



RESPONSE OF SWEET MARJORAM PLANTS TO ORGANIC AND BIO. AND/OR MINERAL FERTILIZATION TREATMENTS

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Received: 24 August 2014

Accepted: 29 October 2014

ABSTRACT

An experimental trail was carried out at the Floriculture Nursery, Fac. of Agric., Minia Univ., during the two successive seasons of 2011/2012 and 2012/2013 to study the effect of FYM and bio. and/or mineral NPK on marjoram plants. The data showed that, using 25 m³/fed. FYM significantly increased vegetative growth (plant height, number of branches/plant/cut, herb fresh and dry weights/plant/cut and total herb yield/plant/season, as fresh and dry weights), oil production (essential oil %, oil yield/plant/cut and oil yield/plant/season) and chemical composition (chlorophyll a, b and carotenoids contents, as well as, the percentages of N, P and K) over the other two used levels (15 and 20 m³/fed.) or control. Fertilizing plants with biofertilizers (phosphorein + Effective microorganisms), bio. + 50 or 75 % NPK dose or mineral NPK (full dose) led to significant increases in all previous studied characters comparing with control treatment. The treatment of bio. + 75 % NPK dose followed by NPK (full dose) treatment were the most effective ones in this concern. It may be recommended to use FYM at the rate of 25 m³/fed. and treating plants with bio. + 75 % NPK dose to give the highest values of vegetative growth, essential oil productivity and chemical composition of marjoram plants.

INTRODUCTION

Sweet marjoram (*Origanum majoranum*, L.) plants belonging to Family Lamiaceae is an aromatic perennial herb. Its essential oil is used

as antimicrobial, antispasmodic, digestive, better tonic, diuretic, antidiabetic and antiparalytic drug (Yadava and Khare, 1995). Marjoram has a strong antioxidant activity,

mainly because of its high content of phenolic acids and flavonoids, which is useful in health supplements and food preservation (Vagi *et al.*, 2005).

The effects of mineral fertilizers in increasing growth, essential oil percentage and yield, as well as, chemical composition of marjoram plants were reported by Refaat (1988), Hanafy (1989), El-Ghadban (1998), Dewidar (2007), Hussein *et al.* (2008) and Shalan (2009).

Many authors demonstrated that organic fertilization treatments significantly increased vegetative growth, essential oil production, as well as, chemical constituents of marjoram plants (Aflatuni *et al.*, 1993; El-Ghadban, 1998; El-Sayed *et al.*, 2002; Edris *et al.*, 2003; Gharib *et al.*, 2008; El-Ghandour *et al.*, 2009 and Al-Fraihat *et al.*, 2011).

The important role of bio-fertilizers (phosphorein or E.M.) in increasing vegetative growth, essential oil production, as well as, chemical composition of marjoram plants is recognized by Abo El-Ala (2002), Eid and El-Ghawwas (2002), Kandeel and

Sharaf (2003), Mahfouz (2003), El-Hindi and El-Boraie (2005), Massoud (2007), Hussein *et al.* (2008) and Erika *et al.* (2008).

MATERIALS AND METHODS

This work was carried out during the two successive seasons of 2011/2012 and 2012/2013 at the Floriculture Nursery, Fac. of Agric., Minia Univ. to study the response of *Origanum majoranum*, L. plants to farmyard manure and bio-fertilizer and/or mineral NPK fertilization treatments.

The seeds of marjoram were obtained from Agric. the Research Center of Medicinal and Aromatic plants section, Giza (Egypt), and were sown in the Nursery on November 24th in both seasons. The seedlings were transplanted on March 11th of both seasons. The experimental unit (plot) was 1.5 × 2.0 m and containing 3 rows, 50 cm apart. The seedlings were cultivated in hills, 40 cm apart, therefore, each plot contained 15 plants.

Table (a): Physical and chemical analysis of the used soil in both seasons :

Soil Character	Value		Soil Character	Value	
	2011/ 2012	2012 /2013		2011/ 2012	2012/ 2013
Sand %	28.30	28.78	Available P %	15.13	15.57
Silt %	29.99	30.55	Exch. K ⁺ mg/100 g	2.12	2.81
Clay %	41.71	40.67	Exch. Ca ⁺⁺ mg/100 g	31.76	31.14
Soil type	Clay loam	Clay loam	Exch. Na ⁺ mg/100 g	2.42	2.50
Organic matter %	1.54	1.62	Fe	8.51	8.21
Ca CO ₃ %	1.58	1.54	Cu	2.07	2.01
pH (1: 2.5)	7.84	7.71	DTPA Zn	2.76	2.89
E. C. (m mhos / cm)	1.08	1.04	Ext. ppm	Mn	8.24
Total N %	0.07	0.08			8.12

The layout of this experiment was split plot design with three replicates. The main plots included four farmyard

manure (FYM) treatments (0, 15, 20 and 25 m³/fed.), while, the sub-plots were devoted to five treatments

namely control (no fertilizer), phosphorein + Effective microorganisms (phos. + E.M.), phos. + E.M. + 50 % NPK, phos. + E.M. + 75 % NPK and 100 % NPK (recommended dose). The recommended mineral NPK fertilization, i.e. 300, 150 and 75 kg/fed. of ammonium nitrate (33.5 %

N), calcium superphosphate (15.5 % P_2O_5) and potassium sulphate (48 % K_2O), respectively. So, 50 and 75 % NPK were 150, 75 and 37.5 kg/fed. and 225, 112.5 and 56.25 kg/fed respectively. Farmyard manure was added during preparing the soil to cultivation in both seasons.

