IMPACT OF FOLIAR APPLICATION OF SOME MICRNUTRIENTS NANAOFERTILIZER ON GROWTH AND YIELD OF JERUSALEM ARTICHOKE

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ABSTRACT

A field experiment was carried out at the fields of Al- Husseiniya District, Taliaa Township, Babylon Governorate, to study the response of the Jerusalem artichoke to foliar application of micro nutrients nano-fertilizes of Nano Iron, Zinc, Copper ,and Manganese foliar applied at 25, 50, 75 and 100 g nano-fertilizer 100 L^{-1} water, and 1 kg naonfertilizers ha^{-1}(as recommended) dissolved in 400 liters of solution ha^{-1}.The experiment included single , di, tri and tetra combinations, as well as a tetra combination of a traditional source, in addition to control(distil water only) using RCBD with 3 replicates . Growth parameters tested were chlorophyll SPAD, dry matter yield of vegetative, tubers yield, inulin yield and % of sucrose and ascorbic acid. Results indicated that nano-applied treatment of (Cu+ Zn+ Fe+ Mn) was significantly higher followed by the triple, di and single spray combinations, in yield of fresh and dry tubers, vegetative and inulin yield giving 77.928, 19.906, 6.584 and 13. 235 Mg ha^{-1}) ,respectively , compared with traditional fertilizers (34.320, 6.284, 3.908, and 3.345 Mg ha^{-1}) and the control (22.655, 3.234, 3.390 and 1.201 Mg ha^{-1}), respectively. The highest % of sucrose and ascorbic acid (vitamin c) (61.13% and 8.1%) were with tetra nano (Cu +Zn +Fe+ Mn) than other treatments.

Keywords: Nanofertlizers, Soft tubers yield, sucrose, Inulin, Ascorbic acid
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مجلة العلوم الزراعية العراقية -2018 :49(4):577-585 الجوذري والسلطاني

تاثير رش بعض أسمدة المغذيات الصغرى النانوية في نمو وحاصل الالمازه Jerusalem Artichoke

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المستخلص

نفذت تجربة حقليه في احد حقول الحسينية – محافظة بابل لدراسة استجابة محصول الالمازة لرش أسمدة المغذيات الصغرى النانوية الحديد والزنك والنحاس والمنغنيز وبتراكيز 25و50و 75و100غم سماد لتر$^{-1}$ ماء) للرشة الاولى والثانية والثالثة والرابعة بالتتابع وحسب التوصية بمقدار 1كغم سماد نانوي هـ$^{-1}$ وبواقع 400 لتر محلول رش هـ$^{-1}$، برش منفرد وبتوليفات ثنائية وثلاثيه ورباعيه فضلا عن توليفه رباعية من مصدر تقليدي بالإضافة إلى معاملة المقارنة (الرش بالماء فقط) ،وفق تصميم القطاعات الكاملة المعشاة وبثلاثة مكررات في بعض معالم مؤشرات النمو ومحتوى الاوراق من الكلوروفيل SPAD وحاصل الوزن الجاف للمجموع الخضري وحاصل الدرنات و محتوى وحاصل الاينولين والنسب المئوية للسكرور والاسكوربيك اسد. أظهرت النتائج تفوق معاملة رش نانو رباعي (Mn+Fe+Zn+Cu) معنويا تلتها التوليفات الثلاثية والثنائية و الرش المنفرد، في حاصل الدرنات الطري والجاف وحاصل الوزن الجاف للمجموع الخضري وحاصل الاينولين (77.928و19.906و6.584 و13.235 ميگا غرام هـ$^{-1}$) بالتتابع، قياسا بالتوليفة الرباعية للأسمدة التقليدية (34.320 و6.284 و3.908و3.345ميگا غرام هـ$^{-1}$) والمقارنة (22.655 و3.234 و3.390 و1.201 ميگا غرام هـ$^{-1}$) بالتتابع . وكانت أعلى نسبة من السكروز وحامض الاسكوربيك (فيتامين C) (61.13 و 8.1 %) مع نانو (Mn+Fe+Zn+Cu) الرباعية من المعاملات الأخرى.

