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## Original Article

# The Effect of Planting Time and Planting Density on Yield and Essential Oil of *Satureja sahendica* Bornm.

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**Abstract**

This experiment was conducted, to study the effect of planting time and planting density on savory (*Satureja sahendica* Bornm.) in 2012 in Alborz Research Station, Research Institute of Forests and Rangelands, Karaj, Iran. The experiment was carried out in split plot in time in the form of a randomized complete block design with three replicates. The main plots were planting times in two levels (including fall and spring planting) and the sub plots were planting density in four levels (including 20×20, 40×40, 60×60 and 80×80 cm). The results indicated that planting time significantly affected the number of lateral branches on the main stem, the number of flowering branches, flowering shoot yield and essential oil yield, the number of tillers, plant height, single plant shoot yield and essential oil percentage. The effect of planting density had also significant differencein all measured traits except the plant height. Mean comparison of planting time showed that in all planting densities, fall planting was better than spring plantingin all traits. Mean comparison of planting densities indicated that the highest number of tillers (7.67), the number of flowering stems (6.5), single plant shoot yield (22.98 g/plant) and essential oil percentage (2.01%) were achieved in the lowest planting density (80×80 cm). However, the highest number of lateral branches (5.67), flowering shoot yield (1587.5 kg/ha) and essential oil yield (14.53 kg/ha) were achieved in the highest planting density (20×20 cm). The interaction of planting time × planting density significantly affected all measured traits except for the number of tillers and the number of flowering branches. The results of this experiment indicated that selection of suitable planting time and planting density is important to obtain high essential oil yield; fall planting × the highest density (20×20 cm) could produced an acceptable yield in Karaj climatic conditions.

**Key words**: Essential oil, Planting density, Planting time, *Satureja sahendica*, Yield

## Introduction

Since the side effects of synthetic medications are revealed to the public, consumption of medicinal plants to cure diseases is increasingly under attention. Because very low data is in hand about yield improvement in medicinal plants, It is important to conduct researches on the techniques of improving yield and quality of these plants [1]. The savory genus with the scientific name *Satureja* is mainly distributed in the Mediterranean area. It has 15 species in Iran which nine of them are endemic; other species are found in Iran, Turkmenistan, Turkey, Caucasian area and Iraq [2]. *Satureja sahendica* Bornm. is one of the endemic species to Iran. It is a perennial aromatic shrub with white to violet flowers which help attracting pollinating bees [3]. These species mainly grow in mountain slopes of north, northwest, northeast, center and south west of Iran, usually on calcareous soils or rocks [2]. Flowering shoots and all aerial parts of this plant are aromatic and are used to cure various diseases [4]. Essential oil of this plant has many applications in food and hygienic industries;

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it has anti microbial activities [5]. Study of eight populations of *S. sahendica* indicated that the main compounds in the essential oil were thymol, p-Cymene and gamma-terpinene [6].

Selection of suitable crop management techniques is important to take the highest advantages of the environmental factors and reach the highest plant potential. Among these management techniques, planting time and planting density are the very important ones; seriously affecting medicinal plants growth and yield [7]. Planting time is important for plant development; plant phenology is affected by different planting times [8]. There is a suitable planting date for each plant and other dates reduce plant growth and yield [9]. Noormohammadi *et al*. reported that most morphologic features such as tillers and height are under control of both genetic and environmental factors [10]. Ebadi *et al*. studied the effect of planting dates (Nov. 6, Mar. 6 and April 4) on yield of chamomile and concluded that flower yield was the highest in November and essential oil yield was the highest in March [11]. Sales *et al*.also tested the effect of planting date on *Isatis tinctoria* and *Isatis indigotica* and found that planting dates at the early winter had higher biomass compared with the early spring dates [12]. Naguib *et al*. studied the effect of two planting dates on *Ruta graveolens* and reported that plant height, the number of leaves and stem dry weight were the highest in Oct. 1, and the highest number of branches, leaf fresh weight and stem dry weight were the highest in Nov. 1 [13].

