



The Effect of Different Densities of Planting on Morphological Characters, Yield, and Yield Components of Fennel (*Foeniculum Vulgare* Mill cv. Soroksary)

Jalal Khorshidi (Corresponding author)

Department of Horticulture Science, University of Tehran, Karaj, Iran

Tel: 98-914-816-5105 E-mail: jalal_khorshidi2006@yahoo.com

Mohammad Fakhr Tabatabaei

Department of Horticulture Science, University of Tehran, Karaj, Iran

Reza Omidbaigi

Department of Horticulture Science, University of Tarbiat Modarres, Tehran, Iran

Fatemeh Sefidkon

Research Institute of Forests and Rangelands, Tehran, Iran

Abstract

In order to study the effect of different densities of planting on yield, yield components and morphological characters of Fennel, an experiment was carried out in Karaj College of agriculture at 2008. Experiment was conducted based on completely randomized block design with three replications and five plant densities. Five plants spaces were 10, 15, 20, 25, and 30cm. Results indicated that the effect of plant density was not significant on the plant height, seed length and thousand seed weight. However, the effect of plant density on yield, number of umbel per plant and number of main branches was significant in 1% level. Maximum yield (2/431kg/plot), minimum number umbel per plant (67.26), and also minimum number of main branches (3/8) were obtained with maximum plant density. While minimum yield (1/315kg/plot), maximum umbel per plant (166.86) and maximum number of main branches (7/3) were obtained with minimum plant density.

Keywords: Fennel, Plant density, Yield, Seed weight, Umbel

1. Introduction

Fennel (*Foeniculum vulgare*) is a plant of the *Apiaceae* (*Umbelliferae*) family largely used to impart flavor to a number of foods, such as soup, sauces, pickles, breads, cakes, etc. Fennel is a shrub that measures 80- 150 cm of a height and has a pungent aroma. It is indigenous to the Mediterranean and is cultivated in England, Germany, Tyrol, China, Iran, Vietnam and South America. Diuretic, analgesic and antipyretic activity has also been found in the fennel fruit as well as antioxidant activity. The most frequently investigated was the essential oil which showed antioxidant, antimicrobial and hepatoprotective activity (Lucinewton et al., 2005). Present world market is around US\$ 80 million. Iran exports these produce worth US\$ 10 million (Masood et al., 2004).

Plant spacing is an important factor in determining the microenvironment in the fennel field. The optimization of this factor can lead to a higher yield in the crop by favorably affecting the absorption of nutrients and exposure of the plant to the light. Gengaihi and Abdallah (1978) reported that number of umbel per plant, seed yield per plant and plant height was increased at the wider spacing. According to results of Verzalova et al (1988) row spacing did not effect on the plant height but number of umbel and seed yield per plant was increased at the wider spacing. Masood et al (2004) investigated the effect of row spacing (40, 50, 60, and 70cm) on morphological characters and seed yield of fennel and reported that the greatest plant height, seed yield per umbel, and seed yield per hectare were obtained with the lowest

row spacing but the lowest plant height, seed yield per umbel, and seed yield per hectare were obtained with the greatest row spacing.

Bianco and Damato (1994) reported that plant density not affected on plant height at flowering of primary umbel, number of stem and umbel per plant, yield per plant and per hectare. Hasanali et al (2002) with study the effect of different plant densities on yield dry material of Thyme (*Thymus vulgaris*) showed that the higher yield of dry material obtained with 15 cm densities of planting.

Aiello and Bezzi (1997) planted fennel at a spacing of 10, 15, 20, and 25 cm in rows and 75 cm apart and found no effect on plant establishment and survival in the first year but seed yield in the second and third years tended to be highest from plants 15 cm apart. Yadav et al (2000) conducted a field experiment on row and plant spacing and reported maximum plant height (182 cm), number of primary braches per plant (6.55), and number of umbels/plant (30.5) at 40x25 cm spacing.

Due to the medicinal and economic importance uses of fennel, the present trend is to increase the seed production and improve the quality of this crop. Keeping in view these facts, the present project was design to enhance the seed production of fennel under the agro climatic condition of Karaj (Table.1) by studying the effect of different densities of planting on morphological characters, yield and yield components on it.