Table (b): Physical and chemical properties of the used FYM:

Properties	2011/ 2012	2012/ 2013	Properties	2011/ 2012	2012/ 2013
Organic matter (%)	27.25	27.75	K (%)	1.11	1.21
Carbon (%)	15.6	15.75	Fe (ppm)	979.4	818.6
Total N (%)	0.83	0.94	Zn (ppm)	271.1	269.2
C/N ratio	18.80	16.76	Mn (ppm)	227.3	237.5
Humidity (%)	8.11	7.99	pH 1:10	7.45	7.21
P (%)	0.26	0.29	E. C. (m mhos / cm)	1.08	1.06

The biofertilizers were applied three times to the soil beside the plants at the rate of 0.3 g/plant of phosphorein and 50 cm³/hill of Effective microorganisms (1 ml = 10⁷ cells of bacteria). The first dose was added after two weeks from transplanting date and repeated two weeks after the first and second cuts. Chemical fertilizers were applied in three equal doses, the first one was added 21 days after transplanting and repeated three weeks after the first and second cuts. All agricultural practices were performed as usual in the region.

The plants were harvested 3 times/season on June 29th, August 17th and November 6th by cutting the vegetative parts at 8 cm above the soil surface.

The following data were recorded or calculated in the three cuts during the two seasons; plant height (cm), number of branches, herb fresh and

dry weights/plant/cut and /plant/season.

Chemical analysis; total chlorophylls (mg/g. F.W.) were determined in fresh leaves according to Moran (1982). Nitrogen, phosphorus and potassium (%) were determined according to Wilde *et al.* (1985), Chapman and Pratt (1975) and Cottenie *et al.* (1982), respectively. Essential oil (%) of herb was determined according to British Pharmacopoeia (1963), essential oil yield (ml/plant/cut and /plant).

The obtained data were statistically analysed according to MSTAT-C (1986). The differences between means were tested using the L.S.D. at 5 % level.

RESULTS AND DISCUSSION

1-Effect of FYM and bio. and/or mineral NPK fertilization on the

vegetative growth of *Origanum majoranum* plant :

Data presented in Tables (1 to 5) showed that plant height, number of branches/plant/cut, herb fresh and dry weights/plant/cut and total herb fresh and dry weights/plant/season were significantly increased due to the three tested FYM fertilization treatments compared with the control treatment in both seasons. The treatment of FYM at the high level (25 m³/fed.) was superior than the other treatments in this concern.

The stupendous effect of FYM may be due to the fact that the decomposition of organic matter decreased the pH value and consequently nutrients in the soil which became more available to plant, hence, it enhanced plant growth. Moreover the increment in number of branches in the second and third cuts may be due to removing the terminal buds (Nijjar, 1985 and Lambers *et al.*, 2000). Similar results were obtained by El-Sayed *et al.* (2002); Gharib *et al.* (2008); El-Ghandour *et al.* (2009) and Al-Fraihat *et al.* (2011) on marjoram plants.

All used bio. and/or mineral NPK fertilization treatments led to significant enhancement of vegetative growth traits (plant height, number of branches/plant/cut, herb fresh and dry weights/plant/cut, as well as, total herb yield either fresh or dry weight/plant/season) in comparison with control treatment. The highest values were resulted from the treatment of bio + 75 % NPK followed by the treatment of 100 % NPK

without significant differences between them in all cases.

The stimulatory effects of the treatment of biofertilizers (phosphorein and effective microorganisms) plus 75 % NPK or NPK (full dose) on growth might be due to the increase in N, P and K, which came from adding NPK. Moreover the increase in N, P, vitamins, auxins, gibberellins, sugars and amino acids adding bacteria, that enhanced plant growth (Sprenat, 1990, El-Merich *et al.*, 1997 and Lambers *et al.*, 2000). Similar results were obtained by Dewidar (2007); Hussein *et al.* (2008) and Shalan (2009) on marjoram concerning the effects of mineral NPK. The important role of biofertilizers in increasing vegetative growth of marjoram plants is recognized by Mahfouz (2003); El-Hindi and El-Boraie (2005) and Erika *et al.* (2008).

The interaction between FYM and bio. and/or mineral NPK fertilization treatments was significant for the six previous parameters in both seasons. The best interaction treatments, were FYM at 25 m³/fed. in combination with bio. + 75 % NPK or full dose of NPK.

2-Effect of FYM and bio. and/or mineral NPK fertilization on essential oil production of marjoram plant.

Data presented in Tables (6, 7 and 8) revealed that the three levels of FYM treatments increased essential oil % and oil yield (ml/plant/cut and /plant/season) over the control with significant differences between themselves. The most effective treatment, which gave the greatest

essential oil % and yield was the high level (25 m³/fed.) of FYM. The stimulatory effect of FYM on essential oil % may be due to that organic fertilization enhances oil biosynthesis. It is evident from data that both traits of herb weight/plant/cut and essential oil % affected the values of essential oil yield/plant during the three cuts in both seasons. These results are in agreement with those of Edris *et al.* (2003) and Gharib *et al.* (2008) on marjoram plants, Ateia *et al.* (2009) on *Thymus vulgaris* and Abdou *et al.* (2012a) on *Mentha piperita*.

The obtained results in Tables (6, 7 and 8) proved that the essential oil % and essential oil yield/plant/cut were significantly increased due to all used four treatments of bio. and/or mineral NPK fertilization when compared to the control during the three cuts in both seasons. Also, all treatments significantly increased essential oil yield/plant/season, in both seasons, compared with control treatment. The most effective treatment which produced the highest essential oil % and oil yield/plant/cut or per plant/season was phosphorein + E.M. + 75 % NPK dose. The plants which received biofertilizers plus reduced dose of mineral NPK contained the highest essential oil and this result may be due to that fertilization enhances oil biosynthesis. In addition to the better role of microorganisms for increasing enzymes, vitamins, proteins, analysis of compounds in soil, promoting hormone and other beneficial substances (organic acids), which enhanced oil biosynthesis.

In this respect, Erika *et al.* (2008) on marjoram and Youssef *et al.* (2004) on sage found that application of biofertilizers increased essential oil productivity. While, Massoud (2007) on marjoram, Golez *et al.* (2006) on sweet basil and Ibrahim (2010) on geranium obtained an increase in essential oil production due to fertilizing plants with NPK.

