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Evaluating the Effect of Planting Density on Yield and Morphology of Savory (*Satureja khuzistanica* Jamzad)

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ABSTRACT

To evaluate the effect of planting density on yield and morphology of savory, this experiment was conducted in 2008-2009 in west Iran (Khorramabad). The experiment was conducted in factorial in the form of a randomized complete block design with three replications. Treatment of the experiment included three inter-row spacing (IRS; space between rows) as the main factor (60, 70 and 80 cm) and three on-row spacing (ORS; space between plants on a row) as the sub factor (25, 35 and 45 cm). At the full flowering stage, traits such as plant height, canopy diameter, the number of main stems, the number of lateral branches, internodes length, leaf length and width were measured. At early fall, plants were harvested and weighted. Then, flowering branches were separated and were considered as the net yield (medicinal) of savory. Results indicated that the lowest flowering shoot yield was achieved in the lowest ORS (25 cm); the highest canopy diameter was achieved in the highest ORS (45 cm) and the lowest planting density (45 × 80 cm). The highest flowering shoot yield was achieved in the lowest IRS (65 cm) and the lowest ORS (25 cm). Regarding the obtained results and the flowering shoot yield, the most suitable planting density for obtaining the highest shoot yield is the highest planting density (6.67 plants/m^2). This proves that although canopy diameter and leaf size of each plant reduce in high planting density; however, the total flowering shoot yield increases.

Keywords: flowering shoot, medicinal plants, *Satureja khuzistanica* Jamzad.

Abbreviations: IRS, inter row spacing (space between rows); ORS, on row spacing (space between plants on a row).

INTRODUCTION

Savory is from the lamiaceae family and *Satureja* genus, with more than 30 species. It is endemic to east Mediterranean and west Asia. 14 species of this plant are found from north to south west and central Iran; eight species are endemic to the area [10, 13]. Among the endemic species to Iran, *S. khuzistanica* and *S. rechingeri* are endangered because of uncontrolled harvest from their habitats and the harsh environmental condition on their habitat, caused by low precipitation in recent years. The limited populations of these species are separated from each other because of human destructions and are distributed in low density as the single plants [6]. *S. khuzistanica* Jamzad is a perennial medicinal plant which is found only in Iran and is distributed in south west of Iran. It is mainly used to cure seizure and flatus. In addition to the medicinal uses, this plant is used in foods, drinks and hygienic industries, because of high aromatic compounds and its anti bacterial and anti fungal features.

There is a general idea that medicinal plants that are cultivated in fields are less useful and effective that those collected from the natural habitats. However, studies have proven that if the medicinal plants are propagated from high quality seeds and are cultivated in suitable environmental conditions, they will be as effective as the wild ones. Good techniques may even make the cultivated plant more effective that the wild plants [5].

Although growth, yield and essential oil of medicinal plants are under control of genetical factors; however, these features are affected by the environmental factors too. In recent years, researchers have conducted experiments on medicinal plants to increase their yield by improving the conditions of their growth area [3, 8, 12]. Optimum planting density is required to enable plants to take the best advantages of light, air, water and nutrients, and to prevent them from competition. The optimum planting density is determined by various plant and environmental factors. Planting density is one of the most important factors affecting plant morphology, yield and essential oil.

In mono cropping systems, optimum planting density is important for desirable yield production. If plants are to much in a certain area, they start a serious competition to obtain higher light, water, air and nutrients. On the other hand, if plants are too low in an area, some parts of the resources remain unused; resulting in yield reduction.

Various experiments have been conducted to evaluate the effect of planting density on the yield and essential oil of medicinal plants. Shalaby and Razin [2] conducted an experiment to test the effect of planting density on *Thymus vulgaris* and reported that when the inter-row spacing was 60 cm, reducing on-row spacing from 45 to 15 cm increased shoot yield. Ashoori Latmahalleh et al. [3] reported the significant effect of planting density on flowers dry weight, biomass and the number of flowers in *Echium amoenum*. Arabaci and Bayram [11] studied the effect of three planting densities (20, 40 and 60 plants/m^2) on basil and concluded that the highest fresh and dry weight, essential oil yield and essential oil percentage were achieved in 20 plants/m^2. Ezz Al-Dein Muhammad [1] studied *Thymus vulgaris* at various growth stages (before flowering, flowering, full flowering and fruiting) in different planting intervals (15, 30 and 45 cm) and reported that at the fruiting stage, plant had the highest yield when the planting interval was 15 cm. Similar results were reported by Morteza et al. [4]; Ganjali et al. [7]; Sadeghi et al. [12] and Khorshidi et al. [8].

