

The Promotive Impact of Using Silicon and Selenium with Potassium and Boron on Fruiting of Valencia Orange Trees Grown Under Minia Region Conditions

Ibrahim, H. I. M. * and Al-Wasfy, M. M.**

*Hort. Dept. Fac. of Agric. Minia Univ. Egypt.

**Hort. Dept. Qena Fac. of Agric. South Valley Univ. Egypt.

faissalfadel@yahoo.com

Abstract: During 2011 and 2012 seasons, Valencia orange trees received four sprays of boric acid at 0.05 % and/ or potassium sulphate at 0.5 % either alone or in combined with application of potassium silicate at 0.1 % and sodium selenite at 50 ppm. This study focused on elucidating the synergistic effects of using silicon and selenium besides boron and/ or potassium on fruiting of the trees. Results revealed that using silicon and/ or selenium along with boron and potassium effectively enhanced growth characters, nutritional status of the trees, yield as well as physical and chemical characteristics of the fruits in relative to using boron and/ or potassium alone. Spraying all nutrients either singly or in all combinations was very effective in this connection rather than non- application. Using silicon with boron and potassium was superior than spraying selenium plus boron and potassium and silicon and selenium with boron and potassium together was preferable than using each alone. Treating Valencia orange trees grown under Minia region conditions four times with a mixture of boric acid at 0.05 % + potassium sulphate at 0.5 % + potassium silicate (as a source of silicon) at 0.1 % + sodium selenite (as a source of selenium) at 50 ppm gave the best results with regard yield and fruit quality.

[Ibrahim, H. I. M. and Al- Wasfy, M. M. **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 Observ* 2014;6(2):28-36]. ISSN: 1944-6543 (Print); ISSN: 1944-6551 (Online). <http://www.sciencepub.net/rural>. 5

Key words: potassium, boron, silicon, selenium, Valencia orange, yield & fruit quality.

1. Introduction

Citrus is considered to be one of the important fruit crops grown in Egypt. Valencia orange cv. is considered the best orange cv. for local and foreign markets.

Nowadays, many efforts had been established for finding out the best horticultural practices that are responsible for enhancing yield and fruit quality of Valencia orange trees growing under Minia region conditions and other regions. Using potassium, boron, silicon and selenium are considered the best treatment for solving the problem of yield decline and inferior fruit quality of such citrus cv. Increasing the tolerance of Valencia orange trees to all stress conditions namely unsuitable environmental conditions, drought and salinity is considered important in this respect.

Boron as essential micro nutrient plays an important role in increasing pollen grains germination and pollen tube elongation, consequently, fruit set % and finally 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 and Ahmad *et al.* 2009).

Boron was found to enhance growth and fruiting of fruit crops (Osman, 1999; Harhash and Abdel-Nasser, 2001; Abdel- Nasser and Harhash, 2001; Abd El- Migeed *et al.* 2002; Saleh and Abd El-

Monem- Eman, 2003; Abd- Allah, 2006; Ebeid-Sanaa, 2007; El- Sayed- Esraa, 2007; Attalla *et al.* 2007; Etman *et al.* 2007 and Abdalla, 2008).

Potassium is considered an essential micronutrient responsible for enhancing cell division, activities of many enzymes, biosynthesis and translocation of carbohydrates and plant pigments, the tolerance of trees to drought and salt stresses and the uptake of different nutrients (Nijjar, 1985).

Using K via leaves and soil was found by many authors to improve growth, yield and fruit quality of different evergreen crops (El- Sherif *et al.* 2000; Ebrahiem *et al.* 2001; Abd El- Latief, 2002; Fouad- Amera *et al.* 2003; Govind and Singh, 2003; Hassan Al- Sayada, 2004; Khayyat *et al.* 2007; Desouky *et al.* 2007; El- Sayed- Esraa, 2010 and Harhash and Abdel- Naser, 2010).