كلمات مفتاحية: الأسمدة النانوية، حاصل الدرنات الطري، السكروز، الاينولين، الاسكوربيك اسيد
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INTRODUCTION

Foliar application is a complementary method to soil additives to improve yield quantity and quality. Many field experiments have shown significant effects of nutrient uptake when spraying their solutions on the vegetative part of the plant (4). In recent years, nano-fertilizers or coated nano-nutrients with effective properties have been emerging to accelerate crop growth and nutrient release on demand, control nutrient release that regulates plant growth and enhance its target activity (13,25 and 27). Materials whose particle sizes are between 1 and 100 nm for at least one dimension are called nano-materials (21). Thus, NMs can equip one or more nutrients to improve growth and production of plants with better performance and lower amounts of traditional fertilizers and slow nutrient release, in line with the crop growth curve (16). Nano fertilizers can achieve rapid plant response, particularly with soil problems, high pH, carbonate minerals and insufficient root growth (32). Some studies have demonstrated the importance of active nano fertilizers in terms of increased nutrient efficiency, higher yield, better quality, and safer environment (26 and 37). Jerusalem artichoke (*Hilianthus tuberosus* L.) one of the perennial vegetable crops of the composite family, but is grown each year after maturation in the autumn to give new spring growth (30). It is also a promising crop of bio-fuel (43)due to high sugar production 9-13 Mg ha^{-1} of tubular carbohydrates (2 and 5).And has many application areas such as green or ensiled forage, a cover crop in marginal area, source of inulin for foods, material for production of various chemicals, pharmaceuticals and industrial applications, etc. (9,12, 18 and 30) were used in the industry for fructose, which is very useful for diabetics (43). This study aims to: Find out the response of Jerusalem artichoke to foliar applied nano fertilizers of micro nutrients individually In some growth parameters and compared to traditional micronutrient fertilizers.

MATERIAL AND METHODS

This study was carried out in a field Al-Husseiniya districts of - Taliaa Township - Babylon Governorate for the agricultural season 2015-2016 between the two points of north (32 10.692 and 32 10.617) and east (44 48.457 and 44 48.538) according to the Universal Transverse Mercator (UTM) Positioning System (GPS) in Silty Clay Loam soil with chemical and physical characteristics, shown in (Table 1), to study the response of Jerusalem artichoke to foliar applied nano fertilizers of micro nutrients. The soil was prepared after plowing by the rotary plow, and furrows was worked on 75 cm apart. The field was divided into three blocks leaving guard spaces among them. A RCBD with three replicates was used in experiment with 17 treatments to foliar applied nano-fertilizers of micro nutrients , copper, zinc, iron and manganese(Table 2.). At 1-4-2016, Jerusalem artichoke was planted local cultivar a white color Gradually of 5.5-7.5 cm with a depth of 15 cm and a distance of 40 cm between hole and others. Irrigation was done as needed and weeds control using herbicide Matador 200 ml in 400 L^{-1}water within optimal spray time. DAP (N-P:18%N- 46% P_2O_5) was added before planting as a starter at 200 kg ha^{-1} and the addition of potash fertilizer 150 kg fertilizer ha^{-1} of potassium sulphate (41.5 K) all the treatments were prose and mixed with the rotary plow with the soil in a homogeneous manner and the addition of nitrogen fertilizer urea 46% N in four split by (10.20,30 and 40%) for each split of the total amount of the fertilizer 300 kgN ha^{-1} agreement with the stages of growth of the first crop after a month from planting followed by other applications in month from one to another. After 60 days of planting, nano fertilizers of chelate micro nutrients were sprayed with nano zinc (20% Zn), nano copper (15% Cu) nano iron (13% Fe) and nano manganese 18% Mn in single, di and try and tetra mixtures In addition to the tetra sources of traditional chelated fertilizers in similar concentrations of nano fertilizers in addition to the treatment of control(distil water), with concentrations of (25, 50, 75 and 100 g of fertilizer dissolved in 100 L^{-1} water) for the spraying of first, second, third and fourth and as recommended by 1 kg nanofertilizer ha^{-1},As recommended by the sepehr parmis company for the production of nanofertilizers Iran (http://www. sepehrparmis. com), 15 days between (Table 2.) dissolved in 400-liter spray solution ha^{-1}.

