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EFFECT OF ORGANIC AND CHEMICAL FERTILIZATION ON GROWTH, YIELD, AND ESSENTIAL OIL CONTENT OF FENNEL (*Foeniculum vulgare* Mill.)

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ABSTRACT

Two field experiments were carried out at a private farm at South Ghor area, Al-Karak, Jordan, during 2009/2010 and 2010/2011 cropping seasons. The study aimed to find the effect of four levels of organic fertilizer manure at 0, 20,40 and 60 ton/ha and three levels of chemical fertilizer at 0, 30, and 60 kg/ha on growth, yield, and essential oil percentage of fennel (*Foeniculum vulgare* Mill.). The experimental design was complete randomized block design with split plot arrangement with three replications. The results showed that organic manure application combined with chemical fertilizers (NPK+ trace elements) significantly ($P<0.01$) increased plant height, number of branches, fresh and dry weights of herb, essential oil (%) in fennel fruits, and essential oil yield/plant, as compared to pure chemical fertilizer treatments. Herb nitrogen and potassium contents were significantly ($P<0.01$) increased with organic fertilizer amendment or chemical fertilizer application , whereas herb-phosphorus content was not significantly affected by all fertilizer treatments. Soil electrical conductivity (EC) and organic matter content increased significantly by adding organic manure, while soil pH was not affected.

***Key words*:** *chemical fertilizer, essential oil, fennel, growth, organic manure, yield.*

1. INTRODUCTION

Fennel plant (*Foeniculum vulgare* Mill.) a member of Apiaceae family, grown within the Mediterranean region, is a short- lived medicinal and aromatic herb. Its fruits are widely used in the preparation of various dishes like sauces, pickles, pastries, confectioneries, and soups (Bhati *et al*., 1988). It is also used in pharmaceutical and cosmetic products (Piccaglia and Marotti, 2001), in addition to its uses in the traditional Arabian medicine as diuretic and digestive appetizer (Karnick, 1994). Fennel fruits contain 1 to 3% essential oils, which have disinfectant and antiinflammatory action on the respiratory and digestive organs and have an antispasmodic effect on smooth muscle (Stary and Jirasek, 1975). Leung and Foster (1996) reported that fennel oils are used to treat diseases like cholera bile disturbances, diarrhea, constipation, and nervous disorder. Recently, Anand *et al*., 2008 found that these oils possess anticancer activity.

Generally, excessive amounts of chemical fertilizers are applied to increase crops productivity (Nilsson,1979, Bengt and Martensoon, 2003). However, long-term applications of these fertilizers have caused a noticeable decrease in crop productivity (Chand *et al.,* 2006), because it mainly contains major macro elements (NPK) in large quantities and are without the use of organic manures and caused deterioration of soil health by increasing soil salinization and in turn it affects human being and plants (Choudhry, 2005).

Organic fertilizers increase crop quality especially medicinal and aromatic plants, and it is more acceptable than chemical fertilizers (Abou El-Fadl *et al.,* 1990), improve plant growth, yield, oil percentage (Ibrahim, 1999), and chemical constituents (Khalil, 2000), they have beneficial impacts on soil physical and chemical properties (Stevenson, 1994 ; O´Brien and Barker, 1996), result in better availability of soil micro-organisms (Zheljazkov and Warman, 2004), and provide energy for these microorganisms (Tejada *et al*., 2006)

Recently, consumers in Jordan are demanding higher quality and safer food especially organic products. In addition, fennel in Jordan is considered a promising medicinal and aromatic plant, that could be developed in Jordan for local and export purposes.The aim of this study was to determine the effects of different doses of organic

and inorganic fertilizers on growth, yield and oil percentage of fennel.

2. MATERIALS AND METHODS

Two field experiments were carried out during the two winter cropping seasons of 2009/2010 and 2010/2011, at a private farm in South Ghor area, south Karak district, Jordan. Some physical and chemical characteristics of the experimental soil are shown in Table (1). Fertilizer treatments consisted of organic fertilizers (chicken, sheep & cow manure at ratio1:1:1) with four levels of 0, 20, 40 and 60 ton/ha and N:P:K-chemical fertilizer (NPK 20-20-20+trace elements) at three levels of 0, 30 and 60 kg/ha monthly. Organic fertilizers were obtained from a Dairalla Company/Al-Salt for organic fertilizer production. Some chemical compositions of the organic manure are presented in Table (1).

Table (1): Chemical analysis of the experimental soil and organic manure during two seasons.

