J. Agric. Sci. Mansoura Univ., 28 (2): 1401 – 1418, 2003

RESPONSE OF BASIL (*Ocimum basilicum* L.) TO DIFFERENT CHEMICAL AND ORGANIC FERTILIZATION TREATMENTS

El- Sayed, A. A.*; Mahassen M. A. Sidky; H. A. Mansour* and Maie M. A. Mohsen****

*Ornamental Horticulture Department, Faculty of Agriculture, Cairo University.

**Medicinal and Aromatic Plant Research Department, Horticulture Research Institute, Agricultural Research Center, Dokky, Cairo, Egypt.

ABSTRACT

The present study was carried out during the two successive seasons of 1998 and 1999, to investigate the response of basil (*Ocimum basilicum* L., cv. Grand Vert) plants to different levels of NPK fertilization (using a fertilizer mixture with a ratio of 5:2:2, applied at 600, 800, 1000 or 1200 kg/fed./season), or organic fertilization using poultry manure (PM) at rates of 12, 18, 24 or 30 m^3/fed./season, cattle manure (CM) or horse manure (HM), each at rates of 24, 36, 48 or 60 m^3/fed./season. The results showed that although all the applied treatments improved the growth and yield parameters of basil, poultry manure (PM) at 24 m^3/feddan proved to be the best treatment in increasing the fresh and dry herb yields per plant, as well as the oil percentage and oil yield per plant. The different fertilization treatments increased the content of linalool in the essential oil (with NPK at 800 kg/fed. giving the highest values, followed by PM at 12 m^3/fed.), but decreased the camphor content, compared to the control. Also, the different fertilization treatments tended to increase the contents of total carbohydrates, N, P, and K in the herb, but decreased the Fe, Mn and Zn contents. The second cut gave the highest oil yield compared with both the 1st and 3rd cuts. This was due to the higher herb yield rather than the oil percentage, that was highest in the 3rd cut.

Keywords: Basil, *Ocimum*, Labiatae, Lamiaceae, Fertilization, Manure.

INTRODUCTION

Aromatic and medicinal plants are an important source of national income and foreign currency in Egypt. They are among the most important agricultural export commodities that are in demand in European and other international markets. Basil is one of the most important species for export among the medicinal and aromatic plants and it has a good reputation in the European countries. The area cultivated with basil in Egypt is about 4-5 thousand feddans, and the exports are more than 4000 tons per year.

During the last few years, medicinal and aromatic plants have been cultivated in newly reclaimed desert areas. Under such conditions, providing the cultivated plants with their nutritional requirements depends on the supply of macro-nutrients (including N, P and K), as well as micro-nutrients (including Fe, Zn and Mn) by the addition of organic and chemical fertilizers. The importance of fertilization to aromatic plants was emphasized by Moa and Craker (1991), who stated that an adequate supply of nutrients, particularly N, is one of several factors responsible for increasing the oil yield.

Also, the importance of fertilization was pointed out by Devlin (1975), who stated that the nutrients supplied by fertilization are necessary for the various biochemical processes that occur within the plant, and that are essential for normal plant growth and development.

Several researchers have investigated the nutritional requirements of a number of *Lamiaceae* (*Labiatae*) plants, with the aim of determining the optimum fertilization treatments for maximum herb and oil production [El-Gamasy *et al.* (1985) on *Majorana hortensis*, Refaat (1988) on sweet marjoram, Khan and Zaidi (1991) on *Mentha arvensis*, Munsi (1992) on Japanese mint, El-Ghadban (1994) on *Mentha viridis*, Jacoub (1995) on *Ocimum basilicum*, El-Sayed *et al.* (2002) on *Mentha viridis* and *Origanum majorana*, and many others]. However, most of this research was concerned with the use of synthetic chemical fertilizers for growing the crops.

The use of organic agriculture is spreading all over the world. Organic fertilizers are an important source for providing the plants with their nutritional requirements, and for alleviation of the problems associated with chemical residues in the export commodities (El-Ghadban, 1998). Organic fertilization is also one of the methods used to reclaim sandy desert land and to improve the chemical and physical characteristics of the soil.

For this reason, this investigation was conducted to determine the effect of different organic fertilizers (viz. poultry, cattle and horse manures) on the growth, oil yield and chemical composition of an important *Lamiaceae* plant (*Ocimun basilicum* L., cv. "Grand Vert"), and to compare this effect with that of conventional NPK fertilization. The results of this study may help in optimizing the herb and essential oil yields as well as the oil quality and the chemical composition of the plants.

MATERIALS AND METHODS

This study was conducted at the Experimental Nursery of the Medicinal and Aromatic Plant Research Department, Horticulture Research Institute, Agricultural Research Center, Dokky, Cairo, during two successive seasons of 1998 and 1999. The aim of the study was to investigate the effect of some organic manures (poultry, cattle and horse) and inorganic (NPK) fertilization on the growth, oil yield and chemical composition of sweet basil (*Ocimum basilicum* L.) cv. "Grand Vert" plants.

Sweet basil seeds were sown on 15th January in a peatmoss medium in the nursery beds. Two months later, when the seedlings were 12-17cm in height with 6-8 leaves, they were transplanted into 30-cm (diameter) clay pots filled with a sandy soil (obtained from Shabrament area, Giza). The soil contained 0.12% N, 0.16% P, 0.25% K, 0.38% Mg, 0.53 ppm Ca, 4.01 ppm Fe, 0.61 ppm Mn, 0.44 ppm Zn, 0.40 ppm Cu, and had an EC of 1.59 ds/m. After transplanting, the pots were placed in a sunny area, and the recommended agricultural practices were followed.

In both seasons, the plants received either conventional chemical NPK fertilization, or were supplied with organic fertilization using poultry manure (PM), cattle manure (CM) or horse manure (HM). Plants receiving chemical fertilization were supplied with an NPK fertilizer mixture with a ratio of 5:2:2 (25%N – 10% P_2O_5 – 10 K_2O), at rates of 12, 16, 20 or 24 g/pot/season (equivalent to 600, 800, 1000 or 1200 kg/feddan/season). Plants fertilized using PM received 212, 318, 424 or 530 cm^3 of PM/pot/season (equivalent to 12, 18, 24 or 30 m^3/feddan/season), while plants fertilized using CM or HM received 424, 636, 849 or 1060 cm^3 of CM or HM/pot/season (equivalent to 24, 36, 48 or 60 m^3/feddan/season). Unfertilized plants were used as the control.

The NPK fertilizer used was a mixture of ammonium sulphate (20.5% N, calcium superphosphate (15.5% P_2O_5), and potassium sulphate (48% K_2O), at a ratio of 5:2:2. The chemical (NPK) treatments were divided into three equal doses. In each season, the first dose was applied as a top dressing after 2 weeks from planting, while the second dose was applied after the first cut, and the third dose was applied after the second cut.

The poultry and cattle manures were obtained from the Animal Production Department, Faculty of Agriculture, Cairo University, while the horse manure was obtained from "El-Ferouseya Club", El-Gezira, Cairo. The physical and chemical characteristics of the three types of manure are presented in Table (A). In each season, the organic fertilization treatments were divided into three doses. The first dose of organic fertilizers was incorporated into the sandy potting soil two weeks before planting. The second dose was applied after the first cut on 15th June, and the third dose was applied after the second cut on 30th July.

The layout of the experiment was a randomized complete blocks design, with 17 treatments (Control + 4 NPK rates + 4 PM rates + 4 CM rates + 4 HM rates) and three replicates (blocks). Each block consisted of 6 pots/treatment.

