PLANT DENSITY AND FOLIAR FERTILIZATION EFFECTS ON ESSENTIAL OIL CONTENT OF FENNEL (*FOENICULUM VULGARE* MILL.)

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Abstract

Aromatic and medicinal plant species can be defined as boundless sources of raw materials which can be used as well in food and pharmaceutical industry. Essential oils extracted from different parts of the aromatic plant species are of increasing interest in cosmetic industry. Some chemical compounds from volatile oils are preferred over the synthetic ones, as natural extracts involve less risk factors as far as consumer`s health goes. The aim of this research was to determine the main effects of plant density and foliar fertilization on essential oil yield of two varieties of fennel *Foeniculum vulgare* var. *vulgare* and *Foeniculum vulgare* var. *dulce*. The experiment was carried out using randomized block design with three replications. The distances between rows were 50 cm, 75 cm and 100 cm. The plant spaces on the row was 30 cm in all treatments. In case of each plant density, three foliar fertilizers were applied, with different composition, in terms of macronutrients, micronutrients and amino acids. The results showed that both factors, plant density and foliar application of fertilizers had significant impact on the essential oil content of both sweet fennel and bitter fennel.

Key words: bitter fennel, sweet fennel, plant density, foliar fertilization, essential oil content

Aromatic and medicinal plant species can be defined as boundless sources of raw materials which can be used as well in food and pharmaceutical industry.

Essential oils extracted from different parts of the aromatic plant species are of increasing interest in cosmetic industry. Some chemical compounds from volatile oils are preferred over the synthetic ones, as natural extracts involve less risk factors as far as consumer`s health goes. (Avar G. *et al*., 2012)

The research is of interest due to the deficiency in accurate data results regarding the influence that various factors have on the oil yield and essential oil composition obtained from aromatic plants.

Fennel is an aromatic and medicinal plant belonging to *Apiaceae* family. The main feature of the species included in this botanical family is the way the flowers are grouped in inflorescences called umbels.

Foeniculum vulgare Mill. is an important aromatic species, cultivated for their fruits. The mature seeds as well as the essential oil obtained by distillation can be utilized as flavors in various food products. (Saharkhiz M., 2011)

Indoubtedly the volatile oil yields of aromatic plants can be influenced by genetic and envionmental factors (Piccaglia R., Marotti M., 2001). Furthermore, according to various researches it can be affected by different fertilization treatments (Geneva M.P. *et al,* 2010; Onofrei V. *et al.*, 2018, Pavela R. *et al*, 2018).

MATERIAL AND METHOD

The aim of this research was to determine the main effects of plant density and foliar fertilization on the essential oil yield of two varieties of fennel *Foeniculum vulgare* var. *vulgare* and *Foeniculum vulgare* var. *dulce*.

Plant material

The plant seeds were provided by the University of Life Sciences “Ion Ionescu de la Brad”, Department of Plant Sciences, Iasi and by National Agricultural Research and Development Institute Fundulea.

The land experiment was laid in USV Iasi, Research Station – Ezareni Farm, in two successive years, 2020 and 2021. The research was carried out using randomized block design with three replications. The distances between rows were 50 cm, 75 cm and 100 cm. The plant spaces on the row was 30 cm in all treatments. In case of each plant density, three foliar fertilizers were applied, with different composition, in terms of macronutrients, micronutrients and amino acids.

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Foliar fertilization

The investigation comprised three plant density, and for each one, four foliar treatments were applied: B – Blank unfertilized, AA – organic foliar fertilizer containing animal hydrolysed proteins, AA+M+µ - foliar fertilizer NPK 14-7-9 + microelements (Cu, Mn, Fe, Zn) and amino acids, M+µ - foliar fertilizer NPK 12-12-12 + microelements (Zn, Cu, Mn). During the research, the foliar treatments were applied one time per year, at the same phase of development: completion of inflorescence rachis.

Harvesting and volatile oil extraction

The fruit and stem+leaf samples were harvested at full ripening stage, when the seeds had a brownish colour, and then shade-dried for two weeks.

The essential oil extraction from dried samples (seeds, stems+leaves) was accomplished using the hydro distillation method for 3 hours. Total volatile oil yields were expressed as percentages (ml volatile oil/100 g dried sample).

Statistical analysis

All data results were expressed as mean of three replications. The results were analyzed by 1-way analysis of variance (ANOVA) using IBM SPSS 28.0. Then Tukey's test was performed in order to gauge the difference by all treatment means at 5% significance level.

RESULTS AND DISCUSSIONS

Effect of plant density on essential oil content

Higher values of essential oil yield were reported for *Foeniculum vulgare* var. *vulgare* (2.1-2.22%) compared to *Foeniculum vulgare* var. *dulce* (1,58-1,72%). Previous researches on fennel have shown similar results on volatile oil yields: 1.2-5.06% (Khammassi M. *et al*., 2018), 1.5-4.4% (Shojaiefar S. *et al.*, 2015) 2-6% (Stănescu U. *et al*., 2004).

Data presented in figure 1 showed that the volatile oil content was significantly influenced by the plant density. Greater distance between plant rows (100cm) led to higher essential oil content: 2.22% *Foeniculum vulgare* var. *vulgare*, and 1.72% *Foeniculum vulgare* var. *dulce.*

These differences can be explained as light exposure response. In the case of fennel, light is an important factor for achieving a significant production capacity, in terms of seeds and essential oil yields. Lack of light causes poor branching, leading to much lower production values.