Finally, it can be conducted that because collecting medicinal plants from the nature is difficult and also poses threat to the natural habitats and wild populations, it is required to domesticate the valuable medicinal plants such as savory and cultivate them in fields. For this purpose, determining the optimum planting density is an important primary step. So, this experiment was conducted to find the best planting density of savory.

MATERIALS AND METHODS

This experiment was conducted in 2008-2009 in west Iran (Khorramabad; 33˚ 35' N, 47˚ 53' E, 1027 m above the sea level, 475.98 mm average annual precipitation and 16.50 average annual temperature). Soil at the test site was sandy loamy. The experiment was conducted in factorial in the form of a randomized complete block design with three replications.

When the field was prepared, 3 blocks were set, 9 plots in each block, and each plot was 4 m × 2 m. The interval of blocks was 2 m and the interval of plots was 1 m. The main factor was inter-row spacing (IRS) (60, 70 and 80 cm), and the sub factor was on-row spacing (ORS) (25, 35 and 45 cm). There were five rows in each plot. The combination of IRS and ORS in plots was:

25 × 60 cm (6.67 plants/m^2), 35 × 60 cm (4.77 plants/m^2), 45 × 60 cm (3.7 plants/m^2), 25 × 70 cm (5.7 plants/m^2), 35 × 70 cm (4.08 plants/m^2), 45 × 70 cm (3.17 plants/m^2), 25 × 80 cm (5 plants/m^2), 35 × 80 cm (3.57 plants/m^2) and 45 × 80 cm (2.78 plants/m^2).

At the beginning of the experiment, in mid winter, prepared scions were planted in alluvial sand in cold frame for rooting. After field preparation, in mid spring, young plantlets (5-7 cm) were planted in holes along with the pot soil, in the required intervals. After transplanting, the field was heavily irrigated. Because the plant is a perennial one, when it was established in field, irrigation was repeated every three week in the first year and every one month in the second year, in summer.

After full flowering stage, five plants were selected from the middle of each plot and plant height, canopy diameter, the number of main stems, the number of lateral branches, internodes length, leaf length and leaf width were measured in different years of the experiment. In early fall, two side rows and 0.5 m of both sides of each rows in plots were removed. From the remaining area of each plot, shoot of 1 m^2 was harvested and was evaluated for their

fresh and dry weight. At the end, leaves and young shoots were detached from the dried woody stems and were considered as the net yield (medicinal) for each treatment.

Data were analyzed using MSTAT-C and means were compared according to the Duncan's multiple rang test ($P \leq 0.05$).

RESULTS

Canopy diameter. According to the combined analysis of variance of two years, ORS had significant effect on the canopy diameter of savory (Table 1). The highest canopy diameter (54.69 cm) was achieved in 45 cm ORS and the lowest canopy diameter (49.87 cm) was achieved in 25 cm ORS (Figure 1).

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

SOV	df	Mean Squares (MS)									
		Fresh yield	Dry yield	Flowering shoot yield	Plant height	Canopy diameter	Leaf width	Leaf length	Internodes length	Number of main stems	Number of lateral branches
R	2	**	**	**	*	**	**	ns	ns	**	**
A	1	**	**	**	**	**	**	**	**	**	*
B	2	ns	ns	*	ns	ns	ns	ns	ns	ns	ns
AB	2	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
C	2	ns	ns	**	ns	*	ns	*	ns	ns	ns
AC	2	ns	ns	ns	ns	ns	ns	*	ns	ns	ns
BC	4	ns	ns	ns	ns	*	ns	ns	ns	ns	ns
ABC	4	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
CV (%)	-	21.63	23.52	25.01	7.66	10.23	12.18	8.24	12.90	40.45	23.89

*ns, non significant; *, significant at P≤0.05; **, significant at P≤0.01.*
R, replication; A, year; B, inter-row spacing; C, on-row spacing.