Various studies on the effect of planting density on plant yield and yield components represents that in most cases, higher planting densities results in the reduction of a single plant growth and yield and enhancement of total yield in hectare [14]. Seghatoleslami and Ahmadi Bonakdar studied the effect of different planting densities (10, 20, 30 and 40 plants/m$^2$) on fenugreek and reported that grain yield was the highest in 40 plant/ha density [15]. Mert and Ayanoglu conducted an experiment to evaluate the effect of planting density (5,10,15,20 and 30 plants/m$^2$) on yield and essential oil of artemisia and reported a significant effect; essential oil was the highest in 15 plants/m$^2$ [16]. Arabaci and Bayram tested basil under three planting densities (20×20, 40×20 and 60×20 cm) and found that plant fresh and dry weight and leaf dry weight were the highest in the highest planting density (20×20 cm) [17].

Reduction of the number of tillers as the result of higher planting densities was reported by KhaliliMoheleh *et al*. on sorghum and by Blue *et al*. and Rezaei *et al*. on triticale. Singh *et al*. observed that fenugreek grew taller in higher planting densities [18-21]. NaghdiBadi *et al*. conducted experiments on thyme and reported that the highest shoot dry weight was achieved in the highest planting density [22]. Heidari *et al*. tested peppermint under 8, 12, 16 and 20 plants/m$^2$ densities and concluded that essential oil was the highest in 8 and 12 plants/m$^2$ densities; however, essential oil yield was the highest in 20 plant/m$^2$ [23]. Because there is no information about the proper planting density and planting time of *Satureja sahendica*, this experiment was conducted with the aim of determining the best planting density and planting time of the plant.

## Material and Methods

This experiment was conducted in 2012 in Alborz Research Station, Research Institute of Forests and Rangelands, Karaj, Iran. The experiment was conducted in split plot in time in the form of a randomized complete block design with three replicates. The main plots were planting time in two levels (including fall and spring planting) and the sub plots was planting density in four levels (including 20×20, 40×40, 60×60 and 80×80 cm). Plots were 2×3 m.

The seeds were collected from a natural habitat and were tested for germination. Theseeds were planted in pots in early fall and early spring and were transplanted in the field in mid fall and mid spring. Irrigation was conducted two times a week in early growth stages after transplanting and one time a week later. No pests or diseases were observed; Weeding operated manually. The measured traits included the number of tillers, plant height, the number of lateral branches on the main stem, the number of flowering branches, shoot yield, essential oil percentage and essential oil yield. Sampling was conducted at full flowering stage to measure fresh and dry weights and essential oil. The samples were dried in shadow, grinded and essential oil was extracted by hydrodistillation using the Clevenger. Essential oil percentage was calculated based on shoot dry weight. Statistical analysis was conducted using SAS and MSTAT-C. Data were normalized by SQRT and Arc sine and mean comparison was by the Duncan's multiple range tests and LSD.

## Results and Discussion

Analysis of variance indicated that planting time significantly affected the number of lateral branches on the main stem, the number flowering branches, flowering shoot yield and essential oil yield at P≤0.01, and the number of tillers, plant height, single plant shoot yield and essential oil percentage(Table 1). Mean comparison of planting time showed that all measured traits had higher values in the first planting time (fall) compared with the second time (spring) (Table 2). The results indicated that planting density had significant effect on the number of tillers, the number of lateral branches, single plant shoot yield, shoot yield and essential oil yield at P≤0.01, and the number of lateral branches on the main stem and essential oil percentage at P≤0.05 (Table 1).

Mean comparison of the planting density showed that reduction of planting intervals reduced the number of tillers in the way that 80×80 cm had the highest number of tillers (7.67 tillers/plant). The lowest number of tillers (3.2) was achieved in 20×20 cm. The results of mean comparison of the effect of planting density on the number of lateral branches on main stem indicated that high planting density (20×20 cm) resulted in the highest number of lateral branches (5.67); reducing the planting density decreased the number of lateral branches. Mean comparison of different planting density levels (Table 3) showed that the number of flowering branches had no significant differences in two lower densities (80×80 and 60×60 cm); it was significantly higher compared with the tow low densities. Mean comparison also showed that the highest single plant shoot yield (22.98 g/plant) was achieved in 80×80 cm. This trait was reduced when planting density increased; it was the lowest in 20×20 density (6.35 g/plant). No significant differences were observed in other treatments. Shoot yield in hectare was unlike the shoot yield of a single plant; it was higher in higher planting densities in the way that the highest shoot yield (1587.5 kg/ha) was achieved in 20×20 cm. The lowest essential oil percentage and the highest essential oil yield were both observed in 20×20 cm and other treatment were significantly the same.

