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RESPONSE OF *Helianthus tuberosus* L. TO ORGANIC AND BIO-ORGANIC FERTILIZERS

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ABSTRACT

Two field experiments were conducted during the summer season of 2003 and 2004 to study the effect of organic and bio-organic fertilizers [esterna biofert, compost, biocompost and effective microorganisms (Em)] on vegetative growth, yield and physical and chemical components in tubers of local and fuseau Jerusalem artichoke cultivars. Results indicated that Em, biocompost and biofert significantly increased plant height, number of main and lateral shoots and dry weight as well as the concentrations of Chl (a+b), carotenoids and total carbohydrates in the leaves. Moreover, dry matter, inulin, nitrogen, phosphorus and potassium of tubers showed a significant increases. The highest vegetative growth and tuber yield were obtained when Em, biocompost and biofert were applied. The respective increase in lateral shoots, Chl (a + b), carotenoids, average tuber weight and size were higher in local cultivar. Whereas fuseau cultivar tubers showed greater dry matter than those of local variety. The application of Em, biocompost and biofert fertilizers in both local and fuseau cultivar gave the relatively higher yield with good quality.

Key words: Jerusalem artichoke, Cultivars, Vegetative growth, Inulin, Tubers yield, Bio-organic fertilizers.

INTRODUCTION

Jerusalem artichoke (*Helianthus tuberosus* L.) is considered one of the comparatively new and non traditional vegetable crop introduced in Egypt. It has a high nutritional value for human health, because it has high fructose content: Viz, 74.20 to 82.30% in dry matter of tubers (**Dorrell and Chubey, 1977**), inulin percentage from 16–20% in fresh weight **(Chubey and Dorrell, 1982)** for 9–10% protein in fresh weight **(El-Sharkawy, 1998)**, and fibers. The carbohydrate content does not exit as simple starch, but as the allied substance called inulin, which is tolerated by diabetics **(Nonnecke, 1989)**. The crop produces, also, a large top growth that can be used for animal feeding.

In recent times, mineral fertilizer is considered a major source of plant nutrients, but excessive use of fertilizers represents the major cost in plant production and creates pollution of agro-ecosystem, as well as deterioration of soil

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fertility **(Fischer and Richter, 1984)**. Therefore, it has become essential to use untraditional fertilizer. Recently, organic farming and biofertilization has become more and more important, biofertilization became a positive alternative to chemical fertilizer **(Mishra & Patjoshi, 1995 and Kato *et al* 1999)**. Effective microorganisms (Em) containing lactic bacteria, Actinomyces and various other bacteria and fungi have been introduced to nature farming system **(Higa, 1994)**. Em applications have been proved effective in many aspects and played important roles in promoting crop production and purifying the environment. Organic matter application to soils is known to improve soil properties and consequently the growth of plant. Organic fertilizer is considered as an important source of humus, macro and micro elements carrier, and at the same time increase the activity of the useful microorganisms **(El-Gizy, 1994)**. The comparable effect of the Esterna biofert could be attributed to the supply of nutrients through mineralization and improvement in the physicochemical and microbial properties of the soil. Also, these fertilizers have the ability to release nutrients (macro and micro-nutrients) gradually and supply the crop throughout the vegetation period **(Adediran *et al* 2004)**.

The aim of this work was to evaluate, the effect of the organic and bio-organic fertilizers (biofert, compost, biocompost and Em) on growth, chemical composition, yield and its quality of two Jerusalem artichoke cultivars.

MATERIAL AND METHODS

Two field experiments were undertaken during the two successive summer seasons of 2003 and 2004 at the Experimental Farm of Horticulture Research Station at El-Kanater El-Khairia, Kalubia governorate to study the response of two Jerusalem artichoke cultivars (Local and fuseau) to organic and bio-organic fertilizers and the effect of these fertilizers on growth characters, tuber yield and its quality of Jerusalem artichoke. The physical and chemical analysis of the soil at experimental sites were determined according to the methods outlined by **Page (1982)**. The physical analysis revealed that soil contained 33.5 and 31.6% sand, 32.5 and 33.5% silt, and 34.0 and 34.9% clay in 2003 and 2004 seasons, respectively. Meanwhile, the chemical analysis resulted a pH of 8 and7.8,total N (%) of 0.15 and 0.149%, P (%) of 0.056 and 0.063, K (%) of 0.075 and 0.078 in the first and second seasons, respectively. While chemical analysis of compost El Nil and biofert are given in Table (1) according to Egyptian Company for Agricultural Residues Utilization "ECARU" and the Easterna Company for Agricultural and industrial development, Belbase, Sharkiya Governorate, respectively.

