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Effect of biofertilizers and organic phosphorus amendments on growth and essential oil of marjoram (*Majorana hortensis L.*)

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ABSTRACT

The effect of bacterial inoculation (biofertilization) and application of faba bean straw and sheep manure considered by the authors to be organic phosphorus sources to marjoram plants that cultivated in field experiment of Atomic Energy Authority, Inshas, Egypt was studied. Faba bean straw and sheep manure were added at rate of 1500 kg P/ ha of both residues. Residues were incorporated into the soil one month prior to marjoram cultivation. Marjoram (root cutting) was inoculated with either *B. polymixa* and/ or *Bradyrhizobium sp.* .The results showed that, growth parameter of marjoram plants were positively affected by bacterial inoculation as well as organic phosphorus sources at three cuts. The herb and oil yield were the highest in case of the combination between sheep manure and *B. polymixa* at the 2nd cut than in control. Nutrient uptake of marjoram plants positively responded to bacterial inoculation and the concerned organic phosphorus sources. The chemical composition of marjoram essential oil did not change due to the bacterial inoculation or applied residues, but the percentages of certain constituents were affected.

Key words: *B. polymixa*, *Bradyrhizobium sp*., Marjoram, Organic phosphorus.

INTRODUCTION

Application of phosphorus fertilizers in agriculture soils has introduced some problems mainly due to P fixation, low recovery and accumulation in soil. Information on chemical forms of phosphorus is fundamental to understanding phosphorus dynamics and its interaction in soil that is necessary for management of phosphorus. Garg and Bahl (2008) reported that, organic materials are known to increase P availability and enhance efficient use of applied P fertilizer.

Marjoram, (*Marjoram hortensi L*,) is a hardy perennial and herbaceous plant which grows in many areas as Egypt and eastern Mediterranean countries. Commercial *Origanum majorana L* oil (sweet marjoram) is used as a spice and condiment. Volatile oil produced by this plant is antispasmodic, digestive, bitter tonic, expectorant, diuretic, antidiabetic, antimicrobial, and antioxidant; it regulates menstruation and carminative astringent, antihysterical, antiasthmatic, antiparalytic drugs. In addition it is used in many industries. It is cultivated as culinary herb and as garden plants (Sivropoulou *et al*. 1996).

High proportions of phosphate-solubilizing microorganisms (PSMs) are concentrated in the rhizosphere of plants, many studies have shown an increase in growth and P-uptake by plants through the inoculation of PSMs in pot experiments and under field conditions (Vassilev *et al*. 2006).

Although PSMs occur in soil, their number is usually not high enough to compete with other microorganisms commonly established in the rhizosphere; therefore, inoculation of plants by target microorganisms at higher rate has beneficial effect. Moreover, only individuals of microorganism may not be effective for plant growth enhancement and crop yield because of their inability to compete with native microorganisms and colonize properly in new soil environment. Hence, a consortium of PSMs is preferred for inoculations so that at least individual of PSMs will be able to establish itself (Mittal *et al.* 2008).

Ghosh and Poi (1998) studied inoculation effect of *Rhizobium*, Phosphate solubilizing bacteria and mycorrhizal organisms on some legume crops. They found that nodulation, plant growth, P-uptake and population of microorganisms in the rhizosphere were high in combined inoculation treatments with all the above microorganisms.

Belimov *et al.* (1995) reported that, inoculation with bacterial mixtures provided a more balance nutrition for plants and improvement in root uptake of nitrogen and phosphorus in a major mechanism of interaction between nitrogen fixing and phosphate solubilizing bacteria.

The present work aimed to study the effect of inoculation with *B. polymixa* and *Bradyrhizobium sp.* (biofertilizer) in presence of faba bean straw and sheep manure considered to be organic phosphorus sources on marjoram plant productivity, oil content and essential oil composition.

MATERIALS AND METHODS

The experiment was carried out in the experimental farm belonging to Soil and Water Research Department, Nuclear Research Center, Atomic Energy Authority, Inshas, Egypt. Some physical and chemical characteristics of the experimental soil are given in Table (1).

