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EFFECT OF COMPOST RATES AND TOPPING TREATMENTS ON GROWTH, YIELD AND QUALITY OF JERUSALEM ARTICHOKE UNDER SANDY SOIL CONDITIONS

R. S. M.Anwar[1]; M.S.M. Shraf[1] and G.S.A. Eisa[2]

1- Potato and Vegetatively Propagation Vegetables Res. Dept., Hort. Res. Inst., Agric. Res. Center, Giza. Egypt

2-Agricultural Botany Dept. Fac. Agric. Zagazig University, Egypt

Refaatsalah22@gmail.com

ABSTRACT

A field experiment was carried out during the summer seasons of 2016 and 2017 at the Experimental Farm at El-Kassasin, Hort. Station Ismailia Governorate, Egypt, to study the effect of compost fertilizer at 3, 6 and 9 ton/fed. and topping frequency (without , once and twice) on growth, shoot chemical composition, yield components (tubers and shoots), tuber quality and blade anatomy of Jerusalem artichoke plants (Helianthus tuberosus L.) cv. Fuseau grown in sandy soil and using drip irrigation system was used.

Fertilizing Jerusalem artichoke plants grown in sandy soil with compost at 9 ton/fed. and un topped plants significantly increased plant height , both fresh and dry weight of shoots , N, P and K content(%) and uptake by shoots and total protein (%) in shoots, average tuber weight, yield per plant and per fed., dry matter, total carbohydrates and total sugars, as well as inulin content in tuber in both seasons and leaf blade parameters in the second season only. In addition, this treatment recorded the best economic traits (average two seasons). While the interaction between compost at 9 ton/fed. and topping plant twice recorded the highest yield of shoots and numbers per plant in both seasons. The interaction between compost at 9 ton /fed. and topping plants once came in the second rank for the most abovementioned traits. On the other hand, the least values of plant growth, chemical constituents in shoots , yield and its components and tuber quality were recorded with the plants which fertilized with compost at 3 ton /fed., and topping plants twice number.

***Conclusively,** it could be concluded that, fertilizing Jerusalem artichoke plants grown in sandy soil with compost at 9 ton/fed. and un topped plants to obtain high yield of tubers and best quality as well as net return under the same conditions.*

Key words: Jerusalem artichoke**,** compost**,** topping**,** vegetative growth**,** leaf blade yield, tuber quality, anatomy.

INTRODUCTION

Jerusalem artichoke (*Helianthus tuberosus* L.) a native plant in North America,and belongs to the sunflower family. It is contains inert carbohydrates in the form of inulin. Synthetically, inulin type fructans are prepared from sucrose (Cooper *et al.*, 2015) and the numbers of fructose units vary from 2 to 60, indicating a combination of oligomers and polymers (Roberfroid, 2005). Jerusalem artichoke has many health benefits, for example, it is considered a from of soluble dietary fiber, reducing the lipid content in blood and liver in saturated fat-fed rats and as a prebiotic, as well as inulin played a vital role in the preventing and inhibiting the colorectal, colon and breast cancers (Yang *et al*., 2015).

Newly reclaimed sandy soil had unfavorable physical, chemical and biological conditions, high pH, low water holding capacity and high ability to erosion and scarcity of amended water. Thus, some attempts were done to improve the sand soil, addition of organic manures to sandy soil is very important to increase soil acidity and soil exchange capacity, provide energy for micro-organisms activity, increase water holding capacity and buffering of the soil infiltration (Hsieh and Hsu, 1993). Also organic manure, contains many species of living organisms, which release phyto-hormones as GA, IAA and CYT that stimulated plant growth (Reynders and Valssar, 1982).

Composting is a biological process in which organic biodegradable wastes are converted into hygienic, hums rich product (compost) for use as a soil conditioner and an organic fertilizer (Popkin, 1995). Application of compost at 10 ton /feddan increased the vegetative growth and yield of potato (Abou-Hussein *et al*., 2002 and Abou-Hussein, 2005). Moreover, Shehata and El-Hady, (2010) stated that fertilizing snap bean plants with compost at 4 ton/fed significantly increased vegetative growth characters and total yield . El-Sayed *et al*. (2014) indicated that, there were increases in plant height, haulm fresh weight, number of main stems, leaves content of phosphorus and potassium and total marketable yields of potato plants from plots treated with 35.7 $Mt.ha^{-1}$ of compost at 90 days after planting, compared to treatment control. Awad and Ahmed (2018) illustrated that application Jerusalem artichoke with (75% pigeon manure + 25% farmyard) recorded the highest values for plant height, number of lateral shoots, number of leaves, leaves fresh and dry weights, stem fresh and dry weights and leaf area / plant. They added that, 75 % poultry manure and 25 % pigeon manure recorded the highest N, P and K contents in shoots, as well as tuber fresh and dry weights, dry matter and total yield as compared to untreated plants with any fertilizers under sandy soil conditions.

Apical dominance is used to describe the mechanism by which the apex of shoot inhibits the outgrowth of secondary of lateral shoots (Cline, 1997). It has been suggested that the phytohormone of auxin is involved in the process .This is supported by findings that high levels of the bioactivate form, indole 3-acetic acid(IAA) , are produced in the apex and transported basipetally along the stem, where the lateral shoots buds reside. Decapitation removes the apical source of IAA and stimulates lateral bud outgrowth (Dun *et al*., 2006).

In this regard, Feleafel, (2001) demonstrated that topping treatment on sweet potato plants significantly increased number of shoots but, decreased fresh weight of canopy compared to control. Olorunnisomo, (2007) indicated that root yield and total biomass production of sweet potato plants were significantly decreased by cutting. Moreover, pruning at longer intervals (6 and 8 weeks) significantly improved forage yield and the expense of root yield. Abou – Sedera *et al.*, (2010) concluded that topping treatments on sweet potato plants recorded the highest values of number of branches, storage roots per plant, T.S.S%, total carbohydrates, reducing and total sugars, as well as carotene contents as compared to plants without topping. Patil *et al.* (2012) showed that growth and productivity of okra are increased with pinching at early compared to later stages of growth, providing sufficient time for regeneration of vegetative parts, enhancing production of branches. Aliyu *et al.* (2015) indicated that pruning significantly influenced growth and yield performance of okra. They added that, the average fresh fruit yield of okra was 10 ton /ha, where pruning treatment was carried out and the control recorded 6 t/ha. pruning delayed the flowering but increased the yield performance of okra. Ahmad *et al.* (2016) found that single pinched plants were recorded with larger canopy spread. Moreover, the maximum number of primary branches/ plant and secondary branches/ plant were recorded with double pinching. Abd El-Hameed (2016) pointed out that apical bud topping at the 4^{th} node or at the 6^{th} node increased dry weight of leaves and total dry weight/ plant, while without topping recorded the maximum N,P, K contents in shoots, total carbohydrates and lowest values of fiber contents in dry pods in the second season only.