The two cultivars were obtained from the Department of vegetable crops of

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Horticulture Research Station a El-Kanater El-Khairia, Kalubia. Tubers were planted on May 15 and 7 May 2003 and 2004, respectively. The experimental layout was a split-plots system in a randomized complete blocks design, with three replications. Cultivars were arranged as the main plots, while the fertilizer treatments were considered as the sub-plots. Each sub-plot consisted of five rows each of 5 m long and 80 cm width. Plant distances were 50 cm apart. Irrigation, pest and disease control were carried

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Table 1. The chemical analysis of the compost El Neel and biofert.

Characters	Compost	Biofert
Organic matter (%)	> 54	16
Total nitrogen (%)	> 1.75	4
Total phosphorus (%)	> 0.44	6
Total potassium (%)	> 1.00	6
Total calcium (%)	-	10
Total magnesium (%)	-	1
Fe (ppm)	> 1000	1000
Zn (ppm)	> 250	1000
Mn (ppm)	> 100	1000
Cu (ppm)	> 50	1000
pH	< 9.00	8.86
Ec (d s/m)	< 6.50	-
N-fixing bacteria (%)	-	4
Phosphate dissolvers bacteria (%)	-	6

out as recommended by Ministry of Agriculture.

Effective microorganisms (Em) contains group of beneficial microorganisms containing about 80 species **(Kato *et al* 1999)**.

Each experiment included ten treatments, two cultivars x five fertilizer treatments as follows:

1. Traditional control treatments received 300 kg ammonium sulfate (20.6% N), 150 kg Potassium sulfate (48% K_2O) per feddan were equally divided and side dressed at 30, 60 and 90 days after planting and 150 kg / fed. calcium super phosphate (15.5% P_2O_5), was based dressed during soil preparation.
2. Esterna biofert, 60 kg / feddan was added in three times with planting, 30 and 60 days after planting.
3. Compost, 5 ton / feddan was thoroughly mixed with 0 – 30 cm of the surface soil layer before planting.
4. Biocompost (compost and biofertilizers) , compost 5 ton / feddan was added by mixing it with the soil before transplanting, nitrobein(N-fixing bacteria) at 10 kg/ fed. and phosphorein (phosphate dissolving bacteria) 5 kg / fed. were thoroughly mixed with the wet seed tubers directly before planting.
5. Effective microorganisms (Em) was added 2 L / feddan with the

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irrigation water at three times (with planting and 30 as well as 60 days after planting).

At 120 days from planting, plant samples were taken from middle rows for each plot. The following data were recorded:

1. Vegetative growth characters

Plant height (cm), number of main and lateral shoots / plant and dry weight (g) of whole plants (leaves + stems) were measured.

2. Chemical analysis

2.1. Photosynthetic pigments and total carbohydrates concentration

Photosynthetic pigments were determined in the leaves as described by **Wettestein (1957)**. Total carbohydrates of leaves were estimated colorimetrically using the phenol sulfuric acid according to the method described by **Dubois *et al* (1956)** the previous parameters were calculated as mg/g dry weight..

3. Total tuber yield

At the harvest (180 days after planting) tubers from the inner two rows of each plot were harvested and weighted to calculate tuber yield (ton / fed).

4. Tuber dry matter

One hundred grams of fresh tubers from each treatment was weighed, cut into slices then dried in an oven at 50°C until constant weight and the dried slices of tubers were weighed then the dry matter was calculated.

5. Average tuber weight and volume

Ten tubers were randomly taken to determine average tuber weight and volume was determined by using water displacement method and average tuber weight and volume were calculated.

6. Chemical compositions of tuber

6.1. Inulin concentration

Inulin concentration was determined in tubers according to the method of **Winton and Winton (1958)**.

6.2. Total carbohydrates

It was colormetrically determined by the method described by **Dubois *et al* (1956)**. Inulin and Total carbohydrates were calculated mg/g dry weight.

6.3. Mineral concentrations

Total nitrogen was estimated in dry tubers using microkjeldahl method according to **Ling (1963)**, while both P and K were determined as mentioned by **A.O.A.C. (1990)**.

