

## Effect of Spraying Some Micronutrients via Normal Versus Nanotechnology on Fruiting of Zaghoul Date Palms

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**Abstract:** This study was carried out during 2015 and 2016 seasons to examine the effect of spraying Zn, Fe and Mn in normal (chelated form) at 25 to 100 ppm or nanotechnology form at 2.5 to 20 ppm, on growth, palm nutritional status, yield and fruit quality of Zaghoul date palms. The selected palms received three sprays. Treating Zaghoul date palms three times with Zn, Fe and Mn in normal form (chelated form) at 25 to 100 ppm or via nano form at 2.5 to 20 ppm had an obvious promotion on all growth characteristics, leaf pigments, N, P, K, Mg, Zn, Fe and Mn in the leaves, number of strands / spathe, number of flowers/strand, strand length, initial fruit setting %, fruit retention %, bunch weight, yield/palm and fruit quality parameters over the control treatment. Treating the palms with these micronutrients via nanotechnology material was superior than using these micronutrients via normal form (chelated form). Carrying out three sprays of a mixture of Zn, Fe and Mn via nanotechnology at 10 ppm was responsible for promoting yield and fruit quality of Zaghoul date palms.

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### 1. Introduction

Since fertilizers, particularly synthetic fertilizers, have a major potential to pollute soil, water and air, in recent years, many efforts were done to minimize these problems by agricultural practice and the design of the new improved fertilizers. The appearances of nanotechnology open up potential novel applications in different fields of agriculture and biotechnology. Nanostructured formulation through mechanisms such as target delivery or slow/controlled release mechanisms, conditional release, could release their active ingredient in responding to environmental triggers and biological demands more precisely. There is the possibility of using these mechanisms to design and construction of nanofertilizers. The use of these nanofertilizers causes an increase in their efficiency, reduces soil toxicity, minimizes the potential negative effects associated with over dosage and reduces the frequency of the application. Nanofertilizers mainly delay the release of the nutrients and extend the fertilizer effect period. Obviously, there is an opportunity for nanotechnology to have a significant influence on energy, the economy and the environment, by improving fertilizers. Hence, nanotechnology has a high potential for achieving sustainable agriculture, especially in developing countries. (DeRosa *et al.*, 2010).

Previous studies showed that using

micronutrients via normal (chelated form) was very effective in improving yield and berries quality in different fruit crops (Hegab, 2000; Etman *et al.*, 2007; El-Sayed-Esraa, 2010; Hamed-Mona, 2011; Yoused-Aml *et al.*, 2011; Hassan-Huda, 2014; Mohamed and Mohamed, 2013; Ahmed *et al.*, 2014 and Sayed-Ola, 2014).

Sabir *et al* (2014); Refaai (2014) and Roshdy and Refaai (2016) found that using different nutrients via nano technology proved to be very effective in improving yield and fruit quality in various fruit crops than using these nutrients via another methods.

This study was initiated to compare the effect of using some micronutrients via normal source versus nanotechnology on the yield and fruit quality of Zaghoul date palms.

### 2. Materials and Methods

This study was conducted during 2015 and 2016 seasons in a private date palm orchard situated at Qena Fac. of Agric., New Valley Univ., Qena district, Qena Governorate on 24 Zaghoul date palms (19-years old). These palms produced through conventional propagation by offshoots as well as characterized by regular bearing. The selected palms were irrigated with well water via drip irrigation. The texture of the soil is sandy.

Hand pollination of all the selected palms was achieved by inserting ten fresh male strands into the

center of one female spathae using the same source of pollens (Zaghloul date palms males) to avoid residues of metaxenia (according to **Musa, 1981**). The pollen gives viability was tested before carrying out pollination with aceto carmine staining. One drop of 1.0 % aceto examined. Colorless or unstained pollen grains were considered non-viable according to **Moreira and Gurgel (1941)**. Pollination was carried out throughout two days after female spathes cracking at the day time of afternoon to prevent contamination of the investigated pollens. Every bunch was bagged after pollination by white paper bags which were tied at the ends using a piece of cotton for aeration and the bags were shaken lightly to ensure pollens distribution and they were removed after one month (**Hussein et al., 1987**). Number of bunches per palm was adjusted to ten bunches and leaf bunch ratio was maintained at 8: 1.

Physical and chemical properties of the experimental soil at 0.0 – 90 cm depth are presented in **Table (1)** according to the procedures of **Black et al (1965)** and **Carter (1993)**.

**Table (1): Analysis of the tested soil:**

Constituents	Values
<b>Particle size distribution</b>	
Sand %	85.0
Silt %	5.0
Sand %	10.0
Texture	Sandy
pH ( 1: 2.5 extract)	8.0
EC ( 1: 2.5 extract ) mmhos/ 1 cm 25°cm	1.1
Organic matter %	0.25
Total CaCO <sub>3</sub> %	1.9
Total N %	0.02
P ppm (Oslen)	2.2
K ppm ( ammonium acetate)	50.0
<b>Available micronutrients ( EDTA, ppm):</b>	
Fe	0.8
Zn	0.9
Mn	0.7
Cu	0.7

All the selected Zaghloul date palms received program of fertilization consists of 10 kg plant compost (2.5 % N), 5.0 kg ammonium sulphate, (20.6 % N) 1.5 kg triple calcium superphosphate (37.5 % P<sub>2</sub>O<sub>5</sub>) and 1.5 kg potassium sulphate (48 % K<sub>2</sub>O) per each palm. Plant compost was added once at the middle of Jan. Ammonium sulphate was splitted into three equal batches and added at the first week of Mar., May and July.

