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EFFECT OF SPRAYING NANO-CHITOSAN AND NANO-SILICON ON PHYSICOCHEMICAL FRUIT QUALITY AND LEAF MINERAL CONTENT OF FLORIDA PRINCE PEACH TREES

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ABSTRACT: This work was carried out in the two successive seasons of 2016 and 2017 on five-year-old peach Florida prince cv. trees (*Prunus persica* L.) grown in sandy silt soil at 3×5 m apart under drip irrigation system of a private peach orchard located at Belbies district, Sharkia Governorate, Egypt. The tested trees sprayed with nano-chitosan at 10, 20, 30 and 40 ppm, nano-silicon at 200, 400 and 600 ppm and potassium silicate at 1000, 2000 and 3000 ppm as well as water (control treatment). The results showed that spraying of nano-chitosan at all rates exhibited the highest TSS/acid ratio in the fruit juice without significant differences between them in the two seasons. Untreated trees had a highest vit. C content in fruits compared to other treatments. Also, 3000 ppm potassium silicate treatment gave the highest total sugars and carbohydrate percentages. The treatment of potassium silicate at 3000 ppm gained highest leaf mineral contents of N, P, K, Fe, Zn and Mn, while, lowest leaf mineral contents of Fe, Zn and Mn were recorded with control and nanochitosan at 10 ppm.

Key words: Peach, Nano, silicon, chitosan, fruit quality, leaf mineral content.

INTRODUCTION

Peach fruits are delicious taste and unique flavor with high nutritional value have popularized it across the world. It's the most popular stone fruits in the world because of its high nutrient level and pleasant flavor. Peach fruits are enriched with ascorbic acid, carotenoids (provitamin A), phenolic compounds and are considered prime sources for antioxidants **(Tomas-Barberan *et al*., 2001; Byrne, 2002)**. Florida Prince is an early ripening cultivar under the Egyptian environmental conditions it starts to ripe in April, two months earlier than the European peaches cvs **(Stino *et al*., 2010)**. The production and commercialization of stone fruits like peaches have increased briskly throughout the world.

The use of Nano applications on fruit trees contributes very effectively to improving the quality of fruits and increasing the productivity of trees by improving nutrient management in modern agriculture as well as increasing the storing potential of fruits, as it was noted that the use of Nano fertilizer in the agricultural field preserves the soil. It reduces their pollution by reducing the amount of fertilizer used, which is positively reflected in the increased economic return of the farmer **(Malerba and Cerana, 2016; Al-Hchami and Alrawi, 2020).**

Chitosan has been used in agriculture as a coating material for vegetables, fruits and seeds **(Photchanachai *et al.*, 2006)**. Chitosan, a polycationic polymer of (3-1,4, linked D-glucosamine chemically derived from crustaceans and soluble in organic acids is one of a range of natural compounds that have been successfully used to maintain the quality of harvested fruits and vegetables **(Li and Yu, 2001 and Dong *et al.*, 2004)**. Plants treated with chitosan may be less prone to stress evoked by unfavorable conditions, such as drought, salinity, low or high

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temperature **(Liu *et al.*, 2011 and Shao *et al.*, 2015)**. Application of chitosan increased key enzymes activities of nitrogen metabolism (nitrate reductase, glutamine synthetase and protease) and improved the transportation of nitrogen (N) in the functional leaves which enhanced plant growth and development and increase the yield **(Mondal *et al.*, 2013)**.

Silicon considered an essential element for higher plants because silicon deprived plants tend to grow abnormally, whereas silicon supplemented plants grow normally **(Artyszak, 2018)**. The application of silicon in fertilization of plants has a positive influence on the growth, development and yield of plants **(Hogendorp, 2008; Górecki and Danielski-Busch, 2009 and Mohaghegh *et al.*, 2010)**.

The aim of this work is improving growth, fruit weight and its quality of Florida prince peach trees by using some natural growth promoters as alternatives to synthetic growth regulators.

