Oil content and yield of *Foeniculum vulgare* Mill. cv. Soroksary seeds as affected by different plant cultivation densities

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Abstract: In this study, the effect of different plant cultivation densities on the oil content and yield of *Foeniculum vulgare* Mill. Cv. Soroksary seeds was studied at the Faculty of Agricultural Sciences and Engineering, Karaj, Iran (Latitude 35° 47´ N and Longitude 50° 59´ E) in 2008. Five plant spaces studied were 10, 15, 20, 25, and 30 cm and the distance between rows in all treatments was 40 cm using a complete randomized block design with three replicates. According to results, the effect of plant density on oil content and yield was significant (P<0.01). The highest oil content (3.33%) and yield per hectare (116.73 liter) was obtained with the lowest plant density.
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Keywords: *Foeniculum vulgare* Mill. cv. Soroksary; Plant density; Oil content; Oil yield

1. Introduction

Fennel (*Foeniculum vulgare* Mill.) is one of the most important medicinal plants, native of Mediterranean regions and belongs to the Apiaceae family (Omidbaigi, 2007). The plant has abundant applications in various industries; for instance, the essential obtained from seeds is added to perfumes, soaps, pharmaceuticals and cosmetics. Fennel oil, seeds or extracts are also used to flavor prepared foods including meats, ice cream, candy, baked goods and condiments. Recent studies have shown that essential oil of this plant can be used as an valuable antioxidant, antibacterial and antifungal agent (Lucinewton et al., 2005).

One of the major restraints in crop production is improper crop spacing in the field (Dupriez and Deleener, 1989). The effect of spacing on growth and secondary metabolites is largely due to change in the interception of radiant energy (Yao and Shaw, 1964). When crops are overcrowded, there will be competition. In the wider spacing, plants have more nutrition, water and air, but in the narrower spacing, they have restricted conditions for development (Ozar, 2003). Plant density is one of the most important factors affecting yield, yield components, oil and essential oil in medicinal plants. Masood et al (2004) investigated the effect of row spacing (40, 50, 60, and 70 cm) on morphological characters and seed yield of fennel and reported that the highest plant height, seed yield per bed, and seed yield per hectare were obtained with the lowest row spacing. Najafi and Moghadam (2002) reported that with increase in the plant density seed and biological yield increased. Arabaci and Bayram (2004) reported that the highest effective substances yield in the Basil (Ocimum basilicum L.) was obtained in lower plant density. The maximum oil percentage and oil yield in Coriander (Coriandrum sativum L.) were obtained in density 30 plant per m2 (Masood et al., 2004).

The objective of this study was to evaluate the percentage variation and oil yield of *Foeniculum vulgare* Mill.cv. soroksary in different plant population densities.

2. Material and Methods

A field study was conducted at the Faculty of Agricultural Sciences and Engineering, Karaj, Iran (Latitude 35° 47´ N and Longitude 50° 59´ E) to determine the effect of different plant cultivation densities on the oil content and yield of *Foeniculum vulgare* Mill. cv. Soroksary seeds in 2008. Results of soil analysis are shown in (Table 1). Experiment was conducted based on completely randomized block design with three replicates and five plant densities. The plot size was 2.5x1.5m. The distance between blocks and plots were 1m. Five plant spaces studied were 10, 15, 20, 25, and 30 cm. The distance between rows in all treatments was 40 cm. Each plot consisted of five rows. The bitter fennel seeds were sown on the 7th March 2008.

The following irrigation regime was followed;

1. 2-3 day's interval irrigation until germination stage,
2. 4-5 day's interval irrigation from germination to appearance of first flowers stage,

3. 7 days interval irrigation from appearance first flowers to harvest stage.

Thinning was done when plants had 4-5 leaves. All agronomic practices were kept for all the treatments. The seeds were harvested twice after ripening (20th August and 30th August) and dried in a shade for 72 hours. Afterwards, 15 grams of seeds were powdered and their oil content was extracted using a soxhlet apparatus with hexane solvent method (Laurence, 1999). After isolation, the oil was purified in a rotary vacuum evaporator apparatus (Buchi, Switzerlan).

Data collected were analyzed using Duncan Multiple Range Test (Duncan, 1955) and statistical software (SPSS).

Table 1. Results of soil analysis

Soil sample	Properties
pH (in 2:1 water)	8.1
Sand (%)	30
Clay (%)	32
Silt (%)	38
Ca (g/kg)	293
Fe (mg/kg)	12.1
Organic matter (g/kg)	0.78
N (g/kg)	0.092
P (cmol/kg)	12.83
K (cmol/kg)	305

3. Results

Results of present study showed that the oil content and yield of seeds was affected by change in plant density. With increasing spaces between plants, the oil content of seeds was increased but the pattern of oil yield changes was irregular. Generally with increase in spaces between plants, the oil percentage increased significantly ($P<0.01$).

The maximum oil percentage (3.33%) and yield (116.73 Lit/he) were obtained in the lowest plant density. While the minimum oil percentage (1.33%) was obtained in the highest plant density and the minimum oil yield (65.27 Lit/he) was obtained in 15cm space between plants (Fig 1 and Fig 2).

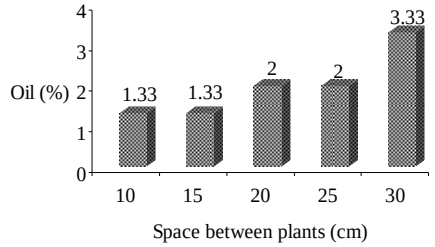

Fig 1. Relationship between plant density and oil percentage

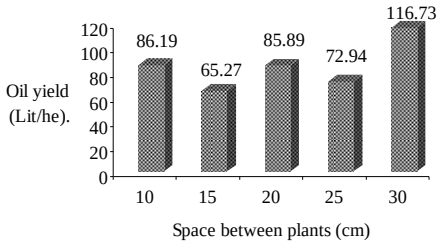

Fig 2. Relationship between plant density and oil yield

Comparison of treatments indicated that there was no significantly difference in the oil percentage between 10 and 15 cm of plant densities. Similarly, there was no significantly difference in the oil percentage between 20 and 30 cm of plant densities (Table 2).

Table 2. Oil content and yield of seeds in different plant cultivation densities

Space between Plants (cm)	Oil content (%)	Oil yield (Lit/he)
10	1.33a	86.19c
15	1.33a	65.27a
20	2b	85.89c
25	2b	72.94b
30	3.33c	116.73d

Different letters in each column indicating significant difference at $P<0.01$

4. Discussions

These results are in agreement with findings Akbarinia et al (2006), and Ozer (2003). The studies in most plants have shown that plant density is an important factor affecting on yield. In the lower plant density, plants have more nutrition, water and air, and therefore have the better growth and finally produce the higher yield. But in the lower plant density, they have restricted conditions for development and thus produce the lower yield. In conclusion, to reach the

maximum oil yield of *Foeniculum vulgare* Mill. cv. Soroksary, the minimum plant density is suggested.

In this study, increases observed in the yield of seeds can be attributed to the better growth of plants and subsequently the better canopy development which led ultimately to the better use of solar irradiance and higher photosynthesis. Considering the significant effect of different plant cultivation densities, it can be argued that seed yield increases in suitable plant densities are due mainly to production of more seeds in each umbel. In other words, plant density by affecting the absorption of nutrients and exposure of the plant to the light can affect the photosynthesis rate and production of oil content.

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