Table (1): Some physical and chemical properties of experimental soil

A- Mechanical analysis

Texture	Clay%	Silt%	Fine sand %
Loamy sand	2.98	22.2	74.82

B- Chemical properties

Ca CO_3%	T. P %	T. N %	Organic matter %	Electric conductivity (2.5:1)) dSm^{-1}	pH (2.5:1)
1.0	0.004	0.007	0.03	0.27	7.97

Soluble anions (meq 100 /gm soil)				Soluble cations (meq 100 /gm soil)			
$SO_4^{=}$	Cl^-	HCO_3^-	$CO_3^{=}$	K^+	Na^+	Mg^{++}	Ca^{++}
0.53	1.25	0.88	----	0.09	0.32	1	1.25

The experiment was performed in a simple complete randomized block design; the experimental area was divided into equal size plots: the plot area was 1.5 x 3 meters, containing three ridges 50 cm apart, every ridge was 3 meters long containing 10 plants at 30 cm in between. Plant and animal residues (feba bean straw and sheep manure) were added at rate of 1500 Kg P/ ha calculated on the base of P % of each residues, Table (2).

Table (2): Some chemical characteristics of residues

Determinations	Faba bean straw	Sheep manure
pH (2.5:1)	4.76	6.68
Electric conductivity (2.5:1) dSm^{-1}	5.00	12.3
Organic matter %	74.1	51.6
N %	1.45	2.7
P %	0.33	2.69
K %	0.98	0.43
Fe ($\mu g\ gm^{-1}$)	836	2737
Cu ($\mu g\ gm^{-1}$)	114	155
Mn (μ g gm^{-1})	103	156
Zn (μ g gm^{-1})	225	131

Residues were grained with a suitable mill and then incorporated with soil during its preparation for cultivation. Residues and bacterial inoculation (B. *polymixa* and /or *Bradyrhizobium sp.* 10^8 c.f.u. /ml) were incorporated into the soil one month prior to cultivation marjoram, soil being maintained wet till planting. Ammonium sulphate (20.5% N) was added at a rate of 750 Kg N /ha as splitted into three equal doses. The first addition was carried out 30 days after transplanting, the second addition was performed after one week from the first cut (3 months after transplanting) and finally the third one was after one weak from the second cut (5 months after transplanting). Rooted cuttings of marjoram were obtained from Sekem Academy for Applied Research in Haikestep, Cairo, Egypt under an organic farming system. Rooted cuttings of marjoram were inoculated with *B. polymixa* and /or *Bradyrhizobium sp.* (10^8 c.f.u./ml). One milliliter of this inoculum was applied to each rooted cuttings in the planting hole and inoculation was repeated after each cut.

The experiment design:-

The experimental treatments were as following:

1-Faba bean straw (uninoculated)

2-Faba bean straw + *B. polymixa*

3- Faba bean straw + *Bradyrhizobium sp.*

4- Faba bean straw + *B. polymixa*+ *Bradyrhizobium sp.*
5- Sheep manure (uninoculated)
6-Sheep manure + *B .polymixa*
7- Sheep manure + *Bradyrhizobium sp.*
8- Sheep manure + *B. polymixa* + *Bradyrhizobium sp.*

Herb parameters determination

Three cuts were harvested, the first one being after three months of planting the second one after five months and the third one after seven months. Herb fresh yield was recorded after each cut. Dry weight of herb were recorded after drying in an oven at 60^{O}C. Total phosphorus content of herb was determined by Murphy and Riley (1962) method and total nitrogen content was determined by Kjeldahl method Bremner and Mulvaney, (1982). Essential oil content of the air-dried herb of marjoram plant was extracted by steam distillation for 5-6 hrs, according to the method of British pharmacopeia (1963). The volatile oil was trapped in a small volume. After the distillation, the oil was dried over anhydrous sodium sulphate and kept in a deep freezer at 2 ^{O}C until analysis. The oil extracted from plant samples of control and the best treatment which gave the highest essential oil yield were analyzed using gas chromatography (GC), to identify and determine its chemical constituents.