The interaction between FYM and bio. and/or mineral NPK fertilization treatments was significant for oil % and oil yield (per plant per cut and per plant per season) in both seasons. The highest values were obtained with FYM (25 m³/fed.) in combination with bio. + 75 % NPK dose (Tables 6, 7 and 8).

3- Effect of FYM and bio. and/or mineral NPK fertilization on chemical composition of marjoram plant:

3-a- Photosynthetic pigments:

Data presented in Table (9) showed that all levels of FYM significantly increased chlorophyll a, b and carotenoids over control treatment in both seasons. The high level of FYM (25 m³/fed.) gave significantly the highest chlorophyll a, b and carotenoids contents over other used treatments. Similar results were obtained by El-Ghadban *et al.* (2008) on lavender plants and Abdou *et al.* (2012b) on sage plants.

A significant and positive influence of the four used treatments on chlorophyll a, b and carotenoids contents were recorded in the present study. The treatments of bio. (phosphorein + E.M.) + 75 % NPK followed by mineral NPK (full dose)

were recorded in the present study. The treatments of bio. (phosphorein + E.M.) + 75 % NPK followed by mineral NPK (full dose) were the most effective ones in this concern without significant differences between such two superior treatments in both seasons (Table, 9). Regarding the positive effect of biofertilizers on pigments, these results are in agreement with those obtained by Mosaad (2012) on sage. While, El-Shora (2009) on *Mentha piperita* and Ibrahim (2010) on geranium stated that mineral NPK fertilization increased chlorophyll a, b and carotenoids contents.

The interaction between main and sub-plots was significant for chlorophyll a and chlorophyll b in both seasons. The highest values were obtained due to fertilizing plants with 25 m³/fed. FYM in combination with bio. + 75 NPK dose or mineral NPK (full dose).

3-b- N, P and K percentages :

Data presented in Table (10) showed that the high level of FYM (25 m³/fed.) gave significantly the highest N, P and K % over the two tested levels of FYM or control. These results proved to be true in the two seasons. The increment in nitrogen and phosphorus percentage in the dry leaves by using the FYM may be due to the increasing of available N and P in root zone of marjoram plant as a result of analysis of organic manure which reflect on N and P uptake by plants. Also, FYM led to decrease of pH soil which has an important role in potassium absorption from the soil (Gad, 2001). These results are in

agreement with those reported by El-Ghadban *et al.* (2003) and El-Leithy *et al.* (2007) on *Origanium* spp.

Regarding the effect of bio. and/or mineral NPK fertilization treatments, all four used treatments significantly increased N, P and K % in both seasons over that of check plants (control). The highest values of N, P and K % resulted from the treatment of bio. + 75 % NPK dose followed by mineral NPK (full dose) without significant differences between them in case of N and K % in both seasons.

The increasing of N % was expected since the biofertilizer application was effective microorganisms (E.M.) with adding of NPK which enhance nitrogen uptake. The stimulatory effect bio. + 75 % NPK on P % may be due to increasing available phosphorus in root zone of plants as a result to adding NPK or inoculation with phosphate-dissolving bacteria, which reflect on phosphorus uptake by plants. The stimulatory effect on K % may be due to the co-operation of activation roles of both biofertilizers and mineral NPK.

These results are in harmony with those obtained by Kandeel and Sharaf (2003), Mahfouz (2003), El-Hindi and El-Boraie (2005), Massoud (2007) and Hussein *et al.* (2008) on marjoram regarding the effects of biofertilizers and Gharib *et al.* (2008), El-Ghandour *et al.* (2009) and Al-Fraihat *et al.* (2011) on marjoram concerning the effects of mineral NPK.

Table (1): Effect of FYM and bio. and/or NPK fertilization treatments on plant height (cm) of *Origanum majoranum*, L. in the first, second and third cuts during 2011/2012 and 2012/2013 seasons.

Bio. and/or NPK treatments	Farmyard manure levels (FYM as m ³ /fed.) (A)									
	1 st season					2 nd season				
	0.0	15	20	25	Mean (B)	0.0	15	20	25	Mean (B)
	1 st cut									
Control	26.10	28.60	31.21	33.75	29.92	27.11	29.75	32.35	34.90	31.03
Phos. + E.M.	29.18	31.80	34.41	36.95	33.09	30.29	32.94	35.62	38.00	34.21
Bio + 50 % NPK	31.34	33.95	36.61	37.15	34.76	32.57	35.00	37.84	38.31	35.93
Bio + 75 % NPK	34.45	37.16	40.94	43.53	39.02	35.67	38.35	42.00	44.81	40.21
100 % NPK	34.15	36.85	39.60	42.21	38.20	35.25	38.00	40.85	43.42	39.38
Mean (A)	31.04	33.67	36.55	38.72		32.18	34.81	37.85	39.89	
L.S.D. at 5 %	A: 0.10		B: 0.83		AB: 1.66	A: 0.32		B: 0.84		AB: 1.68
	2 nd cut									
Control	23.81	25.91	28.18	30.25	27.04	24.71	26.95	29.31	31.38	28.09
Phos. + E.M.	26.35	28.90	31.25	33.85	30.09	27.15	29.81	32.31	35.15	31.15
Bio + 50 % NPK	27.18	29.85	32.45	34.95	31.11	29.10	31.71	34.25	36.71	32.94
Bio + 75 % NPK	30.15	32.71	35.55	38.00	34.10	30.70	33.45	36.71	38.90	34.94
100 % NPK	30.00	32.55	35.40	37.50	33.86	30.16	32.90	35.58	38.11	34.19
Mean (A)	27.50	29.98	32.57	34.91		28.36	30.96	33.63	36.05	
L.S.D. at 5 %	A: 0.93		B: 0.84		AB: 1.68	A: 0.25		B: 0.78		AB: 1.56
	3 rd cut									
Control	24.23	26.35	28.61	30.46	27.41	25.11	27.33	29.75	31.79	28.50
Phos. + E.M.	26.80	29.31	31.68	34.28	30.32	27.57	30.25	32.72	35.56	31.53
Bio + 50 % NPK	27.56	30.30	32.88	35.37	31.53	29.53	32.15	34.66	37.18	33.38
Bio + 75 % NPK	30.65	33.25	36.05	38.51	34.62	31.19	33.95	37.22	39.43	35.45
100 % NPK	30.54	32.99	35.90	38.01	34.36	30.67	33.41	36.09	38.69	34.72
Mean (A)	27.96	30.44	33.02	35.33		28.81	31.42	34.09	36.53	
L.S.D. at 5 %	A: 1.44		B: 0.31		AB: 0.62	A: 0.51		B: 0.74		AB: 1.48

