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EFFECT OF SOME NANO PARTICLE MATERIALS ON LEAF AREA, PHOTO SYNTHETIC PIGMENTS AND MINERALS CONTENT OF MANGO TREES

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ABSTRACT

This study was carried out during the two growing consecutive seasons 2015 / 2016 on mango trees (Mangifera indica L.) cvs. Zebda and Ewasy, grown in a private orchard at Wadi El-Muolak, Sharkia Governorate, Egypt to evaluate the effect of foliar chitosan and potassium silicate components nano or not nano particle at 15 February before flowering on average leaf area and leaf content of pigments and minerals. Ewasy cv. displayed the highest of their tested attributes in most cases A, B, total Chlorophyll and leaf mineral content compared with Zebda cv.

The obtained showed that the tested treatments improved leaf characteristics especially nano chitosan 50 and 150 ppm treatments which increased Chlorophyll B, total Chlorophyll as well as leaf mineral content in leaf. Furthermore, the trees were sprayed with nano-silica 0.6 and 0.8 g/L showed the highest average leaf area Chlorophyll A and caroteniods pigments in leaf.

Conclusively, *from results of this research, the resembling conditions that spraying mango trees nano- nano chitosan 50 and 150 ppm nano-silica 0.6 and 0.8 g/L before flowering is desirable for improving leaf characteristics it is recommending, under Belbeis district, Sharkia Governorate, Egypt*

Key words: Mango, nano chitosan, nano silicate, Chlorophyll, leaf mineral, Zebda, Ewasy.

INTRODUCTION

Mango (*Mangifera indica L.*) is one of the most important tropical fruits in the world (Mukherjee, 1951) and one of the most popular fruits in Egypt. The total area of the Egyptian mangoes reached 281153 feds. (Statistics of the Ministry of Agriculture, 2016).

Chitosan is considered a biopolymer produced from chitin and is very safe for human being. It has bioactivity and bio-compatibility (Dias *et al*., 2013). Using it in plants resulted in improving the yield and reducing transpiration (Dzung *et al*., 2011 and Mondal *et al*., 2012). It is responsible for enhancing the tolerance of plants to bacterial, viral and fungal attack (Al-Hetar *et al*., 2011). The plants subjected to chitosan are less prone to all biotic and abiotic stresses (Lizarraga-Paulin *et al*., 2011, Jabeen and Ahmad, 2013 and Pongprayoon *et al*., 2013). Previous studies emphasized the essential role of chitosan on stimulating growth aspects, as well as, improving yield and quality parameters of fruits (Chibu and Shibayama, 1999, Li and Yu, 2000, Bittelli *et al*., 2001 and Devlieghere *et al.*, 2004 and Hussein Esraa, 2017).

Silicon has many functions in plant nutrition. It has many regulatory roles in enhancing the tolerance of plants to biotic and abiotic stresses, water retention, photosynthesis, plant pigments and building of carbohydrates and natural growth regulators (Gang *et al*., 2003, Lux *et al*., 2003, Ma, 2004 and Hattori *et al*., 2005). Previous studies (Gad El-Kareem *et al.,* 2014, Omar, 2015, Ahmed *et al.,* 2017 and Youssef, 2017) showed that silicon were favorable in enhancing vegetative growth characteristics and leaf mineral content in various fruit trees.

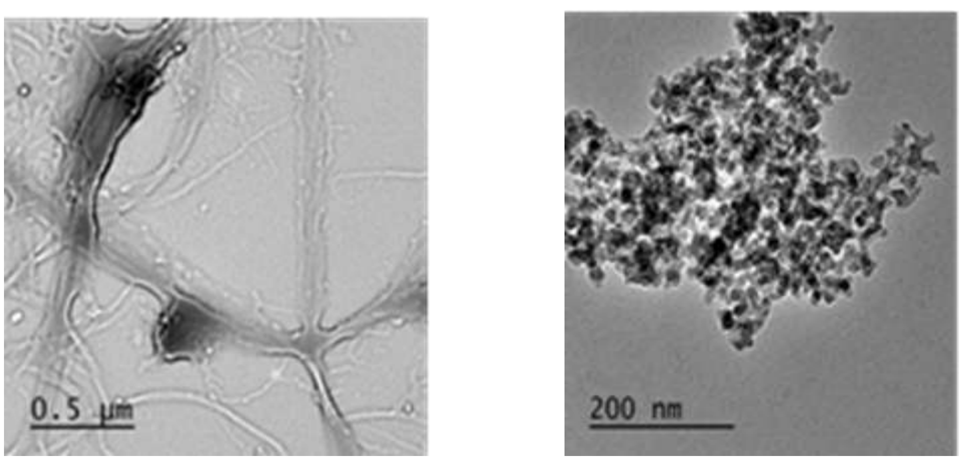
Therefore, the main objective of this study is to investigate the effect of nano particle of chitosan and potassium silicate on leaf area, pigments and minerals contents of two mangoes cultivars Zebda and Ewasy.