The interaction of planting time×planting density significantly affected essential oil yield at P≤0.01 and all other traits at P≤0.05, except for the number of tillers and the number of flowering branches. Mean comparison of the interactions (Table 4) also showed that the number of lateral branches on the main stem was the lowest (1.33) in 80×80 cm×spring planting time which was significantly the same as 60×60 cm×spring. The highest yield of a single plant flowering shoot (36.07 g) was the highest in 80×80 cm×fall planting time; it was lower in higher planting densities. However, flowering shoot yield in hectare was unwise single plant shoot yield and it was the highest in 20×20 cm×fall and 20×20 cm×spring. Generally, results indicated that the highest essential oil percentage was achieved in fall planting time and 40, 60 and 80 cm. The highest essential oil yield was also achieved in fall planting time×20, 40 and 60 cm (18.74, 18.23 and 21.26 kg/ha) without significant differences.

Studying the correlation of the measured traits indicated that the number of lateral branches was significantly correlated to plant height (P≤0.01). The number of flowering branches, single plant flowering shoot yield and essential oil percentage had also significant correlation with the number of tillers. Essential oil percentage was significantly correlated to the number of lateral branches and single plant shoot yield. Essential oil yield had also a significant correlation with plant height, the number of lateral branches, flowering shoot yield and essential oil percentage (Table 5).

According to the results of this experiment, planting time affects biologic yield and essential oil yield of savory; the number of tillers, plant height, the number of flowering branches, the number of lateral branches on the main stem, single plant shoot yield, flowering shoot yield, essential oil percentage and essential oil yield were higher in fall planting time than in spring planting time. So it can be concluded that cultivation of *Satureja sahendica* is preferred in fall because it gives the plant a longer growth season and make it possible to take higher advantages of the environmental sources and it also helps plant to avoid contact with harsh environmental conditions of late spring and early summer [7-13].

Tillering is under control of genetic and environmental factors; the reduction of the number of tillers in higher planting density may be attributed to the lack of sufficient space for growth of plants which limits their access to resources and their potential for tillering. The reduction of the number of tillers in high planting densities was reported on sorghum and triticale [1,10,8-20].

The non significant effect of planting density on plant height (Table 3) indicates that the competition was not high enough to stimulate plants vertical growth. This may be related to the size of leaves, which are too small and their arrangement on the stems which allows light to penetrate to the lower layers of canopy. Lebaschy *et al*. conducted a three year experiment on fennel and observed that the effect of planting density was not significant on plant height in the first and second year [24]. Similar results were achieved in the experiments of Seghatoleslami and Ahmadi Bonakdar on fenugreek and Dadkhah *et al*. on chamomile [15,25]. However, Singh *et al*. reported the enhancement of fenugreek height in higher planting densities [21]. Although in lower planting densities flowering shoot of a single plant was higher because of access to more resources and lower competition; however, total shoot yield in hectare was higher in high planting density. In other words, in very low planting densities, yield would reduce because of lower leaf area and later canopy development which prevents the field to take the highest advantages from the environmental resources and reaching the highest yield. NaghdiBadi *et al*. conducted an experiment on thyme and reported that the highest dry matter yield was achieved in the highest planting density [22]. Russelle *et al*. also reported that in high planting density, single plant yield was reduced but total plant yield in hectare was increased [14]. Similar results were reported in the experiments of Seghatoleslami and Ahmadi Bonakdarand Arabaci and Bayram [15,17].

Results indicated that increasing the planting density resulted in higher essential oil yield. This was directly related to the enhancement of biomass production in 20 × 20 cm treatment because in this treatment, essential oil percentage was the lowest. The essential oil of savory mainly accumulates in leaves and flowering shoots. So, the treatments with high planting density which had the highest leaf yield and flowering shoot yield, had also the highest essential oil yield. These findings were in agreement with those of Heidari *et al*. who tested the effect of different planting densities (8,12,16 and 20 plants/m$^2$) on peppermint and reported that the highest essential oil percentage was achieved in the lowest planting densities (8 and 12 plant/m$^2$); however, the highest essential oil yield was achieved in the highest planting density (20 plant/m$^2$) [23]. Similar results were also reported by Arabaci and Bayram on basil and Rahmati *et al*. on chamomile [17,26].

