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EFFECT OF ORGANIC AND INORGANIC FERTILIZATION ON HERB AND OIL PRODUCTIVITY OF SPEARMINT AND MARJORAM

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ABSTRACT : This study was carried out at the Experimental Nursery of the Ornamental Horticulture Department , Faculty of Agriculture, Cairo University , during the two successive seasons of 1995 and 1996. The aim of the study was to investigate the effect of some organic manures [poultry manure (PM) at 10, 20 or 30 m^3 / fed., cattle manure (CM) and horse manure (HM) each at 20, 40 or 60 m^3 / fed.] and chemical NPK fertilization (5 N: $2P_2O_5$: $2K_2O$) at 400, 800 or 1200 kg/fed. on the growth , oil yield and chemical composition of spearmint (*Mentha viridis* L.) and marjoram (*Origanum majorana* L.) plants. In both species, the fresh and dry herb yields were significantly increased by fertilization , compared to the unfertilized control. PM at 30 m^3/fed. and CM at 60 m^3 / fed. gave the best results in this respect. Moreover, PM at 20 m^3/fed. and CM at 40 m^3/fed. gave the highest leaves : stems fresh weight ratios in *O. majorana.* In *M. viridis*, raising the fertilization rate resulted in a steady increase in the oil content (%) in the fresh herb and the oil yield / plant. CM at 60 m^3/fed. and PM at 30 m^3/fed. gave the highest spearmint oil content and oil yield / plant, respectively. Most of the fertilization treatments increased the total percentage of the main components (carvone and limonene) in spearmint oil (the highest values were obtained from plants fertilized with PM at 10m^3/fed.) as well as the N, P and K contents in the plants, but reduced the Fe and Zn contents . Also, raising the NPK fertilization rate resulted in a steady increase in the

total chlorophyll content in spearmint leaves. In *O. majorana*, the different fertilization treatments increased the oil percentage in the fresh herb as well as the oil yield/plant (especially with PM at 30 m^3/fed. or CM at 60 m^3/fed.). Fertilization also increased the content (%) of ∝-terpineol (the main component), ∝-pinene, β-pinene, cineole and citronellol in marjoram oil, but decreased the linalool and ∝-terpineol acetate contents. In most cases, the different fertilization treatments also increased the N, P and Zn contents in marjoram plants, but decreased the Fe content, compared to the control.

From the above results, it can be concluded that the best productivity of spearmint and marjoram plants (in terms of fresh and dry herb yields, and essential oil yield) were obtained from plants fertilized with poultry manure at the relatively high rate of 30 m^3/fed., or cattle manure at the rate of 60 m^3/fed.

INTRODUCTION

The optimization of biomass production (herb yield) in medicinal and aromatic plants, the accumulation of essential oil (oil yield), as well as the desired oil composition (oil quality) can only be ensured by the application of proper agricultural practices, including adequate fertilization. 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 the several factors responsible for increasing the oil yield. The *Lamiaceae* (*Labiatae*) family includes a large number of medicinal and aromatic species, which have been studied by several researchers in order to determine the optimum fertilization treatments for maximum herb and oil production [Decheva *et al.* (1980) on peppermint var. Kliment-63, Adamovic *et al.* (1982) on Mitcham peppermint, Slavov and Atanasov (1982) on peppermint, 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*, and many others]. However, most of this research work was concerned with the use of synthetic chemical fertilizers for growing the crops.

Recently, there has been an increasing awareness of the undesirable impact of such chemicals on the environment, as well as the potentially dangerous effect of chemical residues in plant tissues on the health of human and animal consumers. As a result of this awareness, strict regulations and restrictions have been imposed in several countries (especially in the European markets) prohibiting the import of "chemically-grown" products. This has led growers of medicinal and aromatic plants in many countries to adopt organic and biological agricultural methods (for fertilization, pest control, etc.). Organic fertilization is a very important method of providing the plants with their nutritional requirements without having an undesirable impact on the environment. Organic fertilization also provides the means for stabilizing soil fertility (especially in newly reclaimed sandy desert land) by sustainably improving the chemical and physical characteristics of the soil. Furthermore, the use of organic fertilizers is often desirable because the herb and oil yields resulting from organic fertilization are free of unnatural chemicals and are, therefore, considered to be of superior quality, compared to yields resulting from mineral fertilizers. Such chemical-free products are usually sold at a much higher price.

This study was conducted with the aim of determining the effect of different organic fertilizers (poultry, cattle and horse manures) on the growth, oil yield and chemical composition of two very important *Lamiaceae* plants (*Mentha viridis* L. and *Origanum majorana* L.), and to compare this effect with that of conventional NPK fertilization.

MATERIALS AND METHODS

This study was carried out at the Experimental Nursery of the Ornamental Horticulture Department, Faculty of Agriculture, Cairo University, Giza, during the two successive seasons of 1995 and 1996. The aim of the study was to investigate the effect of inorganic (NPK) fertilization and some organic manures on the growth, oil yield and chemical composition of spearmint (*Mentha viridis* L.) and marjoram (*Origanum majorana* L.) plants.

Spearmint runners (8-10 cm long, with 5-8 leaves) were planted on 13th March, 1995 and 12th March, 1996 (in the first and second seasons, respectively), while marjoram seedlings (12-15 cm tall, with 10-12 leaves) were planted on 20th March, 1995 and 14th March, 1996 (in the two seasons, respectively), in 30-cm clay pots filled with a sandy soil. The chemical characteristics of the sandy soil are shown in Table 1. The plants were supplied with the following fertilization treatments: (1) Unfertilized control, (2) NPK fertilizer [5 N : 2 P_2O_5 : 2 K_2O] at rates of 8, 16 or 24 g fertilizer/pot/season [equivalent to 400, 800 or 1200 kg fertilizer/fed./season], (3) Poultry manure [PM] at rates of 177.5, 355 or 532.5 cm^3/pot/season [equivalent to 10, 20 or 30 m^3/fed./season], (4) Cattle manure [CM] at rates of 355, 710 or 1065 cm^3/pot/season [equivalent to 20, 40 or 60 m^3/fed./season], or (5) Horse manure [HM] at rates of 355, 710 or 1065 cm^3/pot/season [equivalent to 20, 40 or 60 m^3/fed./season]. The equivalent rates per feddan were calculated, considering the cultivated area per feddan to be 4000 m^3. The physical and chemical characteristics of the three types of manure are shown in Table 2.