In each season, three cuts were taken from the plants on 15th June, 30th July and 15th September. The plants were harvested by cutting the vegetative parts 10-15cm above the soil surface.

In all cuts of the two seasons, data were recorded on plant vegetative growth characteristics, including herb fresh weight/plant (g), herb dry weight/plant (g), leaves fresh weight/plant (g) and leaves dry weight/plant (g). The dry weights of the herb and leaves were recorded after air-drying until a constant weight was obtained. Also, the oil percentage in the fresh herb taken in the second cut of each season was determined by distillation of fresh herb samples, using the method described by the British Pharmacopoeia (1963). Satisfactory results were obtained by distillation of 100 g of fresh herb for 3 hours. The essential oil yield/plant was then calculated in proportion to the herb fresh weight/plant. Samples of the essential oil extracted in the second cut of the first season were subjected to gas-liquid chromatographic analysis (using a Hewlett Packard, 5890 Series II apparatus) to determine their main constituents, as recommended by Bunzen *et al.* (1969) and Hoftman (1967).

Dry herb samples taken from the second cut of each season were also analysed chemically to determine their contents of total carbohydrates (using the method described by Herbert *et al.*, 1971), N (using the modified micro-Kjeldahl method as described by Pregl, 1945), P (according to King, 1951), as well as the K, Fe, Mn and Zn contents (using a "Pye Unicam, Model SP-1900" atomic absorption spectrophotometer with a boiling air-acetylene burner).

Table (A): Physical and chemical characteristics of the organic manures used for fertilization of sweet basil (*Ocimum basilicum* L.) plants during the 1998 and 1999 seasons.

Organic manure Characteristics	Poultry manure (PM)		Cattle manure (CM)		Horse manure (HM)	
	1stseason	2stseason	1stseason	2stseason	1stseason	2stseason
Weight of 1m^3(kg)	691	542	480	470	427	403
Moisture content(%)	6.90	9.52	9.12	9.05	7.15	8.75
Organic matter(%)	62.21	80.21	62.72	62.21	56.32	78.53
Organic carbon(%)	37.42	51.32	32.88	38.26	30.14	45.24
Total N (%)	2.30	3.66	1.85	1.83	1.50	1.56
C:N ratio	15.4:1	13.2:1	17.2	19.7:1	22.1:1	31.5:1
NH_3 - N (ppm)	301.8	348.9	47.7	63.6	79.5	79.5
NO_3 - N (ppm)	174.9	224.6	174.9	206.8	181.3	208.9
Total P (%)	1.08	0.30	0.27	0.60	0.40	0.86
Total K (%)	0.74	1.74	1.06	1.12	1.43	1.02
Fe (ppm)	1709.7	1824.5	1879.5	2690.9	1388.1	1495.2
Mn (ppm)	123.8	163.9	188.3	179.8	162.0	194.9
Zn (ppm)	84.5	86.9	89.90	159.9	100.9	175.1
Cu (ppm)	35.8	52.3	41.4	43.2	61.3	86.9

An analysis of variance (ANOVA) was conducted on the data recorded on vegetative growth characteristics, oil content and oil yield/plant, and the means were compared using the "Least Significant Difference (LSD)" test at the 0.05 level, as described by Little and Hills (1978).

RESULTS AND DISCUSSION

I- Vegetative growth

1- Herb fresh and dry weights / plant

It is obvious from the data in Table (1) that, in most cases, the different fertilization treatments significantly increased the herb fresh and dry weights in all cuts of the two seasons, as well as the total herb fresh and dry weights/season, compared to values obtained from unfertilized control plants. The only exception to this general trend was detected in the third cut of the second season, with plants fertilized using NPK at 600 kg/fed. giving an insignificantly higher herb dry weight (23.6 g/plant) than that of the control (21.7 g/plant). Similar increases in herb fresh and dry weights as a result of fertilization treatments have been reported by Hanafy (1989) on *Majorana hortensis,* Balyan and Sobti (1990) on *Ocimum gratissimum,* Munsi (1992) on *Mentha arvensis,* Jacoub (1995) on *Ocimum basilicum,* El-Ghadban (1998) and El-Sayed *et al.* (2002) on *Mentha viridis* and *Origanum mojorana*, and Jacoub (1999) on *Ocimum basilicum* and *Thymus vulgaris.*

The general increase in the herb fresh and dry weights as a result of the different fertilization treatments can be explained by the important roles played by the different nutrients (especially N, P and K) in the different physiological processes within the plant, which in turn affect plant growth. Nitrogen is present in the structure of protein molecules, while phosphorus is an essential constituent of nucleic acids and phospholipids, and potassium is essential as an activator for enzymes involved in the synthesis of certain peptide bonds (Devlin, 1975).

The data in Table (1) also show that conventional NPK fertilization gave generally lower values than those recorded with the different types of organic manure. On the other hand, poultry manure (PM) was clearly the most effective type of fertilizer for increasing herb fresh and dry weights, especially when applied at the rate 24 m^3/fed. This treatment gave the best results in all cuts of both seasons, as well as the highest values for total herb fresh and dry weights/plant. The application of horse manure (HM) at 60 m^3/fed. was the second best treatment, giving the second highest total herb fresh weight in both seasons, as well as the third highest total herb dry weight in the first season, and the second highest total herb dry weight/plant in the second season. The use of cattle manure (CM) at 60 m^3/fed. came in third place in terms of effectiveness, giving the third highest total herb fresh weight in both seasons, as well as the second highest total herb dry weight in the first season, and the third highest total herb dry weight in the second season.

The generally superior effect of organic manures on vegetative growth, compared to chemical fertilization, may be attributed to their effects on the soil, such as improving some of its chemical and physiochemical properties, improving water use efficiency (Wallace, 1994, a), preventing salt injury to plants that sometimes results from concentration of chemical fertilizers through the buffering properties of organic matter (Wallace, 1994, b), and providing the soil with essential macro and micronutrients (Awad *et al.*, 1993). Also, the addition of manures to the soil increases its cation exchange capacity (CEC) due to the ability of the negatively charged organic matter particles to attract and hold the positively charged cations in the soil, and to provide the plant roots with these cations. Moreover, the addition of manures to the sandy soil increases the soil's water-holding capacity which, in turn, allows higher absorption of water and nutrients from the soil, and enables photosynthesis to occur efficiently within the plant leaves (Hartmann *et al.*, 1981).

It can also be observed from the results recorded in the two seasons (Table 1) that raising the application rates of NPK fertilization or poultry manure caused a generally gradual and steady increase in the herb fresh and dry weights, up to the third application rate (1000 kg/fed. for NPK, and 24 m^3/fed. for PM), at which maximum effectiveness of the two types of fertilizer was reached. A further increase in the application rates to the highest levels (1200 kg/fed. for NPK, and 30 m^3/fed. for PM) caused a significant reduction in the values recorded in all cuts, compared to those recorded at the previous levels. This may be attributed to the high solubility of nutrients in these two types of fertilizers. Thus, when NPK or PM are used at the highest rates, this may lead to an excessive increase in the concentration of nutrient salts in the soil solution, which may cause partial plasmolysis of root cells, and an adverse effect on their ability to uptake water and nutrients. In contrast, raising the application rates of CM or HM (which have lower contents of soluble nutrients) was associated with a steady increase in the recorded values, up to the highest application rates (60 m^3/fed. for both types of fertilizer).

Table (1): Effect of fertilization treatments on the herb fresh and dry weights /plant (g) of sweet basil (*Ocimum basilicum* L., cv. Grand Vert) in the 1998 and 1999 seasons.