Table 1. Some soil properties

property	value	Estimated methods
Particle size distribution (gm kg^{-1}soil)		
Clay	300	
Silt	580	Salim and Ali,2017
Sand	120	
Texture	Silty Clay Loam	
CEC $Cmol_c$ kg^{-1}Soil	26.3	Salim and Ali,2017
OM gm kg^{-1}Soil	16.0	Salim and Ali,2017
Calcite gm kg^{-1}Soil	217	Salim and Ali,2017
pH	7.7	Salim and Ali,2017
EC(1:1) (dS m^{-1})	2.6	Salim and Ali,2017
Available macronutrients (mg kg^{-1}soil)		
N	27	Salim and Ali,2017
P	14	Salim and Ali,2017
K	290	Landon,1984
Available micronutrients (mg kg^{-1}soil)		
Cu	0.24	Tandon,1999
Zn	0.26	Tandon,1999
Fe	0.53	Tandon,1999
Mn	0.32	Tandon,1999
Bulk density Mg m^{-3}	1.4	Landon,1984

Table 2. shows the experiment treatments , spray concentrations and number of spraying

No	Treatments of spraying	gm fetilizer 100 L^{-1} water*	gm fetilizer 100 L^{-1} water**	gm fetilizer 100 L^{-1} water***	gm fertilizer 100 L^{-1} water****
T_1	Control	0	0	0	0
T_2	Nano(Zn)	25	50	75	100
T_3	Nano (Cu)	25	50	75	100
T_4	Nano (Fe)	25	50	75	100
T_5	Nano (Mn)	25	50	75	100
T_6	Nano (Zn+Cu)	25+25	50+50	75+75	100+100
T_7	Nano (Zn+Fe)	25+25	50+50	75+75	100+100
T_8	Nano(Zn+Mn)	25+25	50+50	75+75	100+100
T_9	Nano(Cu+mn)	25+25	50+50	75+75	100+100
T_{10}	Nano(Cu+Fe)	25+25	50+50	75+75	100+100
T_{11}	Nano(Mn+Fe)	25+25	50+50	75+75	100+100
T_{12}	Nano(Cu+Fe+Zn)	25+25+25	50+50+50	75+75+75	100+100+100
T_{13}	Nano(Cu+Fe+Mn)	25+25+25	50+50+50	75+75+75	100+100+100
T_{14}	Nano(Fe+Mn+Zn)	25+25+25	50+50+50	75+75+75	100+100+100
T_{15}	Nano(Cu+Mn+Zn)	25+25+25	50+50+50	75+75+75	100+100+100
T_{16}	Nano(Fe+Mn+Zn+Cu)	25+25+25+25	50+50+50+50	75+75+75+75	100+100+100+100
T_{17}	Traditinal (Zn+Fe+Mn+Cu)	25+25+25+25	50+50+50+50	75+75+75+75	100+100+100+100

fist ,** second, third, and****fourth spraying**

At the stage of tubers maturity some parameters of growth and yield were estimated. Soil analyses were conducted before trial using methods mentioned at (Table 1) for physical and chemical soil properties. Nutrient concentrations in leaves and tubers of plants after wet digestion were measured according to Hayens (14). Total chlorophyll was measured using (SPAD).yield dry matter of vegetative part was estimated for 10 plants and dry mater of tubers yield Mg ha^{-1} were measured according to AOAC, (1). Wight of Fresh tubers yield to all plants in treatments were taken , inulin content in dry tubers was analysis according to Saengkanuk *et al.*,(34) and yield was calculated from (Inulin yield Kg ha^{-1}=% inulin× yield of dry tubers) (31).Percentage of ascorbic acid and sucrose the gas chromatography-mass spectroscopy method was done according to Vijisaral *et al.*, (42). The GC-MS equipment (GCMS-QP2010 Ultra) was used for identification of chemical compound from the crude extract of Jerusalem artichoke tubers. Column oven temperature was initially set at 40 °C for 3 min, then increased to 300°C (ramp, 10 °C/ min) and held for 5min. An HP-5MS fused silica capillary column (Hewlett-Packard, 30 nm, 25 nm i.d., 0.5 μm film Thickness, cross-linked to 5 % phenyl methyl siloxane stationary phase) was used. Ultra-high purity helium (100%)