The NPK fertilizer was prepared by mixing 728g of ammonium sulphate (20.5%N) with 400 g of calcium superphosphate (15.5% P_2O_5) and 120 g of potassium sulphate (48% K_2O). The amount of fertilizer prepared by this way was sufficient for supplying all the pots with the needed doses of chemical fertilization. All the fertilization treatments were divided into two equal doses. NPK was applied as a basal dressing. The first dose was added two weeks after planting, and the second dose was added immediately after the first cut. On the other hand, the first dose of organic fertilization was incorporated into the potting medium 2 weeks before planting, and the second dose was applied after the first cut.

This study was divided into two separate experiments, one for each of the two plant species (*Mentha viridis* L. and *Origanum majorana* L.). The two experiments were designed using the randomized complete blocks design. Each experiment included 13 treatments, with three replicates each, and five pots for each replicate.

In each season, three cuts were taken from the two species, by cutting the vegetative parts of all the plants 5 cm above the soil surface. The three cuts of spearmint and marjoram were taken on 15th June, 1st August and 1st October in the first season, and on 14th June, 30th July and 30th September in the second season. Data recorded on the dry matter (viz. dry weight, nutrient and carbohydrate contents) were recorded after drying the herb at 70° C until the weight became constant. Data recorded on growth, oil content and oil yield were statistically analyzed, and separation of means was performed using the Least Significant Difference (L.S.D.) test at the 5% level, as described by Little and Hills (1978). For some parameters (e.g. herb yield, oil yield), the data presented in this paper represent the total of the three cuts. For other parameters [e.g. oil content (%), contents of nutrients and active ingredients], the data represent the mean of the three cuts.

The oil percentage was determined in the fresh herb using the method described by the British Pharmacopoeia (1963), and the essential oil yield per plant was calculated in proportion to the herb fresh weight (Oil yield per plant = herb fresh weight x oil percentage). Oil samples taken from the second cut of each season were analysed using gas liquid chromatography (GLC), to determine their main constituents [as described by Bunzen *et al.* (1969) and Hoftman (1967)].

The contents of chlorophyll a, b and total carotenoids were determined in fresh leaf samples (mg/g fresh matter) according to Saric *et al.* (1967), while the total carbohydrate content in the dried herb was determined using the method described by Herbert *et al.* (1971).

Samples of dried herb were digested for elements extraction using the method described by Piper (1947). The nitrogen content was determined in the extract by the modified microKjeldahl method as described by Pregl (1945), while the phosphorus content was estimated using the method recommended by King (1951). Potassium, manganese, zinc and iron were determined by using a Pye Unicam Atomic Absorption Spectrophotometer (Model SP 1900) with a boiling air-acetylene burner according to the method described by Dewis and Freitas (1970).

RESULTS AND DISCUSSION

I. Vegetative Growth

1. *Fresh and dry herb yields/plant*

The data presented in Tables 3 and 4 show that the fresh and dry herb yields of *Mentha viridis* and *Origanum majorana* were significantly increased in both seasons as a result of application of the different chemical and organic fertilization treatments, compared to the control. Within the plants supplied with any of the different fertilizer types, raising the fertilization rate resulted in a steady increase in the values recorded, i.e. the higher rates of the different fertilizers usually gave higher herb yields than the lower rates. These conclusions are in agreement with the findings of Decheva *et al.* (1980) on peppermint var. Kliment-63, Chattopadhyay *et al.* (1982) on *Mentha arvensis*, Slavov and Atanasov (1982) on 3 *M. piperita* cultivars, Singh *et al.* (1983) on *M. citrata*, Neshev and Slavov (1985) on *M. piperita*, Singh *et al.* (1988) and Khan and Zaidi (1991) on *M. arvensis*, and El-Ghadban (1994) on *M. viridis*. The favourable effect of the fertilization treatments on the vegetative growth characteristics 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).

In both species, poultry manure (PM) was generally the most beneficial kind of fertilizer in terms of herb yield, followed by cattle manure (CM). In spearmint (Table 3), the application of PM at the high rate (30 m^3/fed.) gave significantly higher values (in both seasons) than any other treatment, followed by CM at 60 m^3/fed. A similar trend was detected for marjoram plants (Table 4) in the first season, but in the second one, marjoram plants fertilized with CM at 60 m^3/fed. gave the highest fresh and dry herb yields, followed by those fertilized using PM at 30 m^3/fed. On the other hand, horse manure (HM) was generally the least effective kind of fertilizer for increasing herb productivity of spearmint plants, whereas chemical NPK was the least effective kind of fertilizer for marjoram plants.

The favourable influence of organic manures (including poultry manure and cattle manure) on vegetative growth 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).

2. *The leaves : stems fresh weight ratio*

The values recorded in the two seasons show that in both seasons, NPK fertilization caused no significant changes in the leaves:stems fresh weight ratio of *Origanum majorana* plants (Table 4), compared to the control. A similar result was detected for *Mentha viridis* plants (Table 3) in the first season, but in the second season, plants fertilized with NPK at 800 or 1200 kg/fed. gave a significantly higher leaves:stems fresh weight ratio than that of control plants. On the other hand, most of the organic fertilization treatments gave significantly higher values for both species, compared to the control. In *Mentha viridis*, only one organic fertilization treatment (PM at 10 m^3/fed.) caused an insignificant reduction in the leaves:stems fresh weight ratio in the first season, compared to the control, whereas all other organic manure treatments increased the recorded values significantly (in both seasons), compared to the control. However, the relative effectiveness of the organic manures (compared to each other) varied considerably in the two seasons, and only a few significant differences were detected between the values obtained with these treatments. The highest ratios recorded in spearmint plants in the two seasons were obtained as a result of the application of CM at 40 m^3/fed. and PM at 20 m^3/fed., in the first and second seasons, respectively. The favourable effect of organic fertilization on the leaves:stems fresh weight ratio was also evident in marjoram (*O. majorana*) plants, with most of the manure treatments giving significant increases in the recorded values, compared to the control. In the first season, the only exceptions to this general trend were recorded with PM at 10 or 30 m^3/fed., which gave insignificant increases in leaves:stems fresh weight ratio, compared to the control, while in the second season PM at 10 m^3/fed. was the only manure treatment which caused an insignificant reduction in the recorded values, compared to the control. On the other hand, the highest values recorded for marjoram plants were obtained with fertilization using HM at 40 m^3/fed. (in both seasons), followed by PM at 20 m^3/fed. These treatments gave values which were significantly higher (in both seasons) than those obtained from plants which received most of the other chemical and organic fertilization treatments.