Chemical analysis	Soil		Organic manure
	First season, 2009/2010	Second season, 2010/2011	
pH	7.5	7.4	5.7
EC (dS m^{-1})	2.32	2.24	3.63
CaCO3 (%)	26	28	14.8
Organic matter(%)	2.23	2.19	24.66
Total N (%)	0.076	0.072	4.86
NaHCO3-P (mg kg^{-1})	12	15	nd*
Total Fe (ppm)	nd	nd	1123
Total Zn (ppm)	nd	nd	324
Total Mn (ppm)	nd	nd	356
Available Fe (ppm)	1.922	1.846	nd
Available Zn (ppm)	1.876	1.578	nd
Available Mn (ppm)	1.247	1.161	nd

*not determined.

The soil was prepared for planting by plowing, disking and leveling. Organic fertilizer was incorporated into the soil of the respective plots to a depth of about 15 cm two weeks before transplantation, and saturated with irrigation water until it reaches its field capacity. Fennel seeds were sown in the two seasons on 7^{th} November. The experimental plot consisted of four rows, 3 m in length with 60 cm apart and a distance of 30 cm between plants within the row. Each plot consisted of four rows. The experimental design was a complete randomized block (CRBD) design with factorial arrangement of the treatments (Organic fertilizer and chemical fertilizer) with three replications. Each plot occupied an area of 7.2 m^2 and contained 40 plants.

Chemical fertilizer (NPK 20-20-20+trace elements) was added monthly using a drip irrigation system. The first application was added 6 weeks after plantation then continued monthly in May. Irrigation commenced at the time of planting and continued throughout the growing season in both cropping seasons. Fennel was harvested at fruit maturity.

The following data were recorded: plant height (cm), number of branches/plant, fresh and dry weights (g/plant), fruit yield (g/plant), essential oil (ml/plant). The essential oil from fennel fruits was obtained by hydro distillation for 3 hours in order to extract the essential oils using the method of Guenther (1961).

Concentrations of nitrogen, phosphorus, and potassium in the herb were determined using the method of (Cottenie *et al*., 1982). Soil samples were taken from all plots at the end of the experiment for chemical analyses. These samples were dried, mixed thoroughly, pulverized in mortar and passed through a 2 mm sieve. Then samples were prepared for pH, electric conductivity (EC) (1:2.5 w/w) and organic matter (%) determination according to Chapman and Pratt (1961).

Data were analyzed by two way analysis of variance using the SAS statistical package (SAS institute, 2003), and the differences between the means were compared using Fisher's least significant difference (LSD) at $P \leq 0.05$ (Steel and Torrie., 1980).

3. RESULTS AND DISCUSSION

3.1.Vegetative growth

The results presented in Tables (2 & 3) show that the application of organic manure caused a huge increase in plant growth parameters, *i.e.* (plant height, number of branches/plant, fresh and dry weights of herbs) compared to the control and the chemical fertilizer treatments. The highest growth values were obtained at 40 or 60 tons organic manure fertilizer/ha. These results are in harmony with many other researchers who worked on different medicinal and aromatic crops. El-Ghadban (1998) worked on *Mentha spicate* and *Origanum majorana*, Kandil (2002) on fennel (*Foeniculum vulgare,* Mill.); Naguib and Aziz (2003) on *Hyosyamus muticus;* and El-Sherbeny *et al.* (2005) on *Sideritis montana* L. All authors showed that vegetative growth of plants significantly increased with organic manure application. The improvement in yield might be due to the fact that organic fertilizers provide plants with different nutrients, and cause an improvement of soil water holding capacity as a result of organic manure application (Nilsson, 1979). According to Pimentel *et al*. (2005), organic manure increases the abundance of soil organisms by providing organic micronutrient for mycorrhiza, which encourage absorption of nutrients by plants. These nutrients became more available when soil pH decreases due to organic manure application(Salem., 1986).On the other hand, the combination of the high level of organic manure (40 or 60 ton/ha) with (30 or 60 kg/ha) of chemical fertilizer resulted in significant increases in plant height, number of branches/plant, plant fresh and dry weights, compared with other combination treatments (Tables 2 & 3). Similar findings were obtained in *Nigella sativa* (Somida *et al.*, 2001) and fennel plant (Badran and Safwat., 2004).

