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## Effect of Organic and Chemical Fertilizers on Growth Parameters and Essential Oil of Iranian Basil (*Ocimum basilicum* L.)

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### ABSTRACT

Basil belongs to the Lamiaceae family, is one of the most important aromatic and medicinal plants, which it widely cultivated in many countries. The areal parts, especially leaves of sweet basil are widely used to enhance the flavor of foods such as salads, pasta, tomato products, vegetables, pizza, meat, soups, marine foods, confectioneries and other products. This study was conducted to investigate the response of basil to different fertilizers (chemical and organic). Treatments consisted of different fertilizers including: F<sub>1</sub>=C (Control, without any fertilization), F<sub>2</sub>= CM (Cow manure 20 t.ha<sup>-1</sup>), F<sub>3</sub>=CM+CF (Cow manure 20 t.ha<sup>-1</sup> + chemical fertilizers), F<sub>4</sub>= CM+CF (Cow manure 10 t.ha<sup>-1</sup>+ chemical fertilizers), F<sub>5</sub>=CF (Chemical fertilizers, N.P.K), F<sub>6</sub>= VC (Vermicompost). This experiment conducted on randomized complete block design with three replications in Saman city, Southwestern Iran. Morphological traits and essential oil yield of the aerial parts of sweet basil (*O. basilicum*) were studied. From the results, it can be concluded that the application of different fertilizers has an influence on morphological traits, essential oil yield of the aerial parts of sweet basil. The highest values for plant height and dry weight (kg.ha<sup>-1</sup>), were observed with application CM (Cow manure 20 t.ha<sup>-1</sup>), CM+ CF (Cow manure 20 t.ha<sup>-1</sup> + chemical fertilizers), respectively. Among different fertilizer, the essential oil yield exhibited the greatest amount in CM+ CF treatment. In finally, the application of integrated manures mixture of organic (cow manure) and chemical fertilizer (20 t.ha<sup>-1</sup>) can cause to improvement dry matter yield and essential oil content in sweet basil.

**Keywords:** *Dry weight, Manure, Organic farming.*

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## INTRODUCTION

The major challenge for agriculture is to enhance crop production in a manner that is sustainable for present and future as well. The agricultural production and sustainable intensification goals in commercially important crops over both short and long terms demand proper plant nutrient and soil management. In arid and semi-arid areas, organic matter level of the soil is often very low. Thus, conservation and improvement of the soil organic matter is crucial for maintaining soil health and sustainability of farming in these regions. Moreover, successful crop production requires replacing adequate nutrients that have been removed by crops from the soil or lost to the environment one way or another. It is generally accepted that continuous and excessive application of chemical fertilizers may have negative impacts on soil health and environment and causes environmental problems including soil, physical destruction and nutrient imbalance (Yadav, 2003). Soil organic amendments therefore are considered as sustainable alternative sources of nutrients compared with synthesized fertilizers. Reports indicated that poultry manure and vermicompost are amongst efficient soil organic amendments for crop production (Keshavarz afshar *et al.*, 2014). However, as a consequence of the continually increasing demand for environmental protection and production of healthy food, it is necessary to increase the use of eco-friendly and environmentally safe natural and organic fertilizers. Organic fertilizers are obtained from animal sources such as animal manure or plant sources. Organic manures can serve as alternative to mineral fertilizers for improving the soil structure (Sharafzadeh and Ordoorkhani, 2011). Daneshian Moghaddam and Gürbüz (2013) reported the highest essential oil

