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Original Article

Evaluation of Basil (*Ocimum basilicum* L.) Essential Oil Content and Yield under Different Plant Densities and Nitrogen Levels

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Abstract

A study was conducted to investigate the effect of different planting densities and nitrogen doses on essential oil content and yield in herb and leaves of basil (*Ocimum basilicum* L.). The research was conducted during 2007 and 2008 using split-plot randomized complete block design with four replications. The experiment consisted of four plant densities (30×20, 40×20 and 50×20 cm) as the main plot and four nitrogen levels (0, 50, 100 and 150 kg/ha) as the sub plots. Results showed plant density did not have significant effect on essential oil content and essential oil yield in herb and leaves. Mean essential oil ratio in herb was 0.49, 0.44%; essential oil ratio in leaf 0.59, 0.54%; essential oil yield in herb 19.4, 23.7 l/ha and essential oil yield in leaf was 12.8, 16.1 l/ha during 2007 and 2008, respectively. The highest essential oil ratio in herb was obtained from 40×20 cm plant density and 50 kg ha^{-1} N during 2007. Nitrogen fertilizer had statistically insignificant effect on oil ratio of herb and leaves during two years of experiment. The highest essential oil yield of herb was obtained from low density (30×20 cm) using 100 kg ha^{-1} N fertilizer. In General, essential oil yield during 2008 with three cuts was better compared to 2007 with two cuts.

Key words: Basil (*Ocimum basilicum*), Essential oil ratio, Essential oil yield, Nitrogen doses, Plant density

Introduction

Main components of basil essential oil are linalool, camphor, 1, 8 cineole and germacren-D [1-2]. Results of a research in Turkey on basil showed that plant density and nitrogen fertilizer had statistically different effects on essential oil yield among years with mean value of 4.42 L ha^{-1} oil yield. In general high and low oil contents were obtained in 20×20 cm (4.25-5.84 L ha^{-1}) and 60×20 cm (2.39-4.20 L ha^{-1}) in 2000, 2001 and 2002, respectively [1]. Other researchers reported that, application of nitrogen doses increased essential oil yield and there was statistical difference between them. The maximum and minimum essential oil yield (13.8 and 3.4 kg ha^{-1}) was obtained with 300 and 0 kg ha^{-1} N respectively [4]. Marotti *et al* [5] reported that essential oil content in basil ranged from 0.3 to 0.8% with an average of 0.51%. In this research, applying fertilizer and different planting densities did not have significant effect on essential oil ratio. Same results were obtained by the other researches, amount of essential oil ranged from 0.3 to 0.5% that was obtained at fresh flower stage. Range of essential oil yield was between 1.1-4.0 L/1000 m^2. The highest essential oil percent (0.5%) and essential oil yield (4.0 L/1000 m^2) were obtained from French basil at the second harvest [6]. Essential oil contents of basil were obtained to range from 0.07 to 1.37%, and different cultivars had different oil contents [8-11]. The genus *Ocimum* is one of the largest genera of the Lamiaceae family. *Ocimum basilicum* L. (sweet basil) is an annual herb

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used in food and perfumery. The leaves and flowers of sweet basil are used as carminative, galactogogue, stomachic and antispasmodic in general folk medicine [9]. Application of nitrogen fertilizers increased leaf biomass and probability that caused enhancement leaf essential oil concentration [10]. Zheljazkov *et al* [12] reported that, essential oil content of three cultivars of *O. basilicum* ranged from 0.17-0.77% that cultivated at North Mississippi. The aim of this study was to evaluate the changes of essential oil percent and essential oil yield of basil in herb and leaves under different planting densities and nitrogen doses.