Fertilization treatments*	First season (1998)				Second season (1999)			
	1st cut	2nd cut	3rd cut	Total	1st cut	2nd cut	3rd cut	Total
	Herb fresh weight/plant (g)							
Control	35.5	48.8	56.8	**141.2**	50.2	46.8	56.3	**153.3**
NPK (600 Kg/ Fed)	63.9	86.2	69.9	**219.9**	58.1	72.0	63.0	**192.4**
NPK (800 Kg/Fed)	76.8	88.7	69.5	**235.1**	70.0	83.2	69.8	**222.9**
NPK(1000 Kg/Fed)	89.8	105.3	99.8	**294.9**	82.7	99.3	98.2	**280.2**
NPK(1200 Kg/Fed)	78.8	100.8	91.8	**271.5**	70.9	94.3	91.9	**257.2**
PM (12 m^3/Fed.)	80.7	107.0	105.9	**293.5**	74.8	103.0	97.6	**275.3**
PM (18 m^3/Fed.)	89.6	114.4	103.4	**307.4**	84.3	109.0	101.2	**294.4**
PM (24 m^3/Fed.)	127.6	151.8	143.5	**423.0**	124.2	147.4	141.0	**412.6**
PM (30 m^3/Fed.)	84.4	110.9	100.4	**295.7**	82.4	106.7	109.5	**298.5**
CM (24 m^3/Fed.)	66.5	70.2	69.1	**205.8**	62.7	67.1	71.0	**200.7**
CM (36 m^3/Fed.)	82.4	93.7	87.3	**263.5**	77.1	87.9	88.2	**253.1**
CM (48 m^3/Fed.)	83.7	98.6	87.6	**269.9**	81.6	94.9	88.1	**264.6**
CM (60 m^3/Fed.)	99.8	115.6	113.2	**328.5**	96.4	109.3	111.9	**317.3**
HM (24 m^3/Fed.)	67.1	64.9	67.1	**201.0**	63.6	61.3	97.7	**222.6**
HM (36 m^3/Fed.)	81.6	92.2	82.3	**256.0**	79.2	85.9	82.1	**247.2**
HM (48 m^3/Fed.)	96.8	110.6	96.8	**294.2**	89.8	96.4	100.1	**286.3**
HM (60 m^3/Fed.)	104.9	118.7	107.5	**331.0**	101.5	118.2	109.8	**329.5**
L.S.D. (at 0.05)	**2.48**	**3.85**	**4.45**	**6.53**	**1.50**	**1.77**	**2.49**	**3.15**
	Herb dry weight/plant (g)							
Control	11.9	16.8	19.7	**48.4**	14.7	14.8	21.7	**51.2**
NPK (600 Kg/ Fed)	21.5	23.0	24.1	**68.5**	18.8	21.9	23.6	**64.3**
NPK (800 Kg/Fed)	25.8	30.6	24.0	**80.3**	21.1	30.5	26.6	**78.2**
NPK(1000 Kg/Fed)	30.1	37.7	34.4	**102.2**	23.9	33.5	26.5	**83.9**
NPK(1200 Kg/Fed)	24.5	35.2	31.7	**91.4**	21.5	32.6	32.7	**86.8**
PM (12 m^3/Fed.)	26.5	39.4	37.7	**103.6**	23.4	39.0	35.5	**97.9**
PM (18 m^3/Fed.)	28.9	42.0	35.7	**106.6**	27.6	40.0	32.7	**100.1**
PM (24 m^3/Fed.)	42.0	55.0	50.2	**147.2**	38.1	51.6	36.7	**126.4**
PM (30 m^3/Fed.)	28.0	40.5	34.5	**103.0**	25.0	40.4	32.1	**97.6**
CM (24 m^3/Fed.)	21.9	24.3	23.5	**69.7**	19.2	23.4	24.0	**66.6**
CM (36 m^3/Fed.)	27.2	35.6	30.8	**93.5**	24.9	33.3	31.5	**89.7**
CM (48 m^3/Fed.)	27.8	36.2	31.1	**95.1**	25.9	33.5	29.7	**89.1**
CM (60 m^3/Fed.)	33.3	42.4	40.2	**115.8**	30.8	38.8	36.1	**105.7**
HM (24 m^3/Fed.)	21.8	22.8	24.5	**67.1**	20.4	21.5	20.1	**61.9**
HM (36 m^3/Fed.)	27.1	34.7	28.5	**90.3**	24.1	32.0	31.0	**87.0**
HM (48 m^3/Fed.)	32.0	38.0	33.6	**103.6**	30.3	34.9	32.9	**98.0**
HM (60 m^3/Fed.)	34.9	44.3	32.4	**111.6**	31.5	40.8	36.1	**108.3**
L.S.D. (at 0.05)	**1.52**	**1.85**	**1.62**	**3.15**	**2.03**	**1.93**	**2.16**	**3.84**

*** PM=Poultry Manure, CM=Cattle Manure, HM=Horse Manure.**

In both seasons, the herb fresh and dry weights recorded in the second cut were generally higher than those recorded in the first or third cuts. This may indicate that seasonal variations in environmental conditions had a considerable effect on the rate of vegetative growth of sweet basil plants, and/or that the first cut taken from the plants led to an increase in branching and, consequently, the formation of a larger foliage (which was taken in the second cut). However, the reduction in the values recorded in the third cut (compared to the second cut) suggest that the effect of unfavourable environmental conditions was greater than that of the increase in branching after the second cut.

2- Leaves fresh and dry weights / plant

As might be expected, the effect of the applied treatments on the leaves fresh and dry weights/plant (Table 2) was generally similar to their effect on the herb fresh and dry weights/plant. In both seasons, plants supplied with NPK or organic fertilization formed leaves with significantly heavier fresh and dry weights, compared to those of unfertilized plants (control). Among the different types of fertilizers, NPK was generally the least effective type in this respect, whereas PM gave the best results. In both seasons, PM at 24 m^3/fed. gave the highest total values for these two parameters, followed by HM at 60 m^3/fed., then CM at 60 m^3/fed.

It could be also noticed that both chemical NPK fertilization and PM were most effective when applied at the second highest rate (1000 kg/fed. for NPK, and 24 m^3/fed. for PM), whereas both CM and HM were most effective when applied at the highest rate (60 m^3/fed. for both types of manure). This may be attributed to the rapid release and availability of nutrients in the NPK fertilizer and PM, in comparison to CM and HM.

As observed for the herb fresh and dry weights/plant, the data in Table (2) also show that the leaves fresh and dry weights/plant were generally higher in the second cut than in the first or third cuts.

II- Herb chemical composition

1- Essential oil production

a- Essential oil percentage

The data in Table (3) clearly show that the essential oil percentage in the fresh herb of basil was significantly increased following application of the different fertilization treatments. In most cases, supplying the plants with PM at 24 m^3/fed. gave significantly higher oil percentages in both seasons, compared to all the other fertilization treatments that were tested. In the first season, raising the PM application rate to the highest level (30 m^3/fed.) gave a slightly lower oil percentage (33%) than that recorded with PM at 24 m^3/fed. (34%), but in the second season, both of these PM rates (24 or 30 m^3/fed.) gave equally high oil contents (35%).

The results recorded in the two seasons (Table 3) also show that NPK fertilization was generally most effective in increasing the essential oil percentage, when it was applied at the highest rate (1200 kg/fed.), whereas the three types of organic manure gave the highest oil percentages when they were applied at the second highest rates (24 m^3/fed. for PM, and 48 m^3/fed. for CM and HM).

