant density on growth traits, yield quality and quantity of matricaria (*Matricaria chamomilla*). *Journal of horticultural sciences*, **23**(2), 100-107.
- Davazdahemami S, Sefidkon F, Jahansooz MR, Mazaheri D. (2008). Comparison of biological yield, essential oil content and composition and phenological stages of moldavian balm (*Dracocephalum moldavica* L.). *Iranian journal of medicinal and aromatic plants research*, **24**(3), 263-270.
- Ebadi M, Azizi M, Omidbaigi R, Hassanzadehkhayyat M. (2010). Effect of sowing date and harvest frequency on flower yield, essential oil percent and composition of chamomile (*Matricaria recutita* L.) CV. *Presov. Iranian Journal of Medicinal and Aromatic Plants*, **26**(2), 213-226.
- El-Gengaihi S, Wahba H. (1995). The response of *Dracocephalum moldavica* L. plant to nitrogen fertilization and sowing density. *Actahorticulturae*, **390**, 33-39.
- Galambosi B, Holm Y. (1989). The effect of nitrogen fertilization on the herb yield of dragonhead. *Journal of Agricultural Science in Finland*, **61**, 387-394.
- Galambosi B, Holm Y. (1991). The effects of spring sowing times and spacing on the yield and essential oil of chamomile (*Matricaria recutita* L. Var. Bona) grown in Finland. *Herba Hungarica*, **1**(2) 47-53.
- Galambosi B, Holm Y, Hiltunen R.(1989). The effect of some agrotechnical factors on the herb yield and volatile oil of dragonhead. *Journal of essential oil research*, **1**, 287-292.
- Haj Seyeedhadi SMR, Khodabande N, Darzi M, Yas N.(2002). Effects of sowing date and plant density on flower yield and active substance in chamomile. *Journal of oloomzerae of Iran*, **4**(3), 208-216.
- Halaszelnik K, Hornok L, Domokos J. (1988). Data on the cultivation of *Dracocephalum moldavica* L. in Hungary. *Herbahungarica*, **28**(1), 8-49.
- Hassani A.(2006). Effect of water deficit stress on growth, yield and essential oil content of (*Dracocephalum moldavica* L.). *Iranian journal of medicinal and aromatic plants research*, **22**(3), 256-261.
- Imam Y, Ranjbar G. (2000). Effect of plant density and drought stress at vegetative growth stage on yield, yield components and water use efficiency in grain corn. *Iranian Journal of Agricultural Researches*, **2**(3), 118-129.
- Mirheydar H. (1994). Maarefgiahi. *Daftarenashrefarhangeislami, Tehran*, **1**, 109-111.
- Mohammadpour M., Ghasemnejad, A. LebaschyMH, Azadbakht M. (2013). Effects of sowing date and plant density on morphological characteristics and yield of Summer savory (*Satureja hortensis* L.). *Iranian Journal of Medicinal and Aromatic Plants*, **29**(3), 621-634.
- Morteza E, Akbari GHA, ModaresSanavi AM, Foghi B, Abdoli M. (2009). The effect of sowing date and sowing density on the essential oil content and composition of *Valeriana officinalis* L. *Iranian journal of medicinal and aromatic plants*, **25**(2), 272-282.
- Mozaffarian V. (1996). A Dictionary of Iranian Plant Names. FarhangMoaser, Tehran, Iran. pp. 542.
- Naghdibadi H, Yazdani D, Sajed MA, Nazari F. (2004). Effects of spacing and harvesting time on herbage yield and quality/quantity of oil in thyme, *Thymus vulgaris* L. *Ind Crops Prod*, **19**, 231-236.
- Omidbaigi, R. (2005). Production and processing of medicinal plants. Vol. 2. Astan Quds Razavi publications. Behnashr. Mashhad. 438.
- Rassam GH, Naddaf M, Sefidcon F. (2007). Effect of sowing date and plant density on yield and seed yield components of Anise (*Pimpinella anisum* L.). *Journal of Pajouhesh & Sazandegi*, **75**, 127-133.
- Sarmadnia GH, Koocheki A. (1990). Physiology of crop plants. Jahaddaneshgahi. Mashhad. 400.
- Shalaby AS, Razin AM. (1992). Dense cultivation and fertilization for higher yield of thyme (*Thymus vulgaris* L.). *Journal of agriculture. Crop sciences*, **168**, 243-248.
- Suchorska K, Starch Z, Osinska E. (1994). Growth and development of *Dracocephalum moldavica* L. in Hungary. *HerbaHungarica*, **27**(1), 49-57.