was used as the carrier gas at flow rate of 1 ml/min. After injection of the samples and obtaining chemical compounds ascorbic acid and sucrose, the obtained compounds were matched with standard compounds National Institute of Standards and Technology (NIST), then the compounds of the extract were distinguished. Analysis of variance were analyzed using a simple one-way experiment and Duncan test using Genstate program.

RESULT AND DISCUSSION

Total chlorophyll SPAD: From (Table 3.), showed that the treatments of spraying fertilizers with different combinations of single, di, tri and tetra have achieved significant effect in the content of chlorophyll SPAD .The highest content was achieved in the tetra combination of nano-spray (Fe+Cu+Mn+Zn) which was 50.2 SPAD compared to control and tetra combination of traditional source (38.6 and 47.4 SPAD), respectively.

Table 3. Effect of spraying of nanofertilizers of micronutrients in the content of leaves of chlorophyll SPAD, soft and dry tubers yield, vegetative and inulin yield and % of dry matter in tubers.

No.Tr	Chlorophyll SPAD	Soft tubers yield Mg ha-1	DM yield of vegetative Mg ha-1	% Tuber dry matter	DM Tubers yield Mg ha-1	Inulin Content % DM tubers	Inulin yield Mg ha-1
T_1	38.6 g	22.655 h	3.390 f	14.28 f	3.234 f	37.12 d	1.201 e
T_2	42.5 f	27.333 g	3.632 ef	18.44 e	5.043 e	45.16 cd	2.285 de
T_3	42.9 f	28.100 fg	3.693 def	18.93 e	5.323 e	45.40 cd	2.407 de
T_4	43.2 f	29.355 fg	3.758 def	19.22 e	5.638 de	45.60 cd	2.571 de
T_5	43.5 ef	30.223 f	3.750 def	18.98 e	5.741 de	45.20 cd	2.582 de
T_6	45.4 de	45.335 d	4.400 cde	21.08 d	9.550 c	53.80 bc	5.142 c
T_7	46.6 cd	45.488 d	4.250 cdef	21.59 cd	9.814 c	54.60 bc	5.354 c
T_8	46.6 cd	45.602 d	4.330 cde	21.00 d	9.583 c	53.40 bc	5.140 c
T_9	45.9 d	45.700 d	4.191 cdef	21.00 d	9.604 c	53.80 bc	5.192 c
T_{10}	46.7 cd	45.688 d	4.592 cd	21.12 d	9.639 c	54.80 bc	5.277 c
T_{11}	47.2 bcd	45.720 d	4.683 c	21.66 cd	9.890 c	54.60 bc	5.407 c
T_{12}	48.2 abc	62.442 c	5.675 b	23.78 b	14.863 b	58.36 ab	8.722 b
T_{13}	48.8 abc	65.556 b	5.642 b	23.89 b	15.677 b	58.60 ab	9.135 b
T_{14}	49.0 ab	66.434 b	5.708 b	23.45 b	15.579 b	58.20 ab	9.080 b
T_{15}	48.8 abc	66.552 b	5.742 b	23.13 bc	15.374 b	57.60 ab	8.870 b
T_{16}	50.2 a	77.928 a	6.584 a	25.55 a	19.906 a	66.40 a	13.235 a
T_{17}	47.4 bcd	34.320 e	3.908 cdef	18.32 e	6.284 d	53.24 bc	3.345 d

Soft tubers yield (Mg ha^{-1}): Above the yield value at nano (Fe+Cu+Mn+Zn) (77.928 Mg ha^{-1}), Significantly higher on all treatments including the teta combination of conventional fertilizer as for the single spray, the Manganese spray was superior to that of the soft tubers, which was 30.223 Mg ha^{-1} compared to zinc, copper and iron (27.333, 28.100 and 29.355 Mg ha^{-1}) respectively.

