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Effect of spraying some microelements through nanotechnology on yield and fruit quality of zebda mango trees

Abd E;-Aziz, A.S. El-Khawaga[1]; Hussien H.M. Saeed[2]; Al- Hussein, S.A. Hamad[3]; Fatma El- Zahraa, S.Abd El-Aziz[2]

[1]Hort. Dept., Qena Fac. Of Agric. South Valley Univ., Egypt.
[2]Hort. Dept., Fac. Of Agric. And Natural Resources, Aswan Univ., Egypt.
[3]Tropical Fruits Res,. Dept. Hort. Res. Instit., ARC, Giza, Egypt.

Abstract

This study was performed during the 2019–2020 and 2021 seasons to examine the effect of the normal method (chelated form) versus the nanotechnology method on some microelements (Fe, Zn, and Mn) on the yield and both physical and chemical properties of the fruits of Zebda mango trees grown under Aswan region conditions. Spraying Zebda mango trees grown under Aswan region conditions three times with some micronutrients (Fe, Zn, and Mn) via the normal method (chelated form), each at 25 to 100 ppm, or via the nanotechnology method, each at 2.5 to 20.0 ppm, yield and fruit quality parameters were remarkably improved due to using some micronutrients (Fe, Zn, and Mn) via nano or normal forms relative to the control treatment. The promotion appeared in terms of increasing the yield per tree, weight, diameter, height, and thickness of fruit, flesh%, TSS%, total, reducing, and non-reducing sugars %, vitamin C, and reducing both total acidity% and fiber% in the fruits. In this respect, using some micronutrients (Fe, Zn, and Mn) via nanotechnology was superior to using them through normal methods.

The best results with regard to the yield per tree and fruit quality of Zebda mango trees were obtained by treating the trees three times with some micronutrients (Fe, Zn, and Mn) via nanotechnology at 20.0 ppm.

Keywords: normal, nanotechnology, micronutrients, yield, fruit quality, Zebda mango trees.

*Corresponding author E-mail: elzhraaf487@gmail.com
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Introduction

Zebda mango cvs. considered a prime and outstanding mango cv. Strong spicy flavour low in fibre %, sweet, producing appealing aroma, regular bearing, popular in the domestic market for fresh consumption, medium season maturity, and has a wide acceptance in international markets **[1].**

Microelements play many important regulatory roles in activating various vitamins, plant pigments, some enzymes, the biosynthesis of organic foods and hormones, and enhancing cell division, water uptake, and some nutrients **[2,3,4]**.

Applications of microelements improves growth aspects such as 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 boron, on tree yield and fruit quality seems to play an important role in achieving satisfactory fruit setting and fruit quality **[6,7]**.

Some micronutrients improves the production of chlorophyll and starch, and the metabolism of carbohydrates and iron chlorosis is easily recognized in iron-sensitive crops growing on calcareous soils. Iron is also a component of many enzymes associated with energy transfer, nitrogen reduction and fixation, and lignin formation. Some micronutrients are associated with sulfur in plants to form compounds that catalyse 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 (fertilization, irrigation, pest control, packing, postharvest, and processing). The utilization of nanotechnology in the agricultural field has several positive impacts on the environment.

Implementation of nanotechnology in agricultural practices could play an essential role in raising productivity and investigating trends in agricultural applications. Whereas **[10]** 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 **[11]**. interpreted that nano-particles of materials are used for their wide surface area, which in turn induces high reactivity, is an effective catalyst for plant metabolism, has better penetration into the cell, and increases plant activity.

The goal of this study was to elucidate the effect of foliar application of Fe, Zn, and Mn nano-micronutrients on the yield and fruit quality of Zebda mango trees grown under Aswan governorate conditions.

Materials and methods

This study was carried out during three seasons (2019, 2020, and 2021) on uniform in vigour twenty-four (18) years of Zebda mango trees onto polyembryonic mango seedling rootstock. The trees are grown in a private mango orchard located on Harbbiab Island, Drao District, Aswan Governorate, Egypt. The selected 24 trees were planted at 5.0 x 5.0 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 **[12].**

Table (1): Mechanical, 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/Icm/25^{o}C)	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-hoeing pruning, and pest management were carried out as usual.