yield of herb was obtained from low density (30×20 cm) with using 100 kg.ha<sup>-1</sup> nitrogen fertilizer. The addition of organic fertilizers to agricultural soils has beneficial effects on crop development and yields by improving soil physical and biological properties (Zheljazkov and Warman, 2004). The suitability and usefulness of organic manure has been attributed to high availability of N.P.K content (Kilande *et al.*, 2011). Organic fertilizers in comparison to the chemical fertilizers have lower nutrient content and slow release but they are as effective as chemical fertilizers over long periods of usage (Naguib, 2011). This was reported by some authors (Amran, 2013) who showed that organic fertilizers enhanced vegetative growth parameters and essential oil productivity of plants. Also, several researchers revealed that organic manure increased the vegetative growth and biomass production effectively (Roy and Hore, 2010; Dineshet *et al.*, 2010). Sweet basil (*Ocimum basilicum* L.), belonging to the family Lamiaceae is an ornamental, culinary, and medicinal and aromatic plant (Putievsky and Galambosi, 1999; Makri and Kintzios, 2007). *O. basilicum* is widely used in traditional medicine as a digestive tonic and for curing ailments such as warts, inflammations, colds, and headaches (Ghasemi Pirbalouti *et al.*, 2013a; Ghasemi Pirbalouti, 2014). Basil extract has known sedative with anticonvulsant, anti-carcinogenic properties (Freire *et al.*, 2006), as well as antiseptic (Suppakul *et al.*, 2003; Carovic-Stanko *et al.*, 2010). In the United States the suggested ratio of NP<sub>2</sub>O<sub>5</sub>-K<sub>2</sub>O elements is 1:1:1, with a N-dose of 230-300 kg.ha<sup>-1</sup>, as broadcasts and plowdown. Nitrogen side-dressing at rates of 50-75 kg.ha<sup>-1</sup> are recommended after each harvest (Politycka and Golcz, 2004). Today, herbs are used not only for cooking but

also in commercial fragrances, flavorings, and for increasing the shelf life of food products (Suppakul *et al.*, 2003). However, recent findings indicated that some of the medicinal plant characteristics can be affected by genetic and ecological factors, including precipitation, temperature, plant competition, fertilization, and nitrogen content in the soil (Ghasemi Pirbalouti *et al.*, 2013b). From the available literature, only a few papers studied the influence of fertilization on essential oil content sweet Iranian basil. In this study, we used fertilizers in different kinds to study the influence of the application of various types of fertilizers on plant growth and yield oil in sweet Iranian basil.

## MATERIALS AND METHODS

### Site description

A experiment was conducted at the Research Farm of Oman-e-Saman, Chaharmahal va Bakhtiari Province (Latitude 32° 29' N, longitude 32° 43' E, altitude 2112 m above sea level), southwestern Iran. Type of study area climate by Emberger's climatology method is cold and semiarid and semi humid with temperate summer and very

cold winter by Karimi's climatology method (IRIMO, 2012).

### Experimental details

The experiment was laid out with a split plot pattern in randomized complete block design with three replicates. Five kinds of fertilizers treatment including; F<sub>1</sub> =C (Control without manure and fertilizer), F<sub>2</sub>= CM (Cow manure 20 t.ha<sup>-1</sup>), F<sub>3</sub>= CM+ CF (Cow manure 20 t.ha<sup>-1</sup> + chemical fertilizers), F<sub>4</sub>= CM+ CF (Cow manure 10 t.ha<sup>-1</sup>+ chemical fertilizers), F<sub>5</sub>= CF (Chemical fertilizers; N.P.K), and F<sub>6</sub>= VC (vermicompost).

### Soil amendments

Prior to planting, soil samples were taken from 0 to 30 cm depth and were analyzed for selected physical and chemical characteristics. The soil was classified as silt clay, pH= 8.23, O.C= 28.19%, EC= 10.34 ds.m<sup>-1</sup>, total N= 200 mg.kg<sup>-1</sup>, Mn= 48.39 mg.kg<sup>-1</sup>, Cu= 18.91 mg.kg<sup>-1</sup>, Fe= 258 mg.kg<sup>-1</sup>, Zn= 48.02 mg.kg<sup>-1</sup>, Mg= 305.71 mg.kg<sup>-1</sup>, and Ca= 896.03 mg.kg<sup>-1</sup> (Table 1). Also the fertilizers were analyzed (Table 2, 3).

