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Effect of Planting Density and Cattle Manure on Some Qualitative and Quantitative Traits in Two Basil Varieties under Guilan Condition, Iran

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Abstract: In order to study the effect of planting density and cattle manure levels on the plant height, seed yield, biologic yield, oil content(%) and oil yield in two Basil (*Ocimum basilicum L.*) Varieties, a field experiment was carried out using a split plot factorial arrangements with four replications at the "Roian Green plant co", agricultural experimental station in Tazeh Abad, Fouman, Iran in cropping season 2008. Cattle manure (cow manure) rates were assigned to main plots at three levels (M_1:0, M_2:15 and M_3:30 t/ha).Combination of two Basil Varieties (V1*: Basil cv. Green* and V2*:* Basil cv. Purple) with three planting densities (D_1:60, D_2:80 and D_3:100 plants/m^2) were randomized in sub-plots. Results showed that both cattle manure and plant density had significantly affected on plant height, seed yield, biologic yield, oil content and oil yield. The highest seed yield (2505 Kg/ha) was obtained from $M_3D_3V_1$ combined treatment and the same result achieved for the highest biologic yield (15730 Kg/ha).The lowest seed yield (1326 Kg/ha) belonged to $M_1D_1V_1$ whereas the lowest biologic yield was that of $M_1D_1V_2$. The effect of variety, except plant height, biological yield, oil content and oil yield was not significant on the seed yield. The interaction between cattle manure × plant density on all studied traits except for oil content; cattle manure × variety on plant height, oil content and oil yield; density× variety on plant height and finally cattle manure × plant density× variety on plant height, oil content and oil yield were significant. The highest oil content (0.39 weight percentage) and oil yield (44.01 Kg/ha) were related to $M_1D_1V_2$, while the lowest value of the same traits were belonged to $M_3D_1V_2$. In summary, Basil cv. Purple due to its higher efficiency is recommended to Growers for producing the highest oil content percentage and oil yield under temperate climates.

Abbreviation:

Word	In Text	In Table
Cattle manure	CM, started from materials and methods	M
Plant density	Plant density/D	D
Variety	Variety/V	V

Key words: *Ocimum basilicum L.* · Cattle manure · Plant density · Oil content (%) · Oil yield

INTRODUCTION

In the recent years, the stable production of healthy food products with regard to the bio-environment protection, social and economic occasions found an important place in different sciences such as agriculture, ecology and environment. This issue becomes the center of interest for farmers, researchers, policy makers and government officials increasingly [1].

Long-term studies indicated that the excessive use of chemical fertilizers results in crop yield reduction. This reduction is due to the soil acidity, reduction of biological activity, a sharp decrease in soil physical properties and lack of micronutrients in NPK fertilizers [2]. In many cases, the application of chemical fertilizers causes environmental pollutions and ecological damages which itself decreases the production costs [3].

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To reduce these risks, a kind of resources and inputs must be used which can provide the current needs of plant and also can follow the agricultural system sustainability in the long-term [4]. The organic matters are considered as one of the important factors of soil fertility due to their beneficial effects on the physical, chemical, biological and productivity of soil [5].

Using the organic matters in agricultural fields decreases the need to apply the chemical fertilizers and it also, reduces the yield differences between the prevalent and low-input agriculture. The use of cattle manure as a source of organic fertilizer is common in the stable soil management systems.

Mosaddeghi *et al.* [6] pointed that by using 5 to 10 t/ha cattle manure can neutralize the negative effects which caused by agricultural machinery on the soil.

Cattle manure, in addition to provide the nutrient element by increasing the capacity of the soil moisture retention, it increases the medicinal plants yield. It also can improve soil structure, soil moisture holding capacity, possibility of seedbed preparation for root growth, vegetative growth and improving the quality of crop yield [6]. The positive effects of the cattle manure on the soil fertility [7], increase of soil organic matter [8], plants growth and development and soil enrichment [9] has been mentioned in different sources frequently. In contrast to the soil, which fed with non-organic fertilizers, the soil, which received the cattle manure, contains more microorganisms, phosphorus, potassium, calcium, magnesium and nitrate. The more application of these fertilizers accumulates additional solutes in the soil. The study on Hubbard squash (*Cucurbita maxima* L.) indicated that because of using cow, goat and chicken manure, rate of crop biomass increased to the control treatment and application of low-level chemical fertilizers. Consequently, with the increase in cattle manure level, the dry matter yield increased in a linear trend [10].

