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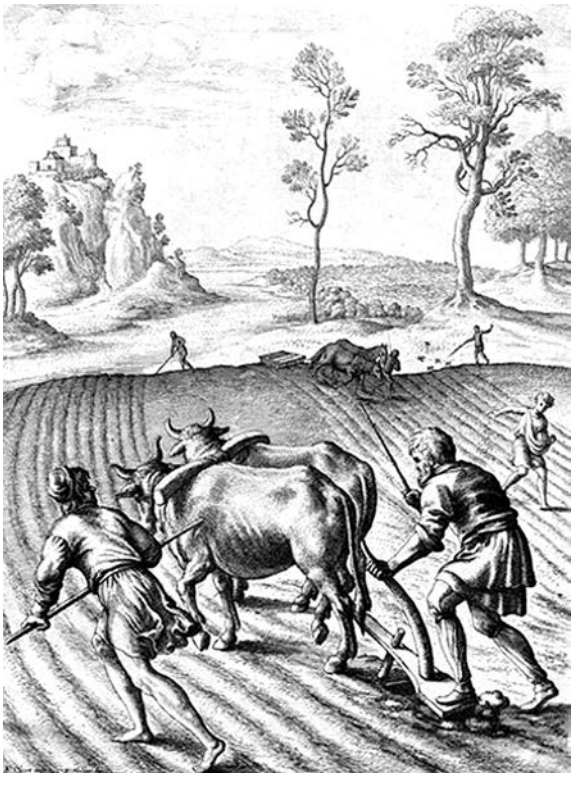

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The Effect of Nitrogen Fertilization and Different Plant Densities on Some Agronomic and Technologic Characteristic of *Ocimum basilicum* L. (Basil)

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Abstract: The effect of nitrogen fertilizer and non nitrogen fertilizer grown conditions with various densities of plants (20x20, 40x20, 60x20 cm) on yield and quality traits of *Ocimum basilicum* L. (Basil) were investigated under ecological conditions of Aydin during consecutive three years. As a result of this research, it was determined that the highest amount of green herb yield (4197.5 kg ha^{-1}), drug herb yield (1078.6 kg ha^{-1}), drug leaves yield (671.1 kg ha^{-1}), essential oil ratio (0.826 %) and essential oil yield (5.164 L ha^{-1}) were determined in 20x20 cm plant density with nitrogen fertilizer conditions, from 2000 to 2002 years. However, the highest essential oil ratio was obtained under non-nitrogen fertilizer condition with 20x20 cm plant density.

Key words: *Ocimum basilicum* L., Basil, nitrogen fertilizer, plant densities, yield, essential oil

INTRODUCTION

The *Ocimum* genus belonging to the *Lamiaceae* family is characterized by a great variability of both morphology and chemotypes[1,2]. Among all the species, *Ocimum basilicum* L. (basil or sweet basil) has the most economic importance and is cultivated and utilized through out the world[2].

Basil, an aromatic plant, was originated North West India, North-East Africa and Middle Asia[3]. It grows in subtropical zone from sea level to altitude of 1800 m. Approximately, 60 species of Basil has been known throughout the world. Basil, growing naturally in South-Asia, Asia and Eastern Europe, has been cultivated in France, Egypt, Hungary, Indonesia, Morocco, The United States, Greece and Israel[4-6].

Basil (*Ocimum basilicum* L.) is an annual herb with 50-60 cm plant height and pink and white flowers. The useful parts of basil plant are leaf and seed. The most component of basil is essential oil. Essential oil ratio varied between 0.1 and 0.45% based on climate and soil conditions[7-9].

Basil has been utilized for its stomachache, expectorant, diuretika, carminative and stimulant properties in folk medicine[7-8]. In addition, it is known that the plant was used as an insecticide, flea and moth repellent[10] and against to snake, scorpion and insect bite[11]. Recently, the usage of fresh and dry leaves of plant has been very common in food and spice industries.

The essential oil of plant is mainly used in food industries, perfumery, dental and oral products and in traditional rituals and medicines[12-14]. The oil possesses antimicrobial activity[2,12]. Some of its components, such as 1,8 cineole, linalool and camphor, are known to be biologically active[15], camphor and 1,8 cineole seem also to be involved as agents in allelopatic reactions[2,16].