Previous studies showed that using silicon was beneficial for counteracting the adverse effects of water stress on growth and nutritional status of the plants. It is also known that silicon increases drought tolerance in plants by maintaining plant water balance, photosynthesis activity, erectness of leaves and structure of xylem vessels under higher transpiration rates. Also, it is responsible for encouraging water transport and root growth under unfavourable conditions and promoting antioxidants defense system (Matoh *et al.*, 1991; Epstein, 1999; Alvarez and

Datnoff, 2001; Aziz et al., 2002; Melo et al., 2003; Epstein and Bloom, 2003 and Hattori et al., 2005).

Most studies showed that using silicon in fruit orchards under drought conditions was accompanied with alleviating the adverse effects of drought on growth, plant pigments as well as nutritional status of the plants (Matichenov et al., 2000; Kanto, 2002; Ma and Takahashi, 2002; Neumann and Zur-Nieden, 2011; Gad El- Kareem, 2012 and Al-Wasfy, 2013).

Many trials to supply selenium to fruit orchards have been carried out since tests have confirmed selenium's role as a medical substance and must be added for its positive action on fruiting.

Selenium as an element chemically similar to sulfur has received considerable attention as an essential micronutrient for human, animals and some species of microorganisms. It has many functions in the active site of a large number of selenium dependent enzymes such as glutathione- peroxidase and as anticancer and other physiological functions. A lower selenium level in body is reported to be responsible for high incidence of cancer and disease (Gupta et al., 2000). It also influences the nutrient balance in the plants (Nowak- Barbara, 2008).

Selenium (Se) is an important element associated with the enhancement of antioxidant activity in plants, animals and humans (Rayman 2002). Beneficial effects of Se were appeared in terms of plant protection against abiotic stress (Hartikainen and Xue 1999), plant protection against reactive oxygen compounds, activator of the protective mechanism that reduces oxidation stress for example in chloroplasts (Seppänen et al. 2003), phloem-feeding aphids and herbivorous caterpillars (Hanson et al. 2003 and 2004), and fungal diseases (Hanson et al. 2003). Selenium has a positive effect also on potato carbohydrate accumulation and possibly on yield formation (Turakainen et al. 2004 and 2006)

The theoretical explanation for the antioxidative effects of Se on plants is increasing the activity of the enzyme glutathione-peroxidase (GSH-Px) in selenium-treated plants, since Se-containing GSH-Px was identified in plants (Dayer et al., 2008). Seppänen et al. (2003) discovered that Se reduced the activity of superoxide dismutase (SOD) and in some cases the amount of tocopherols.

Previous studies showed that application of selenium (Se) was very effective in enhancing growth, yield and fruit quality of fruit crops and other horticultural crops (NAS NRC, 1983; Gissel- Neilsen et al., 1984; Sima and Gissel- Neilsen, 1985; Kim et al., 2005; Gupta et al., 2000; Hartikainen and Xue, 1999; Whanger, 2002; Nowak- Barbara, 2008 and Jakovljevic et al., 2011).

The target of this study was examining the effect of selenium and silicon on improving the efficiency of using potassium and boron on fruiting of Valencia orange trees grown under Minia region.

2. Material and Methods

This study was conducted during 2011/ 2012 and 2012/ 2013 seasons on thirty- nine 25 years old Valencia orange trees onto sour orange rootstock in a private orchard located at Abo Harb village, Bany Mazar district, Minia Governorate where the soil is silty clay and well drained with a water table not less than two meters deep. The selected trees are planted at 5 × 5 meters apart. The trees were irrigated through surface irrigation system (EC = 250 ppm). Analysis of the tested soil according to Carter (1993) are shown in Table (1).

Table (1): Analysis of the tested orchard soil.

