*Assiut J. Agric. Sci., (50) No. (2) 2019 (206-218)* *ISSN: 1110-0486*
***Website:*** *www.aun.edu.eg/faculty_agriculture/journals_issues_form.php* ***E-mail: ajas@aun.edu.eg***

# Effect of Foliar Application of Zinc, Boron and Silicon on Growth and Fruiting of Balady Mandarin Trees

***Masoud, A.A.B.; Fatma El-Zahraa M. Goudaand O.A. Khodair**

[1]Pomology Department, Fac. Agric, Assiut University, Assiut, Egypt.
[2]Horticulture Dept., Fac. Agric., Al-Azhar University, Assiut, Egypt.
*Email: alaa.masoud@agr.aun.edu.eg

**Received on: 24/2/2019** **Accepted for publication on:27/2/2019**

## Abstract

This study was carried out at the experimental orchard, Faculty of Agriculture, Assiut University, Egypt, to investigate the effect of boron, zinc and silicon foliar spray on growth and fruiting of Balady mandarin trees during 2016 and 2017 seasons.

The experiment was arranged in a randomized complete block design with three replications per treatment, one tree each. Boric acid (17% B), zinc sulphate (23% Zn) and potassium silicate (25% Si + 10% $K_2O$) were sprayed three times on March, May and August.

The obtained results could be summarized as follow:

Spraying either boron, zinc or silicon singly or in combination significantly increased the growth traits and the total chlorophyll as well as the total carbohydrates, nitrogen content and C/N ratio of shoots compared to water spraying (control).

The maximum values of these traits were recorded on trees that were sprayed with combination of 0.025% boron, 0.050% zinc and 0.10% silicon followed by silicon, zinc and boron spray, boron or zinc as well as zinc or silicon.

All treatments significantly increased the fruit retention percentage and yield/tree compared to the untreated one.

All foliar application treatments improved the fruit quality in terms of increasing the fruit weight, pulp percentage, total soluble solids, sugar and vitamin C contents and decreasing the total acidity compared to spraying water (control). The best fruit quality was recorded when the trees were sprayed with combination of boron, zinc and silicon.

It is evident from the foregoing results that the foliar application of boron, zinc, silicon alone or combination improved the tree nutrient status, yield and fruit quality.

As a conclusion it is suggested to use boric acid at 0.050%, zinc sulphate at 0.10% and potassium silicate at 0.2% (as a source of silicon) alone or a combination of boron 0.025, zinc 0.050 and silicon 0.10% three times during growth season for improving the growth and fruiting of Balady mandarin trees.

***Keywords:*** *Foliar, Boron, Zinc, Silicon, Balady mandarin, Yield, Fruiting.*

## Introduction

Citrus is one of the most important horticultural crops in the world as well as in Egypt. It has a tremendous economical impact not only in the local market, but also for export. The total area devoted for citrus grown in Egypt is estimated as 530.415 feddan producing 4.402.180 ton of fruit with an average of 9.4

ton/fed. Mandarin trees are ranked in Egypt as the second citrus species after orange, representing 21.7% of the total citrus production (Ministry of Agriculture Statistics, (M.A.L.R.) 2016).

Citrus orchards are facing problems of fruit size, color, quality and excessive premature fruit drop which are due to the deficiencies of essential nutrients (Ibrahim *et al*., 2007). Nowadays, many efforts have been established for finding out the best horticulture practices that are responsible for enhancing yield and fruit quality of balady mandarin trees. Using zinc, boron and silicon are considered the best treatment for solving the problem of yield decline and inferior fruit quality of citrus trees. Produce yield with poor quality due to of micronutrients deficiencies. Citrus growers often use micronutrient fertilizers (Catara, 1987). Foliar spray of micronutrients has been reported to be more effective than soil applications in curing their deficiencies in citrus. Different workers suggested that the application of suitable combinations of macro- and micronutrients can control the fruit trees yield (Aziz *et al*., 2002; Epstein and Bloom, 2003; Abd-Allah, 2006; Ahmad *et al*., 2009; Ashraf *et al*., 2012; Abd El-Motty and Orabi, 2014).

Zinc is an important microelement which is essential for plants due to its involvement in the synthesis of tryptophan which is a precursor of indole acetic acid synthesis. It is important in starch metabolism, which acts as co-factor for many enzymes and affects photosynthesis reaction, nucleic acid metabolism and protein biosynthesis (Swietlik, 1999).

Boron as an essential micronutrient plays an important role in increasing pollen grains germination and pollen tube elongation, resulting in increases in the fruit set percentage and the yield. It is responsible for stimulating cell division, biosynthesis and translocation of sugars, water and nutrient uptake, tolerance of fruit crops to different disorders, nutrient uptake and the biosynthesis of IAA (Nijjar, 1985; Ahmad *et al*., 2009).

Silicon is the most abundant element in the soil after to oxygen and comprises 28 percent of its weight and 3-17 percent in soil solution. Potassium silicate is a source of highly soluble potassium and silicon. It is used in agricultural production systems primarily as a silica amendment and has a benefit in supplying small amounts of potassium for plants (Epstein, 1999; Ma and Takahashi, 2002).

Silicon is beneficial for counteracting the adverse effects of water stress on growth nutritional status of the plants. It is responsible for encouraging water transport and root growth under unfavorable conditions and promoting antioxidant defense system (Epstein, 1999; Alvarez and Datnoff, 2001; Melo *et al*., 2003; Epstein and Bloom, 2003; Hattori *et al*., 2005).