Phosphate fertilizer was splitted into two equal batches. The first was added at the middle of January

and the second one was applied just after fruit setting (last week of April). Potassium sulphate was applied twice before pollination (last week of Feb.) and just after fruit setting (last week of April). Another horticultural practices such as irrigation, pruning, hoeing and pest management were carried out as usual.

The study included the following eight treatments:

1- Control (without application of Zn, Fe and Mn).

2- Spraying Zn, Fe and Mn (14 %) via normal method (chelated form) each at 25 ppm (0.179 g chelated form from each nutrient/L).

3- Spraying Zn, Fe and Mn via normal method each at 50 ppm (0.358 g chelated form from each nutrient/L).

4- Spraying Zn, Fe and Mn via normal method each at 100 ppm (0.716 g chelated form from each nutrient/L).

5- Spraying Zn, Fe and Mn via nanotechnology method each at 2.5 ppm (2.5 mg /L from each nutrient/L).

6- Spraying Zn, Fe and Mn via nanotechnology method each at 5.0 ppm (5 mg /L from each nutrient/L).

7- Spraying Zn, Fe and Mn via nanotechnology method each at 10 ppm (10 mg /L from each nutrient/L).

8- Spraying Zn, Fe and Mn via nanotechnology method each at 20 ppm (20 mg /L from each nutrient/L).

Each treatment was replicated three times, one Zaghloul date palm per each. All sources of Zn, Fe and Mn were purchased from E-Helb Company. Triton B as a wetting agent at 0.5 % was added to all micronutrients solutions and spraying was done till runoff. The selected palms (24 palms) received three sprays started two weeks before hand pollination (before spathes cracking) (second week of Feb.), just after fruit setting (first week of April) and at one month later (first week of May).

Randomized complete block design (RCBD) was followed in which this experiment included eight treatments and each treatment replicated three times, one palm per each.

During the two seasons, the following measurements were recorded:

#### **1. Measurements of vegetative growth characteristics:**

At the first week of July, number of pinnae/new leaf as well as area of pinnae (cm)<sup>2</sup> and leaf (cm) were recorded in the five labeled leaves / palm. For measuring pinnae area (m<sup>2</sup>) one six month old labeled leaf per palm was removed and the four medium pinnae were taken and using the following

equation that outlined by **Ahmed and Morsy (1999)**. Pinnae area ( $m^2$ ) =  $0.37 (\text{length} \times \text{width}) + 10.29$  then the area for the whole leaf ( $m^2$ ) was obtained from multiplying the pinnae area by number of pinnae per leaf. In addition, number of new leaves per palm was also recorded. Number of spines/ leaf and spine length (cm) were measured.

## 2. Measurements of leaf pigments:

## 3. Measurements of leaf content of N, P, K and Mg:

In both seasons and in early September, twenty pinnae from the middle of leaf (according to **Summer, 1985**) for each palm were selected. As soon as the leaflet samples were picked, they were cleaned with cloth damp to remove any residues that might affect the results. The leaflets were oven dried at  $70^\circ\text{C}$  for 48 hours, ground and stored in small pockets prior analysis. Accurate plant material (0.2 g) was digested using hydrogen peroxide and sulfuric acid as recommended by (**Peach and Tracey, 1968**). The digested materials were transferred quantitatively to 50 ml volumetric flask and raised up to the uniformity volume. Then, The following nutrients were determined:

1- Nitrogen % was determined by the modified micro kjeldahl method as described by **Chapman and Pratt, 1965**.

2- Phosphorus % was determined by using spekol spectrophotometer **Cottenie et al., 1982**.

3- Potassium % was determined by using Flame photometer according to the procedure reported by **Wild et al., (1985)**.

4- Magnesium % as well as leaf content of Fe, Zn, Mn and Cu (as ppm) were determined using atomic absorption spectrophotometer Perkin Elmer model 5000 according to **Peach and Tracey (1968)**.

## 4. Number of strands/spathe, number of flowers/strand, strand length, percentages of initial fruit setting and fruit retention as well as length and weight of bunch.

## 5. Yield:

Bunches (ten) of Zaghoul date palms were picked at the optimum commercial harvesting time under Qena region conditions (mid of Aug.) in the two experimental seasons. The yield of each palm was recorded in terms of weight per palm (kg.) by multiplying the average bunch weight (kg.) by total number of bunches per palm (ten bunches).