MATERIALS AND METHODS

This investigation was carried out on two mangoes (*Mangifera indica L.*) cultivars Zebda and Ewasy in 2016 and 2017 seasons on mango trees grown in sandy soil under drip irrigation at private orchard at Wadi El-Muluk, Sharkia Governorate, Egypt.

Trees were 20 years old, planted at 4×6 m apart, grafted on Succary rootstocks grown under the common agricultural practices adopted in the area. Seventy eight healthy trees, similar in vigor and size, selected to evaluate the effect of foliar spray with different of treatments before flowering at 15 February on leaf area and leaf content of pigments and minerals of mango cultivars Ewasy and Zebda.

Chitosan and potassium silicate of nano crystallite powder synthesized by high-energy ball milling. Powder mixture conducted in a 0.4 mini lab planetary ball mill (model DECO-PBM-V-0.4L, Changsha Deco Equipment Co., Ltd., China) to 40 h using ball to powder mass ratio of 8:1 by prof. Dr. Osama M. Hemeda at Central lab., department of physics, faculty of science, Tanta University, Egypt. The microstructure of the sintered samples examined using High Resolution Transmission Electron Microscope (HRTEM) model JOEL EM 2-100. Transmission electron microscope (TEM) imaging showed a spherical, smooth and almost homogenous structure for nanoparticles. In the present study, TEM images (Fig. 1) have shown the morphological properties and surface appearance of chitosan nanoparticles, which have nearly spherical shape, smooth surface and size range of about 50-35 nm, which confirm the result of XRD. The size of chitosan nanoparticles, as evident from the TEM images found to be 50 nm. The TEM analysis of chitosan nanoparticles showed uniform size distribution in nanometer range.



(a) (b)

Fig.1 (a-b): TEM micrograph for chitosan, (a) before milling and (b) after milling

Chitosan dissolving:

For experimental use the stock solution, (2.0%, w/v) of chitosan was prepared by dissolving purified chitosan in 0.5% (v/v) glacial acetic acid (Du *et al.,* 1997), under continuous stirring, and the pH was adjusted to 5.6 using 1 N Na OH. The stock solution was autoclaved and appropriate concentrations were obtained by dilution with sterile distilled water.

Thirteen treatments each treatment included 3 replicates. The replicate represented as one tree of every cultivar were applied on the two cultivars as follows:

1- Trees sprayed only mineral oil 1.5% (control).
2- Trees sprayed with nano chitosan 50 ppm (2.5 ml/l from stock solution) + mineral oil 1 %.
3- Trees sprayed with nano chitosan 100 ppm (5 ml/l from stock solution) + mineral oil 1.5 %.
4- Trees sprayed with nano chitosan 150 ppm (7.5 ml/l from stock solution) + mineral oil 1.5 %.
5- Trees sprayed with chitosan 50 ppm + mineral oil 1 %.
6- Trees sprayed with chitosan 100 ppm + mineral oil 1.5 %.
7- Trees sprayed with chitosan 150 ppm + mineral oil 1.5 %.
8- Trees sprayed with nano potassium silicate 0.4 g/l (40 g/100L).
9- Trees sprayed with nano potassium silicate 0.6 g/l (60 g/100L).
10- Trees sprayed with nano potassium silicate 0.8 g/l (80 g/100L).
11- Trees sprayed with potassium silicate 0.4 g/l (40 g/100L).
12- Trees sprayed with potassium silicate 0.6 g/l (60 g/100L).
13- Trees sprayed with potassium silicate 0.8 g/l (80 g/100L).

The responses of the two mango cvs. to the applied treatments were evaluated through the following parameters:

Leaf characteristics:

Average leaf area:

To determine average leaf area (indicators to plant growth effects), samples of mature leaves grown on unfruitful shoots randomly taken at harvest date length and width of leaf (cm) were measured. Then, average leaf surface area (cm^2) was determined according to the equation reported by Ahmed and Morsy (1999).

Leaf area (cm^2) = 0.7 (blade width x blade length) – 1.06.

Leaf pigments contents:

Leaf disk samples obtained at harvest to determined leaf tissue contents (mg / mg F.W) of chlorophyll A, B, total chlorophyll (A+B) and carotenoids (**Wettestein, 1957).**

Leaf mineral contents:

Leaf samples were washed, dried ground and digested using sulphoric acid and hydrogen peroxide **(Chapman and Pratt 1961**). N, P, K and Zn content were determined in the digested solution as percentages. All chemicals used in different determinations obtained from El-Gomhouria for trading Chemicals and Medical Appliances, El-Sawah, El-Amiria, Cairo, Egypt.