Using silicon in fruit orchards alleviates the adverse effects of drought on growth and plant pigments as well as the nutritional status of plants (Kanto, 2002; Ma and Takahashi, 2002; Gad El-Kareem, 2012; Ibrahim and Al-Wasfy, 2014).

Previous studies showed that the application of boron, zinc and silicon was very effective in enhancing the growth yield and fruit quality of different citrus species (Parveen and Rahman, 2000; Ram and Base, 2000; Matichenkov *et al*., 2000; El-Baz, 2003; Hassan-Al-Sayada, 2004; Abd-Allah, 2006; Tariq *et al*., 2007; Sajid *et al*., 2010; Ashraf *et al*., 2012; Sarrwy *et al*., 2012; Razzaq *et al*., 2013; Abd-El-Motty and Orabi, 2014; Ibrahim and Al-Wasfy, 2014; Aly *et al*., 2015; Mohamed-Shaimaa and El-Tanany, 2016).

So, the present study aims to investigate the response of Balady mandarin trees to boron, zinc and silicon foliar spray.

**Materials and Methods**

This study was conducted during 2016 and 2017 seasons on twenty four trees, fourty five years old Balady mandarin trees (*Citrus reticulate*, Blanco) on grafted sour orange rootstock in the Experimental Orchard of Faculty of Agriculture, Assiut University, Egypt, where the soil texture is clay and well drained with a water table not less than two meter deep and the trees are planted at 5x5 meters apart. The trees were irrigated with water of EC= dS/m) through surface irrigation system (Salinity= 250 ppm).

The selected trees received a basal recommended N, P and K fertilization, FYM as well as other normal horticulture practices such as pruning, hoeing, irrigation and pest management.

This investigation included the following eight treatments:

1- Control (untreated trees).
2- Spraying boron at 0.025%.
3- Spraying boron at 0.050%.
4- Spraying zinc at 0.05%
5- Spraying zinc at 0.10%.
6- Spraying silicon at 0.10%.
7- Spraying silicon at 0.20%.
8- Spraying boric acid at 0.025, Zinc at 0.05 and silicon at 0.10%.

The three fertilizers namely boric acid (17% B) at 0.025 & 0.050%, zinc sulphate (35% Zn) at 0.05 & 0.10% and potassium silicate (25% Si and 10% $K_2O$) at 0.1 & 0.2% were sprayed three times at growth start (1st week of March), just after fruit setting (1st week of May) and after one month of fruit setting (1st week of June). Triton B as a wetting agent was applied at 0.05% to all spraying solutions and spraying was done till runoff (20 L/tree). The control trees were sprayed with tap water and Triton B only. The experiment was setted up in a randomized complete block design (RCBD) with three replications for each treatment, one tree each.

Four shoots of each tree from the current spring growth cycle were labeled for measuring some vegetative traits.

Shoot length (cm), leaf number/shoot, leaf area ($cm^2$) were estimated by picking and weighing 30 full mature leaves/tree and weighing 60 sections of 1 $cm^2$ (2 sections of 1 $cm^2$/leaf) were recorded and the average leaf area ($cm^2$) was calculated as weight of leaves (g) x 2/sections weight (g) Leaf chlorophyll content was estimated by using chlorophyll meter (SPAD 502 plus) using four leaves/replication from the fourth terminal expended leaf of the shoot.

To determine the shoot total carbohydrates and nitrogen, twenty non fruiting shoots of seven months age of the Spring flush were randomly taken from each replication. Shoot samples were air-dried, oven-dried at 70°C to a constant weight, ground in a stainless steel mill and kept for chemical analysis (Nijjar, 1985). One part of each ground sample was analyzed for the total nitrogen using the semi-microkjeldahl technique (Bremner and Mulvaney, 1982; Wilde *et al*., 1985). The other part of each ground shoot sample used to determine the total carbohydrates according to Smith *et al.* (1956).

Ten distributed fruiting shoots around trees were chosen and labeled before the beginning of treatments. The flowers per each shoot were recorded. Before harvest, the fruit retention for each branch was calculated as:

$$Fruit\ retention\ (\%) = \frac{Total\ fruit\ number}{Total\ flower\ number}\ x\ 100$$

At the harvesting date in the last week of December. Yield was expressed in weight (kg) per tree.

Twenty fruits were randomly taken from the yield of each tree and from all directions and then, transferred to the laboratory for determining the following physical and chemical characteristics of the fruits.

1- Average fruit weight (g) using an analytical balance.
2- Average fruit dimensions (height and diameter) using a vernier caliper.
3- Total soluble solids % using a hand refractometer.
4- Total acidity % (as g citric acid/100 ml juice) by the titration with 0.1 N sodium hydroxide using phenolphthalein as an indicator according to A.O.A.C. (1995).
5- Total and reducing sugars % was determined according to Lane and Eynon volumetric method outlined in A.O.A.C. (1995).
6- Vitamin C content (as mg ascorbic acid/100 ml juice) by the titration with 2.6 dichlorophenol indophenol according to A.O.A.C. (1995).

Data were tabulated and statistically analysed according to Gomez and Gomez (1984) and Mead *et al.* (1993). The new L.S.D test was used to define the significance of the differences between the various treatment means.

**Results**

**1- Vegetative Growth**

Table (1) shows the effect of boron, zinc and silicon foliar application singly or in combination on shoot length, leaf number/shoot, leaf area and total chlorophyll percentage of Balady mandarin trees during 2016 and 2017 seasons. It is obvious from the data that the results have a similar trend during the two studied seasons.