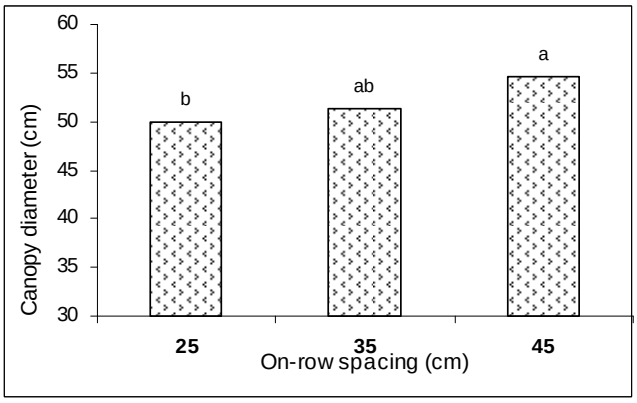

Figure 1. Effect of on-row spacing on canopy diameter.
Columns with the same letter are not significantly different at P≤0.05.

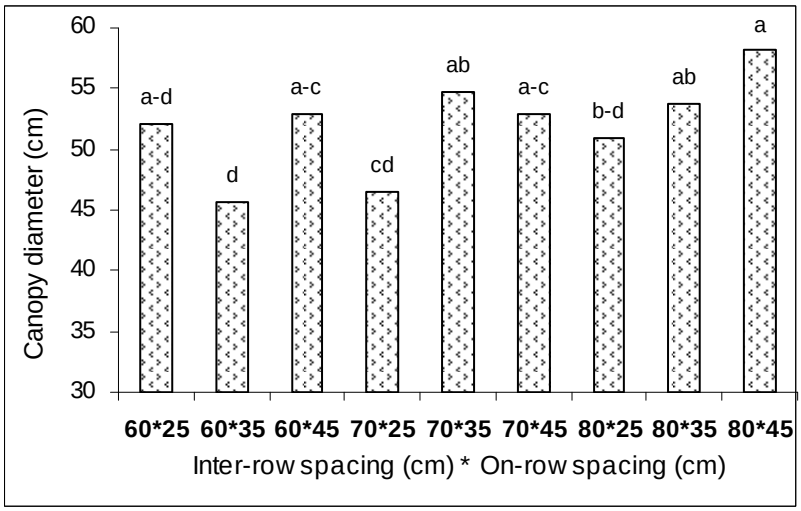

Figure 2. Effect of the interaction of Inter-row spacing × on-row spacing on plant's canopy diameter.
Columns with the same letter are not significantly different at P≤0.05.

Results indicated that the interaction of ORS × IRS had also a significant effect on plant's canopy diameter (Table 1). The highest canopy diameter (58.24 cm) was achieved in 45 × 80 cm (2.78 plants/m^2). The lowest canopy diameter (45.58 cm) was achieved in 35 × 60 cm (4.77 plants/m^2) (Figure 2).

In this experiment, IRS had no significant effect on plant's canopy diameter (Table 1).

Leaf length. The combined analysis of variance of two years indicated that ORS had a significant effect on savory leaf length (Table 1). Mean comparison showed that the highest leaf length (7.67 mm) was achieved in the highest ORS (35 cm) and the lowest leaf length (7.16 mm) was achieved in the lowest ORS (25 cm) (Figure 3).
IRS and the interaction of IRS × ORS had no significant effect on leaf length (Table 1).