Materials and Methods

Experimental design and agronomic practices

This research was carried out at the experimental area of Field Crops Department at Agricultural Faculty of Ankara University (32º 51' E; 39º 57' N); 860 m above sea level during 2007 and 2008. The characteristics of the experimental area was as follows: clay and loam, pH 8.06, lime 9.33%, clay 39.36%, sand 29.56%, silt 31.08%, organic matter 1.07%, total nitrogen 0.132%, phosphorus 9.84 ppm and potassium 0.024%. Total rainfall, mean relative humidity and temperature in 2007 and 2008 were recorded as 305.2 and 267.7 mm; 53.11 and 57.04%; 13.52 and 12.73˚C, respectively. The seeds of basil which were a population grown at the experimental field of this department were sown at a depth of 18 cm in plastic cases containing a commercial peat substrate (Klasmann-Deilmann**,** Potgrond H.) on April 6, 2007 and April 15, 2008. On reaching an adequate height with average of 10-15 cm after about two months in the greenhouse, these seedlings were transplanted to the experimental area. The experimental design consisted of split-plot randomized complete block design with four replications, four planting densities (30×20, 40×20 and 50×20 cm) as main plot and four nitrogen levels (0, 50, 100 and 150 kg/ha) as sub plots. Irrigation and weed control was made manually when required

The Fertilization Application

The first and second fertilization in 2007 was applied on 25 June and 17 August by hand in rows, and then plants were irrigated. Similarly during 2008 the fertilizer was applied on 24 June & 4 August manually followed by irrigation.

The cutting times

The first and second cuttings were made 59 (on 23 July) and 99 days (on 1 September) after transplanting during 2007 and 23 July, 26 August and 6 October during 2008 at the beginning of flowering. After each cutting, the plants were measured to determine the characters after drying them in shade at room temperature to determine the essential oil content.

Determination of essential oil content

The essential oil content was determined separately of 50 g of ground aerial parts (leaves and stems) using a Clevenger-type apparatus. The samples were distilled for 3 h in 500 ml water. Essential oil content and composition results of this research from 2007 and 2008 are already published [2-3].

Data obtaining

In determined cutting date, three rows between five rows of subplot cut off from 10 cm above soil surface and to determine essential oil content ratio and essential oil yield in herb and leaves, this measurement and analyzes were done for each cutting time in both years.

1. Fresh herb yield (kg/ha): It was obtained by harvesting three plants middle five rows of each plot using horticultural knife 10 cm above soil surface and immediately weighted to get fresh herb yield.
2. Drug herb yield (kg/ha): Sample of 500 g of fresh herb yield were separated and dried at 35˚C for 72 hour to obtain dry weight. Then drug herb yield were calculated by multiplying dry weight in fresh herb yield. Thereafter, the yield was transformed to yield per hectare (10000 m^2).
3. Fresh leave yield (kg/ha): Sample of 500 g of fresh herb yield was separating leaves from stems by hand and weighed soon after to minimize the loss of water. Thereafter, the yield was transformed to yield per hectare.
4. Drug leave yield (kg/ha): Sample of 500 g of fresh herb yield were separated leave the stems by hand and dried at 35˚C for 72 hour to obtain dry weight. Then drug herb yield were calculated by multiplying dry weight in fresh herb yield. Thereafter, the yield was transformed to yield per hectare.

5. Essential oil ratio in herb and leaves (%): to determine essential oil ratio in herb and leaves, applied the sample of 50 g herb and leave from each plots that dried at the shade and then were measured by water distillation method in Clevenger apparatus for 3 hours.
6. Essential oil yield (L/ha): Essential oil yields were obtained by multiplying amounts of essential oil ratio to drug yield in herb and leaves separately.

Data evaluation

The data from the experiment was analyzed based on split-plot on randomized complete block design by using SPSS and SAS statistical software package. The comparison of treatment means was made using Duncan test.