Spraying boron, zinc and silicon singly or in combination significantly increased the shoot growth and leaf traits compared to the unsprayed one (control). Increasing the concentration of boron, zinc or silicon in the spray solution did not significantly affected these growth traits. Foliar application of a combination of boron, zinc and silicon significantly increased the growth traits compared to using each one alone. The growth traits decreased with singly spraying these elements in the order of silicon > zinc > boron. No significant differences were observed due to combined boron and zinc spray as well as combined zinc and silicon one.

The maximum value of shoot length and leaf traits was obtained with spraying all these elements in combination.

The highest values of shoot length, leaf area and chlorophyll content were 50.41 cm, 9.38 $cm^2$ and 53.02% (as an average of both seasons), respectively, due to applying thee elements in combination. On the other hand, their respective least values were 41.22 cm, 7.87 $cm^2$ and 45.46% (as an average e of both seasons) were detected for the unsprayed trees.

**Table1. Effect of the foliar spray of zinc, boron and silicon spraying on shoot length (cm) leaves number/shoot, leaf area ($cm^2$) and chlorophyll content of Balady mandarin trees during 2016 and 2017 seasons.**

| Treatment | Shoot length (cm) | | | Number leaf/shoot | | | Leaf area ($cm^2$) | | | Chlorophyll SPAD value | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2016 | 2017 | Mean | 2016 | 2017 | Mean | 2016 | 2017 | Mean | 2016 | 2017 | Mean |
| Control | 42.88 | 39.55 | 41.22 | 39.45 | 38.19 | 38.82 | 7.63 | 8.10 | 7.87 | 42.75 | 48.17 | 45.46 |
| B 0.025% | 46.16 | 42.88 | 44.52 | 42.95 | 41.56 | 42.26 | 8.09 | 8.64 | 8.37 | 44.84 | 50.39 | 47.62 |
| B 0.050% | 47.28 | 43.70 | 45.49 | 43.68 | 42.31 | 42.99 | 8.28 | 8.86 | 8.57 | 45.75 | 51.69 | 48.72 |
| Zn 0.050% | 46.78 | 43.64 | 45.21 | 44.36 | 43.15 | 43.76 | 8.15 | 8.70 | 8.43 | 46.63 | 52.28 | 49.46 |
| Zn 0.10% | 48.26 | 44.69 | 46.48 | 45.75 | 44.77 | 45.26 | 8.43 | 9.04 | 8.74 | 47.15 | 53.16 | 50.16 |
| Si 0.10% | 48.92 | 45.48 | 47.20 | 45.12 | 43.86 | 44.49 | 8.45 | 9.06 | 8.76 | 47.30 | 53.49 | 50.40 |
| Si 0.20% | 49.41 | 45.73 | 47.57 | 46.17 | 44.49 | 45.33 | 8.53 | 9.20 | 8.87 | 47.95 | 54.18 | 51.07 |
| B 0.025, Zn 0.05 & Si 0.1% | 52.13 | 48.68 | 50.41 | 48.78 | 47.43 | 48.11 | 9.06 | 9.69 | 9.38 | 49.88 | 56.15 | 53.02 |
| N-LSD | **2.49** | **2.63** | | **2.29** | **2.45** | | **0.43** | **0.42** | | **1.73** | **1.48** | |

Hence, the increment percentage of shoot length, leaf area, and chlorophyll content attained 22.30, 19.19 and 16.63%, respectively (as an average of both seasons) due to the combined spray of boron, zinc and silicon compared to the control treatment.

### 2- Total Carbohydrates, Nitrogen Content and C/N Ratio of Shoots

The effect of the foliar application of B, Zn and Si on the shoot contents of carbohydrates and nitrogen as well as C/N ratio of Balady mandarin trees during 2016 and 2017 seasons is present in table 2. The results revealed that the shoot carbohydrates, nitrogen and C/N ratio significantly varied according to the studied treatments. They also show a similar trend during the two studied seasons.

Spraying boron, zinc and silicon singly or in combination significantly increased the total carbohydrates, nitrogen content and C/N ratio of the shoots compared to those of the unsprayed trees.

The maximum values of the shoot carbohydrates, nitrogen content and C/N ratio were 13.11%, 1.39% and 9.42%, respectively (as an average of the two studied seasons) due to the triple application of boron, zinc and silicon.

No significant differences were found between the two concentrations of boron, zinc or silicon sprays. The highest values of these studied traits were obtained with the combined spray of boron, zinc and silicon followed by the spray with zinc alone. The C/N ratio of the shoots decreased in the order of spraying a combination of 0.025% boron, 0.050% zinc and 0.10% silicon > 0.20% silicon >

0.10% silicon > 0.10% zinc > 0.05% zinc > 0.050% boron > 0.025% boron > control.

Contrarily, the last corresponding values of these constituents were 10.46%, 1.25% and 8.34 for the control treatments. So, the respective increment percentages of these constituents attained 25.33%, 11.20% and 12.95 (as an average of the two studied seasons) due to the combined spray of boron, zinc and silicon compared to the spray of water.

Therefore, it could be concluded that using a combination of boron, zinc and silicon spray solution is very effective and achieves a beneficial improvement of the vigour and nutritional status of trees.