II. Oil Production

1. Oil percentage

a. In spearmint (Mentha viridis L.)

The essential oil content in fresh *M. viridis* plants was generally increased by the different fertilization treatments, compared to the control (Table 3). Moreover, plants which received NPK fertilization had generally lower oil contents than those supplied with the different organic manures. Within each kind of fertilizer, raising the fertilization level resulted (in most cases) in a steady increase in the mean oil content. Among the different organic fertilizers tested, CM appeared to be the most beneficial in terms of essential oil synthesis and accumulation, especially when applied at the relatively high rate of 60 m^3/fed., which gave significantly higher oil contents in the two seasons than most of the other fertilization treatments.

b. In marjoram (Origanum majorana L.)

As with *M. viridis*, the essential oil content in fresh *O. majorana* herb was generally increased by fertilization, especially using organic manures (Table 4). Also, organic fertilization gave generally higher oil contents than chemical NPK fertilization. However, the results obtained with the different organic manures varied from one season to the other. In the first season, CM (especially at 40 m^3/fed) appeared to be the most effective kind of fertilizer, but in the second season, HM (especially at 40 or 60 m^3/fed.) gave generally better results than the two other kinds of organic fertilizers.

The increases in essential oil contents of the two species as a result of applying the different fertilization treatments are in agreement with the results obtained by Gupta *et al.* (1974) on *Mentha arvensis*, Ramteke *et al.* (1975) on Japanese and English mints, Chattopadhyay *et al.* (1982) on *M. arvensis*, and El-Ghadban (1994) on *M. viridis*.

2. Total oil yield/plant

In both species, the total oil yield/plant was significantly increased in both seasons, as a result of applying the different fertilization treatments, compared to untreated control plants (Tables 3 and 4). In spearmint (Table 3), raising the fertilization rate of any kind of fertilizer always resulted in a steady increase in the total oil yield. Poultry manure (especially at 30 m^3/fed.) was generally the most beneficial type of fertilizer for maximum spearmint oil production, followed by CM (especially at 60 m^3/fed.). The favourable effect of these two treatments may be attributed to their enhancing effect on vegetative growth, in terms of the fresh herb yield. As previously mentioned, these two treatments gave higher fresh spearmint herb yields than any other chemical or organic fertilization treatment. Similarly, PM at 30 m^3/fed. gave the highest yield of marjoram oil in the first season (Table 4), followed by CM at 60 m^3/fed., but in the second season this order was reversed, i.e. CM at 60 m^3/fed. gave the highest oil yield, followed by PM at 30 m^3/fed. It is also clear from the results that in marjoram, NPK fertilization was generally less effective than organic manures in increasing the oil yield.

The favourable effect of the different fertilization treatments on the synthesis and accumulation of essential oil in the herb of spearmint and marjoram is in agreement with the findings of several researchers, including Gupta *et al.* (1974) on *Mentha arvensis*, Ramteke *et al.* (1975) on English mint, Adamovic *et al.* (1982) on *M. piperita*, Chattopadhyay *et al.* (1982) on *M. arvensis*, Singh *et al.* (1983) on *M. citrata*, El-Gamasy *et al.* (1985) on sweet marjoram, Neshev and Slavov (1985) on *M. piperita*, Refaat (1988) on *Origanum majorana*, as well as Singh *et al.* (1988), Munsi (1992) and El-Ghadban (1994) on *M. viridis*.

3. Oil components

a. Spearmint oil

Chromatographic analysis of spearmint oil samples revealed that the ketone carvone was the main oil component, followed by limonene (a monocylic terpene hydrocarbon), while other components (such as α-pinene, caryophyllene, citral, eugenol, linalool, phellandrene and other unknown components) constituted relatively small percentages of the oil (Table 5). The beneficial effect of fertilization on the carvone content, as well as the total content of main components (carvone+limonene), was not quite clear in the first season, with only four fertilization treatments (PM at 10 or 30 m^3/fed., and CM at 20 or 60 m^3/fed.) giving higher values than the control. However, the favourable effect of NPK and organic fertilization on the synthesis and accumulation of the main oil components was evident in the second season, with all the treatments resulting in increases in the percentages of carvone and (carvone +limonene). PM at 10 m^3/fed. gave the highest (carvone+limonene) content in both seasons.

In both seasons, the limonene concentration in the essential oil was generally increased (in most cases) as a result of NPK and organic fertilization, compared to the control. A similar increase in the limonene content of the essential oil as a result of NPK fertilization was obtained by El-Ghadban (1994) *on Mentha viridis*. Raising the rate of NPK fertilization resulted in a steady increase in the limonene content, whereas no clear trend was detected for the effect of raising the application rate of the different types of manure. In the first season, PM at 10 m^3/fed. gave the highest limonene content, while PM at 30 m^3/fed. gave the highest limonene content in the second season.

The effect of different fertilization treatments on the percentage of other minor oil components was inversely correlated with their effect on the total percentage of the main components (carvone + limonene), i.e. the content of minor components was generally reduced by the fertilization treatments, especially in the second season. The greatest reduction (in both seasons) was obtained as a result of fertilization with PM at 10 m^3/fed.

b. Marjoram oil

In both seasons, most of the fertilization treatments increased the percentage of α-terpineol (the main component), as well as that of some other important components (viz., α-pinene, β-pinene, cineole and citronellol), compared to the control (Tables 6 and 7). In the first season (Table 6), the highest contents of α-terpineol, α-pinene, β-pinene, cineole and citronellol were obtained from plants fertilized with NPK at 400 kg/fed., CM at 40 m^3/fed., CM at 20 m^3/fed., CM at 20 m^3/fed. and HM at 60 m^3/fed., respectively. In the second season (Table 7), the highest values for the five compounds were recorded with PM at 20 m^3/fed., CM at 40 m^3/fed., CM at 40 m^3/fed., NPK at 400 kg/fed. and PM at 10 m^3/fed., respectively.

In contrast, the different fertilization treatments caused a general reduction in the contents of linalool (especially in the second season) and α-terpineol acetate (especially in the first season), compared to the control, but had no clear effect on the linalyl acetate content.

As a result of the favourable effect of fertilization on most of the main components, the content of minor components in marjoram oil was generally reduced by the different fertilization treatments (especially organic manures), i.e. fertilization improved the quality of the essential oil.

