# Response of Growth, Flowering and Fruiting of Florida Prince Peach Trees to Spraying with Nanochitosan and Nanosilicon

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**Abstract:** This study was carried out in the two seasons of 2017 and 2018 on five-year-old peach Florida prince cv. trees grown in sandy silt soil at 3×5 m apart under drip irrigation system of a private peach orchard located at Sharkia Governorate, Egypt. The trees were 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 the highest yield / tree, number of harvested fruits / tree and fruit weight for trees treated with nano-chitosan at 10 and 20 ppm in comparison with those sprayed with water and other treatments. Trees were sprayed by nano-silicon at all rates gained the greatest number of flowers/ branch, flower density and fruit set percentage. The trees sprayed with nanosilicon at 600 ppm recorded longest shoot length, largest shoot diameter and highest leaves number/ shoot, while, least values of them were from unsprayed trees (control). The largest leaf area was recorded for trees were sprayed with nano-silicon at 200 ppm, 400 ppm and 600 ppm without significant differences between them.
**Keywords:** Peach; Nano; silicon; chitosan; flowering; yield; fruit quality

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## 1 Introduction

Peach is one of the most popular deciduous fruit crops in the world and Egypt, mainly because of their dessert flavor (Bekheit and Latif, 2013). 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). In Egypt cultivated area with peach reached 70674 feddans out of them 66160 feddans are fruitful producing about 358012 tonnes with an average of 9.55 ton/fed. (FAOSTAT, 2020). 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. Also, the production and commercialization of stone fruits like peaches have increased briskly throughout the world (Stino et al., 2010).

Nano-fertilizers are an effective alternative to traditional fertilizers, as they achieve many advantages due to their use with lower chemicals and the speed of absorption by the plant and their high stability under different conditions, which increases the ability to store them for longer periods, also be used to detect and treat diseases by increasing crop production, improving their quality and ensuring crop sustainability. The use of Nano applications on fruit trees contributes very effectively to improving the quality of fruits and increasing the productivity of

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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 is non-toxic, non-allergenic, edible and safe for domestic animals (Hirano et al., 1990). It is a low acetyl form of chitin mainly composed of glucosamine, 2 - amino – 2 - deoxy – β - D-glucose (Freepons, 1991). Chitosan has been used in agriculture as a coating material for vegetables, fruitsand seeds (Photchanachai *et al.,* 2006), and for controlled agrochemical release of fertilizers (Sukwattanasinitt et al., 2001). Very few efforts were done to study the effect of chitosan on plant growth, development and productivity, which is mainly attributed to stimulation of plants immunity against microorganisms (bacteria and fungi) (Sereih et al., 2007; Gornik et al., 2008). Recently, some researchers reported that chitosan enhanced plant growth and development (Khan et al., 2002; Chibu et al., 2003), they reported that 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.

Silicon is a very important part of the earth's crust and is the second most abundant element after oxygen, consisting about 28 % of the earth's crust (Sommer *et al.,* 2006). Although all plants contain Si at different concentrations according to species, ranging from <0.1 to >10% in dry weight, but it is not considered an essential element for normal plant growth and development (Ma and Yamaji, 2008; Imtiaz et al., 2016). According to a more recent definition of the essentiality of elements proposed by Epstein (2009). Plants can only absorb Si in the form of soluble mono silicic acid, a non-charged molecule. Silicon has a beneficial effect on plants, but crop plants differ radically in their ability to take up and accumulate this element (Savant et al., 1999).

The aim of this study is improving growth, flowering, fruit set and yield of Florida prince peach trees by using some natural growth promoters (chitosan and silicon in Nano form) as alternatives to synthetic growth regulators.

## 2 Materials and methods

This study carried out during two consecutive seasons of 2017 and 2018 on five-year-old peach Florida prince cv. trees (*Prunus persica* L.). The trees were grown in a private peach orchard at Belbies district, Sharkia Governorate, Egypt. The trees were planted at 3 x 5 m apart, in sandy silt soil under drip irrigation system. The usual agriculture practices for peach trees in the orchard were adapted to all trees. The peaches trees were submitted to eleven treatments as follows: Spray trees with 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 (in15 Dec.), 50% of full bloom (in30 Dec.) and 75% of full bloom (on 10 Jan.), in addition, fourth spray after fruit thinning (in 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 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:

## 2.1 **Flowering characteristics:**

2.1.1 Number of flowers/shoot

Number of flowers/shoot was count at cessation of flowering.