Basil (*O basilicum*), is one of the oldest spices belonging to the *Ocimum* genus and to the Lamiaceae (Labiatae) family, is one of the most popular plants grown extensively in many continents around the world, especially in Asia (Iran, Afghanistan and India), Europe and North America [11]. At least 150 species of the genus *Ocimum* are widely cultivated in Asia [11]. Basils (*Ocimum* spp., Lamiaceae) contain a wide range of essential oils rich in phenolic compounds and a wide array of other natural products including polyphenols such as flavonoids and anthocyanins [12].

Basil essential oil has been extensively used in the flavouring of confectionery and baked goods condiments sausages and meat, salad dressing, non-alcoholic beverages, ice creams; it has also found wide application in perfumery, as well as in dental and oral products [13].

Leaves and flowers of basil have been used for the treatment of headaches, coughs, diarrhea, worms and kidney malfunctions, as well as for its carminative, galactagogue, stomachic and antispasmodic properties [14].

The amount of basil essential oil is unstable between 0.5 to 1.5 percent because of environmental conditions. The essential oil formation compounds are also can vary for the reason of environmental conditions. The basil essential oil is extracted from vegetative part of plant (leaves, top branches, fresh and dried flowers) through two methods of Hydro-distillation and steam distillation. As the essential oil is lighter than water, it can be easily separated from water-essential oil mixture [13].

Agronomic factors have considerable effects on the quantitative and qualitative function of the plants like basil. Among these factors, plant density can be mentioned. A study by El-Gendy *et al.* [15] showed that, the highest basil yield is gained from 15 cm row spacing. In a research on basil, Arabaci and Bayram [16] reported that the highest dry mater yield (1078.6 kg/ha), essential oil percentage (0.826) based on a plant dry weight and also essential oil yield (5.164 kg/ha) gained in planting pattern of (20cm×20cm) with the consumption of 5kg N/ha. El-Gendy *et al.* [15] in their experiment on 4 sowing distances (15, 25, 35 and 40cm) revealed that with the increase in plant spaces, the number of branches, leaves and plant dry weight increased greatly, whereas it decreased the plant height. They also reported that, the maximum amount of essential oil is obtained from sowing distance of 35cm.

Gill and Randhawa [17] reported that the maximum amount of essential oil is gained by plant density of (30cm×30cm) and the highest yield is resulted by (40cm×20cm) plant density. The basil dry matter yield is approximately 1.2 t/ha and the essential oil yield is 8 to 10 kg/ha [18].

Considering the global tendency to produce and propagate medical plant in stable and low input agricultural system as well as lack of studies in relation to the basil reaction to the organic fertilizers such as cattle manure, this study was conducted with the aim of evaluating the effect of cattle manure and plant density on the qualitative and quantitative traits of green and purple basil varieties.

MATERIALS AND METHODS

This study was carried out during the spring and summer of 2008 at "Roian Green Plant Co", Agricultural Experimental Station in Tazeh Abad (placed in the suburbs of Fouman, 15 km away from Rasht-North of Iran) which located at 37°15′ N latitude, 49° 23′ E longitude, with the altitude of 2 m above the sea level. The average Annual precipitation is 1200 mm and the minimum and maximum of mean temperature is 16.5 and 29 °C, respectively. The site is considered to be a moderate region. The experimental design of this study was carried out using split plot factorial arrangements based on a complete randomized blocks design with 4 replications. Cattle manure (CM) rates were assigned to main plots at three levels (0, 15 and 30 t/ha). Combination of two spring basil varieties (*O. basilicum* L. *cv.* purple and *O. basilicum* L. *cv.* green) with three planting densities (60, 80 and 100 plants/m^2) were randomized in sub-plots. Each plot consisted of 7 rows with 30 cm row spacing and the plot size was 16 m^2 (2.20m×7.30m). The spaces between the main plots were 1.5 m and the distances between the blocks included 2.5 m. The soil, after random sampling (from 0 to 30 cm depth), was taken to the lab before the trial. The soil tissue was loamy-sand with pH: 6.5 (Table 1). The intended CM was the fully putrefied cow manure. After implementing the experimental plan on the field, the CM was scattered equally in main plots one month before sowing. Then, with the use of rotary tiller, the manure mixed with the experimental soil up to the 20 cm depth thoroughly. On 28th of May 2008, the basil seeds (selected from Rasht local markets) were sown manually on the rows of each plot in 1 to 2cm depth. The irrigation was done immediately after sowing by plastic pipe from the well and it continued once in each 10 days. In order to achieve the desired density based on the treatments, the plants were thinned in two stages after seedling establishment (4 to 6 true leaf stage). During the experimental period, the hand-weeding was done in 3 stages to control the weeds. In this study, No pest or disease was noticed.