Statistical analysis:

This study designed as factorial experimental with to factors; cultivars (2) and treatments (13). data were analyzed using M-Stat program in a randomized complete block design (RCBD) as described by Snedecor and Cochran (1980), and means were compared using mean comparison at 0.05 level (Duncan, 1955).

RESULTS

Average leaf area:

Data in Table 1 revealed that the average leaf area of Ewasy was significantly affected and largest compared to Zebda cv. in both seasons.

The tested treatments showed significant effects on average leaf area. The Nano-silica treatments recorded the highest values compared of other treatments. Whilst, trees sprayed with nano-silica 0.6 and 0.8 g/L showed the highest average leaf area (140.46 &128.73 and 142.28 & 145.01 cm^2) in the first and second seasons, respectively without significant differences between them. While, the lowest average leaf area (43.95 & 51.09 and 59.43 & 51.79 cm^2) in the first and second seasons, respectively without significant differences between them was recorded for trees sprayed with control and chitosan 50 ppm treatments.

The interaction between Ewasy × nano-silica 0.6 and 0.8 g/L had superior values of average leaf area, compared with Zebda × control and chitosan treatments which were in significant differences between them in both seasons.

Table (1): Effect of chitosan and potassium silicate spraying on average leaf area (cm^2) of Zebda and Ewasy mango trees (2016 and 2017 seasons)

Treatments	First season (2016)			Second season (2017)		
	Cultivar		Treat. av.	Cultivar		Treat. av.
	Zebda	Ewasy		Zebda	Ewasy	
Control (water)	27.76 l	37.44 kl	**43.95 E**	36.62 jk	82.24 efg	**59.43 E**
Chitosan 50 ppm	60.14 ij	64.74 ghij	**51.09 E**	39.31 jk	64.27 hi	**51.79 E**
Chitosan 100 ppm	52.09 ijk	95.19 ef	**73.64 D**	48.52 ijk	95.77 de	**72.15 D**
Chitosan 150 ppm	39.42 kl	67.54 ghi	**53.48 E**	31.02 k	84.69 ef	**57.86 E**
Nano-chitosan 50 ppm	51.79 ijk	90.29 ef	**71.04 D**	63.08 hi	92.51 de	**77.80 D**
Nano-chitosan 100 ppm	61.24 ij	79.98 fgh	**70.61 D**	57.48 hi	99.13 de	**78.31 D**
Nano-chitosan 150 ppm	49.46 jk	87.96 ef	**68.71 D**	53.89 hij	103.94 d	**78.91 D**
Silica 0.4 g/L	56.81 ij	148.39 c	**102.60 C**	65.32 ghi	161.11 c	**113.22 C**
Silica 0.6 g/L	82.36 fg	185.37 b	**133.87 AB**	70.20 fgh	195.17 b	**132.69 AB**
Silica 0.8 g/L	101.14 e	152.92 c	**127.03 B**	89.94 de	160.41 c	**125.17 BC**
Nano-silica 0.4 g/L	57.86 ij	131.36 d	**94.61 C**	63.22 hi	170.67 c	**116.95 C**
Nano-silica 0.6 g/L	78.27 fgh	202.64 a	**140.46 A**	65.95 ghi	218.60 a	**142.28 A**
Nano-silica 0.8 g/L	64.27 hij	193.19 ab	**128.73 AB**	65.67 ghi	224.34 a	**145.01 A**
Cultivar av.	**58.45 B**	**119.98 A**		**57.71 B**	**134.84 A**	

Means having the same letter (s) within the same column are not significantly different according to Duncan' s multiple range test at 5% level of probability.

Leaf photosynthetic pigments:

Data in Tables 2 - 5 showed that leaf content of Chlorophyll B and total was significantly differed between the two tested mango varieties but, leaf Chlorophyll was total all insignificant in the leaves in the second season only. While, leaf content of carotenoids was insignificantly between two cultivars.

The data cleared also that leaf photosynthetic pigments were significantly response to treating the trees. The treatments with silica at 0.6 g/L gave the highest values of leaf Chlorophyll A and carotene content (1.697 & 1.743 and 2.789 & 2.953 mg / 100 mg) in the first and second seasons, respectively. Treating the trees with nano chitosan 50 ppm gave the highest values of leaf

Table (2): Effect of chitosan and potassium silicate spraying on chlorophyll A content (mg/ 100 mg F.W.) of Zebda and Ewasy mango leaves (2016 and 2017 seasons)

