Impact of using nano-micronutrients via Spraying versus chelated forms on fruiting of ferehy date palms

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Abstract

This study was conducted during 2016 & 2017 seasons to elucidate the impact of using nano-micronutrients (Zn, Fe, Mn and Cu) at 0.0125 to 0.1 % versus normal micronutrients in the form of chelates at 0.025 to 0.2 % on growth, palm nutritional status, yield and fruit quality of Ferehy date palms grown under Siwa conditions.

Treating the palms with these micronutrients via nano or chelated form at the previous concentrations had an announced promotion on all aspects of growth, palm nutritional status, yield and fruit quality relative to the control treatment. Using nano-micronutrients at the lower concentrations namely 0.0125 and 0.025 % substantially were favorable than using the higher concentrations of chelated forms namely 0.1 and 0.2 % on stimulating all parameters. Using nano-micronutrients at concentrations higher than 0.0125 failed to show measurable effects.

The best results with regard to yield and fruit quality of Ferehy date palms grown under Siwa region conditions were obtained due to spraying the palms three times with Zn, Fe, Mn and Cu via nano system at 0.0125 %.

Keywords: Chelated micronutrients, nano-micronutrients, Ferehy date palms, growth, palm nutritional status, yield, fruit quality.

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Introduction

Nowadays, many efforts were done for enhancing of resources use efficiency with the lower loss to production via using modern technologies. Introducing nano-fertilization system has the potential to revolutionize the agricultural fields. Nano-fertilization was created to improve the use of slow release ability of fertilizers in a suitable alternative to conventional ones to enhance and accelerate nutrient use efficiency and balance fertilization program (Heller and Atkinson, 2007; Baruah and Dutta, 2009; Subramanian and Sharma, 2009; Remya*et al*., 2010; Sheykhabaylou*et al*., 2010; Mausavi and Rezaei, 2011; Ditta, 2012 and Ekinchi*et al*., 2014).

Using micronutrients via chelated from (Abd-Allah, 2006; Fernandes*et al*., 2009; Bozary, 2012; Ahmed *et al*., 2014 and Hassan-Huda, 2014) and Nano-form (Refaai, 2014; Sabir *et al*., 2014; Roshdy and Refaai, 2016; Wassel *et al*, 2017 and Zagzog and Gad, 2017) had announced promotion on growth aspects, tree nutritional status, yield and fruit characteristics in different fruit crops relative to the control. In most cases using these nutrients via nano was superior than using nutrients via traditional method.

The merit of this study was evaluating the effect of using some nutrients via chelated form versus nano-technology on growth, palm nutritional status, yield and fruit quality of Ferehy date palms grown under Siwa environmental conditions.

Materials and methods

This study was conducted during 2016 and 2017 seasons on 20 years Ferehy date palms grown in a private date palm orchard situated at Siwa Oasis, Matrouh Governorate. These palms were produced through conventional propagation by off shoots as well as characterized by regular bearing. Also, they are uniform in vigour, healthy, good physical conditions, free from insects, diseases and damages. They planted at 7x7 meters apart and irrigated with well water through surface irrigation system. The texture of the tested soil is sandy clay. Soil analysis done according to Wilde *et al.,* (1985) and the obtained data are illustrated in Table (1).

Table (1) Physical and chemical analysis of the tested soil**.**

Parameters	**Values**
Particle size distribution:	
Sandy %	66.1
Silt %	13.9
Clay %	20.0
Texture	Sandy clay
pH (1:5 extract)	751.2
EC (1:5 extract) (ppm)	1.02
$CaCO_3$ %	3.99
Total N %	0.005
Available P (ppm)	3.2
Available K (ppm)	111.3
EDTA extractable micronutrients (ppm)	
Zn	1.5
Fe	1.4
Mn	1.7
Cu	0.5

All the selected palms (27 palms) received the common and usual horticultural practices that already applied in the orchard except those dealing with hand pollination. Bunches /leaf were adjusted to 10.1 (according to Mohamed *et al*., 2017). Hand pollination was carried out inserting five spaces into 1 female spathe after two days from spathe cracking.

