# EFFECTIVENESS OF ORGANIC FARMING ON GROWTH PERFORMANCE AND YIELD OF MARJORAM

**Zaghloul, R. A. [1] ; T. M. El-husseiny [1]; Ehsan A. Hanafy[1]; A. GH. Rahal [2] and H. M. A. Abdelrahman[1]**

1- Fac. Agric., Moshtohor, Benha University

2- Soil, Water and Environment Research Inst. Agric. Research Center,

## ABSTRACT

Field experiment was carried out at an organic Farm during 2005- 2006 and 2006-2007 seasons. This experiment was carried out to study the efficiency of biofertilization and compost amendment in presence of *T. harzianum* on some soil enzymes, available nitrogen, phosphorus and potassium, growth characteristics and yield of Marjoram. Obtained data showed that higher records of nitrogenase and phosphatase were observed with dual application of biofertilization and organic manuring in presence of *T. harzianum* rather than each one individually. Similar trend of results was observed with available N, P and K since the available N, P and K records were the highest in dual application of biofertilization and organic manuring. There isn't significant difference of herb yield between the treatments of chemical fertilization and biofertilization treatments.

**key words**: Marjoram, biofertilization, organic manuring, *T. harzianum*, nitrogenase, phosphatase and marjoram herb yield.

## INTRODUCTION

Sweet marjoram (*Majorana hortensis* (M.)) is aromatic herb known to the ancient Egyptians, Greeks and Romans (**Tainter** and **Grenis, 1993**). It has been used not only to flavour food but also as a miraculous herb with the power to heal practically all diseases. Their essential oils have been known since antiquity to possess biological activity, notably antibacterial, antifungal as well as antioxidant properties (**Tiziana** and **Dorman, 1998**).

Nowadays, production of medicinal and aromatic plants using the organic farming became an essential process to ensure the safety, not only for human, but also for the environment.

The potential use of various biological agents as one of organic farming complementation and their effect on growth characters was reported.( **Himadri** and **Dharamvir, 2007)**

Biofertilizers are plant growth promoting rhizobacteria (PGPR) since they induce plant growth promotion by direct or indirect modes of action (**Kloepper, 2003** and **Somers *et al,* 2004**). Direct mechanisms are including the production of stimulatory phytohormones improvement of liberation of phosphates and micronutrients from insoluble sources; non-symbiotic nitrogen fixation and stimulation of disease-resistance mechanisms. Indirect effects are acting like biocontrol agents since they reducing the diseases incidence or protect the plant by degrading xenobiotics in inhibitory infested soils (**Jacobsen, 1997**). Also, biofertilizers contain a variety of beneficial microorganisms and enzymes which accelerate and improve plant growth and protect plants from pests and diseases. (**Abou-Aly *et al*, 2006**).

**Gharib *et al* (2008)** studied the effect of compost and biofertilizers (mixture of *Azospirillum brasiliense*, *Azotobacter chroococcum*, *paenibacillus polymyxa* and *Bacillus circulans*) on growth characteristics, yield and oil constituents of marjoram. They found that the use of of biofertilizers combined with compost gave better results for growth characteristics than those obtained from either $N_2$ fixers (*A. brasiliense, A. chroococcum* and *P. polymyxa*), *B. circulans* or compost individually.

**Mahfouz (2003)** found that application of biofertilizers ( mixture of *A.chroococcum, A. lipoferum, P. polymyxa, Bacillus megatherium and Pseudomonas fluorescence)* led to highly increase of essential oil content in marjoram. **Leithy *et al* (2006)** on rosemary plant found that the essential components were influenced by using of biofertilizer. **Azizi *et al* (2008)** on chamomile reported that essential oil yield increased by the increasing of compost dose .

**Jyoti *et al* (2008)** studied the effect of *A. chroococcum* ($N_2$ fixing) and *Ps. striata* combined with organic manures and vermicompost on productivity, active ingredient and yield of medicinal plant *Coleus forskohlii*. The results showed that the active ingredient of roots of *Coleus forskohlii*, was maximum with biofertilization combined with organic manure.

Therefore, this research was conducted to study the efficiency of various treatments of organic agriculture in form of (combination between organic manuring, biofertilization and biocontrol agents) and their effect on growth performance and yield of marjoram.