Phos. = Phosphorein; *E.M.* = Effective microorganisms; *Bio.* = *Phos.* + *EM.*

Table (2): Effect of FYM and bio. and/or NPK fertilization treatments on number of branches/plant of *Origanum majoranum*, L. in the first, second and third cuts during 2011/2012 and 2012/2013 seasons.

Bio. and/or NPK treatments	Farmyard manure levels (FYM as m ³ /fed.) (A)									
	1 st season					2 nd season				
	0.0	15	20	25	Mean (B)	0.0	15	20	25	Mean (B)
	1 st cut									
Control	9.83	14.10	19.00	21.81	16.19	10.65	14.89	19.58	22.66	16.99
Phos. + E.M.	13.81	18.55	22.95	25.75	20.27	14.71	18.99	23.65	26.71	21.02
Bio + 50 % NPK	15.95	20.81	25.00	27.88	22.41	14.48	20.12	25.98	31.43	23.00
Bio + 75 % NPK	19.11	23.95	28.41	31.25	25.68	17.55	23.33	29.15	34.88	26.23
100 % NPK	19.00	23.75	28.16	31.11	25.51	17.40	23.18	29.00	34.65	26.06
Mean (A)	15.54	20.23	24.70	27.56		14.96	20.10	25.47	30.07	
L.S.D. at 5 %	A: 0.28		B: 0.20		AB: 0.40	A: 0.25		B: 0.21		AB: 0.42
	2 nd cut									
Control	11.80	17.06	22.80	26.18	19.46	12.78	17.87	23.50	27.20	20.34
Phos. + E.M.	16.81	22.55	27.87	31.25	24.62	17.95	23.17	28.85	32.59	25.64
Bio + 50 % NPK	19.46	25.39	30.50	34.01	27.34	17.67	24.58	31.70	38.35	28.08
Bio + 75 % NPK	23.51	29.25	34.94	38.44	31.54	21.60	28.75	35.86	42.90	32.28
100 % NPK	23.37	29.21	34.64	38.27	31.37	21.40	28.51	35.69	42.62	32.06
Mean (A)	18.99	24.69	30.15	33.63		18.28	24.58	31.12	36.73	
L.S.D. at 5 %	A: 0.31		B: 0.38		AB: 0.76	A: 0.45		B: 0.51		AB: 1.02
	3 rd cut									
Control	18.29	26.44	35.34	40.58	30.16	19.81	27.70	36.43	42.16	31.53
Phos. + E.M.	26.05	34.95	43.20	48.45	38.16	27.82	35.91	44.72	50.52	39.74
Bio + 50 % NPK	30.16	39.36	47.29	52.75	42.39	37.49	38.10	49.14	59.44	43.54
Bio + 75 % NPK	36.54	45.44	54.26	59.68	48.98	33.58	44.66	55.68	66.60	50.13
100 % NPK	36.22	45.28	53.69	59.32	48.63	33.17	44.19	55.32	66.06	49.69
Mean (A)	29.45	38.29	46.76	52.16		28.37	38.11	48.26	56.96	
L.S.D. at 5 %	A: 0.83		B: 0.42		AB: 0.84	A: 0.92		B: 0.54		AB: 1.08

Phos. = Phosphorein; *E.M.* = Effective microorganisms; *Bio.* = *Phos.* + *EM.*

Table (3): Effect of FYM and bio. and/or NPK fertilization treatments on herb fresh weight of *Origanum majoranum*, L. in the first, second and third cuts during 2011/2012 and 2012/2013 seasons.

Bio. and/or NPK treatments	Farmyard manure levels (FYM as m ³ /fed.) (A)									
	1 st season					2 nd season				
	0.0	15	20	25	Mean (B)	0.0	15	20	25	Mean (B)
	1 st cut									
Control	22.3	32.0	43.0	48.0	36.3	24.2	33.8	44.5	51.4	38.5
Phos. + E.M.	31.4	42.1	52.1	58.4	46.0	33.4	43.1	53.7	60.6	47.7
Bio + 50 % NPK	36.2	47.2	56.8	63.3	50.9	32.9	45.7	58.9	71.4	52.2
Bio + 75 % NPK	43.4	54.4	64.5	70.9	58.3	39.8	53.0	66.2	79.2	59.6
100 % NPK	43.1	53.9	63.8	70.5	57.8	39.5	52.6	65.8	78.7	59.2
Mean (A)	35.3	45.9	56.0	62.2		34.0	45.6	57.8	68.3	
L.S.D. at 5 %	A: 0.69		B: 0.50		AB: 1.0	A: 1.1		B: 0.5		AB: 1.0
	2 nd cut									
Control	26.9	38.9	52.0	59.7	44.4	29.1	40.7	53.6	59.8	45.8
Phos. + E.M.	38.5	51.4	63.5	71.3	56.2	40.9	52.8	65.8	74.3	58.5
Bio + 50 % NPK	44.4	57.9	69.5	77.5	62.3	40.3	56.0	72.3	87.4	64.0
Bio + 75 % NPK	53.6	66.7	79.7	87.6	71.9	49.2	65.6	81.8	97.8	73.6
100 % NPK	53.3	66.6	78.9	87.3	71.5	48.8	65.0	81.4	97.2	73.1
Mean (A)	43.3	56.3	68.7	76.7		41.7	56.0	71.0	83.3	
L.S.D. at 5 %	A: 1.3		B: 1.1		AB: 2.2	A: 1.4		B: 1.3		AB: 2.6
	3 rd cut									
Control	41.5	60.0	80.2	92.1	68.5	44.9	62.9	82.7	95.7	71.6
Phos. + E.M.	59.1	79.3	98.0	109.0	86.4	63.1	81.5	101.5	114.5	90.2
Bio + 50 % NPK	68.4	89.3	107.3	119.7	96.2	62.4	86.4	111.5	134.0	98.6
Bio + 75 % NPK	82.9	103.1	123.1	135.4	111.1	76.2	101.3	126.3	151.2	113.8
100 % NPK	82.2	102.7	121.8	134.6	110.3	75.2	100.3	125.6	149.9	112.8
Mean (A)	66.8	86.9	106.1	118.2		64.4	86.5	109.5	129.1	
L.S.D. at 5 %	A: 1.6		B: 1.4		AB: 2.8	A: 1.4		B: 1.8		AB: 3.6