The experiment included the following fresh and stored pollen grains treatments:

- Control (spraying with water)
- Spraying Zn, Fe, Mn and Cu in chelated form at 0.025% (0.25 g/L).
- Spraying Zn, Fe, Mn and Cu in chelated form at 0.05% (0.5 g/L).
- Spraying Zn, Fe, Mn and Cu in chelated form at 0.1% (1.0 g/L).
- Spraying Zn, Fe, Mn and Cu in chelated form at 0.2% (2.0 g/L).
- Spraying Zn, Fe, Mn and Cu in nanoformat 0.0125% (0.125 g/L).
- Spraying Zn, Fe, Mn and Cu in nano form at 0.025% (0.25 g/L).
- Spraying Zn, Fe, Mn and Cu in nano form at 0.050% (0.5 g/L).
- Spraying Zn,
- Fe, Mn and Cu in nano form at 0.01% (1.0 g/L).

Each treatment was replicated three times, one palm per each. The four micronutrients namely Zn, Fe, Mn and Cu in both chelated and nano-forms were sprayed three times at growth start and before hand pollination (last week of Feb.), just after fruit setting (2^{nd} week of April) and two months later (2^{nd} week of June). All micronutrients were supplied with wetting agent substance namely triton B at 0.05 % (0.5 ml/l) and the palms were sprayed till runoff.

Generally, during both seasons the following measurements were taken:

- Leaf area (m^2) by multiplying the leaflet area (Ahmed and Morsy, 1999) by the total number of leaflets/leaf.
- Total chlorophylls (a & b) as mg/g F.W in the middle fresh leaflets (Von Wettstein, 1957).
- Percentages of N, P and K in the middle leaflets on dry weight, basis (Summer, 1985 and Wilde *et al*., 1985).

Bunch weight and yield/palm

At ripening bunch weight recorded 30 kg fruits and from each bunch fruits were randomly selected to determine fruit weight (g.); flesh %; T.S.S.%; total reducing and non-reducing sugars (Lane and Eynon, 1965 and A.O.A.C., 2000), total acidity % (as g malic acid/100 g pulp), total fibre % (A.O.A.C., 2000) and total soluble tannins % (Balbaa, 1981).

Statistical analysis

The experiment was set up as a randomized complete block design (RCBD). The analysis of variance (ANOVA) was used according to Mead *et al*., (1993). Treatment means of the six treatments were compared using new L.S.D test at 5 % level.

Results and discussion

1. Leaf area

Data in Table (2) clearly show that spraying Ferehy date palms growing under Siwa Oasis with the four micronutrients namely Zn, Fe, Mn and Cu in chelated form at 0.025 to 0.2 % and via nano-technology at 0.0125 to 0.1 % had significant promotion on the leaf area compared to the control treatment. The promotion on the leaf area was significantly in proportional to the increase in concentration of micronutrients applied via chelated form from 0.025 to 0.1 %. Increasing concentrations of micronutrients applied via chelated forms from 0.1 to 0.2 % view failed to improve the leaf area. However, increasing concentrations of micronutrients applied via nano-form from 0.0125 to 0.2 % had no significant stimulation. In other words using concentrations of micronutrients applied via nano form higher than 0.0125 did not alter such growth aspect. Using micronutrients via nano-technology at 0.0125 to 0.1 % was significantly favorable than using them in chelated form at 0.025 to 0.2% in stimulating the leaf area. The maximum values of leaf area were recorded on the palms that received three sprays of a mixture of micronutrients (Zn, Fe, Mn and Cu) applied via nao-form at 0.0125 %. The lowest values were recorded on untreated palms. Similar trend was noticed during 2016 and 2017 seasons.

2. Total chlorophylls

Table (2) shows that amending Ferehy date palms three times with the mixture of micronutrients namely Zn, Fe, Mn and Cu in both forms (chelated and nano-forms) was significantly followed by enhancing total chlorophylls in the leaves over the control treatment. The promotion was significantly associated with increasing concentrations of micronutrients applied via chelated form from 0.025 to 0.1 %. Negligible stimulation on total chlorophylls in the leaves was observed among the higher two concentrations of micronutrients namely 0.1 and 0.2 % applied via chelated form. Using these micronutrients via nano-system at concentrations above 0.0125 % failed to show significant stimulation on total chlorophylls. A significant promotion was observed on total chlorophylls due to using micronutrients via nano-form relative to the use of these micronutrients via chelated form. The untreated palms produced the minimum values. Nano application of Zn, Fe, Mn and Cu

at 0.0125 % gave the maximum values from statistical point of view. These results were true during both seasons.