This study included the following eight treatments for some micronutrients:

T1: Control treatment (spraying with water).

T2: Spraying Fe, Zn, and Mn at 14% via the normal method, each at 25 ppm $\underline{\sim}$ (0.18g chelated from each nutrient/L).

T3: Spraying Fe, Zn, and Mn at 14% via the normal method, each at 50 ppm $\underline{\sim}$ (0.36g chelated from each nutrient/L).

T4: Spraying Fe, Zn, and Mn at 14% via the normal method, each at 100 ppm $\underline{\sim}$ (0.72 g chelated from each nutrient/L).

T5: Spraying Fe, Zn, and Mn via the nanotechnology method at 2.5 ppm (2.5 mg/L) from each nutrient/L.

T6: Spraying Fe, Zn, and Mn via the nanotechnology method at 5.0 ppm (5.0 mg/L) from each nutrient/L..

T7: Spraying Fe, Zn, and Mn via the nanotechnology method at 10.0 ppm (10.0 mg/L) from each nutrient/L

T8: Spraying Fe, Zn, and Mn via the nanotechnology method at 20.0 ppm (20.0 mg/L) from each nutrient/L

Each treatment was replicated three times, one Zebda mango tree per treatment (24 trees for carrying out all treatments). All sources of Fe, Zn, and Mn were purchased from 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 (24 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).

Randomized Complete Block Design (RCBD) was adopted for carrying out the statistical analysis of this study.

During the three seasons, the following measurements were recorded:

1- Percentages of initial fruit setting and fruit retention.
2- Harvesting was done in the second week of July in the three seasons, and yield expressed in weight (kg.) per tree was recorded.
3- Some physical and fruit properties

1- Some physical and fruit properties
- Fruit weight (g.) and dimensions of fruits (cm.)

- Percentages of flesh.
- Percentages of total soluble solids by handy refractometer.
- Percentage of total acidity (as g citric acid/ 100 ml/ juice) by Titration against 0.1 N sodium hydroxide using phenolphthalein as an indicator **[13].**
- Percentages of total, reducing, and non-reducing sugars according to **[13].**
- Percentages of total, reducing, and non-reducing sugars according to **[14].**
- L-ascorbicacid content (as mg/100 ml juice)by using 2.6 dichlorophenmol indophenol dye [**13].**

All the obtained data during the course of study in the three successive seasons (2019, 2020, and 2021) were tabulated and statistically analyzed.The differences between various 8 treatment means were compared using new L.S.D. at 5% according to **[15,16] .**

Results

<u>1- percent of initial fruit setting and furit retention</u>

It is evident from the obtained data in Table 2 that percentages of initial fruit setting and fruity retention were significantly improved in response to treating the trees with some micronutrients (Fe, Zn, and Mn) either via nanotechnology or a normal system compared to the control treatment. There was a gradual promotion on these two parameters, with increasing concentrations of some micronutrients regardless of the source of treatment. Significant differences in initial fruit setting% and fruit retention% were observed among most concentrations except 10.0 and 20.0 ppm of these micronutrients applied via nano and 50 and 100 ppm applied via normal. Nanotechnology use of some micronutrients (Fe, Zn, and Mn) was significantly superior to using the normal method. The maximum values of percentages of initial fruit setting (11.1, 11.4, and 11.5%) and fruit retention (2.2, 2.3, and 2.5%) were recorded on the trees that were treated with some micronutrients (Fe, Zn, and Mn) at 20.0 ppm via nanotechnology systems during three seasons, respectively.

The untreated trees produced the minimum values. These results were true during the 2019–2020 and 2021 seasons.

Table (2): Effect of normal and nano- technology Fe, Zn, and Mn applications on the percentages of initial fruit setting and fruit retention of Zebda mango trees during 2019 , 2020 and 2021 seasons.