All samples were carried out in triplicates, and the data were analyzed according to DUNCAN'S Multiple range test (SAS, 1985).

RESULTS AND DISCUSSION

Herb fresh yield

Bacterial inoculation under application of faba bean straw or sheep manure positively affected herb fresh yield of marjoram compared to control plant. In the second cut, inoculation of *B. polymixa* under sheep manure application lead to the maximum stimulatory effect on herb fresh yield of marjoram plants Table (3), as compared to uninoculated treatments. Where, it showed 157 % increase in herb fresh yield over uninoculated plants, while, inoculation with either *Bradyrhizobium sp.* or dual inoculation resulted in 82 % and 110 % over control one. On the other hand, in case of faba bean straw and dual inoculation at the second cut, herb fresh yield increased by about 23 % over control plant. In case of using sheep manure with *B. polymixa* at the second cut resulted in higher increases in herb fresh yield than those recorded with faba bean straw and dual inoculation at the 3rd cut comparable to the other treatments; it induced relative increase by about 20 % over the faba bean straw with dual inoculation. In most treatments bacterial inoculation with both organic residues, fresh yield at the third cut (9.9 Ton /ha) was much higher than that of the second (9.7 Ton /ha), which in turn was higher than that of the first one (9.2 Ton /ha).

Table (3): Effect of bacterial inoculation, faba bean straw and sheep manure on herb fresh yield (Ton/ha) of marjoram (*Majorana hortensis L*)

Herb fresh yield (Ton /ha) of marjoram									
Organic residues / Bacterial inoculation	First cut			Second cut			Third cut		
	Faba bean straw	Sheep manure	mean	Faba bean straw	Sheep manure	mean	Faba bean straw	Sheep manure	mean
uninoculated	5.8 c	6.0 c	5.9 c	8.8 d	5.2 e	7.0 d	9.4 e	6.4 f	7.9 c
B. polymixa	9.2 ab	10.7 a	9.9 ab	9.9 bc	13.3 a	11.62 a	10.5 bcd	12.4 a	11.5 a
Bradyrhizobium sp.	8.0 b	10.1 a	9.1 b	9.3 cd	9.5 cd	9.38 c	9.6 de	10.1cde	9.9 b
B. polymixa+ *Bradyrhizobium sp.*	10.6 a	10.1 a	10.3 a	10.9 b	10.9 b	10.87 b	11.1 b	10.9 bc	11.0 a
mean	8.4 b	9.2 a		9.7 a	9.7 a		10.2 a	9.9 a	

Means in the same column followed by the same letter are not significantly different at P ≤ 0.05

Abdul Al-Kiyyam *et al*. (2008) reported that, at the first cut, plants developed the root system, having little foliage and thus very low yield was obtained. After the first cut, plants were well established to produce good canopy and thus an increase in yield was obtained. After the second cut, another flush of leaves was produced but it was lower than first cut. Because the plant was at the flowering stage and most of the reserved food was directed toward the production of flowers. Also, Gewaily *et al* (2006) reported that, inoculation of marjoram plant with biofertilizer and using organic residues enhanced the vegetative growth. Treating marjoram plants with bacterial inoculation had increased the formation of branches, that may reflected the enhancement of herb fresh yield. This may be due to the increase of phosphorus mineralization with *B. polymixa* and /or *Bradyrhizobium sp.*. At the same time increases in nitrogen content in the soil as a result of nitrogen fixation may enhance the mineralization process (Abdel-All-Dewidar 2007). Our results are in line with (Eid and El-Ghawwas 2002)

Herb dry yield

With respect to herb dry yield, inoculation with *B. polymixa* combined with sheep manure induced relative increase by about 87.7 % over the uninoculated treatment at the 3rd cut. Also dual inoculation was found to have the same trend but to lower extent where the relative increase was 53.8 % over the uninoculated treatment at the same cut. In this regard, inoculation treatments could be arranged in ascending order as following: *B. polymixa* > *B. polymixa* + *Bradyrhizobium sp.* > *Bradyrhizobium sp.*. On the other hand, in case of using faba bean straw, herb dry yield increased by about 53.8 % and 36.4 % over the uninoculated when combined with dual inocula and *B. polymixa*, respectively, while a little improvement (21 %) was recorded with *Bradyrhizobium sp.* as compared to the control (uninoculated) at the 3rd cut, Table (4).