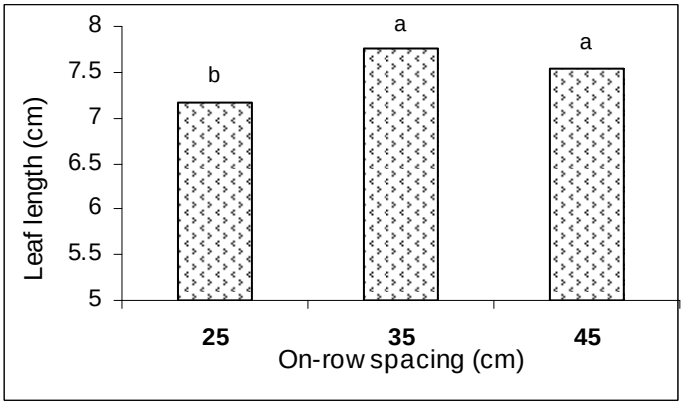

Figure 3. Effect of on-row spacing on plant's leaf length.
Columns with the same letter are not significantly different at P≤0.05.

Flowering shoot yield. Studying the combined analysis of variance of two years showed the significant effect of IRS on plant's flowering shoot yield (Table 1). The highest flowering shoot yield (567.137 g/m^2) was achieved in 60 cm IRS and the lowest flowering shoot yield (447.831 g/m^2) was achieved in 80 cm IRS (Figure 4).

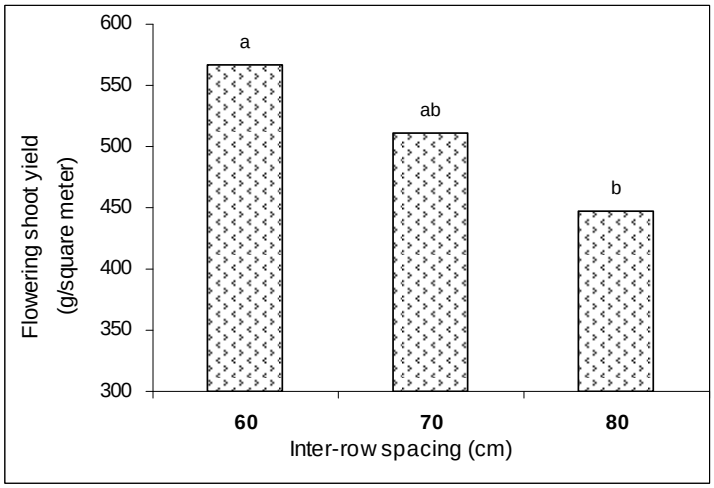

Figure 4. Effect of inter-row spacing on plant's flowering shoot yield.
Columns with the same letter are not significantly different at P≤0.05.

Moreover, results indicated that ORS had significant effect on flowering shoot yield (Table 1). Mean comparison showed that the highest flowering shoot yield (649.3 g/m^2) was achieved when ORS was 25 cm and the lowest flowering shoot yield (394.5 g/m^2) was achieved when ORS was 45 cm (Figure 5).

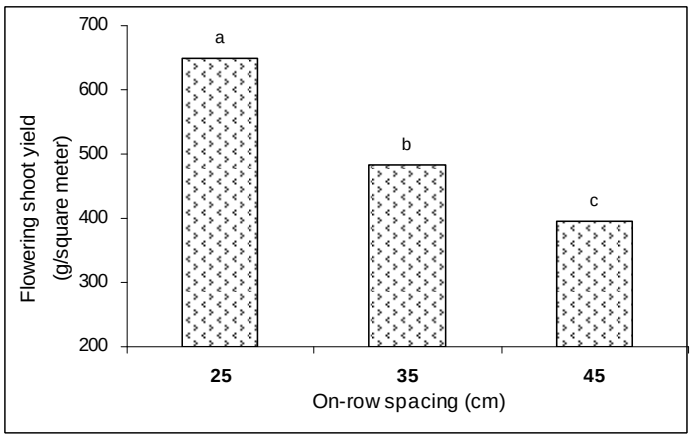

Figure 5. Effect of on-row spacing on plant's flowering shoot yield.
Columns with the same letter are not significantly different at P≤0.05.

The interaction of IRS × ORS had no significant effect on plant's flowering shoot yield (Table 1).

Combined analysis of variance of two years indicted that the effect of IRS, ORS and their interaction was not significant on rest of the measured traits including plant height, the number of main stems, single plant dry weight and fresh weight, internodes length, leaf dry weight and the number of lateral branches (Table 1).