3. Leaf content of N, P and K

Data in Tables (2&3) obviously reveal the percentages of N, P and K in the leaves of Ferehy date. Palms N,P and K, contents were significantly enhanced in response to treating the palms three times with the mixture of micronutrients at 0.025 to 0.2 % applied via chelated form and at 0.0125 to 0.1 % applied via nano-form over the control treatment. Increasing concentrations of the four micronutrients applied via chelated form from 0.025 to 0.1 % succeeded significantly in enhancing these nutrients. Meaningless promotion on N, P and K in the leaves was observed among the higher two concentrations (0.2 & 0.2) of these micronutrients applied via chelated form. Using concentrations above 0.0125 % from nano - micronutrients had no significant stimulation on these nutrients. Using micronutrients via nano-form was significantly superior than using them via chelated form in enhancing these nutrients. The lowest values were recorded on untreated palms. The same trend was observed during both seasons.

Table (2) Effect of spraying some micronutrients via chelated or nano forms on the leaf area, total chlorophylls and percentages of N and P in the leaves of Ferehy date palms during 2016 and 2017 seasons.

Treatments	Leaf area (m^2)		Total chlorophylls (mg/g F.W)		Leaf N %		Leaf P %	
	2016	2017	2016	2017	2016	2017	2016	2017
Control (spraying with water)	0.64	0.65	7.3	7.1	1.59	1.60	0.111	0.110
Spraying Zn, Fe, Fe, Mn and Cu in chelated form at 0.025% (0.25 g/L).	0.72	0.74	7.7	7.7	1.69	1.67	0.117	0.120
Spraying Zn, Fe, Fe, Mn and Cu in chelated form at 0.05% (0.5 g/L).	0.80	0.81	8.1	8.8	1.80	1.75	0.125	0.131
Spraying Zn, Fe, Fe, Mn and Cu in chelated form at 0.1% (1.0 g/L).	0.89	0.86	8.5	9.5	1.89	1.84	0.133	0.141
Spraying Zn, Fe, Fe, Mn and Cu in chelated form at 0.2% (2.0 g/L).	0.90	0.88	8.6	9.6	1.90	1.85	0.134	0.142
Spraying Zn, Fe, Fe, Mn and Cu in chelated nano at 0.0125% (0.125 g/L).	1.09	1.12	9.1	10.2	1.97	1.94	0.145	0.163
Spraying Zn, Fe, Fe, Mn and Cu in chelated nano at 0.25% (0.25 g/L).	1.10	1.13	9.1	10.3	1.98	1.95	0.146	0.164
Spraying Zn, Fe, Fe, Mn and Cu in chelated nano at 0.050% (0.5 g/L).	1.11	1.14	9.2	10.4	1.99	1.96	0.147	0.165
Spraying Zn, Fe, Fe, Mn and Cu in chelated nano at 0.1% (1.0 g/L).	1.12	1.15	9.2	10.5	1.99	1.96	0.147	0.160
New L.S.D. at 5 %	0.06	0.05	0.3	0.5	0.06	0.07	0.005	0.006

4. Bunch weight and yield/palm

Table (3) exhibits that nano and chelated form applications of micronutrients significantly improved both bunch weight and yield/palm relative to the control. The promotion was significantly related to the increase in concentrations of micronutrients applied via chelated form from 0.025 to 0.1 %. However no significant promotion on both bunch weight and yield was observed among the higher two concentrations namely 0.1 and 0.2 % applied via chelated form. Using nano-technology system of the four micronutrients was significantly preferable in improving bunch weight and yield per palm than using these nutrients via chelated form. Bunch weight and yield/palm were significantly unaffected with using these nutrients at concentrations above 0.0125 % in nano-system technology form.

From economical point of view the best results with regard to bunch weight and yield per palm were obtained due to using the four nutrients together via nano-system at 0.0125 %.Under such promised treatment, bunch weight reached 29.9 and 30.5 kg and yield/palm were 299.0 and 305.0 kg during both seasons, respectively. The lowest bunch weight (26.0 & 25.5 kg) and yield/palm (260.0 & 255.0 kg) were recorded on untreated palms. These results were true during both seasons.

Table (3) Effect of spraying some micronutrients via chelated or nano forms on the percentages of K in the leaves, bunch weight, yield/palm and fruit weight of Ferehy date palms during 2016 and 2017 seasons.