Phos. = Phosphorein; E.M. = Effective microorganisms; Bio. = Phos. + EM.

Table (4): Effect of FYM and bio. and/or NPK fertilization treatments on herb dry weight of *Origanum majoranum*, L. in the first, second and third cuts during 2011/2012 and 2012/2013 seasons.

Bio. and/or NPK treatments	Farmyard manure levels (FYM as m ³ /fed.) (A)									
	1 st season					2 nd season				
	0.0	15	20	25	Mean (B)	0.0	15	20	25	Mean (B)
	1 st cut									
Control	8.47	12.16	16.34	18.24	13.80	9.20	12.84	16.91	19.53	14.62
Phos. + E.M.	11.61	15.57	19.27	21.60	17.01	12.35	15.94	19.86	22.42	17.64
Bio + 50 % NPK	13.03	16.99	20.45	22.79	18.32	11.84	16.45	21.20	25.70	18.80
Bio + 75 % NPK	15.19	19.04	22.58	24.82	20.41	13.93	18.55	23.17	27.72	20.84
100 % NPK	15.10	18.87	22.33	24.68	20.25	13.83	18.41	23.03	27.55	20.71
Mean (A)	12.68	16.53	20.19	22.43		12.23	16.44	20.83	24.58	
L.S.D. at 5 %	A: 0.38		B: 0.48		AB: 0.96	A: 0.47		B: 0.46		AB: 0.92
	2 nd cut									
Control	9.68	14.00	18.72	21.49	15.97	10.48	14.65	19.30	21.53	16.49
Phos. + E.M.	13.86	18.50	22.86	25.67	20.22	14.72	19.01	23.69	26.75	21.04
Bio + 50 % NPK	15.54	20.27	24.33	26.25	21.60	14.11	19.60	25.31	30.59	22.40
Bio + 75 % NPK	18.22	22.68	27.10	29.78	24.45	16.73	22.30	27.81	33.25	25.02
100 % NPK	18.12	22.64	26.83	29.68	24.32	16.59	22.10	27.68	33.05	24.86
Mean (A)	15.08	19.62	24.00	26.68		14.53	19.53	24.76	29.03	
L.S.D. at 5 %	A: 0.58		B: 0.72		AB: 1.44	A: 0.48		B: 0.75		AB: 1.50
	3 rd cut									
Control	14.53	21.00	28.07	32.24	23.96	15.72	22.02	28.95	33.50	25.05
Phos. + E.M.	20.68	27.75	34.30	38.15	30.22	22.08	28.52	35.52	40.11	31.56
Bio + 50 % NPK	23.25	30.36	36.48	40.69	32.70	21.21	29.37	37.91	45.55	33.51
Bio + 75 % NPK	27.35	34.02	40.62	44.68	36.67	25.14	33.42	41.67	49.90	37.53
100 % NPK	27.13	33.89	40.19	44.41	36.41	24.82	33.00	41.45	49.47	37.19
Mean (A)	22.59	29.40	35.93	40.03		21.79	29.27	37.10	43.71	
L.S.D. at 5 %	A: 0.56		B: 0.69		AB: 1.38	A: 0.66		B: 0.86		AB: 1.72

Phos. = Phosphorein; *E.M.* = Effective microorganisms; *Bio.* = Phos. + *EM.*

Table (5a): Effect of FYM and bio. and/or NPK fertilization treatments on total fresh weight herb/plant/season (g/plant) of *Origanum majoranum*, L. during 2011/2012 and 2012/2013 seasons.

Bio. and/or NPK treatments	Farmyard manure levels (FYM as m ³ /fed.) (A)									
	1 st season					2 nd season				
	0.0	15	20	25	Mean (B)	0.0	15	20	25	Mean (B)
	Total fresh weight of herb/plant/season (g/plant)									
Control	90.7	131.5	181.2	199.8	150.80	98.2	137.4	180.8	206.9	155.83
Phos. + E.M.	128.8	172.8	213.6	238.7	188.48	137.4	177.4	221.0	249.5	196.33
Bio + 50 % NPK	149.0	194.4	233.6	260.5	209.38	135.6	188.1	242.7	292.8	214.80
Bio + 75 % NPK	179.9	224.2	267.3	293.9	241.33	165.2	219.9	274.3	328.2	246.90
100 % NPK	178.6	223.2	264.5	292.4	239.68	163.5	217.8	272.8	325.8	244.98
Mean (A)	145.4	189.22	232.04	257.06		139.98	188.12	238.32	280.64	
L.S.D. at 5 %	A: 13.1		B: 18.4		AB: 36.7	A:15.6		B:16.2		AB: 32.4

Phos. = Phosphorein; E.M. = Effective microorganisms; Bio. = Phos. + EM.