Treatments	First season (2016)			Second season (2017)		
	Cultivar		Treat. av.	Cultivar		Treat. av.
	Zebda	Ewasy		Zebda	Ewasy	
Control (water)	0.818 p	0.909 o	**0.864 L**	0.931 m	0.894 m	**0.913 I**
Chitosan 50 ppm	1.135 m	1.224 l	**1.180 J**	1.115 l	1.217 jk	**1.166 G**
Chitosan 100 ppm	1.317 j	1.515 f	**1.416 F**	1.420 fg	1.320 i	**1.370 D**
Chitosan 150 ppm	1.210 l	1.304 j	**1.257 H**	1.233 jk	1.495 e	**1.364 D**
Nano-chitosan 50 ppm	1.448 g	1.682 d	**1.565 C**	1.653 c	1.554 d	**1.604 B**
Nano-chitosan 100 ppm	1.205 l	1.885 b	**1.545 D**	1.318 i	1.380 gh	**1.349 D**
Nano-chitosan 150 ppm	1.212 l	1.424 h	**1.318 G**	1.112 l	1.612 c	**1.362 D**
Silica 0.4 g/L	1.045 n	1.045 n	**1.045 K**	2.305 a	1.222 jk	**1.764 A**
Silica 0.6 g/L	1.651 e	1.743 c	**1.697 A**	1.854 b	1.632 c	**1.743 A**
Silica 0.8 g/L	1.142 m	1.213 l	**1.178 J**	1.098 l	1.124 l	**1.111 H**
Nano-silica 0.4 g/L	1.205 l	1.260 k	**1.232 I**	1.197 k	1.248 j	**1.222 F**
Nano-silica 0.6 g/L	1.400 i	1.515 f	**1.457 E**	1.505 e	1.425 f	**1.465 C**
Nano-silica 0.8 g/L	1.697 a	1.306 j	**1.650 B**	1.255 j	1.359 hi	**1.307 E**
Cultivar av.	**1.291 B**	**1.387 A**		**1.384 A**	**1.345 B**	

Means having the same letter (s) within the same column are not significantly different according to Duncan' s multiple range test at 5% level of probability.

Table (3): Effect of chitosan and potassium silicate spraying on chlorophyll B content (mg/ 100 mg F.W.) of Zebda and Ewasy mango leaves (2016 and 2017 seasons)

Treatments	**First season (2016)**			**Second season (2017)**		
	Cultivar		**Treat. av.**	**Cultivar**		**Treat. av.**
	Zebda	**Ewasy**		**Zebda**	**Ewasy**	
Control (water)	1.216 w	1.311 v	**1.263 L**	1.310 kl	1.236 l	**1.273 F**
Chitosan 50 ppm	1.521 r	1.628 n	**1.574 J**	1.563 ghi	1.661 e-i	**1.612 D**
Chitosan 100 ppm	1.447 s	1.836 h	**1.641 H**	1.663 d-i	1.725 d-g	**1.694 CD**
Chitosan 150 ppm	1.624 o	1.704 l	**1.664 G**	1.588 f-i	1.716 d-g	**1.652 CD**
Nano-chitosan 50 ppm	2.182 a	1.865 g	**2.024 A**	2.217 a	1.924 bc	**2.071 A**
Nano-chitosan 100 ppm	1.634 m	1.992 b	**1.813 C**	1.713 d-g	1.784 cde	**1.479 BC**
Nano-chitosan 150 ppm	1.423 t	1.953 c	**1.688 F**	1.563 ghi	1.803 cde	**1.683 CD**
Silica 0.4 g/L	1.334 u	1.562 p	**1.458 K**	1.505 hij	1.347 jkl	**1.426 E**
Silica 0.6 g/L	1.217 w	1.944 d	**1.580 I**	0.736 n	1.763 c-f	**1.250 F**
Silica 0.8 g/L	1.876 f	1.547 q	**1.711 E**	2.042 ab	1.472 ijk	**1.757 BC**
Nano-silica 0.4 g/L	1.621 o	1.708 k	**1.664 G**	1.538 g-j	1.695 d-h	**1.616 D**
Nano-silica 0.6 g/L	1.764 j	1.923 e	**1.843 B**	1.805 cde	1.840 cd	**1.823 B**
Nano-silica 0.8 g/L	1.634 m	1.794 i	**1.714 D**	1.031 m	1.713 d-g	**1.372 EF**
Cultivar av.	**1.576 B**	**1.751 A**		**1.560 B**	**1.668 A**	

Means having the same letter (s) within the same column are not significantly different according to Duncan' s multiple range test at 5% level of probability.

Table (4): Effect of chitosan and potassium silicate spraying on total chlorophyll content (mg/ 100 mg F.W.) of Zebda and Ewasy mango leaves (2016 and 2017 seasons)