Treatments	Leaf K %		Bunch weight (kg)		Yield/palm (kg)		Fruit weight (g)	
	2016	2017	2016	2017	2016	2017	2016	2017
Control (spraying with water)	1.10	1.08	26.0	25.5	260	255	6.1	5.9
Spraying Zn, Fe, Fe, Mn and Cu in chelated form at 0.025% (0.25 g/L).	1.16	1.17	26.6	26.7	266	267	6.5	6.4
Spraying Zn, Fe, Fe, Mn and Cu in chelated form at 0.05% (0.5 g/L).	1.23	1.25	27.3	27.8	273	278	6.8	6.9
Spraying Zn, Fe, Fe, Mn and Cu in chelated form at 0.1% (1.0 g/L).	1.31	1.32	28.0	28.5	280	285	7.1	7.3
Spraying Zn, Fe, Fe, Mn and Cu in chelated form at 0.2% (2.0 g/L).	1.32	1.33	28.1	28.6	281	286	7.2	7.4
Spraying Zn, Fe, Fe, Mn and Cu in chelated form at 0.0125% (0.125 g/L).	1.41	1.51	29.9	30.5	299	305	7.6	7.8
Spraying Zn, Fe, Fe, Mn and Cu in chelated form at 0.25% (0.25 g/L).	1.41	1.51	30.0	30.6	300	306	7.7	7.8
Spraying Zn, Fe, Fe, Mn and Cu in chelated form at 0.050% (0.5 g/L).	1.42	1.52	30.0	30.6	300	306	7.7	7.9
Spraying Zn, Fe, Fe, Mn and Cu in chelated form at 0.1% (1.0 g/L).	1.43	1.53	30.0	30.7	300	307	7.8	7.9
New L.S.D. at 5 %	0.05	0.06	0.5	0.6	2.6	3.0	0.3	0.4

5. Fruit characteristics

Data in Tables (3 to 6) measurably indicate that subjecting Ferehy date palms growing under Siwa environmental condition to the four nutrients (Zn, Fe, Mn and Cu) in chelated form at 0.025 to 0.2 % and in nano- form at 0.0125 to 0.1 % was significantly responsible for improving fruit quality in terms of increasing weight, length and width of fruit, fruit flesh %, flesh/seeds, T.S.S.%, total, reducing and non-reducing sugars % and decreasing seed length, total acidity %, total crude fibre % and total soluble tannins relative to the control treatment. The promotion on both physical and chemical characteristics of the fruits was significantly in proportional to the increase in concentrations of these micronutrients applied via chelated form from 0.025 to 0.1 %. Increasing concentrations of these nutrients applied via chelated form from 0.1 to 0.2 % had no significant promotion on fruit characteristics. Using these micronutrients via nano-form significantly realized the best effect on the fruit characteristics than using the other form namely chelated. Fruit quality characteristics were significantly unaffected with using these micronutrients via nano-system at concentrations above 0.0125 %, therefore the best results with regard to quality parameters were obtained due to treating the palms three times with a mixture of these micronutrients via nano-technology at 0.0125 %. The untreated palms produced unfavorable promotion on fruit quality attributes. These results were true during both seasons.

Table (4) Effect of spraying some micronutrients via chelated or nano forms on some physical and chemical characteristics of the fruits of Ferehy date palms during 2016 and 2017 seasons.

Treatments	Fruit length (cm)		Fruit width (cm)		Seed length (cm)		Flesh / seed	
	2016	2017	2016	2017	2016	2017	2016	2017
Control (spraying with water)	2.9	2.7	1.4	1.3	2.4	2.5	4.99	4.88
Spraying Zn, Fe, Fe, Mn and Cu in chelated form at 0.025% (0.25 g/L).	3.1	3.1	1.6	1.6	2.2	2.2	5.67	5.45
Spraying Zn, Fe, Fe, Mn and Cu in chelated form at 0.05% (0.5 g/L).	3.3	3.3	1.8	1.8	2.0	2.0	6.14	6.14
Spraying Zn, Fe, Fe, Mn and Cu in chelated form at 0.1% (1.0 g/L).	3.5	3.5	2.0	2.0	1.8	1.8	6.70	6.70
Spraying Zn, Fe, Fe, Mn and Cu in chelated form at 0.2% (2.0 g/L).	3.6	3.6	2.1	2.1	1.7	1.7	6.87	6.87
Spraying Zn, Fe, Fe, Mn and Cu in nano form at 0.0125% (0.125 g/L).	3.8	3.9	2.4	2.5	1.5	1.4	8.90	8.90
Spraying Zn, Fe, Fe, Mn and Cu in nano form at 0.25% (0.25 g/L).	3.8	3.9	2.4	2.5	1.5	1.4	9.00	9.00
Spraying Zn, Fe, Fe, Mn and Cu in nano form at 0.050% (0.5 g/L).	3.8	3.9	2.4	2.5	1.5	1.4	9.10	9.10
Spraying Zn, Fe, Fe, Mn and Cu in nano form at 0.1% (1.0 g/L).	3.8	3.9	2.4	2.5	1.5	1.4	9.10	9.10
New L.S.D. at 5 %	0.2	0.2	0.2	0.2	0.2	0.2	0.18	0.20