## MATERIALS AND METHODS

Field experiments were carried out at an organic Farm in Minoufia Governorate, Egypt, during 2005- 2006 and 2006-2007 seasons. This experiment was designed to study the effect of organic farming agents on growth performance and yield of Marjoram.

Seeds of Marjoram were obtained from Medicinal and Aromatic Research Dept., A.R.C., Ministery of Agriculture.

**Experimental soil .**

Soil samples obtained from different field places were mixed. Representative soil samples were taken from the upper 15 cm layer. Physical and chemical analyses of experimental soil are presented in Table (1).

**Table1. Mechanical and chemical analyses of the experimental soil.**

| Particle size distribution | | | | Textural class | pH | E.C. ( ds/m) | Organic mater % | Soluble cations meq / l | | | | Soluble anions meq / l | | | | Total and available macronutrients (ppm) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | | N | | P | | K | |
| Coarse sand % | Fine sand % | Silt % | Clay % | | | | | $Ca^{++}$ | $Mg^{++}$ | $Na^{+}$ | $K^{+}$ | $HCO_3^{-}$ | $CO_3^{=}$ | $Cl^{-}$ | $SO_4^{=}$ | total | available | total | available | total | available |
| 6.59 | 27.64 | 12.60 | 53.17 | Clay | 8.03 | 2.02 | 2.12 | 12.1 | 5.8 | 0.44 | 1.86 | 4.40 | 0 | 11.2 | 4.6 | 1730 | 53.64 | 561.2 | 130.94 | 3500 | 1612.8 |

Mechanical and chemical analyses were carried out according to the methods described by **Page *et al* (1982)**.

**Table (2): Chemical analysis of compost used in this experiment.**

| parameters | Unit | Value |
|---|---|---|
| **pH** | - | 8.11 |
| **EC (1:5 extract)** | ds/m | 8.21 |
| **Organic matter** | % | 21.57 |
| **Organic-C** | % | 12.54 |
| **Total-N** | % | 1.21 |
| **C/N ratio** | - | 10.36 |
| **Total-P** | % | 0.91 |
| **N-$NH_4$** | ppm | 274.7 |
| **N-$NO_3$** | ppm | 50.1 |

**Experimental design**

Treatments were distributed in a randomized complete block design with three replicates. The experimental area was 10.5 $m^2$ (3 x 3.5 m). This experiment included the following treatments:

- Control1 (non-fertilized and non-inoculated).
- Control 2 (recommended doses of chemical fertilization N,P and K).
- *P. polymyxa* H1, *B. megaterium var phosphaticum*, *B. circulans* and *T. harzianum*.
- *P. polymyxa* H1, *B. megaterium var phosphaticum*, *B. circulans* and *T. harzianum* + half dose of compost.
- *P. polymyxa* H1, B. *megaterium var phosphaticum*, *B. circulans* and *T. harzianum* + 3/4 dose of compost.
- *P. polymyxa* H1, *B. megaterium var phosphaticum*, *B. circulans* and *T. harzianum* + recommended dose of compost.
- Recommended dose of compost (8 ton/ fed).

**Inocula preparation**

Inocula of *P. polymyxa*, *B. megaterium* var. *phosphaticum*, *B. circulans* and *T. harzianum* were prepared in nutrient broth, Modified Bunt and Rovira broth, Alexandrov and gliotoxin fermentation media according to **Cross *et al*, 1968**; **Abdel-Hafez ,1966**; **Zahra 1969** and **Brain** & **Hemming, 1945** respectively.

**Cultivation process.**

Prior to cultivation, plant bed was prepared. The seeds of marjoram were sown in prepared seed beds on 15$^{th}$ October for both study seasons. After 50-60 days seedlings 10-15 cm length were individually transplanted in experimental field.

Chemical fertilizers were supplemented with full dose of inorganic nitrogen (50 kg N/fed) as ammonium sulphate, inorganic phosphorus (25 kg $P_2O_5$/fed) as super phosphate and potassium (40 kg $K_2O$/fed) as potassium sulphate .The chemical fertilizers were applied in tow equal doses i.e. at vegetative and flowering stages.

Compost was added as organic manure to the soil at a rate of recommended dose (8 ton/fed), 1/2 dose and 3/4 dose before planting.