III. Chemical Composition

1. Leaf pigments content

The different fertilization treatments generally increased the chlorophyll contents in spearmint leaves (Table 8). In the first season, the highest contents of chlorophyll 'a', chlorophyll 'b' and total chlorophyll in spearmint leaves were obtained with fertilization using HM at 60

m^3/fed. However, NPK fertilization was generally more effective than most of the other organic manure treatments for increasing the chlorophyll contents. The superior effect of chemical NPK fertilization on chlorophyll synthesis and accumulation in spearmint plants was more evident in the second season, with NPK fertilization giving higher chlorophyll 'a', chlorophyll 'b' and the total (a+b) chlorophyll contents, compared to most of the organic fertilization treatments. Moreover, the total chlorophyll content was increased steadily as a result of raising the NPK fertilization rate. In both seasons, the highest NPK rate (1200 kg/fed.) gave higher values than any other chemical or organic fertilization treatment. The favourable effect of chemical fertilization on the chlorophyll content in spearmint leaves is similar to that obtained by El-Ghadban (1994) on *Mentha viridis*, and Jacoub (1995) on *Ocimum basilicum*. The increase in the chlorophyll content of fertilized plants may be attributed, at least partly, to the role played by nitrogen as an essential component in the structure of porphyrines, which are found in many metabolically active compounds, including chlorophylls. Also, chlorophylls are bound to, and perhaps even embedded within protein molecules, of which nitrogen is an essential component (Devlin, 1975). Moreover, the favourable effect of organic manures (compared to the control) may be attributed to the increase in the soil's water-holding capacity, which prevents the leaching of NO_3^- ions from the soil, and makes them available to the plant roots.

On the other hand, neither the chlorophyll (a, b, and total chlorophyll) contents in *Origanum majorana* plants (Table 9), nor the carotenoids content in both *M. viridis* and *O. majorana* (Tables 8 and 9, respectively) showed a clear trend in response to the different fertilization treatments. Regarding these parameters, most of the treatments gave results that varied from one season to the other. It is possible that these characteristics are less sensitive to fertilization than to other environmental factors.

2. Total carbohydrate content

In both species, the effect of most of the fertilization treatments on the total carbohydrate content in the herb varied from one season to the other (Tables 8 and 9). In both species, only three treatments (NPK at 400 or 800 kg/fed., and CM at 40 m^3/fed.) increased the mean carbohydrate content in the two seasons, compared to the control. On the other hand, the results recorded in both seasons show that two treatments (NPK at 1200 kg/fed., and PM at 30 m^3/fed.) reduced the values recorded in both species, compared to the control. In *M. viridis* only (Table 8), PM at 20 m^3/fed. also reduced the values recorded in both seasons, while CM at 20 m^3/fed. reduced the values recorded in *O. majorana* only (Table 9), compared to the control. All other treatments gave different results in the two seasons.

3. Nutrient contents in the herb

a. Nitrogen

Data recorded in the two seasons show that the different fertilization treatments increased the mean nitrogen content in both *M. arvensis* (Table 10) and *O. majorana* (Table 11), compared to the control. However, the relative effects of the treatments on the N content, compared to each other, varied from one season to the other. The increase in the N content in fertilized plants 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. This may be accompanied by an increase in the absorption of these essential elements. 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*, and Jacoub (1995) on *O. basilicum.*

b. Phosphorus

The results presented in Tables 10 and 11 also indicate that the different fertilization treatments increased the phosphorus content in both species, compared to the control. The increase in the P content of fertilized plants is similar to that obtained by Balyan and Sobti (1990) on *Ocimum gratissimum*. In *Mentha viridis* (Table 10), plants supplied with NPK fertilization had lower mean P contents (in both seasons) than those supplied with organic fertilization. In the first season, the highest mean P content recorded in spearmint plants was obtained in plants fertilized with HM at the rate of 60 m^3/fed., whereas the highest mean P content recorded in the second season was found in plants fertilized with PM at the rate of 30 m^3/fed. In *O. majorana* (Table 11), CM (especially at the rate of 60 m^3/fed.) gave generally higher P contents during the first season, compared to the other fertilization treatments, whereas HM at 40 m^3/fed. gave the highest mean P content in the second season.

c. Potassium

Most of the fertilization treatments increased the K content in spearmint plants in both seasons, compared to the control (Table 10). On the other hand, the results recorded on marjoram plants (Table 11) varied from one season to the other. In the first season, marjoram plants receiving the different fertilization treatments had lower K contents than the control, but in the second season, an opposite trend was observed, i.e. most of the fertilization treatments increased the K content, compared to the control. However, the application of CM at the highest rate (60 m^3/fed.) appeared to have a more beneficial effect on the potassium content than most of the other treatments. This treatment gave the highest values in *M. viridis* plants in the two seasons (Table 10), as well as the highest value in *O. majorana* in the second season (Table 11).

d. Iron

Results recorded in the two seasons (Tables 10 and 11) show that, in most cases, the different fertilization treatments reduced the iron content in both species (especially *Mentha viridis*), compared to the control. 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.

e. Zinc

In general, spearmint plants supplied with NPK or organic fertilization had lower mean Zn contents in both seasons, compared to the control (Table 10), especially in the second season. In contrast, the general trend observed in marjoram plants (Table 11) was opposite to that detected in spearmint, i.e. the different fertilization treatments increased the mean Zn content in *Origanum majorana* plants, compared to the control. The favourable effect of fertilization on the accumulation of Zn in marjoram plants is in agreement with the conclusions reached by Kaddous and Morgans (1986) on several vegetable crops.

Recommendations: From the results of this study, it can be recommended that spearmint and marjoram plants should be supplied with adequate fertilization (especially using organic manures) in order to obtain the highest fresh and dry herb yields, as well as the highest essential oil yield. The best results (in terms of fresh and dry herb yields, and essential oil yield) were obtained from plants fertilized with poultry manure at the relatively high rate of 30 m^3/fed., or cattle manure at the rate of 60 m^3/fed. However, due to the high cost of poultry manure, cattle manure may be more economical to use.

Table 1: Chemical characteristics of the sandy soil used for growing *Mentha viridis* L. and *Origanum majorana* L. plants during the 1995 and 1996 seasons.

Growing season	Nutrient contents									
	N (%)	P_2O_5 (%)	K (%)	Mg (%)	Ca (%)	Fe (ppm)	Mn (ppm)	Zn (ppm)	Cu (ppm)	EC (ds/m)
First season (1995)	0.10	0.18	0.20	0.38	0.55	4.00	0.66	0.44	0.48	1.55
Second season (1996)	0.15	0.27	0.50	0.31	0.58	4.00	0.60	0.40	0.40	1.30

Table 2: Physical and chemical characteristics of the organic fertilizers applied to *Mentha viridis* L. and *Origanum majorana* L. plants during the 1995 and 1996 seasons.