**Table 1.** Soil analysis at 0-30 cm depth

Cu (mg.kg <sup>-1</sup> )	Fe (mg.kg <sup>-1</sup> )	Mn (mg.kg <sup>-1</sup> )	Zn (mg.kg <sup>-1</sup> )	N (%)	K ava. (mg.kg <sup>-1</sup> )
0.76	1.96	6.21	0.42	0.049	195
P ava (mg.kg <sup>-1</sup> )	T.N.V (%)	O.C (%)	pH of past	E.C (ds.m <sup>-1</sup> )	-
8.6	32.5	0.346	7.65	0.891	-

### Plant Material

*O. basilicum* seeds were purchased from the seed company (Esfahan, Iran). In April 2013, transplants were produced in a green house in the pot (20 × 35 cm), and in June 2014, the seedlings were transplanted in the farm system (Sandy loam soil). Experiment con-

ducted in split plot based on randomized complete block design with three replications, during the period from 2013 and 2014 in the research farm of Oman-e-Saman. The distance between plants in each row was 30 cm; each experimental plot size was 2.5×2 m.

**Table 2.** Some characteristics of animal manure

T.N.V (%)	O.C (%)	Moisture (%)	Cu (mg.kg <sup>-1</sup> )	Mn (mg.kg <sup>-1</sup> )	Fe (mg.kg <sup>-1</sup> )	Zn (mg.kg <sup>-1</sup> )	Mg (mg.kg <sup>-1</sup> )
39.06	28.91	8.36	18.91	48.39	258	48.02	305.71
Ca (mg.kg <sup>-1</sup> )	Na (%)	K (%)	P <sub>2</sub> O <sub>5</sub> (%)	N <sub>2</sub> O (%)	Ec (ds.m <sup>-1</sup> )	pH	-
896.03	2.86	1.244	0.262	0.841	10.340	8.23	-

### Measurement of morphological Characteristics

Three uniform plants were selected from each plot at the full blooming stage (95 days from sowing) to measure the morphological characteristics. The growth parameters studied in this experiment were plant height, fresh herbal

and dry weights. Plant height was measured from the soil surface to the tip of the tallest flowering stem. Plants were cut from 1 cm area just above the lignified parts of the stem, immediately weighed (fresh weight) and then dried in room temperature until it reached a constant weight (dry weight).

**Table 3.** Chemical properties of the used compost

T.N.V (%)	O.C (%)	Moisture (%)	Cu (mg.kg <sup>-1</sup> )	Mn (mg.kg <sup>-1</sup> )	Fe (mg.kg <sup>-1</sup> )	Zn (mg.kg <sup>-1</sup> )	Mg (mg.kg <sup>-1</sup> )
18.5	16.11	11.28	19.71	247.23	4581.23	106.11	0.72
Ca (mg.kg <sup>-1</sup> )	Na (%)	K (%)	P <sub>2</sub> O <sub>5</sub> (%)	N <sub>2</sub> O (%)	Ec (ds.m <sup>-1</sup> )	pH	-
1.91	0.63	1.441	0.421	1.62	3.428	7.75	-

### Essential oil isolation

Dried plant material (50 g) was powdered and subjected to hydro-distillation for three hours using a Clevenger-type apparatus. The essential oils were dried with anhydrous sodium sulphate and kept in amber vials at 4°C prior to use.

### Statistical analysis

Analysis of variance was conducted by SAS software (Ver.9.1) and mean comparisons were applied via LSD test at 5% probability level.

## RESULTS AND DISCUSSION

### Effect of different fertilizers on plant morphology

The result of the variance analysis indicated a significant effect ( $p \leq 0.01$ ) of treatments on plant height and dry weight of plant (Table 4). The results revealed that plant height of sweet Iranian basil was influenced by the different treatments, especially the treatments

$F_2 = CM$  (Cow manure 20 t.ha<sup>-1</sup>). The highest values for plant height was observed under CM (Cow manure 20 t.ha<sup>-1</sup>). As shown in Fig. 1 there are no significant different among  $F_1 = C$  (Control, without manure and fertilizer),  $F_3 = CM + CF$  (Cow manure 20 t.ha<sup>-1</sup> + chemical fertilizers),  $F_5 = CF$  (Chemical fertilizers; N.P.K) and  $F_6 = VC$  (Vermicompost) in plant height (Fig. 1). The elongation and improving of plant height may be due to the role of organic fertilizers by enhancing the cell division rate and cell enlargement (Shalaby and El-Nady, 2008). Additionally, the positive effect of organic manure on plant height can derived from providing equilibrium plant nutrients and imposed a direct effect on number of nod and inter nod length that finally lead to increasing plant height. In comparison with chemical fertilizers, nutrients in organic manure, are used by plants more efficient (Halajnia *et al.*, 2007).