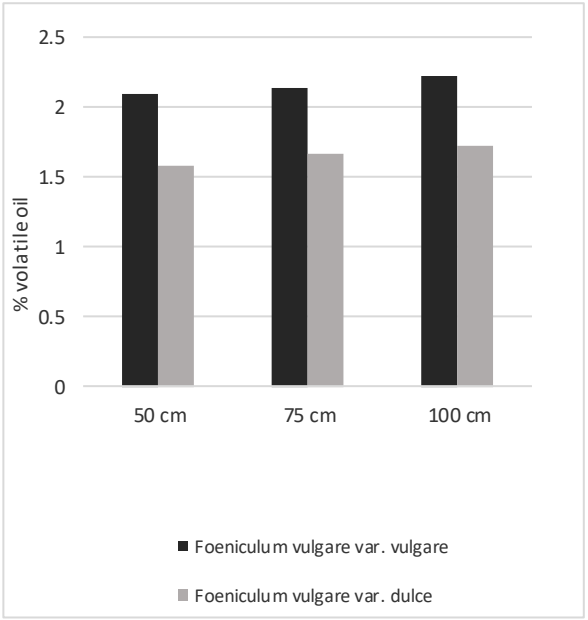

Figure 1 **The effect of plant denisty on volatile oil yield of *Foeniculum vulgare* Mill.**

Effect of foliar fertilization on volatile oil content

The yields of the two hydro distilled seeds and stems+leaves bitter fennel, *Foeniculum vulgare* var. *vulgare*, in the two years of experiment are shown in *Table 1*.

The volatile oil was defined by a pale yellow color. The data results showed significant differences in the essential oil contents among all foliar treatments, on the samples extracted from seeds. The application of AA, AA+M+µ and M+µ foliar fertilizers led to higher oil yield compared with the control (blank) sample. In case of the oil extracted from stems and leaves, the results were not statistically significant, with one exception for the variant sown at 75 cm between plant rows and treated with AA+M+µ foliar fertilizer where the essential oil content was significantly ($P<0.05$) influenced by the treatment.

The essential oil content extracted from seed and stem+leaf samples of sweet fennel, *Foeniculum vulgare* var. *dulce*,in two succesive years of experiment, are presented in Table 2.

The extracted samples were defined by a pale yellow colour, similar to bitter fennel oil.

The seeds essential oil contents were significantly swayed by all three foliar treatments, compared to blank sample, untreated.

Table 1

The effect of fertilizers on essential oil yield of *Foeniculum vulgare* var. *vulgare* in the first and second year of cultivation

		% VOLATILE OIL			
		2020		2021	
		seeds	stems+leaves	seeds	stems+leaves
50 CM	Blank	2.11 c	0.06 a	2.10 c	0.06 a
	AA	2.26 b	0.06 a	2.30 b	0.06 a
	AA+M+µ	2.36 a	0.07 a	2.35 a	0.06 a
	M+µ	2.28 b	0.07 a	2.29 b	0.06 a
75 CM	Blank	2.12 c	0.06 a	2.13 c	0.07 a
	AA	2.26 b	0.07 a	2.29 b	0.06 a
	AA+M+µ	2.35 a	0.08 ab	2.38 a	0.07 a
	M+µ	2.21 b	0.06 a	2.25 b	0.06 a
100 CM	Blank	2.22 c	0.06 a	2.21 c	0.07 a
	AA	2.34 b	0.07 a	2.36 b	0.07 a
	AA+M+µ	2.45 a	0.07 a	2.45 a	0.08 a
	M+µ	2.37 b	0.07 a	2.39 b	0.07 a

Means with the same lower-case letter are not significantly different at P < 0.05 according to Tukey's test

The highest oil yield was reported under AA+M+µ foliar fertilizer sown at 100 cm between plant rows (2.05%), while the lowest oil yield was reported in untreated samples, sown at 50 cm between rows (1.54%).

The yield of essential oil obtained by hydrodistillation from stems and leaves, did not differ significantly from the control samples. The data showed slightly increased mean values for the samples treated with AA and AA+M+µ foliar fertilizer, but the differences were not statistically significant.

Table 2

The effect of fertilizers on essential oil yield of *Foeniculum vulgare* var. *dulce* in the first and second year of cultivation

		% VOLATILE OIL			
		2020		2021	
		seeds	stems+leaves	seeds	stems+leaves
50 CM	Blank	1.54 c	0.02 a	1.62 c	0.02 a
	AA	1.8 b	0.03 a	1.80 b	0.02 a
	AA+M+µ	1.92 a	0.02 a	1.83 b	0.03 a
	M+µ	1.83 b	0.02 a	1.79 b	0.03 a
75 CM	Blank	1.64 c	0.02 a	1.7 c	0.02 a
	AA	1.78 b	0.02 a	1.89 b	0.03 a
	AA+M+µ	1.94 a	0.03 a	1.92 b	0.03 a
	M+µ	1.93 a	0.02 a	1.91 b	0.03 a
100 CM	Blank	1.69 c	0.03 a	1.74 c	0.04 a
	AA	1.87 b	0.03 a	1.90 b	0.03 a
	AA+M+µ	2.05 a	0.03 a	2.03 a	0.04 a
	M+µ	1.94 b	0.03 a	1.94 b	0.04 a

Means with the same lower-case letter are not significantly different at P < 0.05 according to Tukey's test

CONCLUSIONS

This research aimed to determine the effects of foliar fertilization and plant density on the volatile oil content of two varieties of fennel *Foeniculum vulgare* var. *vulgare* and *Foeniculum vulgare* var. *dulce*. Significant distinctions were identified in essential oil yield among fennel samples sown at different plant density and treated with various foliar fertilizers.

It is concluded that application of foliar treatments with AA, AA+M+µ and M+µ improves the oil content of *Foeniculum vulgare* Mill. compared to the untreated samples. Also, for the highest volatile oil yield is recomended sowing at 100 cm between plant rows, with 30 cm plant spaces on the row.

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