The plant of basil (*Ocimum basilicum* L.) was studied by many researches to determine yield, yield component, essential oil ratio and composition of essential oil under different ecological conditions, but a few research were focused on fertilizer and plant densities.

Vömel and Ceylan[17] reported that *Ocimum basilicum* L. has average of 1551 kg ha^{-1} green herb yield. The yield of *Ocimum minimum* is 1320 kg ha^{-1}[18] and the highest yield was reached under 15 cm between rows[19]. Gill and Randhawa[20] indicated that the highest drug herb yield was obtained from 40x20 cm plant density. According to the Serin and Özgüven[11] drug leaves yield of basil was 173.78 kg ha^{-1}, on the other hand Tansı and Nacar[21] reported that the yield was 571.52 kg ha^{-1}. The essential oil ratio was ranged from 0.1 to 1.39%[7,8,11,18,22]. Gill and Randhawa[20] reported that the highest essential oil ratio was obtained from 30x30 cm plant density. The main component of essential oil of *Ocimum basilicum* L. is linalool[7,22-25] and the range of linalool was between 40 and 60%[26].

The aim of this research was to determine both agronomical and technological characteristic of basil and to identify optimum plant density under nitrogen fertilizer and non-nitrogen fertilizer growing conditions.

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MATERIALS AND METHODS

Ocimum basilicum L. (basil) seeds obtained from market were used as a material in this study.

The dominated climate condition in Aydin where the research was conducted is mild Mediterranean clime type. Long-term average temperature was 17.5°C, the highest monthly average temperature in July was recorded as 28.1°C and the lowest monthly average temperature in January was recorded as 8°C. The average monthly temperature was higher than long-term average during experimental years. According to the results of long-term observation, although annual total rainfall was 657.7 mm, it has shown irregular distribution in experiment years. Total rainfalls reached the highest level in December and the lowest level in August with 135.1 and 2.2 mm, respectively[27].

The soil texture was a sandy-loam. Soil (30-54 cm soil deep) characteristics of experimental field are presented in Table 1.

This study was carried out in the experimental fields of Adnan Menderes University, Faculty of Agriculture, Department of Field Crops during the 2000, 2001 and 2002 years.

The experiment was designed in a Randomized Complete-Block Design with a split-plot arrangement with four replications. The treatments were carried out with and without the application of nitrogen fertilizers in the main plot (5 kg ha^{-1}) and the sub plots consisted of three different plant densities (20x20, 40x20 and 60x20 cm).

To grow necessary seedling for the experiment, seeds were planted on January 01, 2000, December 12, 2001 and January 04, 2002 into a mixture of sand, manure and mulch (1:1:1). When basil seedlings reached 10 cm plant height, they were transformed to the field on April 17, 2000, May 2, 2000 and 2001. In the experiment, nitrogen fertilizer (5 kg ha^{-1}) and non-nitrogen fertilizer applications were main plots and three planting densities 20x20, 40x20, 60x20 cm (25 000, 12 500 and 8333 plant densities) were subplots. Plot consisted of 6 rows of 4 m length in 20x20 cm row apart and the other plots consisted of 3 rows of 4 m length. The plants on the four central rows in 20x20 cm plots and central row in the other plots were harvested when the basil plants had full flowers. Weeds were removed by hoeing as needed and plants were grown under watered conditions.

The following agronomic and technological quality characters of basil were recorded and evaluated;

Green herb yields (kg ha^{-1}): After the side effect was eliminated, the remaining plants in each plot were harvested by hand with saw knife 10 cm above the surface and immediately weighted for obtaining plot yields. Then plot yield was transformed to yield for ha^{-1} (1000 square meters).

Table 1: Structure and chemical composition of soil in trial areas at Çakmar-Aydin

Sand (%)	Clay (%)	Silt (%)	Total salt (%)	$CaCo_3$ (%)	Organic matter (%)	PH H_2O
65.2	21.2	13.6	0.020	5.7	2.01	7.91

Source: Aksoy[28]

Drug herb yields (kg ha^{-1}): A sample of 500 g of green herb was taken from each plot. Samples were dried at 35°C for 72 h to determine dry weight.

