Aswan University Journal of Science and Technology Volume 4, issue 2, June 2024

Effect of spraying chelated and nano microelements on growth and nutritional status of Zebda mango trees

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ABSTRACT

This study was performed during 2019, 2020 and 2021 seasons to examine the effect of nano versus chelated micronutrients (Fe, Zn, and Mn) on some growth aspects and the nutritional status of Zebda mango trees grown under Aswan region conditions. Zebda mango trees were sprayed three times during the season with nano micronutrients (Fe, Zn, and Mn) at 2.5, 5, 10 or 20 ppm or via chelated micronutrients at 25, 50 or 100 ppm. All growth aspects, namely shoot length and thickness, number of leaves per shoot, and leaf area, as well as leaf pigments and nutrients content, namely chlorophylls a, b, total chlorophylls, and total carotenoids, N, P, K, Mg, Fe, Zn, and Mn, were remarkably enhanced in response to spraying the trees with micronutrients (Fe, Zn, and Mn) in the chelated form at 25 to 100 ppm or via nano form at 2.5 to 20 ppm over the control treatment.

Nano Fe, Zn and Mn micronutrients was superior than application of these nutrients in their normal form (chelated form) in improving the growth and nutritional status of Zebda mango trees. The maximum values were recorded when nano micronutrients (Fe, Zn, and Mn) were applied at 20 ppm.

Keywords: nanofertilizers, micronutrients, growth aspects, nutritional status, Zebda mango trees.

INTRODUCTION

Zebda mango is considered a prime and outstanding mango cultivar. It has strong spicy, flavor, low fibre %, sweet, appealing aroma, regular bearing, and medium season maturity. It is popular in the domestic market for fresh consumption and has a wide acceptance in international markets **[1].**

Microelements play important regulatory roles in activating the biosynthesis of various vitamins, plant pigments, enzymes, organic foods and hormones, and enhancing cell division, waterabsorption, and nutrients uptake **[2-4]**.

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Received February, 6, 2024 received in revised form, March 7, 2024, accepted March 10, 2024.
(ASWJST 2021/ printed ISSN: 2735-3087 and on-line ISSN: 2735-3095) https://journals.aswu.edu.eg/stjournal

Applications of microelements improve growth aspects, tree nutritional status, fruit set %, fruit retention %, and development, as well as total yield and fruit quality **[5]**. The impact of some micronutrients, such as zinc, on tree growth seems to play an important role in achieving satisfactory fruit setting and fruit quality **[6, 7]**.

Some micronutrients improve the production of chlorophyll and starch, and the metabolism of carbohydrate. It is also improve tolerance to iron (Fe) chlorosis which is easily recognized in iron-sensitive crops growing on calcareous soils. Fe is a component of many enzymes associated with energy transfer, nitrogen reduction and fixation, and lignin formation. Some micronutrients are associated with sulphur in plants to form compounds that catalyze other reactions **[4, 8]**.

Nanotechnology is considered a type of science that deals with a tiny size of material ranging from 1 to 100 nanometers **[9]**. There are many applications referred to as nanotechnology involved in several agricultural processes (i.e., fertilization, irrigation, pest control, packing, postharvest, and processing). The utilization of nanotechnology in the agricultural field has several positive impacts on the environment **[10]**.

Implementation of nanotechnology in agricultural practices could play an essential role in raising productivity and investigating trends in agricultural applications. Whereas **[11]** mentioned that the potential utilization and positive impacts of nanotechnology are tremendous. These impacts include maximizing agricultural productivity involving nanoporous zeolites for efficient usage of both water and fertilizer by controlling their release. Also, **[12]** interpreted that nano-particles of materials are used for their wide surface area, which in turn induces high reactivity, an effective catalyst for plant metabolism, better penetration into the cell, and increased plant activity.

The goal of this study was to elucidate the effect of foliar application of Fe, Zn, and Mn in chelated and nano form on vegetative growth aspects and the nutritional status of Zebda mango trees grown under Aswan governorate conditions.

MATERIALS AND METHODS

This study was carried out during three seasons (2019, 2020, and 2021) using uniformly vigorous twenty-four 18-year-old Zebda mango trees grafted on polymbyonic mango seedling rootstock. The trees are grown in a private mango orchard located on Harbbiab Island, Drao District, Aswan Governorate, Egypt. The selected trees were planted at 5 × 5 meters apart (168 trees per fed.)