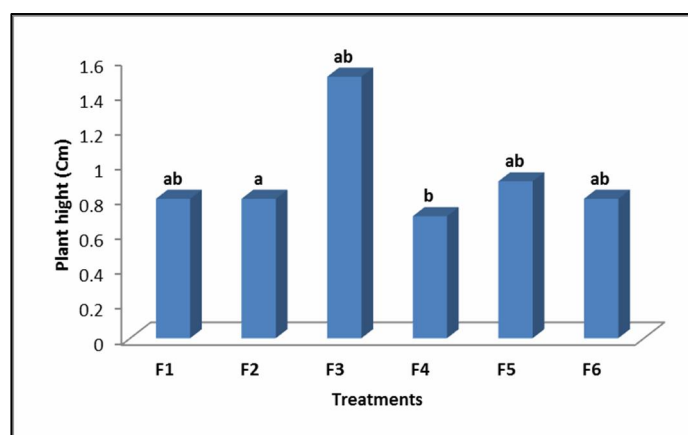
**Table 4.** Analysis of variance of studied traits

S. O. V	df	Yield oil	Height plant	Dry weight	Fresh weight
Block	2	0.01 <sup>ns</sup>	413.78 <sup>ns</sup>	54531 <sup>ns</sup>	213422 <sup>ns</sup>
Fertilizer	5	0.44 <sup>**</sup>	459.82 <sup>*</sup>	52438 <sup>*</sup>	1292124 <sup>ns</sup>
Error	10	0.01	212.7	28128	170664
CV	-	14.91	24.42	32.10	50.51

<sup>ns</sup>, <sup>\*</sup> and <sup>\*\*</sup>: non-significant, significant at 5% and 1% probability levels, respectively.

Moreover, nutrients balance in organic manure are important factor that can affect on plant growth and development compared with chemical fertilizer. On the other hands, increasing in plant height might be attributed to the effect of organic fertilizer that improves physical, chemical, and biological properties of soil; that is, increasing soil organic matter, cation exchange capacity, and water holding capacity and availability of mineral nutrients and, this in turn, increases plant height (Al-Fraihat, 2011). These results are in agreement

with Jacoub (1999) on *Thymus vulgaris*, Abd EL-Gawad (2001) on *Coriandrum sativum* and Hussain (2002) on *Majorana hortensis*. However, organic fertilization is a very important method of providing plants with their nutritional requirement without having an undesirable impact on the environment (El-Sayed *et al.*, 2002). The highest dry weight was scored by CM+ CF (cow manure 20 t.ha<sup>-1</sup> + chemical fertilizers), followed by CM (cow manure 20 t.ha<sup>-1</sup>), then the treatment control (without manure and fertilizer) (Fig. 2).



**Fig. 1.** Mean comparison effect of different fertilizers on plant height of basil via LSD test at 5% probability level.

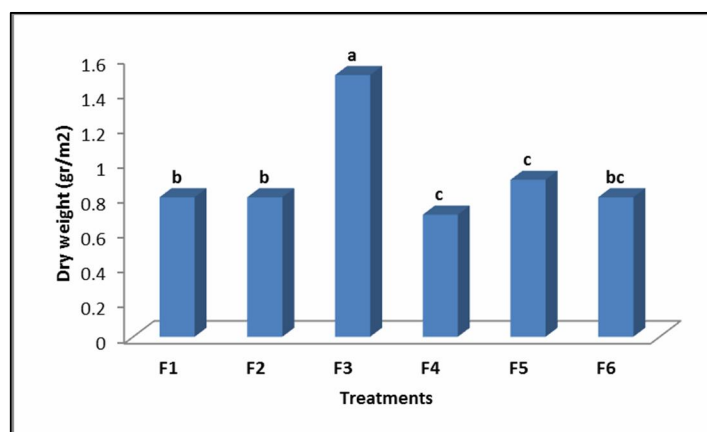
F<sub>1</sub>= C (Control, without any fertilization), F<sub>2</sub>= CM (Cow manure 20 t.ha<sup>-1</sup>), F<sub>3</sub>= CM+CF (Cow manure 20 t.ha<sup>-1</sup> + chemical fertilizers), F<sub>4</sub>= CM+CF (Cow manure 10 t.ha<sup>-1</sup>+ chemical fertilizers), F<sub>5</sub>= CF (Chemical fertilizers, N.P.K), F<sub>6</sub>= VC (Vermicompost)