**Biofertilizers and biocontrol agents application**

Except for control treatment, transplants of Marjoram were inoculated by dipping the root system in mixture of cell suspension of each *P. polymyxa H1* ($7x10^{11}$ c.f.u./ml), *B. megatherium var phosphaticum* ($8.3x10^{11}$ c.f.u./ml), *B. circulans* ($4.1x10^{11}$ c.f.u./ml) and *T. harzianum* ($5x10^{7}$ spores/ml) for 60 minutes before transplanting. Sucrose solution (30%) was added as an adhesive agent prior to inoculation. The same prepared inocula were added to the soil three times throughout the growing seasons.

**Microbiological analysis.**

Microbiological analysis (nitrogenase and phosphatase) were carried out in rhizosphere soil samples at (30, 60, 90 and 150 day) from planting. Phosphatase activity was assayed according to **Drobnikova (1961)**, nitrogenase activity was determined by the method described by **(Okafor** and **MacRae, 1973).**

**Soil chemical analysis**

Soil chemical analysis (available nitrogen, available phosphorus and soluble potassium) were estimated in rhizosphere at (30, 60, 90 and 150 days) from planting. $NH_4$-N and $NO_3$- N were determined according to the method described by **Bremner** and **Keeny (1965),** available-phosphorus was determined according to the method described by **Watanabe** and **Oleson (1965) and** soluble-potassium was determined according to the method described by **Jackson (1973).**

**Growth characteristics and yield**

Plant height (cm), number of branches, dry weight of plant (gm) and dry weight of herb yield/fed were determined.

**Statistical analysis.**

Obtained data were statistically analyzed according to **Gomez** and **Gomez (1984)**. For comparison between means, **Duncan's multiple range test** was used **( Duncan , 1955)**.

## RESULTS AND DISCUSSIONS

**Periodical changes of $N_2$-ase activity under biofertilization and organic manuring in presence of *T. harzianum*.**

It is not a surprising result that, $N_2$-ase activity (Table, 3) was decreased in soil amended with chemical fertilizer compared with inoculated and manured soil. Lower values of $N_2$-ase activity may be due to the inhibition of $N_2$-ase activity with the amendment of inorganic nitrogen fertilizer at a high rate. This result is in agreement with **(Anne-Sophie *et al*, 2002)** who found that the addition of $NH_4NO_3$ decreased the $N_2$-ase activity.

In presence of *T. harzianum*, higher records of $N_2$-ase activity were observed in soil inoculated with biofertilizer (*P. polymyxa* H1,*B. megaterium var phosphaticum* and *B. circulans*) than soil treated with compost only. This result externalized importance of inoculation on proliferation and enhancement of $N_2$-fixers in rhizosphere.

These results are in harmony with **Cheng** and **Zhiping (2007)** who found that when increase the amount of compost application, the soil enzymes activities were increased.

**Table** 3. **Periodical changes of nitrogenase activity under biofertilization and organic manuring in presence of *Trichoderma harzianum*.**

| Treatments | Nitrogenase activity (µL $C_2H_4$ . $g^{-1}$ dry soil / h) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | First season | | | | Second season | | | |
| | 30 | 60 | 90 | 150 days | 30 | 60 | 90 | 150 days |
| Control | 22.23 $^{e}$ | 22.70 $^{f}$ | 19.49 $^{g}$ | 5.60 $^{d}$ | 16.09 $^{f}$ | 10.10 $^{f}$ | 9.21 $^{g}$ | 12.26 $^{f}$ |
| Chemical fertilization | 23.80 $^{d}$ | 18.42 $^{g}$ | 28.07 $^{f}$ | 5.60 $^{d}$ | 20.16 $^{e}$ | 11.43 $^{f}$ | 17.29 $^{f}$ | 3.03 $^{g}$ |
| Biofertilization | 26.46 $^{c}$ | 47.14 $^{d}$ | 44.79 $^{d}$ | 17.93 $^{c}$ | 25.94 $^{d}$ | 41.64 $^{d}$ | 48.65 $^{d}$ | 21.09 $^{e}$ |
| Biofert. + compost (1/2 dose) | 26.17 $^{c}$ | 55.49 $^{c}$ | 58.04 $^{c}$ | 18.06 $^{c}$ | 37.84 $^{c}$ | 53.06 $^{c}$ | 56.86 $^{c}$ | 20.19 $^{d}$ |
| Biofert.+ compost (3/4 dose) | 32.62 $^{b}$ | 66.37 $^{b}$ | 69.52 $^{b}$ | 22.47 $^{b}$ | 40.30 $^{b}$ | 65.26 $^{b}$ | 68.78 $^{b}$ | 26.16 $^{b}$ |
| Biofert.+ compost (full dose) | 47.45 $^{a}$ | 74.46 $^{a}$ | 74.16 $^{a}$ | 25.12 $^{a}$ | 45.92 $^{a}$ | 72.81 $^{a}$ | 73.82 $^{a}$ | 37.12 $^{a}$ |
| Full dose of compost | 32.37 $^{b}$ | 30.37 $^{e}$ | 37.03 $^{e}$ | 17.41 $^{c}$ | 25.61 $^{d}$ | 20.20 $^{e}$ | 36.83 $^{e}$ | 22.34 $^{c}$ |