**Table 2. Effect of zinc, boron and silicon foliar applications on total carbohydrate, total nitrogen % and C/N ratio of Balady mandarin trees shoots during 2016 and 2017 seasons.**

| Treatment | Total carbohydrate (%) | | | Total nitrogen (%) | | | C/N ratio | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2016 | 2017 | Mean | 2016 | 2017 | Mean | 2016 | 2017 | Mean |
| Control | 9.58 | 11.33 | 10.46 | 1.18 | 1.32 | 1.25 | 8.10 | 8.57 | 8.34 |
| B 0.025% | 10.53 | 12.58 | 11.56 | 1.23 | 1.38 | 1.31 | 8.58 | 9.12 | 8.85 |
| B 0.050% | 10.78 | 12.69 | 11.74 | 1.25 | 1.39 | 1.32 | 8.79 | 9.18 | 8.99 |
| Zn 0.050% | 10.96 | 13.08 | 12.02 | 1.26 | 1.41 | 1.34 | 8.71 | 9.26 | 8.99 |
| Zn 0.10% | 11.13 | 13.47 | 12.30 | 1.28 | 1.43 | 1.36 | 8.70 | 9.19 | 8.95 |
| Si 0.10% | 11.21 | 13.38 | 12.30 | 1.29 | 1.44 | 1.37 | 8.65 | 9.30 | 8.98 |
| Si 0.20% | 11.38 | 13.63 | 12.51 | 1.30 | 1.43 | 1.37 | 8.76 | 9.52 | 9.14 |
| B 0.025, Zn 0.05 & Si 0.1% | 11.85 | 14.37 | 13.11 | 1.32 | 1.46 | 1.39 | 8.98 | 9.86 | 9.42 |
| N-LSD | **0.32** | **0.49** | | **0.04** | **0.05** | | **0.41** | **0.34** | |

## 3- Yield

It could be observed that the fruit retention percentage and yield of balady mandarin trees significantly increased with spraying a combination of boron, zinc and silicon as well as the single (spray) each element of compared to the spray of water (Table 3).

The greatest significant fruit yield was recorded for spraying the trees with a combined solution of boron, zinc and silicon followed single solutions of silicon, zinc and boron.

The maximum values of the fruit retention and yield were 1.70% and 48.16 kg/tree, respectively (as an average of the two studied seasons) which were recorded with using 0.025% boron, 0.050% zinc and 0.10% silicon for combination. However, the minimum values of the fruit retention and yield/tree were 1.44% and 36.41 kg/tree with the spray of water (control).

Hence the increment of fruit retention and yield/tree due to the spray of a combination of these three elements attained 18.06 and 32.27%, respectively (as an average of the two studied seasons) compared to the check treatments.

The yield/tree had a descending order of 48.16, 45.80, 44.94, 43.07, 42.09, 41.74, 40.09 and 36.41 kg/tree (as an average of the two studied seasons) for the combined spray with 0.025% boron, 0.050% zinc and

0.10% silicon, 0.20% silicon, 0.10% silicon, 0.10% zinc, 0.050% zinc, 0.050% zinc, 0.025% zinc and water, respectively. Hence, the respective increment percentages of yield/tree attained 32.27, 25.79, 23.43, 18.29, 15.60, 14.64 and 10.11% for these respective treatments compared the water spray (control).

**Table 3. Effect of zinc, boron and silicon spraying on the fruit retention, yield/tree, fruit height and fruit diameter of Balady mandarin trees during 2016 and 2017 seasons.**

| Treatment | Fruit retention (%) | | | Yield tree (kg) | | | Fruit height (cm) | | | Fruit diameter (cm) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2016 | 2017 | Mean | 2016 | 2017 | Mean | 2016 | 2017 | Mean | 2016 | 2017 | Mean |
| **Control** | 1.31 | 1.56 | 1.44 | 31.86 | 40.95 | 36.41 | 6.38 | 6.76 | 6.57 | 7.82 | 8.16 | 7.99 |
| **B 0.025%** | 1.39 | 1.68 | 1.54 | 34.84 | 45.34 | 40.09 | 6.73 | 7.21 | 6.97 | 8.26 | 8.62 | 8.44 |
| **B 0.050%** | 1.42 | 1.71 | 1.57 | 36.35 | 47.13 | 41.74 | 6.91 | 7.48 | 7.20 | 8.48 | 8.70 | 8.59 |
| **Zn 0.050%** | 1.46 | 1.77 | 1.62 | 36.50 | 47.68 | 42.09 | 6.84 | 7.37 | 7.11 | 8.39 | 8.70 | 8.55 |
| **Zn 0.10%** | 1.47 | 1.76 | 1.62 | 37.20 | 48.93 | 43.07 | 7.02 | 7.51 | 7.27 | 8.54 | 8.91 | 8.73 |
| **Si 0.10%** | 1.51 | 1.83 | 1.67 | 38.69 | 51.18 | 44.94 | 7.25 | 7.63 | 7.44 | 8.79 | 9.09 | 8.94 |
| **Si 0.20%** | 1.50 | 1.83 | 1.67 | 39.16 | 52.43 | 45.80 | 7.31 | 7.68 | 7.50 | 8.88 | 9.13 | 9.01 |
| **B 0.025, Zn 0.05 & Si 0.1%** | 1.53 | 1.86 | 1.70 | 41.13 | 55.19 | 48.16 | 7.56 | 7.94 | 7.75 | 9.18 | 9.40 | 9.29 |
| **N-LSD** | **0.07** | **0.11** | | **1.78** | **2.34** | | **0.31** | **0.42** | | **0.40** | **0.43** | |

There were no significant differences of the fruit retention and yield/tree values between using two concentrations of each element in the spray solution. Moreover, no significant differences of these characters between using boron and zinc as well as using zinc and silicon.

It is clear that the combined use of boron, zinc and silicon as a spray solution has beneficial effects on C/N ratio and yield/tree. In addition, such treatment increased the yield and reduced the production cost.