Haque (2012) reported that the effect of the mixed fertilizer application (organic and inorganic) resulted in the highest yield of the cabbage head. This increase in dry weight may be due to increment in number of leaves and leaf

area. These results were in harmony with EL-Gendy *et al.* (2001) and Alves *et al.* (2005) on *Coriandrum sativum*. In addition, the results of this study are consistent with those of Arancon *et al.* (2004), who reported that organic fertil-

izer application significantly increases growth and biomass production in different varieties of strawberry. The results were in agree with who reported the use of organic materials, as an alternative source of chemical fertilizer increased the yield of fennel (*Foeniculum vulgare* Mill), (Darzi *et al.*, 2008; Moradi, 2009) black cumin (*Nigella sativa* L.) (Akbarnejad *et al.*, 2010) and (*Silybum marianum* L.) (Yazdani Buick *et al.*, 2010). Increasing in dry weight in treatment F<sub>3</sub> (cow manure 20 t.ha<sup>-1</sup> + chemical fertilizers) can be attributed to applying nitrogen in different growth stages has stimulating effects in organic compounds of the plant system. Moreover, the increasing effect of N fertilization on plant biomass may be due to the positive effects of nitrogen on activation of photosynthesis and metabolic processes of organic compounds in plants. When basil plants were exposed to integrated fertilizers, an increase in biomass yield was observed which may be due to integration of organic manures and chemical fertilizers that can increase the organic matter level of metabolic processes in plant. This event increases nu-

trient availability resulting in more nutrient content leading to higher biomass yield. Only use of organic manures or chemical fertilizer indicated lower nutrient uptake leading to lower biomass yield. Organic manure and chemical fertilizer alone need to more complex compound in the soil for development and growth in each plant cell for its proper functioning (Pandey and Patra, 2015). The fertilizer treatments had no significant effect on fresh weight of basil. In general, fertilization is the main factor affecting plant growth of active substances per unit area in plants (Kozera *et al.*, 2013). According to Koeduka *et al.* (2006) nitrogen plays a key role in the biosynthesis of many organic compounds such as amino acids, proteins, enzymes, and nucleic acid. This phenomenon boosts nutrient availability resulting in higher nutrient content leading to higher plant growth. Nitrogen is the essential constituents of the chlorophyll molecule. The higher levels of N resulted in enhanced chlorophyll concentration leading to higher photosynthesis activity and the plant growth.



**Fig. 2.** Mean comparison effect of different fertilizers on dry weight of basil via LSD test at 5% probability level

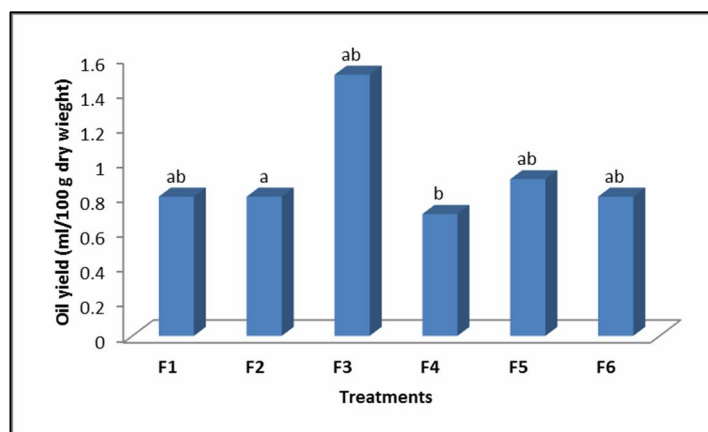
F<sub>1</sub>= C (Control, without any fertilization), F<sub>2</sub>= CM (Cow manure 20 t.ha<sup>-1</sup>), F<sub>3</sub>= CM+CF (Cow manure 20 t.ha<sup>-1</sup> + chemical fertilizers), F<sub>4</sub>= CM+CF (Cow manure 10 t.ha<sup>-1</sup>+ chemical fertilizers), F<sub>5</sub>= CF (Chemical fertilizers, N.P.K), F<sub>6</sub>= VC (Vermicompost)

Further, organic amendments increased the availability of nutrients for plant growth and simultaneously decreased the nitrogen leaching. The combined phenomenon boosted nutrient availability resulting in higher nutrient content and plant growth (Pandey and Patra, 2015).