2. Material and Methods

This experiment was carried out in the Tehran university, college of agriculture of Karaj in 2008 (Fig. 1). Field was plowed during the fall season and was disked before sowing time to provide a proper seedbed. Experiment was conducted based on completely randomized block design with three replications and five plant densities. The experiment includes 3 blocks and each block is contained 5 plots. Each plot size was 2.5x1.5m. Distance between blocks and plots were 1m. Five plant spaces were 10, 15, 20, 25, and 30cm. The distance among rows in all treatments was 40cm. Each plot was consisted of five rows. The bitter fennel seeds were sown at the 7th March 2008. Irrigation were done as: 1. 2-3 days interval irrigation until germination stage, 2. 4-5 days interval irrigation from germination to appearance first flowers stage, and 3. 7 days interval irrigation from appearance first flowers to harvest stage. Thinning was done when plants had 4-5 leaves. In order to better growing of plants, crust breaking operation were done at three stages (18th April, 4th May, and 19th May). All agronomic practices were keeping normal and uniform for all the treatments. Ten plants were selected at random from each plot for recording individual plant observation. Records in the growth stages were: plant height after appearance of first flower (Fig. 2-a) in many plants and after opening 50 percentages of flowers (Fig. 2-b), number of main branches, and number of umbel per plant. Then seeds harvested after ripening at two stages (20th August and 30th August) and dried in shade for 72 hour and measured the yield of seed per plot, length of seed, and weight of 1000 seeds. Data collected were analyzed using Duncan's test. Statistical software (SPSS) was used in order to analyze data.

3. Results and discussion

The effect of different densities of planting were significant on seed yield, number of main branches per plant, and number of umbel per plant at the 0.01 probability levels, but on Plant height, seed length, and thousand seed weight were not significant (Table.2).

3.1 Seed yield per plot

Different densities of planting had significant effect on the seed yield of fennel (Fig.3). Generally with decrease space among plants, Seed yield per plot increased. Maximum seed yield per plot (2.431 kg) was obtained with the highest plant density. While minimum Seed yield per plot (1.315 kg) was obtained with the lowest plant density. Although maximum seed yield per plot were obtained with the highest plant density but the highest seed yield per plant was obtained with the lowest plant density.

3.2 Length of seed

The length of seed was not affected significantly by different densities of planting. The maximum length of seed (5.1 mm) was recorded in 20cm among plant spacing. Minimum length of seed (4.06mm) was recorded in 30cm among plant spacing (Fig.4).

3.3 Weight of 1000 seeds

Effect of different densities of planting on 1000-seed weight was not significant. The maximum weight of 1000 seeds (8.26 gr) was recorded in 20cm among plant spacing. Minimum weight of 1000 seeds (6.03 gr) was recorded in 30cm among plant spacing (Fig.5).

3.4 Number of umbel per plant

Number of umbel per plant was affected significantly by different densities of planting. Generally with increase space among plants, number of umbel per plant increased. The maximum number of umbel per plant (166.86) was recorded in lowest plant density. While minimum number of umbel per plant (67.26) was recorded in highest plant density (Fig.6).

3.5 Number of main branches per plant

Our measurements showed that different densities of planting had also an expressive effect on the number of main branches per plant. Generally with increase space among plants, number of main branches per plant increased. The maximum number of main branches per plant (7.3) was recorded in lowest plant density. While minimum number of main branches per plant (3.8) was recorded in highest plant density (Fig.7).

3.6 Plant height after appearance of first flower in many plants and after opening 50 percentage flowers

Plant height in different growth stages was not affected significantly by different densities of planting. But the maximum plant height in different growth stages was recorded with maximum plant density. While the minimum plant height was recorded with minimum plant density. Maximum plant height after appearance of first flower (28.86 cm) and after opening 50 percentage flowers (89.7 cm) was belonged to 10 cm plant spacing. Minimum plant height after appearance of first flower (19.96 cm) and after opening 50 percentage flowers (74.53 cm) was belonged to 30 cm plant spacing (Fig.8 and Fig. 9).