* Control : Non-fertilized and non-inoculated.

** Biofertilizer content: *Paenibacillus polymyxa* H1+*Bacillus megaterium var phosphaticum* + *Bacillus circulans*

Means followed by the same letter(s) were not significantly different at 5% level of significance.

The highest values of $N_2$-ase activity were obtained with full dose of compost + biofertilizer in presence of *T. harzianum*. While, the lowest values were obtained with non-fertilized and non-inoculated control.

From obtained data in Table (3) it's worthily to mention that the $N_2$-ase activity values were higher at flowering stage rather than vegetative one. Higher records of $N_2$-ase activity at flowering stage could be attributed to the beneficial effect of root exudates which increase during flowering stage of cultivated plants. This result is in harmony with those obtained by **Neweigy *et al* (1997)** and **Hanafy *et al* (1998)** who found that the densities of $N_2$-fixer bacteria in rhizosphere were higher at heading (flowering) stage of plant growth rather than other plant growth stages.

**Periodical changes of Phosphatase activity under biofertilization and organic manuring in presence of *T. harzianum*.**

Results in Table (4) showed that phosphatase activity in soil amended with compost was significantly higher than chemical fertilization. This result is in agreement with **Cheng and Zhiping (2007)** who reported that the activity of microbial enzymes are greatly stimulated by the addition of manure. Also, **Krishnakumar *et al* (2007)** found that the recommended chemical fertilization showed significant lower phosphatase activity than organic manuring.

Also, phosphatase activity was enhanced in soil inoculated and treated with compost compared to soil treated with either biofertilizer or compost each one individually. This result may likely be due to the efficiency of biofertilizer in phosphatase production as well as the beneficial effect of compost as nutritional substances for stimulating of different soil microorganisms specially P-solubilizers. This result is in accordance with **(Nelidov *et al*, 1988** and **Balakrishnan *et al*, 2007)** who found that the application of compost in combination with phosphate solubilizing bacteria significantly increased soil microflora such as bacteria, fungi and actinomycetes and soil enzyme activities such as phosphatase.

The highest records of phosphatase activity were observed in soil treated with full dose of compost in combination with biofertilizer inoculation. Records of phosphatase activity were higher at flowering stage. This result can be attributed to the positive effect of the root exudates of cultivated plants.

**Table 4. Periodical changes of phosphatase activity under biofertilization and organic manuring in presence of *Trichoderma harzianum*.**

| Treatments | Phosphatase activity (µg inorganic phosphorus . $g^{-1}$ dry soil / 24 hrs.) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | First season | | | | Second season | | | |
| | 30 | 60 | 90 | 150 days | 30 | 60 | 90 | 150 days |
| **Control** | **10.22 d** | **2.81 g** | **12.15 d** | **1.36 g** | **10.67 g** | **2.52 g** | **10.74 g** | **1.30 g** |
| **Chemical fertilization** | **12.81 b** | **7.63 f** | **13.59 b** | **9.58 f** | **13.68 e** | **4.90 f** | **15.33 f** | **3.89 f** |
| **Biofertilization** | **11.37 c** | **14.54 d** | **21.80 c** | **11.15 e** | **12.74 f** | **12.59 d** | **22.82 e** | **11.58 e** |
| **Biofert. + compost (1/2 dose)** | **13.10 b** | **15.04 c** | **21.87 c** | **12.05 d** | **14.89 d** | **13.10 c** | **24.90 c** | **12.30 d** |
| **Biofert.+ compost (3/4 dose)** | **15.04 a** | **15.54 b** | **22.59 b** | **16.46 b** | **15.48 c** | **14.61 b** | **25.19 b** | **13.67 b** |
| **Biofert.+ compost (full dose)** | **15.47 a** | **17.64 a** | **22.81 b** | **18.50 a** | **16.49 a** | **14.90 a** | **27.93 a** | **16.34 a** |
| **Full dose of compost** | **14.82 a** | **13.96 e** | **16.74 a** | **12.86 c** | **13.58 f** | **5.83 e** | **16.34 d** | **2.74 c** |

Abbreviations: as those stated for Table (3).