**4- Fruit Properties**

Tables 3, 4 and 5 show the effect of boron, zinc and silicon foliar spray on fruit weight, fruit dimension, pulp percentage, total soluble solids, TSS/acidity ratio, sugar content and Vitamin C (V.C) contents as well as total acidity of Balady mandarin fruits during 2016 and 2017 seasons. In general, the obtained results took similar trend during the two studied seasons.

All studied treatments improved the fruit quality in terms of increasing the fruit weight, size, pulp percentage, total soluble solids (TSS), sugar and vitamin C contents and decreasing the total acidity compared to the control treatment.

Highest values of 147.44, 142.09 and 140.75 g for fruit weight, 11.89, 11.62 and 11.65% for TSS and 57.72, 54.77 and 53.87 mg/100 g for V.C. (as an average of both seasons) were obtained with the combined spray of boron, zinc and silicon, as well as the single spray of 0.20% silicon 0.20 and 0.10% silicon, respectively. On the other hand, the lowest values of fruit weight, TSS and V.C. were 125.41 g, 10.60% and 46.43 mg/100g, respectively (as an average of both seasons) which were recorded on the trees that were sprayed with water only.

Hence, the respective increment percentages of these fruit properties were 17.57, 13.30 and 12.23% for fruit weight, 12.17, 9.62 and 9.91%

and for TSS 24.32, 17.96 and 16.02% for V.C. (as an average of the two studied seasons) due to the respective treatments relative to the control one.

**Table 4. Effect of zinc, boron and silicon foliar spray on the fruit weight, pulp %, TSS and acidity of Balady mandarin fruits during 2016 and 2017 seasons.**

| Treatment | Fruit weight (g) | | | Pulp (%) | | | TSS (%) | | | Acidity (%) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2016 | 2017 | Mean | 2016 | 2017 | Mean | 2016 | 2017 | Mean | 2016 | 2017 | Mean |
| **Control** | 122.71 | 128.10 | 125.41 | 67.52 | 70.28 | 68.90 | 10.49 | 10.71 | 10.60 | 1.40 | 1.38 | 1.39 |
| **B 0.025%** | 128.86 | 134.50 | 131.68 | 70.84 | 73.78 | 72.31 | 10.93 | 11.28 | 11.11 | 1.34 | 1.31 | 1.32 |
| **B 0.050%** | 132.93 | 138.28 | 135.61 | 71.16 | 74.41 | 72.79 | 11.05 | 11.47 | 11.26 | 1.32 | 1.36 | 1.34 |
| **Zn 0.050%** | 130.58 | 136.90 | 133.74 | 71.12 | 74.38 | 72.75 | 11.26 | 11.68 | 11.47 | 1.30 | 1.28 | 1.29 |
| **Zn 0.10%** | 133.85 | 140.20 | 137.03 | 72.46 | 75.36 | 73.91 | 11.30 | 11.85 | 11.58 | 1.27 | 1.25 | 1.26 |
| **Si 0.10%** | 136.90 | 144.59 | 140.75 | 72.78 | 75.83 | 74.31 | 11.36 | 11.93 | 11.65 | 1.25 | 1.22 | 1.24 |
| **Si 0.20%** | 138.18 | 146.00 | 142.09 | 73.28 | 76.41 | 74.85 | 11.43 | 11.80 | 11.62 | 1.2 | 1.20 | 1.22 |
| **B 0.025, Zn 0.05 & Si 0.1%** | 143.69 | 151.18 | 147.44 | 76.93 | 80.20 | 78.57 | 11.63 | 12.14 | 11.89 | 1.19 | 1.17 | 1.18 |
| **N-LSD** | **5.11** | **4.93** | | **2.68** | **2.92** | | **0.33** | **0.28** | | **0.05** | **0.06** | |

**Table 5. Effect of zinc, boron and silicon foliar spray on TSS/acid ratio, V.C and sugar contents of Balady mandarin juice during 2016 and 2017 seasons.**

| Treatment | Total sugar (%) | | | Reducing sugar (%) | | | TSS/acidity | | | V.C. (mg/100 g) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2016 | 2017 | Mean | 2016 | 2017 | Mean | 2016 | 2017 | Mean | 2016 | 2017 | Mean |
| **Control** | 7.83 | 8.03 | 7.93 | 3.06 | 3.12 | 3.09 | 7.57 | 7.79 | 7.68 | 45.82 | 47.03 | 46.43 |
| **B 0.025%** | 8.40 | 8.63 | 8.52 | 3.24 | 3.30 | 3.27 | 8.18 | 8.60 | 8.39 | 48.53 | 49.38 | 48.96 |
| **B 0.050%** | 8.49 | 8.75 | 8.62 | 3.25 | 3.31 | 3.28 | 8.39 | 8.83 | 8.61 | 50.13 | 51.25 | 50.69 |
| **Zn 0.050%** | 8.68 | 8.90 | 8.79 | 3.47 | 3.55 | 3.41 | 8.68 | 9.10 | 8.89 | 50.79 | 52.16 | 51.48 |
| **Zn 0.10%** | 8.88 | 9.06 | 8.97 | 3.66 | 3.63 | 3.65 | 9.02 | 9.23 | 9.13 | 51.50 | 53.65 | 52.58 |
| **Si 0.10%** | 8.96 | 9.19 | 9.08 | 3.67 | 3.75 | 3.71 | 9.10 | 9.64 | 9.37 | 52.96 | 54.77 | 53.87 |
| **Si 0.20%** | 9.03 | 9.26 | 9.15 | 3.72 | 3.78 | 3.75 | 9.28 | 9.75 | 9.52 | 54.23 | 55.30 | 54.77 |
| **B 0.025, Zn 0.05 & Si 0.1%** | 9.18 | 9.44 | 9.31 | 3.86 | 3.92 | 3.89 | 9.76 | 10.28 | 10.02 | 56.76 | 58.68 | 57.72 |
| **N-LSD** | **0.36** | **0.28** | | **0.11** | **0.13** | | **0.32** | **0.26** | | **1.89** | **2.05** | |

Contrarily, using a combined spray of boron, zinc and silicon, single spray 0.20% and 0.10% silicon gave the lowest values of the total acidity (1.18, 1.22 and 1.24%, respectively) compared to the highest value 1.39% of the water spray (control). Therefore, the decrement percentages of the total acidity attained 15.11, 12.23 and 10.79% (as an average of the two studied seasons) due to the respective previous treatments compared to the water spray.