Table (5b): Effect of FYM and bio. and/or NPK fertilization treatments on total fresh weight of herb/plant/season (g/plant) of *Origanum majoranum*, L. during 2011/2012 and 2012/2013 seasons.

Bio. and/or NPK treatments	Farmyard manure levels (FYM as m ³ /fed.) (A)									
	1 st season					2 nd season				
	0.0	15	20	25	Mean (B)	0.0	15	20	25	Mean (B)
	Total dry weight of herb/plant/ season (g/plant)									
Control	32.68	47.16	63.13	71.97	53.74	35.40	49.51	65.16	74.53	56.15
Phos. + E.M.	46.15	61.82	76.43	85.42	67.46	49.15	63.47	79.07	89.29	70.25
Bio + 50 % NPK	51.82	67.62	81.26	89.73	72.61	47.16	65.42	84.42	101.84	74.71
Bio + 75 % NPK	60.76	75.79	90.30	99.28	81.53	55.80	74.27	92.65	110.87	83.40
100 % NPK	60.35	76.40	89.25	98.77	81.19	55.24	73.51	92.16	110.07	82.75
Mean (A)	50.35	65.76	80.07	89.03		48.55	65.24	82.69	97.32	
L.S.D. at 5 %	A: 4.00		B: 5.10		AB: 10.20	A: 2.00		B: 3.40		AB: 6.80

Phos. = Phosphorein; *E.M.* = Effective microorganisms; *Bio.* = Phos. + EM.

Table (6): Effect of FYM and bio. and/or NPK fertilization treatments on essential oil % /cut of *Origanum majoranum*, L. in the first, second and third cuts during 2011/2012 and 2012/2013 seasons.

Bio. and/or NPK treatments	Farmyard manure levels (FYM as m ³ /fed.) (A)									
	1 st season					2 nd season				
	0.0	15	20	25	Mean (B)	0.0	15	20	25	Mean (B)
	1 st cut									
Control	0.73	0.75	0.78	0.80	0.77	0.74	0.77	0.81	0.84	0.79
Phos. + E.M.	0.83	0.86	0.93	0.99	0.90	0.85	0.88	0.95	1.01	0.92
Bio + 50 % NPK	0.85	0.94	1.05	1.18	1.01	0.87	0.96	1.06	1.22	1.03
Bio + 75 % NPK	0.99	1.23	1.45	1.57	1.31	1.02	1.26	1.49	1.63	1.35
100 % NPK	0.94	0.99	1.21	1.33	1.12	0.97	1.05	1.25	1.39	1.17
Mean (A)	0.87	0.95	1.08	1.17		0.89	0.98	1.11	1.22	
L.S.D. at 5 %	A: 0.04		B: 0.05		AB: 0.10	A: 0.05		B: 0.05		AB: 0.10
	2 nd cut									
Control	0.75	0.78	0.80	0.84	0.79	0.76	0.80	0.83	0.88	0.82
Phos. + E.M.	0.87	0.92	0.99	1.06	0.96	0.88	0.94	1.02	1.10	0.99
Bio + 50 % NPK	0.88	0.98	1.11	1.23	1.05	0.89	1.01	1.14	1.26	1.07
Bio + 75 % NPK	1.18	1.31	1.57	1.69	1.44	1.22	1.35	1.63	1.74	1.49
100 % NPK	1.00	1.24	1.43	1.59	1.32	1.04	1.29	1.50	1.69	1.38
Mean (A)	0.94	1.05	1.18	1.28		0.96	1.08	1.22	1.33	
L.S.D. at 5 %	A: 0.06		B: 0.06		AB: 0.12	A: 0.07		B: 0.05		AB: 0.10
	3 rd cut									
Control	0.69	0.72	0.75	0.78	0.74	0.71	0.75	0.79	0.83	0.77
Phos. + E.M.	0.79	0.82	0.88	0.94	0.86	0.82	0.86	0.93	0.99	0.90
Bio + 50 % NPK	0.81	0.89	1.00	1.12	0.96	0.84	0.91	1.03	1.16	0.99
Bio + 75 % NPK	0.97	1.19	1.33	1.51	1.25	0.99	1.22	1.36	1.57	1.29
100 % NPK	0.92	0.97	1.12	1.22	1.06	0.95	1.02	1.17	1.28	1.11
Mean (A)	0.84	0.92	1.02	1.11		0.86	0.95	1.06	1.17	
L.S.D. at 5 %	A: 0.04		B: 0.06		AB: 0.12	A: 0.06		B: 0.07		AB: 0.14

Phos. = Phosphorein; E.M. = Effective microorganisms; Bio. = Phos. + EM.

Table (7): Effect of FYM and bio. and/or NPK fertilization treatments on essential oil yield /cut of *Origanum majoranum*, L. in the first, second and third cuts during 2011/2012 and 2012/2013 seasons.