3.2. Fruits and oil yield

Tables (4 & 5) show the effect of different organic and inorganic (*i. e*. chemical fertilizers) on fruit yield (g/plant), oil yield (ml /plant), and essential oil (%). In general, adding chemical fertilizer in combination with organic fertilizer tended to increase fruit yield in comparison with the application of each of them alone.

The highest average fruit yield (76.7 g/plant) was obtained in 2009/2010 cropping season, while the average yield in 2010/2011 cropping season was 74.0g/plant, obtained by adding 40 or 60 tons of organic fertilizer combined with 30 or 60 kg/ha chemical fertilizer. The lowest fruit yield was obtained from untreated plot with a yield of 48.8 and 44.0 g/plant in the first and second cropping seasons, respectively. Addition of 0 and 30 kg/ha chemical fertilizer without organic fertilizer significantly ($P<0.01$) produced lower fruit yield compared with other treatment combinations. Essential oil (%) in fennel fruits was significantly ($p<0.01$) increased by all organic fertilizer levels when compared to the chemical fertilizer. The highest organic fertilizer level (40 or 60 ton/ha) alone or with chemical fertilizer treatments, resulted in a significant increment in oil (%) compared with plots that untreated with organic fertilizer in both cropping seasons. It is clear that oil yield (ml /plant) had a parallel trend to oil (%), the three organic fertilizer levels significantly raised oil yield over the chemical fertilizer treatments. Raising organic fertilizer level progressively increased fennel oil yield. It was clearly evident that all treatments that received organic fertilizer recorded higher fruits yield, oil yield as well as essential oil (%), when compared with plots that did not receive organic fertilizer, indicating the importance of organic fertilizer in enhancing fennel productivity. The increase in the fruit yield, oil yield, and essential oil of fennel that resulted from organic fertilizer application might be due to the increase in soil organic content (Mona *et al.,* 2008) and enhancement of soil fertility (Fortun *et al.,* 1989), and stimulating effect of the organic manure that supplies plants with nutrient requirement for high yield and oil yield (Hussein *et al.,* 2006; Wong *et al.,* 1999). The high fruit crop yield due to organic fertilizer could be attributed to favorable changes in soil condition which might result in loose soil and enables better root growth (Amanullah *et al*., 2006). In addition, the improvement of plant biomass is related to positive influence of organic fertilizer which causes slow and steady availability of nutrients throughout the growing season (Amanullah e*t al*., 2006; Tejada *et al*., 2006).

3.3. Chemical Composition

Nitrogen content of fennel herb was significantly increased ($P<0.01$) by organic fertilizer application (Tables 6 & 7). The highest herb-N content (1.37 and 1.31 % D.W in 2009/2010 and 2010/2011 cropping seasons, respectively) occurred in plots received 60 tons/ha organic fertilizer/ha) with 60 kg chemical fertilizer/ha, while the lowest herb-N content (1.04 and 0.96 % D.W in 2009/2010 and 2010/2011 cropping seasons, respectively) was obtained from the plant in untreated plots. These results are in agreement with those obtained by

Table (2): Interactive effect of organic manure and chemical fertilizer on plant height, number of branches, fresh weight and dry weight of fennel, *Foeniculum vulgare* **Mill .during the two seasons.**

Fertilizer type		First season, 2009/2010				Second season, 2010/2011			
Organic (ton/ha)	Chemical (kg/ha)	Plant height (cm)	Number of branches	Plant fresh weight (g)	Plant dry weight (g)	Plant height (cm)	Number of branches	Plant fresh weight (g)	Plant dry weight (g)
0	0	135.9	4.8	364.6	87.9	126.5	4.5	329.0	80.9
	30	136.0	5.1	373.8	93.2	126.8	4.7	336.5	83.7
	60	137.1	5.3	380.1	96.3	127.2	5.1	345.1	86.9
20	0	141.7	5.3	408.7	105.4	132.5	5.3	371.6	96.1
	30	142.8	5.5	418.5	108.9	133.5	5.3	380.3	98.0
	60	143.6	5.6	422.5	109.2	134.0	5.5	384.4	99.4
40	0	143.1	5.7	460.0	121.5	135.1	5.5	420.6	102.3
	30	144.3	5.7	466.2	123.7	135.9	5.6	431.7	113.6
	60	144.3	5.9	470.5	125.3	136.1	5.7	434.8	114.3
60	0	144.6	5.9	474.8	126.4	136.6	5.9	435.2	114.6
	30	144.5	6.1	481.9	129.2	136.8	5.9	437.1	115.4
	60	144.8	6.3	487.1	129.1	136.8	6.0	438.6	116.4
LSD(0.05)		0.96	0.19	3.32	2.17	0.63	0.16	3.54	2.98