The soil texture of the tested orchard is silty clay with a water table depth of not less than two meters. A surface irrigation system was followed using Nile water [**13**].

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

Particle size distribution:	Values
Sand %	7.0
Silt %	52.8
Clay %	40.2
Texture	Silty clay
pH (1:2.5 extract)	7.88
EC (1: 2.5 extract) (mmhos/lcm/25oC)	0.91
O.M. %	3.11
$CaCO_3$ %	1.16
Total N %	0.22
Available P (ppm, Olsen)	4.5
Available K (ppm/ ammonium acetate)	488.0
Available EDTA extractable micronutrients (ppm)	
Zn	1.55
Fe	11.20
Mn	10.00

Common horticultural practices such as fertilization, irrigation, twice-hoed pruning, and pest management were carried out as usual.

Randomized Complete Block Design (RCBD) was adopted for carrying out this study. This study included the following eight treatments for some micronutrients:

T1: Control treatment (spraying with water).

T2: Spraying chelated form of Fe, Zn, and Mn at 25 ppm

This concentration was prepared by dissolving 0.18 g/L of 14% mixed fertilizer of Fe, Zn and Mn.

T3: Spraying chelated form of Fe, Zn, and Mn at 50 ppm

It was prepared by dissolving 0.36 g/L of 14% mixed fertilizer.

T4: Spraying chelated form of Fe, Zn, and Mn at 100 ppm

It was prepared by dissolving 0.72 g/L of 14% mixed fertilizer.

T5: Spraying nano form of Fe, Zn, and Mn at 2.5 ppm (2.5 mg of each nutrient/L)

T6: Spraying nano form of Fe, Zn, and Mn at 5.0 ppm (5.0 mg/L) of each nutrient/L)

T7: Spraying nano form of Fe, Zn, and Mn at 10.0 ppm (10 mg of each nutrient/L.)

T8: Spraying nano form of Fe, Zn, and Mn at 20.0 ppm (20.0 mg of each nutrient/L.)

Each treatment was replicated three times, one Zebda mango tree was selected per plot (total of 24 trees). All sources of Fe, Zn, and Mn were purchased from the Nanotech company. Triton B as a wetting agent (0.5 mL/L) was added to micronutrient solutions, and spraying was done till runoff. The selected trees received three sprays at growth start (mid-February), just after fruit setting (first week of April), and one month later (first week of May).

During three seasons the following measurements were recorded:

1- Vegetative growth characteristics were shoot length (cm), number of leaves /shoots, leaf area (cm^2), and shoot thickness (cm) [**14**].

2- Leaf chemical components, namely chlorophylls a, b, total chlorophylls, and total carotenoids (mg/g F.W.) were measured according to [**15**]. N, P, K, and Mg (as %), Zn, Fe, and Mn (as ppm) were analyzed in the leaves according to **[16, 17**].

Statistical analysis was done using one way ANOVA, and treatment means were compared using the new L.S.D. at 5%. **[18, 19]**.

Results

<u>1- Vegetative growth aspects:</u>

It is clear from the obtained data in Table (2 & 3) that treating Zebda mango trees with micronutrients (Fe, Zn and Mn) via chelated form at 25 to 100 ppm or via nano form at 2.5 to 20.0 ppm significantly increased shoot length, number of leaves per shoot, leaf area, and shoot thickness relative to the control treatment. There was a gradual promotion of these growth characteristics with increasing concentrations of the micronutrients (Fe, Zn, and Mn) on both forms. Treating the trees with Fe, Zn, and Mn via nano form at 2.5 to 20.0 ppm was significantly superior in enhancing these growth traits than using chelated form of Fe, Zn, and Mn. The maximum values of shoot length (39.5, 40.0, and 41.0 cm), number of leaves per shoot (18.6, 19.0, and 19.5 leaves), leaf area (108.0, 109.0, and 111.0 cm^2), and shoot thickness (1.22, 1.24, and 1.28 cm) were recorded on the trees that were treated with nano Fe, Zn, and Mn at 20 ppm in the three seasons, respectively. The lowest values were recorded on the untreated trees.

Table (2): Effect of chelated and nano Fe, Zn, and Mn applications on shoots length and number of leaves/shoot of Zebda mango trees during 2019, 2020 and 2021 seasons.