Therefore, the purpose of the present work was to study the effect of different rates of compost and topping frequency on vegetative growth, yield and its components, chemical constituents and blade anatomy of Jerusalem artichoke plants.

MATERIALS AND METHODS

A field experiment was carried out during the summer seasons of 2016 and 2017at the Experimental Farm of El- Kassasin Hort. Station, Ismailia

Governorate, Egypt, to study the effect of different rates of compost and some topping treatments on plant growth, yield and its components, tuber quality and blade anatomy of Jerusalem artichoke plants (*Helianthus tuberosus* L.) cv. Fuseau grown in sandy soil conditions using drip irrigation system. The Physical and chemical properties of the experimental soil are consists of sandy in texture which had 6.5 and 6.8 % FC, 2.4 and 2.5 % WP, 4.5 and 4.5 available water, 13.8 and 14.5% water holding capacity, 0.03 and 0.08 % organic matter, 8.1 and 8.1 pH ,5.4 and 6.9 ppm available N, 5.5 and 6.2 ppm available P ,52. and 54 ppm available K ,0.18 and 0.26% Calcium carbonate, in the 1st and 2nd seasons, respectively .

This experiment included 9 treatments, which were the combinations between three rates of compost (3, 6 and 9 ton/fed.) and three topping treatments (Without topping, topping the main and lateral shoots 30 cm from apical (once) after 70 days from planting and (twice) after 70 and 100 days from planting. These treatments were arranged in a split plot design with three replicates, where the rates of compost were randomly assigned in the main plots, while topping treatments were randomly distributed in the sub-plots.

The characteristics of botanical compost used in the experimental (compost Al Obor) as follows: Weight of m^3 was (600 kg), moisture content (27.5 %), pH (8) Ec (5), total nitrogen (1 %), total phosphorus (0.5%), total potassium (1.1 %), C-N ratio (1:16.25%), organic matter (35 %) and organic carbon (15.75%) average of two seasons.

Tuber seed of Jerusalem artichoke were sown in April 30th in both seasons at 40 cm apart. The experiment al plot area was 12.6 m^2. (three dripper lines with 6m length each 70 cm distance between each two dripper lines). One line was used to measure the vegetative growth parameters and the other two lines were for yield determination. The agricultural practices were conducted according to the recommendation of the Ministry of Agriculture for Jerusalem artichoke commercial production.

Data recorded:

1. Plant growth parameters:

Three plants from each experimental unit were randomly taken at 120 days after planting to determine plant height (cm), number of branches per plant, shoots fresh weight / plant and shoots dry weight (g)/plant which was measured by dried fresh shoot/ plant at 70^{o}C till constant weight.

2. Nitrogen, phosphorus and potassium contents in shoots:

The contents of nitrogen, phosphorus and potassium were assayed in the dry matter of shoots at 120 days after planting in both seasons, then, finely

ground and wet digested for N, P and K determination according to the methods advocated by A.O.A.C. **(**1990). N, P and K uptake by shoots (mg/shoots) were calculated by multiplying the percentage of nutrient in dry matter of shoots. Total protein in shoots was determined by multiplying the total nitrogen content in 6.25.

3. Yield and its components:

At harvest time, 180 days after planting approxmitly , number of tuber roots/ plant, average tuber weight (g), tuber yield per plant (kg), total yield (ton/ fed.) and total yield of shoots produced topping /fed. were recorded.

4. Tuber quality:

Dry matter (%): it was determined by drying 100 g of grated tuber tissues at 105 ^{o}C till constant weight, and then DM (%) was calculated.

Total carbohydrates percentage*:* It was determined colorimetrically in dry tuber according to the method described by A.O.A.C. (1990).

Inulin contents: Tuber concentration of inulin was determined according to (Winton and Winton, 1985).

Total sugars (%): It was determined according to the method described by A.O.A.C. (1990).

5. Economic feasibility:

Economic analysis was calculated according to Heady and Dillon (1961) as following:

Gross income (L.E./fed.)= total yield (tubers/ fed.) × price of ton tubers + yield of shoots produced from topping × price of ton shoots (L.E.)

Net return (L.E. /fed.) = gross income – total cost of production.

Profit margin = net return/ gross income

Return of Pound= net return/ total cost of production

Benefit/cost ratio =gross income / total cost

6- Anatomical study:

Specimens were taken at the age of 150 days from planting (the beginning of flowering stage) during the second season only, and subjected to microtechniqe practices given by Willey (1971) at Agricultural Botany Dept. Laboratory, Fac. Agric., Zagazig Univ., Zagazig, Egypt. Specimens from various treatments of *Helianthus tuberosus* plants were taken from the fifth upper leaf. These specimens (0.5 cm long) were killed and fixed at least for 24 hrs in FAA solution (10 ml formalin, 5 ml glacial acetic acid and 85 ml ethyl alcohol 70%). After fixation, they were washed and dehydrated in ascending

concentration series of ethyl alcohol then transferred to absolute alcohol before being embedded in paraffin wax (melting point 52-54ºC). Transverse sections were cut using a rotary microtome (EPMA) to a thickness of 14 microns. Paraffin ribbons were mounted on slides and sections were clarified in pure xylole for 10-20 min. before transferring to absolute alcohol, stained with safranin/light green. Sections were mounted in Canada Balsam. Selected sections were examined microscopically and photomicrographed using light microscope (Olympus) provided with digital camera, (Canon power shot S80) connected to a computer. The photographs were taken by Zoom Browser Ex Program. Dimensions of leaves were measured by using Corel Draw Program ver.11.

Statistical analysis:

Recorded Data were subjected to the statistical analysis of variance according to Snedecor and Cochran (1980), and means separation were done according to Duncan (1958) at all tables and using LSD (least significant differences at 5% level of probability for Table (g) only.

RESULTS AND DISCUSSTION

1. Plant growth:

1.1. Effect of compost rates:

Data presented in Table 1 show that, there were a significant differences between all compost rates (3, 6 and 9 ton/fed.) for Jerusalem artichoke plant growth parameters, such as plant height, number of shoots, both fresh and dry weight of shoots / plant after 120 days from planting in both growing seasons.

Application of Jerusalem artichoke plants with 9 ton/fed. botanical compost significantly increased plant height, number of shoots, both fresh and dry weight of shoots / plant after 120 days from planting in both seasons. On the other hand, the lowest values of all abovementioned parameters were recorded with 3 ton /fed. compost in both seasons, while fertilizing with compost at 6 ton /fed. in both seasons. The increases in dry weight of shoots / plant were about 25.02 and 7.41 % for 6 ton /fed. compost and 40.25 and 17.51% for compost at 9 ton/fed. Compared to the application of compost at 3 ton/fed. in the 1^{st} and 2^{nd} seasons, respectively.