MATERIALS AND METHODS

This study carried out during two seasons of 2016 and 2017 on five-year-old peach Florida prince cv. trees (*Prunus persica* L.). The trees are grown in a private peach orchard at Belbies district, Sharkia Governorate, Egypt. The trees were planted at 3 x 5 m apart, in silt sandy soil under drip irrigation system. The usual agriculture practices for peach trees in the orchard will be adapted to all trees. The tested treatments could be summarized as follows: Spray trees with tap water (control), spray trees with nano-chitosan at 10, 20, 30 and 40 ppm, spray trees with nano-silicon at 200, 400 and 600 ppm and spray trees with potassium silicate at 1000, 2000 and 3000 ppm. The selected trees were sprayed three times at 25% of full bloom (on 15 Dec.), 50% of full bloom (on 30 Dec.) and 75% of full bloom (on 10 Jan.), in addition, fourth spray after fruit thinning (on 15 Feb.). Each of the previous 11 spraying treatments has been supplied to 3 Florida prince peach trees.

Nano Chitosan and Silicon Preparation

The stock solution of chitosan (2% W/V) was prepared by dissolving chitosan powder in 2% acetic acid as described by **Park *et al.* (2002).** Chitosan nanoparticles was prepared by addition of 1ml aqueous tripolyphosphate solution (0.25%, w/v) to 3mL of chitosan solution under magnetic stirring. The nano chitosan particle size was characterized and described by **Qi *et al.* (2004).**

Potassium silicate of nano crystallite powder synthesized by high-energy ball milling by prof. Dr. Osama M. Hemeda at Central lab., department of physics, faculty of science, Tanta University, Egypt**.**

The responses of the tested trees to the applied treatments were evaluated through the following characteristics:

Fruit characteristics

At time of harvesting (end of April in both seasons), 10 fruits were randomly collected from each replicate to determine the following fruit characteristics:

1. Fruit length (cm) and diameter (cm) were measured by using Vernier caliper.
2. Fruit volume (cm^3): was determining by immersing fruits in water in a graduated cylinder.
3. Fruit firmness (g/cm^2) was determined by using a push pull Dynamometer.
4. Total soluble solids: acidity ratio (TSS: acid ratio).
5. Vitamin C content as mg ascorbic acid / 100 ml juice was determined by titration against 2, 6-dichlorophenol endo phenol dye as index **(AOAC, 2006).**
6. Total sugars (%): were determined in juice according to the method of Lane and Eynon as described in the **AOAC (2006).**
7. Carbohydrate percentage: were determined colorimetrically according to the method described by **Smith and Dubois (1956)**.

Leaf mineral content

The sample of leaves were taken from the third of shoot top. The middle part of the blade free from the midrib was cut. Samples of 200 g of fresh leaves were cleaned and washed several times with tap water, the leaf samples be air dried then put in an electrical furnace at 60 - 70°C for 48 h. till constant weight and finally ground. An adequate processed sample was providing to determine the following minerals:

- Total nitrogen was determined by modified microkjeldahl method as outlined by **Black *et al.* (1965).**
- Phosphorus content was determined calorimetrically according to **Chapman and Pratt (1975).**
- Potassium content was determined by using flame photometer **(Browen and Lilleland, 1964).**
- Iron, zinc and manganese were determined according to the standard method described by **Jackson (1958).** The concentration was expressed as a percentage of dry weight bases.

Statistical Analysis

The obtained data were statistically analyzed according to the randomized complete block design with 3 replicates and one tree for each replicate and subjected to analysis of variances (ANOVA) according to **Snedecor and Cochran (1990)** using CoStat program. Furthermore, means were compared using mean comparison at 0.05 level **(Duncan, 1958)**.

RESULTS AND DISCUSSION

Effect of Foliar Spray on Fruit Quality

Fruit length and diameter (cm)

It is quite evident from Table 1, that fruit dimensions; *i.e.;* length and diameter were significantly affected by the tested treatments in both seasons. However, trees sprayed with nano-chitosan, nano-silicon and potassium silicate markedly increased fruit dimensions in comparison with those of water sprayed trees. Treatments of nano-chitosan, nano-silicon and potassium silicate recorded insignificantly differences between them in the first season only. While, in the second season the longest fruits were from nano-chitosan at 20 (5.72 cm) and 30 (5.76 cm) and trees sprayed with potassium silicate at 2000 (5.82 cm) and 3000 ppm (5.84 cm) without significant differences between them. The trees sprayed with water produced the shortest length (4.97 and 4.33 cm) and diameter (5.22 and 4.75 cm) values in the first and second seasons, respectively. As a general, trees spayed with 3000 ppm potassium silicate exhibited higher dimensions than other spraying treatments, while that water spayed produced fruits with smallest length and diameter.