The Traits under Study Included: (plant height, essential oil percentage, essential oil yield, biological yield and seed yield). One week before the final harvest, for computing plant height, 10 plant samples collected from each experimental plot randomly and their height average was considered. The other traits calculated during the full maturity stage (when plants turned in to yellow) after the final harvest. For assessing the final yield of the aerial parts in each plot, in 10th of September 2008 the remaining level (2m^2 per plot) was harvested from the surface and dried in the field for 72 hours. All plots were evaluated on 1 m^2 area. They weighed by the 0.001 digital precise scale after reaching to the constant weight (biological yield).The next step was the seed separation stage In which the seeds related to each plot separated and weighed based on kg/ha (seed yield). For the more accurate statistical results, the edge lines of each experimental plot (during the sampling) and in the rows a half-meter of each side (during the final harvest) were ignored.

The extraction of the essential oil was carried out at the Laboratory of Guilan University, Rasht, Iran. For determination of essential oil percentage and oil yield, at full flowering stage, the aerial parts of cultivated *O. basilicum* L. *cv.* purple and *O. basilicum* L. *cv.* green was harvested, weighed, bulked, placed in a paper bag and oven dried at 40 °C for 48 h [19].

The essential oil content was estimated by hydro distillation of branches and leaves (aerial part) using Clevanger's apparatus for 3h according to the method recommended in the British Pharmacopoeia [20]. The resulted essential oil from each treatment was dehydrated over anhydrous sodium sulfate and weighed, in the other hand; 100g of the dry biomass with 400 ml of distilled water was boiled in the distillation apparatus. After three hours, volume of distilled essential oils was noted based on the herb dry weight and expressed as (%). The oil yield was calculated by multiplying the oil content with dry herbage weight and expressed as kg/ha.

In this study, analysis of variance (ANOVA) was used, to determine the significant differences. The Multiple Range Test of Duncan performed the separation of means at 5% probability level. All statistics was performed with MSTATC program (version 2.10).

Table 1: Physical and chemical properties of experimental soil before planting

						Texture			
O.C (%)	N (%)	P ppm	K ppm	EC (dS/m)	pH	Sand (%)	Silt (%)	Clay (%)	Sp (%)
2.2	0.21	9.2	106	0.8	6.5	34.8	24.4	22.8	65

RESULTS AND DISCUSSION

Plant Height: Results from the analysis of variance (Table 2) indicated that effects of CM ($p<0.01$), plant density ($p<0.01$) and variety ($p<0.05$) treatments on plant height were significant. Moreover, all interaction effects (including: CM × variety; CM × plant density; variety × plant density and CM × plant density × variety) on this trait were highly significant ($p<0.01$). In addition, means comparison (Table 3) suggested that as CM consumption increased from 0 to 30 t/ha, the plant height increased as well. The highest plant height (64.01cm) belonged to $M_3D_3V_2$ being the only combined treatment in a separate statistical group, while the lowest plant height (45.89cm) was obtained from $M_1D_1V_1$ (i.e., M_1: 0 t CM/ha; D_1:60 plants/m^2 and V_1: *Basil cv. Green*). One of the main determining factors of plant height is providing its essential nutritional elements and through a gradual supply of these elements, CM works well in this regard and causes the vegetative growth and plant height to increase. Studies conducted by Tahami *et al.* [21] along with Kandeel *et al.* [22] confirmed the effect of CM consumption on plant height as well. In their study of the effect of CM consumption on the qualitative and quantitative yield and the chemical compositions of cumin (*Cuminum cyminum*) essential oil, Ahmadian *et al.* [23]

Table 2: Analysis of variance results (Mean of Square) for different traits of basil under varying Cattle manure (Cow manure) and plant density

S.O.V	df	Plant height	Seed yield	Biological yield	Oil content	Oil yield
R	3	1.645 ^{ns}	224377.631^{ns}	186140.181^{ns}	0.002**	49.803**
M	2	339.007**	2183161.224**	22730986.568**	0.030**	1605.591**
E_a	6	4.007	81136.889	141728.856	0.001	8.942
D	2	198.830**	1208456.062**	10363583.059**	0.075**	727.827**
M×D	4	9.967**	91655.386**	459862.417*	0.00^{ns}	23.704**
V	1	5.270*	1826.201^{ns}	6607757.940**	0.006**	5.562^{ns}
M×V	2	10.266**	17110.779^{ns}	48259.575^{ns}	0.001*	18.592*
D×V	2	10.660**	9393.562^{ns}	51200.266^{ns}	0.000^{ns}	4.282^{ns}
M×D×V	4	5.091**	9863.344^{ns}	176281.290^{ns}	0.001**	16.353*
E_b	45	0.402	20159.565	123376.073	0.000	911.3
C.V (%)		3.65	7.56	2.56	2.75	4.08