Treatments	Initial Fruit Setting%			Fruit retention %		
	2019	2020	2021	2019	2020	2021
T_1-Control (untreated trees)	7.2	7.4	7.5	0.6	0.6	0.7
T_2- Spraying Normal Fe, Zn and Mn each at 25 ppm	7.9	8.0	8.1	0.8	0.9	0.9
T_3- Spraying Normal Fe, Zn and Mn each at 50 ppm	8.3	8.4	8.5	1.0	1.1	1.2
T_4- Spraying Normal Fe, Zn and Mn each at 100 ppm	8.7	8.8	8.9	1.3	1.4	1.5
T_5- Spraying Nano Fe, Zn and Mn each at 2.5 ppm	8.6	8.6	8.7	1.2	1.3	1.4
T_6- Spraying Nano Fe, Zn and Mn each at 5 ppm	9.4	9.6	9.7	1.6	1.7	1.8
T_7- Spraying Nano Fe, Zn and Mn each at 10 ppm	10.2	10.5	10.8	1.8	1.9	2.0
T_8- Spraying Nano Fe, Zn and Mn each at 20 ppm	11.1	11.4	11.5	2.2	2.3	2.5
New L.S.D. at 5%	03	0.3	0.4	0.2	0.2	0.3

2-Yield per tree:

It is clear from the obtained data in Table 3 that spraying Zebda mango trees three times with some micronutrients (Fe, Zn, and Mn) via nanotechnology or normal forms had a significant promotion on the yield per tree over the control treatment. Spraying the trees with Fe, Zn, and Mn in the form of nanotechnology was significantly superior to using the same micronutrients via the normal method in improving the yield per tree. proportional to the increase in concentration of Fe, Zn, and Mn applied in both forms. Increasing concentrations of Fe, Zn, and Mn applied via nanotechnology from 10.0 to 20.0 ppm failed to show significant promotion in the yield per tree. From an economical point of view, using some micronutrients (Fe, Zn, and Mn) via nanotechnology at 10.0 ppm gave the best results with regard to yield per tree. Yield per tree in such a promized treatment reached 130.5, 133.6, and 136.9 kg during the 2019–2020 and 2021 seasons, respectively. The yield per tree of the untreated trees reached 93.2, 95.7, and 96.2 during the three seasons, respectively. And the percentage increment on the yield due to using the previous recommended treatment reached 40.0, 39.6, and 40.7% during the 2019–2020 and 2021 seasons, respectively. These results were true during three seasons.

Table (3): Effect of normal and nano- technology Fe, Zn, and Mn applications on the percentages of yield per tree of Zebda mango trees during 2019 , 2020 and 2021 seasons.

Treatments	No. of Fruit Per tree			Yield/tree (Kg)		
	2019	2020	2021	2019	2020	2021
T_1-Control (untreated trees)	255.0	260.0	260.0	93.2	95.7	96.2
T_2- Spraying Normal Fe, Zn and Mn each at 25 ppm	270.0	272.0	275.0	100.6	102.1	103.9
T_3- Spraying Normal Fe, Zn and Mn each at 50 ppm	278.0	281.0	285.0	105.4	107.5	109.4
T_4- Spraying Normal Fe, Zn and Mn each at 100 ppm	290.0	295.0	298.0	113.1	115.8	117.4
T_5- Spraying Nano Fe, Zn and Mn each at 2.5 ppm	288.0	293.0	295.0	111.3	114.3	115.5
T_6- Spraying Nano Fe, Zn and Mn each at 5 ppm	300.0	305.0	308.0	118.7	121.4	123.2
T_7- Spraying Nano Fe, Zn and Mn each at 10 ppm	310.0	312.0	315.0	125.8	127.3	129.2
T_8- Spraying Nano Fe, Zn and Mn each at 20 ppm	314.0	318.0	322.0	130.5	133.6	136.9
New L.S.D. at 5%	2.8	2.9	3.1	3.9	4.1	4.3

3-Some physical and chemical characteristics of the fruits:

It is noticed from the obtained data in Tables (4, 5, 6 & 7) that treating the trees three times with some micronutrients (Fe, Zn, and Mn) via nanotechnology at 2.5 to 20.0 ppm (Fe, Zn, and Mn) via normal at 25 to 100 ppm was significantly effective in improving the physical and chemical characteristics of fruits in terms of increasing fruit weight, fruit height, fruit diameter, fruit thickness, flesh%, TSS%, total, reducing and non-reducing sugars%, vitamin C, and reducing total acidity% and total fibre % in the fruits relative to the control. The promotion of fruit quality was associated with increasing concentrations of some micronutrients (Fe, Zn, and Mn) via normal and nanotechnology. No significant promotion in fruit characteristics was observed among 25 to 100 ppm of some micronutrients (Fe, Zn, and Mn) via normal and 2.5 to 20.0 ppm of nanotechnology Fe, Zn, and Mn. Using Fe, Zn, and Mn via nanotechnology at 2.5 to 20.0 ppm significantly enhanced fruit quality relative to the application of Fe, Zn, and Mn via normal. The best results with regard to the physical and chemical characteristics of fruit (fruit quality) and from an economical point of view were obtained due to the application of some micronutrients (Fe, Zn, and Mn) via nanotechnology at 10.0 ppm. Unfavourable effects on the physical and chemical characteristics of fruit were obtained on the untreated trees. These results were true during the 2019–2020 and 2021 seasons.

Table (4): Effect of normal and nano- technology Fe, Zn, and Mn applications on some physical characteristics of the fruits of Zebda mango trees during 2019 , 2020 and 2021 seasons.

Treatments	Fruit weight (g.)			Fruit height (cm.)			Fruit diameter (cm.)		
	2019	2020	2021	2019	2020	2021	2019	2020	2021
T_1-Control (untreated trees)	365.5	368.0	370.0	12.2	12.3	12.5	7.2	7.3	7.3
T_2- Spraying Normal Fe, Zn and Mn each at 25 ppm	372.6	375.5	378.0	12.8	12.9	12.9	7.5	7.8	7.9
T_3- Spraying Normal Fe, Zn and Mn each at 50 ppm	379.0	382.5	384.0	13.4	13.6	13.7	7.8	7.9	8.1
T_4- Spraying Normal Fe, Zn and Mn each at 100 ppm	390.0	392.5	394.0	14.1	14.2	14.3	8.3	8.4	8.6
T_5- Spraying Nano Fe, Zn and Mn each at 2.5 ppm	386.5	390.0	391.5	14.0	14.1	14.1	8.1	8.2	8.5
T_6- Spraying Nano Fe, Zn and Mn each at 5 ppm	395.6	398.0	400.0	14.6	14.7	14.8	85	8.7	8.8
T_7- Spraying Nano Fe, Zn and Mn each at 10 ppm	405.8	408.0	410.0	15.1	15.2	15.3	8.9	8.9	9.1
T_8- Spraying Nano Fe, Zn and Mn each at 20 ppm	415.5	420.0	425.0	15.9	16.2	16.4	9.1	9.2	9.3
New L.S.D. at 5%	4.1	4.2	4.2	0.3	0.3	0.4	0.2	0.3	0.3

Table (5): Effect of normal and nano- technology Fe, Zn, and Mn applications on some physical characteristics and chemical characteristics of the fruits of Zebda mango trees during 2019 , 2020 and 2021 seasons.

Treatments	Fruit thickness(cm.)			Flesh%			TSS%		
	2019	2020	2021	2019	2020	2021	2019	2020	2021
T_1-Control (untreated trees)	6.1	6.2	6.2	65.5	66.0	66.2	16.2	16.5	16.8
T_2- Spraying Normal Fe, Zn and Mn each at 25 ppm	6.3	6.6	6.8	68.2	68.8	69.0	16.8	17.0	17.1
T_3- Spraying Normal Fe, Zn and Mn each at 50 ppm	6.5	6.7	6.9	69.1	69.4	69.5	17.1	17.4	17.5
T_4- Spraying Normal Fe, Zn and Mn each at 100 ppm	7.1	7.5	7.6	70.0	70.4	70.6	17.6	17.8	17.9
T_5- Spraying Nano Fe, Zn and Mn each at 2.5 ppm	7.0	7.4	7.5	69.6	69.8	70.0	17.4	17.6	17.7
T_6- Spraying Nano Fe, Zn and Mn each at 5 ppm	7.3	7.6	7.8	71.0	71.4	71.6	18.0	18.3	18.5
T_7- Spraying Nano Fe, Zn and Mn each at 10 ppm	7.8	7.9	8.0	71.5	71.9	72.2	18.4	18.5	18.6
T_8- Spraying Nano Fe, Zn and Mn each at 20 ppm	8.0	8.1	8.3	72.5	73.0	73.5	18.6	18.7	18.8
New L.S.D. at 5%	0.2	0.2	0.2	0.3	0.3	0.4	0.2	0.3	0.3