Soil characteristics	Poultry manure		Cattle manure		Horse manure	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
Physical characteristics						
Weight of 1 m^3 (kg)	685	526	491	470	415	314
Moisture content (%)	6.90	9.60	9.50	9.10	7.80	9.20
Chemical characteristics						
Organic matter (%)	61.16	83.61	63.76	62.24	57.11	84.87
Organic carbon (%)	35.47	48.49	31.88	36.10	33.12	49.22
C : N ratio	15.4 : 1	13.2 : 1	17.2 : 1	19.7 : 1	22.1 : 1	31.5 : 1
Total N (%)	2.30	3.66	1.85	1.83	1.50	1.56
NH_3 - N (ppm)	3021.80	3489.90	47.70	63.60	79.50	79.50
NO_3 - N (ppm)	174.90	224.60	174.90	206.80	181.30	208.90
P (%)	1.08	0.30	0.27	0.60	0.40	0.86
K (%)	0.74	1.74	1.06	1.12	1.43	1.02
Fe (ppm)	1709.70	1824.50	1879.50	2690.90	1388.10	1495.20
Mn (ppm)	123.80	163.90	188.30	179.80	162.00	194.90
Zn (ppm)	84.50	86.90	89.90	159.90	100.90	175.10
Cu (ppm)	35.80	52.30	41.40	43.20	61.30	86.90

Table 3: Effect of chemical NPK fertilization and organic manures on the total fresh and dry herb yields, the mean leaves: stems fresh weight ratio, the mean essential oil content and the total oil yield of *Mentha viridis* L. during the 1995 and 1996 seasons.

*Fertilization treatments	Total fresh herb yield (gm/plant)		Total dry herb yield (gm/plant)		Mean leaves:stems fresh weight ratio		Mean oil content (% of fresh herb)		**Total oil yield (ml/plant)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Control	68.72	46.82	27.64	22.69	2.24	2.28	0.203	0.207	0.129	0.095
NPK (400 kg/fed.)	193.62	141.17	74.94	64.84	2.38	2.48	0.241	0.283	0.511	0.406
NPK (800 kg/fed.)	241.43	153.61	98.48	76.81	2.18	2.55	0.244	0.316	0.652	0.492
NPK (1200 kg/fed.)	304.87	188.90	117.59	94.16	2.31	2.78	0.258	0.367	0.822	0.707
PM (10 m^3/fed.)	231.12	191.52	92.38	96.59	2.21	3.15	0.284	0.450	0.745	0.867
PM (20 m^3/fed.)	339.13	285.63	132.60	143.74	2.54	3.29	0.288	0.484	1.060	1.401
PM (30 m^3/fed)	467.55	374.21	180.30	179.01	2.53	2.88	0.301	0.451	1.461	1.682
CM (20 m^3/fed.)	131.85	121.32	53.92	56.62	2.57	3.11	0.283	0.461	0.378	0.558
CM (40 m^3/fed.)	211.71	193.13	81.84	94.82	2.67	3.10	0.296	0.485	0.650	0.939
CM (60 m^3/fed.)	340.00	286.91	128.53	134.85	2.60	3.11	0.318	0.500	1.119	1.433
HM (20 m^3/fed.)	121.47	98.21	47.01	48.45	2.64	3.07	0.279	0.369	0.356	0.365
HM (40 m^3/fed.)	197.92	147.57	75.21	72.95	2.49	3.11	0.302	0.415	0.631	0.607
HM (60 m^3/fed.)	283.52	194.97	108.08	101.31	2.60	3.03	0.304	0.442	0.882	0.865
L.S.D. (at 0.05)	**3.83**	**2.79**	**2.31**	**1.70**	**0.16**	**0.26**	**0.007**	**0.022**	**0.013**	**0.011**

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

** The total oil yield/plant was calculated by addition of the oil yields/plant in the three cuts. In each cut, the oil yield/plant was calculated by multiplication of the herb fresh weight by the oil percentage.

Table 4: Effect of chemical NPK fertilization and organic manures on the total fresh and dry herb yields, the mean leaves: stems fresh weight ratio, the mean essential oil content and the total oil yield of *Origanum majorana* L. during the 1995 and 1996 seasons.

*Fertilization treatments	Total fresh herb yield (gm/plant)		Total dry herb yield (gm/plant)		Mean leaves:stems fresh weight ratio		Mean oil content (% of fresh herb)		**Total oil yield (ml/plant)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Control	20.60	10.47	8.015	5.448	3.57	3.77	0.330	0.231	0.067	0.026
NPK (400 kg/fed.)	43.31	19.16	15.089	10.759	3.36	3.67	0.363	0.333	0.151	0.066
NPK (800 kg/fed.)	53.62	28.91	19.483	15.109	3.51	3.68	0.483	0.410	0.255	0.120
NPK (1200 kg/fed.)	54.02	39.74	23.899	20.215	3.59	3.80	0.514	0.433	0.290	0.170
PM (10 m^3/fed.)	141.33	122.87	54.230	59.613	3.70	3.70	0.526	0.477	0.739	0.575
PM (20 m^3/fed.)	206.02	157.48	80.307	78.442	5.19	5.96	0.561	0.534	1.161	0.845
PM (30 m^3/fed)	246.15	176.31	90.233	85.646	4.00	4.71	0.563	0.523	1.398	0.930
CM (20 m^3/fed.)	122.83	103.62	46.340	52.779	4.72	5.53	0.542	0.537	0.667	0.556
CM (40 m^3/fed.)	167.32	149.36	61.009	78.370	4.26	5.24	0.587	0.536	0.981	0.798
CM (60 m^3/fed.)	232.97	187.89	80.988	98.354	4.72	5.47	0.551	0.540	1.290	1.010
HM (20 m^3/fed.)	77.21	51.00	28.547	26.383	4.05	4.83	0.402	0.498	0.312	0.248
HM (40 m^3/fed.)	141.31	82.44	51.478	44.064	5.19	6.21	0.503	0.581	0.725	0.479
HM (60 m^3/fed.)	185.55	118.91	65.350	66.384	4.67	5.43	0.503	0.584	0.955	0.691
L.S.D. (0.05)	**0.86**	**1.39**	**0.511**	**0.582**	**0.48**	**0.52**	**0.010**	**0.009**	**0.010**	**0.005**

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

** The total oil yield/plant was calculated by addition of the oil yields/plant in the three cuts. In each cut, the oil yield/plant was calculated by multiplication of the herb fresh weight by the oil percentage.