## 6. Quality parameters:

Samples of fifty dates from the yield of each palm were taken randomly and the following physical and chemical characteristics were measured:

### 6.1. Physical properties:

Weights of fruit seed and flesh (g.) were also estimated in a top pan balance of 0.01 g. sensitivity. Fruit dimensions (height and diameter in cm) were

recorded. Percentages of seeds and flesh was estimated by dividing weights of seeds and fresh by the whole weight of fruit and multiplying the product by 100.

## 6.2. Chemical characteristics:

### 6.2.1. Total soluble solids % (T.S.S. %)

The fruit fresh was well minced with an electric blender and past was squeezed and the total soluble solids % was determined by using hand refractometer (according to **A.O.A.C., 2000**).

### 6.2.2. Total and reducing sugars:

The percentages of total and reducing sugars were determined according to **Lane and Eynon (1965)** volumetric method that outlined in **A.O.A.C. (2000)**.

### 6.2.3. Total acidity %:

Twenty five grams of flesh were mixed with 100 ml distilled water in an electric blender, the extract was filtered and twenty ml of it were titrated against 0.1 N sodium hydroxide using phenolphthalein as an indicator according to **A.O.A.C., (2000)**. Total acidity % was determined as g. malic acid per 100 g pulp.

### 6.2.4. Total soluble tannins:

The tannin content was determined using the Indigo Carmen indicator according to **Balbaa (1981)**. Titration was carried out using 0.1 N potassium permanganate solution. Tannins in fresh weight were calculated (as total tannins percentage) according to the following equation:

$$1 \text{ ml potassium permanganate (0.1 N)} = 0.00416 \text{ g. tannins.}$$

### 6.2.5. Crude fibers content:

Determination of crude fibers content was achieved using acetic acid glacial and nitric acid at 10: 1 solution according to the official methods described in **A.O.A.C., (2000)**.

Thereafter, the obtained data during the two seasons were collected, tabulated and subjected to the proper statistical analysis of variance method reported by **Mead et al., (1993)**. The differences between treatment means were differentiated using New L.S.D at 5% parameter.

## 3.Results

### 1- Effects of normal and nano Zn, Fe and Mn applications on some vegetative growth characteristics:

It is clear from the obtained data in Tables (2 & 3) that subjecting Zaghoul date palms three times with normal (25 to 100 ppm) or nano Zn, Fe and Mn (2.5 to 20 ppm) significantly was accompanied with stimulating the nine growth aspects namely length, width and area of pinnae, leaf area, number of pinnae/ leaf, length and width of leaf, number of spines/leaf and spine length over the control

treatment. Significant differences on these growth characteristics were observed among the application of Zn, Fe and Mn either via normal or via nano methods. Using Zn, Fe and Mn via nano technology was significantly superior than using these nutrients via normal method in enhancing these growth aspects. There was a gradual stimulation on these growth aspects with increasing concentration of Zn, Fe and Mn normal method from 25 to 100 ppm and those applied via nano technology from 2.5 to 20 ppm. Significant differences on these growth aspects

were observed between all concentrations except among the higher two concentration of these nutrients applied via nano system (10 & 20 ppm). The maximum values of pinnae length (60.7 & 61.6 cm), pinnae area (145.7 & 144.8 cm<sup>2</sup>), number of pinnae/ leaf (238 & 242 pinnae) and leaf area (3.47 & 3.50 m<sup>2</sup>) were recorded on the palms that received Zn, Fe and Mn in nano form each at 20 ppm during both seasons, respectively. The untreated palms produced the minimum values. These results were true during both seasons.

**Table (2): Effect of normal and nano Zn, Fe and Mn applications on some vegetative growth characteristics of Zaghloul date palms during 2015 and 2016 seasons**

Treatments	Pinnae length (cm)		Pinnae width (cm)		Pinnae area (cm)		No. of pinnae/leaf		leaf area (m <sup>2</sup> )	
	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
Control	50.1	49.8	1.91	1.87	74.0	72.7	209.0	211.0	1.56	1.53
Normal Zn Fe and Mn each at 25 ppm	52.0	52.6	2.21	2.17	87.3	86.8	215.0	218.0	1.88	1.89
Normal Zn Fe and Mn each at 50 ppm	53.7	54.5	2.41	2.37	97.0	97.0	220.0	223.0	2.13	2.16
Normal Zn Fe and Mn each at 100 ppm	55.0	55.7	2.63	2.59	107.2	105.8	224.0	227.0	2.40	2.40
Nano Zn Fe and Mn each at 2.5 ppm	56.9	57.5	2.89	2.85	120.5	120.1	228.0	231.0	2.75	2.77
Nano Zn Fe and Mn each at 5 ppm	58.9	59.5	3.11	3.04	133.0	131.5	233.0	236.0	3.10	3.10
Nano Zn Fe and Mn each at 10 ppm	60.4	61.3	3.31	3.25	144.2	143.8	237.0	241.0	3.42	3.47
Nano Zn Fe and Mn each at 20 ppm	60.7	61.6	3.33	3.26	145.7	144.8	238.0	242.0	3.47	3.50
New L.S.D at 5%	1.1	0.9	0.14	0.18	4.1	4.7	3.0	3.3	0.09	0.08