No significant differences were detected due to spraying boron and zinc as well as zinc and silicon. Moreover, the combined spray of 0.025% boron, 0.050% zinc and 0.10% silicon gave higher improvement in the fruit characteristics than using the other foliar application treatments. Such foliar application program is very important for the fruit production of mandarin, since increasing of the fruit weight and size and improving the fruit quality induce an increase in the marketable yield.

## Discussion

The effect of boron, zinc or silicon spraying on enhancement of growth and fruiting of Balady mandarin may be ascribed to enhance the activity of photosynthesis, biosynthesis of IAA, nutrient uptake and carbohydrate or protein biosynthesis in leaves, which in turn encourage plant growth that are reflected on the growth promotion and yield (Nijjar, 1985; Matichenkov *et al*., 2000; Hafez and El-Metwally, 2007; Ahmed *et al*., 2009 and Ngullie *et al*., 2014).

Using silicon in fruit orchards is beneficial because it counteracts the adverse stresses on growth and fruiting of trees. It increases drought tolerance and photosynthesis activity as well as encourage, the water transport and root growth and promotes antioxidants defense system of mandarin trees (Melo *et al*., 2003; Epstein and Boloom, 2003; Matichenkov *et al*., 2000; Hallorie *et al*., 2005; Dayer *et al*., 2008).

The results of the current study clarifies that the foliar application of boron, zinc and silicon alone or in combination induces increases of 8.89, 11.05, 12.71 and 19.19%, respectively the leaf area, 7.79, 7.31, 8.59 and 12.94% respectively in C/N ratio and 14.64, 18.29, 25.79 and 32.27%m respectively in the yield) of Balady mandarin trees. These results are in harmony with those obtained by Parveen and Rehman (2000), El-Baz (2003), Hassan-Al-Sayada (2004), Sarrwy *et al*. (2012), Razzaq *et al*. (2013), Ibrahim and Al-Wasfy (2014) and Mohamed-Shaimaa and El-Tanany (2016).

The fruit quality improvement registered by the foliar spray of boron, zinc and silicon may be due to improving cell number and size through enhancing the fruit growth and nutrient uptake that accelerate the metabolic processes. Zinc has an important role in photosynthesis and related enzymes and regulates the carbohydrate metabolism. Boron stimulates the cell division and translocates the sugar, water and the biosynthesis of IAA. Silicon has an essential role in maintaining plant water balance and increasing photosynthesis activity and antioxidant defense systems (Nijjar, 1985; Matichenkov *et al*., 2000; Ma and Takahashi, 2002; Hafez and El-Metwally, 2007; Alloway, 2008; Gad El-Kareem, 2012; Ibrahim and Al-Wasfy, 2014; Nguillie *et al*., 2014).

The results also show that spraying boron, zinc or silicon either alone or in combination causes increases of 8.13, 9.26, 13.30 and 17.57%, respectively in fruit weight, 6.23, 9.24, 9.26 and 12.17%, respectively in TSS and 9.18, 13.24, 17.96 and 24.32%, respectively in V.C. content. These results came on line with those obtained by Ram and Base (2000), Matichenkov *et al*. (2000), El-Baz (2003), Hassan-Al-Sayada (2004), Tariq *et al*. (2007), Sajid *et al*. (2010), Sarrwy *et al*. (2012), Razzaq *et al*. (2013), Ibrahim and Al-Wasfy (2014), Aly *et al*. (2015) and Mohamed-Shaimaa and El-Tanany (2016). They revealed that there is a potential benefit is obtained from the foliar application of boron, zinc and silicon in the commercial production of citrus for their effective influence on yield and fruit quality.

## Conclusion

From the obtained results, it can be concluded that spraying Balady mandarin trees grown under similar environmental conditions and horticultural practices adopted in the present experiment with 0.05% boron, 0.10% zinc and 0.20% silicon alone or a combination of 0.025% boron, 0.050% zinc and 0.10% silicon, three times during the growth season is a beneficial means in order to improve the productivity, fruit quality and nutritional status.

**References**

Abd-Allah, A.S.E. (2006). Effect of spraying some macro and micro nutrients on fruit set, yield and fruit quality of Washington Navel orange trees. J. Agric. Appl. Sci. Res. 2 (11): 1059 – 1063.

Abd El-Motty, E.Z. and S.A. Orabi (2014). The beneficial effects of using zinc, yeast and selenium on yield, fruit quality and antioxidant defense system in navel orange tree grown under newly reclaimed sandy soil. J. Appl. Sci. Res., 9 (10): 6487- 6497.

Ahmad, W.; A. Niaz; S. Kanwal and A. Rahmatullah (2009). Role of boron in plant growth. A Review J. Agric. Res. 47 (3): 329-338.