The increase in the essential oil content of fertilized plants, compared to the control, is in agreement with the results obtained by Asthana and Gupta (1984) and Sreseli (1984) on *Ocimum basilicum*, El-Agamawy (1989) on *Melissa officinalis*, Chattopadhyay *et al.* (1993) on *Mentha arvensis*, El-Ghadban (1994) on *Mentha viridis*, Jacoub (1995) on *Ocimum basilicum*, Kassem (1997) on *Rosmarinus officinalis*, El-Ghadban (1998) and El-Sayed *et al.* (2002) on *Mentha viridis* and *Origanum majorana*, and Jacoub (1999) on *Ocimum basilicum* and *Thymus vulgaris*.

Table (2): Effect of fertilization treatments on the leaves fresh and dry weights/plant (g) of sweet basil (*Ocimum basilicum* L., cv. Grand Vert) in the 1998 and 1999 seasons.

Fertilization treatments*	First season (1998)				Second season (1999)			
	1st cut	2nd cut	3rd cut	Total	1st cut	2nd cut	3rd cut	Total
	Leaves fresh weight/plant (g)							
Control	28.5	27.8	33.1	**89.4**	25.5	26.5	32.7	**84.6**
NPK (600 Kg/ Fed)	59.6	71.1	63.5	**194.2**	53.6	67.4	55.9	**176.9**
NPK (800 Kg/Fed)	70.6	79.9	63.3	**213.8**	65.1	75.7	61.1	**201.9**
NPK(1000 Kg/Fed)	82.0	93.0	89.2	**264.1**	76.7	89.5	86.4	**252.6**
NPK(1200 Kg/Fed)	72.9	89.9	82.4	**245.2**	67.4	85.2	81.6	**234.2**
PM (12 m³/Fed.)	72.6	90.6	88.3	**251.5**	68.8	87.6	82.2	**238.6**
PM (18 m³/Fed.)	81.8	97.1	92.0	**270.9**	76.7	93.5	87.9	**258.1**
PM (24 m³/Fed.)	117.3	130.5	124.8	**372.5**	115.2	127.5	123.5	**366.1**
PM (30 m³/Fed.)	77.7	95.1	89.9	**262.7**	75.8	92.0	98.7	**266.6**
CM (24 m³/Fed.)	62.7	65.4	63.7	**191.8**	59.4	62.6	64.3	**186.4**
CM (36 m³/Fed.)	74.1	77.4	75.7	**227.1**	70.4	73.1	75.6	**219.1**
CM (48 m³/Fed.)	75.4	82.7	71.7	**228.8**	73.9	80.4	75.1	**229.3**
CM (60 m³/Fed.)	88.9	96.8	94.9	**280.7**	86.4	92.3	93.8	**272.5**
HM (24 m³/Fed.)	61.6	96.8	63.0	**184.3**	58.6	56.9	90.4	**205.9**
HM (36 m³/Fed.)	73.8	59.8	73.3	**223.1**	71.9	70.9	72.9	**215.6**
HM (48 m³/Fed.)	87.9	83.4	85.6	**256.9**	83.4	80.8	87.8	**252.0**
HM (60 m³/Fed.)	93.2	98.7	95.4	**287.3**	91.2	98.8	98.1	**288.0**
L.S.D. (at 0.05)	1.71	3.04	3.27	6.22	1.31	1.54	2.55	6.10
	Leaves dry weight/plant (g)							
Control	7.8	8.9	10.6	**27.3**	6.4	7.4	11.5	**25.4**
NPK (600 Kg/ Fed)	18.4	20.1	20.3	**58.9**	17.8	18.1	20.8	**56.7**
NPK (800 Kg/Fed)	22.3	25.3	20.3	**67.9**	18.6	24.7	21.0	**64.4**
NPK(1000 Kg/Fed)	26.2	29.8	28.5	**84.5**	21.2	27.1	20.6	**68.9**
NPK(1200 Kg/Fed)	22.2	28.7	26.4	**77.2**	19.7	26.3	24.6	**70.7**
PM (12 m³/Fed.)	23.2	28.8	28.3	**80.3**	20.8	29.9	26.4	**77.0**
PM (18 m³/Fed.)	25.4	30.9	29.4	**85.8**	25.3	29.6	26.1	**81.0**
PM (24 m³/Fed.)	37.5	41.7	40.2	**119.5**	34.9	39.3	26.4	**100.7**
PM (30 m³/Fed.)	24.9	30.4	28.8	**84.1**	21.9	30.9	24.4	**77.2**
CM (24 m³/Fed.)	20.1	20.9	20.4	**61.4**	17.6	20.6	19.5	**57.7**
CM (36 m³/Fed.)	23.7	24.8	24.3	**72.7**	21.8	24.1	23.8	**69.6**
CM (48 m³/Fed.)	23.9	26.4	23.0	**73.3**	22.6	24.8	22.8	**70.3**
CM (60 m³/Fed.)	28.5	30.9	30.4	**89.7**	27.1	27.9	27.5	**82.6**
HM (24 m³/Fed.)	19.4	19.1	20.2	**58.6**	18.2	18.0	15.8	**52.0**
HM (36 m³/Fed.)	23.6	24.3	23.5	**71.4**	21.6	22.5	24.7	**68.8**
HM (48 m³/Fed.)	28.4	26.7	27.4	**82.5**	27.5	24.5	25.7	**77.7**
HM (60 m³/Fed.)	30.1	31.6	30.5	**92.2**	27.4	29.1	28.6	**85.0**
L.S.D. (at 0.05)	1.43	1.29	0.98	2.55	1.93	1.74	2.03	2.41

*** PM=Poultry Manure, CM=Cattle Manure, HM=Horse Manure.**

b- The essential oil yield / plant

It is clear from date in Table (3) that all the applied treatments enhanced the synthesis and accumulation of essential oil by sweet basil plants, with most of the treatments giving more than a three-fold increase in the oil content, compared to that of unfertilized plants. The most effective type of fertilizer in this respect was poultry manure (PM), especially when applied at the rate of 24 m³/fed. This treatment increased the oil yield per plant to 1.382 and 1.377 ml/plant in the first and second seasons, respectively, but at the highest PM rate (30 m³/fed.), the oil yield was decreased. A similar trend was detected with NPK fertilization, which gave higher oil yields when applied at 1000 kg/fed. than when applied at 1200 kg/fed. On the other hand, plants supplied with CM or HM showed a steady increase in their oil yield as the application rate was raised up to the highest level (60 m³/fed.).

The above results are in agreement with those obtained by Dey and Choudhari (1984) on *Ocimum sanctum*, Neshev and Slavov (1985) on *Mentha piperita*, Singh *et al.* (1992) on mint, El-Agamawy (1989) on *Melissa officinalis*, Munsi (1992) and Chattopadhyay *et al.* (1993) on *Mentha arvensis*, El-Ghadban (1998) and El-Sayed *et al.* (2002) on *Mentha viridis* and *Origanum majorana*, and Jacoub (1999) on *Ocimum basilicum* and *Thymus vulgaris*

Table (3): Effect of fertilization treatments on the oil percentage and oil yield (ml/plant) in the fresh herb of sweet basil (*Ocimum basilicum* L., cv. Grand Vert) in the second cut of the 1998 and 1999 seasons.