Results and Discussion

Results of essential oil ratio and yield in herb and leaves of *O. basilicum* for both years of experiment are shown in Table 1.
Essential oil ratio in herb (%): Planting density, nitrogen dose and interaction between them insignificantly affected essential oil ratio in herb. The maximum essential oil ratio was obtained from 40×20 cm planting density (0.5%) and 50 kg ha^{-1} N (0.51%) during 2007.
Essential oil ratio in leaves (%): Planting density had significant difference *($p<0.05$)* on essential oil of leaves only in 2008. This character was not affected by nitrogen doses, but interaction between factors had statistical effect on leaves essential oil ratio *($p<0.01$)* during 2008. The maximum values were recorded from 50×20 cm planting density (0.62%) and 50 kg ha^{-1} N (0.63%) during 2007.
Essential oil yield in herb (L/ha^{-1}): During 2008, plant density and nitrogen doses statistically affected ($p<0.01$) essential oil yield of herb. The maximum yield (27.8 L/ha^{-1}) was obtained from low density (30×20 cm) and 100 kg ha^{-1} N fertilizer (26.7 L/ha^{-1}). None of applied factors in the experiment had not affected essential oil yield during 2007. Minimum oil yield was observed in no fertilizer treated plants (17.7 L/ha^{-1}).
Essential oil yield in leaves (L/ha^{-1}): Applying nitrogen fertilizer had significant effects ($p<0.05$) on leaves essential oil but planting density had statistically insignificant effects on yield during 2007. Essential oil yield of leaves was affected by planting density ($p<0.05$) and nitrogen fertilizer ($p<0.01$) during 2008. Among planting densities, high density (30×20 cm) and 100 kg ha^{-1} N had the best response for essential oil yield (19.4 l/ha^{-1}) during 2008. The minimum essential oil yield of leaves was related to control nitrogen fertilizer (11.4 L/ha^{-1}) during 2007. In General, essential oil yield of 2008 was higher compared to yield of 2007, because there were three and two cuts during 2008 and 2007, respectively. Planting density affected essential oil yields and resulted in increased yield with high planting density (30×20). High planting density increased essential oil yield in herb and leaves. Arabaci *et al* [1] obtained

Table 1 Mean comparison of essential oil ratio and yield in herb & leaves of *Ocimum basilicum* L.

S.V.		Essential oil (in herb) (%)		Essential oil (in leaves) (%)		Essential oil yield (in herb) (L/ha)		Essential oil yield (in leaves) (L/ha)	
		2007	2008	2007	2008	2007	2008	2007	2008
Plant density	D1	0.46	0.44	0.60	0.55 a	18.3	27.8 A	13.5	19.4 A
	D2	0.50	0.45	0.57	0.55 a	21.2	23.4 AB	12.1	15.6 AB
	D3	0.49	0.44	0.62	0.52 b	18.9	20.1 B	12.7	13.3 B
LSD		-	-	-	-	-	471.8 0.01%	-	560.5 0.01 %
Nitrogen doses	N0	0.48	0.43	0.58	0.52	17.7	18.8 B	11.4 b	12.5 B
	N1	0.51	0.44	0.63	0.55	20.2	23.6 A	13.5 a	16.5 A
	N2	0.48	0.46	0.60	0.55	20.2	26.7 A	13.3 a	18.0 A
	N3	0.48	0.44	0.58	0.54	19.7	25.7 A	13.0 ab	17.4 A
LSD		-	-	-	-	-	425.3 0.01 %	171.2 0.05%	307.4 0.01 %
C.V. (%)		12.77	14.17	13.84	6.87	16.93	15.82	15.94	16.85

similar results, high and low contents were obtained in 20×20 cm (4.25-5.84 l ha^{-1}) and 60×20 cm (2.39-4.20 l ha^{-1}); these values were lower compared to the results of this study. In general, nitrogen fertilizer reduced the essential oil ratio from 0 to 150 kg ha^{-1}. The maximum essential oil ratio was obtained at 50 kg ha^{-1} N fertilizer in both years. Applying nitrogen fertilizer improved vegetative growth and it may have reduced the essential oil ratio in plants, but resulted in total increased oil yield of herb and leaves and the highest yield content was observed in 100 kg ha^{-1} N during 2007 and 2008. Similar results were obtained by Isabella Sifola *et al* [4] and Marotti *et al* [5]. There was opposite conclusion in the experiment of some researchers Sangwan *et al* [10]. The results show that in general, planting density and nitrogen fertilization could be effectively used to increase essential oil ratio and yield in basil. Also, the results emphasize possibilities of three cuts from basil under climatic conditions of Central Anatolian region.

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