Drug leaves yield (kg ha^{-1}): A sample of 500 g of green herb was taken from each plot. The leaves of the samples were separated from the stems by hand and weighed. The leaves were dried in an oven at 35°C for 72 h dry weight to determined.

Essential oil ratio (%): A sample of 20 g of drug leaves was taken from dry leaves sample for each plot. Then 200 ml of distilled water was added to each sample and water distillation was run for 45 min using a neo-clevenger apparatus. The essential oil rate was measured by the volumetric method (v/w)[29].

Essential oil yield (L ha^{-1}): The yield of essential oil was calculated by multiple drug herb yields with essential oil ratio.

Composition of essential oil (%): Components of essential oil were determined by gas chromatography (GC) (2380 model Carlo Erbaa-Fractovap) which has 3 m column length at Ege University Central Laboratory. Temperatures of injector, column and detector were 250°C, 110°C and 250°C, respectively. The material of the column was 3% OV-1 and gas chrom Q. Peaks taken from GC were identified using reference solutions of α-pinene, β-pinene, 1,8 cineole, linalool, camphor, citronellal, methylchavicol, geraniol and eugenol.

All the data were analyzed by using the Statistical Software Package[30]. The comparison of the treatment means was made using the Least Significant Difference (LSD) test.

RESULTS

It was found that fertilizer usage was a significant factor to all investigated characteristics except for essential oil yield (Table 2). Plant density positively affected all the characteristics except for essential oil ratio and fertilizer x plant density interaction was found to be

Table 2: Analysis of variance results related to examine some characteristic of *Ocimum basilicum* L

Variation source	Mean squares														
	Green herb yield (kg ha^{-1})			Drug herb yield (kg ha^{-1})			Drug leaves yield (kg ha^{-1})			Essential oil ratio (%)			Essential oil yield (l ha^{-1})		
	2000	2001	2002	2000	2001	2002	2000	2001	2002	2000	2001	2002	2000	2001	2002
Fertilizer (F)	ns	*	*	ns	*	**	ns	ns	*	ns	*	ns	ns	ns	ns
Error-1	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Plant density (Pd)	*	*	*	ns	*	**	**	*	ns	ns	ns	ns	**	ns	**
FxPd	ns	ns	ns	ns	ns	**	ns	ns	*	ns	ns	ns	ns	ns	*
Error	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

*,**indicates significance at 0.05 and 0.01 respectively, ns indicates non significant

Table 3: The green herb yield of *Ocimum basilicum* L. in 2000, 2001 and 2002 years (kg ha^{-1})

Plant density (cm)	2000			2001			2002		
	Non nitrogen fertilizer	Nitrogen fertilizer	Mean	Non nitrogen fertilizer	Nitrogen fertilizer	Mean	Non nitrogen fertilizer	Nitrogen fertilizer	Mean
20x20	3499.8	3759.6	3629.7	4092.3	5612.5	4852.4	3718.9	4502.1	4110.5
40x20	2372.1	3608.1	2990.1	3816.3	5045.6	4431.0	3706.3	3634.6	3670.5
60x20	2513.1	2291.8	2402.5	3066.1	3961.3	3512.7	2940.6	3848.6	3394.8
Mean	2795.0	3219.8	3007.4	3658.2	4873.1	4265.7	3455.3	3995.2	3725.3
$LSD_{0.05}$	LSD (Pd)=897.945			LSD (F)=1044.106			LSD (F)=296.068		
				LSD (Pd)=948.446			LSD (Pd)=446.513		

Table 4: The drug herb yield of *Ocimum basilicum* L. in 2000, 2001 and 2002 years (kg ha^{-1})

Plant density (cm)	2000			2001			2002		
	Non nitrogen fertilizer	Nitrogen fertilizer	Mean	Non nitrogen fertilizer	Nitrogen fertilizer	Mean	Non nitrogen fertilizer	Nitrogen fertilizer	Mean
20x20	1035.6	1156.1	1095.9	989.5	1303.8	1146.7	917.4	1069.0	993.2
40x20	803.5	1107.8	955.7	922.9	1156.4	1039.7	912.6	893.7	903.2
60x20	815.8	768.3	792.1	721.5	951.2	836.4	699.7	974.5	837.1
Mean	885.0	1010.7	947.9	878.0	1137.1	1007.6	843.2	979.1	911.2
$LSD_{0.05}$		ns		LSD (F)=244.917			LSD (FXPd)=87.278		
				LSD (Pd)=201.631					

significant for all characteristics except for green herb yield and essential oil ratio.