Fertilization treatments*	Oil content (%)		Oil yeild ml/plant	
	1st season	2nd season	1st season	2nd season
Control	0.20	0.21	0.267	0.304
NPK (600 Kg/ Fed)	0.28	0.26	0.602	0.505
NPK (800 Kg/Fed)	0.29	0.30	0.684	0.650
NPK(1000 Kg/Fed)	0.29	0.30	0.855	0.838
NPK(1200 Kg/Fed)	0.30	0.31	0.812	0.784
PM (12 m³/Fed.)	0.27	0.28	0.802	0.780
PM (18 m³/Fed.)	0.31	0.30	0.931	0.887
PM (24 m³/Fed.)	0.34	0.35	1.382	1.377
PM (30 m³/Fed.)	0.33	0.35	0.955	1.008
CM (24 m³/Fed.)	0.26	0.27	0.530	0.525
CM (36 m³/Fed.)	0.29	0.30	0.736	0.734
CM (48 m³/Fed.)	0.31	0.31	0.802	0.809
CM (60 m³/Fed.)	0.30	0.31	0.996	0.951
HM (24 m³/Fed.)	0.25	0.27	0.524	0.613
HM (36 m³/Fed.)	0.27	0.28	0.68	0.689
HM (48 m³/Fed.)	0.30	0.30	0.844	0.846
HM (60 m³/Fed.)	0.29	0.29	0.982	0.966
L.S.D. (0.05)	**0.016**	**0.015**	**0.036**	**0.0234**

*** PM=Poultry Manure, CM=Cattle Manure, HM=Horse Manure.**

c- The essential oil components

The data presented in Table (4) clearly show that the basil type used in this study belongs to the linalool type. Regardless of the used treatments, linalool was the major constituent, with a mean content of about 39.80 %, followed by anethol (18.33%), then cineol and camphor. It could be seen from the data in Table (4) that all the applied treatments improved the linalool content compared with the untreated plants, at the expense of champhor. Application of NPK at 800 kg/fed. was the most effective treatment in increasing the linalool content. As shown in Figure (1), oil extracted from plants receiving this treatment had the highest linalool content (55.08%), followed by plants fertilized with PM at 12 m^3/fed. (which gave a linalool content of 49.68%). It was also noticed that in plants fertilized using CM or HM, the linalool content was highest when the lowest application rate (24 m^3/fed.) was used.

Table (4): Effect of fertilization treatments on the components (%) of sweet basil (*Ocimum basilicum* L., cv. Grand Vert) essential oil in the second cut of the 1998 season.

Treatments*	Essential oil components (%)					
	Cineol	Linalool	Camphor	Anethol	Total	Others
Control	7.48	28.77	16.92	19.63	72.79	27.21
NPK (600 Kg/ Fed)	16.06	30.61	20.53	7.78	74.97	25.03
NPK(800 Kg/Fed)	5.34	55.08	2.95	17.40	80.78	19.22
NPK(1000Kg/Fed)	10.83	34.72	2.50	21.95	69.99	30.01
NPK(1200Kg/Fed)	15.96	25.80	5.31	16.99	63.74	36.27
PM (12 m^3/Fed)	8.78	49.68	2.63	23.12	84.20	15.80
PM (18 m^3/Fed)	8.38	41.65	7.83	16.06	73.92	26.08
PM (24 m^3/Fed)	7.50	45.22	1.37	24.73	78.82	21.18
PM (30 m^3/Fed)	7.20	27.41	1.60	19.81	56.02	43.98
CM (24 m^3/Fed)	9.49	44.36	6.46	12.32	72.61	27.39
CM (36 m^3/Fed)	15.54	38.28	2.56	19.42	75.80	24.21
CM (48 m^3/Fed)	11.05	41.84	1.43	17.52	71.57	28.43
CM (60 m^3/Fed)	11.12	41.66	6.15	17.43	76.35	23.65
HM (24 m^3/Fed)	7.50	47.87	3.66	20.82	79.85	20.15
HM (36 m^3/Fed)	11.71	35.00	5.91	21.33	73.94	26.06
HM (48 m^3/Fed)	7.64	42.24	1.95	21.12	72.94	27.06
HM (60 m^3/Fed)	10.42	46.36	3.88	14.10	74.75	25.25
Means	**10.12**	**39.80**	**5.51**	**18.33**	**73.71**	**26.29**

*** PM=Poultry Manure, CM=Cattle Manure, HM=Horse Manure.**

In average, the four major constituents represented about 73.71% of the oil composition. It seemed that the four groups of fertilizers did play a role in influencing their proportion in the oil. However, the treatments which most effectively increased the herb and dry yields (such as PM at 24 m^3/fed.), did not have the same effect on the linalool content of the oil.

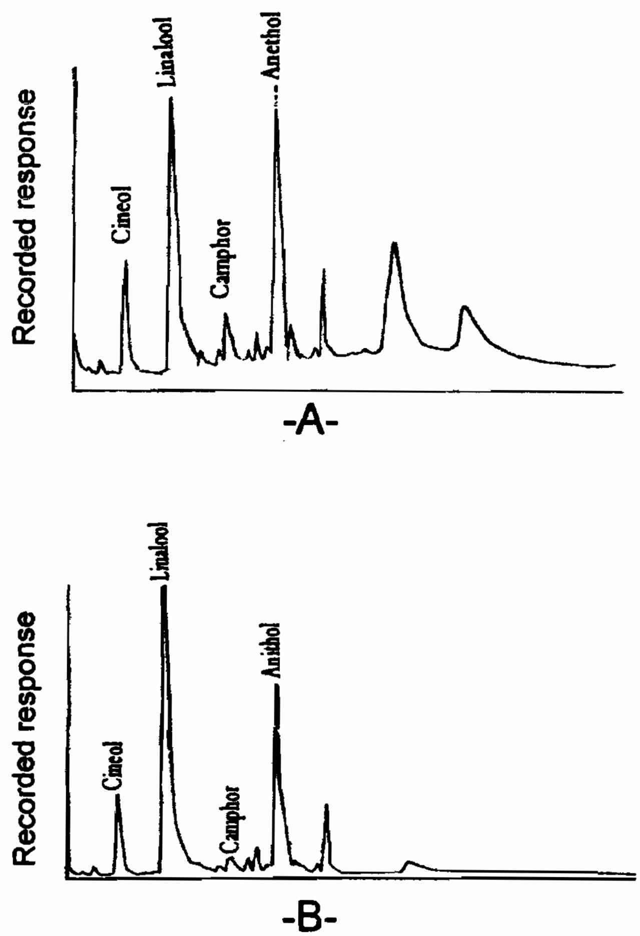

Fig (1): G.L.C. chromatogram of the essential oil of sweet basil (*Ocimum basilicum*)- cv. Grand Vert plants receiving no fertilization (A), or fertilized with NPK at 800 kg/fed. (B).

2- Total carbohydrates content

It could be noticed from the data in Table (5) that in the first season, the total carbohydrates content in sweet basil dry herb was increased (compared to the control) by fertilization using the highest levels of NPK (1200 kg/fed.) and PM (30 m3/fed.), as well as the two highest levels of CM and HM (48 or 60 m3/fed.). All the other fertilization treatments decreased the total carbohydrates content in the first season compared to the control, except NPK at 1000 kg/fed., which gave an equal value (18.75%) to that recorded in control plants. The favourable effect of fertilization on the synthesis and accumulation of carbohydrates was more evident in the second season, with most of the tested treatments giving higher values than the control. All the NPK fertilization rates, as well as the three highest rates of PM (18, 24 or 30 m^3/fed), CM and HM (36, 48 or 60 m^3/fed.), gave higher values in the second season, compared to the control. In contrast, the lowest levels of the organic manures (PM, CM and HM) caused some reduction in the carbohydrates content, compared to that of control plants. The highest levels of CM and HM (60 m^3/fed. for the two types of manure) were the most effective treatments in increasing the carbohydrates content, giving values of 26.45 and 25.60% for CM and HM, respectively in the first season, and values of 25.20 and 26.45%, respectively, in the second one.