Constituents	Values
Particle size distribution:	
Sand %	: 10.1
Silt %	: 59.9
Clay %	: 30.0
Texture grade	: Silty clay
pH (1 : 2.5 extract)	: 7.78
E.C (1: 2.5 extract) (mmhos/ cm 25 °C)	: 1.11
Organic matter %	: 1.85
CaCO ₃ %	: 1.72
Total N %	: 0.11
Available P (ppm) (Olsen)	: 5.2
Available K (meq/100 g. soil)	: 3.85
Available Mg (meq/ 100 g. soil)	: 0.55
DTPA extractable micronutrients (ppm)	
Zn	: 3.5
Fe	: 4.1
Cu	: 0.4
B	: 0.7

The selected trees received a basal recommended N, P and K fertilizers, F.Y.M as well as the other normal horticultural practices such as pruning, hoeing, irrigation and pest management.

This investigation included the following thirteen treatments:-

1. Control (untreated trees).
2. Spraying boric acid at 0.05 %.
3. Spraying potassium sulphate at 0.5 %.
4. Spraying boric acid at 0.05 % + potassium sulphate at 0.5 %.
5. Spraying boric acid + selenium at 50 ppm.
6. Spraying potassium sulphate + selenium at 50 ppm.

7. Spraying potassium sulphate + boric acid + selenium at 50 ppm.
8. Spraying boric acid + silicon at 0.1 %.
9. Spraying potassium sulphate + silicon at 0.1 %.
10. Spraying potassium sulphate + boric acid + silicon at 0.1 %.
11. Spraying boric acid + selenium + silicon.
12. Spraying potassium sulphate + selenium + silicon.
13. Spraying potassium sulphate + boric acid + selenium + silicon.

Each treatment was replicated three times, one tree per each. The four fertilizers namely boric acid (17 % B) at 0.05 %, potassium sulphate (48 % K₂O) at 0.5 %, potassium silicate (25 % Si + 10 % K₂O) at 0.1 % and sodium selenite at 50 ppm (the recommended concentrations according to **El- Sayed- Esraa, 2010 and Jakovljevic et al. 2011**) were sprayed four times at growth start (1st week of Mar.), just after fruit setting, (1st week of May) and at two months intervals (1st week of July and Sept.). 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 received tap water and Triton B. Randomized complete block design was followed.

Four branches one year old were chosen for each tree. Four shoots from the current Spring growth cycle were labelled for measuring leaf area in these shoots, twenty mature leaves (7 months age) were picked from non- fruiting shoots of such cycle for measuring the leaf area (cm²) using the following equation as reported by **Ahmed and Morsy (1999)**. $LA = 0.49 (L \times W) + 19.09$ where LA = leaf area (cm²) L and W were maximum length and width of leaf (cm.), respectively. In these fresh leaves, chlorophylls a & b, total carotenoids (as mg/ g⁻¹ F.W) and total chlorophylls were determined according to the procedures of **Arnon (1949) and Wettstein (1957)**.

To determine the percentages of N, P and K in the leaves, fifty mature leaves seven months age from non- fruiting shoots in the Spring growth cycle (1st week of Sept.) were taken (according to **Summer, 1985**). These leaves were dried at 70 °C and digested using H₂SO₄ and H₂O₂ (according to **Wilde et al. 1985**). In the digested solutions nutrients namely N, P and K on dry weight basis were determined according to the procedures that outlined by (**Piper, 1950 and Wilde et al. 1985**).

Harvesting was achieved during the regular commercial harvesting time under Minia Governorate conditions (1st week of April) in both seasons when T.S.S./ acid reached at least 8: 1 according to **Hulme (1971)**. Yield was expressed in weight (kg.) and number of fruits per tree.