Agronomical characters

Green herb yield (kg ha^{-1}): The second year yield reached to the highest level (4265.7 kg ha^{-1}) compared to the years of 2000, 2002 (3007.4 kg ha^{-1}, 3725.3 kg ha^{-1}, respectively) in the evaluation of the two applications (Table 3).

The nitrogen application had positive effect on green herb yield for the second and the third year. The green herb yields were 4873.1 and 3995.2 kg ha^{-1} in 2001 and 2002, respectively. The effect of plant density was significant factor for all years. The highest green herb yield was obtained from the density of 20x20 cm (respectively, 3629.7, 4852.4 and 4110.5 kg ha^{-1}). It was found out that decreasing plant density (60x20 cm) reduced the yield to the lowest level (2402.5, 3512.7 and 3394.8 kg ha^{-1}).

Drug herb yield (kg ha^{-1}): When the data of year 2000 was examined, the difference between fertilizer and plant density was not seen clearly. It was determined that the mean drug herb yield is 947.9 kg ha^{-1} (Table 4). Although the variation was between 768.3-1156.1 kg ha^{-1}, fertilizer and plant density did not have any effect on drug herb yield.

The date of 2001 displayed that the factors of fertilizer and plant density were statistically significant. While drug herb yield was 1137.1 kg ha^{-1} in growing condition with nitrogen fertilizer, the drug herb yield reduced to 878 kg ha^{-1} under non-nitrogen fertilizing condition. While at 20x20 cm and 40x20 cm plant density high drug herb yield (1146.7 and 1039.7 kg ha^{-1}, respectively) obtained, 60x20 cm plant density caused to yield decrease (836.4 kg ha^{-1}).

In the 2002 date, fertilizer x plant density interaction was found to be significant. The results showed that under non-nitrogen fertilizing condition the highest yield was obtained from 20x20 cm (917.4 kg ha^{-1}) and 40x20 cm (912.6 kg ha^{-1}) plant densities. However under nitrogen fertilizing conditions the highest yield (1069.0 kg ha^{-1}) was obtained from 20x20 cm plant density.

Drug leaves yield (kg ha^{-1}): Drug leaves yield was 591.4 kg ha^{-1} in the first year, 668.6 kg ha^{-1} in the second year and 470.8 kg ha^{-1} in the third year (Table 5). The yield with nitrogen fertilizer was an increased, although it

Table 5: The drug leaves yield of *Ocimum basilicum* L. in 2000, 2001 and 2002 years (kg ha^{-1})

Plant density (cru)	2000			2001			2002		
	Non nitrogen fertilizer	Nitrogen fertilizer	Mean	Non nitrogen fertilizer	Nitrogen fertilizer	Mean	Non nitrogen fertilizer	Nitrogen fertilizer	Mean
20x20	696.7	762.0	729.4	630.0	930.3	780.2	437.6	569.7	503.7
40x20	458.8	682.4	570.6	633.2	744.3	688.8	483.3	475.6	479.5
60x20	473.9	474.6	474.3	481.9	591.9	536.9	365.3	493.1	429.2
Mean	543.1	639.7	591.4	581.7	755.5	668.6	428.7	512.8	470.8
$LSD_{0.05}$	LSD (Pd)=129.875			LSD (Pd)=160.824			LSD (FXPd)=86.875		

Table 6: The essential oil ratio of *Ocimum basilicum* L. in 2000, 2001 and 2002 years (%)

Plant density (cru)	2000			2001			2002		
	Non nitrogen fertilizer	Nitrogen fertilizer	Mean	Non nitrogen fertilizer	Nitrogen fertilizer	Mean	Non nitrogen fertilizer	Nitrogen fertilizer	Mean
20x20	0.656	0.569	0.613	0.781	0.712	0.747	1.125	1.108	1.117
40x20	0.744	0.575	0.660	0.788	0.694	0.741	0.933	0.975	0.954
60x20	0.650	0.494	0.572	0.894	0.712	0.803	0.967	0.917	0.942
Mean	0.683	0.546	0.615	0.821	0.706	0.764	1.008	1.000	1.004
$LSD_{0.05}$	ns			LSD (F)=0.099			ns		