This general increase in the carbohydrates content of fertilized plants (compared to the control) that was recorded in the second season can be easily explained, since the nitrogen supplied by fertilization is essential in the structure of porphyrines, which are found in the cytochrome enzymes essential in photosynthesis. This increase in the cytochrome enzymes results in an increase in the rate of photosynthesis, and a promotion in carbohydrate synthesis and accumulation. Moreover, the potassium added by fertilization acts as an activator for several enzymes involved in carbohydrate metabolism (Devlin, 1975).

Similar increases in the carbohydrates content as a result of fertilization treatments have been reported by Mustyatse *et al.* (1983) on *Salvia sclarea*, Jacoub (1995) on *Ocimum basilicum,* Kassem (1997) on *Rosmarinus officinalis,* El-Ghadban (1998) and El-Sayed *et al.* (2002) on *Mentha viridis* and *Origanum majorana*, and Jacoub (1999) on *Ocimum basilicum* and *Thymus vulgaris.*

3- Macroelements content

a- Nitrogen

Results regarding the effect of the fertilization treatments on the nitrogen content (Table 7) show that all the treatments increased the nitrogen content of basil herb considerably, in comparison with the untreated plants. However, no clear difference was detected between the effect of the different types of fertilizers on the N content. Even among the same type of fertilizer, the different application rates had different effects in the two seasons.

Table (5): Effect of the fertilization treatments on the contents of total carbohydrates, nitrogen, phosphorus and potassium contents (% of dry matter) in herb of sweet basil (*Ocimum basilicum* L., cv. Grand Vert) in the 1998 and 1999 seasons.

Fertilization treatments*	Total carbohtydrates content (%)	Nutrient contents		
		N (%)	P (%)	K (%)
	First season (1998)			
Control	18.75	2.10	0.23	2.05
NPK (600 Kg/ Fed)	14.25	2.63	0.32	2.75
NPK (800 Kg/Fed)	17.35	3.31	0.45	2.80
NPK(1000 Kg/Fed)	18.75	3.42	0.52	2.60
NPK(1200 Kg/Fed)	23.50	3.40	0.61	2.20
PM (12 m³/Fed.)	13.00	2.62	0.33	2.50
PM (18 m³/Fed.)	14.95	2.47	0.44	2.50
PM (24 m³/Fed.)	16.40	2.53	0.51	2.76
PM (30 m³/Fed.)	21.10	2.82	0.64	2.80
CM (24 m³/Fed.)	12.00	2.94	0.35	2.65
CM (36 m³/Fed.)	15.40	3.19	0.52	2.90
CM (48 m³/Fed.)	25.60	3.05	0.55	2.90
CM (60 m³/Fed.)	26.45	2.98	0.68	2.98
HM (24 m³/Fed.)	12.60	2.50	0.41	2.50
HM (36 m³/Fed.)	16.00	2.45	0.58	2.65
HM (48 m³/Fed.)	24.15	2.83	0.58	2.62
HM (60 m³/Fed.)	25.60	3.42	0.68	2.65
	Second season (1999)			
Control	13.45	2.25	0.23	1.65
NPK (600 Kg/ Fed)	14.252	3.45	0.32	2.20
NPK (800 Kg/Fed)	16.40	3.68	0.36	2.45
NPK(1000 Kg/Fed)	20.15	3.50	0.54	2.00
NPK(1200 Kg/Fed)	23.05	3.61	0.62	2.05
PM (12 m³/Fed.)	12.50	3.87	0.35	1.88
PM (18 m³/Fed.)	14.80	3.24	0.50	1.74
PM (24 m³/Fed.)	16.75	3.45	0.53	2.14
PM (30 m³/Fed.)	20.55	3.80	0.66	2.22
CM (24 m³/Fed.)	11.90	3.17	0.36	2.40
CM (36 m³/Fed.)	14.65	3.44	0.54	2.35
CM (48 m³/Fed.)	22.80	3.53	0.57	2.30
CM (60 m³/Fed.)	25.20	3.47	0.69	2.50
HM (24 m³/Fed.)	13.00	3.05	0.42	1.95
HM (36 m³/Fed.)	17.00	2.77	0.60	1.95
HM (48 m³/Fed.)	22.90	2.57	0.69	2.10
HM (60 m³/Fed.)	26.45	2.68	0.64	2.20

* PM=Poultry Manure, CM=Cattle Manure, HM=Horse Manure

Similar increases in the N content of fertilized plants have been reported by El-Agamawy (1989) on *Melissa officinalis*, Balyan and Sobti (1990) on *Ocimum gratissimum*, Kandeel *et al.* (1992) on rosemary, El-Ghadban (1994) on *Mentha viridis*, Jacoub (1995) on *Ocimum basilicum*, El-Sherbeny *et al.* (1997) on lavander, Kassem (1997) on *Rosmarinus officinalis*, El-Ghadban (1998) and El-Sayed *et al.* (2002) on *Mentha viridis* and *Origanum majorana*, and Jacoub (1999) on *Ocimum basilicum* and *Thymus vulgaris*.

b- Phosphorus

The data in Table (5) show that all the applied treatments increased the phosphorus content of the dry herb in comparison with the control plants. In all types of fertilizers, the effect was dose dependent. In most cases, raising the application rate of the different fertilizers resulted in a steady increase in the P content. In the first season, plants fertilized with the highest rate of CM or HM (60 m^3/fed.) had the highest P content (0.68% in plants receiving these two treatments). Application of CM at 60 m^3/fed. also gave the highest P content in the second season (0.69%), which was equal to that of plants fertilized with HM at 48 m^3/fed.

The increase in the P content of fertilized plants, compared to the control, is similar to that obtained by Balyan and Sobti (1990) on *Ocimum gratissimum*, Kandeel *et al.* (1992) on rosemary plants, Kassem (1997) on *Rosmarinus officinalis,* El-Ghadban (1998) and El-Sayed *et al.* (2002) on *Mentha viridis* and *Origanum majorana,* and Jacoub (1999) on *Ocimum basilicum* and *Thymus vulgaris.*

c- Potassium

The data recorded in the two seasons (Table 5) show that the different fertilization treatments had a generally favourable effect on the uptake and accumulation of K in the sweet basil herb. In both seasons, the lowest K contents (2.05 and 1.65% in the first and second seasons, respectively) were obtained in the herb of unfertilized (control) plants. On the other hand, the highest K contents (2.98 and 2.50% in the two seasons, respectively) were obtained in the herb of plants fertilized with the highest CM rate (60 m^3/fed.).

The increase in the K contents of fertilized plants, compared to control plants, is in agreement with the results obtained by Balyan and Sobti (1990) on *Ocimum gratissium*, Kandeel *et al.* (1992) on rosemary, El-Ghadban (1998) and El-Sayed *et al.* (2002) on *Mentha viridis* and *Origanum majorana*, and Jacoub (1999) on *Ocimum basilicum* and *Thymus vulgaris.*

The general increase in the contents of N, P and K as a result of the different fertilization treatments was explained by Jain (1983), who stated that raising the levels of N, P and K in the root medium leads to an increase in vegetative growth, and this may be accompanied by an increase in the absorption of these essential elements.