2.1.2 Flowering density

Flowering density was counted according to Equation (1).

$$FD = \frac{A \times B}{C} \text{ (Flowers/100 cm)} \qquad (1)$$

Where, A is the average number of flowers is found in a shoot of 100 cm length;

B is the average number of flowers/ one select shoot;

C is the length of selected shoots, cm.

2.1.3 Fruit set %

Fruit set was recorded after 75% of petal fall. Date was tabulated as fruit – set percentage of perfect flowers according to Equation (2):

$$Fruit\ set = \frac{Number\ of\ set\ fruitles}{Total\ number\ of\ flowers} \times 100 \qquad (2)$$

## 2.2 **Yield and its components**

2.2.1 Fruit number/tree

The number of fruits per replicate tree were estimated at mature stage.

2.2.2 Fruit weight (g)

At time of harvesting (end of April in both seasons),10 fruits were randomly collected from each replicate to determine fruit weight.

2.2.3 Fruit yield (kg/tree)

A maturity stage average weight of fruit (kg) per tree was determined in each tree.

2.4 Fruit retention (%)

The number of harvested fruits on the shoots tagged per tree were count. The percent of fruit retention was calculated according to Equation (3):

$$Fruit\ retention\% = \frac{Number\ of\ harvested\ fruits}{Number\ of\ set\ fruitlets} \times 100 \qquad (3)$$

## 2.3 **Vegetative growth**

2.3.1 Length of shoot (cm) and diameter (mm)

Length of shoot and diameter should be estimated.

2.3.2 Number of leaves/shoo

The average number of leaves per one shoot in the spring flush were counted at cessation of shoot growth.

2.3.3. Leaf area ($cm^2$)

The leaf samples were taken from the middle part of the shoot of the spring flush and the leaf area ($cm^2$) was determined by using the following equation according to Demirsoy et al. (2004).

$$\text{Leaf area } (cm^2) = -0.5 + 0.23\,[L/W] + 0.67\,LW \qquad (4)$$

Where, $L$ is leaf length and $W$ is leaf width.

### **2.4 Statistical analysis**

The obtained data were statistically analyzed according to the complete randomized block design with 3 replicates and one tree for each replicate (33 tree/ experiment) 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).

## **3 Results**

### **3.1 Effect of foliar spray on floral aspects**

3.1.1 Number of flowers per branch

Data in Table (1) revealed that the treatments improved number of flowers/branches throughout the studied seasons. Trees were sprayed by nano-silicon at 600 and 400 ppm and 30 ppm nano-chitosan recorded a significant difference in number of flowers/ branch (19.33, 21.33 and 21.33 flowers respectively) in the first season 2017 and (21.67 and 21.33 flowers) in the second season 2018, respectively, compared with all treatments in the two seasons. The lowest number of flowers/ branch (13.67 and 9.33 flower) were gained by trees sprayed with water (control) in the first and second seasons, respectively, and 10 ppm nano-chitosan and potassium silicate at 2000 & 3000 ppm.

3.1.2 Flowering density (flowers/ 100 cm)

The tested treatments improved the flowering density in the two seasons (Table, 1). Trees sprayed with nano-silicon at 200 and 400 ppm gave the highest flowering density values (8.61 and 9. 63 flowers/ 100 cm), followed by unsprayed trees without significant differences between them in the first season. While, in the second season, most of nano-chitosan and nano-silicon treatments induced insignificantly differences of flowering density and also with potassium silicate at 2000 ppm. The lowest flowering density values (3.02 and 3.46 flowers/ 100 cm) were by potassium silicate at 3000 and 2000 ppm in the first season and unsprayed treatment (1.99 flowers/ 100 cm) in the second one.