Bio. and/or NPK treatments	Farmyard manure levels (FYM as m ³ /fed.) (A)									
	1 st season					2 nd season				
	0.0	15	20	25	Mean (B)	0.0	15	20	25	Mean (B)
	1 st cut									
Control	0.06	0.09	0.13	0.15	0.11	0.07	0.10	0.14	0.16	0.12
Phos. + E.M.	0.10	0.13	0.18	0.21	0.16	0.10	0.14	0.19	0.23	0.17
Bio + 50 % NPK	0.11	0.16	0.21	0.27	0.19	0.10	0.16	0.22	0.31	0.20
Bio + 75 % NPK	0.15	0.23	0.33	0.39	0.28	0.14	0.23	0.35	0.45	0.29
100 % NPK	0.14	0.19	0.27	0.33	0.23	0.13	0.19	0.29	0.38	0.25
Mean (A)	0.11	0.16	0.22	0.27		0.11	0.16	0.24	0.31	
L.S.D. at 5 %	A: 0.04		B: 0.04		AB:0.08	A: 0.04		B: 0.03		AB: 0.06
	2 nd cut									
Control	0.07	0.11	0.15	0.18	0.13	0.08	0.12	0.16	0.19	0.14
Phos. + E.M.	0.12	0.17	0.23	0.27	0.20	0.13	0.18	0.24	0.29	0.21
Bio + 50 % NPK	0.14	0.20	0.27	0.32	0.23	0.13	0.20	0.29	0.39	0.25
Bio + 75 % NPK	0.21	0.30	0.43	0.50	0.36	0.20	0.30	0.45	0.58	0.38
100 % NPK	0.18	0.29	0.38	0.47	0.33	0.17	0.29	0.42	0.56	0.36
Mean (A)	0.15	0.21	0.29	0.35		0.14	0.22	0.31	0.40	
L.S.D. at 5 %	A: 0.05		B: 0.07		AB: 0.14	A: 0.07		B: 0.05		AB: 0.10
	3 rd cut									
Control	0.10	0.15	0.21	0.25	0.18	0.11	0.17	0.23	0.28	0.20
Phos. + E.M.	0.16	0.23	0.30	0.36	0.26	0.18	0.25	0.33	0.40	0.29
Bio + 50 % NPK	0.19	0.27	0.36	0.46	0.32	0.18	0.27	0.39	0.53	0.34
Bio + 75 % NPK	0.27	0.41	0.54	0.67	0.47	0.25	0.41	0.57	0.78	0.50
100 % NPK	0.25	0.33	0.45	0.54	0.39	0.24	0.34	0.48	0.63	0.42
Mean (A)	0.19	0.28	0.37	0.46		0.19	0.28	0.39	0.52	
L.S.D. at 5 %	A :0.06		B:0.07		AB:0.14	A :0.06		B:0.06		AB:0.12

Phos. = Phosphorein; *E.M.* = Effective microorganisms; *Bio.* = *Phos.* + *EM.*

Table (8): Effect of FYM and bio. and/or NPK fertilization treatments on essential oil yield/plant/season of *Origanum majoranum*, L. during 2011/2012 and 2012/2013 seasons.

Bio. and/or NPK treatments	Farmyard manure levels (FYM as m ³ /fed.) (A)									
	1 st season					2 nd season				
	0.0	15	20	25	Mean (B)	0.0	15	20	25	Mean (B)
	Total fresh weight of herb/plant/season (g/plant)									
Control	0.23	0.35	0.49	0.58	0.41	0.26	0.38	0.53	0.63	0.45
Phos. + E.M.	0.38	0.53	0.71	0.84	0.62	0.42	0.56	0.76	0.92	0.66
Bio + 50 % NPK	0.44	0.63	0.85	1.05	0.74	0.41	0.62	0.90	1.23	0.79
Bio + 75 % NPK	0.63	0.94	1.29	1.57	1.11	0.60	0.94	1.37	1.81	1.18
100 % NPK	0.57	0.81	1.10	1.34	0.96	0.54	0.81	1.19	1.57	1.03
Mean (A)	0.45	0.65	0.89	1.08		0.44	0.67	0.95	1.23	
L.S.D. at 5 %	A: 0.15		B: 0.010		AB: 0.20	A:0.18		B:0.11		AB:0.22

Phos. = Phosphorein; *E.M.* = Effective microorganisms; *Bio.* = Phos. + *EM.*

Table (9): Effect of FYM and bio. and/or NPK fertilization treatments on chlorophyll a, b and carotenoids (mg/g f.w.) of *Origanum majoranum*, L. in the first, second and third cuts during 2011/2012 and 2012/2013 seasons.

Bio. and/or NPK treatments	Farmyard manure levels (FYM as m ³ /fed.) (A)									
	1 st season					2 nd season				
	0.0	15	20	25	Mean (B)	0.0	15	20	25	Mean (B)
Chlorophyll a										
Control	2.713	2.743	2.773	2.783	2.753	2.749	2.787	2.806	2.827	2.797
Phos. + E.M.	2.790	2.821	2.852	2.863	2.832	2.815	2.858	2.885	2.888	2.862
Bio + 50 % NPK	2.817	2.848	2.877	2.888	2.858	2.851	2.900	2.935	2.941	2.907
Bio + 75 % NPK	2.844	2.876	2.906	2.926	2.888	2.870	2.915	2.958	2.973	2.929
100 % NPK	2.836	2.875	2.903	2.921	2.884	2.865	2.911	2.956	2.970	2.926
Mean (A)	2.800	2.833	2.858	2.874		2.829	2.874	2.908	2.920	
L.S.D. at 5 %	A: 0.014		B: 0.009		AB: 0.018	A: 0.011		B: 0.007		AB: 0.014
Chlorophyll b										
Control	0.894	0.904	0.915	0.916	0.907	0.906	0.918	0.931	0.932	0.922
Phos. + E.M.	0.920	0.930	0.940	0.944	0.934	0.928	0.942	0.951	0.952	0.943
Bio + 50 % NPK	0.927	0.928	0.947	0.950	0.941	0.938	0.955	0.966	0.968	0.957
Bio + 75 % NPK	0.937	0.949	0.956	0.968	0.953	0.951	0.965	0.976	0.988	0.970
100 % NPK	0.935	0.946	0.954	0.964	0.950	0.948	0.964	0.975	0.986	0.968
Mean (A)	0.923	0.933	0.942	0.948		0.934	0.949	0.960	0.965	
L.S.D. at 5 %	A: 0.006		B: 0.005		AB: 0.010	A: 0.005		B: 0.005		AB: 0.010
Carotenoids										
Control	0.915	0.925	0.935	0.938	0.928	0.928	0.940	0.953	0.954	0.944
Phos. + E.M.	0.950	0.961	0.971	0.975	0.964	0.958	0.973	0.982	0.983	0.974
Bio + 50 % NPK	0.956	0.967	0.977	0.982	0.971	0.970	0.986	0.990	0.995	0.985
Bio + 75 % NPK	0.962	0.976	0.982	0.995	0.979	0.975	0.990	0.993	0.999	0.989
100 % NPK	0.961	0.974	0.982	0.993	0.978	0.975	0.988	0.990	0.996	0.987
Mean (A)	0.949	0.961	0.969	0.977		0.961	0.975	0.982	0.985	
L.S.D. at 5 %	A: 0.007		B: 0.006		AB: N.S.	A: 0.003		B: 0.003		AB: N.S.