4- Microelements content

a- Iron

The Fe content in sweet basil herb was generally reduced by the different fertilization treatments, compared to values obtained in unfertilized control plants (Table 6). However, no clear trend was detected regarding the relative effectiveness of the different types of fertilizers (compared to each other) in reducing the Fe content. In the first season, the greatest reduction in the Fe content (i.e., the lowest value) was obtained in plants fertilized using PM at 12 or 18 m^3/fed. However, the lowest value in the second season was obtained from plants supplied with CM at 60 m^3/fed.

The general reduction in the Fe concentration in the tissues of fertilized plants may be attributed to the vigorous growth and greater dry weight of the herb, compared to unfertilized control plants. This vigorous growth, combined with a limited supply of Fe in the soil, result in a reduction in Fe concentration in the plant tissues.

b- Manganese

Most of the tested fertilization treatments caused reductions in the Mn content in the herb of sweet basil, compared to values obtained in unfertilized control plants. In the first season, only one treatment (NPK at 1000 kg/fed.) gave a slightly higher Mn content (66.7 ppm) than that of control plants (65.2 ppm), whereas all other treatments resulted in lower values than the control. The greatest reduction in the Mn content recorded in the first season was caused by fertilization using CM at 24 m^3/fed. (which gave an Mn content of 51.0 ppm). Moreover, only two treatments (CM at 24 m^3/fed. and HM at 36 m^3/fed.) increased the Mn content slightly in the second season (giving values of 58.9 and 58.3 ppm, respectively), compared to the control (with a value of 58.2 ppm). In contrast, the lowest Mn content in the second season (53.0 ppm) was found in the herb of plants fertilized using PM at 18 m^3/fed.

Table (6): Effect of the fertilization treatments on the iron, manganese and zinc contents (ppm of dry matter) in the herb of sweet basil (*Ocimum basilicum* L., cv. Grand Vert) in the 1998 and 1999 seasons.

Treatments*	Fe content (ppm)		Mn content (ppm)		Zn content (ppm)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
Control	33.1	37.6	65.2	58.2	19.5	27.0
NPK (600 Kg/ Fed)	27.5	33.0	61.0	54.0	15.0	26.5
NPK (800 Kg/Fed)	29.9	32.0	64.2	54.6	15.5	23.0
NPK(1000 Kg/Fed)	30.4	35.1	66.7	55.5	22.5	19.5
NPK(1200 Kg/Fed)	24.4	34.7	64.4	56.2	24.0	18.5
PM (12 m^3/Fed.)	15.7	29.4	58.8	53.2	21.0	12.0
PM (18 m^3/Fed.)	15.7	21.0	54.2	53.0	17.5	12.5
PM (24 m^3/Fed.)	23.1	24.7	61.5	54.5	16.5	14.0
PM (30 m^3/Fed.)	21.7	22.9	52.7	56.0	14.5	19.5
CM (24 m^3/Fed.)	24.2	23.5	51.0	58.9	13.0	15.5
CM (36 m^3/Fed.)	23.9	23.2	55.0	58.0	23.5	14.0
CM (48 m^3/Fed.)	21.0	20.9	53.5	54.2	19.5	13.5
CM (60 m^3/Fed.)	18.5	20.2	61.0	53.9	17.5	11.5
HM (24 m^3/Fed.)	21.4	22.0	53.2	54.7	26.5	12.5
HM (36 m^3/Fed.)	21.5	22.9	56.3	58.3	16.5	17.0
HM (48 m^3/Fed.)	20.8	26.6	58.7	55.4	13.5	19.5
HM (60 m^3/Fed.)	20.1	27.0	62.0	56.2	19.5	20.5

*** PM=Poultry Manure, CM=Cattle Manure, HM=Horse Manure**

c- Zinc

No clear trend was detected in the first season regarding the effect of the different fertilization treatments on the Zn content in sweet basil herb. However, all the tested chemical and organic fertilization treatments decreased the Zn content in the second season, compared to the control. In the second season, the greatest reduction recorded in the Zn content (i.e., the lowest Zn content) was obtained in plants supplied with CM at 60 m^3/fed. On the other hand, NPK at 600 kg/fed. was the least effective treatment in reducing the Zn content, giving a slightly lower value (26.5 ppm) than that obtained from control plants (27.0 ppm).

Recommendation: Although all the applied treatments improved the growth and yield parameters of basil, poultry manure (PM) at 24 m^3/feddan proved to be the best treatment in increasing the fresh and dry herb yields per plant, as well as the oil percentage and oil yield per plant.

REFRENCES

Asthana, O. P. and R. S. Gupta (1984). Effect of nitrogen and phosphorus levels on physiological parameters at 3 growth stages in sacred basil *Ocimum sanctum*. Ind. Perf., 28 (1): 49-53.

Awad, F.; K.W. Khalil and M.A. Maksoud (1993). Comparative effects of some organic manures and bentonite as soil amendments. Agrochimica 37 (6): 369-387. (Soils and Fertilizers, 58: 2948).

Balyan, S. S. and S. N. Sobti (1990). Effect of nitrogen, phosphorus and potassium on dry matter accumulation and nutrient uptake pattem in *Ocimum gratissimum* L. var. *clocimum* . Ind. Perf., 34 (3): 225-231. (Hort. Abst., 61: 8334).

British Pharmacopoeia (1963). Determination of Volatile Oils in Drugs. The Pharmaceutical Press, 17 Bloomsbury Square, London, WC1.

Bunzen, J. N.; J. Guichard; P. Labbe; J. Prevot; J. Sperpinet and J. Tranchant (1969). Practical Manual of Gas Chromatography. J. Tranchant, Ed., El-Seivier Publ. Co., Amesterdam - London.

Chattopadhyay, A.; K. Subrahmanyam and D. V. Singh (1993). Recycling of nutrients in Japanese mint - assessment of soil fertility and crop yield. Fert. Res., 35 (3): 177-181. (Hort. Abst., 64: 8964).

Devlin, R.M. (1975). Plant Physiology. 3rd Ed., Affiliated East-West Press Pvt. Ltd., New Delhi.

Dey, B. B. and M. A. Choudhari (1984). Effect of application of N, P and K on the growth and yield of essential oil and eugenol in *Ocimum sanctum* L. Pafi J., 6 (1): 20-24. (Hort. Abst., 55: 6351).

El-Agamawy, M. H. (1989). Effect of chemical fertilization and light instensity on production of drug and essential oil in palm plant *Melissa officinalis* L. M. Sc. Thesis, Fac. Agric., Cairo Univ.

El-Gamasy, A.M.; K.M. El-Gamasy and F.A. El-Sharkawy (1985). Effect of some cultural treatments on the growth and yield of sweet marjoram plants, *Majorana hortensis*. Annals of Agricultural Science, Ain-Shams Univ., 25 (122) : 283-298.

El-Ghadban, E. A. E. (1994). The effect of some trace elements on growth and oil yield of spearment (*Mentha viridis* L.) M.Sc. Thgesis, Fac. Agric., Cairo Univ.

El-Ghadban, E. A. E. (1998). Effect of some organic and inorganic fertilizers on growth, oil yield and chemical composition of spearmint and marjoram plants. Ph.D. Thesis, Fac. Agric., Cairo Univ.

El-Sayed, A. A.; H. A. Mansour; Effat I. El-Maadawy; Mahassen M. A. Sidky and E.A. El-Ghadban (2002). Effect of organic and inorganic fertilization on herb and oil productivity of spearmint and marjoram. Zagazig J. Agric. Res., 29 (6): 1859-1888.