All obtained data were subjected to statistical analysis with the help of COSTAT-C program, and the L.S.D. at

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5% level was calculated according to **Snedecor and Cochran (1972)**.

RESULTS AND DISCUSSION

1. Vegetative growth characteristics:

Growth characters of local and fuseau Jerusalem artichoke cultivars were affected by organic and bio-organic fertilizers presented in Table (2).

Regarding the effect of fertilizers, data indicated that, Em, biocompost and biofert. caused a significant increase in plant height, number of lateral shoots as well as dry weight per plant as compared with the control (NPK) or compost alone. The best results in this concern, were obtained from Em treatment followed by

biocompost then biofert. The obtained results are in agreement with **Kato *et al* (1999)** who reported that the promotion of root development by Em application might be due to the effect of plant growth regulators (ouxins, gibberellins and kinetin-like substances) produced by inoculated microbes. GA_3 and kinetin improved the plant growth and physiology, GA_3 has been reported to be involved in the synthesis of m-RNA and protein in many plant organs **Wellburn *et al* (1981)**. Also, Em is effective in improving soil quality, stimulating of crop, increasing tolerance and other functions **(Kato *et al* 1999)**. As for, biocompost, it was found that it improved the status of soil-moisture-plant interrelationship **(Fattahallah, 1992)**, nitrobien (non-Symbiotic N_2 fixing bacteria) *Azotobacter* and *Azospiriillum* strains produced adequate amounts of IAA and cytokinins with increasing the surface area per unit root length and enhanced the root hair branching with and eventual increase on the uptake of nutrients from the soil **(Jagnow *et al* 1998)**. Phosphorin (P-solubilizing bascteria) release organic and inorganic acids which reduce soil pH leading to change of phosphorus and other nutrients to available forms ready for uptake by plants **(Singh and Kapoor, 1999)**. The promotion of plant growth of Jerusalem artickoke plants when treated with biocompost and biofert may be attributed to the highest available elemental nutrition i.e., N, P and K as well as some other micro elements, consequently increasing these elements in rooting zone area **(Shafeek *et al* 2003)**.

As for the effect of cultivars on growth characters, data presented in Table (2), indicated that no significant differences among the two tested cultivars in plant height, number of main shoots per plant and dry weight of plant in both seasons were observed. Number of lateral shoots was significantly increased in local cultivar compared with fuseau cultivar in the second season only. These results agreed with those reported by **El-Sharkawy (1998) and Mclaurin *et al* (1999)**.

Concerning the interaction between fertilizers and cultivars, it is clear that, both local or fuseau cultivars treated with biocompost and Em gave the highest growth parameters in both seasons as compared with the other treatments. The promotion of root development by Em, biocompost and biofert applications might be due to the effects of plant growth regulators produced by inoculated microbes **(Kato *et al* 1999 and Jagnow *et al* 1998)**.

2. Chemical analysis

2.1. Photosynthetic pigments and total carbohydrates

It is evident from Table (3) that, Em, biocompost, biofert and compost increased the concentration of Chl (a + b), carotenoids and total carbohydrates concentration as compared with control plants. These results coincide with those of **Arshad and Frankenberger (1992)**, who reported that Em contained some phytohormones and the derivatires are synthesized by soil microbes. The enhancement of Chl. concentration by GRs may be due to the effects of GA_3 or kinetins on both Chl. synthesis. Kinetins stimulation of Chl. formation may be due to an influence on synthesis of protochlorophyllide **(Shlyk and Averina,**

1973). In this regard, compost, biocompost and biofert contains nitrogen and phosphorus both are essential constituent of proteins and chlorophyll and are present in many other compounds of physiological importance in plant metabolism **(Gajbhiye *et al* 2003)**.

Concerning the cultivars effect, results in Table (3) show that local cultivar had a significant increase in Chl a + b, carotenoids and total carbohydrate concentration as compared with fuseau cultivar. The results were similar in the two growing seasons. These results are in agreement with those obtained by **El-Sharkawy (1998)**.

As for the interaction, it is clear from the given data in Table (3) that the highest values in Chl (a + b) and carotenoids were obtained from local cultivar with biocompost and Em treatments. There was no significant effect on the interaction between the tested cultivars and fertilizers regarding total carbohydrate concentration in both seasons.