These results are in parallel with those reported by **Lalithya *et al*. (2014a&b)** on sapota; **El-Gioushy (2016) and Kotb and Abdel-Adl (2017)** on orange; **Mohamed (2016)** on olives; **Patil and Jagadeesh (2016)** on banana; **El Kholy *et al*. (2018)** on loquat. They indicated that, silicon or potassium silicate enhanced fruit physical properties as fruit dimensions (length and diameter).

Alwea (2018) and Elsheery *et al*. (2020) reported that, nano-silicon foliar spray improved physiochemical characteristics of mango fruits.

Grapevines were sprayed with nano chitosan exhibited significantly higher berry length **(Ibrahim *et al*., 2019)**. Also, mango foliar spray with nano chitosan improved fruit physical properties **(Alwea, 2018)**.

Fruit volume (cm^3)

Data presented in Table 1 emphasized that, fruit volume was significantly affected by the studied treatments in both seasons. Fruit volume of Florida prince peach fruits ranged between 85.00– 120.00 and 54.67 – 115.67 cm^3 in the first and second seasons, respectively. The largest fruit volume was recorded by potassium silicate at 3000 ppm (120.00 and 115.67 cm^3) in the two seasons, respectively, without significant differences between it and those treated with 600 ppm nano-silicon (113.00 cm^3) in the first season and treatments of potassium silicate at 2000 ppm (109.33 cm^3) and nano-chitosan at 20 & 40 ppm (110.00 & 114.00 cm^3) in the second one, respectively. Unsprayed trees (control) produced the lowest fruit volume (85.00 and 54.67 cm^3) in the first and second seasons, respectively. The other treatments gained intermediate fruit volumes.

Similar results were stated by application of potassium silicate or nano silicon enhanced fruit quality and increased fruit size (**Lalithya *et al*., 2014 a &b** on sapota; **Verma *et al*., 2017** on mandarin; **Youssef, 2017** on date palms; **El Kholy *et al*., 2018** on loquat; **Elsheery *et al*., 2020** on mango).

Table 1. Effect of spraying treatments on some physical characteristics of Florida prince peach fruits in 2015 and 2016 seasons

Spraying treatments		First season (2015)				Second season (2016)			
		Fruit length (cm)	Fruit diameter (cm)	Fruit firmness (g/cm^2)	Fruit volume (cm^3)	Fruit length (cm)	Fruit diameter (cm)	Fruit firmness (g/cm^2)	Fruit volume (cm^3)
Control		4.97 c	5.22 c	1774.0 a	85.00 f	4.33 d	4.75 d	1780.6 cd	54.67 g
Nano-chitosan	**10 ppm**	5.55 ab	5.76 ab	1729.0 ab	102.80 de	5.13 b	5.66 abc	1772.2 d	94.67 def
	20 ppm	5.58 ab	5.83 ab	1658.5 b	104.00 cde	5.72 a	5.93 ab	1797.2 bc	110.00 abc
	30 ppm	5.23 bc	5.55 bc	1707.0 ab	101.00 e	5.76 a	5.96 a	1798.3 bc	114.00 ab
	40 ppm	5.43 ab	5.66 ab	1706.0 ab	111.10 bc	4.73 c	4.90 c	1788.9 bcd	82.00 f
Nano-silicon	**200 ppm**	5.49 ab	5.61 ab	1774.0 a	108.47 b-e	4.72 c	5.29 c	1829.2 a	87.33 ef
	400 ppm	5.60 a	5.82 ab	1450.0 c	105.00 cde	5.31 b	5.46 bc	1805.6 b	102.00 bcd
	600 ppm	5.61 a	5.75 ab	1768.0 a	113.00 ab	4.63 cd	5.33 c	1801.4 b	102.00 bcd
Potassium silicate	**1000 ppm**	5.33 abc	5.48 bc	1743.7 a	110.00 bcd	5.27 b	5.62 abc	1797.2 bc	97.33 cde
	2000 ppm	5.36 ab	5.48 bc	1757.0 a	103.00 de	5.82 a	6.01 a	1787.5 bcd	109.33 abc
	3000 ppm	5.67 a	5.94 a	1787.3 a	120.00 a	5.84 a	6.05 a	1798.6 bc	115.67 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.

