QJAS Al-Qadisiyah Journal For Agriculture Sciences
ISSN: 2618-1479 Volume 9, No.1 ,(2019), PP 156-164
http://qu.edu.iq/jouagr/index.php/QJAS/index
doi.org/10.33794/qjas.Vol9.Iss1.74

Fertilizer Use Efficiency of Nano Fertilizers of Micronutrients Foliar Application on Jerusalem Artichoke

Hayyawi wewa atia Al-juthery,Sahar fadhil saadoun
(College of Agriculture / University of Al-Qadisiyah, Iraq)
Email: hayyawi.aljutheri@qu.edu.iq

Received : 05/09/2018
Final Revision : 01/11/2018

Abstract: **A field experiment was carried out in one of the fields of plot 158 district 41 Husseiniya, township of Taliaa, Babylon Governorate, to study fertilizer use efficiency of nano fertilizers micronutrients foliar application on Jerusalem artichoke (Helianthus tuberosus L.).The experiment included 17 treatments of spraying the nano-fertilizes micronutrients of nano iron 13% Fe ,nano zinc 20% Zn, nano copper 15% Cu and nano manganese 18% Mn, single spray, dual, triple and quadruple combinations, as well as a quadratic combination of a traditional source as well as the treatment of water-only control. In nutrients content in arial parts and tubers, nutrients uptake, total uptake ,FUE,MNUE. RCBD design with three replicates, and the solutions were sprayed early in the morning after 60 days of planting and at 25, 50, 75 and 100 g fertilizer 100 L-1 Water for to spray the first, second, third and fourth respectively, and according to the recommendation by 1 kg Naon fertilizers h-1, and another 400 liters of spray solution h-1.**

The results of the duncan test showed a probability level of 0.05 The superiority of the single spray treatments followed by the treatment of nano (Zn+Cu+Fe+Mn) in micronutrients content of arial parts and tubers of zinc, copper, iron, manganese and total uptake, While achieved the nutrient use efficiency of nano-zinc, nano-copper, nano-iron and nano-manganese (93.10, 85.00, 99.00 and 85.50%) sequentially. For individual spray treatments and (91.60, 81.30, 91.85, and 83.40%) sequentially for the treatment of nano spray common quartet (Zn + Cu + Fe + Mn).

Keyword: **Jerusalem artichoke, foliar nutrition, nano micronutrients ,FUE**

I. INTRODUCTION

Foliar fertilization or foliar feeding is a complementary method to soil additives to improve yield quality and quality. Many field experiments have shown significant effects of nutrient uptake when spraying their solutions on the air parts of the plant [1].

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 [2],[3]. Materials whose particle sizes are between 1 and 100 nm for at least one dimension are called nano materials [4]. Thus, NMs can equip one or more plant nutrients to improve growth and production with better performance and lower amounts of traditional fertilizers and slow nutrient release, in line with the crop growth curve [5].

Nano fertilizers can achieve rapid plant response, particularly with soil problems, high pH, carbonate minerals and insufficient root growth [6],[7]. Some studies have demonstrated the importance of active nano fertilizers in terms of increased nutrient efficiency, higher yield, better quality, and safer environment [8],[9].

And Jerusalem artichoke (Hilianthus tuberosus L.) of the perennial vegetable crops of the composite family, but is grown each year after maturation in the autumn to give new spring growth [10]. It is also a promising crop of biofuel [7]. As it has a high production of sugar 9-13 meg h-1 of tubular carbohydrates [11],[12]. The part that is eaten is the tubers which are formed at the end of the terrestrial stalks (risomat) and have irregular shape and have protrusions which are the eyes that contain the shoots, and are eaten cooked or used in pickling It is rich in Inulin, [13],[14],[15],[16]. Used in the industry for fructose, which is very useful for diabetics [17].

So this study aims to: Find out the response of Jerusalem artichoke to spray the nano fertilizers of micro nutrients in micronutrients content in arial pats and tubers,total uptake, FUE and MNUE compare them with traditional fertilizers.