Table (6): Effect of normal and nano- technology Fe, Zn, and Mn applications on some chemical characteristics of Zebda mango trees during 2019 , 2020 and 2021 seasons.

Treatments	Total sugars %			Reducing Sugars%)			Non-reducing Sugars%		
	2019	2020	2021	2019	2020	2021	2019	2020	2021
T_1-Control (untreated trees)	11.5	11.8	11.9	3.7	3.9	4.0	7.8	7.9	7.9
T_2- Spraying Normal Fe, Zn and Mn each at 25 ppm	11.9	12.0	12.3	3.8	3.7	3.9	8.1	8.3	8.4
T_3- Spraying Normal Fe, Zn and Mn each at 50 ppm	12.3	12.5	12.6	3.9	3.9	3.8	8.4	8.6	8.8
T_4- Spraying Normal Fe, Zn and Mn each at 100 ppm	12.5	12.7	12.9	3.6	3.6	3.6	8.9	9.1	9.3
T_5- Spraying Nano Fe, Zn and Mn each at 2.5 ppm	12.4	12.7	12.9	3.6	3.7	3.7	8.8	9.0	9.2
T_6- Spraying Nano Fe, Zn and Mn each at 5 ppm	12.8	13.1	13.3	3.7	3.7	3.8	9.1	9.4	9.5
T_7- Spraying Nano Fe, Zn and Mn each at 10 ppm	13.2	13.5	13.8	3.8	3.9	4.0	9.4	9.6	9.8
T_8- Spraying Nano Fe, Zn and Mn each at 20 ppm	13.9	14.1	14.4	4.1	4.2	4.4	9.8	9.9	10.0
New L.S.D. at 5%	0.1	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.2

Table (7): Effect of normal and nano- technology Fe, Zn, and Mn applications on some chemical characteristics of Zebda mango trees during 2019 , 2020 and 2021 seasons

Treatments	Total Acidity%			Vitamin C (mg/100mLJuice)			Total Fibre %		
	2019	2020	2021	2019	2020	2021	2019	2020	2021
T_1-Control (untreated trees)	0.355	0360	0.350	43.0	43.5	43.8	0.52	0.50	0.48
T_2- Spraying Normal Fe, Zn and Mn each at 25 ppm	0.335	0.335	0.330	44.0	44.8	45.0	0.48	0.46	0.44
T_3- Spraying Normal Fe, Zn and Mn each at 50 ppm	0.320	0.315	0.310	44.9	45.2	45.5	0.42	0.41	0.40
T_4- Spraying Normal Fe, Zn and Mn each at 100 ppm	0.300	0.290	0.285	45.4	45.8	46.0	0.39	0.37	0.35
T_5- Spraying Nano Fe, Zn and Mn each at 2.5 ppm	0.305	0.295	0.290	45.0	45.3	45.8	0.41	0.39	0.37
T_6- Spraying Nano Fe, Zn and Mn each at 5 ppm	0.280	0.270	0.265	46.2	46.6	46.9	0.33	0.31	0.29
T_7- Spraying Nano Fe, Zn and Mn each at 10 ppm	0.265	0.260	0.250	46.8	47.1	47.2	0.28	0.26	0.25
T_8- Spraying Nano Fe, Zn and Mn each at 20 ppm	0.240	0.235	0.230	47.2	47.5	47.8	0.22	0.21	0.20
New L.S.D. at 5%	0.015	0.018	0.022	0.4	0.4	0.5	0.02	0.02	0.03

Discussion

Nanotechnology has provided the feasibility of exploiting nanostructured or nanooscale materials like fertilizers to carry or control release vectors for the building of so-called smart fertilizer as a new facilities to enhance most nutrients use efficiency **[17]**.