Foliar spray of chitosan or nano-chitosan improved fruit physical quality (**Zagzog *et al*., 2017, Zahedi *et al*., 2020** on mango; **Mohamed and Ahmed, 2019** on orange and **Ibrahim *et al*., 2019** on grapevine) .

Fruit firmness (g/cm^2)

It is clear from Table 1 that, peach fruit firmness was significantly affected by the spraying treatments in the two seasons. Generally, the hardness of Florida prince peach fruits was significantly affected by spraying treatments, where the values ranged between 1450.0 – 1787.3 and 1772.2 – 1829.2 g/cm^2 in the first and second seasons, respectively. Anyhow in the first season, the highest fruit firmness was gained by trees sprayed with potassium silicate at 3000 ppm (1787.3 g/cm^2) followed by other spraying treatments without significant differences between them, except the trees treated at 400 ppm nano-silicon which recorded the lowest value (1450.0 g/ cm^2). But in the second season, the trees sprayed with 200 ppm nano-silicon gave the highest fruit firmness (1829.2 g/cm^2) compared by those sprayed by water and nano-chitosan at 10 ppm which gave the lowest values (1780.6 and 1772.2 g/cm^2), respectively without significant differences between them, and the other treatments produced significantly differences in-between fruit firmness.

These results agreed with those reported by **El-Badawy (2012)** on peach, **Giacalone and Chiabrando (2015)** on nectarines, **Ahmed *et al.* (2016)** on orange, **Gad *et al.* (2016)** on peach, **Zagzog *et al*. (2017) and Zahedi *et al*. (2020)** on mango and **Mohamed and Ahmed (2019)** on orange. They stated that chitosan or nano-chitosan applications mostly had positive effects on improving fruit quality and maintained fruit pulp firmness.

The hardness or firmness and anti-stress abilities of fruits were improved and increased by using silicon (**Jia, 2011; Jia *et al*., 2011** on apple and grape; **Kotb and Abdel-Adl, 2017** on orange; **Youssef, 2017** on date palms; **El Kholy *et al*., 2018** on Loquat; **Elsheery *et al*., 2020** on mango**)**. While, **Su *et al*. (2011)** said that, the apple fruit hardness did not affect.

TSS/ acid ratio

It is clear from Table 2 that, the tested spraying treatments significantly affected TSS/acid ratio in fruit juice in the two seasons. The other treatments gave intermediate insignificantly different ratios. The TSS/acid ratio in the juice of Florida prince peach fruits ranged between 5.93 – 14.04 and 5.77 – 10.70 in the first and second seasons, respectively. Anyhow, spraying of nano-chitosan at all rates (10, 20, 30 and 40 ppm) (12.77 & 10.70, 14.04 & 8.59, 12.45 & 9.36 and 12.90 & 7.68) and nano-silicon at 200 ppm (11.28 & 8.59) and 400 ppm (12.48 & 7.91) exhibited the highest TSS/acid ratio in the fruit juice without significant differences between them in the two seasons, respectively, and those treated with potassium silicate at 2000 ppm (7.86) and at 3000 ppm (9.10) in the second season only. Control trees gained the lowest TSS/acid ratios (5.93 and 5.77) in the two seasons, respectively. TSS/acid ratio in the fruit juice was markedly increased due mainly to reducing juice total acidity percentage in each season.