Table (4) Effect of bacterial inoculation, faba bean straw and sheep manure on herb dry yield (Ton /ha) of marjoram (*Majorana hortensis L*)

Organic residues / Bacterial inoculation	Herb dry yield (Ton /ha) of marjoram								
	First cut			Second cut			Third cut		
	Faba bean straw	Sheep manure	mean	Faba bean straw	Sheep manure	mean	Faba bean straw	Sheep manure	mean
uninoculated	1.9 d	1.9 d	1.9 c	2.5 bc	1.9 c	2.2 b	2.5 ef	2.1 f	2.3 c
B. polymixa	2.9 b	3.6 a	3.3 a	3.3 ab	3.8 a	3.6 a	3.4 bc	3.9 a	3.7 a
Bradyrhizobium sp.	2.5 c	2.9 b	2.7 b	2.5 bc	2.6 bc	2.6 b	3.0 cd	2.8 de	2.9 b
B. polymixa+ *Bradyrhizobium sp.*	3.2 ab	3.5 a	3.3 a	3.5 a	3.6 a	3.6 a	3.8 a	3.7 ab	3.7 a
Mean	2.6 b	2.9 a		2.9 a	2.9 a		3.2 a	3.1 a	

Means in the same column followed by the same letter are not significantly different at $P \leq 0.05$

Herb dry yield values during the three cut behaved similarly in the same trend shown by herb fresh yield of marjoram plant for both organic residues. In general, inoculation induced significant increases of herb dry yield when accompanied with sheep manure and faba bean straw during the three studied cuts.

The interaction between bacterial inoculations had significant influence on herb dry yield due to bacterial inoculation. These results confirmed the result obtained by Gewaily *et al* (2006).The increase in total herb dry yield may be due to increase in herb fresh yield, which was reflected as an increase in the number of basal branches, total branches, leaves number and yield. Consequently the total herb dry yield increased, especially in presence of bacterial inoculation in soil (Abdul Al-Kiyyam *et al*. 2008)

P uptake

At the third cut, the maximum value of herb P uptake was obtained by *B. polymixa* combined with sheep manure followed by dual inoculation then *Bradyrhizobium sp.*. It relatively accounts for 162 %, 133 % and 68 % over the uninoculated ones, respectively Table (5).

Table (5) Effect of bacterial inoculation, faba bean straw and sheep manure on phosphorus uptake (Kg/ha) of marjoram (*Majorana hortensis L*)

Organic residues / Bacterial inoculation	Phosphorus uptake (Kg /ha) of marjoram								
	First cut			Second cut			Third cut		
	Faba bean straw	Sheep manure	mean	Faba bean straw	Sheep manure	mean	Faba bean straw	Sheep manure	mean
uninoculated	4.13 e	4.2 e	4.2 c	5.1 cd	3.9 d	4.6 c	5.1 e	4.4 e	4.8 c
B. polymixa	8.3 bcd	10.2 a	9.2 a	8.9 ab	11.2 a	10.1 a	9.4 c	11.7 a	10.5 a
Bradyrhizobium sp.	6.7 d	7.9 cd	7.3 b	6.7 bc	6.8 bc	6.8 b	7.9 d	7.5 d	7.7 b
B. polymixa+ *Bradyrhizobium sp.*	8.9 abc	9.6 ab	9.2 a	10.3 a	9.9 a	10.1 a	10.9 ab	10.4 bc	10.6 a
mean	6.9 b	7.9 a		7.8 a	8.0 a		8.3 a	8.5 a	