3.1.3 Fruit set percentage

Data presented in Table (1) indicated that, there are significant differences in fruit set percentage in both seasons. The uppermost values of fruit set percentage were recorded from treatments of nano-silicon at 400 and 600 ppm (86.21 and 95.31 %) and also nano-chitosan at 30 and 40 ppm (78.25 and 80.15 %) without significant differences between them in the first season. In the second season, all trees were sprayed with nano-chitosan at 10, 20, 30 and 40 ppm (88.79, 90.08, 90.56 and 88.23 %), nano-silicon at 200, 400 and 600 ppm (89.04, 87.60 and 87.56 %) and potassium silicate at 1000 and 3000 ppm (92.11and 87.52 %) produced highest fruit set percentage without significant differences between them except the trees were sprayed with potassium silicate at 2000 ppm (79.78%) and control recorded lowermost fruit set percentages. The least fruit set percentages (42.13 and 64.44 %) were for unsprayed trees (control) in the two seasons respectively.

3.1.4 Fruit retention (%)

It is clear from Table (1) that the tested treatments improved fruit retention percentage in both seasons. Treatments of nan-chitosan at 10 ppm (91.04 and 79.61%) and nano-silicon at 200 ppm (77.66 and 89.04), 400 ppm (91.67 and 84.33%) and 600 ppm (94.44 and 87.56 %) and potassium silicate at 1000 ppm (95.24 & 88.56%) exhibited the highest fruit retention percentages in the first and second season, respectively without significant differences between them, and also insignificant differences with treatments of nano-chitosan at 20 & 30 ppm and potassium silicate at 3000 ppm in the second season only. The unsprayed trees (control) showed the lowest fruit retention percentage (49.13 and 57.41 %) in the two seasons, respectively.

**3.2 Effect of foliar spray on yield and its components**

3.2.1 Fruit yield (kg/tree)

Data in Table (2), demonstrated that significantly affected fruit yield (kg/ tree) in both seasons. Fruit yield ranged between 36.51 – 167.75 and 38.55 – 162.83 kg/ tree in the two seasons, respectively. The untreated peach trees (control) produced the lowest yield/ tree (36.51 and 38.55 kg/ tree) in the two studied seasons, respectively. The greatest yield was recorded by sprayed trees with nano-chitosan at 10 ppm (161.04 and 159.42 kg/ tree) and 20 ppm (167.75 and 162.83 kg/ tree), without significant differences between them in the first and second seasons, respectively. The yield of trees sprayed with nano-chitosan, nano-silicon and potassium silicate were (287.89 % and 249.52 %), (238.10 % and 180.13 %) and (151.1 %9 and 139.40 %) higher than those sprayed with water in the first and second seasons, respectively. Trees sprayed with nanochitisan produced higher yield than those sprayed with nano-silicon (14.73 % and 24.77 %) and potassium silicate (54.47 % and 45.99 %) in the two seasons, respectively. As for trees sprayed with nano-silicon significantly higher yield (34.64 % and 17.01 %) compared to those produced by tress sprayed with potassium silicate in the two seasons, respectively.

3.2.2 Number of fruits / tree

It is obvious from Table (2), that the number of harvested fruits was significantly affected by spraying treatments in the two seasons. Trees sprayed with nano-chitosan at 10 and 20 ppm produced larger number of fruits/ tree (1493.3 &1513.3 and 1495.0 &1516.7) in the first and second season, respectively without significant differences between them. The least number of fruits/ tree (374.0 and 421.7 fruit/ tree) came from unsprayed trees in the two seasons, respectively. Trees sprayed with nano-silicon and potassium silicate gained intermediate number of fruit/ trees in both seasons. The number of fruits/ tree was significantly greater with nano-silicon treatments than those with potassium silicate treatments in the two seasons.