These results came in line with those of **Mondal *et al*. (2013)** on mungbean, **Zagzog *et al.* (2017), Alwea, (2018)** and **Zahedi *et al*. (2020)** on mango, **Mohamed and Ahmed (2019)** on orange, **Ibrahim *et al*. (2019)** on grapevines, they reported that application of chitosan or nano-chitosan increased TSS/acid ratio in fruit juice. On the other hand, **Gad *et al.* (2016)** found that decreased TSS/acid ratio in peach fruit juice .

Similar results were stated by application of potassium silicate in normal or nano form enhanced fruit quality and increased TSS/acid ratio in fruit juice (**Su *et al*., 2011** on apple; **El-Gioushy, 2016** on orange; **Youssef, 2017** on date palms; **Abd-Elall and Hussein, 2018** on orange; **El Kholy *et al*., 2018** on loquat; **Alwea, 2018** and **Elsheery *et al*., 2020** on mango).

Juice Vitamin C content (mg ascorbic acid/ 100 ml juice)

Data illustrated in Table 2, indicated that ascorbic acid (vit. C) content in the fruit juice was significantly affected by the tested treatments in both tested seasons. However, vit. C content in Florida prince peach fruits ranged between 23.00 – 31.67 and 26.40 – 46.80 mg/ 100 ml juice in the first and second seasons, respectively. Fruits on unsprayed trees (control) produced the highest vit. C content (31.67 and 46.80 mg/100 ml juice) of juice in the two seasons, respectively, followed by those trees treated by potassium silicate at 1000, 2000 and 3000 ppm (28.67, 28.00 and 28.00 mg/100 ml juice) in the first season, respectively without significant differences between them and control and 10 nano-chitosan treatment (34.00 mg/100 ml juice) in the second one only. The lowest vit. C content (23.00 and 26.40 mg/100 ml juice) was found in fruit juice on trees treated by 20 ppm nano-chitosan in the both seasons, respectively, and trees sprayed with 200 ppm nanosilicon without significant differences between them in the first season only. The other treatments gave intermediate contents and recorded insignificant differences lower vit. C contents.

The obtained data were in line with those stated by **Jitareerat *et al.* (2007)** on mangoes and **Xing *et al*. (2015)** on jujube fruits. They showed that chitosan reduced ascorbic acid in fruit juice. On the contrast, chitosan or nano-chitosan increased ascorbic acid in fruit juice according to **Zagzog *et al*. (2017), Alwea (2018) and Zahedi *et al*. (2020)** on mango and **Mohamed and Ahmed (2019)** on orange.

Jia (2011) and **Jia *et al*. (2011)** on nectarine, **Su *et al*. (2011)** on apple fruit, **Youssef (2017)** on date palms, **El Kholy *et al*. (2018)** on loquat, **Alwea (2018)** and **Elsheery *et al*. (2020)** on mango, they found that application of silicon or nano-silicon increased ascorbic acid in fruit juice.

Table 2. Effect of spraying treatments on vitamin C, total sugars % and carbohydrate % of Florida prince peach fruit juice in 2015 and 2016 seasons

Spraying treatments		First season (2015)				Second season (2016)			
		TSS / acid ratio	Vitamin C (mg/ 100 ml)	Total sugars (%)	Carbohydrate (%)	TSS / acid ratio	Vitamin C (mg/ 100 ml)	Total sugars (%)	Carbohydrate (%)
Control		5.93 c	31.67 a	12.11 k	7.03 k	5.77 c	46.80 a	12.69 k	7.29 k
Nano-chitosan	10 ppm	12.77 a	26.00 bcd	14.05 j	7.15 j	10.70 a	34.00 a	14.67 j	7.65 j
	20 ppm	14.04 a	23.00 d	14.17 i	7.33 i	8.59 abc	26.40 c	14.93 i	7.92 i
	30 ppm	12.45 a	26.67 bcd	14.61 h	7.51 h	9.36 ab	35.60 b	15.06 h	8.02 h
	40 ppm	12.90 a	25.67 bcd	14.79 g	7.89 g	7.68 bc	32.00 bc	15.32 g	8.18 g
Nano-silicon	200 ppm	11.28 ab	23.33 d	15.28 f	8.01 f	8.59 abc	30.40 bc	15.64 f	8.55 f
	400 ppm	12.48 a	24.67 cd	15.44 e	8.19 e	7.91 abc	29.60 bc	15.93 e	8.92 e
	600 ppm	8.50 bc	26.33 bcd	16.02 d	8.42 d	7.46 bc	36.80 b	16.36 d	9.16 d
Potassium silicate	1000 ppm	8.28 bc	28.67 ab	16.29 c	8.75 c	6.75 bc	30.00 bc	16.93 c	9.37 c
	2000 ppm	8.79 bc	28.00 abc	17.05 b	9.20 b	7.86 abc	32.00 bc	17.37 b	9.72 b
	3000 ppm	8.24 bc	28.00 abc	18.78 a	9.42 a	9.10 ab	31.60 bc	19.08 a	10.18 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.