Percentage of tubers dry matter: The treatment of spray nano (Fe+Cu+Mn+Zn) was recorded (25.55%), The highest ratio was superior to all other spraying treatments, while the comparison treatment with water spraying was only 14.28% (lowest).

Dry matter tubers yield (Mg ha^{-1}): Also,the results showed that the nano spray (Fe+Cu+Mn+Zn) was (19.906 Mg ha^{-1}) as compared with the control (3.234 Mg ha^{-1}) and treatment of traditional fertilizers (6.284 Mg ha^{-1}).

Dry matter yield of vegetative (Mg ha^{-1}): It appears from Table 3. that all fertilizer combinations have a significant effect on the yield of the vegetative dry matter by compared with the control treatment, The treatment of nano (Fe+Cu+Mn+Zn) was recorded (6.584 Mg ha^{-1}) While the comparative treatment recorded a dry matter yield (3.390 Mg ha^{-1}) .

Inulin yield (Mg ha^{-1}): Single spray treatments, di combinations, tri, tetra combination of nano fertilizer and traditional tetra combination, had a significant effect on the inulin yield, and achieved the highest rate of inulin in the treatment of spray nano (Fe+Cu+Mn+Zn) which amounted to (13.235 Mg ha^{-1}) in comparison to the control treatment (1.201 Mg ha^{-1}) (Table 3). Effect of spraying micro-nutrient nano fertilizers in the content of dry tubers of active sucrose and ascorbic acid: Figure 1. Shows the treatments for spraying of nanofertilizers with their different combination single, di, tri, tetra and tetra synthesis with traditional has made leaps in sucrose percentages compared with the control treatment. The treatment of the quaternary combination of nano (Fe+Cu+Mn+Zn) recorded the highest percentage (61.13%) compared to the control treatment (27.5%).