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

- 1- Average fruit weight (g.) by using analytical balance.
- 2- Average fruit dimensions (height and diameter) by vernier caliper.
- 3- Fruit peel thickness (cm.) by using vernier caliper.
- 4- Total soluble solids % by using handy refractometer.
- 5- Total acidity % (as g citric acid/ 100 ml juice) by titration against 0.1 N sodium hydroxide using phenolphthalein as an indicator according to **A.O.A.C. (2000)**.
- 6- Total and reducing sugars % was determined according to Lane and Eynon volumetric method that outlined in **A.O.A.C. (2000)**.
- 7- Vitamin C content (as mg ascorbic acid/ 100 ml juice) by titration with 2.6 dichlorophenol indophenol according to **A.O.A.C. (2000)**.

All the obtained data were tabulated and statistically analyzed according to the procedures of **Mead et al. (1993)**. The individual comparisons on the studied parameters in the twelve investigated treatments were compared by using new L.S.D test at 5 %.

3. Results and Discussion

1- Leaf area and its content of plant pigments and nutrients:

It is clear from the obtained data in Tables (2 & 3) that single and combined applications of boric acid at 0.05 % and potassium sulphate at 0.5 % with or without potassium silicate at 0.1 % and/ or sodium selenite at 50 ppm significantly enhanced the leaf area and its contents of chlorophylls a & b, total carotenoids, total chlorophylls and nutrients namely N, P, K & Mg in relative to the check treatment. Single application of potassium was superior than using boron in this respect. Combined application of boron and potassium was superior than using each alone in this respect. Using silicon and/ or selenium besides boron and/ or potassium was significantly very favourable in improving growth and nutritional status of the trees rather than using boron and/ or potassium alone (without silicon and selenium). Using silicon was preferable using selenium in this respect. Using such two antioxidants (silicon + selenium) together along with boron and/ or potassium effectively enhanced growth and trees nutritional status comparing with using silicon or selenium alone with boron and potassium. Using selenium, silicon

and selenium + silicon besides boron and potassium, in ascending order was very effective from economical point of view in enhancing growth and the investigated plant pigments and nutrients in the leaves. The maximum values were recorded on the trees that received four sprays of a mixture containing boron, potassium, silicon and selenium. Untreated trees produced the minimum values. These results were true during both seasons.

The beneficial effects of B on stimulating cell division, building and translocation of sugars, water and Mg uptake and the biosynthesis of IAA (Nijjar, 1985 and Ahmad *et al.* 2009) could explain the present results. The beneficial effects of using K on enhancing the biosynthesis and translocation of sugars and cell division (Nijjar, 1985) could explain the present results.

The positive action of silicon and selenium on counteracting the adverse effects of most stresses around the trees as well as their essential role on reducing reactive oxygen species and increasing antioxidant defense systems could explain the present results (Hattori *et al.* 2005 and Dayer *et al.* 2008). Their essential role in root development and water uptake (Melo *et al.* 2003 and Seppänen *et al.* 2003) did not neglect in this respect.

These results are in harmony with those obtained by Etman *et al.* (2007) and Abdalla (2008) on boron; El- Sayed- Esraa (2010) on potassium; Al- Wasfy (2013) on silicon and Nowak- Barbara (2008) on selenium.

2- Yield/ tree:

It is evident from the data in Table (3) that yield expressed in weight and number of fruits per trees was significantly improved in response to spraying boron and/ or potassium in combined with silicon and/ or selenium rather than non- application. Using silicon and/ or selenium with boron and/ or potassium was significantly very effective in promoting the yield in relative to using boron and/ or potassium without silicon and selenium. Using potassium was preferable than spraying boron in this connection. Using boron and potassium together was preferable than using each nutrient alone in this respect. The promotion on the yield was significantly associated with using selenium, silicon and silicon + selenium, in ascending order. The maximum yield (77.3 and 78.5 kg) was presented on the trees that sprayed four times with a mixture of the four nutrients (B, K, Si and Se). The untreated trees produced 42.0 and 39.5 kg during both

seasons, respectively. The percentage of increase on the yield due to spraying all nutrients together over the check treatment reached 84.0 and 98.0 % during both seasons, respectively. These results were true during both seasons.