**Table 1 Effect of spraying treatments on number of flowers/ branch, flowering density and fruit set percentages of Florida prince peach trees in 2017 and 2018 seasons**

| Spraying treatments | | First season (2017) | | | | Second season (2018) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | No. of flowers/ branch | *Flowering density | Fruit set % | Fruit retention (%) | No. of flowers/ branch | *Flowering density | Fruit set % | Fruit retention (%) |
| Control | | 13.67 e | 7.20 abc | 42.13 d | 49.13 e | 9.33 f | 1.99 d | 64.44 c | 57.41 d |
| Nano-chitosan | 10 ppm | 16.00 cde | 5.40 cd | 72.20 bc | 91.04 ab | 15.00 de | 4.05 ab | 88.79 a | 79.61 abc |
| | 20 ppm | 17.67 bc | 5.36 cd | 69.85 bc | 64.94 cde | 16.67 cde | 3.51 abc | 90.08 a | 84.07 abc |
| | 30 ppm | 19.33 ab | 6.35 bc | 78.25 ab | 73.25 bc | 17.33 cd | 4.37 a | 90.56 a | 81.13 abc |
| | 40 ppm | 16.67 bcd | 5.18 cd | 80.15 ab | 72.22 bcd | 14.00 e | 3.50 abc | 88.23 a | 74.40 c |
| Nanosilicon | 200 ppm | 18.67 abc | 8.61 ab | 57.04 cd | 77.66 abc | 18.33 bc | 4.00 ab | 89.04 a | 89.04 a |
| | 400 ppm | 21.33 a | 9.63 a | 86.21 ab | 91.67 ab | 21.33 ab | 4.56 a | 87.60 a | 84.33 abc |
| | 600 ppm | 21.33 a | 5.20 cd | 95.31 a | 94.44 a | 21.67 a | 3.30 a-d | 87.56 a | 87.56 ab |
| potassium silicate | 1000 ppm | 16.67 bcd | 4.96 cd | 43.44 d | 95.24 a | 16.67 cde | 2.82 bcd | 92.11 a | 88.56 a |
| | 2000 ppm | 14.33 de | 3.46 d | 71.53 bc | 52.69 de | 16.33 cde | 3.20 a-d | 79.78 b | 75.61 bc |
| | 3000 ppm | 14.67 de | 3.02 d | 56.92 cd | 71.59 cd | 13.67 e | 2.24 cd | 87.52 a | 77.95 abc |

*Flowers/100 cm

a, b, c, d, e 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 2 Effect of spraying treatments on yield (kg/ tree) and yield components of Florida prince peach trees in 2017 and 2018 seasons**

| Spraying treatments | | First season (2017) | | | | | Second season (2018) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Fruit number/ tree | Fruit weight (g) | Fruit yield/ tree | | | Fruit number/ tree | Fruit weight (g) | Fruit yield/ tree | | |
| | | | | (kg) | Av. / material | ± (%) | | | (kg) | Av. / material | ± (%) |
| Control | | 374.0 e | 97.71 c | 36.51 g | 36.51 | - | 421.7 f | 76.67 e | 38.55 e | 38.55 | - |
| Nano-chitosan | 10 ppm | 1493.3 a | 107.78 ab | 161.04 ab | 141.62 | 287.89 | 1495.0 a | 106.67 ab | 159.42 a | 134.74 | 249.52 |
| | 20 ppm | 1513.3 a | 110.84 ab | 167.75 a | | | 1516.7 a | 106.67 ab | 162.83 a | | |
| | 30 ppm | 1113.7 bc | 109.25 ab | 126.62 cde | | | 1120.3 bc | 113.33 a | 127.26 b | | |
| | 40 ppm | 1154.7 bc | 99.41 c | 111.06 def | | | 1160.0 bc | 76.67 e | 89.44 cd | | |
| Nanosilicon | 200 ppm | 983.3 cd | 97.20 c | 95.60 f | 123.44 | 238.10 | 996.7 cd | 80.00 de | 79.53 d | 107.99 | 180.13 |
| | 400 ppm | 1270.0 b | 106.12 b | 134.74 cd | | | 1276.7 b | 90.00 cd | 116.62 bc | | |
| | 600 ppm | 1271.0 b | 109.95 ab | 139.98 bc | | | 1278.3 b | 100.00 bc | 127.83 b | | |
| potassium silicate | 1000 ppm | 956.7 cd | 105.37 b | 100.76 ef | 91.68 | 151.19 | 965.0 cde | 100.00 bc | 96.22 cd | 92.29 | 139.40 |
| | 2000 ppm | 873.3 d | 98.92 c | 86.47 f | | | 888.3 de | 100.00 bc | 88.53 cd | | |
| | 3000 ppm | 780.3 d | 112.67 a | 87.90 f | | | 791.7 e | 116.67 a | 92.13 cd | | |

± (%) = increase or decrease (%) in relation to control.

a, b, c, d ,e, f 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.