Treatments	First season (2016)			Second season (2017)		
	Cultivar		Treat. av.	Cultivar		Treat. av.
	Zebda	Ewasy		Zebda	Ewasy	
Control (water)	2.034 u	2.220 t	**2.127 K**	2.241 m	2.130 m	**2.186 G**
Chitosan 50 ppm	2.655 p	2.852 m	**2.753 I**	2.291 lm	2.877 hij	**2.584 F**
Chitosan 100 ppm	2.764 o	3.351 g	**3.057 E**	3.084 e-h	3.045 e-i	**3.064 CD**
Chitosan 150 ppm	2.834 mn	3.008 j	**2.921 G**	2.820 ijk	3.211 c-f	**3.016 D**
Nano-chitosan 50 ppm	3.630 c	3.547 d	**3.588 A**	3.789 a	3.478 b	**3.633 A**
Nano-chitosan 100 ppm	2.839 mn	3.877 a	**3.358 B**	3.031 f-i	3.164 d-g	**3.098 CD**
Nano-chitosan 150 ppm	2.635 q	3.377 f	**3.006 F**	2.674 jk	3.415 bc	**3.045 CD**
Silica 0.4 g/L	2.378 s	2.607 r	**2.493 J**	3.810 a	2.569 kl	**3.190 BC**
Silica 0.6 g/L	2.872 l	3.687 b	**3.279 D**	3.264 b-f	3.395 bcd	**3.329 B**
Silica 0.8 g/L	3.01 j	2.760 o	**2.889 H**	2.909 g-j	2.596 k	**2.753 EF**
Nano-silica 0.4 g/L	2.826 n	2.967 k	**2.896 H**	2.734 jk	2.942 g-j	**2.838 E**
Nano-silica 0.6 g/L	3.163 h	3.439 e	**3.301 C**	3.311 b-e	3.264 b-f	**3.2878 B**
Nano-silica 0.8 g/L	3.626 c	3.100 i	**3.363 B**	2.287 lm	3.073 e-i	**2.680 EF**
Cultivar av.	**2.867 B**	**3.138 A**		**2.942 A**	**3.012 A**	

Means having the same letter (s) within the same column are not significantly different according to Duncan' s multiple range test at 5% level of probability.

Table (5): Effect of chitosan and potassium silicate spraying on carotenoids content (mg/ 100 mg F.W.) of Zebda and Ewasy mango leaves (2016 and 2017 seasons)

Treatments	First season (2016)			Second season (2017)		
	Cultivar		Treat. av.	Cultivar		Treat. av.
	Zebda	Ewasy		Zebda	Ewasy	
Control (water)	1.837 i	1.815 i	**1.826 F**	1.915 h-k	1.741 jk	**1.828 F**
Chitosan 50 ppm	2.083 gh	2.221 efg	**2.152 E**	2.112 f-j	2.156 e-i	**2.134 CDE**
Chitosan 100 ppm	2.211 efg	2.479 bc	**2.345 BC**	2.287 c-h	2.365 c-f	**2.326 BCD**
Chitosan 150 ppm	2.240 d-g	1.953 hi	**2.096 E**	2.209 d-h	2.359 c-f	**2.284 BCD**
Nano-chitosan 50 ppm	2.063 gh	2.324 cde	**2.193 DE**	2.833 ab	2.773 ab	**2.803 A**
Nano-chitosan 100 ppm	2.345 cde	2.085 gh	**2.215 CDE**	1.597 k	2.546 bcd	**2.072 DEF**
Nano-chitosan 150 ppm	2.223 efg	1.354 j	**1.788 F**	2.647 bc	2.374 c-f	**2.510 B**
Silica 0.4 g/L	2.122 fgh	2.123 fgh	**2.122 E**	2.055 f-j	1.786 ijk	**1.921 EF**
Silica 0.6 g/L	3.024 a	2.554 b	**2.789 A**	3.063 a	2.843 ab	**2.953 A**
Silica 0.8 g/L	2.282 def	2.322 cde	**2.302 BCD**	2.333 c-f	1.946 g-k	**2.139 CDE**
Nano-silica 0.4 g/L	2.183 efg	2.414 bcd	**2.298 BCD**	2.144 e-i	2.286 c-h	**2.215 CD**
Nano-silica 0.6 g/L	2.223 efg	2.586 b	**2.404 B**	2.209 d-h	2.509 b-e	**2.359 BC**
Nano-silica 0.8 g/L	2.087 gh	2.485 bc	**2.286 BCD**	2.364 c-f	2.315 c-g	**2.339 BCD**
Cultivar av.	**2.225 A**	**2.209 A**		**2.290 A**	**2.307 A**	

Means having the same letter (s) within the same column are not significantly different according to Duncan's multiple range test at 5% level of probability.

Chlorophyll B and total Chlorophyll content (2.024 & 2.071 and 3.588 & 3.633 mg / 100 mg) in the first and second seasons, respectively.

Leaf mineral contents:

Data presented in Tables 6 to 9 indicated that, there are significant varietal differences in leaf mineral content in both seasons except K% in the second season and P% in the first season only. Ewasy cv trees showed highest significant values of leaf mineral content compared with Zebda cv.

Effect of treatments on leaf mineral content showed significantly increase of values with nano chitosan treatments compared with other treatments. Generally, the lowest mineral contents recorded with control treatment.