Alvarez, J. and L.E. Datnoff (2001). The economic potential of silicon for integrated management and sustainable rice production. Crop Prot. 20: 43-48.

Aly, M.A.; M.M. Harhash; R.M. Awad and H.R. El-Kelawy (2015). Effect of foliar application with calcium, potassium and zinc treatments on yield and fruit quality of Washington Navel Orange Trees. Middle East J. Agri. Res., 4 (3): 564-568.

Ashraf, M.Y.; M. Yaqub; J. Akhtar; A.M. Khan and G. Ebert (2012). Control of excessive fruit drop and improvement in yield and juice quality of Kinnow (Citrus deliciosa x Citrus nobilis) through nutrient management. Pak. J. Bot., 44: 259-265.

Association of Official Agricultural Chemists (1995). Official Methods of Analysis 14th ed. (A.O.A.C.) Benjamin Franklin Station, Washington D.C., U.S.A..

Aziz, T.; M.A. Gill and R. Rahmatullah (2002). Silicon nutrition and crop production: A review. Pak. J. Agric. Sci. 39 (3): 181-187.

Bremner, J.M. and C.S. Mulvaney (1982). Nitrogen- Total pp. 595-624. In A. L. Page, R. H. Miller and D. R. Keeny (eds.) Methods of soil Analysis- part 2. Chemical and Microbiological properties 2nd ed. Am. Soc. Agron. Madison, Wisconsin, U. S. A.

Catara, A. (1987). Compendium of citrus disease and disorder in Pakistan Results of preliminary survey. Agrotec. SPA, Rome Project for research and development in the cultivation of fruit, vegetables and olvies. PARC, Islamabad, Pakistan, pp. 14-15.

Dayer, R.; B.B. Fischer; R.L.L. Eggen and S.D. Lemaire (2008). The peroxiredoxin and glutathione peroxidase families in *Chlamydomonas reinhardtii*. Genetics, 179: 41-57.

EL-Baz, EL-EL. T. (2003). Effect of foliar sprays of zinc and boron on leaf mineral composition, yield and fruit storability of balady mandarin trees. J. Agric. Sci. Mansoura Univ., 28: 6911-6926.

Epstein, E. (1999). Silicon. Annl. Rev. Plant Physiol. Plant Mol. Biol. 50: 641-664.

Epstein, E. and A.J. Bloom (2003). Mineral Nutrition of Plants, Principles and Perspectives. 2nd Ed. John Wiley & Sons, New York.

Gad El- Kareem, M.R. (2012). Improving productivity of Taimour mango trees by using glutathione, silicon and vitamins B. Minia J. of Agric. Res. & Develop., 32 (2): 161 – 180.

Gomez, K.A. and A.A. Gomez (1984). Statistical procedures for Agriculture Researches ($2^{nd}$ ed.) Published by John Wiley and Sons, New York, U.S.A.

Hafez, O.M. and I.M. El-Metwally (2007). Efficiency of zinc and potassium sprays alone or in combination with some weed control treatments on weeds growth, yield and fruit quality of Washington Navel Orange orchards. J. Appl. Sci. Res., 3 (7): 613-621.

Hassan-Al-Sayada, S. (2004). Productivity of balady mandarin trees as affected by some macro and micronutrients. M.Sc. Thesis Fac. of Agric. Minia Univ. Egypt.

Hattori, T.; S. Inanaga; H. Araki; P. An; S. Mortia; M. Luxova and A. Lux (2005). Application of silicon enhanced drought tolerance in sorghum bicolor. Physiolgia Plantarum. 123: 459-466.

Ibrahim, H.I.M. and M.M. Al-Wasfy (2014). The promotive impact of using silicon and selenium with potassium and boron on fruiting of Valencia orange trees grown under Minia region conditions. World Rural Observation, 6 (2): 28-36.

Ibrahim, M.; N. Ahmad; S.A. Anwar and T. Majeed (2007). Effect of micronutrients on citrus fruit yield growing on calcareous soils. pp. 179–182. In: Advances in Plant and Animal Boron Nutrition, X.U. Fangsen, H.E. Goldbach, P.H. Brown, R.W. Bell, T. Fujiwara, C.D. Hunt, S. Goldberg, and L.Shi. (Ed.), Springer Netherlands.

Kanto, T. (2002). Research of silicate for improvement of plant defense against pathogens in Japan. Abstract of Second Silicon in Agriculture Conference p. 22-26.

M.A.L.R. (2016). Ministry of Agriculture and Land Reclamation Economic. Affairs Sector Bull., Agric. Statistics.

Ma, J. F. and E. Takahashi (2002). Soil, Fertilizer and Plant. Silicon Research in Japan. Elsevier Science, Amsterdam, the Netherlands.

Matichenkov, V.V.; D.V. Calvert and G.H. Snyder (2000). Prospective of silicon fertilization for citrus in Florida. Proc. Soil and Crop Sci. Soc. of Florida 5: 137-141.

Mead, R.; R.N. Curnow and A.M. Harted (1993). Statistical Methods in Agricultural and Experimental Biology. Second Ed. Chapman & Hall London.

Melo, S.P.; G.H. Korndorfer; C.M. Korndorfer; R.M.Q. Lana and D.G. Santan (2003). Silicon accumulation and water deficit tolerance in grasses. Scientia Agricola. 60: 755-759.

Mohamed-Shaimaa, A. and M.M. El-Tanany (2016). Efficacy of foliar application of salicylic acid, zinc and potassium on reducing fruit drop, yield improvement and quality of Balady mandarins. Egypt. J. Hort. 43 (2): 371-388.