3.2.3 Fruit weight (g)

As shown in Table (2), that weight of peach fruits was significantly affected by the studied spraying treatments during the two seasons. The striking effect and heaviest fruit weight were for trees sprayed with nano-chitosan at 10 ppm (107.78 and 106.67 g), 20 ppm (110.84 and 106.67 g), 30 ppm (109.25 and 113.33 g) and potassium silicate at 3000 ppm (112.67 and 116.67 g) in the first and second seasons, respectively, without significant differences between them, and those sprayed with nano-silicon at 600 ppm (109.95 g) in the first season only. The smallest fruits weight was from control trees sprayed with water (97.71 and 76.67 g), nano-chitosan at 40 ppm (99.41 and 76.67 g) and nano-silicon at 200 ppm (97.20 and 80.00 g) without significant differences between them in the two seasons, respectively, and those sprayed with potassium silicate at 2000 ppm (98.92 g) in the first season only.

### 3.3 Effect of foliar spray on vegetative growth

3.3.1 Shoot length (cm)

As shown in Table (3), the longest shoot length (93.50 & 120.92 cm) was recorded for trees sprayed with nano-silicin at 600 ppm in the two seasons, respectively. Unsprayed trees (control) induced the shortest shoot length (56.17 and 66.51 cm) in the first and second seasons, respectively. Trees sprayed with nano-chitosan at 20, 30 and 40 ppm and potassium silicate at 1000, 2000 and 3000 ppm in the first season, as well as those sprayed with nano-silicon at 400 ppm and potassium silicate at 1000 & 3000 ppm in the second season gave intermediate shoot length and higher values than control trees without significant differences between them in each season.

3.3.2 Shoot diameter (mm)

The obtained data in Table (3) clear that the trees sprayed with nano-silicon at 600 ppm gained the largest shoot diameter (5.47 and 6.13 mm) in the first and second season, respectively without significant differences between it and those sprayed with nano-chitosan at 20 and 30 ppm and nano-silicon at 200 ppm in the first season as well as those subjected to spray by 400 ppm nano-silicon in the second one. Trees spayed with water produced the least shoot diameter (2.71 and 3.16 mm) in the two seasons, respectively. The other treatments induced insignificantly different intermediate leaf areas in the two seasons.

3.3.3 Number of leaves/shoot

It is clear from Table (3) that the leaf number/ shoot of peach trees significantly affected by spraying treatments during the two seasons. Trees sprayed with 600 ppm nano-silicon gained the highest leaves number/ shoot (68.55 and 95.42 leaves/shoot) in the first and second season, respectively, without significant differences between it and those sprayed with 20 ppm nano-chitosan (63.00 leaves/shoot) and 2000 ppm potassium silicate (64.65 leaves/shoot) in the first season only. Whereas, the lowest leaves number/ shoot was recorded for trees sprayed with water (40.60 and 43.67 leaves/ shoot) and 10 ppm nano-chitosan (42.15 and 48.22 leaves/ shoot) in the two seasons, respectively, and insignificant differences with those treated by nano-silicon at 400 ppm in the first season only. The other spraying treatments produced in-between number of leaves/shoot with significant differences between most of them .

**Table 3 Effect of spraying treatments on some growth physical characteristics of Florida prince peach trees in 2017 and 2018 seasons**