**Table (3): Effect of normal and nano Zn, Fe and Mn applications on some vegetative growth characteristics of Zaghloul date palms during 2015 and 2016 seasons**

Treatments	Leaf length (m)		Leaf width (cm)		No. of spines/ leaf		Spine length (cm)	
	2015	2016	2015	2016	2015	2016	2015	2016
Control	3.71	3.40	71.0	69.9	12.0	11.8	9.5	9.4
Normal Zn Fe and Mn each at 25 ppm	4.01	3.66	72.5	72.0	13.3	13.0	10.1	9.8
Normal Zn Fe and Mn each at 50 ppm	4.29	4.01	74.6	73.9	14.9	14.1	10.7	10.3
Normal Zn Fe and Mn each at 100 ppm	4.61	4.22	77.0	76.0	16.3	16.0	11.3	10.9
Nano Zn Fe and Mn each at 2.5 ppm	5.00	4.57	79.1	78.1	18.0	17.1	12.0	11.7
Nano Zn Fe and Mn each at 5 ppm	5.22	5.00	81.1	80.0	19.0	19.3	12.6	12.4
Nano Zn Fe and Mn each at 10 ppm	5.43	5.21	83.1	81.9	20.3	21.6	13.3	13.1
Nano Zn Fe and Mn each at 20 ppm	5.46	5.23	84.0	82.0	21.0	22.0	13.4	13.2
New L.S.D at 5%	0.21	0.17	1.9	1.8	1.0	0.9	0.4	0.4

## 2- Effects of normal and nano Zn, Fe and Mn applications on the leaf pigments:

It is clear from the obtained data in table (4) that treating the palms with Zn, Fe and Mn in normal method at 25 to 100 ppm or in nano technology at 2.5 to 20 ppm significantly was followed by enhancing chlorophylls a & b, total chlorophylls and total carotenoids over the check treatment. The promotion on most cases was significantly depended on increasing concentration of Zn, Fe and Mn either

applied via normal method or applied via nano system. Increasing concentrations of the three micronutrients applied via nano system from 10 to 20 ppm failed to show significant promotion on these plants pigments. Using nano system for application of Zn, Fe and Mn was significantly superior than using normal method in enhancing these plant pigments. Treating the palms with Zn, Fe and Mn in nano system at 20 ppm gave the maximum values of chlorophyll a (7.2 & 7.2 mg/g F.W), chlorophyll b

(4.2 & 4.4 mg/g F.W), total chlorophylls (11.4 & 11.6 mg/ g F.W) and total carotenoids (3.7 & 3.7 mg/g F.W) during both seasons, respectively. The

lowest values were recorded on untreated palms. These results were true during both seasons.

**Table (4): Effect of normal and nano Zn, Fe and Mn applications on some leaf pigments of Zaghloul date palms during 2015 and 2016 seasons**

Treatments	Chlorophyll a (mg/ 100g F.W)		Chlorophyll b (mg/ 100g F.W)		Total chlorophylls (mg/ 100g F.W)		Total carotenoids (mg/ 100g F.W)	
	2015	2016	2015	2016	2015	2016	2015	2016
Control	4.1	3.9	1.9	2.0	6.0	5.9	1.7	1.9
Normal Zn Fe and Mn each at 25 ppm	4.6	4.5	2.2	2.4	6.8	6.9	2.0	2.2
Normal Zn Fe and Mn each at 50 ppm	5.1	5.0	2.6	2.8	7.7	7.8	2.2	2.5
Normal Zn Fe and Mn each at 100 ppm	5.5	5.4	3.0	3.1	8.5	8.5	2.6	2.8
Nano Zn Fe and Mn each at 2.5 ppm	6.0	6.1	3.4	3.5	9.4	9.6	2.9	3.1
Nano Zn Fe and Mn each at 5 ppm	6.6	6.6	3.8	4.0	10.4	10.6	3.2	3.3
Nano Zn Fe and Mn each at 10 ppm	7.1	7.1	4.1	4.3	11.2	11.4	3.6	3.6
Nano Zn Fe and Mn each at 20 ppm	7.2	7.2	4.2	4.4	11.4	11.6	3.7	3.7
New L.S.D at 5%	0.3	0.4	0.2	0.3	0.4	0.5	0.2	0.2

**Table (5): Effect of normal and nano Zn, Fe and Mn applications on the percentages of N, P, K and Mg of Zaghloul date palms during 2015 and 2016 seasons**