Total Sugars and Carbohydrate Percentages

Data presented in Table 2 indicated that the total sugars and carbohydrate percentages in fruit juice of Florida prince peach trees was significantly affected with spraying nano-chitosan, nano-silicon and potassium silicate in two seasons. The highest total sugars and carbohydrate percentages (18.78, 9.42, 19.08 and 10.18%) were found in fruit juice of trees sprayed with 3000 ppm potassium silicate in the first and second seasons, respectively, followed by those sprayed with 2000 and 1000 ppm potassium silicate with significant differences between them in both seasons. The lowest total sugars and carbohydrate percentages (12.11, 7.03, 12.69 and 7.29%) were recorded for trees sprayed with water (cont.) in the two seasons, respectively. The other treatments gained intermediate significantly different total sugars and carbohydrate percentages in each season.

Generally, Florida prince peach trees sprayed with potassium silicate gave total sugars and carbohydrate percentages in fruit juice (20.54, 11.49, 18.68 and 11.26% for total sugars (%), and 22.09, 11.08 and 22.92, 9.91% for carbohydrate %) higher than those treated with nano-chitosan and nano-silicon.

These results were in accordance with those found by **Ahmed *et al.* (2016)** on orange, **Mohamed and Ahmed (2019)** on sugars orange and **Hidangmayum *et al*. (2019)** on many plants. They cleared that, foliar spray of chitosan or nano-chitosan had a significant improvement of chemical fruit properties and induces production sugars in fruits.

In addition, Si applications were very effective on improving fruit quality increased sugars **(Shi *et al*. (2010)** on grapevine; **Jia, 2011 and Jia *et al*. (2011)** on apple and grapes; **Rong (2011)** on cherry; **Hanumanthaiah *et al*. (2015)** on banana; **Badran (2016)** on date palms; **El-Gioushy (2016)** on orange; **Patil and Jagadeesh (2016)** on banana; **Youssef (2017)** on date palms; **El Kholy *et al*. (2018)** on loquat; **Elsheery *et al*. (2020)** on mango**)**.

Leaf Mineral Content

Nitrogen (N), phosphorus (P) and potassium (K) percentages

As shown in Table 3, there are significant varietal differences in leaf mineral content in both seasons. Since, N percentage ranged between 1.87 – 2.44% & 1.97 – 2.91% and P percentage ranged between 0.220 – 0.387% & 0.226 – 0.396 % as well as K percentage ranged between 1.05–1.86% & 1.08 – 1.88% in the first and second seasons, respectively. The treatment of potassium silicate at 3000 ppm gained highest leaf mineral contents of N (2.44 & 2.91%), P (0.387 & 0.396%), K (1.86 & 1.88%) and significantly increase of values with other treatments in two seasons, respectively, except N% in the first season only, whereas the trees sprayed with potassium silicate at 2000 ppm gave high value insignificant differences with potassium silicate at 3000 ppm in the first season. Generally, the lowest mineral contents of N (1.87 & 1.97%), P (0.220 & 0.226%), K (1.05 & 1.08%) were recorded with nano-chitosan treatment at 10 ppm in the two seasons, respectively, also, nano-chitosan treatment at 20 ppm gained low N % (1.93%) in the first season and K% (1.13%) in the second one without significant differences with nano-chitosan at 10 ppm. The leaves of other treatments gave intermediate values of N, P and K% in both seasons.