3. Total tuber yield

The obtained results in Table (4) indicated that fertilizing with Em, biocompost and biofert significantly increased the total tuber yield ton / fed. as compared with the control (NPK), no significant difference was observed between the control and compost. The highest values of total tuber yield was obtained in case of Em, followed by biocompost. These results are in agreement with those obtained by **Xu-Huilian and Xu (2000)**, who reported that the foliar application of Em was shown to promote root growth and activity, and to enhance photosynthetic efficiency and capacity, which resulted in increased grain yield. Em consists of beneficial microorganisms (i.e., bacteria, fungi, actinomycetes and yeast) that are applied as inoculants to change the microbial diversity and interaction in soils and plants. Em has been shown to improve soil fertility and the plant growth, and yield of crop over a wide range of agro-ecological conditions **(Higa and Parr, 1994)**. Jerusalem, artichoke yield increases might be due to biofertilizer stimulate both vegetative and root growth (Table 2) or changes root morphology **(Carletti *et al* 1996)** and enhances uptake of mineral as reported by **Pol (1998) and Noel *et al* (1996)**. Biofert gave almost similar effects on Jerusalem artichoke yield. The comparable effect of this fertilizer could be attributed to the supply of nutrients through mineralization and improvement in the physicochemical and microbial properties of the soil. Also, these fertilizers have the ability to release macro- and micro-nutrients gradually and supply the crop throughout the vegetation period, which cause promotion of vegetative growth characters which reflected positively on the yield **(Adediran *et al.,* 2004)**. This suggests that, the increase in yield was due to the efficiency of Em, compost, biocompost and biofert as fertilizer supplementing the necessary for plant growth.

Local cultivar had significant increment in total tubers yield / feddan as compared with fuseau cultivar in both seasons. These results may be due to the increment in some vegetative growth and chemical characteristics viz. number of lateral shoots and photosynthetic pigments (Tables 2 and 3) in local cultivar as compared with fuseau cultivar.

These results coincide with those of **Toxopeus *et al* (1994)** who showed that total yield of Jerusalem artichoke cultivars differed by

the used cultivars. With regard to the effect of interaction, fuseau or local cultivars gave the highest significant tuber yield when treated with the Em and / or biocompost, meanwhile, the lowest one was obtained from fuseau cultivar treated with control (NPK).

4. Tuber dry matter

It is obvious from results presented in Table (4), that tuber dry matter content was increased in the plants treated with Em, biocompost and biofert compared with the control (NPK) or compost treatment. No significant difference was observed between the control and compost treatments in both seasons. The effective microorganisms (biocompost, biofert and Em), used in this study contained a group of beneficial microbes. Em applications with organic fertilizers promoted plant growth at all growth stages and increased grain yield **(Kato *et al* 1999)**. Biocompost and biofert contain phosphorin and nitrobein which acted mainly in increasing the availability of phosphorus and nitrogen and consequently increasing their absorption by the plant. It is well known that each of the two elements play a main role in the plant development and production **(Hauka *et al* 1990)**.

As for the effect of cultivars on the dry matter content, fuseau cultivar had higher dry matter than local cultivar in both seasons. Similar results were obtained by **El-Sharkawy (1998)**.

Results also indicated that the interaction effect between cultivars and fertilizers on tuber dry matter was significant in both seasons (Table 4), tuber dry matter of the fuseau cultivar significantly enhanced by the application of Em only, but tuber dry matter of local cultivar was significantly increased when treated with organic and bio-organic fertilizers (compost, biocompost, biofert and Em).

5. Average tuber weight and volume

Results in Table (4) clearly indicated that, Em and biocompost increased the tuber weight as well as tuber volume. The results are in harmony with those recorded by **Higa and Parr (1994)** who reported that, Em has been shown to improve soil fertility and the growth, yield and quality of crops. In this respect, application of organic matter has been known to improve physical properties of soil **(Schjonning *et al* 1994)**. The possible reasons for increased fruit yield might be associated to better development of root system and possible higher synthesis of plant growth hormones **(Panday and Kumar, 1989)**.

Also, results indicated that average tuber weight and tuber volume of local cultivar was greater than that of fuseau cultivar in the both growth seasons. These results are in agreement with those obtained by **Soja *et al* (1990)**, who mentioned that violele de Rennes produced higher tuber weight than Topianka, the averages tuber weights were 54.5 and 36.79 for the two cultivars, respectively. Fuseau cultivar gave the highest average of tuber weight and volume when Em, biocompost were applied, meanwhile, local cultivar gave the lowest ones when treated with Em, biocompost, biofert and compost.