II. Materials and Methods

The study was carried out in the fields of piece 158 of the 41 districts of Husseiniya - Taliaa region - 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 the selection, In Silty Clay Loam soil with chemical and physical characteristics, shown in Table 1. To study the response of Jerusalem artichoke to spray nano fertilizers of micro nutrients,

Table 1: Some soil properties for the studied soil

Particle size distribution (gm kg-1soil)		Estimated methods
Clay Silt Sand	300 580 120	Kilmer and Alexander ,1949
Texture	Silty Clay Loam	
CEC Cmol+ kg-1Soil	26.3	Salim and Ali,2017
SOM gm kg-1Soil	16.0	Salim and Ali,2017
Calcite gm kg-1Soil	217	Salim and Ali,2017
pH	7.7	Richards,1954
EC(1:1) (dS m-1)	2.6	Richards,1954
Available macronutrients (mg kg-1soil) N P K	 27 14 290	 Bremner,1965 Olsen et al.,1954 Landon,1984
Available micronutrients (mg kg-1soil) Cu Zn Fe Mn	 0.24 0.26 0.53 0.32	 Tandon,1999 Tandon,1999 Tandon,1999 Tandon,1999
Bulk density Meg m-3	1.4	Landon,1984

The soil was prepared after it was plowed by the rotary plow. furrows was worked between furrow and the last 75 cm. The field was divided into three replicates and each 15 m. each furrow was treated with two lines and with leaving between furrow and another as guard cells. Use the RCBD design with three replicates the trial included 17 consensual treatments to spry nano fertilizers of micro nutrients , copper, zinc, iron and manganese table 2.

Date 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 400 L-1water within optimal spray time.

DAP (NP18: 46) was added before planting as a starter of 200 kg h-1 and the addition of potash fertilizer 150 kg fertilizer h-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 and four batches by (10.20,30 and 40%) for each batch of the total amount of the fertilizer to be added 300 kg h-1 in harmony with the stages of growth of the first crop after a month of agriculture followed by other payments for one month from one to another. After 60 days of planting, nano fertilizers of micro nutrients were sprayed with nano zinc 20% Zn, nano copper15% Cu nano iron 13% Fe and nano manganese 18% Mn single,dual and triple and quadrilateral mixtures In addition to the quaternary sources of traditional chelae fertilizers After weighing their weights to balance the same concentrations of nano fertilizers in addition to the treatment of water-only control. with concentrations (25, 50, 75 and 100 g of fertilizer 100 L-1 water) for the spraying first, second, third and fourth and as recommended by 1 kg h-1 nano fertilizer, 15 days between. Table 2.The reality of the 400-liter spray solution h-1.

At the stage of tubers maturity some parameters of growth and yield were estimated . Soil analyses were conducted before and at the end of the trial using methods mentioned table 1. for physical and chemical soil properties. Nutrient concentrations

in leaves and tubers of plants after wet digestion were measured according to [18] yield of dry air parts was estimated for 10 plants, were measured too after isolation and removing of straw at 12% humidity[19]. dry tubers yield Meg ha-1 were measured according to [19]. Fertilizer use efficiency % = uptake in fertilizer treatment – uptake in treatment control / the amount of fertilizer added × 100, Nutrient Use Efficiency or recovery efficiency for each element % = uptake of the treated fertilizer - uptake in treatment \ quantity of element added × 100 [20].

Analysis of variance were analyzed using a simple one-way experiment and duncan testig using Genstate program.