Table 7: The essential oil yield of *Ocimum basilicum* L. in 2000, 2001 and 2002 (L ha^{-1})

Plant density (cru)	2000			2001			2002		
	Non nitrogen fertilizer	Nitrogen fertilizer	Mean	Non nitrogen fertilizer	Nitrogen fertilizer	Mean	Non nitrogen fertilizer	Nitrogen fertilizer	Mean
20x20	4.260	4.258	4.259	4.818	6.875	5.847	4.480	6.290	5.385
40x20	3.170	3.943	3.557	4.758	5.387	5.073	4.490	4.573	4.532
60x20	2.720	2.070	2.395	4.100	4.300	4.200	3.457	4.417	3.937
Mean	3.383	3.424	3.404	4.558	5.521	5.040	4.142	5.093	4.618
$LSD_{0.05}$	LSD (Pd)=1.074			ns			LSD (FXPd)=0.765		

was not statistically significant. However, the effect of plant density on drug leaves yield was significant for two years. While high yield was obtained from excessive plant density (20x20 cm), low plant density leads to low yield, the mean drug leaves yield of 20x20 and 60x20 cm plant densities were 754.8 and 505.6 kg ha^{-1}, in 2000 and 2001 year, respectively (Table 5).

Second level interactions of fertilizer x plant density were noticed. When the effect of plant densities on drug leaves yield was examined, it was seen that under non-nitrogen fertilizer condition high yield was obtained from 40x20 cm (483.3 kg ha^{-1}) plant density and low yield was obtained from 60x20 cm (365.3 kg ha^{-1}) plant density, high yield with under nitrogen fertilizer condition the highest and the lowest yield were obtained from 20x20 cm (569.7 kg ha^{-1}) and 40x20 cm (475.6 kg ha^{-1}) plant density, respectively (Table 5).

Technologic characteristics

Essential oil ratio (%): In 2000, mean essential oil ratio was 0.615%. Although variation was between 0.494-0.744%, the effect of fertilizer and plant density did not have any effect on essential oil ratio (Table 6). In 2001, the mean essential oil ratio was 0.764% and unlike 2000, fertilizer had significant effect on essential oil ratio. It was determined that essential oil ratio was higher in non-nitrogen fertilizer condition than nitrogen fertilizer condition (Table 6). On the other hand, plant density did not play important role on essential oil ratio.

In 2002, fertilizer application and plant density did not affect essential oil ratio, which was similar to the results of 2000 year. The mean essential oil ratio was 1.004% and variation was between 0.917-1.125%, but the effect of factors was not statistically significant on essential oil ratio.

Essential oil yield (L ha^{-1}): In 2000, plant density affected essential oil yield and this effect caused differentiations for the investigated factor (Table 7). The highest essential oil yield (4.259 L ha^{-1}) was obtained from 20x20 cm plant density. However, fertilizer did not change essential oil yield, which was between 3.383-3.424 L ha^{-1}.

In 2001, plant density and fertilizer did not have statistically significant affected essential oil yield. The mean essential oil yield was 5.040 L ha^{-1} and between 4.100-6.875 L ha^{-1}.

In 2002, it was shown that essential oil yield was affected by fertilizer and plant density. Under non-nitrogen fertilizer condition, high yield was obtained from 40x20cm (4.490 L ha^{-1}) and 20x20 cm (4.480 L ha^{-1}) plant densities and low yield (3.457 L ha^{-1}) was obtained from 60x20 cm plant density. Under nitrogen fertilizer condition high yield (6.290 L ha^{-1}) was obtained from 20x20 cm plant density and low yield was obtained from

Table 8: The composition of essential oil of *Ocimum basilicum* L. in 2000, 2001 and 2002 growing seasons (%).