* and ** Significant at the 5% and 1% levels of probability, respectively; ns: Non significant; Cattle manure: M in Table, CM in Text; D: Plant density; V:Variety;M×D, M×V, D×V, M×D×V represents interaction terms between the treatment factors; Oil content: Essential oil content; Oil yield: Essential oil yield

Table 3: Means comparison of qualitative and quantitative trais of two variety of Basil (*O. basilicum* L. *cv.* Green and *O. basilicum* L. *cv.* Purple) under different plant density and Cattle manure (cow manure) levels

M	D	V	Plant height (cm)	Seed yield (kg/ha)	Biological yield (kg/ha)	Oil content (%)	oil yield (kg/ha)
	D_1	V_1	45.89 j	1326f	11980h	0.36d	43.96fg
		V_2	48.53i	1336f	11100i	0.39c	44.01fg
M_1	D_2	V_1	52.45 h	1564ef	13020g	0.31f	41.24gh
		V_2	49.61i	1582ef	11900h	0.32f	38.84hi
	D_3	V_1	57.28 d	1624ef	13700ef	0.26gh	36.58ij
		V_2	54.15fg	1636def	13270fg	0.25h	34.04j
	D_1	V_1	49.91 i	1747de	13290fg	0.41c	54.45c
		V_2	52.99gh	1712de	12810g	0.40c	51.64cd
M_2	D_2	V_1	54.67 f	1939cd	14540bcd	0.32f	47.02ef
		V_2	54.54fg	2126bc	14100de	0.37d	53.16cd
	D_3	V_1	55.05 f	2213abc	14890bc	0.26h	38.23hi
		V_2	57.05 de	2161bc	13980de	0.27g	38.68hi
	D_1	V_1	55.56ef	1760de	14280cde	0.43b	63.32b
		V_2	56.67 de	1722de	13910de	0.47a	66.25a
M_3	D_2	V_1	60.12 c	2431ab	15140b	0.39c	60.04b
		V_2	60.79bc	2339ab	14410cd	0.42b	55.25c
	D_3	V_1	61.78 b	2505a	15730a	0.31f	49.78de
		V_2	64.01 a	2389ab	14800bc	0.34e	51.33cd

Means followed by similar letters in each column are not significantly different at 5% probability level using Duncan Multiple Range Test (DMRT).
Cattle manure: M in Table, CM in Text; M_1:0 t CM/ha; M_2:15 t CM/ha; M_3:30 t CM/ha; D: plant density; D_1:60 plants/m^2; D_2:80 plants/m^2; D_3:100 plants/m^2; V: variety; V_1: *Basil cv. Green*; V2: *Basil cv. Purple*; Oil content (%): Essential oil percentage; Oil yield: Essential oil yield

found about the ineffectiveness of CM in the plant's height. Means comparison revealed that, upon the increase in plant density (from 60-to100 plants/m^2) for every CM amount, a significant increase in plant height, particularly in *Basil cv. Purple* was obtained (Table 3). Apparently, this increase occurred due to increased activity of stem growth hormone as a consequence of less light. In this regard, Sadeghi *et al.* [24] and Damato *et al.* [25] concluded that plant density had a significant effect on the height of basil and fennel, respectively.

Seed Yield: The results in Table 2 indicated that, Basil seed yield was significantly ($p<0.01$) affected by different planting density, CM rates and interaction thereof, while other simple and interaction effects regarding this trait did not show a significant difference. Means comparison of the interaction effects of CM × plant density × variety, using Duncan's test at the probability level of 5% showed that, the seed yield of a 100 plants/m^2 with consumption of 30 t CM/ha in Basil cv. Green (i.e. $M_3D_3V_1$) was more than other treatment combinations (2505 kg/ha). So it was placed in the same group as $M_3D_2V_1$, $M_3D_2V_2$, $M_2D_3V_1$ and $M_3D_3V_2$ (Table 3).