Study of the correlation of the measured traits indicated that there was significant correlation between essential oil yield, plant height, the number of lateral branches on the main stem, flowering shoot yield and essential oil percentage. In fact, high planting density affects all the mentioned traits. The interaction of planting time×planting density had no significant effect on the number of tillers and flowering branches. Results of this experiment indicated that selection of suitable planting time and planting density affects essential oil yield and 20×20 cm×fall planting time resulted in good yield in the first year.

**Table 1** Analysis of variance of the effect of treatments on the measured traits.

| S.O.V | df | Mean Squares (MS) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | N of tillers | P. height | N. of L.branche | N. of F. branches | S.P.Sh. yield | T.F.Sh. yield | E. oil percentage | E. oil yield |
| Block | 2 | ns | ns | ns | ** | ns | ns | ns | ns |
| Planting time (A) | 1 | * | * | ** | ** | * | ** | * | ** |
| Error | 2 | 10.79 | 333.65 | 0.29 | 0.06 | 3.07 | 46300 | 1.5 | 2305 |
| Planting density (B) | 3 | ** | ns | * | ** | ** | ** | * | ** |
| A × B | 3 | ns | * | * | ns | * | * | * | ** |
| Error | 12 | 1.26 | 99.42 | 0.12 | 0.83 | 0.36 | 29418 | 0.11 | 274.9 |
| CV (%) | - | 20.28 | 29.56 | 17.22 | 23.22 | 17.27 | 21.48 | 19.84 | 22.35 |

Ns, non significant; *, significant at P≤0.05; **, significant at P≤0.01.
N=number, P=plant, L=lateral, S=single, Sh= shoot, F=flowering, T=total, E=essential, O=oil

**Table 2** Means comparision of the measured traits.under planting times

| Treatments | N of tillers | P. height (cm) | N of L. branches | N. of F branches | S.P. Sh (g/plant) | T.F. Sh. yield (kg/ha) | E. O. percentage | E.O. yield (kg/ha) |
|---|---|---|---|---|---|---|---|---|
| Fall | 7.83 a | 40.9 a | 5.5 a | 5.9 a | 21.33 a | 992.9 a | 2.4 a | 18.29 a |
| Spring | 3.25 b | 26.5 b | 3.08 b | 3 b | 8.1 b | 604 b | 0.9 b | 3.33 b |

Means in a column followed by the same letter are not significantly different at P≤0.01.

**Table 3** Means comparision of the measured traits.under plant densities

| Treatments | N of tillers | P. height (cm) | N of L. branches | N. of F branches | S.P. Sh (g/plant) | T.F. Sh. yield (kg/ha) | E. O. percentage | E.O. yield (kg/ha) |
|---|---|---|---|---|---|---|---|---|
| 80 × 80 | 7.67 a | 31.5 a | 3 b | 6.5 a | 22.98 a | 359 c | 2.01 a | 7.94 b |
| 60 × 60 | 6.5 a | 32.08 a | 3.66 b | 6.2 a | 17.16 ab | 476.8 bc | 1.2 a | 10.142 ab |
| 40 × 40 | 4.83 b | 32.83 a | 4.83 ab | 2.7 b | 12.3 bc | 769.7 b | 1.74 a | 10.47 ab |
| 20 × 20 | 3.2 c | 38.5 a | 5.67 a | 2.5 b | 6.35 c | 1587.5 a | 1.2 b | 14.53 a |

Means in a column followed by the same letter are not significantly different at P≤0.01.