Years	Fertilizer	Plant density	α-Pinene	β-Pinene	1,8-Cineole	Linalool	Camphor	Citronellal	Methylcavicol	Geraniol	Eugenol
2000	Non nitrogen	20x20	1.71	-	10.04	67.93	-	2.14	2.96	3.10	4.92
	fertilizer	40x20	1.02	-	9.82	69.62	0.59	1.37	1.83	3.22	11.17
		60x20	1.61	-	9.29	72.27	-	2.02	1.79	3.40	9.62
		Mean	1.45		9.72	69.94	0.59	1.84	2.19	3.24	8.57
	Nitrogen	20x20	-	-	8.31	76.46	-	-	2.38	3.96	8.89
	fertilizer	40x20	-	-	7.49	74.56	-	1.60	3.09	3.33	9.41
		60x20	-	-	7.44	75.33	-	1.50	1.80	3.05	10.88
		Mean			8.08	74.12		1.55	2.42	3.78	10.39
2001	Non nitrogen	20x20	2.11	2.22	13.67	63.36	-	2.23	1.84	2.95	11.62
	fertilizer	40x20	1.58	2.05	10.36	70.47	-	2.57	2.26	2.70	8.01
		60x20	1.05	2.14	11.48	68.49	-	2.13	1.78	2.20	10.73
		Mean	1.58	2.14	11.84	67.44		2.31	1.96	2.62	10.12
	Nitrogen	20x20	2.10	1.84	14.06	64.33	-	1.95	2.05	2.95	10.72
	fertilizer	40x20	2.24	-	14.81	65.07	-	2.14	1.34	1.45	10.60
		60x20	2.21	-	11.10	67.29	-	2.31	2.25	1.74	12.91
		Mean	2.18	1.84	13.32	65.56		2.13	1.88	2.05	11.41
2002	Non nitrogen	20x20	3.41	-	15.64	60.76	1.82	0.71	1.07	5.48	9.97
	fertilizer	40x20	2.88	-	13.69	71.43	2.23	1.64	1.36	2.36	4.41
		60x20	2.12	-	12.18	66.25	2.03	1.06	1.14	5.25	9.53
		Mean	2.80		13.84	66.15	2.03	1.14	1.19	4.36	7.97
	Nitrogen	20x20	3.28	-	16.46	65.76	1.61	1.45	0.87	1.84	8.73
	fertilizer	40x20	3.33	-	16.10	61.50	1.33	1.57	0.55	1.86	8.68
		60x20	2.86	-	13.79	69.44	1.75	1.30	1.27	1.46	8.13
		Mean	3.16		15.45	65.57	1.56	1.44	0.90	1.72	8.51

Table 9: Agronomic and technological variation in *Ocimum basilicum* L.

			Plant density (cm)		
Investigated characters	Non nitrogen fertilizer	Nitrogen fertilizer	20x20	40x20	60x20
Green herb yield (kg ha^{-1})	3302.800	4029.400	4197.500	3697.200	3103.300
Drug herb yield (kg ha^{-1})	868.700	1042.300	1078.600	966.200	821.900
Drug leaves yield (kg ha^{-1})	517.800	636.000	671.100	579.600	480.100
Essential oil ratio (%)	0.837	0.751	0.826	0.785	0.772
Essential oil yield (L ha^{-1})	4.028	4.679	5.164	4.387	3.511

40x20 cm (4.573 L ha^{-1}) and 60x20 cm (4,417 L ha^{-1}) plant densities (Table 7).

Composition of essential oil (%): It is determined that the main component of essential oil was linalool followed by 1,8 cineole and eugenol (Table 8). Linalool ratio was between 60.76-76.46%, 1,8 cineole ratio was between 7.44-16.46% and eugenol ratio was between 4.41-12.91%. Nitrogen fertilizer and plant density did not affect the composition of essential oil. While the highest linalool ratio (76.46%) was determined under nitrogen fertilizer condition with 20x20 cm plant density in the first year, the highest linalool ratio (70.47 and 71.43%, respectively) was determined in the second and third years under non-nitrogen fertilizer condition with 40x20 cm plant density. As a second component the ratio of 1,8 cineole was highest in all years with the 20x20 cm plant density at both growing conditions except for second year under nitrogen fertilizer growing (40x20 cm) condition.