Table 2: 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
T1	Control	0	0	0	0
T2	Nano(Zn)	25	50	75	100
T3	Nano (Cu)	25	50	75	100
T4	Nano (Fe)	25	50	75	100
T5	Nano (Mn)	25	50	75	100
T6	Nano (Zn+Cu)	25+25	50+50	75+75	100+100
T7	Nano (Zn+Fe)	25+25	50+50	75+75	100+100
T8	Nano(Zn+Mn)	25+25	50+50	75+75	100+100
T9	Nano(Cu+mn)	25+25	50+50	75+75	100+100
T10	Nano(Cu+Fe)	25+25	50+50	75+75	100+100
T11	Nano(Mn+Fe)	25+25	50+50	75+75	100+100
T12	Nano(Cu+Fe+Zn)	25+25+25	50+50+50	75+75+75	100+100+100
T13	Nano(Cu+Fe+Mn)	25+25+25	50+50+50	75+75+75	100+100+100
T14	Nano(Fe+Mn+Zn)	25+25+25	50+50+50	75+75+75	100+100+100
T15	Nano(Cu+Mn+Zn)	25+25+25	50+50+50	75+75+75	100+100+100
T16	Nano(Fe+Mn+Zn+Cu)	25+25+25+25	50+50+50+50	75+75+75+75	100+100+100+100
T17	Traditinal (Zn+Fe+Mn+Cu)	25+25+25+25	50+50+50+50	75+75+75+75	100+100+100+100

Results and Discussion

The amount of zinc uptake in the arial parts is gm Zn h-1: It appears from Table 3. that the zinc uptake was the same as the zinc content in the air parts. The highest uptake amount was recorded in the treatment of nano-zinc spray (71.5 gm Zn h-1) (Cu+Zn+Fe+Mn), which reached 42.6 gm Zn h-1.

The amount of zinc uptake in the tubers gm Zn h-1: From the same table it is clear that all the transactions significantly increased the amount of zinc in the tubers and the highest quantity was achieved when the common spraying spray nano (Cu+Zn+Fe+Mn) 180.6 gm Zn h-1) Compared with the treatment of water-only control (22.9 gm Zn h-1) and the single-nano-zinc spraying treatment of 149.7 gm Zn h-1 (table 3).

Table 3: Effect of spraying nano micronutrient in the content of zinc in leaves and tubers , total uptake of Zn, fertilizer use efficiency and Zn use efficiency .

No. Tr	mg Zn kg-1 DM Arial parts	mg Zn kg-1 DM tubers	uptake Zn in aril parts g ha-1	uptake Zn in tubers g ha-1	Total Uptake Zn g ha-1	FUE% of Zn	ZnUE %
T1	5.024 j	7.08 j	17.1 g	22.9 h	40.0 h	0.0	0.00
T2	21.087a	29.70 a	76.5 a	149.7 b	226.2 a	18.62	93.10
T3	8.683 d	12.23 d	32.0 de	65.2 fg	97.2 fg	0.0	0.00
T4	12.404 b	17.47 b	46.7 b	98.5 cd	145.2 d	0.0	0.00
T5	11.784 bc	16.60 bc	44.1 bc	95.1 cde	139.2 d	0.0	0.00
T6	5.676 ij	7.99 ij	24.9 ef	76.4 def	101.3 f	6.13	30.65
T7	11.353 c	15.99 c	48.3 b	156.9 b	205.2 abc	16.52	82.60
T8	5.676 ij	7.99 ij	24.8 ef	76.9 def	101.7 f	6.17	30.85

T9	7.568 e	10.66 e	31.9 de	102.6 c	134.5 de	0.0	0.00
T10	5.676 ij	7.99 ij	25.9 ef	77.0 ef	102.9 f	0.0	0.00
T11	6.055 hi	8.53 hi	28.2 ef	84.4 cdef	112.6 ef	0.0	0.00
T12	7.442 ef	10.48 ef	42.1 bc	156.4 b	198.4 bc	15.84	79.20
T13	7.005 efg	9.87 efg	39.3 c	155.3 b	194.6 c	0.0	0.00
T14	6.742 fgh	9.50 fgh	38.3 cd	147.8 b	186.0 c	14.6	73.00
T15	7.267 ef	10.24 ef	41.5 bc	157.1 b	198.6 c	15.86	79.30
T16	6.433 ghi	9.06 ghi	42.6 bc	180.6 a	223.2 ab	18.32	91.60
T17	5.933 i	8.36 i	23.2 fg	52.5 g	75.7 g	3.57	17.85

Total uptake of zinc gm Zn h-1: All spraying treatments were found to have a significant effect on total zinc uptake by comparison. The highest uptake was achieved when spraying nano zinc (226.2 gm Zn h-1). Minimum when treated the control is sprayed with water only and adult (40 gm Zn h-1). The highest fertilizer use efficiency of zinc was achieved by spraying single nano-zinc and nano-quaternary (18.62 and 18.32%) in the same direction with ZnUE (93.10 and 91.60%) Sequentially (table 3).