These findings may be attributed to the main role of compost fertilizers which they are as a source of slow release macro-nutrients and improved the physical, chemical and biological properties of the soil then in turn increased plant growth (Anwar *et al.*, 2011).

Table 1. Effect of compost rates and topping treatments on plant growth characters of Jerusalem artichoke after 120 days from planting, during 2016 and 2017 seasons

Treatments	Plant height (cm)		Number of shoots /plant		Shoot Fresh weight /plant (g)		Shoot Dry weight /plant (g)	
	2016 season	2017 season	2016 season	2017 season	2016 season	2017 season	2016 season	2017 season
Ton /fed.	***Effect of compost rates***							
3	150.33	133.44	16.11	22.98	731.1	780.00	203.20	218.04
6	171.22	139.64	19.88	25.77	913.9	843.33	254.05	234.22
9	202.22	148.97	28.33	31.44	1025.1	923.33	284.98	256.22
LSD at 5 % level	**6.54**	**5.93**	**1.45**	**0.87**	**33.15**	**23.08**	**11.63**	**7.27**
	Effect of topping number							
Without topping	206.00	186.42	15.10	20.87	977.75	960.00	271.78	268.00
Topping once	171.22	134.20	20.66	26.22	920.22	835.00	255.81	231.82
Topping twice	146.55	101.43	28.55	33.10	772.11	751.67	214.65	208.67
LSD at 5 % level	**5.13**	**4.65**	**1.14**	**0.68**	**14.82**	**24.68**	**9.12**	**5.70**

Values having the same alphabetical letter (s) in each column did not significantly different according to LSD at 0.05 level of probability.

These results are accordance with those obtained by Ragab *et al.* (2008), Awad and Ahmed (2018) on Jerusalem artichoke, El-Sayed *et al*. (2014), Abou-Hussein (2005) on potato and Shehata and El-Hady (2010) on snap bean who concluded the organic manure application to these plants significantly increased the vegetative growth parameters of plants.

1.2. Effect of topping treatments:

Results in Table 1 illustrated that, different plant growth traits, *i.e*., plant height and both fresh and dry weight of shoots / plant after 120 days from planting significantly decreased by both topping treatments (once or twice) than untreated in both seasons, however, the plants with un topped treatment significantly increased plant height and both fresh and dry weight of shoots / plant , followed by the plants treated once number (after 70 days only) in both seasons. On the contrary, topping the main and lateral branches after 70 and 100 days from planting treatment (twice) recorded the lowest values in all measured growth characters except number of shoots in both seasons.

The decreases in dry weight of shoots / plant were about 5.9 and 13.5 % for topping once and 21.0 and 22.1 % for topping twice less than without topping in the 1st and 2nd seasons, respectively.

The enhancing effect of topping on number of lateral branches can be discussed on the basis that, the topping treatment terminated the apical dominance and promoted the lateral shoots to grow strongly (El-Hallwany *et al*., 1988). Similar findings with topping were obtained by Feleafel (2001) on potato and Abou-Sedera *et al*., (2010) on sweet potato who illustrated that topping plants increased the vegetative growth parameters of these plant.

1.3. Effect of interaction:

Data in Table 2 show clearly that, all interaction treatments had a significant effect on plant growth parameters after 120 days from planting in both seasons.

The interaction between fertilizing plants with compost at 9 ton/fed. and without topping gave the highest values of plant height , and both fresh and dry weight of shoots/plant in both seasons. As well as, with no significant differences with compost at 6 ton /fed. and without topping concerning plant height and with compost at 9 ton/fed. and topping plant once respecting dry weight of shoots in the 1st season whereas, the highest values of number of shoots per plant were recorded at 9 ton compost/fed. and topping plant twice. On the other hand, the interaction between fertilizing with compost at 3 ton/fed. and topping treatment twice recorded the lowest values of all plant growth parameters in both seasons.

2. Shoot chemical composition:

2.1. Effect of compost rates:

The results indicated that compost rates significantly increased N, P and K contents and its uptake, as well as, total protein by shoots of Jerusalem artichoke at 120 days after planting in both growing seasons (Tables 3 and 4). Increasing compost level up to the highest level 9 ton /fed. recorded the highest contents and its uptake of these nutrients, as well as total protein in shoots , followed by fertilizing plants with compost at 6 ton /fed. in both seasons , while the lowest values were recorded as response to 3 ton compost /fed. in both seasons.

Organic manures could raise the concentrations of many nutrients and the soil enhance the nutritional value and nutrient balance of plants (Graham *et al*., 2000). Also, compost is relatively resistant to microbial degradation, establishing and maintaining optimum soil physical conditions that are important for plant growth. It is a good source of nitrogen for sustainable crop production (Massri and Labban , 2014).

These results are confirmed with those recorded with Awad and Ahmed (2018). They showed that the best treatment conferred highest leaf contents of

Table 2. Effect of interaction between compost rates and topping treatments on plant growth characters of Jerusalem artichoke after 120 days from planting during 2016 and 2017 seasons

Treatments		Plant height (cm)		Number of shoots /plant		shoot Fresh weight/plant (g)		shoot Dry weight/plant (g)	
Compost rates	Topping no	2016 season	2017 season	2016 season	2017 season	2016 season	2017 season	2016 season	2017 season
3	0	180.66	176.66	10.00	18.30	816.6	870.0	226.89	246.00
	Once	155.33	130.00	15.00	23.00	726.7	780.0	202.01	216.80
	twice	115.00	93.66	23.33	27.66	650.0	690.0	180.70	191.33
6	0	215.33	184.00	14.66	20.00	1008.3	960.0	280.32	266.67
	Once	173.33	133.60	18.66	25.66	950.3	805.0	264.17	223.33
	twice	125.00	101.33	26.33	31.66	783.0	765.0	217.67	212.67
9	0	222.00	198.60	20.66	24.33	1108.3	1050.0	308.12	291.33
	Once	185.00	139.00	28.33	30.00	1083.7	920.0	301.26	255.33
	twice	199.66	109.30	36.00	40.00	883.3	800.0	245.57	222.00
LSD at 5 % level		8.89	**8.06**	**1.97**	**1.18**	**25.68**	**42.68**	**15.81**	**9.88**

Values having the same alphabetical letter (s) in each column did not significantly different according to LSD at 0.05 level of probability.