These results were in accordance with those found by **Ahmed *et al*. (2012)** on K mango; **Al-Wasfy (2013)** on date palms; **Al-Wasfy (2014)** on grapevines; **Lalithya *et al*. (2014 a &b)** on Sapota; **Abd El-Rahman (2015)** on mango; **Mohamed *et al*. (2015)** on mango; **Rizwan *et al*. (2015)** on many plants; **Mohamed (2015)** on pomegranate; **Nagy-Dina (2015)** on grapevines; **El-Gioushy (2016)** on orange; **Kotb and Abdel-Adl (2017)** on orange; **Mohamed (2017)** on grapevines; **Verma *et al*. (2017)** on mandarin; **Elsheery *et al*. (2020)** on mango. They concluded that foliar sprays potassium silicate in normal or nano form increased leaf mineral content. The application of silicic acid enhanced uptake of essential nutrient and improving nutrient content **(Bhavya (2010)** on grapevines; **Neeru *et al*. (2016)** on rice plants and **Javaid and Misgar (2017)** on apple).

Foliar application of chitosan or nano chitosan increased leaf mineral content **(Ahmed *et al*. (2016)** on orange; **Khafagy (2018)** on grapevines; **Abdel-Aziz *et al*. (2016)** on orange; **Alwea (2018)** on mango).

Iron (Fe), zinc (Zn) and manganese (Mn) contents (ppm)

Data in Table 4 demonstrated that, leaf Fe, Zn and Mn contents (ppm) were significantly affected by the tested treatments in the two seasons. Fe content ranged between 193.25 – 284.2 & 201.60 – 292.54 ppm and Zn content ranged between 26.17 – 51.22 & 29.23 – 54.16 ppm as well as Mn content ranged between 0.228 – 0.377 & 0.237 – 0.442 ppm in the first and second seasons, respectively. The leaves on the trees were sprayed with potassium silicate at 3000 ppm recorded highest leaf Fe (284.21 & 292.54 ppm), Zn (51.22 & 54.16 ppm) and Mn (0.377 & 0.442 ppm) contents in the first and second season, respectively. Also, in the second season only leaf Mn content at all levels of nano-chitosan, nano-silicon and potassium silicate were insignificant differences between them. The least mineral contents of Fe (193.25 & 201.60 ppm) and Zn (26.17 & 29.23 ppm) from leaves trees were sprayed with nano-chitosan at 10 ppm in the two seasons, respectively, and also leaves of control gave lowest Mn content (0.228 ppm & 0.237 ppm) in the first and second season, respectively. The leaves of other treatments gave intermediate values of Fe, Zn and Mn ppm in both seasons.

The obtained findings are in agreement with those reported by **Al-Wasfy (2014)** on grapevines, **El-Gioushy (2016)** on orange, **Kotb and Abdel-Adl (2017)** on orange and **Alwea (2018)** on mango. They indicated that leaf Fe, Zn, Mn and Cu contents were increased by all investigated silicate spray treatments in normal or nano form.

Ahmed *et al*. (2016) on orange and **Alwea (2018)** on mango, they mentioned that foliar spray of chitosan or nano-chitosan increased values of Zn in leaves.

Table 3. Effect of spraying treatments on N, P and K percentages in Florida prince peach leaves in 2015 and 2016 seasons

Spraying treatments		First season (2015)			Second season (2016)		
		N content (%)	P content (%)	K content (%)	N content (%)	P content (%)	K content (%)
Control		2.19 d	0.320 d	1.23 h	2.24 fg	0.327 d	1.30 e
Nano-chitosan	10 ppm	1.87 g	0.220 k	1.05 k	1.97 i	0.226 j	1.08 g
	20 ppm	1.93 g	0.232 j	1.12 j	2.15 h	0.247 i	1.13 g
	30 ppm	2.08 ef	0.254 i	1.18 i	2.29 e	0.263 h	1.20 f
	40 ppm	2.18 d	0.276 h	1.29 f	2.40 d	0.288 g	1.31 e
Nano-silicon	200 ppm	2.05 f	0.287 g	1.24 g	2.19 gh	0.299 f	1.25 ef
	400 ppm	2.14 de	0.293 f	1.38 e	2.27 ef	0.3030 f	1.38 d
	600 ppm	2.27 c	0.304 e	1.42 d	2.35 d	0.314 e	1.43 cd
Potassium silicate	1000 ppm	2.33 b	0.349 c	1.46 c	2.52 c	0.352 c	1.46 c
	2000 ppm	2.44 a	0.361 b	1.62 b	2.73 b	0.374 b	1.64 b
	3000 ppm	2.44 a	0.387 a	1.86 a	2.91 a	0.396 a	1.88 a