Means in the same column followed by the same letter are not significantly different at $P \leq 0.05$

On the other hand in case of using of faba bean straw, P uptake increased by about 113 % and 85 %, over the uninoculated treatment, when combined with dual inocula and *B. polymixa* respectively. P uptake at the third cut was much higher than that of the second cut, which in turn was higher than that of the first cut in both organic residues with dual inoculation. These results emphasize the use of bacterial inoculation and organic matter to replace a part of the inorganic phosphorus and in the same time minimize the environmental pollution in the production cost of such medicinal plants (Abou-Aly and Gomaa 2002 and Migahed *et al*. 2004). Many investigators such as Song *et al*. (2000), Melero *et al*. (2006), Kremer and Li (2003) and Criquet *et al*. (2004) explained the role of phosphate solubilizing bacteria on the bases of increases in the availability of phosphorus in the soil through secretion of phosphatase enzyme which leads to transfer organic phosphorus to available form. Consequently, it increases phosphorus absorption and accumulation in plant tissues. Similar increases in nutrient uptake as affected by combined inoculation of *Rhizobium* and PSB were reported by (Rudresh *et al.* 2005)

N uptake

Nitrogen uptake of herb was found to be highest in faba bean straw combined with dual inoculation followed by *B. polymixa* and *Bradyrhizobium sp.*, Table (6).

Table (6) Effect of bacterial inoculation, faba bean straw and sheep manure on nitrogen uptake (Kg /ha) of marjoram (*Majorana hortensis L*)

Organic residues / Bacterial inoculation	Nitrogen uptake (Kg /ha) of marjoram								
	First cut			Second cut			Third cut		
	Faba bean straw	Sheep manure	mean	Faba bean straw	Sheep manure	mean	Faba bean straw	Sheep manure	mean
uninoculated	15.1 e	13.3 e	14.2 d	19.5 d	13.2 d	16.3 c	16.3 c	13.7 c	15.0 c
B. polymixa	39.5 d	57. 6 b	48.5 e	45.2 e	65.6 ab	55.5 b	75.7 b	71.6 b	73.7 b
Bradyrhizobium sp.	47.7 c	59.1 b	53.4 b	51.4 bc	62.9 ab	57.1 b	66.9 b	70.5 b	68.7 b
B. polymixa+ Bradyrhizobium sp.	61.8ab	67.0 a	64.4 a	72.4 a	73.2 a	72.8 a	88.7 a	75.8 b	82.2 a
mean	41.0 b	49.2 a		47.1 a	53.7 a		61.9 a	57.9 a	

Means in the same column followed by the same letter are not significantly different at P ≤ 0.05

It accounts for 5.4, 4.6 and 4.1 fold over the uninoculated for the same sequence at the 3rd cut. The same trend was obtained in case of using sheep manure combined with dual inoculation. Organic residues affected N uptake of marjoram plant in all cutting in all bacterial inoculation. Gewaily *et al*. (2006) stated that, Organic residues supply the plant with the most essential elements required by plants; this leads to the production of energy sources, extra-protein and allow the plant leaves to grow larger and hence to have larger surface available for synthesis.

Generally, dual inoculum was superior over both single inoculum under the three studied cuttings; faba bean straw and sheep manure organic residues were the best in terms of N uptake in case of inoculation with dual inoculation as compared to individual. Belimov *et al* (1995) reported that, the inoculation with bacterial mixtures provided a more nutrition for the plants and the improvement in root uptake of both nitrogen and phosphorus as a balance result of mechanism of interaction between nitrogen fixing and phosphate solubilizing bacteria. El-Komy (2005) demonstrated the beneficial influence of co-inoculation of *Azospirillum lipoferum* and *Bacillus megaterium* for providing balanced nitrogen and phosphorus nutrition of wheat plants**.**

Oil yield

Generally, oil yield was higher in sheep manure amendment treatment compared with that of faba bean straw. The data showed that, increase in the oil yield was due to bacterial inoculation but the reverse effect could be seen in case of uninoculated. Besides, individual inoculation with *B. ploymixa* combined with sheep manure was the best among the other inoculation treatments. With respect to oil yield, this treatment induced relative increase by about 3.3 fold over the control at the 2nd cut Table (7). On the other hand, the incorporation of faba bean straw with dual inoculation induced increase of oil yield.