The amount of iron uptake in the arial parts gm Fe h-1: From Table 4. the treatment of single iron spraying is distinguished by its significant superiority over all spray treatments, including the common quaternary spraying of conventional and nano fertilizer and comparison. The highest amount of iron uptake in the binary nano was treated with (Cu+Fe) and (Mn+Fe), which was equal in the uptake amount (36.4 gm Fe h-1), The nano triple combination showed no significant differences between them , other than treatment (Cu+Mn+ Zn) which is 24.4 gm Fe h-1.

The amount of iron uptake in the tubers gm Fe h-1: Table 4. shows the superiority of nano-spray treatment (Cu+Zn+Fe+Mn), which is 123.1 gm Fe h-1, Followed by nano-spray (Cu+Fe+Mn) and (Fe+Mn+Zn), which have reached (117 and 113.6 gm Fe h-1) and without significant differences between them , Bilateral spraying coefficients are equal to nano-spray (Zn +Cu) with nano-spray (Cu+Mn) at the maximum value (72.0 gm Fe h-1).

Table 4: Effect of spraying nano micronutrient in the content of Iron in leaves and tubers , total uptake of Fe, fertilizer use efficiency and Fe use efficiency .

No. Tr	mg Fe kg-1 DM Arial parts	mg Fe kg-1 DM tubers	uptake Fe in aril parts g ha-1	uptake Fe in tubers g ha-1	Total uptake Fe g ha-1	FUE% of Fe	Fe NUE %
T1	4.254 g	5.828 g	14.5 h	18.9 h	33.3 i	0.0	0.00
T2	6.913 e	9.470 e	25.2 def	47.8 f	73.0 g	0.0	0.00
T3	7.355 d	10.076 d	27.1cdef	53.7 f	80.8 fg	0.0	0.00
T4	14.102 a	19.318 a	53.1a	108.9 bc	162 a	12.87	99.00
T5	8.572 b	11.742 b	32.2 bc	67.6 e	99.8 e	0.0	0.00
T6	5.497 f	7.530 f	24.3 ef	72.0 e	96.1e	0.0	0.00
T7	6.623 e	9.073 e	28.1cdef	89.1 d	117.2 d	8.39	64.54
T8	5.133 f	7.031 f	22.1 fg	67.2 e	89.4 ef	0.0	0.00
T9	5.464 f	7.485 f	23.0 f	72.0 e	95.0 e	0.0	0.00
T10	7.948 c	10.887 c	36.4 b	104.9 c	141.3 bc	10.8	83.10
T11	7.782 c	10.660 c	36.4 b	105.5 c	141.8 bc	10.85	83.46
T12	5.318f	7.284 f	30.2 cde	108.1bc	138.3 c	10.5	80.77
T13	5.436 f	7.446 f	30.6 cd	117.0 ab	147.6 bc	11.43	87.92
T14	5.318 f	7.284 f	30.4 cd	113.6 abc	144.0 bc	11.07	85.15
T15	4.254 g	5.828 g	24.4 ef	89.5 d	113.9 d	0.0	0.00
T16	4.517 g	6.188 g	29.6 cde	123.1 a	152.7ab	11.94	91.85

T17	4.403 g	6.032 g	17.3 gh	37.9 g	55.2 h	2.19	16.85

Total uptake of iron gm Fe h-1: : All fertilizer spraying treatments appear to have significant effect on iron uptake and the highest uptake of iron was achieved when treated with nano-iron alone (162,0 gm Fe h-1) Thus significantly exceeding all the spraying treatments Including comparative treatment (33.3 gm Fe h-1) beyond the quaternary nano synthesis (Zn+Cu+ Fe+Mn) (152.7 gm Fe h-1). The treatment of nano-iron spraying was unique in both FUE and Iron UE(12.87 and 99.00%) sequentially, Followed by nano treatment (Zn + Cu + Fe + Mn) (11.94 and 91.85%) sequentially (table 4).