Treatments	Shoot length (cm)			No. of leaves per shoot		
	2019	2020	2021	2019	2020	2021
T_1-Control (untreated trees)	23.6	24.5	25.0	11.0	11.4	11.8
T_2- Spraying Normal Fe, Zn and Mn each at 25 ppm	26.5	27.0	27.4	12.0	12.3	12.6
T_3- Spraying Normal Fe, Zn and Mn each at 50 ppm	28.2	28.8	29.2	13.0	13.5	14.0
T_4- Spraying Normal Fe, Zn and Mn each at 100 ppm	30.0	30.6	30.9	14.5	14.8	15.2
T_5- Spraying Nano Fe, Zn and Mn each at 2.5 ppm	29.6	30.0	30.6	14.2	14.5	15.0
T_6- Spraying Nano Fe, Zn and Mn each at 5 ppm	32.9	33.0	33.5	16.0	16.4	16.9
T_7- Spraying Nano Fe, Zn and Mn each at 10 ppm	36.8	37.4	38.0	17.5	18.0	18.2
T_8- Spraying Nano Fe, Zn and Mn each at 20 ppm	39.5	40.0	41.0	18.6	19.0	19.5
New L.S.D. at 5%	0.9	1.1	1.2	0.8	0.8	0.9

Table (3): Effect of chelated and nano Fe, Zn, and Mn applications on leaf area and shoot thickness of Zebda mango trees during 2019, 2020 and 2021 seasons.

Treatments	Leaf area (cm.)^2			Shoot thickness (cm.)		
	2019	2020	2021	2019	2020	2021
T_1-Control (untreated trees)	85.2	86.0	87.4	0.66	0.69	0.75
T_2- 25 ppm chelated Fe, Zn and Mn	88.0	89.0	89.0	0.86	0.91	0.95
T_3- 50 ppm chelated Fe, Zn and Mn	91.2	91.9	92.2	0.96	0.98	0.99
T_4- 100 ppm chelated Fe, Zn and Mn	93.5	95.0	96.0	1.05	1.08	1.09
T_5- 2.5 ppm Nano Fe, Zn and Mn	93.2	94.6	96.8	1.02	1.04	1.05
T_6- 5 ppm Nano Fe, Zn and Mn	98.0	99.2	99.8	1.11	1.14	1.16
T_7- 10 ppm Nano Fe, Zn and Mn	102.5	106.0	108.0	1.18	1.20	1.22
T_8- 20 ppm Nano Fe, Zn and Mn	108.0	109.0	111.0	1.22	1.24	1.28
New L.S.D. at 5%	2.2	2.3	2.5	0.04	0.05	0.06

2- The leaf pigments:

It is obvious from the obtained data in Table (4 & 5) that treating the trees with micronutrients (Fe, Zn, and Mn) via chelated form at 25 to 100 ppm or nano form at 2.5 to 20.0 ppm significantly enhanced the leaf pigments, namely chlorophyll a, b, total chlorophylls, and total carotenoids, relative to the control treatment. The promotion of these plant pigment aspects was significantly associated with an increasing concentration of the micronutrients regardless its form. Increasing concentrations of nano micronutrients (Fe, Zn, and Mn) from 10.0 to 20.0 ppm failed significantly to show significant promotion of these plant pigments. Spraying of nano Fe, Zn, and Mn was significantly superior than chelated form spraying for enhancing these plant pigments. The 20.0 ppm nano micronutrients gave the maximum values of plant pigments, namely chlorophyll a (6.6, 6.8, and 6.9 mg/g F.W.), chlorophyll b (3.2, 3.3, and 3.4 mg/g F.W.), total chlorophylls (9.8, 10.1, and 10.3 mg/g F.W.), and total carotenoids (2.4, 2.5, and 2.7 mg/g F.W.) during three seasons, respectively. Meanwhile the lowest values were recorded on untreated trees.

Table (4): Effect of chelated and nano Fe, Zn, and Mn applications on some chlorophyll “a” and “b” (mg/g F.W.) of Zebda mango trees during 2019, 2020 and 2021 seasons.