Table (7) Effect of bacterial inoculation, faba bean straw and sheep manure on oil yield (L /ha) of marjoram ((*Majorana hortensis L*)

Organic residues / Bacterial inoculation	Oil yield (L /ha) of marjoram								
	First cut			Second cut			Third cut		
	Faba bean straw	Sheep manure	mean	Faba bean straw	Sheep manure	mean	Faba bean straw	Sheep manure	mean
Uninoculated	13.7de	9.63 f	11.7 c	12.2 d	11.5 d	11.9 c	11.5 d	12.0 d	11.8 c
B. polymixa	16.2 cd	29.8 a	23.0 a	18.1 c	38.3 a	28.2 a	19.4 c	34.3 a	26.9 a
Bradyrhizobium sp.	12.0 ef	18.7 c	15.4 b	14.4 d	21.3 c	17.9 b	14.5 d	22.9 c	18.7 b
B. polymixa+ Bradyrhizobium sp.	23.3 b	25.1 b	24.2 a	27.6 b	27.6 b	27.6 a	27.6 b	28.3 b	27.9 a
Mean	15.3 b	21.8 a		18.1 b	24.7 a		18.2 b	24.4 a	

Means in the same column followed by the same letter are not significantly different at P ≤ 0.05

In this respect, the relative increase was accounted for 2.4 fold over control at the 3rd cut. Consequently it could be concluded that sheep manure added into the soil and combined with *B. polymixa* was the best treatment for the 2nd cut comparable to the other treatments. In case of using faba bean straw combined with dual inoculation, oil yield was much higher for the third cut than that of the second, which in turn was higher than that of the first one. Relatively, it accounts for 18.3 % for third cut over the first one. While, in case of using sheep manure combined with *B. polymixa* at the 2nd cut, oil yield was much higher than that of the first one. Relatively, it account for 28.6 % for second cut over the first one. Banchio *et al* (2008) reported that, few studies have attempted to elucidate the relative qualitative contributions of rhizobacteria formation secondary compound in essential oil for aromatic crops. Their results suggested that inoculation with *P. fluorescens* and *Bradyrhizobium sp.* can significantly increase oil concentration of *Origanum marjorana L.*

Essential oil constituents:

The percentages of the essential oil components according to the gas chromatography (GC) analysis of samples obtained from plant grown on sandy soil treated with organic residues and bacterial inoculation are shown in Table (8). The GC profile of the essential oil of all plants showed eleven compounds namely eugenol, linalool, trans-sabinene hydrate, cis-sabinene hydrate, linalyl acetate, ά-terpineol, terpinene-4-ol and thymol. The main components were terpinene 4-ol, ά-terpineol, cis -sabinene hydrate, trans-sabinene linalyl acetate and three components unknown.

Table (8) Effect of bacterial inoculation, faba bean straw and sheep manure on constituents of the essential oil (relative concentration) of marjoram (*Majorana hortensis L*)

Peak no	Components %	RRT	uninoculated	faba bean straw+ *B. polymixa* + *Bradyrhizobium sp.* (3rd cut)	uninoculated	sheep manure+ *B. polymixa* (2nd cut)
1	Eugenol	0.44	2.05	2.25	2.00	2.47
2	Linalool	0.53	4.77	4.97	7.00	7.22
3	trans-Sabinene hydrate	0.61	9.81	9.00	10.1	10.55
4	cis - Sabinene hydrate	0.70	13.00	13.55	13.20	14.70
5	Linalyl acetate	0.74	6.93	7.98	11.31	11.45
6	ά-Terpineol	0.83	5.28	6.28	2.00	2.27
7	Terpinene-4-ol	1.00	34.00	35.22	34.23	36.60
8	Thymol	1.03	5.58	5.45	5.0	6.00
9	Unknown	1.07	5.93	5.81	6.22	4.80
10	Unknown	1.27	5.85	5.80	3.64	2.2
11	Unknown	1.36	6.81	4.24	5.60	2.37