| Spraying treatments | | First season (2017) | | | | Second season (2018) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Shoot length (cm) | Shoot diameter of (mm) | Number of leaves/ shoot | Leaf area ($cm^2$) | Length of shoot (cm) | Diameter of shoot (mm) | Number of leaves/ shoot | Leaf area ($cm^2$) |
| Control | | 56.17 f | 2.71 d | 40.60 e | 46.67 ab | 66.51 f | 3.16 f | 43.67 g | 45.25 ef |
| Nanochetosan | 10 ppm | 70.08 cd | 4.58 b | 42.15 e | 46.72 ab | 75.17 ef | 4.60 de | 48.22 fg | 47.55 def |
| | 20 ppm | 76.37 b | 5.29 a | 63.00 abc | 48.79 a | 89.75 cd | 4.87 cde | 64.08 de | 48.13 def |
| | 30 ppm | 77.19 b | 5.27 a | 58.15 c | 38.84 c | 83.50 de | 5.08 cde | 71.83 cd | 45.14 ef |
| | 40 ppm | 73.42 bcd | 4.67 b | 62.05 bc | 40.18 bc | 75.58 ef | 4.56 e | 56.33 ef | 42.58 f |
| Nanosilicone | 200 ppm | 63.62 e | 5.12 a | 58.15 c | 45.96 ab | 92.17 bcd | 5.17 bc | 70.75 cd | 53.91 abc |
| | 400 ppm | 69.00 de | 4.50 b | 46.15 de | 50.23 a | 100.08 bc | 5.62 ab | 79.83 bc | 58.78 a |
| | 600 ppm | 93.50 a | 5.47 a | 68.55 a | 50.13 a | 120.92 a | 6.13 a | 95.42 a | 56.58 ab |
| Potassium silicate | 1000 ppm | 75.17 bc | 4.28 bc | 50.86 d | 47.54 a | 102.08 b | 5.34 bc | 75.53 bc | 48.85 cde |
| | 2000 ppm | 77.00 b | 4.45 b | 64.65 ab | 47.98 a | 91.25 cd | 5.13 bcd | 82.75 b | 51.05 bcd |
| | 3000 ppm | 78.83 b | 3.87 c | 44.70 de | 44.20 abc | 91.75 bcd | 5.23 bc | 77.33 bc | 49.69 cde |

a, b, c, d ,e, f 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.

3.3.4 Leaf area ($cm^2$)

As shown in Table (3), the leaf area of Florida prince peach ranged between 38.84 – 50.23 $cm^2$ in the first season and 42.58 – 58.78 $cm^2$ in the second one. However, the largest leaf area was recorded for trees sprayed with nano-silicon at 200 ppm (45.96 and 53.91 $cm^2$), 400 ppm (50.23 and 58.78 $cm^2$) and 600 ppm (50.13 and 56.58 $cm^2$) in the first and second season, respectively without significant differences between them, and other treatments of silicic acid at all rates and nano-chitosan at 10 & 20 ppm and control in the first season only with insignificant differences between them and the high values leaf area. The smallest leaf area was produced from the trees sprayed with nano-chitosan at 30 (38.84 & 45.14 $cm^2$) and 40 ppm (40.18 & 42.58 $cm^2$) in the first and second seasons, respectively with insignificant differences between them and also trees sprayed with nano-chitosan at 10 ppm (47.55 $cm^2$) & 20 ppm (48.13 $cm^2$) and control (45.25 $cm^2$) produced small leaf without significant differences between them in the second season only.

## 4 Discussion

Our results indicated that 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 (Khan et al., 2002; Chibu et al., 2003).

Silicon should be considered an essential element for higher plants because silicon deprived plants tend to grow abnormally, whereas silicon supplemented plants grow normally (Agarie et al., 1992; Artyszak, 2018). Silicon provides strength and rigidity to the cell wall, improves growth, health and productivity (Rafi et al., 1997). 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, building of carbohydrates and natural growth regulators (Gang et al., 2003).

These results are consistent with those obtained by Mondal et al. (2013) on mungbean, they indicated that number of flowers/plant increased by using chitosan. Roshdy (2014) concluded that applications of potassium silicate were very effective in stimulating all growth characters and flowering. The promotive effect of potassium silicate on fruit set and fruit retention percentages was in harmony with Ahmed et al. (2012); Abd El-Rahman (2015); Alwea (2018) on mango; El-Gioushy (2016); Kotb and Abdel-Adl (2017) on orange and El Kholy et al. (2018) on Loquat.

The present study revealed that foliar application of nano-chitosan increased yield of peach Florida prince cv. trees and improved the vegetative growth and fruit quality, this was in harmony with those reported by Zagzog et al. (2017); Alwea (2018) and Zahedi et al. (2020) on mango and Ibrahim et al. (2019) on grapevine.