Table 3. Effect of compost rates and topping treatments on shoot chemical composition of Jerusalem artichoke after 120 days from planting during 2016 and 2017 seasons

Treatments	Contents (%)							
	N		P		K		Total protein	
	2016 season	2017 season	2016 season	2017 season	2016 season	2017 season	2016 season	2017 season
Ton /fed.	**Effect of compost rates**							
3	2.26	2.32	0.320	0.349	1.31	1.34	14.14	14.50
6	2.85	2.98	0.359	0.377	1.83	1.84	17.83	18.66
9	3.46	3.53	0.380	0.398	2.40	2.42	21.64	22.08
LSD at 5 % level	0.11	0.16	0.014	0.021	0.13	0.15	0.70	1.01
	Effect of topping number							
Without topping	2.91	3.01	0.371	0.392	1.87	1.91	18.19	18.81
Topping once	2.85	2.93	0.352	0.380	1.85	1.87	17.83	18.35
Topping twice	2.81	2.89	0.337	0.352	1.82	1.82	17.60	18.08
LSD at 5 % level	**0.08**	**NS**	**0.011**	**0.017**	**NS**	**NS**	**0.55**	**NS**

Values having the same alphabetical letter (s) in each column did not significantly different according to LSD at 0.05 level of probability.

Table 4. Effect of compost rates and topping treatments on N,P and K uptake by shoot of Jerusalem artichoke after 120 days from planting during 2016 and 2017 seasons

Treatments	Uptake (mg/ shoot)					
	N		P		K	
	2016 season	2017 season	2016 season	2017 season	2016 season	2017 season
Ton /fed.	***Effect of compost rates***					
3	4606.2	5066.7	655.7	767.0	2679.3	2928.2
6	7256.3	7007.0	916.0	887.0	4675.0	4332.0
9	9881.3	9068.3	1088.0	1022.7	6843.7	6224.7
LSD at 5 % level	498.0	564.9	72.4	80.27	438.0	483.6
	Effect of topping number					
Without topping	8072.0	8160.0	1019.3	1054.3	5246.4	5213.6
Topping once	7497.2	6882.7	909.3	883.7	4927.9	4412.7
Topping twice	6174.7	6099.3	731.0	738.7	4023.7	3858.7
LSD at 5 % level	**197.2**	**270.8**	**56.8**	**36.4**	**192.0**	**273.1**

Values having the same alphabetical letter (s) in each column did not significantly different according to LSD at 0.05 level of probability.

NPK (75% poultry manure + 25% pigeon manure) than un fertilizers Jerusalem Artichoke plant were added.

2.2. Effect of topping treatments:

At the same Table, data indicated that there were significant differences between topping treatments regarding N, P and K contents and its uptake by shoots and total protein in both seasons, except N contents and total protein in the 2nd season and K contents in both seasons. The plants with not topping recorded the maximum concentration of N , P and total protein contents in shoots, N, P and K uptake by shoots in both seasons, followed by the plant which topped once (after 70 days from planting), while the lowest values of three nutrients contents and its uptake, as well as, total protein were recorded when the plants, which topped twice number (after 70 and 100 days from planting) in both seasons.

This mean that there were no significant differences between without topping treatment (18.19 and 18.81 %) and topping treatment once number (17.83 and 18.35 %) concerning total protein in shoot in the 1st and 2nd seasons, respectively These results are in concurrence recorded by Abd El-Hameed (2016) showed that okra plants without apical bud pinching (ABP) recorded the maximum N,P and K contents in shoots than ABP plants.

2.3. Effect of interaction:

Nitrogen , phosphorus and potassium contents and its uptake by shoots, as well as total protein in shoots had significant affected by the interaction between compost rates and topping treatments in both seasons (Tables 5 and 6). The interaction between compost at 9 ton/fed. and all topping treatments un topped, once and twice) significantly increased N,P,K and total protein in shoots than other interaction treatments in both growing seasons.

The interaction between 9 ton /fed. compost and un topped plant gave the maximum values for N,P and K uptake by shoots with no significant differences between the same rate of compost and topped plants once for P and K uptake in the 1st season.

3. Yield and its components of tubers:

3.1. Effect of compost rates:

There were a significant differences among the three compost rates (3, 6 and 9 ton/fed.) on yield and its components in both seasons (Table 7). Fertilizing Jerusalem artichoke with compost at 9 ton/fed significantly increased all components of yield, such as number of tuber/plant, average tuber weight, tuber yield/plant and total tuber yield/fed. in both seasons, except number of tuber/plant in the 1st season. This means that treating plants with compost at 9 ton /fed. recorded 24.268 and 22.649 ton/fed as compared to 20.678 and 18.847 ton/fed for 6 ton/fed and 17.232 and 16.346 ton/fed., for 3 ton/fed. in the 1st and 2nd seasons, respectively.

Increasing Jerusalem artichoke yield and its components as a result of increasing compost rates from 3 up to 9 ton/fed was may be due to the enhancing effect of compost on vegetative growth characters (Table 2).

Similar results were reported by Abou-Hussein (2005) and El-Sayed *et al*., (2014) on potato and Awad and Ahmed (2018)on Jerusalem artichoke showed that fertilizing with (75% pigeon manure + 25% farmyard) recorded the highest values of tuber weight and total yield as compared to un treated plants (control) under sandy soil conditions.

3.2. Effect of topping treatments:

It is clear from the data in Table 7 that, topping treatments showed significant differences in yield and its components of Jerusalem artichoke in both seasons. Un topped plants gave the highest values of average tuber weight, tuber yield/plant and total tuber yield /fed. in both seasons, while topping treatment twice number recorded the highest values of number of tubers / plant and lowest values of average tuber weight, tuber yield / plant and total tuber yield /fed. in both seasons.

Table 5. Effect of interaction between compost rates and topping treatments on shoot chemical composition of Jerusalem artichoke after 120 days from planting during 2016 and 2017 seasons

Treatments		Chemical constituents (%)							
		N		P		K		Total protein	
Compost rates	Topping no	2016 season	2017 season	2016 season	2017 season	2016 season	2017 season	2016 season	2017 season
3	0	2.31	2.37	0.334	0.375	1.34	1.36	14.44	14.81
	Once	2.26	2.31	0.326	0.366	1.32	1.34	14.12	14.44
	twice	2.22	2.28	0.301	0.306	1.29	1.32	13.88	14.25
6	0	2.90	3.05	0.381	0.391	1.87	1.92	18.13	19.06
	Once	2.84	2.99	0.351	0.377	1.85	1.86	17.75	18.69
	twice	2.82	2.92	0.346	0.365	1.79	1.75	17.63	18.25
9	0	3.52	3.61	0.398	0.411	2.42	2.46	22.00	22.56
	Once	3.46	3.51	0.379	0.398	2.40	2.42	21.63	21.94
	twice	3.41	3.48	0.365	0.385	2.38	2.40	21.31	21.75
LSD at 5 % level		**0.15**	**0.21**	**0.020**	**0.029**	**0.18**	**0.21**	**0.96**	**1.37**

Values having the same alphabetical letter (s) in each column did not significantly different according to LSD at 0.05 level of probability.