**Table 4** Interaction of planting densities in planting times on the measured traits.

| Treatments | N of tillers | P. height (cm) | N of L. branches | N. of F branches | S.P. Sh (g/plant) | T.F. Sh. yield (kg/ha) | E. O. percentage | E.O. yield (kg/ha) |
|---|---|---|---|---|---|---|---|---|
| Fall × 80 | 10.67a | 39.33 ab | 4.67 ab | 8 ab | 36.07 a | 563.5 bc | 2.96 a | 14.6 ab |
| Fall × 60 | 9 ab | 41.67 ab | 5 ab | 8.67 a | 25.6 b | 711b c | 2.37 a | 18.74 a |
| Fall × 40 | 7 b | 36ab | 5.33 a | 3.67 bc | 17.13 bc | 1071 ab | 2.46 a | 18.23 a |
| Fall × 20 | 4.67 c | 46.67 a | 7 a | 3 c | 6. d | 1625 a | 1.53 b | 21.26 a |
| Spring × 80 | 4.67 c | 23.67 b | 1.33 c | 5 abc | 9.9 cd | 155 d | 1.06 bc | 1.3 c |
| Spring × 60 | 4c | 24 ab | 2.33 bc | 3.66b c | 8.7 cd | 143 cd | 0.91 bc | 1.6 c |
| Spring × 40 | 2.67 cd | 28.17 ab | 4.33 ab | 1.67 c | 7.5 cd | 469 bcd | 0.84 c | 2.71 c |
| Spring × 20 | 1.67 d | 30.33ab | 4.33 ab | 1.67 c | 6.2 d | 1550 a | 0.79 c | 7.8b c |

Means in a column followed by the same letter are not significantly different at P≤0.01.

**Table 5** The correlation between the measured traits.

| | The number of tillers | Plant height | The number of lateral branches | The number of flowering branches | Single plant shoot yield | Total flowering shoot yield | Essential oil percentage | Essential oil yield |
|---|---|---|---|---|---|---|---|---|
| The number of tillers | 1 | - | - | - | - | - | - | - |
| Plant height | $0.55^{ns}$ | 1 | - | - | - | - | - | - |
| The number of lateral branches | $0.23^{ns}$ | $0.86^{**}$ | 1 | - | - | - | - | - |
| The number of flowering branches | $0.91^{**}$ | $0.41^{ns}$ | $0.01^{ns}$ | 1 | - | - | - | - |
| Single plant shoot yield | $0.96^{**}$ | $0.40^{ns}$ | $0.11^{ns}$ | $0.14^{ns}$ | 1 | - | - | - |
| Total flowering shoot yield | $-0.12^{ns}$ | $0.67^{ns}$ | $0.83^{*}$ | $0.28^{ns}$ | $0.19^{ns}$ | 1 | - | - |
| Essential oil percentage | $0.95^{**}$ | $0.67^{ns}$ | $0.45^{ns}$ | $0.78^{*}$ | $0.88^{**}$ | $0.12^{ns}$ | 1 | - |
| Essential oil yield | $0.56^{ns}$ | $0.95^{**}$ | $0.87^{**}$ | $0.26^{ns}$ | $0.42^{ns}$ | $0.73^{*}$ | $0.74^{*}$ | 1 |

$^{ns}$, non significant; $^{*}$, significant at P≤0.05; $^{**}$, significant at P≤0.01.