Yield promotion by silicon was in agreement with those reported by More et al. (2017); Verma et al. (2017); Alwea (2018); El Kholy et al. (2018) on different fruit trees and also on rice (Zhang et al., 2007 and Shang et al., 2009). Elsheery et al. (2020), they showed that foliar spray of nano-silicon improved mango fruit yield.

These findings were in line with Zagzog et al. (2017) and Alwea (2018) on mango; Ibrahim et al. (2019) on grapevine and Zahedi et al. (2020) on fruit crops. They mentioned that foliar application of chitosan or nano-chitosan increased number of fruits/ trees.

The obtained data showed that number of fruits per tree was significantly increased with foliar spray of potassium silicate, this was in accordance with those stated by El-Gioushy (2016), Kotb and Abdel-Adl (2017) on orange, Alwea (2018) and El Kholy et al. (2018) on Loquat.

These results demonstrated that foliar spray of nano-chitosan increased fruit weight, this was in line with those reported by Ahmed et al. (2016), Zagzog et al. (2017), Alwea (2018) and Zahedi et al. (2020)

on mango; Mohamed and Ahmed (2019) on orange and Ibrahim et al. (2019) on grapevine.

The positive effect of silicon or nano-silicon spray on fruit weight was in harmony with those obtained by Lalithya et al. (2014 a; b) on sapota; Badran (2016); Youssef (2017) on date palms; El-Gioushy (2016); Kotb and Abdel-Adl (2017); Abd-Elall and Hussein (2018) on orange; Mohamed (2016) on olives; Patil and Jagadeesh (2016) on banana; El Kholy et al. (2018) on loquat; Alwea (2018); Elsheery et al. (2020) on mango.

The obtained results are in line with those found by Mohamed (2015) on pomegranate, Nagy-Dina (2015) on grapevines, Kotb and Abdel-Adl (2017) on orange, Mohamed (2017) on grapevines. They mentioned that shoot length was significantly increased by silicon treatments. The response of grapevine to foliar silicic acid was examined by Bhavya (2010); Bhavya (2010) who found that silicic acid increased cane length.

Mondal et al. (2013) showed that chitosan increased plant height, branch, leaf number/plant and leaf area of mungbean. Alwea (2018) on mango showed that chitosan or nano-chitosan increased leaf area. While, Iriti et al. (2009) mentioned that chitosan not affected on plant height and leaf area.

The obtained results indicated that applications of potassium silicate increased growth and leaf area, this was in agreement with those reveled by Al-Wasfy (2013) on date palms, Al-Wasfy (2014) on grapevines, Mohamed (2015) on pomegranate, Nagy-Dina (2015) on grapevines and Mohamed (2016) on olives, Mohamed (2017) on grapevines and Alwea (2018) on mango. Mohamed (2015) on pomegranate; Kotb and Abdel-Adl (2017) on orange; Youssef (2017) on date palms, they found that foliar spray of potassium silicate increased number of leaves/shoot in fruit trees.

Analogical results were found by Katiyar et al. (2015); Zagzog et al. (2017); Khafagy (2018); Hidangmayum et al. (2019); Zahedi et al. (2019), they indicated that growth of different plants increased by using of chitosan or nano-chitosan.

In addition, applications of silicon or nano-silicon increased growth of different fruit trees and other plants (Sahebi et al., 2015; Xie et al., 2015; Rizwan et al., 2015; Neeru et al., 2016; Laane, 2017 and 2018; More et al., 2017; Elsheery et al., 2020). The response of grapevine to foliar silicic acid was examined by Bhavya (2010 and 2011), who found that silicic acid increased leaf area.

## 5 Conclusion

The tested spraying treatments exhibited that the 10 or 20 ppm nanochitosan is the best economic treatment to which mature Florida prince peach trees, without compromising vegetative growth, yield and fruit quality of the sprayed trees. Also, exhibited the highest values of the considered parameters recording approximately similar values, descendingly followed by those sprayed at 400 ppm nanosilicon, 600 ppm nanosilicon and 30 ppm nanochitosan treatments. The lowest values were recorded for water sprayed trees.

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