In addition, the lowest seed yield (1326 kg/ha) was obtained from a 60 plants/m^2 without any CM consumption for Basil cv. Green which was at par with $M_1D_1V_2$, $M_1D_2V_1$, $M_1D_2V_2$, $M_1D_3V_1$ and $M_1D_3V_2$ combined treatments. As seen in Table 3, consumption of CM caused the seed yield to be increased significantly for each variety and density. It seems that besides improving the soil structure and increasing soil water holding capacity, by making a plant's essential elements available, CM causes a better growth, increases the number of umbrellas per plant and the biological yield, which is followed by increased seed yield. Ahmadian *et al.* [23] reported increased cumin (*Cuminum cyminum*) yield due to CM consumption as well. Rezaenejad and Afyuni [26] stated that organic fertilizers significantly increased the soil's organic matter and besides increasing its Zn, Cu, Fe, P, K and N absorption capacity, they had the greatest effect on the corn yield. Furthermore, Azizi *et al.* [27] showed that increased CM consumption led to the significant improvement of chamomile (*Matricaria recutita*) flower yield. In this study, as the plant density increased for each CM amount, seed yield in the unit of surface increased as well which was comparable to the results of studies conducted by Ehteramian [28] and Sadeghi *et al.* [24].

Biological Yield: Results showed that cattle manure (CM), plant density and variety had a significant effect on the biological yield at the probability level of 1%. In addition, among the interaction effects, only those of CM and plant density on this trait were highly significant ($p<0.01$) (Table 2). According to means comparison results in Table 3, the highest biological yield (15,700 kg/ha) achieved from Basil cv. Green under 100 plants/m^2 and an application of 30 t CM /ha ($M_3D_3V_1$). On the other hand, the lowest biological yield (11,100 kg/ha) was that of Basil cv. Purple for 60 plant/m^2 and not-consuming CM ($M_1D_1V_2$) in a way that statistically, both treatment combinations were separately placed in independent statistical groups.

For each variety and plant density, when CM application increased, the plant's biological yield increased as well. Also, when plant density under each CM application increased, the biological yield increased too (Table 3).

Considering the fact that with density increase, each plant's weight decreases due to the increase in the interplant competition and the fact that the lowest plant weight would be obtained from the highest densities, it can be concluded that despite the decreased dry weight per plant, the increased number of plants in the unit of surface would result in the increased biological yield in the unit of surface.

As a whole, in plants whose yields result from the vegetative growth (e.g. Basil), there must be a dense vegetation (canopy) for them to absorb maximum radiation. The efficiency of the solar radiation absorption on a crop's surface requires adequate leaf area to be uniformly distributed and to cover the ground surface, which is achievable with the changes of plant density and distribution [29]. Naghdi *et al.* [30] in their study of thyme (*Thymus vulgaris*), reported that the highest dry matter yield of this plant was obtained in the highest density. Regarding the cause of a significant increase in the biological yield ($p<0.01$) due to applying 0 to 30 t CM/ha, it could be said that since these manures are less exposed to sublimation and leaching, they are less probable to be inaccessible to the plant[31].Moreover, such manures have most of the essential elements of a plant. Due to having macro-elements and less micronutrient, they lead the soil towards a more nutritional balance state in the long run; thus, by improving soil conditions, they would lead to a better growth, maturity and consequently, an increased biological yield. Similar results concerning the positive effects of CM consumption on the biological yield have been reported earlier [32, 33].

Oil Content (%): During our investigation, analysis of variance showed that, simple effects of plant density, CM and variety were highly significant ($p<0.01$) on the essential oil percentage (oil content). Interaction effects of the CM and variety along with those of CM × plant density × variety on the oil content showed a significant difference at probability levels of 5% and 1%, respectively; while interaction effects of CM × plant density and plant density × variety on the oil content were not significant (Table 2). As seen in Table 3, when plant density increased from 60-to100 plants/m^2 at each level of CM application, a significant reduction in the oil content was observed.