Uptake of copper in arial parts gm Cu h-1: It appears from Table (5) that the highest amount of copper has been achieved in the treatment of spray nano copper single (41 gm Cu h-1) The coefficients of nano (Mn+Cu) and nano (Fe+ Mn) Which were 41.6 and(43.6 gm Cu h-1) respectively on their equivalents nano (Zn+Cu) (30.5 gm Cu h-1).

Amount of copper uptake in tubers gm Cu h-1: Table (5) shows that the treatment of nano (iron + copper + manganese + zinc) is superior to multiple spraying treatments, With an amount of (121.4 gm Cu h-1) The triple combinations did not reach the moral boundary between them, while the nano-synthesis (Cu+ Mn) (120.3 gm Cu h-1) On their counterparts with a significant superiority over nano (Cu+ Fe) (99.3 gm Cu h-1).

Table 5: Effect of spraying nano micronutrient in the content of copper in leaves and tubers , total uptake of Cu, fertilizer use efficiency and Cu use efficiency .

No. Tr	mg Cu kg-1 DM Arial parts	mg Cu kg-1 DM tubers	uptake Cu in aril parts g ha-1	uptake Cu in tubers g ha-1	Total Uptake Cu g ha-1	FUE% of Cu	CuUE %
T1	5.38 k	5.785 k	18.2 e	18.7 i	36.9 g	0.0	0.00
T2	11.273 b	12.121 b	41 bc	61.2 g	102.3e	0.0	0.00
T3	18.318 a	18.182 a	67.8 a	96.7 cd	164.4a	12.75	85.00
T4	11.273 b	11.189 c	38.3 bcd	63.1 fg	101.4e	0.0	0.00
T5	10.145 c	10.909 c	34.5 bcd	62.8 fg	97.2 e	0.0	0.00
T6	6.917 gh	7.438 gh	30.5 d	71 efg	101.5 e	6.46	43.10
T7	8.784 e	9.445 e	37.2 bcd	92.7d	130 cd	0.0	0.00
T8	7.357 fg	7.910 fg	31.7 cd	75.6 ef	107.3 e	0.0	0.00
T9	9.882 cd	10.626 cd	41.6 b	102.3 bcd	143.8bc	10.69	71.30
T10	7.686 f	8.264 f	35.5 bcd	79.7 e	115.2 de	7.83	52.20
T11	9.333 de	10.035 de	43.6 b	99.3 bcd	142.9 bc	0.0	0.00
T12	6.516 h	7.041 h	37.1 bcd	104.3 bcd	141.4 bc	10.45	69.70
T13	6.369 hi	6.848 hi	35.8 bcd	107.8 bc	143.5 bc	10.66	71.10
T14	6.19 hij	6.655 hij	35.2 bcd	103.6 bcd	138.7 bc	0.0	0.00
T15	6.728 gh	7.234 gh	38.8 bcd	111.3 ab	150.2abc	11.33	75.50
T16	5.665 ijk	6.092 ijk	37.5 bcd	121.4 a	158.9 ab	12.2	81.30
T17	5.534 jk	5.950 jk	21.7 e	37.4 h	59.1 f	2.22	14.80

Total uptake of copper gm Cu h-1: Table (5) shows the superiority of the single nanoalanach spray treatment followed by nano (iron + copper + manganese + zinc), which reached 164.4 and 158.9 gm Cu h-1 respectively.FUE in range 2.22 to12.75% to traditional source fertilizer and single nano copper Sequentially, The highest CuUE were at spray nano iron alone and nano (Fe+Cu+Zn+Mn) 85.00 and 81.30% Sequentially.