Treatments	Leaf N %		Leaf P %		Leaf K %		Leaf Mg %	
	2015	2016	2015	2016	2015	2016	2015	2016
Control	1.39	1.41	0.120	0.127	1.11	1.13	0.61	0.65
Normal Zn Fe and Mn each at 25 ppm	1.46	1.46	0.131	0.140	1.17	1.19	0.67	0.71
Normal Zn Fe and Mn each at 50 ppm	1.54	1.53	0.141	0.151	1.23	1.26	0.73	0.79
Normal Zn Fe and Mn each at 100 ppm	1.61	1.60	0.153	0.164	1.28	1.33	0.80	0.85
Nano Zn Fe and Mn each at 2.5 ppm	1.69	1.67	0.166	0.176	1.33	1.40	0.84	0.90
Nano Zn Fe and Mn each at 5 ppm	1.80	1.73	0.180	0.188	1.40	1.46	0.89	0.94
Nano Zn Fe and Mn each at 10 ppm	1.86	1.79	0.192	0.199	1.44	1.52	0.93	0.99
Nano Zn Fe and Mn each at 20 ppm	1.87	1.80	0.193	0.206	1.45	1.53	0.94	0.99
New L.S.D at 5%	0.06	0.05	0.010	0.011	0.04	0.05	0.04	0.05

### 3- Effects of normal and nano Zn, Fe and Mn applications on the leaf content of N, P, K, Mg, Zn, Fe and Mn:

It is noticed from the obtained data in Tables (5 & 6) that supplying the palms with Zn, Fe and Mn in normal (25 to 100 ppm) significantly increased the leaf content of N, P, K, Mg, Zn, Fe and Mn related to the control treatment. Using nano technology in the addition of Zn, Fe and Mn was significantly favourable than using these nutrients via normal method in enhancing N, P, K, Mg, Zn, Fe and Mn. The promotion on these nutrients was significantly correlated with increasing concentrations of Zn, Fe and Mn regardless the form that used. Increasing concentrations of these nutrients from 10 to 20 ppm when applied via nano form had no significant promotion on these nutrients (N, P, K, Mg, Zn, Fe and Mn). The maximum values of N (1.87 & 1.80 %), P (0.193 & 0.206 %), K (1.45 & 1.53 %), Mg (0.94 & 0.99 %), Zn (86 & 87 ppm), Mn (90.4 & 87.3 ppm) and Fe (82.3 & 84.9 ppm) were recorded on the palms that received Zn, Fe and Mn in nano technology form at 20 ppm, during both seasons, respectively. The lowest values were recorded on untreated palms. Similar results were announced during 2015 and 2016 seasons.

### 4- Effects of normal and nano Zn, Fe and Mn applications on some flowering aspects:

It is clear from the obtained data in Table (7) that treating the palms three times with Zn, Fe and Mn in normal or nano forms significantly enhanced the number of strands/ spathe, number of flowers/strand and strand length relative to the control treatment. There was a gradual and significant promotion on these parameters with increasing concentrations of Zn, Fe and Mn applied via normal method from 25 to 100 ppm and via nano system from 2.5 to 20 ppm. No significant promotion on these parameters was recorded with increasing concentrations of the three micronutrients applied via nano method from 2.0 to 20 ppm. Using three sprays of Zn, Fe and Mn in nano form each at 20 ppm gave the highest values of number of strands / spathe (70.0 & 73.00 strands), number of flowers / strand (79.0 & 84.0 flowers) and strand length (77.3 & 78.2 cm) during both seasons, respectively. The untreated palms produced the lowest values of number of strands /spathe (51.0 & 52.0 strands), number of flowers/strand (60 & 61 flowers) and strand length (68 & 69 cm) during both seasons, respectively. Similar results were announced during both seasons.

### **5- Percentages of initial fruit setting and fruit retention:**

Percentages of initial fruit setting and fruit retention in Tables (7 & 8) were significantly improved in response to treating the palms with Zn, Fe and Mn either via normal or nano technology systems compared to the control treatment. There was a gradual promotion on such two parameters with increasing concentrations of micronutrients regardless the source of application. Significant differences on such two parameters were observed among most concentrations except 10 and 20 ppm of these nutrients applied via nano technology. Nano technology use of Zn, Fe and Mn were significantly superior than using traditional method. The maximum values of initial fruit setting (60.7 & 57.6 %) and fruit retention % ( 29 & 30.3 %) were recorded on the palms that sprayed with Zn, Fe and Mn at 20 ppm in nano technology system form during both seasons, respectively. The untreated palms produced the minimum values. These results were true during both seasons.

### **6- Effects of normal and nano Zn, Fe and Mn applications on Bunch length and weight:**

It is clear from the obtained data in Table (8) that using Zn, Fe and Mn in normal or nano systems significantly was accompanied with enhancing length and weight of bunch relative to the control. Using these nutrients via nano system significantly improved length and weight of bunch rather than using normal method of application. Increasing concentrations of Zn, Fe and Mn applied via normal method and those applied via nano method from 2.5 to 20 ppm was accompanied with a gradual promotion on the length and weight of bunch. Significant differences on such two parameters were recorded among most concentrations of Zn, Fe and Mn regardless the source of application except among the concentrations 10 and 20 ppm applied via nano technology. The maximum values of bunch weight (13.3 & 13.5 kg) were recorded on the palms that received three sprays of Zn, Fe and Mn in nano form at 20 ppm during both seasons, respectively. The untreated palms bore the lightest bunches (9.0 & 8.9 kg) during both seasons, respectively. These results were true during both seasons.