Table (5) Effect of spraying some micronutrients via chelated or nano forms on some physical and chemical characteristics of Ferehy date palms during 2016 and 2017 seasons.

Treatments	Fruit flesh %		T.S.S%		Total sugars %		Reducing sugars %	
	2016	2017	2016	2017	2016	2017	2016	2017
Control (spraying with water)	83.3	83.0	69.1	70.0	55.0	55.0	16.1	16.0
Spraying Zn, Fe, Fe, Mn and Cu in chelated form at 0.025% (0.25 g/L).	85.0	84.5	69.7	70.9	56.0	55.9	16.5	16.5
Spraying Zn, Fe, Fe, Mn and Cu in chelated form at 0.05% (0.5 g/L).	86.0	86.0	70.9	71.9	56.5	56.5	17.0	16.9
Spraying Zn, Fe, Fe, Mn and Cu in chelated form at 0.1% (1.0 g/L).	87.0	87.0	72.0	73.0	57.1	57.1	17.4	17.5
Spraying Zn, Fe, Fe, Mn and Cu in chelated form at 0.2% (2.0 g/L).	87.3	87.3	72.1	73.1	57.2	57.2	17.5	17.6
Spraying Zn, Fe, Fe, Mn and Cu in nano form at 0.0125% (0.125 g/L).	89.9	89.9	73.9	75.0	59.0	59.0	18.0	18.1
Spraying Zn, Fe, Fe, Mn and Cu in nano form at 0.25% (0.25 g/L).	90.0	90.0	74.0	75.1	59.1	59.1	18.1	18.2
Spraying Zn, Fe, Fe, Mn and Cu in nano form at 0.050% (0.5 g/L).	90.1	90.1	74.1	75.2	59.2	59.2	18.2	18.2
Spraying Zn, Fe, Fe, Mn and Cu in nano form at 0.1% (1.0 g/L).	90.1	90.1	74.1	75.2	59.2	59.2	18.2	18.2
New L.S.D. at 5 %	0.9	1.0	0.4	0.4	0.3	0.3	0.3	0.3

Table (6) Effect of spraying some micronutrients via chelated or nano forms on some chemical characteristics of Ferehy date palms during 2016 and 2017 seasons.

Treatments	Non-reducing sugars %		Total acidity %		Total fiber crude %		Total soluble tannins %	
	2016	2017	2016	2017	2016	2017	2016	2017
Control (spraying with water)	38.9	39.0	0.219	0.221	0.94	0.95	0.39	0.38
Spraying Zn, Fe, Fe, Mn and Cu in chelated form at 0.025% (0.25 g/L).	39.5	39.4	0.210	0.212	0.89	0.90	0.35	0.35
Spraying Zn, Fe, Fe, Mn and Cu in chelated form at 0.05% (0.5 g/L).	39.5	39.6	0.199	0.201	0.81	0.80	0.31	0.30
Spraying Zn, Fe, Fe, Mn and Cu in chelated form at 0.1% (1.0 g/L).	39.7	39.6	0.180	0.182	0.76	0.75	0.27	0.27
Spraying Zn, Fe, Fe, Mn and Cu in chelated form at 0.2% (2.0 g/L).	39.7	39.6	0.179	0.181	0.75	0.74	0.25	0.25
Spraying Zn, Fe, Fe, Mn and Cu in nano form at 0.0125% (0.125 g/L).	41.0	40.9	0.160	0.159	0.61	0.58	0.19	0.18
Spraying Zn, Fe, Fe, Mn and Cu in nano form at 0.25% (0.25 g/L).	41.0	40.9	0.159	0.158	0.60	0.57	0.18	0.17
Spraying Zn, Fe, Fe, Mn and Cu in nano form at 0.050% (0.5 g/L).	41.0	41.0	0.158	0.158	0.60	0.56	0.18	0.17
Spraying Zn, Fe, Fe, Mn and Cu in nano form at 0.1% (1.0 g/L).	41.0	41.0	0.157	0.157	0.59	0.56	0.18	0.16
New L.S.D. at 5 %	0.4	0.4	0.009	0.012	0.04	0.04	0.03	0.03