Table 6. Effect of interaction between compost rates and topping treatments on N, P and K uptake by shoot of Jerusalem artichoke after 120 days from planting during 2016 and 2017 seasons

Treatments		Nutrients Uptake (mg/ shoot)					
		N		P		K	
Compost rates	Topping no	2016 season	2017 season	2016 season	2017 season	2016 season	2017 season
3	0	5241	5830	764.0	923.0	3040.3	3353.7
	Once	4566	5008	659.0	793.0	2666.7	2905.0
	twice	4012	4362	544.0	585.0	2331.0	2526.0
6	0	8129	8133	1068.0	1043.0	5242.0	5120.0
	Once	7502	6678	927.0	842.0	4887.0	4154.0
	twice	6138	6210	753.0	776.0	3896.0	3722.0
9	0	10846	10517	1226.0	1197.0	7457.0	7167.0
	Once	10424	8962	1142.0	1016.0	7230.0	6179.0
	twice	8374	7726	896.0	855.0	5844.0	5328.0
LSD at 5 % level		**341.6**	**469.0**	**98.4**	**63.2**	**332.6**	**473.1**

Values having the same alphabetical letter (s) in each column did not significantly different according to LSD at 0.05 level of probability.

Table 7. Effect of compost rates and topping treatments on yield and its components of Jerusalem artichoke during 2016 and 2017 seasons

Treatments	Number of tubers/ plant		Average tuber weight (g)		Yield /plant (g)		Total yield (ton/fed)	
	2016 season	2017 season	2016 season	2017 season	2016 season	2017 season	2016 season	2017 season
Ton /fed.	***Effect of compost rates***							
3	50.19	47.44	23.97	24.44	1206.3	1143.7	17.232	16.346
6	50.22	45.77	29.06	28.91	1447.4	1319.0	20.678	18.847
9	49.99	47.77	34.23	32.60	1698.3	1585.3	24.268	22.649
LSD at 0.05 level	**NS**	**1.01**	**0.90**	**0.97**	**152.2**	**75.6**	**1.058**	**0.470**
	Effect of topping number							
Without topping	47.31	44.66	35.87	34.73	1697.4	1565.0	24.250	22.364
Topping once	50.55	46.10	28.02	28.73	1425.8	1373.0	20.371	19.618
Topping twice	52.55	50.21	23.37	22.48	1228.7	1110.0	17.556	15.859
LSD at 5 % level	**1.48**	**0.79**	**0.70**	**0.76**	**61.6**	**77.6**	**0.434**	**0.519**

Values having the same alphabetical letter (s) in each column did not significantly different according to LSD at 0.05 level of probability.

The beneficial effect of topping on herb yield potential of Jerusalem artichoke plants could be explained on the basis that topping treatments caused a significant increment in number of shoots per plant and consequently, the photosynthetic surface was increased. These results are in harmony those reported by Feleafel (2001) on potato and Abou- sedera *et al.* (2010) 0n sweet potato.

3.3. Effect of interaction:

The interaction treatments between compost rates and topping treatments had a significant effect on yield and its components of Jerusalem artichoke in both seasons (Table 8). It is seen that the interaction between compost at 9 ton/fed. without topping treatment (control) significantly increased the average tuber weight , tuber yield / plant and total tuber yield /fed. Moreover the highest values of tubers number / plant. were recorded with the interaction between compost at 9 ton /fed. and topping treatment twice number in both seasons.

This means that, the highest values of total yield of tuber/fed. (27.457 and 26.370 ton/fed., were recorded with the interaction between 9 ton/fed. compost., and without topping , followed by the interaction between 9 ton/fed. compost., and topping once (24.836 and 23.142 ton/fed.) in the 1st and 2nd seasons, respectively. While the lowest total yield (14.353 and 12.715 ton/fed.) was recorded with the interaction between compost at3 ton/fed. and topping treatment twice number in the 1st and 2nd seasons, respectively.

Table 8. Effect of interaction between compost rates and topping treatments on yield and its components of Jerusalem artichoke during 2016 and 2017 seasons

Treatments		Number of tubers/ plant		Average tuber weight (g)		tuber Yield /plant (g)		Total tuber yield (ton/fed)	
Compost rates	Topping no	2016 season	2017 season	2016 season	2017 season	2016 season	2017 season	2016 season	2017 season
3	0	47.60	44.33	30.72	30.20	1464.1	1342.0	20.915	19.181
	Once	47.00	46.33	22.00	25.90	1150.0	1199.0	16.427	17.141
	twice	47.33	51.66	19.20	17.23	1004.7	890.0	14.353	12.715
6	0	49.66	44.00	36.30	34.00	1706.1	1507.0	24.379	21.540
	Once	50.66	44.66	27.07	29.11	1389.5	1300.0	19.849	18.571
	twice	51.33	48.66	23.82	23.62	1246.5	1150.0	17.806	16.429
9	0	52.33	45.66	40.61	40.00	1922.0	1846.0	27.457	26.370
	Once	52.33	47.33	35.01	31.20	1738.0	1620.0	24.836	23.142
	twice	53.00	50.33	27.09	26.60	1435.0	1290.0	20.510	18.434
LSD at 5 % level		**2.56**	**1.38**	**1.22**	**1.32**	**106.7**	**134.5**	**0.752**	**0.900**

Values having the same alphabetical letter (s) in each column did not significantly different according to LSD at 0.05 level of probability.

3.4. Yield of shoots for animal feeding after topping treatments:

Data in Table 9 show the effect of shoots produced from compost rates, topping treatments and their interaction between them on yield of shoots for animal feeding in both seasons. There were significant differences between the two factors and their interactions in both seasons.

Fertilizing plants with 6 and/or 9 ton/fed. compost were the best treatments for increasing the yield of shoots from topping treatments in both seasons , while the least was recorded with 3 ton /fed. compost in both seasons. As for topping treatments, topping treatment twice recorded the highest yield of shoots (6.080 and 5.685 ton/fed), while once treatment recorded (4.175 and 3.810 ton/fed.) in the 1st and 2nd seasons, respectively. Regarding the interaction treatments, the highest yield was recorded with the interaction between9ton/fed. and topping twice (6.750 and 6.150 ton/fed.), followed by the interaction between 6 ton/fed. and topping twice (6.150 and 5.955 ton/fed.) in the 1st and 2nd seasons, respectively. These results are harmony with those obtained by Olorunnisomo, (2007) who indicated that total biomass production of sweet potato plants were significantly decreased by cutting. Moreover, pruning at longer intervals (6 and 8 weeks) significantly improved forage yield.