Table (3):Plant height, number of branches, fresh weight and dry weight of fennel, *Foeniculum vulgare* **Mill as affected by organic manure and chemical fertilizer during the two seasons.**

Treatments	First season, 2009/2010				Second season, 2010/2011			
	Plant height (cm)	Number of branches	Plant fresh weight (g)	Plant dry weight (g)	Plant height (cm)	Number of branches	Plant fresh weight (g)	Plant dry weight (g)
Organic matter								
0	136.27	5.02	371.83	92.45	125.83	4.71	336.87	83.84
20	142.67	5.49	416.55	107.83	135.14	5.36	378.76	97.83
40	143.57	5.76	465.56	123.53	135.29	5.62	429.07	116.23
60	144.10	6.16	481.27	128.20	136.27	5.98	432.62	115.87
LSD(0.05)	0.82	0.12	3.11	1.01	0.56	0.14	3.43	2.91
Chemical fertilizer								
0	136.22	5.40	426.24	110.30	132.99	5.28	387.84	102.89
30	136.54	5.62	435.10	113.73	132.91	5.37	395.41	102.69
60	137.37	5.80	440.10	114.98	133.49	5.60	399.73	102.75
LSD(0.05)	0.71	0.10	2.70	0.87	0.49	0.12	2.97	2.52
Interaction	ns	*	*	**	*	ns	ns	*

***, ** and n.s. indicate P < 0.05, P < 0.01 and not significant, respectively.**

Table (4): Interactive effect of organic manure and chemical fertilizer on fruit (yield g plant-1), essential oil (%)and oil yield /plant(ml) of fennel, *Foeniculum vulgare* **Mill. During the two cropping seasons.**

Fertilizer type		First season, 2009/2010			Second season, 2010/2011		
Organic (ton/ha)	Chemical (kg/ha)	Fruit (yield g plant-1)	Oil (%)	Oil yield /plant(ml)	Fruit (yield g plant-1)	Oil (%)	Oil yield /plant(ml)
0	0	48.8	1.86	0.91	44.0	1.84	0.81
	30	51.2	2.30	1.18	46.1	2.30	1.06
	60	53.1	2.31	1.23	51.1	2.32	1.18
20	0	57.9	2.50	1.45	55.0	2.37	1.30
	30	61.8	2.52	1.56	57.8	2.38	1.38
	60	63.4	2.52	1.60	60.0	2.39	1.43
40	0	74.3	2.55	1.89	70.2	2.40	1.68
	30	75.5	2.57	1.94	73.0	2.40	1.75
	60	75.4	2.57	1.94	73.2	2.41	1.76
60	0	75.6	2.55	1.93	73.4	2.40	1.76
	30	76.7	2.56	1.96	73.8	2.42	1.79
	60	76.1	2.57	1.96	74.0	2.43	1.80
LSD(0.05)		1.23	0.08	0.05	1.21	0.08	0.06

Table (5) : Fruit (yield g plant-1), essential oil (%), and oil yield/ plant (ml) of fennel, *Foeniculum vulgare* **Mill as affected by organic manure and chemical fertilizer during the two cropping seasons.**

Treatments	First season, 2009/2010			Second season, 2010/2011		
	Fruit (yield g plant-1)	Oil (%)	Oil yield /plant (ml)	Fruit (yield g plant-1)	Oil (%)	Oil yield /plant (ml)
Organic matter						
0	51.02	1.88	0.96	47.09	1.85	0.87
20	61.01	2.42	1.48	57.59	2.26	1.30
40	75.07	2.53	1.90	71.75	2.37	1.70
60	76.13	2.56	1.95	71.68	2.38	1.71
LSD(0.05)	1.10	0.14	0.07	0.94	0.15	0.028
Chemical fertilizer						
0	50.83	1.91	0.97	45.54	1.84	0.84
30	54.30	2.27	1.23	48.29	2.22	1.07
60	55.72	2.33	1.30	52.15	2.23	1.22
LSD(0.05)	0.96	0.11	0.06	0.81	0.18	0.012
Interaction	*	**	*	*	*	*

***, ** and n.s. indicate P < 0.05, P < 0.01 and not significant, respectively.**

Table (6): Interactive effect of organic manure and chemical fertilizer on chemical composition of fennel, *Foeniculum vulgare* **Mill. during the two seasons.**