**Periodical changes of ammoniacal nitrogen under biofertilization and organic manuring in presence of *T. harzianum*.**

Data in Table (5) showed that soil treated with chemical fertilization gave lower values of $NH_4$-N compared with soil inoculated with biofertilizer and amendment with compost.

Furthermore, soil inoculated with biofertilizer in combination with compost showed higher $NH_4$-N records than soil treated with either biofertilizer or compost individually. The higher records of $NH_4$-N is likely be due to the positive effect of compost by their high organic nitrogen content which it is converted through microbial metaboilism into readily usable ammoniacal and nitrate nitrogen. This organic fertilizer supply microorganisms with variables nitrogen for longer periods.

**Table 5. Periodical changes of ammoniacal nitrogen under biofertilization and organic manuring in presence of *Trichoderma harzianum*.**

| Treatments | Ammoniacal nitrogen (ppm) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | First season | | | | Second season | | | |
| | 30 | 60 | 90 | 150 days | 30 | 60 | 90 | 150 days |
| **Control** | **20.59 g** | **14.92 f** | **5.65 d** | **22.46 e** | **5.32 f** | **4.43 g** | **11.52 e** | **13.30 g** |
| **Chemical fertilization** | **36.67 d** | **23.67 e** | **11.11 c** | **39.50 c** | **54.96 c** | **17.98 f** | **19.50 c** | **28.65 a** |
| **Biofertilization** | **32.04 f** | **30.01 d** | **11.94 c** | **36.48 d** | **42.55 e** | **26.21 e** | **13.30 e** | **23.94 e** |
| **Biofert. + compost (1/2 dose)** | **34.51 e** | **39.80 b** | **12.12 c** | **39.67 c** | **49.65 d** | **28.87 d** | **16.84 d** | **24.82 d** |
| **Biofert.+ compost (3/4 dose)** | **38.57 c** | **42.98 a** | **13.42 b** | **42.74 b** | **55.85 b** | **35.46 c** | **22.16 b** | **25.71 c** |
| **Biofert.+ compost (full dose)** | **41.79 a** | **42.42 a** | **15.15 a** | **42.69 b** | **63.83 a** | **41.67 b** | **40.34 a** | **38.37 b** |
| **Full dose of compost** | **40.40 b** | **36.30 c** | **14.80 a** | **59.23 a** | **55.85 b** | **49.65 a** | **24.82 b** | **25.96 f** |

Abbreviations: as those stated for Table (3).

Moreover, the positive role of biofertilizer on $N_2$-fixation and ammonification processes. Similar trend of results were observed by **Yin-Po and Cben-Ching (1995)** who mentioned that application of organic farming practices improved chemical, physical and biological properties of soil than conventional one.

Also, the highest values of $NH_4$-N level were observed in soil treated with biofertilizer and full dose of compost. This result confirms the importance of inoculation with biofertilizer on microbial society and their activities in the rhizosphere

It is worthily to mention that using of compost in presence of *T. harzianum* showed higher records of $NH_4$-N level compared with soil amendment with chemical fertilization in presence of *T. harzianum*.

Generally, data recorded in Table (5) showed that the $NH_4$-N records were fluctuated during growth period. This fluctuation is likely be due to the temperature changes and drying & remoistening during the experimental period which occurs in open field.

**Periodical changes of nitrate nitrogen under biofertilization and organic manuring in presence of *T. harzianum*.**

Data in Table (6) showed that soil inoculated with biofertilizer and fertilized with compost showed higher records of $NO_3$-N than the soil treated with either biofertilizer or compost individually. The higher values of $NO_3$-N is likely be due to the beneficial effect of compost and biofertilizer on $N_2$-fixation and nitrification processes. Similar trend of results were observed by **Yin-Po and Cben-Ching (1995)**.