DISCUSSION

The green herb yield (4029.4 kg ha^{-1}) under nitrogen fertilizer condition was higher than non- nitrogen fertilizer condition (Table 9). Nitrogen fertilizer encouraged vegetative growth. Similar results were reported by Arabaci[31], Ceylan *et al.*[32] and Koç[33]. The highest green herb yield (4197.5 kg ha^{-1}) was obtained from 20x20 cm plant density, which shows the effect of plant density on the green herb yield. The green herb yield was increased with the higher plant density. Since the green herb yield was affected with the number of plant per area, the green herb yield was increased with the high plant density. The green herb yield in our experiment was higher than the results of previous studies[17,18]. On the other hand, the highest herb green yield obtained from the nitrogen fertilizer and 20x20 cm plant density was shown similarity to the results given by El-Gendy *et al.*[19].

Drug herb yield was determined from the higher nitrogen fertilizer condition (1042.3 kg ha^{-1}) than non-nitrogen fertilizer and with 20x20 cm plant density (1078.6 kg ha^{-1}) as the others density. Our results were similar to that of Gill and Randhawa[20]. While the plant density increased, the number of plant per area increased.

Similar to the results of green and drug herb yield, nitrogen fertilizer and different plant densities affected drug leaves yield. Nitrogen fertilizer results higher drug leaves yield (671.1 kg ha^{-1}) than non-nitrogen fertilizer growing condition. The effect of plant density was found to be significant for drug yield and the highest drug

leaves yield (671.1 kg ha^{-1}) was obtained from 20x20 cm plant density. With the increase of the plant density, the number of plant per area was excessive and the plant covered the soil surface in a short period. Also, the area of photosynthesis surface was at arrived the highest level. That is why the drug leaves yield increased. Generally, as the plant density increased the drug leaves yield was also increased, which coincide with Ceylan *et al.*[34]. In our experiment, the drug leaves yield was found to be higher than previous studies[11,21].

The essential oil ratio varied from 0.751 to 0.837% (Table 9). Essential oil ratio under non-nitrogen fertilizer growing was higher than nitrogen fertilizer growing. It was determined that nitrogen fertilizer decreased the essential oil ratio. Koç[33] has reported the similar result. The effect of plant density on essential oil ratio was not found to be significant. Ceylan *et al.*[35] also supported this result. However, similar to the other examined characters, essential oil ratio with 20x20 cm plant density (0.826%) was higher than the other plant density. Essential oil ratio in our results was a little lower than Serin and Özgüven[11], Tansı and Nacar[18], although these results were fairly higher than reported by Ceylan[7], Baytop[8] and Akgül[22]. It is known that the essential oil ratio in plant dependents on different factors and is fairly affected by the environment conditions[36-41].

It was determined that the effect of experiment factors on essential oil yield was obvious. The essential oil yield (4.679 L ha^{-1}) under nitrogen fertilizer condition was higher than non-nitrogen fertilizer. The essential oil yield with 20x20 cm plant density was higher than the others densities. This is the result of increasing plant density per area. Present results were higher than reported by Gill and Randhawa[20]. The results, which effect plant density on essential oil yield, were coincidental with Gill and Randhawa[20].

It was determined that the main component of essential oil was linalool, the second and third components were 1, 8 cineole and eugenol, respectively. Linalool ratio was between 60.76-76.46%, 1, 8 cineole ratio was between 7.44-16.46% and eugenol ratio was between 4.41-12.91%. These results were higher than reported by Ceylan[7], Akgül[22], Simon *et al.*[23], Kostrzewa and Karwowska[24], Özek *et al.*[25] and Lemberkovics *et al.*[26].

In conclusion, green herb yield, drug herb yield; drug leaves yield and essential oil yield in *Ocimum basilicum* L. (basil) was significantly affected by 20x20 cm plant density and nitrogen fertilizer condition. As a conclusion, basil should be grown with 20x20 cm plant density and under nitrogen fertilizer condition for high drug herb and essential oil yield. In addition, the plant does not have germination, harvesting or any disease and insect problems during the growing period. The yield of all investigated characters were higher than previous studies. It can be said that basil could be grown easily and yield of this plant could be increased by using appropriate agronomical methods.

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