RRT: Relative retention time where Terpinene-4-ol was given RRT of 1.00

However, there were clear differences in the quantities of the different constituents of the essential oil between plants treated with bacterial inoculation and those of the control. The highest concentrations of the different compounds in the profile of essential oil of marjoram plants were grown in soil treated sheep manure plus *B. polymixa*. It could be concluded that, the maximum terpinene-4-ol and cis- sabinene content (36.60 and 14.70 %) respectively, was obtained from *B. polymixa* and sheep manure amendment. These two components represented 50 % of the total oil. Trans-sabinene was the third most component in marjoram oil, with concentration (10.55 %). Similar findings were obtained Edris *et al* (2003) on marjoram, they found that terpinene 4-ol and cis -sabinene hydrate were the major constituents obtained from organic fertilization. The essential oil of marjoram plants grown on soil treated with faba bean straw combined with *B. polymixa* plus *Bradyrhizobium sp.*; the profile showed the same compounds in both control and treated plants like those grown on soil treated sheep manure plus *B. polymixa.* However, the concentration of different compounds showed higher percentages compared to control (uninoculated).

CONCLUSION

It can be concluded that, marjoram plants as medicinal plants normally grown on desert areas significantly responded to biofertilization which positively affected plants growth characters and the essential oil yield. So, this work may be considered as applied work, at small scale; it could be used at large scale to replace, at least partly biofertilizers instead of inorganic phosphorus fertilizers in order to reduce the costs of fertilization in specific and to avoid the hazard of environmental pollution, in general.

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ARABIC SUMMARY

تأثير الأسمدة الحيوية والفوسفور العضوى على نمو والزيت الطيار لنبات البردقوش

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أجريت تجربة فى الحقل لدراسة استجابة نبات البردقوش للتلقيح بالأسمدة الحيوية (الباسلس بولوميكس وبراديريزوبيم) فى وجود مصادر من الفوسفور العضوى (قش الفول ومخلفات الغنم).تم إضافة المخلفات إلى التربة الزراعية قبل زراعة نبات البردقوش بشهر. وقد بينت النتائج ان نبات البردقوش كنبات طبى يستجيب للتسميد الحيوى والعضوى.

وجد أن إضافة مخلفات الغنم والمعامل بالميكروبات المختلفة كانت الأفضل فى إعطاء أعلى أنتاج للمجموع الخضرى الطازج لنبات البردقوش يليه قش الفول أثناء الحشات الثلاثة تحت الدراسة بحيث كانت أفضل معاملة هى المتضمنة استخدام مخلفات الغنم مع الباسلس بولوميكس.

وجد أن إضافة مخلفات الغنم مع التلقيح با لباسلس بولوميكس نتج عنة أعلى محتوى من الفوسفور فى المجموع الخضري للبردقوش فى الحشة الثالثة بالمقارنة بالمعاملات الميكروبية الاخرى يلية اضافة قش الفول مع التلقيح المزدوج الذى له لتأثير الأفضل على المحتوى الفوسفور للبردقوش فى الحشة الثالثة بحيث كانت مخلفات الغنم أفضل اضافة عضوية بالمقارنة بالاضافة العضوية الاخرى.

وجد بشكل عام ان التلقيح المزدوج هو الأفضل بالمقارنة بالتلقيح الفردى عند الأخذ فى الاعتبار المحتوى النيتروجينى للمجموع الخضرى وبالنسبة لتأثير الإضافات العضوية أوضحت النتائج أفضلية قش الفول عن مخلفات الغنم

واخيرا ادت المعاملة بمخلفات الغنم مع الباسلس بولوميكس الى زيادة محصول الزيت فى الحشة الثانية يلية المعاملة بقش الفول مع الباسلس بولوميكس وبراديريزوبيم.