Also, encapsulation of fertilizer within a nanoparticale is one of these new facilities, which is done in three ways. Coated with thin polymer film, some nutrients can be encapsulated inside nanoporous materials, or delivered as particles or emulsions of nanoscale dimensions **[18].**

In addition, nanotechnology 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 **[17,19].**

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 some 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, preventing undesirable nutrient losses to soil, water, and air via direct internalization by fruit crops, 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**[20,21,22].**

The important regulatory effect of iron in building chlorophylls and some plant pigments and regulating reducing and oxidant reactions **[23,24]**. Mn in 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**[8, 23, 25]**. and Zn in activating metabolism enzymes, biosynthesis of organic foods, IAA, cell division and enlargement, water absorption, and some nutrient transport **[2, 26].**

These results regarding the effect of using some nutrients via nanotechnology on the promotion growth, yield, and fruit quality of some fruit crops are in agreement with those obtained by **[27,28,29.30].**

These results concerning the promoting effect of using some nutrients via normal methods are in harmony with those obtained by [**31**] on mango cv **[7]** on Zaghloul date palms **[32]** on Ewaise mangoes **[33]** on Balady mandarin **[34]** on chemlali olives **[35]** on Valencia oranges **[36]** on Sewy data palms **[37]** on El- Saidy date palms **[38]** on El- Saidy date palms **[39]** on Flame seedless grapevines **[40]** 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 nanotechnology system at 20.0 ppm to promote yield and fruit quality.

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تأثير رش بعض العناصر الصغرى من خلال تكنولوجيا النانو على كمية المحصول وجودة ثمار اشجار المانجو الزبدة

الملخص العربى

تم تنفيذ هذه الدراسة خلال مواسم 2019 و 2020 و 2021 لاختبار مقارنة تأثير بعض العناصر الصغرى (الحديد والزنك والمنجنيز) بالنظام العادى (فى الصورة الكيلاتية) ونفس العناصر بنظام النانوتكنولوجى على كمية المحصول للشجرة وبعض الصفات الطبيعية والكيميائية للثمار فى أشجار المانجو الزبدة النامية تحت الظروف المناخية لمنطقة أسوان.

تم رش اشجار المانجو الزبدة النامية تحت ظروف منطقة أسوان ثلاثة مرات ببعض العناصر الصغرى (الحديد والزنك والمنجنيز) بالنظام العادى (فى الصورة الكيلاتية) بتركيز من 25 الى 100 جز فى المليون أو بنظام النانوتكنولوجى بتركيز من 2.5 الى 20.0 جزء فى المليون .

تحسنت كمية المحصول للاشجار وكذلك خصائص الجودة للثمار كثيرا برش بعض العناصر الصغرى (الحديد والزنك والمنجنيز) بالطريقة العادية او طريقة النانوتكنولوجى مقارنة بمعاملة الكونترول.

وكان هذا التحسن يظهر فى صورة زيادة المحصول للشجرة وزن وارتفاع وقطر وسمك الثمرة والنسبة المئوية للب والنسبة المئوية للمواد الصلبة الذائبة الكلية والسكريات الكلية والمختزلة والغير مختزلة وفيتامين ج وفى نقص نسبة الحموضة الكلية والالياف الخام فى الثمار.

استخدام بعض العناصر الصغرى (الحديد والزنك والمنجنيز) بنظام النانوتكنولوجى يفوق عن استخدام (الحديد والزنك والمنجنيز) بالطرق العادية فى تلك الصفات.

أحسن النتائج المتحصل عليها بالنسبة لكمية المحصول وصفات الجودة للثمار فى أشجار المانجو الزبدة التى يتم معاملتها ببعض العناصر الصغرى (الحديد والزنك والمنجنيز) بنظام النانوتكنولوجى بتركيز 20 جزء فى المليون .

الكلمات الدالة: النظام العادى – نظام النانوتكنولوجى –العناصر الصغرى – المحصول – جودة الثمار – أشجار المانجو الزبدة.