Table 5: Effect of chemical NPK fertilization and organic manures on the essential components of spearmint (*Mentha viridis* L.) oil during the 1995 and 1996 seasons.

*Fertilization treatments	Spearmint essential oil components (%)							
	First season (1995)				Second season (1996)			
	Carvone (C)	Limonene (L)	Total (C+L)	Other components	Carvone (C)	Limonene (L)	Total (L+C)	Other components
Control	72.039	1.680	73.719	26.281	73.591	1.683	75.274	24.726
NPK (400 kg/fed.)	59.272	2.086	61.358	38.642	88.708	2.304	91.012	8.988
NPK (800 kg/fed.)	57.237	3.385	60.622	39.378	90.020	2.409	92.429	7.571
NPK (1200 kg/fed.)	53.328	3.599	56.927	43.073	84.459	6.512	90.971	9.029
PM (10 m^3/fed.)	75.865	9.038	84.903	15.097	84.872	7.942	92.814	7.186
PM (20 m^3/fed.)	62.641	6.234	68.875	31.125	87.946	3.848	91.794	8.206
PM (30 m^3/fed)	78.517	1.021	79.538	20.462	79.997	10.453	90.450	9.550
CM (20 m^3/fed.)	74.360	4.272	78.632	21.368	85.117	3.998	89.115	10.885
CM (40 m^3/fed.)	66.839	4.136	70.975	29.025	82.617	9.371	91.988	8.012
CM (60 m^3/fed.)	78.634	2.481	81.115	18.885	86.005	5.052	91.057	8.943
HM (20 m^3/fed.)	70.459	1.039	71.498	28.502	85.867	4.620	90.487	9.513
HM (40 m^3/fed.)	69.781	2.792	72.573	27.427	88.022	1.863	89.885	10.115
HM (60 m^3/fed.)	69.673	4.039	73.712	26.288	.80.009	7.926	87.935	12.065

* PM = Poultry Manure CM = Cattle Manure HM = HorseManure

Table 6: Effect of chemical NPK fertilization and organic manures on the essential components of marjoram (*Origanum majorana* L.) oil during the 1995 season.

*Fertilization treatments	Marjoram essential oil components (%)								
	α-terpineol	α-pinene	β-pinene	Cineole	Citronellol	Linalool	α-terpineol acetate	Linalyl acetate	Other components
Control	53.75	2.60	1.35	2.72	4.74	2.88	4.22	5.26	22.48
NPK (400 kg/fed.)	59.90	3.89	1.36	3.64	3.79	3.69	4.94	5.24	13.55
NPK (800 kg/fed.)	55.35	4.50	2.45	5.64	7.41	4.67	2.32	5.57	12.09
NPK (1200 kg/fed.)	59.70	3.39	2.18	7.69	8.90	0.45	2.73	5.49	9.47
PM (10 m^3/fed.)	53.31	5.52	4.32	8.90	8.44	1.86	3.09	6.43	8.13
PM (20 m^3/fed.)	57.64	5.25	4.68	8.61	8.35	0.44	3.11	6.01	5.91
PM (30 m^3/fed)	55.89	4.83	4.67	11.20	7.27	1.87	4.21	6.22	4.44
CM (20 m^3/fed.)	53.22	4.92	5.81	13.98	8.00	1.14	2.57	4.53	5.83
CM (40 m^3/fed.)	56.72	6.19	5.72	10.83	4.36	0.73	2.85	4.93	7.67
CM (60 m^3/fed.)	55.64	4.50	3.81	10.29	6.11	3.71	2.51	5.66	8.43
HM (20 m^3/fed.)	59.27	2.54	1.46	7.93	10.39	0.62	2.79	6.04	8.96
HM (40 m^3/fed.)	58.41	0.22	5.17	11.11	4.85	4.77	3.12	4.98	7.37
HM (60 m^3/fed.)	55.57	3.19	2.25	5.72	12.09	0.21	5.10	7.52	8.35

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

Table 7: Effect of chemical NPK fertilization and organic manures on the essential components of marjoram (*Origanum majorana* L.) oil during the 1996 season.

*Fertilization treatments	Marjoram essential oil components (%)								
	α-terpineol	α-pinene	β-pinene	Cineole	Citronellol	Linalool	α-terpineol acetate	Linalyl acetate	Other components
Control	53.13	0.44	0.81	2.28	5.25	10.15	4.77	4.22	18.95
NPK (400 kg/fed.)	51.88	0.70	0.93	7.56	6.00	8.67	7.50	0.43	16.33
NPK (800 kg/fed.)	53.25	0.58	0.92	0.67	6.06	10.29	6.22	4.02	17.99
NPK (1200 kg/fed.)	63.56	2.73	3.22	3.51	6.07	9.41	7.04	4.26	0.20
PM (10 m^3/fed.)	63.20	3.17	4.09	4.93	6.48	8.38	4.77	4.25	0.73
PM (20 m^3/fed.)	67.76	3.85	4.24	4.31	3.37	6.44	3.66	5.38	0.99
PM (30 m^3/fed)	63.41	3.85	5.00	6.75	3.56	8.41	3.27	3.91	1.84
CM (20 m^3/fed.)	64.92	3.90	4.45	4.79	5.04	7.70	3.95	4.74	0.51
CM (40 m^3/fed.)	61.71	4.07	5.14	6.60	4.81	9.36	2.92	4.48	0.91
CM (60 m^3/fed.)	60.74	3.79	4.94	6.70	6.01	9.98	2.69	4.47	0.68
HM (20 m^3/fed.)	65.42	3.12	3.36	3.72	5.13	8.44	4.86	5.03	0.92
HM (40 m^3/fed.)	65.83	2.58	3.05	3.98	5.11	8.30	3.70	5.18	2.27
HM (60 m^3/fed.)	58.56	1.38	1.55	1.90	4.28	6.73	3.74	4.71	17.15

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

Table 8: Effect of chemical NPK fertilization and organic manures on the mean contents of leaf pigments (chlorophyll "a", "b", total chlorophyll and carotenoids) and total carbohydrates in the herb of *Mentha viridis* L. plants during the 1995 and 1996 seasons.