For instance, at the CM application level of 30 t/ha, with the increase in plant density, the oil content changed from 0.43 (weight percentage) for 60 plants/m^2 to 0.34 (weight percentage) for 100 plants/m^2 , in a way that this oil content reduction was statistically significant. In this regards, Pop *et al*. [34] showed that the highest polyphenol content in Marigold (*Calendula officinalis L.*) was obtained from the highest plant density, a finding that was inconsistent with the results of the present experiment. With consideration of means comparison in Table 3, it can be said that for each variety and plant density, as the CM consumption increases, we will observe increased oil content of basil. Therefore, the highest oil content (0.47 weight percentage) was obtained from Basil cv. Purple under 60 plants/m^2 and consumption of 30 t CM/ha (i.e. $M_3D_1V_2$), while its lowest percentage (0.25 weight percentage) was that of $M_1D_3V_2$ (a density of 100 plants/m^2 and not-consuming CM for Basil cv. Purple). Franz [35] believed that nutrition directly affects active substances and that the essential oil content increases with the increase in CM consumption, of course to a certain extent. Moreover, other researchers have shown the effect of using organic fertilizers on the oil content (%) of medicinal herbs [23,36]. Regarding the increase in this percentage with the increase in CM consumption, it can be concluded that organic fertilizer treatments (CM) with their soil water holding capacities and supplying nutritional elements provide an optimum bed for plant growth. Of course, warmer weathers and intensive solar radiations during growth period could be some other effective factors of increased oil content in this plant.

Oil Yield: Essential oil yield is the product of the essential oil percentage by the dry matter yield (biomass) per unit area. According to analysis of variance (ANOVA) results, the oil yield was significantly affected by difference among applied densities and CM levels ($p<0.01$); however, the effect of variety on this yield was not significant. In addition, interaction effects of CM × plant density and CM × variety on this trait were significant at probability levels of 1% and 5%, respectively (Table 2). Results showed that oil yield was not affected by interaction effects of variety × plant density, whereas interaction effects of CM × plant density × variety on this yield were significant at the probability level of 5%. With consideration of results in Table 3, as CM consumptions for each variety and plant density increases, we will observe a growing trend in the oil yield. Also, it can be seen that for each CM level, as the plant density per square meter increases, the said yield will decrease. Thus, the lowest oil yield (34.04 kg/ha) belonged to $M_1D_3V_2$ (Basil cv. Purple under 100 plants/m^2 along with not-consuming CM), which was placed in the same statistical group as $M_1D_3V_1$, i.e. mean oil yields of Basil cv. Green and Basil cv. Purple were not significantly different. On the other hand, the highest oil yield (66.25 kg/ha) was that of Basil cv. Purple for 60 plants/m^2 and 30 t CM/ha ($M_3D_1V_2$), which was placed in a separate statistical group. Increase in the oil yield proportional to increase in CM consumption was consistent with the results obtained by Tahami *et al.* [21]. In his experiment on fennel (*Foeniculum vulgare* Mill), Moradi [37] observed that the highest oil yield was achieved from applying organic fertilizers. Therefore, it could be said that basil's oil yield, due to producing more foliages per unit area as a result of CM consumption had increased [38]. Regarding the reason of the reduced oil yield by the increased plant density at each level of CM consumption (Table 3), it can be said that since basil' essential oil accumulates in the leaves and top flowered branches [38],with the increase in plant density from 60-to 100 plants/m^2 ,the number of plants in the unit of surface increased more than the optimum density for producing essential oil, which results in an increased interplant competition for receiving light, nutrients and moisture and also leads to competition between its parts for distributing assimilates. It seems that insufficient light caused the plants not to reach the necessary light saturation limit for achieving an optimum qualitative and quantitative yield and ultimately, it led to a reduced production of essential oil compounds. The existence of a significant difference between mean oil yields of various combined treatments in this experiment confirms this claim. Therefore, by helping plants to have more access to light, reduced plant density leads to more oil yields. This result is inconsistent with the findings of El-Gendy *et al.* [15] along with Arabaci and Byram [16], who reported that the highest oil yield of basil is observed in its high densities. Pop *et al.* [34] and Ramos *et al.* [39] have also obtained contradictory results in this regard.

The differences in results might be due to differences in environmental conditions under which these experiments were conducted.

CONCLUSIONS

- In spite of the fact that, the highest biological yield was belonged to Basil cv. Green with a density of 100 plants/m^2 and application of 30 t CM /ha, the highest oil yield was obtained from Basil cv. Purple under 60 plants/m^2 and application of 30 t CM /ha. This is an indication of Basil cv. Purple's high efficiency in producing essential oil compounds.
- Experiment results indicate the positive effect of CM from source of cow manure and the ideal response of basil to applying these manures in a way that plantation density and CM consumption have had significant effects on basil's qualitative and quantitative yield.
- Not using chemical inputs in medicinal herbs and their products is the main requirement for their being healthy and natural. Thus, with consideration of the positive reaction of Basil to applying CM, it seems that using these manures besides reducing the consumption of chemical fertilizers and their not having environmental hazards is a suitable method for a healthy and sustainable production of such crops.

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