DISCUSSION

In plant such as savory which the yield is plant's vegetative parts, a dense canopy which fully covers the soil and effectively receives sunlight is desirable. Results of this experiment indicated that the highest canopy diameter was achieved in 45 × 80 cm (2.78 plants/m^2). It may be concluded that the open area between plants allow the canopy to develop in width. Moreover, in higher planting densities, the leaf area decreased. In fact, when plants are closer to each other, there is lower space for each leaf to grow; resulting in the reduction leaf area. In higher planting densities, leaves cover each other and compete for sunlight which ends in lower leaf area [9]. Regarding the results of our experiment, which showed enhancement of flowering branches in higher planting densities, it looks that in higher planting densities plants increase their shoots growth instead of their leaf area, in order to ensure sufficient photosynthesis.
Results indicated that in 25 cm ORS and 60 cm IRS (6.67 plants/m^2), a dense canopy was produced that gave the highest flowering shoot yield, maybe because leaves were in a better position to receive sunlight, compared with stems. So, stems were the looser of competition for sunlight, reducing stem proportion, increasing the share of leaves in whole plant biomass.

In high planting density, the competition was higher, so 6.67 plants/m^2 had the highest flowering shoot yield. So, 6.67 plants/m^2 is the suitable planting density for *Satureja khuzistanica* Jamzad cultivation. This indicates that in Lorestan province of Iran, light intensity is so high which is enough for plants even when they are planted in high density. Similar results were reported by Ezz Al-Dein Muhammed [1]; Arabaci and Bayram [11] and Shalaby and Razin [2].

The significant differences between two years may be due to enhancement of plant growth, shoot development, flowering branches and consequently, seed production in the second year. On the other hand, different environmental factors may cause the variation of the measured traits between the two years.

Non-significant effect of treatments on most of the measured traits in this experiment may be attributed to low differences between treatments especially fresh and dry weight, so a planting density is more suitable which produce higher net yield (medicinal).

CONCLUSION

Generally, results obtained in this experiment suggest that cultivating savory in the highest density (60 cm IRS and 25 cm ORS) is required to obtain the highest flowering shoot yield. This can also results in the enhancement of essential oil yield and even carvacrol (an important compound in the essential oil) concentration.

REFERENCES

[1] AR Ezz Al-Dein Muhammed, *Industrial Crops and Products*, **2009**, 30 (3), 389-394.
[2] AS Shalaby and AM Razin, *Hort Abs*, **1994**, 64, 13-75.
[3] D Ashoori Latmahalleh, SA Noorhosseini Niyaki and V Safarzadeh, *Journal of Medicinal Plants Research*, **2011**, 5 (6), 932-937.
[4] E Morteza, G Ali Akbari, SAM Modares Sanavi and H Aliabdi Farahani, *J Ecology and The Natural Environment*, **2009**, 1 (9), 201-205.
[5] H Fluck, Medicinal Plants, W.Foulsham & Co. Ltd, U.K, **1988**
[6] H Nybom, *Molecular Ecology*, **2004**, 13 (5), 1143-1155.
[7] HR Ganjali, B Ayeneh and A Heidari Sharifi, H Bad and M Moussavi Nik, *Environ Sci*, **2010**, 9 (2), 149-155.
[8] J Khorshidi, SMF Tabatabaei, R Omidbaigi and F Sefidkon, *J Agric Sci*, **2009**, 1, 152-157.
[9] JC Zubriski and DC Zimmerman, *Agron J*, **1974**, 66, 798-801.
[10] KH Rechinger, *Akademische Druku Verlags Antalt Graz Austria*, **1982**, 150, 495-504.
[11] O Arabaci and E Bayram, *Journal of Agronomy*, **2004**, 3 (4), 255-262.
[12] S Sadeghi, A Rahnavard and Z Ashrafi, *Journal of Agricultural Technology*, **2009**, 5 (2), 413-422.
[13] Z Jamzad, *Naturhist Mus Wien*, **1996**, 98, 75-77.