Table 9. Effect of compost rates and topping treatments and their interactions between them on yield of shoots produced from topping of Jerusalem artichoke during 2016 and 2017 seasons

Compost rates (ton/fed.)	Topping treatments			
	Without topping	Once	Twice	Mean (Compost)
	2016 season			
3	0.000	3.675	5.340	3.005
6	0.000	4.350	6.150	3.500
9	0.000	4.500	6.750	3.750
Mean (topping)	0.000	4.175	6.080	
LSD at 0.05 level	Compost rates =0.294 Topping treatments = 0.231 Compost x Topping =0.400			
	2017 season			
3	0.000	3.480	4.950	2.810
6	0.000	3.750	5.955	3.235
9	0.000	4.200	6.150	3.450
Mean (topping)	0.000	3.810	5.685	
LSD at 0.05 level	Compost rates = 0.209 Topping treatments = 0.164 Compost x Topping =0.284			

Values having the same alphabetical letter (s) in each column did not significantly different according to LSD at 0.05 level of probability.

4. Tuber quality:

4.1. Effect of compost rates:

It is clear from the date presented Table 10 show that, there were a significant differences among the three tested rates of compost in tuber quality of Jerusalem artichoke at harvesting time in both growing seasons.

All tuber quality ,*i.e*. dry matter (%), total carbohydrates (%), total sugars (%) and inulin content (%) significantly increased with increasing compost rates up to 9 ton /fed., while there were no significant differences with compost at 6 ton/fed., regarding dry matter in the 1st season, total sugars (%) in the 1st and 2nd season and Inulin content (%) in the 1st season . As well as all tuber quality parameters were significantly decreased with 3 ton /fed. compost in both seasons. Obtained results are in conformity with those of El-Sayed *et al*., (2014) on potato and Awad and Ahmed (2018) 0n Jerusalem artichoke showed that fertilizing with 75 % poultry manure and 25 % pigeon manure recorded the highest dry matter, (%) as compared to without fertilizers (control) under sandy soil conditions.

4.2. Effect of topping treatments:

All tuber quality of Jerusalem artichoke had significantly affected by different topping treatments in both seasons (Table10).

Table 10. Effect of compost rates and topping treatments on tuber quality at harvesting time of Jerusalem artichoke during 2016 and 2017 seasons

Treatments	Dry matter (%)		Total carbohydrates (%)		Total sugars (%)		Inulin content (%)	
	2016 season	2017 season	2016 season	2017 season	2016 season	2017 season	2016 season	2017 season
Ton /fed.	***Effect of compost rates***							
3	23.09	22.12	16.56	16.49	12.87	12.87	11.64	11.57
6	23.44	22.69	16.85	16.81	13.48	13.40	12.03	11.91
9	23.96	22.62	17.58	17.52	13.91	13.73	12.42	12.22
LSD at 0.05 level	**0.18**	**0.29**	**0.51**	**0.48**	**0.47**	**0.53**	**0.51**	**0.24**
	Effect of topping number							
Without topping	24.19	23.47	17.29	17.23	13.93	13.80	12.46	12.25
Topping once	23.45	22.68	17.06	17.01	13.30	13.23	12.02	11.87
Topping twice	22.85	21.28	16.63	16.58	13.03	12.96	11.61	11.58
LSD at 5 % level	**0.14**	**0.22**	**0.40**	**0.38**	**0.37**	**0.41**	**0.40**	**0.18**

Values having the same alphabetical letter (s) in each column did not significantly different according to LSD at 0.05 level of probability.

It is clear from data that, plants without topping significantly increased the percentage of dry matter, total carbohydrates, total sugars and inulin content in both seasons, with no significant differences with topping once for total carbohydrates in both seasons. Topping treatment twice number recorded the lowest values of all abovementioned traits for tuber quality in both seasons. These results are in agreement with those reported by Feleafel (2001) and Abou-Sedera *et al*. (2010) on sweet potato and Abd El-Hameed (2016) on okra.

4.3. Effect of interaction:

Data in Table 11 show the effect of interaction between compost rates and topping on tuber quality of Jerusalem artichoke at harvesting time in both seasons .It is clear that, the interaction between compost fertilization with 9 ton /fed., without topping gave the highest values of dry matter (%), total carbohydrates (%), total sugars (%) and inulin content (%) ,and with no significant differences with the same rate of compost and topping treatment once for total carbohydrates and total sugars (%) in both seasons and inulin content (%) in the 1st season. These results are true in both seasons of study.

5- Economic feasibility:

The cost benefit analysis was done with a view to observing the comparative cost and benefit trend of Jerusalem artichoke cultivation as affected by cultural practices as the fixed costs including land leasehold, seed

Table 11. Effect of interaction between compost rates and topping treatments on tuber quality at harvesting time of Jerusalem artichoke during 2016 and 2017 seasons

Treatments		Dry matter (%)		Total carbohydrates (%)		Total sugars (%)		Inulin content (%)	
Compost rates	Topping no	2016 season	2017 season	2016 season	2017 season	2016 season	2017 season	2016 season	2017 season
3	0	23.72	22.96	16.90	16.83	13.37	13.22	12.10	11.97
	Once	23.02	22.20	16.60	16.52	12.71	12.80	11.65	11.55
	twice	22.53	21.22	16.18	16.12	12.55	12.60	11.17	11.20
6	0	24.17	23.50	17.03	17.00	14.05	14.00	12.45	12.22
	Once	23.54	22.98	16.98	16.92	13.29	13.20	11.93	11.85
	twice	22.61	21.60	16.55	16.51	13.10	13.00	11.71	11.67
9	0	24.68	23.97	17.94	17.87	14.37	14.20	12.83	12.56
	Once	23.79	22.88	17.62	17.59	13.91	13.70	12.49	12.21
	twice	23.42	22.96	17.18	17.11	13.46	13.30	11.95	11.89
LSD at 5 % level		**0.25**	**0.40**	**0.69**	**0.66**	**0.65**	**0.72**	**0.69**	**0.32**

Values having the same alphabetical letter (s) in each column did not significantly different according to LSD at 0.05 level of probability.

costs, cultivation, irrigation, fertilizers, harvesting and the variable costs including compost and topping treatments . The details of economic analysis (average of two seasons) are presented in Table 12.

The total production cost ranged between LE. 16325 LE./fed. to 19325 LE./fed. among the treatments. The highest gross return and net return LE./fed. were obtained from the combination of compost at 9 ton /fed. and topping once treatment. This treatment recorded the best values of gross return and net return (54282 LE./fed., and 35557 LE./fed.), respectively, whereas, the treatment of 3 ton compost /fed., and topping twice recorded the lowest value of gross return and net return L.E/fed., (34080and 17333LE./fed.) , respectively (average two seasons).

Regarding the profit margin, return of pound and Benefit/cost ratio the application of compost at 9 ton/fed., without topping gave the highest values (0.656, 1.910 and 2.910) respectively, meanwhile the fertilizing with compost at 3 ton /fed. and topped plants twice gave the lowest values (0.509, 0.989, 1.945), respectively.

Table 12. Effect of compost rates and topping treatments on Economic costs for production of Jerusalem artichoke (average 2016 and 2017 seasons).