Table (6): Effect of chitosan and potassium silicate spraying on leaf nitrogen percentage of Zebda and Ewasy mango trees (2016 and 2017 seasons)

Treatments	First season (2016)			Second season (2017)		
	Cultivar		Treat. av.	Cultivar		Treat. av.
	Zebda	Ewasy		Zebda	Ewasy	
Control (water)	2.15 kl	2.27 f-i	**2.21 FG**	2.03 n	2.19 k	**2.11 H**
Chitosan 50 ppm	2.20 jk	2.39 cd	**2.29 DE**	2.23 i	2.38 de	**2.30 D**
Chitosan 100 ppm	2.25 ghi	2.21 jk	**2.23 EFG**	2.18 k	2.36 de	**2.27 E**
Chitosan 150 ppm	2.29 e-i	2.42 bc	**2.35 CD**	2.31 f	2.36 e	**2.33 C**
Nano-chitosan 50 ppm	2.56 a	2.52 ab	**2.54 A**	2.46 b	2.45 bc	**2.46 A**
Nano-chitosan 100 ppm	2.34 c-g	2.39 cd	**2.37 BC**	2.43 c	2.46 b	**2.44 AB**
Nano-chitosan 150 ppm	2.35 c-f	2.36 cde	**2.35 CD**	2.43 c	2.46 b	**2.45 A**
Silica 0.4 g/L	2.44 bc	2.43 bc	**2.43 B**	2.21 ij	2.12 l	**2.17 F**
Silica 0.6 g/L	2.20 jk	2.32 d-h	**2.26 EF**	2.03 n	2.26 g	**2.15 G**
Silica 0.8 g/L	2.22 ijk	2.35 c-f	**2.28 DE**	2.20 jk	2.32 f	**2.26 E**
Nano-silica 0.4 g/L	2.13 l	2.24 hij	**2.18 G**	2.10 m	2.24 hi	**2.17 F**
Nano-silica 0.6 g/L	2.32 d-h	2.42 bc	**2.37 BC**	2.26 gh	2.39 d	**2.32 C**
Nano-silica 0.8 g/L	2.24 hij	2.42 bc	**2.33 CD**	2.32 f	2.53 a	**2.43 B**
Cultivar av.	**2.28 B**	**2.37 A**		**2.24 B**	**2.35 A**	

Means having the same letter (s) within the same column are not significantly different according to Duncan' s multiple range test at 5% level of probability.

Table (7): Effect of chitosan and potassium silicate spraying on leaf potassium percentage of Zebda and Ewasy mango trees (2016 and 2017 seasons)

Treatments	First season (2016)			Second season (2017)		
	Cultivar Zebda	Cultivar Ewasy	Treat. av.	Cultivar Zebda	Cultivar Ewasy	Treat. av.
Control (water)	1.67 k	1.72 j	1.69 F	1.66 jk	1.70 i	**1.69 F**
Chitosan 50 ppm	1.56 p	1.61 o	**1.58 I**	1.55 m	1.64 k	**1.60 H**
Chitosan 100 ppm	1.93 ab	1.78 gh	**1.86 A**	1.82 d	1.68 j	**1.75 E**
Chitosan 150 ppm	1.61 o	1.66 lm	**1.63 H**	1.62 l	1.71 hi	**1.67 G**
Nano-chitosan 50 ppm	1.63 m	1.83 d	**1.73 E**	1.77 f	1.82 de	**1.80 D**
Nano-chitosan 100 ppm	1.73 ij	1.92 bc	**1.82 B**	1.93 a	1.89 b	**1.91 A**
Nano-chitosan 150 ppm	1.83 d	1.77 h	**1.80 C**	1.92 ab	1.64 kl	**1.78 D**
Silica 0.4 g/L	1.94 a	1.68 k	**1.81 BC**	1.74 gh	1.77 f	**1.75 E**
Silica 0.6 g/L	1.64 m	1.72 j	**1.68 G**	1.74 gh	1.64 k	**1.69 F**
Silica 0.8 g/L	1.60 o	1.74 i	**1.67 G**	1.65 k	1.86 c	**1.75 E**
Nano-silica 0.4 g/L	1.75 i	1.82 de	**1.79 D**	1.80 e	1.85 c	**1.83 C**
Nano-silica 0.6 g/L	1.80 fg	1.81 def	**1.81 C**	1.75 fg	1.76 fg	**1.75 E**
Nano-silica 0.8 g/L	1.81 ef	1.90 c	**1.85 A**	1.81 de	1.92 a	**1.87 B**
Cultivar av.	**1.73 B**	**1.77 A**		**1.75 A**	**1.76 A**	

Means having the same letter (s) within the same column are not significantly different according to Duncan' s multiple range test at 5% level of probability.