### **7- Effects of normal and nano Zn, Fe and Mn applications on the yield/palm:**

It is clear from the obtained data in Table (8) that treating Zaghoul data palms three times with Zn, Fe and Mn in normal or nano forms had significant promotion on the yield/palm over the control treatment. Treating the palms with Zn, Fe and Mn in the form of nano technology was significantly superior than using the same nutrients via normal method in improving the yield per palm.

The promotion on the yield was significantly in proportional to the increase in concentrations of Zn, Fe and Mn applied in both forms. Increasing concentrations of Zn, Fe and Mn applied via nano technology from 10 to 20 ppm failed to show significant promotion on the yield / palm. From economical point of view, using Zn, Fe and Mn in nano form at 10 ppm gave the best results with regard to yield/palm. Yield/palm in such promised treatment reached 132 & 134 kg during both seasons, respectively. The yield / palm of the untreated palms reached 90 and 89 kg during both seasons, respectively. The percentage of increment on the yield due to using the previous recommended treatment reached 47.8 and 51.7 % during 2015 and 2016 seasons, respectively. These results were true during both seasons. The yield of the palms treated with Zn, Fe and Mn at 100 ppm via normal method reached 111 & 113 kg during both seasons, respectively. The percentage of increment on the yield of the palms that treated with 10 ppm Zn, Fe and Mn via nano system above the palms treated with Zn, Fe and Mn via normal method at 100 ppm reached 18.9 and 19.50 % during both seasons, respectively. This means that with the lowest concentrations of Zn, Fe and Mn applied via nano system, the yield in this treatment was higher than with application of Zn, Fe and Mn at higher concentrations.

### **8- Effects of normal and nano Zn, Fe and Mn applications on physical and chemical characteristics of the fruits:**

One can say from the obtained data in Tables (9 to 11) that treating the palms with Zn, Fe and Mn in the form of normal method at 25 to 100 ppm and in the form of system at 2.5 to 20 ppm was significantly very effective in improving fruit quality in terms of increasing fruit weight and dimensions, pulp %, Seed %, pulp/seed, T.S.S. %, total, reducing and non-reducing sugars, decreasing fruit seed %, titratable acidity %, total crude fibre % and total soluble tannins % relative to the control treatment. The promotion on both physical and chemical characteristics was significantly associated with increasing concentration of Zn, Fe, Mn applied via normal and via nano technology. Increasing concentrations of Zn, Fe and Mn applied via nano technology from 10 to 20 ppm had no significant promotion on all parameters of fruit quality. Using Zn, Fe and Mn via nano technology at 2.5 to 20 ppm significantly enhanced fruit quality relative to application of Zn, Fe and Me via normal method. The best results with regard to fruit quality from economical point of view were obtained due to application of Zn, Fe and Mn in nano form at 10 ppm. Unfavourable effects on fruit quality were

obtained on the untreated palms. These results were true during both seasons.

**Table (6): Effect of normal and nano Zn, Fe and Mn applications on the leaf content of Zn, Mn and Fe of Zaghoul date palms during 2015 and 2016 seasons**

Treatments	Leaf Zn (ppm)		Leaf Mn (ppm)		Leaf Fe (ppm)	
	2015	2016	2015	2016	2015	2016
Control	55.9	56.0	51.3	52.0	48.1	49.0
Normal Zn Fe and Mn each at 25 ppm	56.0	56.1	59.9	60.6	53.3	55.0
Normal Zn Fe and Mn each at 50 ppm	62.9	63.1	66.0	52.8	60.1	61.8
Normal Zn Fe and Mn each at 100 ppm	68.0	68.3	72.3	59.9	65.9	68.9
Nano Zn Fe and Mn each at 2.5 ppm	73.0	74.1	79.0	68.9	71.7	74.0
Nano Zn Fe and Mn each at 5 ppm	80.0	79.9	80.3	76.3	76.9	79.0
Nano Zn Fe and Mn each at 10 ppm	85.4	86.3	92.0	85.0	82.0	84.0
Nano Zn Fe and Mn each at 20 ppm	86.0	87.0	90.4	87.2	82.3	84.9
New L.S.D at 5%	4.6	4.7	5.1	4.7	3.7	4.1

**Table (7): Effect of normal and nano Zn, Fe and Mn applications on setting aspects on some flowering and fruit of Zaghoul date palms during 2015 and 2016 seasons**