*Fertilization treatments	Leaf pigments content (mg/gm fresh matter)								Total carbohydrates content (% of dry matter)	
	Chlorophyll "a"		Chlorophyll "b"		Total chlorophyll (a+b)		Carotenoids			
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Control	0.638	0.481	0.466	0.342	1.136	0.827	0.376	0.321	7.56	7.45
NPK (400 kg/fed.)	0.775	0.642	0.604	0.470	1.398	1.113	0.303	0.383	8.36	9.44
NPK (800 kg/fed.)	0.812	0.705	0.653	0.506	1.549	1.211	0.300	0.419	7.93	10.05
NPK (1200 kg/fed.)	0.838	0.733	0.646	0.517	1.574	1.250	0.281	0.425	6.92	6.05
PM (10 m^3/fed.)	0.650	0.565	0.411	0.443	1.015	1.008	0.345	0.350	6.83	8.14
PM (20 m^3/fed.)	0.796	0.629	0.586	0.461	1.405	1.090	0.324	0.386	7.41	6.56
PM (30 m^3/fed)	0.755	0.674	0.561	0.498	1.316	1.172	0.330	0.411	7.07	5.70
CM (20 m^3/fed.)	0.652	0.529	0.418	0.352	1.036	0.881	0.350	0.342	7.02	7.50
CM (40 m^3/fed.)	0.762	0.553	0.485	0.360	1.214	0.910	0.356	0.347	8.64	7.89
CM (60 m^3/fed.)	0.756	0.576	0.452	0.383	1.174	0.967	0.326	0.331	8.05	6.52
HM (20 m^3/fed.)	0.738	0.564	0.526	0.407	1.264	0.971	0.313	0.347	6.72	8.02
HM (40 m^3/fed.)	0.817	0.553	0.578	0.375	1.395	0.929	0.335	0.365	8.43	5.47
HM (60 m^3/fed.)	0.904	0.519	0.693	0.401	1.620	0.920	0.351	0.329	6.72	8.54

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

Table 9: **Effect of chemical NPK fertilization and organic manures on the mean contents of leaf pigments (chlorophyll "a", "b", total chlorophyll and carotenoids) and total carbohydrates in the herb of *Origanum majorana* L. plants during the 1995 and 1996 seasons.**

***Fertilization treatments**	**Leaf pigments content (mg/gm fresh matter)**								**Total carbohydrates content (% of dry matter)**	
	Chlorophyll "a"		Chlorophyll "b"		Total chlorophyll (a+b)		Carotenoids			
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Control	0.618	0.478	0.430	0.325	1.049	0.830	0.373	0.310	7.16	7.43
NPK (400 kg/fed.)	0.640	0.548	0.430	0.378	1.071	0.926	0.382	0.354	7.69	8.52
NPK (800 kg/fed.)	0.594	0.576	0.413	0.387	0.973	0.937	0.322	0.386	7.41	8.68
NPK (1200 kg/fed.)	0.612	0.595	0.419	0.419	1.024	1.013	0.337	0.372	6.84	6.73
PM (10 m^3/fed.)	0.564	0.567	0.367	0.398	0.931	1.015	0.334	0.372	6.55	7.79
PM (20 m^3/fed.)	0.557	0.600	0.348	0.427	0.906	1.027	0.361	0.375	7.29	6.81
PM (30 m^3/fed)	0.660	0.589	0.472	0.414	1.132	1.033	0.336	0.370	7.11	6.75
CM (20 m^3/fed.)	0.532	0.600	0.302	0.417	0.817	1.017	0.378	0.387	6.92	7.20
CM (40 m^3/fed.)	0.541	0.568	0.322	0.392	0.863	0.960	0.364	0.369	7.32	7.53
CM (60 m^3/fed.)	0.614	0.598	0.397	0.403	1.011	1.001	0.347	0.361	9.20	7.23
HM (20 m^3/fed.)	0.588	0.523	0.360	0.351	0.948	0.873	0.309	0.356	6.50	7.52
HM (40 m^3/fed.)	0.544	0.452	0.345	0.300	0.889	0.752	0.342	0.320	7.69	6.39
HM (60 m^3/fed.)	0.614	0.551	0.389	0.321	1.003	0.872	0.382	0.316	6.75	7.89

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

Table 10: Effect of chemical NPK fertilization and organic manures on the mean contents (of three cuts) of nitrogen, phosphorus, potassium, iron and zinc in the dry herb of *Mentha viridis* L. during the 1995 and 1996 seasons.

*Fertilization treatments	N content (% of dry matter)		P content (% of dry matter)		K content (% of dry matter)		Fe content (mg/gm of dry matter)		Zn content (mg/gm of dry matter)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Control	1.73	1.97	0.137	0.123	1.97	1.87	0.437	0.898	0.207	0.210
NPK (400 kg/fed.)	2.59	2.72	0.172	0.138	2.15	2.08	0.310	0.741	0.120	0.135
NPK (800 kg/fed.)	2.73	2.83	0.205	0.153	2.27	2.13	0.323	0.805	0.203	0.140
NPK (1200 kg/fed.)	2.59	2.72	0.208	0.157	2.15	2.18	0.251	0.755	0.223	0.177
PM (10 m^3/fed.)	2.41	3.08	0.265	0.213	2.37	1.92	0.262	0.542	0.207	0.108
PM (20 m^3/fed.)	2.53	2.63	0.303	0.197	2.33	1.80	0.219	0.619	0.132	0.115
PM (30 m^3/fed)	2.67	3.69	0.250	0.282	2.30	2.07	0.148	0.568	0.115	0.207
CM (20 m^3/fed.)	2.28	3.56	0.272	0.195	2.22	2.30	0.334	0.692	0.132	0.137
CM (40 m^3/fed.)	2.72	3.51	0.307	0.230	2.35	2.28	0.304	0.524	0.170	0.110
CM (60 m^3/fed.)	2.43	3.38	0.290	0.253	2.60	2.42	0.307	0.442	0.152	0.085
HM (20 m^3/fed.)	2.08	3.17	0.252	0.240	2.42	2.07	0.283	0.712	0.212	0.118
HM (40 m^3/fed.)	2.38	2.87	0.298	0.220	2.50	2.13	0.262	0.636	0.118	0.165
HM (60 m^3/fed.)	2.56	2.78	0.315	0.210	2.50	2.18	0.233	0.502	0.142	0.153

* PM = Poultry Manure CM = Cattle Manure HM = HorseManure

Table 11: Effect of chemical NPK fertilization and organic manures on the mean contents (of three cuts) of nitrogen, phosphorus, potassium, iron and zinc in the dry herb of *Origanum majorana* L. during the 1995 and 1996 seasons.