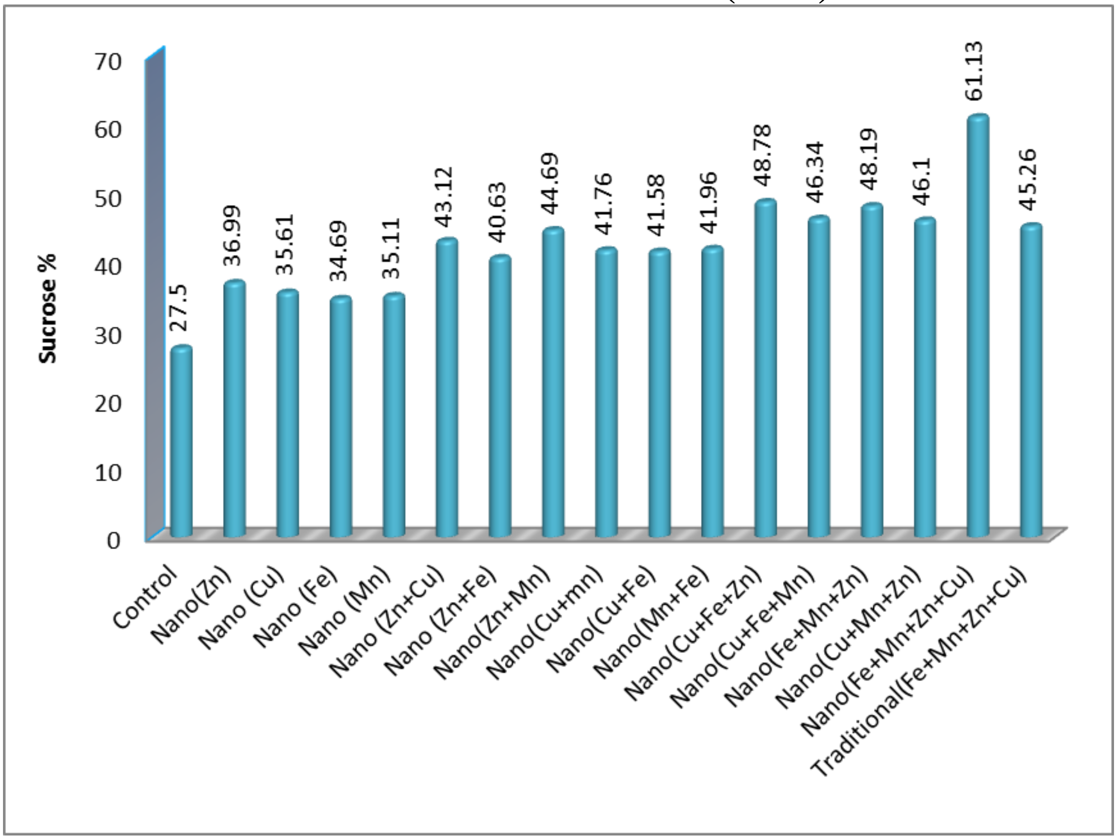

Figure 1. The effect of spraying of nano and traditional micronutrients in the percentage of sucrose in tubers DM according to the GC-MS technique

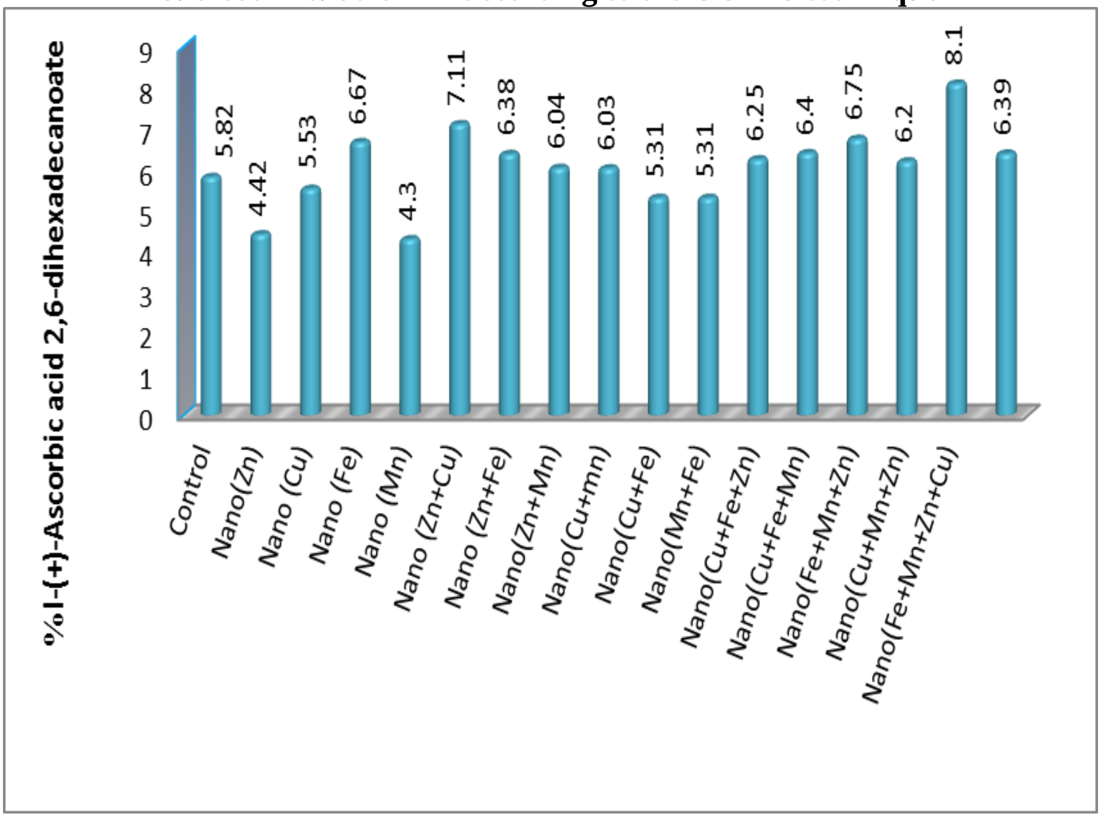

Figure 2: Effect of spraying nano micronutrients in percentage of l - (+) - Ascorbic acid2.6-dihexadecanoate according to the G C-MS technique