6. Chemical composition of the tubers

6.1. Inulin concentration

It is clear from Table (5) that the application of Em, biocompost, biofert and compost fertilizers increased the inulin

concentration in the tubers as compared with control plants (NPK). Similar finding was reported by **Higa (1994)**, who reported that Em application have been proved effective in many aspects and played important roles in promoting crop production. Result presented in Table (5) indicated that there were no significant differences in inulin concentration of tuber between the two tested cultivars in both seasons. These results coincide with those mentioned by **El-Sharkawy (1998)** who reported that inulin percentage in tubers of fuseau and local cultivars had insignificant differences. As for the interaction the highest concentration of inulin concentration was found in fuseau treated with biocompost, followed by fuseau treated with Em. Meanwhile, the lowest one was found in fuseau fertilized with control (NPK).

6.2. Total carbohydrates

It is obvious from results presented in Table (5) that, Em, biocompost, biofert and compost caused a significant increase in carbohydrate concentration in the tuber as compared with control plants. Results also showed that no significant differences were detected in total carbohydrates concentration in the two tested cultivars. With respect to the effect of interaction on total carbohydrates, adding organic and bio-organic fertilizers to both cultivars stimulated significantly the total carbohydrates of tubers and the highest concentration of total carbohydrates in tubers was obtained in fuseau cultivar when treated with Em.

6.3. Mineral concentrations

Results presented in Table (5) indicated that, the concentrations of N, P and K have been increased in the tubers when plants treated with Em, biocompost, biofert and compost as compared with the control. The role of these fertilizers enhanced the N, P, K-uptake owing to N_2-fixation by the bacteria **(Nour El-Dein *et al* 2005)**. Release of organic and inorganic acids and increasing O_2 evolution due to phosphate dissolving microorganisms and other microbial types, reduce soil pH leading to change of phosphorus and other nutrients to available forms ready for uptake by plants and release of plant growth hormones causing increase of plant root area which improve root effectively to absorb nutrient from soil **(Singh and Kapoor, 1999)**. Results also indicated that there were no significant differences among the tested cultivars in the mineral content. With respect to the effect of interaction, local cultivar fertilized with Em, biocompost, biofert and compost decreased mineral concentration (NPK) in the tubers. On the other hand, fuseau cultivar had higher significant mineral concentration when the plants fertilized with the above mentioned fertilizers.

Finally, it could be concluded that, the application of organic and bio-organic fertilizers are very important to improve the yield and its quality. Moreover, using these fertilizers is not only recognized as an economic factor, but also, it is an important factor in reducing chemical fertilizers pollution.

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استجابة نباتات الطرطوفة للتسميد العضوي والحيوي

[40]

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1- قسم النباتات الزراعية – كلية الزراعة – جامعة المنوفية – شبين الكوم – مصر

تم إجراء تجربتين حقليتين خلال الموسم 2003 ، 2004 بهدف دراسة تأثير السماد Em والبيوكمبوست والبيوفيرتيل والكمبوست على النمو الخضري والمحصول وبعض الصفات الطبيعية والكيماوية للدرنات في صنفين من نباتات الطرطوفة ويمكن **تلخيص أهم النتائج المتحصل عليها فيما يلي:**

- أدى استخدام Em – بيوكمبوست – بيوفيرتيل إلى زيادة معنوية في طول النبات وعدد الأفرع الرئيسي وعدد السيقان والوزن الجاف للمجموع الخضري وزيادة تركيز الكلوروفيل (أ+ب) والكلوروفيل الكلي والكاروتينات والأوراق.
- أدت الأسمدة المستعملة إلى زيادة محصول الدرنات بالإضافة إلى زيادة متوسط وزن الدرنة وحجمها والنسبة المئوية للمادة الجافة ومحتوى الدرنات من الكربوهيدرات الكلية والإنيولين والبروتين والفوسفور والبوتاسيوم.
- تفوق النصف المحمل على النصف المستخدم في عدد الأفرع والجذور والكلوروفيل الكلي والكاروتينات ومتوسط وزن الدرنات وحجمها. بينما تفوق النصف المستخدم في نسبة المادة الجافة ومحتوى الدرنات من الكربوهيدرات والإنيولين والبروتين.

توصي الدراسة باستخدام Em – بيوكمبوست – بيوفيرتيل للحصول على أعلى محصول للنصف المستخدم مع أفضل جودة للدرنات.

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