Fertilizer type		First season, 2009/2010			Second season, 2010/2011		
Organic (ton/ha)	Chemical (kg/ha)	N %	P %	K %	N %	P %	K %
0	0	1.04	0.21	2.55	0.96	0.20	2.53
	30	1.14	0.25	3.38	1.07	0.24	3.37
	60	1.18	0.26	3.42	1.12	0.26	3.43
20	0	1.12	0.24	2.93	1.07	0.25	2.90
	30	1.16	0.26	3.50	1.12	0.26	3.47
	60	1.21	0.27	3.52	1.16	0.26	3.50
40	0	1.16	0.26	3.07	1.12	0.25	3.04
	30	1.23	0.27	3.52	1.17	0.25	3.51
	60	1.30	0.27	3.54	1.26	0.26	3.52
60	0	1.24	0.25	3.23	1.25	0.25	3.19
	30	1.31	0.27	3.56	1.27	0.26	3.50
	60	1.37	0.26	3.51	1.31	0.26	3.54
LSD(0.05)		0.03	ns	0.09	0.03	0.05	0.11

n.s. indicate not significant

Table (7): Chemical composition of fennel , *Foeniculum vulgare* **Mill as affected by organic manure and chemical fertilizer during the two cropping seasons.**

Treatments	First season, 2009/2010			Second season, 2010/2011		
	N %	P %	K %	N %	P %	K %
Organic matter						
0	1.05	0.24	2.58	0.97	0.24	2.54
20	1.16	0.26	2.96	1.09	0.26	2.92
40	1.23	0.27	3.10	1.14	0.26	3.06
60	1.31	0.26	3.24	1.26	0.26	3.21
LSD(0.05)	0.02	ns	0.07	0.02	ns	0.06
Chemical fertilizer						
0	1.06	0.22	2.57	0.98	0.21	2.55
30	1.16	0.26	3.40	1.09	0.23	3.39
60	1.19	0.27	3.45	1.14	0.26	3.48
LSD(0.05)	0.03	ns	0.06	0.02	0.05	0.05
Interaction	**	ns	*	*	ns	*

***, ** and n.s. indicate P < 0.05, P < 0.01 and not significant, respectively.**

Table (8): Interactive effect of organic manure and chemical fertilizer on soil pH, EC and organic matter content of fennel, *Foeniculum vulgare* Mill. during the two seasons.

Fertilizer type		First season, 2009/2010			Second season, 2010/2011		
Organic (ton/ha)	Chemical (kg/ha)	pH	EC (dS m^{-1})	OM (%)	pH	EC (dS m^{-1})	OM (%)
0	0	7.4	2.34	2.55	7.4	2.24	2.48
	30	7.5	2.33	2.59	7.5	2.24	2.52
	60	7.6	2.33	2.57	7.5	2.24	2.49
20	0	7.3	2.39	2.78	7.4	2.31	2.69
	30	7.4	2.40	2.75	7.4	2.30	2.73
	60	7.4	2.39	2.80	7.4	2.28	2.66
40	0	7.4	2.46	3.04	7.3	2.38	2.98
	30	7.3	2.47	3.02	7.4	2.37	2.94
	60	7.4	2.45	3.07	7.4	2.35	2.89
60	0	7.3	2.55	3.17	7.3	2.47	3.08
	30	7.3	2.53	3.21	7.3	2.45	3.11
	60	7.4	2.52	3.19	7.3	2.45	3.06
LSD(0.05)		Ns	0.08	0.08	ns	0.09	0.07

n.s. indicate not significant

Table (9): Soil pH, EC and organic matter content of fennel, *Foeniculum Vulgare* Mill as affected by organic manure and chemical fertilizer during the two seasons.

Treatments	First season, 2009/2010			Second season, 2010/2011		
	pH	EC (dS m^{-1})	OM (%)	pH	EC (dS m^{-1})	OM (%)
Organic matter						
0	7.4	2.32	2.55	7.4	2.25	2.50
20	7.4	2.37	2.82	7.4	2.33	2.70
40	7.4	2.46	3.08	7.3	2.38	2.97
60	7.3	2.56	3.19	7.3	2.48	3.14
LSD(0.05)	ns	0.07	0.04	ns	0.08	0.06
Chemical fertilizer						
0	7.4	2.34	2.58	7.4	2.25	2.41
30	7.5	2.36	2.56	7.6	2.27	2.57
60	7.5	2.36	2.63	7.5	2.28	2.55
LSD(0.05)	ns	0.01	0.02	ns	0.01	0.03
Interaction	ns	*	**	ns	**	**