### Effect of different fertilizers on oil yield of basil

Data presented in Table 4 indicated, a significant effect ( $p \leq 0.01$ ) of treatments on essential oil yield of basil. The highest essential oil yield was found in plants under mixed fertilizer application  $F_3 = \text{CM} + \text{CF}$  (Cow manure  $20 \text{ t.ha}^{-1}$  + chemical fertilizers) with 1.5%. Other fertilizers treatments [ $F_4 = \text{CM} + \text{CF}$  (Cow manure  $10 \text{ t.ha}^{-1}$  + chemical fertilizers) and  $F_5 = \text{CF}$  (chemical fertilizers; N.P.K)], also indicated significant difference as compared to the control (Fig.3). There are no significant different among [ $F_2 = \text{CM}$  (Cow manure  $20 \text{ t.ha}^{-1}$ ) and  $F_6 = \text{VC}$  (Vermicompost)] to the control. The enhance in essential oil yield by using of integrated fertilizer (CF+CM) may be due the higher supply of N from cow manure and chemical

fertilizer, which could lead to higher essential oil yield and dry matter (Pandey and Patra, 2015). The synthesis of essential oils is dependent on photosynthetic activity. Providing of photosynthetic nutrient boost and metabolic processes correlated to cell division and elongation (Hatwar *et al.*, 2003). According to Pandey and Patra (2015) nitrogen plays a key role in the division, growth and development of cells that stimulate essential oil accumulation via higher density of oil glands due to the improvement in biomass yield. Thus, it is useful to combine organic fertilizer with chemical fertilizer for optimum basil productivity and essential oil yield. Kandeel *et al.* (2002) focused on the effect of inorganic and organic nitrogen fertilizers and their combinations on yield and oil composition of basil. They showed that when combined, nitrogen supply increased oil yield (mainly composed by terpenoid-like compounds) compared to plants fertilized with inorganic nitrogen alone. However, fertilizers can significantly affect the content of essential oil.



**Fig. 3.** Mean comparison effect of different fertilizers on oil yield of basil via LSD test at 5% probability level.

$F_1 = \text{C}$  (Control, without any fertilization),  $F_2 = \text{CM}$  (Cow manure  $20 \text{ t.ha}^{-1}$ ),  $F_3 = \text{CM} + \text{CF}$  (Cow manure  $20 \text{ t.ha}^{-1}$  + chemical fertilizers),  $F_4 = \text{CM} + \text{CF}$  (Cow manure  $10 \text{ t.ha}^{-1}$  + chemical fertilizers),  $F_5 = \text{CF}$  (Chemical fertilizers, N.P.K),  $F_6 = \text{VC}$  (Vermicompost)

These results can be explained in the light of facts that, using organic manure, led to increase organic matter, availability of nutrients, nitrogen fixation and rizosphere microorganisms that release phytohormones, and substances which lead to increased growth and dry matter accumulation which in turn increases the concentration of oil (Edris *et al.*, 2003). Results of other studies indicate increasing the essential oil yield and improving the quality of essential oils in chamomile (Liuc and Pank, 2005) following organic fertilizer application. These results were agreement with those obtained by Naga (2004) on *Foeniculum vulgare* and *Carium carvi* L. Louise *et al.* (2009) on *Plectranthus neochilus* plants.

## CONCLUSION

The results recommended that combination of organic manure and chemical fertilizer gave higher dry weight and essential oil in *O. basilicum*. Combination of organic manure and chemical fertilizers was the most suited combination for improving the crop productivity, oil yield and overall profitability and economics of cultivation of the *O. basilicum*. In general, this improvement will greatly help in development of organic farming techniques and considerably reduce the cost of production and environmental hazards due to dependence on synthetic fertilizers.

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