The result showed that there is a differential effect of single spray treatments ,dual, triple and quaternary nano micronutrients and the traditional combination in the percentage of ascorbic acid compared with the treatment of the control the treatment of nano-spray combination (Fe+Cu+Mn+Zn) recorded the highest rate (8.1%) Figure 2..While the control treatment (5.82%).Also the results showed the same chart that the dual combinations of nano (Cu+ Fe) and (Mn+Fe) were equal (5.31%). but the treatment of traditional combination (Fe+Cu+Mn+Zn) arrived to (6.39%). The availability of micronutrients, such as copper, zinc, iron and manganese, is clearly and significantly affected by soil pH, $CaCO_3$ content, and micronutrient deficiencies are usually associated with calcareous soils of arid and semi-arid regions (33).the response of Jerusalem artichoke crop to spraying the micro-nutrients fertilizers is expected. The role of copper, zinc, iron and manganese in the formation of amino acids, carbohydrates, energy compounds, and increased respiration and photosynthesis processes in the plant has been supported by a number of researchers (23 and 45).zinc is a promoter of enzymes and the formation of nucleic acids and is involved in the formation of amino acid Tryptophan, which is the basic material for manufacturing Indole Acetic Acid(IAA) It is important to elongate and grow cells so there have been increases significantly in the studied traits that are consistent with what he found(11 and 41). The results of the study showed that the treatment of foliar fertilization with four nano chelate micro-nutrients (Mn + Fe + Zn + Cu) showed significant superiority over the others the treatments, Including the quadruple treatment of traditional fertilizer sources. In most characteristics of vegetative growth and components of the studied yield. There was also a significant increase in the rest of the transactions compared to the control treatment, Three nano micro nutrients sprayers came in second two nutrients were sprayed in the third place, followed by single fertilization with one element It can be attributed to its role in many physiological processes such as increasing the chlorophyll content in the leaves necessary to raise the efficiency of photosynthesis (8 and 44).The significant increase in chlorophyll and vegetative yield increases the efficiency of photosynthesis, respiration and plant activity in the absorption of water and nutrients, which was reflected in the increase of soft tubers yield as well as in the metabolism of proteins (17).And increase the percentage of dry matter and its yield due to increases in the components of the yield. The results of this study showed that the addition of micronutrients spray on the vegetative parts was greater than the percentage of inulin and was similar to the effect of nutrient spraying on these parameters as reported in Yadegari, (44).In this study, the effect of nano(Fe, Cu, Zn and Mn) was determined by single and combination on the growth and yield of Jerusalem artichoke To our knowledge this is the first report showing that the spraying of nano-fertilizers of micro-elements has affected the improvement of the growth and yield of Jerusalem artichoke and the same response was obtained in other types of crops that have different requirements for micro-nutrients.(15,24 and 28).there are still many unanswered questions about how the effects of micronutrients are affected by the increase in the yield and its components, the percentage of sucrose, ascorbic acid (vitamin C) in the Jerusalem artichoke tubers. one possibility is that micronutrient foliar nutrition can affect the accumulation of dry matter in vegetative parts and increase the percentage of dry matter in tubers (3,7 and 22). And that the spraying of the micro-nutrients was a catalyst for response to growth traits, which showed that the parameters of vegetative growth and different plants were significantly increased when nano fertilizers were sprayed similar compare to traditional fertilizers (10,16, 19 and 36). Nano fertilizers a high ability to penetrate and enter various plant tissues, especially the addition of spray on the Vegetative total of plant (19, 40 and 46). From obtained results, we conclude that spray nano micronutrients Fe, Cu, Zn and Mn are commonly used to be very useful for the long-growth Jerusalem artichoke crop at the level of 1 kg nano fertilizer ha^{-1}.which resulted in high chlorophyll SPAD and vegetative parts yield (Mg ha^{-1}), which have direct functions in the growth and development of the plant and maximize the yield, which was reflected on the yield of soft tubers and inulin (Mg ha^{-1}) sequentially.

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