Table (8): Effect of chitosan and potassium silicate spraying on leaf phosphorus percentage of Zebda and Ewasy mango trees (2016 and 2017 seasons)

Treatments	First season (2016)			Second season (2017)		
	Cultivar		Treat. av.	Cultivar		Treat. av.
	Zebda	Ewasy		Zebda	Ewasy	
Control (water)	0.205 hi	0.235 c-i	**0.220 CD**	0.193 q	0.225 o	**0.209 K**
Chitosan 50 ppm	0.237 b-i	0.274 a-d	**0.256 ABC**	0.252 k	0.293 b	**0.273 D**
Chitosan 100 ppm	0.222 e-i	0.235 c-i	**0.229 CDE**	0.203 p	0.225 o	**0.214 J**
Chitosan 150 ppm	0.244 b-i	0.264 a-f	**0.254 ABC**	0.266 h	0.282 e	**0.274 D**
Nano-chitosan 50 ppm	0.266 a-e	0.282 abc	**0.274 A**	0.273 g	0.302 a	**0.288 A**
Nano-chitosan 100 ppm	0.274 a-d	0.253 a-h	**0.264 AB**	0.263 i	0.236 mn	**0.249 H**
Nano-chitosan 150 ppm	0.278 abc	0.285 ab	**0.281 A**	0.263 i	0.305 a	**0.284 B**
Silica 0.4 g/L	0.266 a-e	0.235 c-i	**0.251 A-D**	0.252 k	0.252 jk	**0.252 G**
Silica 0.6 g/L	0.209 ghi	0.246 b-h	**0.228 CDE**	0.232 n	0.278 f	**0.255 F**
Silica 0.8 g/L	0.213 f-i	0.260 a-g	**0.236 B-E**	0.236 m	0.242 l	**0.239 I**
Nano-silica 0.4 g/L	0.214 f-i	0.254 a-h	**0.234 B-E**	0.239 l	0.272 g	**0.256 F**
Nano-silica 0.6 g/L	0.270 a-d	0.296 a	**0.283 A**	0.264 i	0.290 c	**0.277 C**
Nano-silica 0.8 g/L	0.223 d-i	0.197 i	**0.210 E**	0.255 j	0.286 d	**0.270 E**
Cultivar av.	**0.240 A**	**0.255 A**		**0.245 B**	**0.268 A**	

Means having the same letter (s) within the same column are not significantly different according to Duncan' s multiple range test at 5% level of probability.

Table (9): Effect of chitosan and potassium silicate spraying on leaf zinc content (ppm) of Zebda and Ewasy mango trees (2016 and 2017 seasons)

Treatments	First season (2016)			Second season (2017)		
	Cultivar		Treat. av.	Cultivar		Treat. av.
	Zebda	Ewasy		Zebda	Ewasy	
Control (water)	28.12 q	29.13 n	**28.63 K**	27.48 u	28.64 q	**28.06 L**
Chitosan 50 ppm	31.46 g	28.12 q	**29.79 I**	31.52 g	30.22 m	**30.87 F**
Chitosan 100 ppm	30.15 m	28.34 p	**29.24 J**	29.70 o	30.60 k	**30.15 G**
Chitosan 150 ppm	31.80 f	30.13 m	**30.97 F**	31.82 e	28.17 s	**29.99 H**
Nano-chitosan 50 ppm	28.32 p	33.23 b	**30.78 G**	30.17 n	33.35 b	**31.76 B**
Nano-chitosan 100 ppm	31.22 h	31.06 i	**31.14 E**	28.83 p	31.12 h	**29.98 H**
Nano-chitosan 150 ppm	31.82 f	33.40 a	**32.61 A**	30.44 l	33.64 a	**32.04 A**
Silica 0.4 g/L	32.13 e	30.72 j	**31.42 D**	30.46 l	28.12 t	**29.29 I**
Silica 0.6 g/L	28.61 o	28.62 o	**28.62 K**	26.34 v	30.20 mn	**28.27 K**
Silica 0.8 g/L	30.12 m	30.33 l	**30.22 H**	28.53 r	28.55 r	**28.54 J**
Nano-silica 0.4 g/L	30.16 m	32.15 e	**31.16 E**	30.21 m	31.67 f	**30.94 E**
Nano-silica 0.6 g/L	31.05 i	32.62 d	**31.84 B**	30.64 j	32.09 d	**31.37 D**
Nano-silica 0.8 g/L	30.46 k	33.04 c	**31.75 C**	30.78 i	32.16 c	**31.47 C**
Cultivar av.	**30.42 B**	**30.84 A**		**29.76 B**	**30.66 A**	

Means having the same letter (s) within the same column are not significantly different according to Duncan' s multiple range test at 5% level of probability.