*Fertilization treatments	N content (% of dry matter)		P content (% of dry matter)		K content (% of dry matter)		Fe content (mg/gm of dry matter)		Zn content (mg/gm of dry matter)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Control	1.79	1.86	0.127	0.090	2.52	1.82	0.438	0.444	0.077	0.118
NPK (400 kg/fed.)	2.31	2.64	0.150	0.162	1.93	1.88	0.473	0.493	0.128	0.247
NPK (800 kg/fed.)	2.27	2.97	0.188	0.112	2.15	1.95	0.396	0.372	0.103	0.170
NPK (1200 kg/fed.)	2.62	2.66	0.200	0.165	2.08	2.28	0.424	0.412	0.135	0.250
PM (10 m^3/fed.)	2.15	2.88	0.205	0.205	1.82	2.05	0.422	0.495	0.130	0.253
PM (20 m^3/fed.)	2.42	3.05	0.203	0.218	1.70	2.20	0.277	0.436	0.127	0.208
PM (30 m^3/fed)	2.38	3.22	0.247	0.212	2.03	2.08	0.384	0.355	0.148	0.207
CM (20 m^3/fed.)	2.46	2.67	0.255	0.188	2.08	2.10	0.406	0.436	0.122	0.152
CM (40 m^3/fed.)	2.23	2.71	0.230	0.192	2.17	2.25	0.395	0.381	0.118	0.185
CM (60 m^3/fed.)	2.23	2.67	0.282	0.215	2.32	2.43	0.440	0.382	0.170	0.185
HM (20 m^3/fed.)	2.23	1.96	0.173	0.172	2.08	1.75	0.393	0.438	0.115	0.145
HM (40 m^3/fed.)	2.41	2.38	0.167	0.230	2.22	1.88	0.277	0.420	0.080	0.130
HM (60 m^3/fed.)	2.17	2.34	0.168	0.218	2.22	1.93	0.367	0.459	0.143	0.125

* PM = Poultry Manure CM = Cattle Manure HM = HorseManure

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تأثير التسميد العضوى وغير العضوى على إنتاجية العشب و الزيت في النعناع البلدى و البردقوش

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أجريت هذه الدراسة بمشتل تجارب قسم الزينة بكلية الزراعة ، جامعة القاهرة ، خلال الموسمين المتتاليين ١٩٩٥ و ١٩٩٦ بهدف بحث تأثير بعض الأسمدة العضوية (سماد الدواجن بمعدلات ١٠ ، ٢٠ و ٣٠ م^3/فدان ، و كذلك سماد الماشية و سماد الخيول بمعدلات ٢٠ ، ٤٠ و ٦٠ م^3/فدان لكل منهما) و السماد الكيماوى NPK (٥ ن : ٢ فو$_2$أ$_5$: ٢ بو$_2$أ) بمعدلات ٤٠٠ ، ٨٠٠ و ١٢٠٠ كجم / فدان على النمو و محصول الزيت و التركيب الكيماوى لنباتات النعناع البلدى (*Mentha viridis* L.) و البردقوش (*Origanum majorana* L.). و قد أدى التسميد إلى زيادة معنوية في محصول العشب الطازج و الجاف في النوعين بالمقارنة بالنباتات غير المسمدة، وتم الحصول على أفضل النتائج لهذه الصفات عند إستخدام سماد الدواجن بمعدل ٣٠ م^3/فدان أو

سـماد الماشية بمعدل ٦٠م^٣/فدان. كذلك فقد أدت الأسمدة العضوية إلى زيادة نسبة الوزن الطازج للأوراق : الوزن الطازج للسيقان فى النوعين. وفى البردقوش أعطى سماد الدواجن بمعـدل ٢٠ م^٣/فدان و سماد الماشية بمعدل ٤٠ م^٣/فدان أعلى نسبة وزن طازج للأوراق : وزن طازج للسيقان . كما أدى رفع معدل التسميد العضوى المضاف إلى النعناع البلدى إلى زيـادة مطردة في النسبة المئوية للزيت فى العشب الطازج، و أعطى سماد الماشية أفضل النـتائج، و كذلك فى محصول الزيت للنبات (وكان أعلى محصول زيت هو الناتج عن سماد الدواجن بمعدل ٣٠ م^٣/فدان). هذا و قد أدت معظـم المعاملات السمادية إلى زيادة النسـبة المئـوية الإجمالية للمكـونات الأسـاسـية (carvone و limonene) فى زيت النعناع (وكانـت أعلـى القـيم هى الناتجة عن سماد الدواجن بمعدل ١٠ م^٣/فدان) ، و إلى زيادة محـتـوى النـبات من النتروجين و الفوسـفور و البوتاسيوم ، إلا أنها قللت من محتوى الحديـد و الزنك. كذلك فقد أدى رفع معدل التسميد الكيماوى إلى زيادة مطردة فى المحتوى الكلـى للكلوروفـيل فـى أوراق النعـناع. أما فى البردقوش فقد أدت المعاملات السمادية المختلفة إلى زيادة النسبة المئوية للزيت فى العشب الطازج ، و كذلك زيادة محصول الزيت للنـبات (خاصــة بالتسـميد العضوى بإستخدام سماد الدواجن بمعدل ٣٠ م^٣/فدان أو سماد الماشية بمعدل ٦٠ م^٣/فدان). كما أدى التســميد أيضا إلى زيادة محتويات زيت البردقوش (%) من الـ ∝-terpineol (المكون الرئيسى) و ∝-pinene و β-pinene و cineole و citronellol ، إلا أنه قلل من محتويات الــــ linalool و ∝-terpineol acetate. و فــى أغلب الحالات فإن المعاملات الســمادية المختلفــة أدت أيضا إلى زيــادة فى محتوى نــباتات البردقــوش من النتروجين و الفوسفور و الزنك ، إلا أنها قللت من محتوى الحديد بالمقارنة بنباتات الكنترول .

من النتائــج الســابقة، يمكن القول أن أفضــل إنتاجــيــة لنباتات النعناع البلدى و الــبردقــوش (من حيث محصول العشب الطازج و الجاف، و محصول الزيت الطيار) تم الحصــول علــيها مــن النباتات المسمدة بسماد الدواجن بالمعدل المرتفع نســبياً (٣٠ م^٣ /فدان)، أو سماد الماشية بمعدل (٦٠ م٣/فدان).