4. Conclusion

Fennel plant is one of the most interesting research plants. It is between medicinal and aromatic plant. Plant density is an important factor in determining yield of fennel. Results of this experiment showed that influence of different densities of planting on seed yield, number of main branches per plant, and number of umbel per plant were significant. The lowest plant density produced higher number of main branches, seed yield, and umbel per plant. While the higher seed yield per plot was belonged to the highest plant density. These results are supported by the findings of Gengaihi and Abdallah (1978), Verzalova et al (1988), and Masood et al (2004). But these results are in contrast by the findings of Bianco and Damato (1994), and Akbariani et al (2006). Plant height, seed length, and thousand seed weight not affected significantly by different densities of planting. These results are in agreement with findings Bianco and Damato (1994). Akbarinia et al (2006) with study the effect of plant density on seed yield, essential oil and oil content of Coriander (*Coriandrum sativum* L.) showed that with increasing of plant density, seed yield and oil content had a significant decrease. Heidari et al (2008) reported that in peppermint (*Mentha piperita* L.) dry yield increased by increasing the plant density. Baldwin and Wesley (2006) suggested that in Kenaf (*Hibiscus cannabinus* L.), the narrowest row spacing of 35.5 cm, gave the greatest biomass yield as well as the highest bark yield per hectare. Lebaschy et al (2008) with study the effect of plant density on growth indices of Safflower (*Carthamus tinctorius* L.) showed that the maximum dry matter was obtained in the highest density but the maximum RGR (relative growth rate) and CGR (crop growth rate) were observed in low density. Gimplinger et al (2008) reported that in Amaranth (*Amaranthus cruentus*), total shoot biomass did not respond to crop density but the highest grain yield was obtained at the lowest plant population. Generally in order to gain maximum fennel yield, plants must be cultivated with 10 cm space between them. But more research is needed for understanding the effect of plant density on oil and essential oil content of fennel.

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Table 1. Geographical coordinates, average annual rainfall and mean annual temperature of Karaj

longitude	latitude	height of sea level(m)	average annual rainfall(mm)	mean annual temperature(°c)
50° 59'E	35° 47'N	1312/5	230	14/3

Table 2. Analysis of variance for morphological characters, yield, and yield components of fennel

Source	d.f	Yield of seed per plot	Length of seed	Weight of 1000 seeds	Number of main branches	Plant height after appearance of first flower	Plant height after opening 50 percentage flowers	Number of umbel per plant
Repeat	2	58503/8	0/416	0/715	0/641	99/22	29/64	284/32
Treat	4	614414/9**	0/544ns	2/538 ^{ns}	5/302**	40/54 ^{ns}	102/28 ^{ns}	4539/5**
Error	8	75142/2	0/299	1/536	0/566	27/14	26/91	522/3
C.V.	-	16	11/34	16/17	13/05	21/81	6/30	18/34

** : significant responses at the 0.01 probability levels

ns: not significant

Table 3. The effect of different densities of planting on morphological characters, yield, and yield components of fennel

Factor Space between plants	Yield of seed per plot	Length of seed	Weight of 1000 seeds	Number of main branches	Plant height after appearance of first flower	Plant height after opening 50 percentage flowers	Number of umbel per plant
10	2431/06 ^a	5/03 ^a	8 ^a	3/8 ^a	28/86 ^a	89/7 ^a	67/26 ^a
15	1841/3 ^b	4/93 ^a	8/03 ^a	5/5 ^b	26/53 ^a	85 ^{ab}	105/86 ^{ab}
20	1611/7 ^b	5/1 ^a	8/26 ^a	5/6 ^b	21/93 ^a	83/8 ^{abc}	136/23 ^{bc}
25	1368/5 ^b	4/96 ^a	8 ^a	6/63 ^{bc}	22/13 ^a	78/86 ^{bc}	146/8 ^{bc}
30	1315/2 ^b	4/06 ^a	6/03 ^a	7/3 ^c	19/96 ^a	74/53 ^c	166/86 ^c