It is worthily to mention that the amendment of compost in combination with biofertilizer showed higher records of $NO_3$-N compared with soil amendment with compost only.

**Table 6. Periodical changes of nitrate nitrogen under biofertilization and organic manuring in presence of *Trichoderma harzianum*.**

| Treatments | Nitrate nitrogen (ppm) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | First season | | | | Second season | | | |
| | 30 | 60 | 90 | 150 days | 30 | 60 | 90 | 150 days |
| Control | 4.08 g | 13.15 f | 15.50 g | 13.18 g | 4.51 g | 12.03 g | 13.95 f | 9.52 g |
| Chemical fertilization | 47.13 b | 30.81 b | 50.41 b | 33.94 b | 52.16 b | 34.71 b | 46.39 c | 40.65 b |
| Biofertilization | 22.69 e | 20.65 d | 22.84 e | 20.75 e | 26.09 e | 18.10 e | 26.95 d | 12.04 e |
| Biofert. + compost (1/2 dose) | 42.25 d | 18.38 e | 42.67 d | 22.41 d | 41.32 d | 23.38 d | 46.09 c | 23.38 d |
| Biofert.+ compost (3/4 dose) | 44.31 c | 26.33 c | 44.45 c | 30.48 c | 44.33 c | 28.27 c | 48.58 b | 25.01 c |
| Biofert.+ compost (full dose) | 58.30 a | 58.95 a | 59.72 a | 42.09 a | 57.73 a | 52.16 a | 64.93 a | 48.22 a |
| Full dose of compost | 16.16 f | 17.28 e | 20.65 f | 17.32 f | 15.49 f | 12.44 f | 26.43 e | 11.67 f |

Abbreviations: as those stated for Table (3).

Moreover, the highest values of $NO_3$-N were observed in inoculated soil and fertilized with full dose of compost. Obtained data showed that higher records of $NO_3$-N were observed at flowering stage. The higher records at flowering stage were as a result of the positive qualitative and quantitative changes in nature of the plant root exudates during different growth stages. These results are in harmony with those obtained by **Neweigy *et al* (1997)** and **Hanafy *et al* (1998)** .

**Periodical changes of available phosphorus under biofertilization and organic manuring in presence of *T. harzianum.***

Data presented in Table (7) showed that soil amendment with chemical fertilizer gave lower records of available phosphorus compared with soil inoculated with biofertilizer and amendment with full dose of compost. While it showed higher records than biofertilization treatment.

It is worthily to mention that the soil amendment with full dose of compost in combination with biofertilizer showed higher records of available phosphorus than soil amendment with compost only. This result distinguished the role of biofertilizer in phosphorus solubilization.

Available phosphorus was increased with the increasing of compost amendment. Highest values of available phosphorus showed in inoculated and fertilized soil with full dose of compost. While, the lowest values were observed in chemical fertilization.

**Table 7. Periodical changes of available phosphorus under biofertilization and organic manuring in presence of *Trichoderma harzianum*.**

| Treatments | Available-phosphorus (ppm) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | First season | | | | Second season | | | |
| | 30 | 60 | 90 | 150 days | 30 | 60 | 90 | 150 days |
| **Control** | **32.39 g** | **22.10 g** | **34.19 g** | **24.05 f** | **33.41 g** | **9.94 g** | **35.21 f** | **12.31 f** |
| **Chemical fertilization** | **70.85 d** | **34.63 d** | **80.56 c** | **37.80 e** | **70.85 d** | **34.40 d** | **81.67 c** | **22.03 d** |
| **Biofertilization** | **32.89 f** | **32.97 f** | **46.22 f** | **43.40 d** | **33.91 f** | **32.76 e** | **44.42 e** | **20.16 e** |
| **Biofert. + compost (1/2 dose)** | **72.85 c** | **34.84 c** | **49.97 e** | **45.49 c** | **73.87 c** | **36.27 c** | **46.51 d** | **21.60 de** |
| **Biofert.+ compost (3/4 dose)** | **80.34 b** | **36.93 b** | **79.84 d** | **66.24 a** | **81.36 b** | **37.06 b** | **80.86 c** | **27.00 c** |
| **Biofert.+ compost (full dose)** | **85.88 a** | **38.30 a** | **95.94 a** | **66.60 a** | **86.90a** | **37.86 a** | **95.48 a** | **40.03 a** |
| **Full dose of compost** | **44.28 e** | **33.34 e** | **83.30 b** | **50.07 b** | **44.28 e** | **24.12 f** | **84.50 b** | **30.24 b** |

Abbreviations: as those stated for Table (3).