The interaction between cultivars × treatments recorded significantly the highest values of leaf nitrogen percentage from Zebda cv × 50 ppm nano chitosan in the first season and 0.8 g/l nano silica in the second season. While, the lowest values came from, generally, Zebda cv × control during both seasons. The values of leaf potassium percentage was significantly the highest in Zebda cv × 0.4 g/l silica in the first season and 100 ppm nano chitosan in the second season. But, the lowest values came from Zebda cv × 0.6 g/l silica in the first season and 50 ppm chitosan in the second season. The highest values of leaf phosphorus percentage, obtained from Ewasy cv × nano chitosan treatments during the two seasons. The lowest values came from Ewasy cv × nano silica 0.8 g/l treatment in the first season and 0.6 g/l silica with Zebda cv in the second season. The values of leaf zinc content (ppm) was significantly the highest in Ewasy cv and 150 ppm nano chitosan treatment in the first and second seasons. While, the lowest values came from Ewasy cv and control treatment in the first season and 50 ppm nano chitosan with Zebda cv in the second season.

DISCUSSION

Ewasy cv. displayed the higher effect in most cases of their tested attributes (average leaf area leaf, content of Chlorophyll B & total and mineral) compared with Zebda cv. Differences between the two mango cvs in all parameters are due to varietal differences that go back to genetic composition. In this respect, Bally (2006) reported that growth vigor of a mango cv. is an inherent property ascribing to the genetic make-up of the cultivar. Outweigh of a mango cv in growth traits especially the area of photosynthetic leaves indicates its higher capacity for accumulating photosynthesis. It is well known that mango cvs; as any other plant cultivars; differ greatly in response of their genetic make up to the environmental factors that affecting developmental processes and ability to thrive benefit from the available growth factors. (Zuo *et al*., 2007).

Results indicated that, tested treatments were improving leaf content of pigments and minerals especially silica at 0.6 g/L and nano chitosan 50 ppm treatments. The obtained results are in agreement with those Hussein and Radwan (2017) on mango, Mondal *et al*. (2012) on okra, Mondal *et al.* (2013) on mungbean and Esraa, (2017) on prime seedless grapevines by treatment of chitosan improved growth aspects and leaf content of pigment and mineral. Silicon were favorable in enhancing growth aspects, leaf pigments and nutrients content (Gad El-Kareem *et al*., 2014, Omar, 2015, Ahmed *et al*., 2017, Youssef, 2017 and Faissal *et al*., 2018).

Zong *et al.* (2016) in edible rape (*Brassica rapa* L.) found that, foliar application of chitosan promoted the plant growth and leaf chlorophyll contents. So, Pereira *et al*. (2017) reported that, bioactivity assays using Phaseolus vulgaris showed that the alginate/chitosan (ALG/CS)-GA3 nanoparticles were most effective in increasing leaf area and the levels of chlorophylls and carotenoids.

Silicon has many functions in plant nutrition. It has many regulatory roles in enhancing the tolerance of plants to biotic and abiotic stresses, water retention, photosynthesis, plant pigments and building of carbohydrates and natural growth regulators (Gang *et al*., 2003, Lux *et al*., 2003, Ma, 2004 and Hattori *et al.*, 2005).

Conclusively, from results of this research, the resembling conditions that spraying mango trees nano- nano chitosan 50 and 150 ppm nano-silica 0.6 and 0.8 g/L before flowering is desirable for improving leaf characteristics it is recommending, under Belbeis district, Sharkia Governorate, Egypt

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تأثير بعض المواد المتناهية الصغر على المساحة الورقيه والصبغات الضوئيه ومحتوى العناصر فى أشجار المانجو

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اجريت هذه الدراسة فى موسمي ٢٠١٥ و٢٠١٦ لأشجار المانجو أصناف الذبده والعويس النامية فى مزرعه خاصة بوادى الملاك – محافظة الشرقية - مصر. لتقيم تأثير الرش الورقى بالشيتوزان وسيليكات البوتاسيوم نانو وبدون نانو فى قبل الأزهار فى منتصف فبراير على متوسط المساحة الورقية ومحتوى الأوراق من الصبغات والعناصر.

تفوق صنف العويس بالمقارنة بالصنف الذبده فى لمعظم الصفات المختبرة – كلورفيا أ ، ب والكلى وأيضا العناصر المعدنية.

أدىت المعاملات لتحسين صفات الورقة خصوصا معاملتى الشيتوزان النانو ٥٠ و ١٥٠ جزء فى المليون الكلورفيل ب والكلى وأيضا العناصر المعدنية. بينما الأشجار التى تم رشها بالنانو سيليكا ٠.٦ و ٠.٨ جرام / لتر ادت الى زيادة المساحة الورقية وصبغات كلورفيل أ والكاروتينات فى الورقة.

التوصية: من نتائج هذه الدراسة ننصح تحت ظروف فى منطقة صحراء بلبيس محافظة الشرقية والظروف المماثلة برش أشجار المانجو الشيتوزان متناهى الصغر بتركيز ٥٠ و ١٥٠ جزء فى المليون أو سيليكا متناهى الصغر ٠.٦ بتركيز و ٠.٨ جرام / لتر قبل الأزهار لتحسين صفات النمو الخضرى.