Quantity of manganese uptake in arial parts gm Mn h-1: The single manganese spray treatment increased to a significant level superior to their monolithic counterparts and other spraying treatments, which reached 60.1 gm Mn h-1 ,In the same direction with the uptake in the tubers155.9 gm Mn h-1 with Nano(Cu+Fe+Mn), While the total uptake of manganese reached a maximum of 195.4 and 191.7 gm Mn h-1 with spry nano manganese alone and Nano(Zn+Cu+Fe+Mn) Sequentially. High FUE was15.39 and 15.02% at Single nano Mn and Nano(Zn+Cu+Fe+Mn) Sequentially compare with traditional treatment 2.61%,MnUE equal to 85.50, 83.40 and 14.50 % at spry nano Mn alone, Nano(Zn+Cu+Fe+Mn) and traditional(Zn+Cu+Fe+Mn) Sequentially

Table 6: Effect of spraying nano micronutrient in the content of manganese in leaves and tubers , total uptake of Mn, fertilizer use efficiency and Mn use efficiency .

No. Tr	mg Mn kg-1 DM areal parts	mg Mn kg-1 DM tubers	uptake Mn in aril parts g ha-1	uptake Mn in tubers g ha-1	Total uptake Mn g ha-1	FUE% of Mn	Mn NUE %
T1	5.100 h	7.50 h	17.3 j	24.3 i	41.5 h	0.0	0.00
T2	8.831e	12.99e	32.2 defg	65.6 g	97.8 ef	0.0	0.00
T3	10.487c	15.42c	38.6 bcd	82.2 ef	120.9 cd	0.0	0.00
T4	11.591b	17.05b	43.7 bc	96.1 de	139.8 c	0.0	0.00
T5	16.006a	23.54a	60.1 a	135.3 bc	195.4 a	15.39	85.50
T6	6.162fg	9.06 fg	27.2 ghi	86.5 e	113.7 de	0.0	0.00
T7	6.729f	9.90 f	28.7 efgh	97.1de	125.8 cd	0.0	0.00
T8	8.713e	12.81e	37.6 bcd	122.6 c	160.2 b	11.87	65.90
T9	9.208de	13.54 de	38.7 bcd	130.3 bc	169.0 b	12.75	70.80
T10	4.958h	7.29 h	22.9 hij	70.3 fg	93.3 f	0.0	0.00
T11	9.421d	13.85 d	44.2 b	137.0 bc	181.2 ab	13.97	77.60
T12	4.857h	7.14 h	27.5 fghi	106.5 d	134.0 cd	0.0	0.00
T13	6.746f	9.92 f	38 .0 bcd	155.9 a	193.9 a	15.24	84.70
T14	6.314fg	9.29 fg	35.9 cde	144.6 ab	180.5 ab	13.9	77.20
T15	5.937g	8.73 g	34.2 defg	134.3 bc	168.5 b	12.7	70.60
T16	5.354h	7.87 h	35.1 def	156.6 a	191.7 a	15.02	83.40
T17	5.228h	7.51 h	20.4 ij	47.2 h	67.6 g	2.61	14.50

The availability of micronutrients, such as copper, zinc, iron and manganese, is clearly and significantly affected by soil pH, CaCO3 content, and micronutrient deficiencies are usually associated with calcareous soils of dry and semi-arid regions [21]. 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 [22] .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 in morale in the studied traits that are consistent with what he found [23]. 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 rest of the treatments, including the quadruple treatment of traditional fertilizer sources.

In most traits 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 sprayers came in second Two elements 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 and micronutrients content in the leaves necessary to raise the efficiency of photosynthesis [24],[25]. The significant increase in chlorophyll and areal parts 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 [26]. 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 leaves was greater than the yield of dry mater or tubers and arial parts was similar to the effect of nutrient spraying on these indicators as reported in [24].

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. There are still many unanswered questions about how the effects of micronutrients are affected by the increase in the yield and its components, and(Fe, Cu, Zn and Mn) content in leaves and tubers of the Jerusalem artichoke, One possibility is that micronutrient foliar nutrition can affect the accumulation of dry matter in arial parts and increase the percentage of dry matter in tubers [18],[27].