Phos. = Phosphorein; *E.M.* = Effective microorganisms; *Bio.* = *Phos.* + *EM.*

Table (10): Effect of FYM and bio. and/or NPK fertilization treatments on N, P and K percentages of *Origanum majoranum*, L. in the first, second and third cuts during 2011/2012 and 2012/2013 seasons.

Bio. and/or NPK treatments	Farmyard manure levels (FYM as m ³ /fed.) (A)									
	1 st season					2 nd season				
	0.0	15	20	25	Mean (B)	0.0	15	20	25	Mean (B)
	N %									
Control	3.09	3.35	3.77	4.18	3.60	3.15	3.48	3.86	4.23	3.68
Phos. + E.M.	3.20	3.52	3.97	4.43	3.78	3.35	3.58	4.08	4.45	3.87
Bio + 50 % NPK	3.23	3.59	4.02	4.50	3.83	3.37	3.69	4.12	4.59	3.94
Bio + 75 % NPK	2.97	3.72	4.13	4.62	3.86	3.43	3.83	4.23	4.72	4.05
100 % NPK	3.25	3.62	4.06	4.53	3.86	3.39	3.75	4.18	4.63	3.99
Mean (A)	3.15	3.56	3.99	4.45		3.34	3.67	4.09	4.52	
L.S.D. at 5 %	A: 0.09		B: 0.04		AB: 0.08	A: 0.07		B: 0.06		AB: 0.12
	P %									
Control	0.385	0.443	0.481	0.537	0.461	0.397	0.462	0.500	0.551	0.478
Phos. + E.M.	0.417	0.467	0.517	0.563	0.491	0.424	0.489	0.520	0.581	0.503
Bio + 50 % NPK	0.423	0.470	0.522	0.572	0.497	0.438	0.485	0.535	0.579	0.509
Bio + 75 % NPK	0.441	0.479	0.534	0.577	0.508	0.454	0.498	0.544	0.587	0.521
100 % NPK	0.429	0.471	0.524	0.570	0.499	0.447	0.491	0.541	0.586	0.516
Mean (A)	0.419	0.466	0.516	0.564		0.432	0.485	0.528	0.577	
L.S.D. at 5 %	A: 0.002		B: 0.003		AB: 0.006	A: 0.003		B: 0.004		AB: 0.007
	K %									
Control	2.18	2.67	3.08	3.38	2.83	2.28	2.82	3.21	3.58	2.97
Phos. + E.M.	2.46	2.91	3.31	3.68	3.09	2.56	2.97	3.35	3.88	3.19
Bio + 50 % NPK	2.55	2.96	3.31	3.71	3.13	2.61	3.06	3.38	3.88	3.23
Bio + 75 % NPK	2.65	3.02	3.35	3.86	3.22	2.73	3.18	3.46	4.03	3.35
100 % NPK	2.57	3.00	3.34	3.83	3.19	2.71	3.10	3.50	3.96	3.32
Mean (A)	2.48	2.91	3.28	3.69		2.58	3.03	3.38	3.87	
L.S.D. at 5 %	A: 0.02		B: 0.04		AB: 0.08	A: 0.02		B: 0.03		AB: 0.07

Phos. = Phosphorein; E.M. = Effective microorganisms; Bio. = Phos. + EM.

The interaction between the two main factors was significant for N, P and K % in both seasons. The highest values of N, P and K % were resulted from the treatment of FYM at 25 m³/fed. in combination with bio. + 75 % NPK or 100 % NPK (Table, 10).

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الملخص العربي

استجابة البردقوش لمعاملات التسميد العضوي والحيوي والمعدني

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أجري هذا البحث في مشتل الزينة كلية الزراعة - جامعة المنيا في موسمي 2012/2011 و 2013/2012 ويهدف إلى دراسة تأثير سماد المزرعة والسماد الحيوي أو المعدني أو هما معاً على نباتات البردقوش.

أوضحت النتائج أن استعمال السماد العضوي بمستوى 25 م³/فدان أدى إلى زيادة معنوية في النمو الخضري (ارتفاع النبات ، عدد الفروع/نبات/حشة ، وزن العشب طازج وجاف للنبات/حشة ووزن العشب طازج وجاف للنبات/موسم) وإنتاجية الزيت (النسبة المئوية للزيت العطري ، محصول الزيت للنبات/حشة و محصول الزيت للنبات/موسم) والمكونات الكيماوية (محتوى كلوروفيل أ ، ب والكاروتينويدات والنسب المئوية لكل من النتروجين والفسفور والبوتاسيوم) مقارنة بالمعاملتين الأخرتين (15 ، 20 م³/فدان) أو معاملة الكنترول.

تسميد النباتات بالأسمدة الحيوية (الفسفورين+الميكروبات الدقيقة النشطة) والحيوية + 50 أو 75 % ن فو بو أو الجرعة الكاملة للسماد المعدني (ن فو بو) أدى إلى زيادة معنوية في كل الصفات المدروسة السابقة مقارنة بمعاملة الكنترول. معاملة التسميد الحيوي + 75 % ن فو بو تليها معاملة التسميد المعدني ن فو بو (جرعة كاملة) كانتا أكثر فاعلية في هذا الصدد.

يمكن التوصية باستعمال السماد العضوي عند 25 م³/فدان سماد المزرعة مع معاملة النباتات بخليط من السماد الحيوي + 75 % من السماد المعدني (ن فو بو) للحصول على أفضل نمو وإنتاجية للعشب والزيت العطري والتركيبة الكيماوي للنبات.