Discussion

The favorable effects of using Zn, Fe, Mn and Cu on growth, palm nutritional status, bunch weight, yield and fruit characteristics might be attributed to their positive action on enhancing cell division, biosynthesis of chlorophylls and other plant pigments, natural hormones, uptake and movement of water and nutrients, building most of organic foods, enzyme activity, tolerance of plants to all stresses (biotic and abiotic stresses), pollen germination and photosynthesis (Nijjar, 1985).

The superiority of using micronutrients applied via nano-form when compared with the use of these micronutrients via chelated form on the previous parameters was mainly attributed to their five sizes that responsible for enhancing nutrient use efficiency, facilitating the uptake of nutrients and balancing nutrients absorption at longer peroids **(**Heller and Atkinson, 2007 and Ditta, 2012).

The results of Abd-Allah, (2006); Fernandes *et al*., (2009); Bozary, (2012); Ahmed *et al.*, (2014) and Hassan-Huda, (2014) confirmed the present results regarding the beneficial effects of chelated micronutrients on growth and fruiting on different fruit crops. These results regard the promoting effect of nano-form of micronutrients on growth and fruiting of Ferehy are in concordance with Refaai, (2014); Sabir *et al*., (2014); Roshdy and Refaai, (2016); Wassel *et al*, (2017) and Zagzog and Gad, (2017).

Conclusion

The best results with regard to yield and fruit quality of Ferehy date palms grown under Siwa region conditions were obtained due to spraying the palms three times with Zn, Fe, Mn and Cu via nano system at 0.0125 %.

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تأثير إستخدام العناصر الصغرى رشاً من خلال نظام النانو تكنولوجى فى مواجهة إستخدامها فى الصورة الكيلاتية علي الاثمار فى نخيل البلح الفريحى

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الملخص العربي

أجريت هذه الدراسة خلال موسمى 2016،2017 وذلك لتوضيح تأثير إستخدام العناصر الصغرى (الزنك والحديد والمنجنيز والنحاس) رشاً من خلال نظام النانو تكنولوجى بتركيز 0.0125 الى 0.1 % فى مواجهة إستخدام هذه العناصر بالطرق التقليدية فى الصورة الكيلاتية بتركيز 0.025 الى 0.2 % علي النمو الخضري والحالة الغذائية للنخلة وكمية المحصول وخصائص الجودة للثمار فى نخيل البلح الفريحى النامي تحت ظروف منطقة سيوة.

أدت معاملة النخيل بهذه العناصر الصغرى من خلال نظام النانو تكنولوجى او فى الصورة الكيلاتية بالتركيزات السابقة الى حدوث تحسن واضح فى جميع خصائص النمو والحالة الغذائية للنخلة وكمية المحصول وخصائص الجودة وذلك مقارنة بمعاملة الكنترول .أدى إستخدام العناصر الغذائية من خلال نظام النانو تكنولوجى بالتركيزات المنخفضة وهى 0.0125 و 0.025 إلى حدوث تحسن واضح بالمقارنة فى كل المقاييس باستخدام التركيزات العالية فى الصورة الكيلاتية وهى 0.1 و 0.2 % . أدى إستخدام العناصر الصغرى من خلال نظام النانو تكنولوجى بتركيزات أعلي من 0.0125 إلى عدم حدوث تأثيرات إيجابية واضحة.

أمكن الحصول علي أفضل النتائج بخصوص كمية المحصول وخصائص الجودة للثمار فى نخيل البلح الفريحى النامي تحت ظروف منطقة سيوة عند رش النخيل ثلاث مرات بالعناصر الصغرى الأربعة وهى (الزنك والحديد والمنجنيز والنحاس) المستخدمة بنظام النانو تكنولوجى بتركيز 0.0125.

الكلمات الدالة: العناصر الصغرى المخلبي، العناصر الصغرى من خلال النانو تكنولوجى، نخيل البلح الفريحى، النمو الخضرى، الحالة الغذائية للنخلة، كمية المحصول، خصائص الجودة للثمار.