Treatments	No. of strands /spathe		No. of flowers per strand		Strand length (cm)		Initial fruit setting %	
	2015	2016	2015	2016	2015	2016	2015	2016
Control	51.0	52.0	60.0	61.0	68.0	69.0	47.0	46.9
Normal Zn Fe and Mn each at 25 ppm	53.0	56.0	63.0	64.0	69.3	70.2	49.0	49.0
Normal Zn Fe and Mn each at 50 ppm	56.0	59.0	67.0	68.0	70.5	71.5	51.6	50.9
Normal Zn Fe and Mn each at 100 ppm	59.0	62.0	69.0	72.0	72.0	72.9	53.7	53.0
Nano Zn Fe and Mn each at 2.5 ppm	64.0	65.0	72.0	75.0	73.4	74.5	56.0	54.6
Nano Zn Fe and Mn each at 5 ppm	66.0	69.0	75.0	80.0	75.0	75.9	58.3	56.0
Nano Zn Fe and Mn each at 10 ppm	69.0	72.0	78.0	83.0	77.2	78.1	60.4	57.4
Nano Zn Fe and Mn each at 20 ppm	70.0	73.0	79.0	84.0	77.3	78.2	60.7	57.6
New L.S.D at 5%	2.0	2.3	2.0	2.6	1.1	1.0	1.6	1.3

**Table (8): Effect of normal and nano Zn, Fe and Mn applications on the percentage of fruit retention, bunch length and weight and yield/palm of Zaghoul date palms during 2015 and 2016 seasons**

Treatments	Fruit retention %		Bunch length (cm)		Bunch weight (kg)		Yield / palm (kg)	
	2015	2016	2015	2016	2015	2016	2015	2016
Control	21.0	21.9	1.04	1.08	9.0	8.9	90.0	89.0
Normal Zn Fe and Mn each at 25 ppm	22.3	23.2	1.11	1.14	9.7	9.7	97.0	97.0
Normal Zn Fe and Mn each at 50 ppm	23.7	24.6	1.18	1.21	10.5	10.6	105.0	106.0
Normal Zn Fe and Mn each at 100 ppm	25.0	25.8	1.25	1.30	11.1	11.3	111.0	113.0
Nano Zn Fe and Mn each at 2.5 ppm	26.1	27.6	1.32	1.36	11.8	12.0	118.0	120.0
Nano Zn Fe and Mn each at 5 ppm	27.2	28.0	1.40	1.42	12.5	12.6	125.0	126.0
Nano Zn Fe and Mn each at 10 ppm	28.5	30.2	1.46	1.49	13.2	13.4	132.0	134.0
Nano Zn Fe and Mn each at 20 ppm	29.0	30.3	1.48	1.50	13.3	13.5	133.0	135.0
New L.S.D at 5%	1.1	1.3	0.05	0.06	0.6	0.5	4.8	4.6

**Table (9): Effect of normal and nano Zn, Fe and Mn applications on some physical characteristics of the fruits of Zaghoul date palms during 2015 and 2016 seasons**

Treatments	Fruit weight (g.)		Fruit height (cm)		Fruit diameter (cm)		Fruit pulp %	
	2015	2016	2015	2016	2015	2016	2015	2016
Control	15.9	16.0	4.00	4.04	2.11	2.16	85.1	85.2
Normal Zn Fe and Mn each at 25 ppm	16.5	16.6	4.06	4.08	2.15	2.20	86.6	86.3
Normal Zn Fe and Mn each at 50 ppm	17.2	17.2	4.12	4.14	2.20	2.24	88.0	87.5
Normal Zn Fe and Mn each at 100 ppm	18.0	17.9	4.21	4.25	2.23	2.28	89.3	88.6
Nano Zn Fe and Mn each at 2.5 ppm	18.7	18.9	4.28	4.32	2.27	2.31	90.7	89.9
Nano Zn Fe and Mn each at 5 ppm	19.7	20.0	4.49	4.51	2.33	2.38	92.0	91.0
Nano Zn Fe and Mn each at 10 ppm	20.4	20.6	4.61	4.64	2.38	2.44	93.3	91.1
Nano Zn Fe and Mn each at 20 ppm	20.5	20.7	4.63	4.66	2.39	2.45	93.4	91.2
New L.S.D at 5%	0.6	0.4	0.04	0.03	0.03	0.04	1.0	1.1

**Table (10): Effect of normal and nano Zn, Fe and Mn applications on some physical and chemical characteristics of the fruits of Zaghoul date palms during 2015 and 2016 seasons**

Treatments	Fruit seed %		Pulp/seed		T.S.S.%		Total sugars %		Reducing sugars %	
	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
Control	14.9	14.8	5.71	5.76	27.0	26.9	18.8	19.0	14.9	14.5
Normal Zn Fe and Mn each at 25 ppm	13.4	13.7	6.46	6.30	27.6	27.5	19.3	19.5	15.4	15.1
Normal Zn Fe and Mn each at 50 ppm	12.0	12.5	7.33	7.00	28.2	28.3	20.0	20.1	16.0	15.9
Normal Zn Fe and Mn each at 100 ppm	10.7	11.4	8.35	7.77	29.0	29.1	20.5	21.0	16.5	16.4
Nano Zn Fe and Mn each at 2.5 ppm	9.3	10.1	9.75	8.90	29.7	29.9	21.1	21.6	17.0	16.9
Nano Zn Fe and Mn each at 5 ppm	8.0	9.0	11.50	10.11	30.5	30.4	21.7	22.9	17.4	17.5
Nano Zn Fe and Mn each at 10 ppm	6.7	8.9	13.90	10.23	31.0	31.2	22.5	24.0	17.9	18.0
Nano Zn Fe and Mn each at 20 ppm	6.6	8.8	14.15	10.36	31.1	31.3	22.7	24.1	18.0	18.1
New L.S.D at 5%	<b>0.8</b>	<b>0.7</b>	<b>0.60</b>	<b>0.55</b>	<b>0.5</b>	<b>0.4</b>	<b>0.4</b>	<b>0.5</b>	<b>0.5</b>	<b>0.5</b>