El-Sherbeny, S. E., H. M. El-Saeid and M. S. Hussein (1997). Response of lavender (*Lavandula officinalis*) plants to different nitrogen sources. Egypt. J. Hort., 24 (1): 7-17.

Hanafy, M. S. (1989). Effect of chemical fertilization and salinity on production of herb and essential oil of marjoram plants (*Majorana hortensis* Moench.). Ph.D. Thesis, Fac. Agric., Cairo Univ.

Hartmann, H.T.; W.J. Flocker and A.M. Kofranek (1981). Plant Science. Growth, Development, and Utilization of Cultivated Plants. Prentice-Hall, Inc., Englewood Cliffs, N.J., USA, pp. 178-179.

Herbert, D.; P. J. Philipps and R. E. Strange (1971). Determination of total carbohydrates. Methods in Microbiology 5, pp. 290-344.

Hoftman, E. (1967). Chromatography. Reinhold Publ. Corp., 2nd Ed., pp. 208-515.

Jacoub, R. W. (1995). Effect of chemical fertilization on growth and oil yield of sweet basil (*Ocimum basilicum* L.) plants. M.Sc. Thesis, Fac. Agric., Cairo Univ.

Jacoub, R. W. (1999). Effect of some organic and non-organic fertilizers on growth, oil yield and chemical composition of *Ocimum basilicum* L. and *Thymus vulgaris* L. plants. Ph.D. Thesis, Fac. Agric., Cairo Univ.

Jain, V.K. (1983). Fundamentals of Plant Physiology. S. Chand and Co., Ltd., Ram Nagar, New Delhi.

Kandeel, A. M.; S. M. Mohamed and A. A. Sadek (1992). Effect of some agriculture treatments on the growth and chemical composition of Rosemary plant (*Rosmarinus officinalis* L.). Effect of nitrogen fertilization. Egypt. J. App. Sci., 7 (6): 340-352.

Kassem, Abeer H. M. (1997): Effect of chemical fertilization on *Rosmarinus officinalis* L. plant. M.Sc. Thesis, Fac. Agric., Cairo Univ.

Khan, A.A. and S.H. Zaidi (1991). Cultivation prospects of *Mentha arvensis* L. Journal of Forestry, 41 (4) : 170-173. (Hort. Abst., 61 : 7318).

King, E. J. (1951). Micro-Analysis in Medical Biochemistry. 2nd Ed., Churchill Publishing Co., London.

Little, T. M. and F. J. Hills (1978). Agricultural Experimentation - Design and Analysis. John Wiley and Sons, Inc., pp. 53-60, 63-56.

Moa, Z. and L. Craker (1991). Photosynthesis and the production of herbs. The Herbse, Spice and Medicine Plant Digest, 9 (2): 15-18.

Munsi, P. S. (1992). Nitrogen and phosphorus nutrition response in Japanese mint cultivation. Acta Hort., 306: 436- 443.

Mustyatse, G. I.; N. D. Roshka and F. Kleshch (1983). Effect of nitrogen-phosphorus fertilizer rates on clary sage growth and productivity. Kishinev, Moldavian SSR, 82-92. (Hort. Abst., 54: 7460).

Neshev, M. and S. I. Slavov (1985). Effectiveness of long term cropping of mint for oil at different fertilizer levels. Rastenev dni Nauki, 22 (10): 48-53. (Hort. Abst., 56: 2740).

Pregl, P. (1945). Quantitative Organic Microanalysis. 4th Ed., Churchill Publ. Co., London.

Refaat, A. M. (1988). Effect of fertilization levels, methods of drying and periods of storage on the sweet marjoram. Ph. D. Thesis, Fac. Agric., Ain Shams Univ.

Singh, V. P.; B. N. Chattergee and D. V. Singh (1992). Effect of varying levels of N application on the growth and development of mint species. Int. J. Trop. Agric., 10 (1): 45-51.

Sreseli, N. M. (1984). Dates of nitrogen fertilizer application for basil. Maslichnye Kul'tury, No. 3, 39. From Referativny: Zhurnal, 55 (Rastenievodstvo), 10.55.634. (Hort. Abst., 55:2099).

Wallace, A. (1994, a). Soil organic matter is essential to solving soil and environmental problems. Communications in Soil Science and Plant Analysis, 25 (1-2): 15-28. (Soils and Fertilizers, 58: 4876).

Wallace, A. (1994, b). Ten reasons why organic growers do not use synthetically compounded fertilizers. Communications in Soil Science and Plant Analysis, 25 (1-2): 125-128. (Soils and Fertilizers, 58: 4264).

إستجابة نبات الريحان لبعض معاملات التسميد الكيميائى والعضوى

عبدالغفور عوض السيد* ، محاسن محمد عبد الغنى صدقى** ، حازم عبد الجليل منصور*، مى محمد أحمد محسن**

* قسم بساتين الزينة- كلية الزراعة- جامعة القاهرة.

** قسم بحوث النباتات الطبية والعطرية - معهد بحوث البساتين - مركز البحوث الزراعية - وزارة الزراعة-القاهرة.

أجريت هذه الدراسة على مدى موسمين نمو متتاليين (١٩٩٨، ١٩٩٩) لدراسة مدى إستجابة نبات الريحان (*Ocimum basilicum* L. cv. Grand Vert) للتسميد المعدنى (بإستخدام خليط من الأسمدة النتروجينية و الفوسفاتية و البوتاسية بنسبة ٢:٢:٥، و ذلك بمعدلات ٦٠٠، ٨٠٠، ١٠٠٠ أو ١٢٠٠ كجم/فدان/موسم)، أو التسميد العضوى بإستخدام سماد الدواجن بمعدلات ١٢، ١٨، ٢٤ أو ٣٠ م٣/فدان/موسم، أو سماد الماشية أو سماد الخيول، بمعدلات ٢٤، ٣٦، ٤٨ أو ٦٠ م٣/فدان/موسم لكل من النوعين الأخيرين من الأسمدة.

ولقد أوضحت النتائج إنه رغم أن كل المعاملات المستخدمة قد أدت إلى تحسين قياسات النمو والمحصول لنبات الريحان إلا أن المعاملة بسماد الدواجن بمعدل ٢٤م٣/فدان كانت أفضل المعاملات فى زيادة محصول العشب الطازج أو الجاف/نبات. وكذلك محتوى الزيت (كنسبة مئوية) فى العشب الطازج و محصول الزيت المتحصل عليه من النبات. هذا و قد أدت المعاملات السمادية المختلفة إلى زيادة محتوى اللينالول فى الزيت الطيار (و تم الحصول على أعلى القيم عند التسميد الكيماوى NPK بمعدل ٨٠٠ كجم/فدان يليها سماد الدواجن بمعدل ١٢م٣/فدان)، إلا أنها خفضت الكامفور، مقارنة بالكنترول. كذلك فإن المعاملات السمادية المختلفة إتجهت إلى زيادة محتوى الكربوهيدرات والعناصر الكبرى (نتروجين، فوسفور، بوتاسيوم) فى العشب، إلا أنها خفضت محتوى الحديد و المنجنيز و البوتاسيوم. من ناحية أخرى فقد كان محصول الزيت المتحصل عليه من الحشة الثانية أعلى من أى من الحشتين الأولى أو الثالثة، وكانت تلك الزيادة راجعة للزيادة فى محصول العشب بتلك الحشة أكثر من إرتباطها بالنسبة المئوية للزيت والتى كانت أعلى فى الحشة الثالثة.