Treatments		Total cost production (L.E/fed.)	Gross income (L.E/fed)	Net return (L.E/fed.)	Profit margin (L.E)	Return of Pound	Benefit cost ratio
Compost rates	Topping no						
3	0	16325	38362	22037	0.574	1.350	2.350
	Once	16925	40910	23985	0.586	1.417	2.417
	twice	17525	34080	17333	0.509	0.989	1.945
6	0	17225	43080	25855	0.600	1.501	2.501
	Once	17825	44284	26459	0.597	1.484	2.484
	twice	18425	44200	25425	0.575	1.380	2.399
9	0	18125	52740	34615	0.656	1.910	2.910
	Once	18725	54282	35557	0.655	1.899	2.899
	twice	19325	48580	29255	0.602	1.514	2.514

Total production costs /fed. including (fixed costs+variabl costs).
Gross income (L.E. /fed.) = total yield (tubers/ fed) × price of ton tubers + yield of shoots/fed. x price of ton shoots (L.E.)
Net return (L.E. /fed) = gross income – total cost of production.
Profit margin = net return/ gross income
Return of Pound= net return/ total cost of production
Benefit/cost ratio =gross income / total cost

6. Anatomical characteristics:

a) Effect of compost rates:

As for the main effect of compost rates on anatomical features of Jerusalem artichoke plant leaves blades tabulated in Table 13. Results indicated that compost of Jerusalem artichoke plant at the highest rate (9 ton/fed.) gave the highest values for leaf blade parameters (midrib thickness, midrib width, midrib vascular bundle thickness, midrib vascular bundle width, phloem tissue thickness, xylem tissue thickness, diameter of xylem vessel average, blade thickness, palisade tissue thickness and spongy tissue thickness) as compared to other compost rates (6 and 3 ton /fed.), in addition, the low compost rate (3 ton /fed.) markedly decreased all the previous mentioned parameters of leaf blade. The obtained results are in good accordance with that previously recorded by Hassan *et al*. (2006). Tartoura (2010) reported that wheat plant biomass production was higher in compost treated plants than that in untreated ones. Stimulatory effects of compost on plant growth have often been related to alteration of the chemical and physical properties of the soil, increasing organic matter content, water holding capacity, microbes diversity, providing the essential macro-and micro nutrients for plant growth and suppressing plant

Table 13. Effect of compost, topping and their interaction on measurements of certain anatomical features in transverse sections through the leaf blade of the fourth upper on Jerusalem artichoke during the second growing season 2017 (Means of three sections from three specimens)

Treatments		Leaf parameter									
		Dimensions of the midrib		Dimensions of the midrib					Dimensions of the lamina		
		Thick. (µ)	Width (µ)	Length (µ)	Width (µ)	Phloem tissue thick. (µ)	Xylem tissue thick. (µ)	Average diameter of xylem vessel (µ)	Lamina thick. (µ)	Palisade tissue thick. (µ)	Spongy tissue thick. (µ)
Effect of compost rates											
3 ton/fed		777.76	583.99	290.04	218.17	158.17	131.87	22.85	228.06	113.20	64.00
6 ton/fed		1015.94	773.69	329.51	279.91	195.67	134.51	26.58	241.73	120.75	71.43
9 ton/fed		1039.96	832.63	354.89	300.51	202.69	152.20	27.73	244.25	123.01	72.74
Effect of No. topping											
Non		1269.84	956.88	405.16	343.04	237.03	168.80	30.47	248.54	126.03	74.40
Once		964.12	785.96	341.90	291.06	194.89	147.01	28.48	240.60	119.34	71.52
Twice		599.70	447.46	227.38	164.49	124.62	102.77	18.21	224.91	111.58	62.26
Effect of interaction											
3 ton/fed	**0**	1170.25	927.11	385.68	321.49	231.58	154.1	28.77	246.49	123.56	71.06
	Once	813.73	668.78	284.85	230.98	140.78	144.07	26.19	232.24	116.18	66.36
	Twice	349.30	156.07	199.58	102.04	102.15	97.43	13.59	205.45	99.85	54.58
6 ton/fed	**0**	1317.67	959.88	391.77	342.66	238.60	155.17	30.74	247.59	125.60	75.46
	Once	1016.76	790.27	361.46	306.72	215.53	145.93	28.77	244.13	120.72	73.93
	Twice	713.39	570.91	235.31	190.36	132.89	102.42	20.22	233.48	115.94	64.90
9 ton/fed	**0**	1321.61	983.66	438.02	364.97	240.90	197.12	31.89	251.53	128.94	76.67
	Once	1061.86	898.83	379.38	335.49	228.35	151.03	30.47	245.42	121.12	74.27
	Twice	736.40	615.40	247.26	201.06	138.81	108.45	20.82	235.80	118.96	67.29

diseases, which collectively contributes to plant growth enhancement (Tejada *et al.*, 2009). Mazhar *et al.* (2011) mentioned that all growth parameters and chemical constituents of gatrofa, except the percentage of Na and proline content, tended to increase by increasing the rates of Nile compost up to 200 g/pot as compared to the untreated ones.

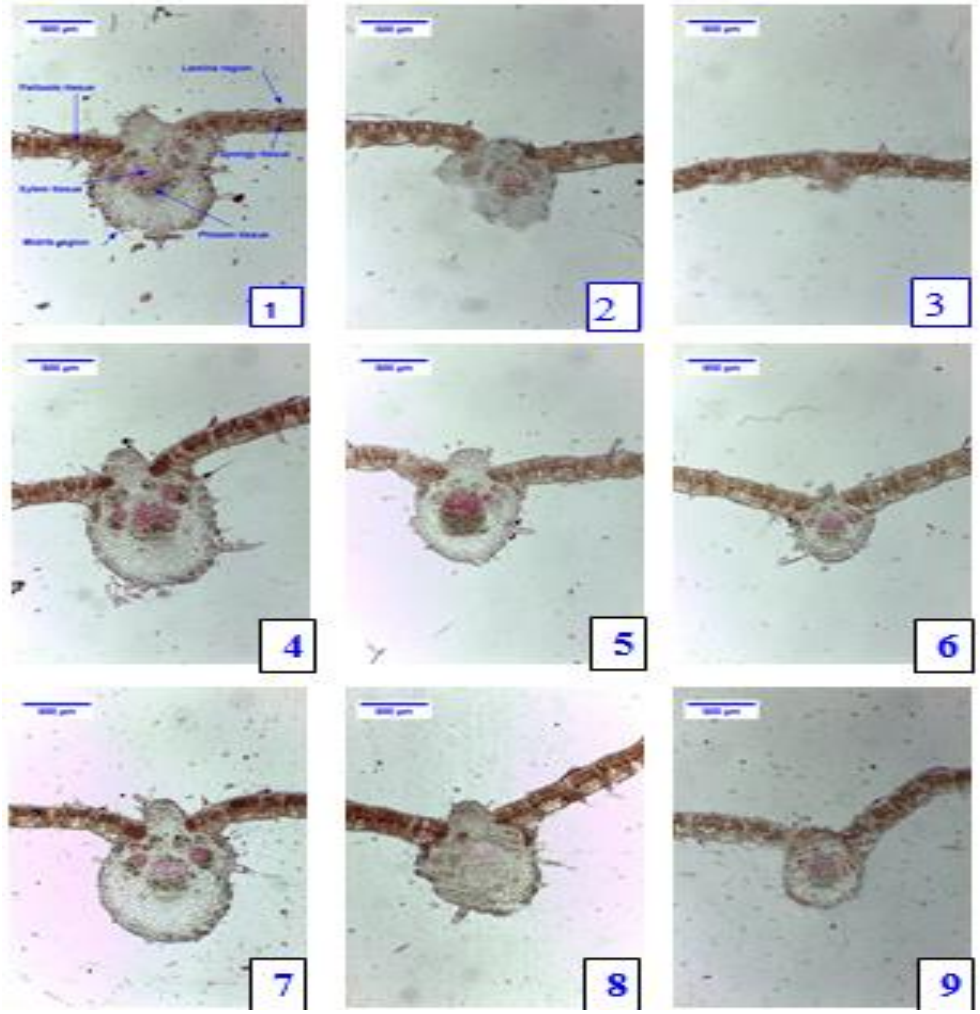
b) Effect of topping treaments:

Concerning the main effect of topping, it is clear from the data in the same table that disincentive effect of topping on Jerusalem artichoke leaf blade previous mentioned parameters, which markedly decreased with topping. Topping twice gave the lowest values for leaf blade previous mentioned parameters as compared to non- topping or topping once.

c) Effect of interaction:

Data in Table 13 and illustrated in Figure 1 indicate the interaction between compost rates and topping. It is evident from such data that all interaction treatments either under topping or under non- topping had a

Figure 1: Changes in transverse sections through the fifth upper leaf blade of Jerusalem artichoke plants grown under their interaction between compost and topping during the second growing season of 2017.



1) 3 ton compost / fed. + non-topping **6) 6** ton compost / fed. + topping twice
2) 3 ton compost / fed. + topping once **7) 9** ton compost / fed**.** + non-topping
3) 3 ton compost / fed. + topping twice **8) 9** ton compost / fed. + topping once
4) 6 ton compost / fed. + non-topping 9**) 9** ton compost / fed. + topping twice
5) 6 ton compost / fed. + topping once

prominent increase on Jerusalem artichoke leaf blade previous mentioned parameters. Generally, the compost treatments help to partially compensate the

reduction in thickness of midrib region and leaf blade of Jerusalem artichoke that caused by topping. Therefore, the compost overcome the destructive effect of topping. The same data presented in Table 8 and Figure 1 reveal that the topping once of Jerusalem artichoke and high fertilization with 9 tons compost/fed. tended to become similar to that of the non-topping and low fertilization with 3 tons compost/fed. The presented results are in agreement with those obtained by Tartoura (2010) who reported that application of compost had markedly alleviated oxidative stress damage in wheat induced by drought as indicated by improving total biomass production (TBP) and decreasing activated oxygen species, thereby reducing lipid peroxidation. It is interesting to note that the levels of superoxide (O_2) anion radical and hydrogen peroxide (H_2O_2) along with the by-product of lipid peroxidation {malondialdehyde (MDA)} were significantly lower in compost treated plants than in untreated ones under well-watered and drought stress conditions.

Conclusively, it could be concluded that, fertilizing Jerusalem artichoke plants grown in sandy soil with compost at 9 ton/fed. and un topped plants to obtain high yield of tubers and best quality as well as net return under the same conditions.

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تأثير معدلات الكمبوست والتطويش على النمو والمحصول وجودة الطرطوفة تحت ظروف الاراضى الرملية

رفعت صلاح الدين محمد انور[1]، محمد شرف محمد شرف[1]، جلال سرور عبد الحميد عيسى [2]

1- قسم بحوث البطاطس والخضر خضرية التكاثر- معهد بحوث البساتين- مركز البحوث الزراعية - جيزة

2- قسم النبات- كلية الزراعة - جامعة الزقازيق- مصر

أجريت تجربه حقليه خلال الموسم الصيفى لعامى2016 – 2017 بالمزرعة البحثية بمحطة بحوث البساتين بالقصاصين – محافظة الاسماعيلية . مصر. لدراسة تأثير التسميد بالكمبوست بمعدل (3 ، 6 ،9طن/فدان) و التطويش (بدون، مرة ، مرتين) على النمو الخضرى، التركيب الكيماوى للمجموع الخضرى، ومكونات المحصول (درنات, مجموع خضرى), جودة الدرنات, و تشريح الورقة لنباتات الطرطوفة صنف فيوزا النامية فى الاراضى الرملية مع استخدام نظام الرى بالتنقيط.

تسميد نباتات الطرطوفة المزروعة فى التربة الرملية بالكمبوست بمعدل 9 طن/ فدان بدون تطويش النباتات أدى الى زيادة معنوية فى ارتفاع النبات وكل من الوزن

الطازج والجاف للمجموع الخضرى, النيتروجين, الفوسفور, البوتاسيوم الممتص فى المجموع الخضرى، ونسبة البروتين الكلى فى المجموع الخضرى، ومتوسط وزن الدرنة، ومحصول النبات, ومحصول الفدان، والمادة الجافة، الكربوهيدرات الكلية, والسكريات الكلية, بالاضافة الى محتوى الدرنات من الانيولين فى كلا الموسمين. وقياسات تشريح الورقة للموسم الثانى فقط. بالاضافة الى ان هذه المعاملة سجلت افضل الصفات الاقتصادية (متوسط الموسمين). بينما سجلت معاملة التفاعل بين الكمبوست بمعدل 9 طن /فدان والتطويش مرتين أعلى قياسات محصول للمجموع الخضرى فى كلا الموسمين. بينما جاء التفاعل بين الكمبوست 9 طن/فدان وتطويش النباتات مرة واحدة فى المرتبة الثانية لأكثر الصفات المذكورة أعلاه. من ناحية أخرى سجلت أقل القيم بالنسبة لنمو النبات والمحتوى الكيماوى فى المجموع الخضرى,والمحصول ومكوناته, وجودة الدرنات مع النباتات المسمدة بالكمبوست بمعدل 3 طن /فدان والتطويش مرتين.

التوصية: يمكن أن نوصي بتسميد نباتات الطرطوفة النامية في الأراضي الرملية بالكمبوست بمعدل 9طن /فدان بدون تطويش النباتات وذلك للحصول على أعلى محصول وأفضل جودة وصافي عائد تحت الظروف المشابهة.