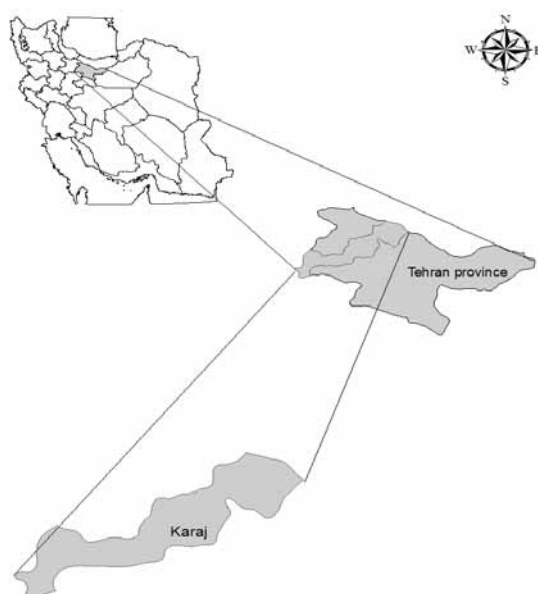


Figure 1. The location of Karaj

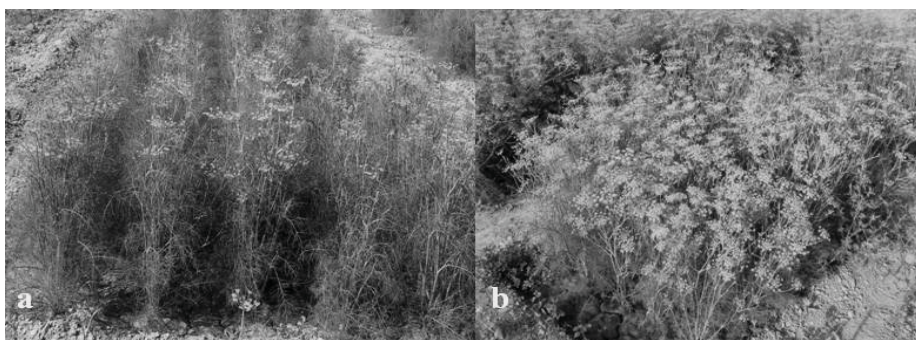


Figure 2. a. Appearance of first flowers

b. Opening of 50 percentages of flowers

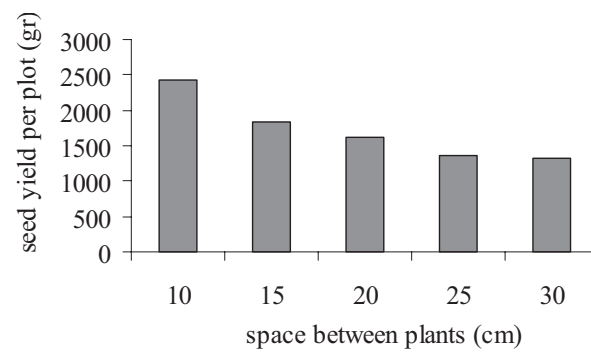


Figure 3. Effect of space between plants on Seed yield

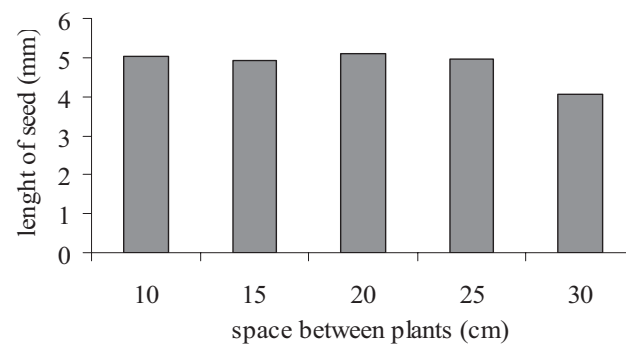


Figure 4. Effect of space between plants on length of seed

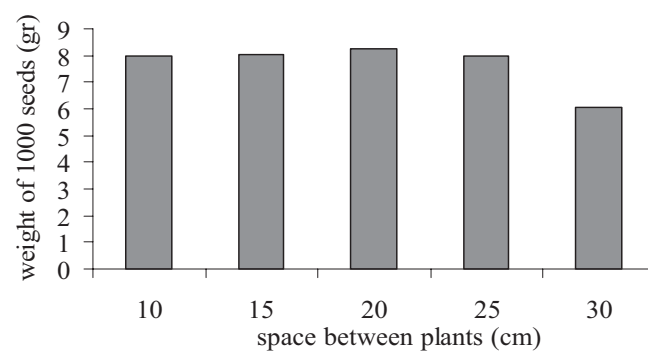


Figure 5. Effect of space between plants on weight of 1000 seeds