Treatments	Chlorophyll a (mg/gf.w.)			Chiorophyll b (mg/gf.w.)		
	2019	2020	2021	2019	2020	2021
T_1-Control (untreated trees)	3.4	3.5	3.7	1.4	1.5	1.6
T_2- 25 ppm chelated Fe, Zn and Mn	3.9	4.1	4.4	1.7	1.8	1.9
T_3- 50 ppm chelated Fe, Zn and Mn	4.7	4.8	4.9	2.0	2.1	2.3
T_4- 100 ppm chelated Fe, Zn and Mn	5.2	5.4	5.5	2.3	2.4	2.6
T_5- 2.5 ppm Nano Fe, Zn and Mn	5.1	5.2	5.4	2.2	2.2	2.4
T_6- 5 ppm Nano Fe, Zn and Mn	5.9	6.1	6.3	2.6	2.7	2.8
T_7- 10 ppm Nano Fe, Zn and Mn	6.2	6.4	6.5	2.9	2.9	3.0
T_8- 20 ppm Nano Fe, Zn and Mn	6.6	6.8	6.9	3.2	3.3	3.4
New L.S.D. at 5%	0.2	0.2	0.3	0.1	0.2	0.2

Table (5): Effect of chelated and nano Fe, Zn, and Mn applications on total chlorophyll and carotenoids (mg/g F.W.) of Zebda mango trees during 2019, 2020 and 2021 seasons.

Treatments	Total chlorophylls (mg/g F.W.)			Total carotenoids (mg/g F.W.)		
	2019	2020	2021	2019	2020	2021
T_1-Control (untreated trees)	4.8	5.0	5.3	1.1	1.2	1.3
T_2- 25 ppm chelated Fe, Zn and Mn	5.6	5.9	6.3	1.3	1.4	1.5
T_3- 50 ppm chelated Fe, Zn and Mn	6.7	6.9	7.2	1.6	1.7	1.8
T_4- 100 ppm chelated Fe, Zn and Mn	7.5	7.8	8.1	1.8	1.8	1.9
T_5- 2.5 ppm Nano Fe, Zn and Mn	7.3	7.4	7.8	1.7	1.8	1.8
T_6- 5 ppm Nano Fe, Zn and Mn	8.5	8.8	9.1	2.0	2.1	2.2
T_7- 10 ppm Nano Fe, Zn and Mn	9.1	9.3	9.5	2.2	2.4	2.5
T_8- 20 ppm Nano Fe, Zn and Mn	9.8	10.1	10.3	2.4	2.5	2.7
New L.S.D. at 5%	0.4	0.4	0.5	0.1	0.1	0.2

3- The leaf nutrients content:

It is obvious from the obtained data in Tables (6,7 &8) that supplying Zebda mango trees with micronutrients (Fe, Zn, and Mn) in nano from 2.5 to 20.0 ppm, or normal from 25.0 to 100.0 ppm, significantly enhanced the leaf content of N, K, Mg, Fe, Zn, and Mn in the leaves compared to the control treatment. Using nano Fe, Zn, and Mn was significantly more favourable than using these micronutrients via the chelated form in enhancing N, P, K, and Mg (as%) and Fe, Zn, and Mn (as ppm). The promotion of these nutrients was significantly correlated with increasing the concentrations of Fe, Zn, and Mn, regardless of the form used. Increasing concentrations of these micronutrients from 10.0 to 20.0 ppm when applied in nano form had no significant promotion on N, P, K, and Mg (as%) and Fe, Zn, and Mn (as ppm).

The maximum values of N (1.86, 1.89, and 1.92%), P (0.28, 0.29, and 0.29%), K (1.45, 1.46, and 1.48%), Mg (0.74, 0.75, and 0.77%), Fe (63.5, 64.0, and 65.0 ppm), Zn (71.0, 71.5, and 72.0 ppm), and Mn (55.5, 55.9, and 56.2 ppm) were recorded on the trees that received nano micronutrients (Fe, Zn, and Mn) at 20.0 ppm during three seasons (2019, 2020, and 2020), respectively. While the lowest values were recorded on untreated trees.

Table (6): Effect of chelated and nano Fe, Zn, and Mn applications on N and P percentages in the leaves of Zebda mango trees during 2019, 2020 and 2021 seasons.

Treatments	Leaf N%			Leaf P%		
	2019	2020	2021	2019	2020	2021
T_1-Control (untreated trees)	1.33	1.35	1.36	0.16	0.16	0.17
T_2- 25 ppm chelated Fe, Zn and Mn	1.38	1.40	1.41	0.18	0.19	0.20
T_3- 50 ppm chelated Fe, Zn and Mn	1.43	1.44	1.46	0.21	0.22	0.23
T_4- 100 ppm chelated Fe, Zn and Mn	1.49	1.51	1.53	0.23	0.24	0.25
T_5- 2.5 ppm Nano Fe, Zn and Mn	1.48	1.50	1.51	0.22	0.22	0.23
T_6- 5 ppm Nano Fe, Zn and Mn	1.62	1.66	1.68	0.24	0.25	0.26
T_7- 10 ppm Nano Fe, Zn and Mn	1.71	1.74	1.77	0.26	0.27	0.28
T_8- 20 ppm Nano Fe, Zn and Mn	1.86	1.89	1.92	0.28	0.29	0.29
New L.S.D. at 5%	0.05	0.06	0.07	0.02	0.03	0.03

Table (7): Effect of chelated and nano Fe, Zn, and Mn applications on K and Mg percentages in the leaves of Zebda mango trees during 2019, 2020 and 2021 seasons.