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 [6], [28], [29].

Nanoparticles have a high ability to penetrate and enter various plant tissues, especially the addition of spray on the Vegetative total of plant [29],[30].

III. Conclusions

From our current data, we conclude that foliar application of 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 h-1 fertilizer. Which resulted in an increase in content of micronutrients arial parts and tubers, Which have direct functions in the growth and development of the plant, which was reflected on amount uptake of each spraying micronutrients and total uptake towards increasing FUE and MNUE sequentially compare with traditional fertilizers of micronutrients.

REFERENCES

[1] Ali, A., S. Perveen, S. N. M. Shah, Z. Zhang, F. Wahid, M. Shah, S. Bibi, A. Majid .2014. Effect of foliar application of micronutrients on fruit quality of peach. *American Journal of Plant Sciences*, 5, 1258-1264. http://dx.doi.org/10.4236/ajps.2014.59138 .

[2] Drostkar ,E., R. Talebi and H. Kanouni. 2016.Foliar application of Fe, Zn and NPK nano-fertilizers on seed yield and morphological traits in chickpea under rain fedcondition.*Journal of Research in Ecology* . 4(2): 221-228.

[3] Moinuddin, G., S. Jash, A. Sarkar , S. Dasgupta .2017.Response of potato (*Solanum tuberosum*L.) to foliar application of macro and micronutrients in the red and lateritic zone of west bengal. *Journal of Crop and Weed*, 13(1) : 185-188.

[4] Liu, R.,and R. Lal.2016.Ruiqiang Liu and Rattan Lal, (2016). Nanofertilizers. In: R. Lal (ed.) Encyclopedia of Soil Science, 3rdEdition, CRC Press.

[5] Janmohammadi, M., Pornour N., Javanmard A., Sabaghnia, N. 2016. Effects of bio-organic, conventional and nanofertilizers on growth, yield and quality of potato in cold steppe. *Bot. Lith*., 22(2): 133–144.

[6] Sarlak, N., and A. Taherifar .2017. Encapsulation of nanomaterials and production of nanofertilizers and nanopesticides: Insecticides for agrifood production and plant disease treatment. In: M. Ghorbanpour et al. (Eds.), *Nanoscience and Plant–Soil Systems, Soil*.

[7] Tatcha, O.,T. Pornthap.,T. Sudarat.,andY. Mamoru .2007. Ethanol production from Jerusalem artichoke by *zymomonasmobilis* in batch fermentation. *kmitl Sci. Tech. J*. 7 . S1 .

[8] Salim,S.Ch and N.Sh.Ali.2017.Guide for chemical analyses of soil ,water ,plant and fertilizers. University of Baghdad-College of Agriculture.

[9] Liu, X.M., F.D.Zhang, , S.Q. Zhang, X.S.He, R. Fang., and Z.Feng, Y. Wang.2005. Effects of nano-ferric oxide on the growth and nutrients absorption of peanut. *Plant Nutr. Fert. Sci*., 11:14-18.

[10] Rebora, C., 2008.Topinambur (*Helianthus tuberosus*L.): uses, crop and potentiality in Cuyo region. *Horticultura Argentina* .27(63): 30-37.

[11] Southgate, D.A.T. 1991. Determination of food carbohydrates. 2nd ed. New York: Elsevier Science Publishers Ltd. 232 p.

[12] Alina,K.J., J.Krzysztof ,G.Magdalena and Z. Janusz. 2012.Jerusalem artichoke (*Helianthus Tuberosus* L.) as renewable energy raw material.*teka*. commission of motorization and energetics in agriculture. 12(2): 117–121.

[13] Karolina, A.V., Ekaterina, A. P., Elena, A. V., Lilia, T.V., Kirienne, B. Z., 2000. Usage of the inulin containing phytopreparation made of Jerusalem artichoke tubers in medical practice. Odessa Hydro meteorological Institute, Odessa, Ukraine.