Table 4. Effect of spraying treatments on Fe, Zn and Mn contents (ppm) in Florida prince peach leaves in 2015 and 2016 seasons

Spraying treatments		First season (2015)			Second season (2016)		
		Fe content (ppm)	Zn content (ppm)	Mn content (ppm)	Fe content (ppm)	Zn content (ppm)	Mn content (ppm)
Control		221.13 e	42.22 d	0.228 i	229.46 e	44.98 d	0.237 b
Nano-chitosan	10 ppm	193.25 k	26.17 k	0.254 h	201.60 k	29.23 k	0.371 ab
	20 ppm	200.36 j	27.37 j	0.272 g	208.55 j	31.03 j	0.384 ab
	30 ppm	209.86 i	30.76 i	0.299 e	217.65 i	33.39 i	0.307 ab
	40 ppm	218.78 g	34.12 g	0.311 c	226.70 g	37.03 g	0.323 ab
Nano-silicon	200 ppm	215.13 h	33.03 h	0.291 f	223.45 h	36.09 h	0.300 ab
	400 ppm	220.43 f	36.52 f	0.305 d	228.67 f	39.28 f	0.314 ab
	600 ppm	237.27 d	40.712 e	0.312 c	245.40 d	43.37 e	0.320 ab
Potassium silicate	1000 ppm	244.12 c	44.09 c	0.304 d	252.67 c	47.01 c	0.312 ab
	2000 ppm	266.28 b	46.37 b	0.319 b	274.77 b	49.20 b	0.327 ab
	3000 ppm	284.21 a	51.22 a	0.377 a	292.54 a	54.16 a	0.442 a

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تأثير رش النانوشيتوزان والنانوسيليكون على صفات الجودة الطبيعية والكيماوية للثمار والمحتوى المعدني لأوراق أشجار الخوخ فلوريدا برنس

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أجريت هذه الدراسة خلال موسمين متتاليين 2016 و 2017 على أشجار خوخ صنف فلوريدا برنس عمر 5 سنوات ومنزرعة في تربة رملية سلتية على مسافة 3 × 5 متر تحت نظام الري بالتنقيط لبستان خوخ خاص بمركز بلبيس بمحافظة الشرقية ، مصر. تم رش الأشجار المختبرة بالنانوشيتوزان بمعدلات 10، 20، 30 و 40 جزء في المليون ، النانوسيليكون بمعدلات 200، 400 و 600 جزء في المليون و سليكات البوتاسيوم بمعدلات 1000، 2000 و 3000 جزء في المليون بالأضافة للرش بالماء (معاملة الكنترول). أظهرت النتائج أن رش النانوشيتوزان بجميع معدلاته أعطي أعلى نسبة مواد صلبة ذائبة/ الحموضة في عصير الثمار دون وجود فروق معنوية بينهم في الموسمين. احتوت ثمار الأشجار غير المعاملة على أعلى محتوى من فيتامين ج مقارنة بالمعاملات الأخرى. كما أعطى رش سليكات البوتاسيوم بمعدل 3000 جزء في المليون أعلى نسبة من السكريات الكلية والكربوهيدرات. وأعطت معاملة سليكات البوتاسيوم بمعدل 3000 جزء في المليون أعلى محتوى لعناصر النيتروجين، الفوسفور، البوتاسيوم، الحديد، الزنك والمنجنيز بالأوراق، بينما أعطت معاملة الكنترول والنانوشيتوان بمعدل 10 جزء في المليون أقل محتوي من عناصر الحديد والزنك والمنجنيز.

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