## References


1. Abbaszadeh B. Effect of different levels of nitrogen fertilizer and application methods on essential oil of balm (*Melissa officinalis* L.). M Sc thesis Islamic Azad University Karaj Branch Iran. 2005;120 p. (In Persian with English abstract).
2. Rechinger KH. Satureja in Fl. Iranica. Akademische Druck-u. Verlagsanstalt Graz. 1982;150:495-504.
3. Ghahreman A. Plant Systematic. Tehran University Press Tehran, Iran. 1992. (In Persian).
4. Zargari A. Medicinal Plants, vol. II, 3rd edition, Tehran University Press, Iran. 1982. (In Persian).
5. Sefidkon F, Jamzad Z, Barazandeh MM. Essential oil of *Satureja bachtiarica* Bunge as the source of carvacrol. Journal of Medicinal and Aromatic Plants Research. 2004a;20:425-439.
6. Sefidkon F, Jamzad Z, Mirza M. Chemical variation in the essential oil of *Satureja sahendica* from Iran. Food Chemistry. 2004b;88:325-328.
7. Darzi MT, Haj Seyed Hadi MH, Yasa N. Effects of sowing date and plant density on yield and quality of *Foeniculum vulgare* Mill. J Agronomy. 2005;2:27-36.
8. Khajehpour MR. Principles of Agronomy. Jahad Daneshgahi of Isfahan Publications Isfahan, Iran. 1999.
9. Sarmadnya GR, Kochaki A. Crop Physiology. Jahad Daneshghahi of Mashhad Publications, Iran. 1990.
10. Noormohammadi G, Siadat A, Kashani A. Agronomy. vol. 1: Cereal Crops. Shahid Chamran University Press Ahwaz, Iran. 2001; pp:446.
11. Ebadi M, Azizi M, Omidbaigi R, Hassanzadeh Khayyat M. Effect of sowing date and harvest frequency on flower yield, essential oil percent and composition of Chamomile (*Matricaria recutita* L.) cv. Presov. Journal of Medicinal and Aromatic Plants. 2009;26:269-308.
12. Sales E, Kanhonou R, Baixauli C, Giner A, Cooke D, Gilbert K, Arrillaga I, Sequra J, Ros R. Sowing date, transplanting, plant density and nitrogen fertilization affect indigo production from Isatis species in a Mediterranean region of Spain. Industrial Crops and Products. 2006;23:29-39.
13. Naguib YN, Hussein MS, El-Sherbeny SE, Khalil M.Y, Lazari D. Response of *Ruta graveolens* L. to sowing dates and foliar micronutrients. J Appl Sci Res. 2007;3:1534-1543.
14. Russelle MP, Wilhelm WW, Olson RA, Power JF. Growth analysis based on degree days. Crop Sci. 1984;24:28-32.
15. Seghatoleslami MJ, Ahmadi Bonakdar K. The effect of sowing date and plant density on yield and yield components of Fenugreek (*Trigonella foenum-gracum* L.). Journal of Medicinal and Aromatic Plants. 2009;26:265-274.
16. Mert A, Ayanoglu F. The effect of different plant density on yield, yield component and quality of *Artemisia annua*. J Haworth. 2002;48:413-418.
17. Arabaci O, Bayram E. The effect of nitrogen fertilization and different plant densities on some agronomic and technologic characteristic of *Ocimum basilicum* L. (Basil). J Agronomy. 2004;3:255-262.
18. KhaliliMoheleh J, Tajbakhsh M, Faiaz Moghdam A. Effects of plant density on quantitative and qualitative characteristics of forage sorghum in second cropping. Iranian Journal of Research and Development. 200;75:59-67.
19. Blue EN, Teich AH, Smid A. Seed rate for soft winter wheat in south western Ontario. Can J Plant Sci. 1993;73:1071-1073.
20. Rezaei F, Ghodsi M, Kelarestaghi K. Study of the effect of planting date and plant density on yield, developmental rate and agronomical traits of 2 triticale genotypes. Field Crops Research. 2011;9:297-405.
21. Singh S, Buttar G.S, Singh S.P, Brar D.S. Effect of different dates of sowing and row spacing on yield of fenugreek (*Trigonella foenum-gracum* L.). Journal of Medicinal and Aromatic Plant Science. 2005;27:629-630.
22. NaghdiBadi H, Yazdani D, Mohammad Ali S, Nazari F. Effects of spacing and harvesting time on herbage yield and quality/quantity of oil in thyme, *Thymus vulgaris* L. Industrial Crops and Products. 2004;5:51-56.
23. Heidari F, ZehtabSalmasi S, Javanshir A, Aliari H, Dadpoor M.R. The effects of plant densities on yield and essential oil of Peppermint (*Menth apiperita* L.). J Sci Tech Agri Nat Res. 2008;45:501-519.
24. Lebaschy MH, Sharifi Ashoorabadi E, Bakhtiary M. The effects of plant densities on yields of *Foeniculum vulgare* Mill. under dry farming J of Medicinal and Aromatic Plants. 2009;26:121-132.
25. Dadkhah A, Kafi M, Rasam G. The effect of planting date and plant density on growth traits, yield quality and quantity of matricaria (*Matricaria chamomilla*). J Hor Sci. 2009;23:100-107.
26. Rahmati M, Azizi M, Hasanzadeh Khayyat M, Neamati H. The effects of different level of nitrogen and plant density on the agro morphological characters yield and essential oils content of improved Chamomile (*Matricari achamomilla*) cultivar "Bodegold". J Hor Sci. 2009;23:27-35.