Treatments	Leaf K%			Leaf Mg%		
	2019	2020	2021	2019	2020	2021
T_1-Control (untreated trees)	1.22	1.24	1.25	0.55	0.55	0.57
T_2- 25 ppm chelated Fe, Zn and Mn	1.26	1.27	1.28	0.58	0.59	0.61
T_3- 50 ppm chelated Fe, Zn and Mn	1.30	1.32	1.33	0.61	0.63	0.65
T_4- 100 ppm chelated Fe, Zn and Mn	1.33	1.34	1.36	0.64	0.66	0.68
T_5- 2.5 ppm Nano Fe, Zn and Mn	1.32	1.32	1.34	0.62	0.64	0.66
T_6- 5 ppm Nano Fe, Zn and Mn	1.38	1.39	1.41	0.68	0.69	0.69
T_7- 10 ppm Nano Fe, Zn and Mn	1.41	1.42	1.44	0.71	0.73	0.74
T_8- 20 ppm Nano Fe, Zn and Mn	1.45	1.46	1.48	0.74	0.75	0.77
New L.S.D. at 5%	0.04	0.04	0.05	0.03	0.03	0.04

Table (8): Effect of chelated and nano Fe, Zn, and Mn applications on the leaf content of Fe , Zn and Mn (as ppm) in the leaves of Zebda mango trees during 2019, 2020 and 2021 seasons.

Treatments	Leaf Fe (ppm)			Leaf Zn (ppm)			Leaf Mn (ppm)		
	2019	2020	2021	2019	2020	2021	2019	2020	2021
T_1-Control (untreated trees)	53.0	53.5	54.0	58.4	59.0	59.5	48.5	48.8	49.2
T_2- 25 ppm chelated Fe, Zn and Mn	54.5	55.2	55.4	61.3	61.8	62.0	49.8	50.0	50.4
T_3- 50 ppm chelated Fe, Zn and Mn	56.0	57.4	58.0	62.4	63.0	64.5	51.3	51.5	51.8
T_4- 100 ppm chelated Fe, Zn and Mn	58.1	58.4	58.6	64.6	65.0	65.8	52.5	53.2	53.5
T_5- 2.5 ppm Nano Fe, Zn and Mn	58.0	58.2	58.5	64.2	64.8	65.5	52.4	53.0	53.4
T_6- 5 ppm Nano Fe, Zn and Mn	61.0	61.5	62.0	66.8	67.2	67.7	53.5	54.0	54.4
T_7- 10 ppm Nano Fe, Zn and Mn	62.4	62.8	63.0	68.9	69.2	69.5	54.6	55.0	55.3
T_8- 20 ppm Nano Fe, Zn and Mn	63.5	64.0	65.0	71.0	71.5	72.0	55.5	55.9	56.2
New L.S.D. at 5%	1.1	1.2	1.3	1.3	1.3	1.4	0.8	0.9	1.1

Discussion

Nanotechnology has provided the feasibility of exploiting nanostructured or nanoscale materials like fertilizers to carry or control release vectors for the building of so-called smart fertilizer as a new facility to enhance most nutrients use efficiency [**20**].

Also, encapsulation of fertilizer within a nanoparticle is one of these new facilities, which is done in three ways; coated with thin polymer film, or some nutrients can be encapsulated inside nanoporous materials or delivered as particles or emulsions of nanoscale dimensions [**21**].

In addition, nano fertilizers will combine nanodevices in order to synchronize the release of some macronutrients (N and P) and some micronutrients with their uptake by crops, preventing undesirable nutrient losses to the soil, air, and water via direct internalization by the crops and avoiding the interaction of most nutrients with microorganisms, soil, air, and water **[20, 22**].