[14] Brkljača, J., Bodroža-Solarov, M., Krulj, J., Terzić, S., Mikić, A., Jeromela, A.M. 2014. Quantification of inulin content in selected accessions of Jerusalem artichoke (*Helianthus tuberosus*L.). *Helia*, 37(60), 105–112.

[15] Paungpt,D.,J.Sanun,V.Nimitr and P.Aran.2015. Growth and phenology of Jerusalem artichoke (*Helianthus Tuberosus* L.). *Pak. J. Bot*., 47(6): 2207-2214.

[16] Danilcenko,H., J.Elvyra, S.Alvyra, S.Barbara., and Z.Sandra .2017.The Distribution of bioactive compounds in the tubers of organically grown Jerusalem artichoke (*Helianthus tuberosus* L.) during the growing period. *Acta Sci. Pol. Hortorum Cultus*. 16(3): 97–107.

[17] Wang,Z., H.H.Seung,Y.L. Sun ., and S.L. Soon.2016.Fermentation of purple Jerusalem artichoke extract to improve the α-glucosidase inhibitory effect *in vitro* and ameliorate blood glucose in *db/db*mice .*Nutrition Research and Practice*. Published online.http://e-nrp.org

[18] Alexander, A.and M. Hunsche. 2016.Influence of formulation on the cuticular penetration and on spray deposit properties of manganese and zinc foliar fertilizers. agronomy. 6(39);doi:10.3390/agronomy6030039.

[19] A.O.A.C. 1990. Official Methods of Analysis. 13th . Ed. Washington D.C. Association of the Official Analytical Chemist. 1015 P.

[20] Ali, N.S,.2011. Fertilizers technologies and uses. Baghdad University. College of Agriculture.

[21] Rengel, Z.,2015.Availability of Mn, Zn and Fe in the rhizosphere. *Journal of Soil Science and Plant Nutrition*, 15 (2), 397-409.

[22] Zain,M., I. Khan, R. W. K. Qadri, U. Ashraf, S. Hussain, S.Minhas, A.Siddique, M. M. Jahangir and M. Bashir. 2015 .Foliar application of micronutrients enhances wheat growth, yield and related attributes. *American Journal of Plant Sciences*, 6, 864-869. http://dx.doi.org/10.4236/ajps.2015.67094.

[23] Valadkhan, M., K.H. Mohammadi., and N. M.T. Karimi. 2015. Effect of priming and foliar application of nanoparticles on agronomic traits of chickpea. *Biological Forum*, 7(2):599-602.

[24] Yadegari,M.,2013. Effect of foliar application of Fe, Zn, Cu and Mn on yield and essential oils of *Boragoofficinalis*. *J. Appl. Sci. & Agric.*, 8(5): 568-575.

[25] Bouis, H. E. and A. Saltzman .2017. Improving nutrition through biofortification: A review of evidence from HarvestPlus, 2003 through 2016. *Global Food Security*, 12, 49-58.

[26] Kamiab ,F ., and E. Zamanibahramabadi. 2016.The effect of foliar application of nano-chelate Super Plus ZFM on Fruit Set and some quantitative and qualitative traits of almond commercial cultivars. *Journal of Nuts*. 7(1):9 – 20.

[27] Maghsud,S. G., H. R. Mobasser and H. R. Fanaei. 2014. Effect of foliar application and time foliar application microelements (Zn, Fe, Mn) on safflower.*J Nov. Appl Sci.*, 3 (4): 396-399.

[28] Chhipa, H. 2017.Nanofertilizers and nanopesticides for agriculture. *Environ ChemLett*15,15–22. DOI 10.1007/s10311-016-0600-4.

[29] Khan, M. R., and T. F. Rizvi .2017. Application of nanofertilizer and nanopesticides for improvements in crop production and protection. In: M. Ghorbanpour et al. (Eds.), Nanoscience and Plant–Soil Systems, *Soil Biology* 48, DOI 10.1007/978-3-319-46835-8_15,Springer International Publishing AG.

[30] Khater, M. S. 2015.Magnetite- Nanoparticles effects on growth and essential oil of peppermint.*Curr. Sci. Int.* 4(2): 140-144.