**Table (11): Effect of normal and nano Zn, Fe and Mn applications on some chemical characteristics of the fruits of Zaghoul date palms during 2015 and 2016 seasons**

Treatments	Non-reducing sugars %		Titratable acidity %		Total crude fibre %		Total soluble tannins %	
	2015	2016	2015	2016	2015	2016	2015	2016
Control	3.9	4.5	0.341	0.344	0.99	1.00	0.84	0.83
Normal Zn Fe and Mn each at 25 ppm	3.9	4.4	0.320	0.318	0.94	0.90	0.79	0.80
Normal Zn Fe and Mn each at 50 ppm	4.0	4.2	0.301	0.299	0.88	0.84	0.71	0.70
Normal Zn Fe and Mn each at 100 ppm	4.0	4.6	0.281	0.279	0.82	0.78	0.66	0.65
Nano Zn Fe and Mn each at 2.5 ppm	4.1	4.7	0.259	0.257	0.77	0.74	0.60	0.59
Nano Zn Fe and Mn each at 5 ppm	4.3	5.4	0.239	0.237	0.72	0.69	0.52	0.51
Nano Zn Fe and Mn each at 10 ppm	4.6	6.0	0.223	0.220	0.67	0.65	0.47	0.46
Nano Zn Fe and Mn each at 20 ppm	4.6	3.9	0.221	0.218	0.66	0.64	0.46	0.45
New L.S.D at 5%	<b>0.3</b>	<b>0.2</b>	<b>0.016</b>	<b>0.014</b>	<b>0.03</b>	<b>0.03</b>	<b>0.02</b>	<b>0.03</b>

#### 4. Discussion:

The beneficial effects of using nano micronutrients on growth and fruiting of Zaghoul date palms might be attributed to their positive action on synchronizing the release of micronutrients and preventing undesirable nutrient losses to soil, water and air via direct internalization by crops and avoiding the interaction of nutrients with soil, microorganisms of water and air as well as increasing their efficiency and reducing soil toxic and potential negative effects associated with over dosage and frequency of application. They may delay the release of the nutrients and extend the fertilizer effect period (Prasad *et al.*, 2014; Mukhopadhyay, 2014 and Manjunotha *et al.*, 2016).

The important regulatory effect of N on building of proteins, amino acids, enzymes, natural hormones, vitamins, antioxidants and plant pigments and encouraging photosynthesis and cell division (Mengel, 1984), in enhancing the biosynthesis of sugars, plant pigments, enzymes, natural hormones, cell division, vitamins, root development and photosynthesis (Nijjar, 1985 and Mengel and Kirkby, 1987), K in stimulating the biosynthesis and translocation of sugars, plant pigments, cell division, tolerance of fruit crops to biotic and abiotic stresses, water tolerance, root development, Mg in building chlorophylls and enhancing the biosynthesis of sugars, proteins and fats, sugars translocation and amino acid (Miller *et al.*, 1990), Fe in building chlorophylls and plant pigments and regulating

reduction and oxidants reactions (Nijjar, 1985), Mn in enhancing co-enzymes that are responsible for enhancing the activity of respiration and oxidation enzymes and the biosynthesis of organic acids, N metabolism, nitrate reduction and the biosynthesis of IAA (Mengel *et al.*, 2001), Zn in activating metabolism enzymes, biosynthesis of organic foods, IAA, cell division and enlargement, water absorption and nutrient transport (Yagodin, 1999) and B in enhancing the biosynthesis of N, proteins, IAA, carbohydrates, water uptake and pallor germination (Pilbeam and Kirkby, 1983; Gupta *et al.*, 1985 and Blevins and Lukaszewski, 1998) surely reflected on stimulating growth, palm nutritional status, yield and fruit quality of zaghoul date palms.

These results are in agreement with those obtained by Sabir *et al* (2014); Refaai (2014); Roshdy and Refaai (2016) and Ahmed (2017).

These results are in harmony with those obtained by Etman *et al* (2007) on Zaghoul date palms; El-Sayed-Esraa (2010) on Ewaise mangoes; Hamed-Mona (2011) on Balady mandarin; Yousef-Aml *et al* (2011) on chemlali olives; Hassan- Huda (2014) on Valencia oranges; Mohamed and Mohamed (2013) on Sewy date palms; Ahmed *et al* (2014) on El-Saidy date palms and Sayed- Ola (2014) on El-Saidy date palms.

#### 5. Conclusion:

Carrying out three sprays of a mixture of Zn, Fe and Mn via nanotechnology at 10 ppm was



responsible for promoting yield and fruit quality of Zaghoul date palms.

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