The positive actions of some macro- and micronutrients in these fertilizers on activating metabolism of proteins, enzymes, IAA, lipids, carbohydrates, and nucleic acids, enhancing photosynthetic activity, cell division, and the biosynthesis of plant pigments gave more reasons for the present effect **[8].**

The beneficial effects of using nano micronutrients (Fe, Zn, and Mn) on the growth and fruiting of Zebda mango trees might be attributed to their positive action on synchronizing the release of some micronutrients and preventing undesirable nutrient losses to soil, water, and air via direct internalization by fruit crops and avoiding the interaction of nutrients with soil and microorganisms in water and air, as well as increasing their efficiency and reducing soil toxicity. The potential negative effect associated with overdosage and frequency of spraying They delay the release of some nutrients and extend the fertilizer effect period **[23-25].**

Iron has important regulatory effects on building chlorophylls and plant pigments and regulate reducing and oxidant reactions **[26, 27].** Mn is enhancing co-enzymes that are responsible for enhancing the activity of respiration and oxidation enzymes and the biosynthesis of organic acids, metabolism, nitrate reduction, and the biosynthesis of IAA **[28, 4, 29**]. Zn is activating metabolism enzymes, biosynthesis of organic foods, IAA, cell division and enlargement, water absorption, and some nutrient transport **[2, 30**].

These results regarding the effect of using nano nutrients on the promotion gross, yield, and fruit quality of some fruit crops are in agreement with those obtained by **[31, 32, 33, 34].**

These results concerning the promoting effect of chelated nutrients are in harmony with those obtained by [**35**] on mango cv. **[7],** on Zaghloul date palms [**36**], on Ewaise mangoes [**37**], on Balady mandarin [**38**], on chemlali olives [**39**], on Valencia oranges **[40],** on Sewy data palms [**41**], on El- Saidy date palms [**42],** on El- Saidy date palms [**43**], on Flame seedless grapevines [**44**], and on Zaghloul date palms and **[9]**.

Conclusion

Under the present and resembling conditions, it is recommended to spray Zebda mango trees three times at growth start, just after fruit setting, and one month later with a mixture of three micronutrients (Fe, Zn, and Mn) in a nano form at 20.0 ppm for promoting growth aspects and tree nutritional status.

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المانجو الزبدة تأثير رش العناصر الصغرى المخلبية والنانوية على النمو والحالة الغذائية لاشجار

الملخص العربى

تم تنفيذ هذه الدراسة خلال مواسم 2019 و2020 و2021 لاختبار مقارنة تأثير بعض العناصر الصغرى (الحديد والزنك والمنجنيز) في صورة النانو أو الصورة المخلبية على بعض صفات النمو الخضرى والحالة الغذائية لاشجار المانجو الزبدة النامية تحت الظروف المناخية لمنطقة اسوان.

تم معاملة أشجار المانجو الزبدة ثلاثة مرات خلال الموسم بالرش ببعض العناصر الصغرى (الحديد والزنك والمنجنيز) في صورة النانو بتركيز من 2.5، 5، 10 أو 20 جزء فى المليون أو نفس العناصر بالصورة المخلبية بتركيز من 25، 50 أو 100 جزء فى المليون لكلا منهما.

تحسنت جميع صفات النمو الخضرى وهى طول النموات وعدد الاوراق عليها ومساحة الورقة وسمك النموات وكذلك الصبغات والعناصر الغذائية فى الورقة وهى الكلوروفيل أ وكلوروفيل ب، والكلوروفيل الكلى والكاروتينات الكلية وعناصر النتتروجين والفوسفور والبوتاسيوم والماغنسيوم والحديد والزنك والمنجنيز وذلك برش بعض العناصر الصغرى (الحديد والزنك والمنجنيز) فى الصورة المخلبية بتركيز من 25 الى 100 جزء فى المليون وفى صورة النانو بتركيز من 2.5 الى 20 جزء فى المليون وذلك مقارنة بمعاملة الكونترول.

ولقد تفوق استخدام العناصر الصغرى فى صورة النانو عن استخدامها فى الصورة المخلبية فى تحسين صفات النمو الخضرى والحالة الغذائية لاشجار المانجو الزبدة وأمكن الحصول على أعلى القيم عند رش العناصر الصغرى الثلاثة فى صورة النانو بتركيز 20 جزء فى المليون.

الكلمات الدالة: النانوتكنولوجى –العناصر الصغرى –صفات النمو الخضرى- الحالة الغذائية للاشجار – أشجار المانجو الزبدة