***, ** and n.s. indicate P < 0.05, P < 0.01 and not significant, respectively.**

Yuonis *et al.* (2004) on *Ammi visnaga*, L and Kandeel and Sharaf (2003) on marjoram plant. Tejada *et al*. (2006) attributed this increase in nutrient concentration in plants amended with organic manure to the increase in quantity and activity of soil microorganisms, which in turn resulted in a considerable accumulation of N in plants. Moreover, Goyal *et al*. (1993) reported that the incorporation of organic amendments to soil profile increases enzymatic activities. Organic matter contains intra- and extra cellular enzymes and also it might stimulate microbial activity in the soil.

The obtained results on herb –P and K content (%) are presented (Tables, 6 &7). herb -P content was not significantly affected by all fertilizer treatments in both cropping seasons. However, herb -K content was positively affected by all fertilizer treatments in comparison with untreated plots in both cropping seasons. These results are in line with those obtained by Al-Fraihat *et al*. (2011) who reported that the increment in K content of marjoram plant may explain the efficiency of suitable quantity of organic fertilizers that can attract and hold more nutrients and water on its surface to supply the plants with suitable amounts for a long time.

The application of organic manure either alone or in combination with NPK positively affected N,P and K contents of fennel plants. The promotive effect of this character by low compost and mineral level may be due to the important role of N in metabolic processes like photosynthesis and carbohydrate synthesis(Naguib and Aziz ., 2003).

3.4. Certain soil characteristics

The data presented in (Tables 8 & 9) show some soil chemical analysis at the end of the experiment. The results revealed that soil pH was not significantly affected by adding organic and chemical fertilizers or both. This could be due to the high soil carbonate content that can fix any change in its pH during organic matter decomposition. Similar results for soil pH were obtained by Abu-Zahra and Tahboub (2008). Soil E.C was significantly ($P<0.01$) increased by adding the chemical fertilizer with organic manure compared with those received chemical fertilizer. This could be attributed to the addition of organic fertilizers that supplied soil with soluble compounds (Wong *et al.*, 1999).

Application of different doses of organic manure with or without chemical fertilizer significantly ($P<0.01$) enhanced soil organic matter content, however, the application of chemical fertilizer alone had no effects on soil organic matter content in both cropping seasons. These results are in harmony with those obtained by Herencia *et al*. (2007) and Theodora *et al.* (2003).

In conclusion fennel plants can be grown better in soil amended with organic manure as a fertilizer but application rate and availability of all minerals should be considered. Fennel plants grown in soil amended with organic manure showed a vigorous vegetative growth (plant height, number of branches, fresh and dry weights), high fruit and oil yield compared with plots received only chemical fertilizer. Further studies are needed to determine optimal rates of fertilizers to be used for proper growth and production of fennel crop.

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تأثير التسميد العضوي والكيميائي على نمو وإنتاجية الشمر ومحتوى الزيت العطري

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ملخص

تم إجراء تجربتين حقليتين في منطقة الأغوار الجنوبية –الكرك في الأردن، خلال الموسمين الـــزراعيين 2010/2009 و2011/2010 بهدف دراسة تأثير أربعة مستويات من السماد العضوي (صفر،20،40،60 طن/هكتار) وثلاثة مســـتويات من السماد الكيميائي (صفر،30،60 كغم/هكتار) على نمو وإنتاجية ونسبة الزيت العطري في الشـــمر. اســـتخدم تصـــميم القطاعات العشوائية المنشقة بثلاث مكررات.

أظهرت النتائج أن إضافة السماد العضوي مع السماد الكيميائي أدى إلى زيادة معنوية في ارتفاع نبات الشـــمر، وعـــدد فروعه والوزن الرطب والجاف ونسبة وكمية الزيت في الثمار ، عند مقارنتها بمعاملات التسميد الكيميـــائي . وتبـــين أن محتوى النبات من النيتروجين والبوتاسيوم زاد معنوياً بزيادة معدل السماد العضوي أو بإضافة السماد الكيميائي بينمـــا لـــم يتأثر معنوياً محتوى النبات من الفسفور في كل معاملات التسميد. وقد ارتفع محتوى التربة من المادة العضوية ،والتوصيل الكهربائي (EC) معنويا بإضافة الأسمدة العضوية ولم تتأثر درجة حموضة التربة(pH) في كافة المعاملات.

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