**Periodical changes of soluble potassium under biofertilization and organic manuring in presence of *T. harzianum*.**

Obtained data in Table (8) showed that soluble-K values had significant decreases in the treatment of soil inoculated with biofertilizer compared with soil amendment with full dose of compost.

Concerning the combination between biofertilizer and compost, obtained data showed that the dual treatments showed higher records from soluble-K than the soil treated with biofertilizer singularly. Higher values of soluble-K is likely be due to the beneficial effect of compost on multiplication rate of silicate dissolving bacteria. Similar trend of results were observed by **Brandjes *et al* (1996) and Luo Ancheng and Sun Xi (1994)** who found that organic manure significantly increased K solubilizing rate soil respiration rate and enzyme activities.

It is worthily to mention that the soil amendment with full dose of compost in combination with biofertilizer showed higher records of soluble potassium than soil amendment with compost only.

Soluble-K was increased with the increasing of compost amendment. The highest values of soluble-K showed in inoculated and fertilized soil with full dose of compost.

Concerning the soluble-K during the experimental periods, obtained data revealed that the soluble-K values were the highest at flowering stage. This result can be explicated by increasing of microbial activity in this stage where root exudates are increasing. These results are in harmony with those obtained by **Neweigy *et al* (1997)** and **Hanafy *et al* (1998)** .

**Table 8. Periodical changes of soluble potassium under biofertilization and organic manuring in presence of *Trichoderma harzianum*.**

| Treatments | Soluble-potassium (ppm) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | First season | | | | Second season | | | |
| | 30 | 60 | 90 | 150 days | 30 | 60 | 90 | 150 days |
| Control | 1679 e | 1632 f | 1585 e | 1632 e | 1240 f | 1275 d | 1243 g | 1220 b |
| Chemical fertilization | 1867 b | 1726 e | 1820 a | 1726 c | 1736 c | 1330 c | 1499 e | 1330 a |
| Biofertilization | 1726 d | 1773 d | 1632 d | 1679 d | 1438 e | 1330 c | 1785 d | 1220 b |
| Biofert. + compost (1/2 dose) | 1820 c | 1867 b | 1726 c | 1726 c | 1686 d | 1330 c | 1918 c | 1333 a |
| Biofert.+ compost (3/4 dose) | 1867 b | 2008 a | 1726 c | 1726 c | 1785 b | 1550 b | 2083 b | 1336 a |
| Biofert.+ compost (full dose) | 2102 a | 2008 a | 1773 b | 1914 a | 1835 a | 1660 a | 2232 a | 1337 a |
| Full dose of compost | 1679 e | 1820 c | 1820 a | 1773 b | 7937 g | 1660 a | 1289 f | 1332 a |

Abbreviations: as those stated for Table (3).

**Effect of biofertilization and organic manuring in presence of *T. harzianum* on growth characteristics and herb yield of marjoram.**

Data in Table (9) indicated that growth characteristics of marjoram i.e. plant height ,number of branches, herb dry weight per plant and herb yield/fed were significantly increased under investigated treatments in the two growing seasons.

Generally, significant increases were observed in most plant growth characteristics and herb yield with compost amendment compared to biofertilizer inoculation.

Whereas, dual application of marjoram with biofertilizer and compost gave higher records of growth characteristics and herb yield than the application of each one singularly. This result can be attributed to integrated effect of dual application on all previous parameter which led to improve growth performance and herb yield. These results are in accordance with those obtained by **Gharib *et al* (2008)** who reported that the use of biofertilization and organic manuring gave the best results for growth performance and herb yield than those obtained from either biofertilization or organic manuring individually.