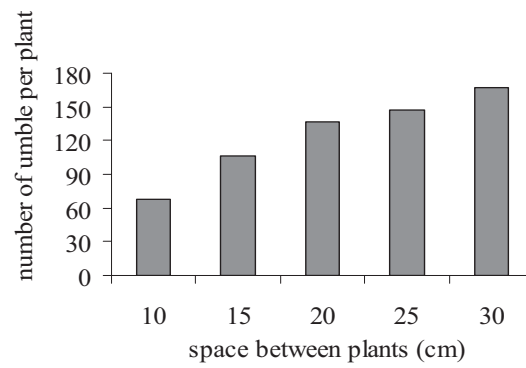


Figure 6. Effect of space between plants on number of umbel per plant

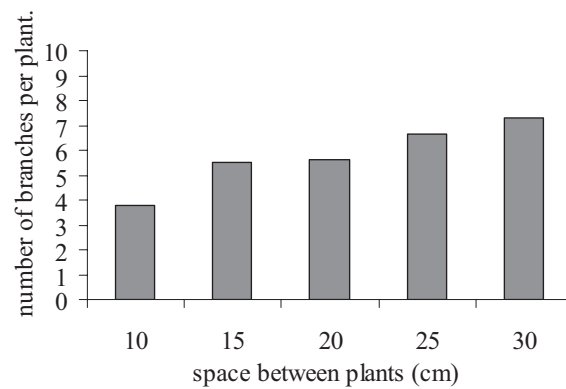


Figure 7. Effect of space between plants on number of main branches per plant

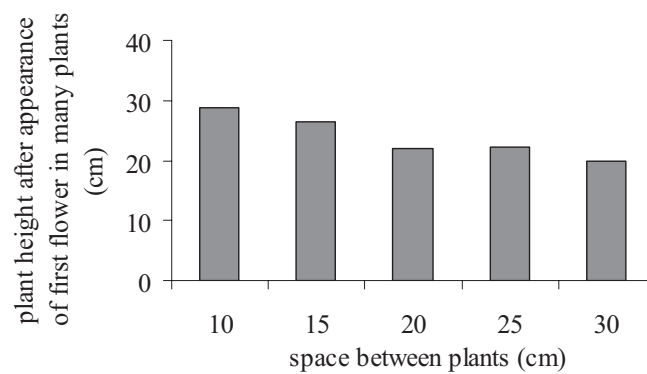


Figure 8. Effect of space between plants on plant height after appearance of first flower

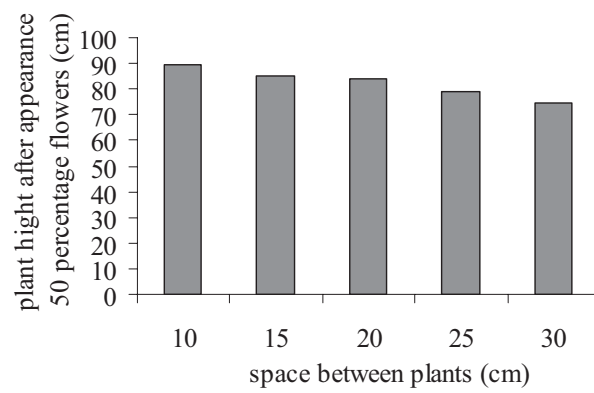


Figure 9. Effect of space between plants on plant height after opening 50 percentage flowers