Ngullie, C.R.; R.V. Tank and D.R. Bhanderi (2014). Effect of salicylic acid and humic acid on flowering, fruiting, yield and quality of mango (*Mangifera indica* L.) cv. Kesar. Adv. Res. Crop Improv., 5 (2): 136-139.

Nijjar, G.S. (1985). Nutrition of fruit tees. Mrs. Usha Raj Kumar for Kalyanin publishers, New Delhi.

Parveen, S. and H. Rehman (2000). Effect of Zn, Mn and B in combination with urea on the yield of sweet orange. Pak. J. Agric. Res. 16: 135-141.

Ram, R.A. and T.K. Base (2000). Effect of foliar application of Mg and micronutrients on growth, yield and fruit quality of mandarin orange (*Citrus reticulate* Blanco). Indian J. Hort. 57 (30: 215-220.

Razzaq, K.; A.S. Khan; A.U. Malik; M. Shahid and S. Ullah (2013). Foliar application of zinc influences the leaf mineral status, vegetative and reproductive growth, yield and fruit quality of "Kinnow" mandarin. Journal of Plant Nutrition, 36: 1479-1495.

Sajid, M.; N.A. Abdur-Rab; M. Arif; L. Ferguson and A.A. Ahmed (2010). Effect of foliar application of Zn and B on fruit production and physiological disorders in sweet orange cv. Blood orange. Sarhad J. Agric., 26 (3): 355-360.

Sarrwy, S.M.A.; M. El-Sheikh; S.S. Kabeil and A. Shamseldin (2012). Effect of foliar application of different potassium forms supported by zinc on leaf mineral contents, yield and fruit quality of "Balady" mandarin trees. Middle –East Journal of Scientific Research, 12 (4): 490- 498.

Smith, F.; M.A. Gilles; J.K. Homilton and P.A. Godes (1956). Colorimetric methods for determination of sugar and related substances. Chem. 28: 350-356.

Swietlik, D. (1999). Zinc Nutrition in Horticultural Crops, pp. 109-118. In: Horticultural Reviews, J. Janick (ed.), John Wiley & Sons, Inc.

Tariq, M.; M. Sharif; Z. Shah and R. Khan (2007). Effect of foliar application on the yield and quality of sweet orange (*Citrus sinensis* L.). Pak. J. Biol. Sci. 10 (11): 1823-1828.

Wilde, S.A., B.B. Gorey, J.G. Layer and J.K. Voigt (1985). Soils and Plant Analysis for tree culture. Published by Mohan primlani, Oxford and IBH publishing Co., New Delhi, p. 1- 142.

*Assiut J. Agric. Sci., (50) No. (2) 2019 (206-218)* *ISSN: 1110-0486*
***Website:*** *www.aun.edu.eg/faculty_agriculture/journals_issues_form.php* ***E-mail: ajas@aun.edu.eg***

# تأثير الرش الورقي بالزنك والبورون والسيليكون علي نمو وإثمار أشجار اليوسفي البلدي

**علاء عبد الجابر بدوي مسعود، فاطمة الزهراء محمد عبد الله جودة[1] أسامة عبد الله علي خضير**

[1]قسم الفاكهة – كلية الزراعة – جامعة أسيوط

[2]قسم البساتين – كلية الزراعة – جامعة الأزهر بأسيوط

**الملخص**

أجريت هذه الدراسة علي أشجار اليوسفي البلدي النامية بمزرعة كلية الزراعة – جامعة أسيوط – مصر خلال موسمي ٢٠١٦ و ٢٠١٧ بهدف دراسة تأثير الرش الورقي بكل من حمض البوريك أو سلفات الزنك أو سيليكات البوتاسيوم (كمصدر للسيليكون) علي النمو الخضرى والمحصول وخصائص الثمار. وقد صممت التجربة بنظام القطاعات العشوائية الكاملة وتحتوي علي ثمانية معاملات وكررت كل معاملة ثلاثة مرات لكل مكررة / شجرة.

وقد أوضحت النتائج ما يلي:

-أدي الرش بكل من البورون أو الزنك أو السيليكون فردياً أو خلطياً إلي زيادة مؤكدة في صفات النمو الخضري من حيث طول الأفرع ومساحة الورقة ومحتوي الأوراق من الكلوروفيل.

-سبب الرش بالبورون أو الزنك أو السيليكون فردياً أو بصورة خليط زيادة مؤكدة في محتوي الأفرع من الكربوهيدرات ونسبة الكربوهيدرات للنيتروجين وبالتالي زيادة نسبة العقد النهائي ووزن المحصول/ شجرة مقارنة برش الأشجار بالماء فقط (المقارنة).

-سببت كل المعاملات تحسين مؤكد في صفات الثمار الطبيعية والكيميائية مقارنة بعدم المعاملة.

-سجلت أفضل النتائج نتيجة الرش بمخلوط من العناصر الثلاثة مقارنة بالرش الفردي أو عدم الرش.

من نتائج هذه الدراسة يمكن التوصية بأهمية رش الأشجار بحمض اليوريك بتركيز ٠،٠٠٥% أو سلفات الزنك بتركيز ٠،٠١% أو سيليكات البوتاسيوم بتركيز ٠،٠٢% أو مخلوط منهم بتركيز ٠،٠٠٢٥% بورون و ٠،٠٠٥% زنك و ٠،٠١% سيليكون حيث تؤدي هذه المعاملات إلي تحسين النمو الخضري والحالة الغذائية للأشجار مع إنتاج محصول عال ذو خصائص ثمرية جيدة لأشجار اليوسفي البلدي.