**Table 9. Effect of biofertilization and organic manuring in presence of *Trichoderma harzianum* on growth characteristics of marjoram.**

| Treatments | Plant height (cm) | | Number of branches | | Herb dry weight (g/plant) | | Herb dry weight (kg/ fed) | |
|---|---|---|---|---|---|---|---|---|
| | 1st season | 2nd season | 1st season | 2nd season | 1st season | 2nd season | 1st season | 2nd season |
| Control | 32.0 d | 34.2 d | 36.5 g | 40.00 g | 22.23 d | 23.99 f | 535.89 d | 578.23 f |
| Chemical fertilization | 47.7 a | 50.0 a | 85.0 b | 95.17 b | 61.87 a | 64.27 a | 1461.17 a | 1549.09 a |
| Biofertilization | 42.0 c | 45.0 c | 54.0 f | 59.00 f | 29.97 c | 34.78 e | 722.28 c | 838.18 e |
| Biofert. + compost (1/2 dose) | 44.7 b | 47.0 bc | 66.0 e | 69.17 e | 42.10 b | 45.25 d | 1014.73 b | 1090.54 d |
| Biofert.+ compost (3/4 dose) | 46.7 ab | 49.7 ab | 77.5 c | 79.17 c | 46.60 b | 56.13 b | 1123.20 b | 1352.78 b |
| Biofert.+ compost (full dose) | 48.0 a | 50.7 a | 91.0 a | 99.50 a | 60.83 a | 65.67 a | 1466.26 a | 1582.72 a |
| Full dose of compost | 42.3 c | 45.0 c | 68.5 d | 77.50 d | 44.06 b | 52.03 c | 1061.89 b | 1253.99 c |

Abbreviations: as those stated for Table (3).

The high significant increase in marjoram growth characteristics and herb yield were observed in the treatment of marjoram plants inoculated with biofertilizer and manured with full dose of compost. These results could be attributed to the high $N_2$-ase activity (Table,3) as well as the high records of $NH_4$-N, $NO_3$-N and available phosphorus (Table,5 and 6) which observed in the treatment of marjoram plants inoculated with biofertilizer and manured with full dose of compost.

## Conclusion and recommendation

In view of the obtained results, it can be concluded that the dual application of biofertilization and organic manuring had great effect on growth performance and yield of marjoram. As well as, maximum activity of nitrogenase and phosphatase were observed. According to obtained results, it may be recommended that the use of both biofertilization and organic manuring together can substitute chemical fertilization to obtain high productivity of marjoram. In addition, to obtain safety plant and reduce environmental pollution

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## فعالية الزراعة العضوية على مواصفات نمو ومحصول نبات البردقوش

**راشد عبدالفتاح زغلول[١]، طلعت محمد الحسيني[١] ، إحسان أحمد حنفى[١] ، أحمد عنيم رحال[٢] ، هاني محمد أحمد عبدالرحمن[١]**

١ - كلية الزراعة- جامعة بنها.

٢ - معهد بحوث الأراضي والمياه والبيئة- مركز البحوث الزراعية.

أقيمت تجربة حقلية في أحدي المزارع العضوية خلال موسمي ٢٠٠٥ - ٢٠٠٦ ، ٢٠٠٦-٢٠٠٧. وقد أجريت هذه التجربة لدراسة كفاءة التسميد الحيوي والعضوي في وجود المقاومة الحيوية بفطر *Trichoderma. harzianum* علي بعض الأنزيمات في التربة ، محتوي التربة من النيتروجين والفوسفور والبوتاسيوم الميسر ، مواصفات نمو ومحصول نبات البردقوش.

وقد أظهرت النتائج المتحصل عليها أن أعلى نشاط لإنزيم الـ phosphatase والـ nitrogenase شوهدت عند استخدام التسميد الحيوي مع الجرعة الكاملة من السماد العضوي الصناعي في وجود فطر. *T. harzianum* مقارنة باستخدام كل منهما على حده. وكذلك عند مقارنتها بالتسميد الكيماوي.

كذلك أظهرت النتائج أن معاملات التسميد الحيوي و العضوي في وجود فطر *T. harzianum* أعطي أعلى تركيز من النتروجين والفوسفور والبوتاسيوم الميسر في التربة.

ومن الجدير بالذكر أنه لا يوجد فرقا معنويا بين محصول نبات البردقوش المنتج بالتسميد الكيماوي والمنتج بالزراعة العضوية . لذلك يوصي بتطبيق نظام الزراعة العضوية باستخدام كلا من التسميد العضوي والحيوي للحصول علي إنتاجية ذات جودة عالية من البردقوش مع الحد من التلوث الناتج عن استخدام الأسمدة الكيماوية.