The beneficial effects of using these nutrients on stimulating growth characters and nutritional status of the trees surely reflected on promoting the yield.

These results are in agreement with those obtained by Abdalla (2008) on boron; Harhash and Abdel- Nasser (2010) on potassium; Gad El- Kareem (2012) on silicon and Rayman (2002) on selenium.

3- Physical and chemical characteristics of the fruits:

It is obvious from the data in Tables (3 & 4) that single and combined applications of boron, potassium, silicon and selenium significantly was followed by improving fruit quality in terms of increasing fruit weight and dimensions (diameter & height), T.S.S %, reducing and total sugars % and vitamin C content and reducing total acidity percentage and thickness of fruit peel rather than non- application. The promotion on fruit quality was significantly associated with using selenium, silicon and selenium + silicon besides boron and/ or potassium, in ascending order. Using potassium was significantly favourable in promoting the fruit quality rather than using boron and the beneficial effects on fruit quality was appeared with using all nutrients together. The best results with regard fruit quality were observed with using all nutrients together. Similar trend was observed during both seasons.

The essential roles of B, K, Se and Si on enhancing the biosynthesis and translocation of plant pigments and sugars (Nijjar, 1985) surely reflected on enhancing fruit quality.

These results are in agreement with those obtained by Abdalla (2008) on boron; Harhash and Abdel- Nasser (2010) on potassium; Gad El- Kareem (2012) on silicon and Rayman (2002) on selenium.

Conclusion:

As a conclusion, it is suggested to use boric acid at 0.05 %, potassium sulphate at 0.5 %, potassium silicate at 0.1 % (as a source of silicon) and sodium selenite (as a source of selenium) at 50 ppm for improving yield and fruit quality of Valencia orange trees grown under Minia region conditions.

Table (2): Effect of silicon and selenium applied with boron and potassium on the leaf area, plant pigments and percentages of N and P in the leaves of Valencia orange trees during 2011/ 2012 and 2012/ 2013 seasons.

Treatments	Leaf area (m ²)		Chlorophyll a (mg/ g ⁻¹ F.W)		Chlorophyll b (mg/ g ⁻¹ F.W)		Total chlorophylls (mg/ g ⁻¹ F.W)		Total carotenoids (mg/ g ⁻¹ F.W)		Leaf N %		Leaf P %	
	2011/ 2012	2012/ 2013	2011/ 2012	2012/ 2013	2011/ 2012	2012/ 2013	2011/ 2012	2012/ 2013	2011/ 2012	2012/ 2013	2011/ 2012	2012/ 2013	2011/ 2012	2012/ 2013
Control	29.1	28.7	6.1	5.9	3.1	2.9	9.2	8.8	1.5	1.6	1.96	2.00	0.14	0.13
Boric acid at 0.05 % (boron)	30.3	29.5	6.5	6.2	3.3	3.4	9.8	9.6	1.7	1.8	2.03	2.07	0.17	0.18
Potassium sulphate at 0.5 % (potassium)	31.5	30.7	6.8	6.5	3.6	3.6	10.4	10.1	1.9	2.0	2.10	2.15	0.19	0.20
Boron + potassium	32.7	32.0	7.1	6.8	3.9	4.2	11.0	11.0	2.1	2.2	2.15	2.20	0.20	0.21
Boron + silicon at 0.1 % (S)	37.5	36.7	8.3	8.0	4.8	5.1	13.1	13.1	2.9	3.0	2.55	2.61	0.26	0.27
Potassium + silicon at 0.1 %	38.6	38.0	8.6	8.3	4.9	5.2	13.5	13.5	3.1	3.2	2.62	2.66	0.28	0.28
Boron + potassium + silicon at 0.1 %	39.7	39.0	9.0	8.7	5.0	5.5	14.0	14.3	3.3	3.4	2.71	2.75	0.31	0.32
Boron + selenium at 50 ppm (Se)	34.1	33.3	7.4	7.1	4.1	4.4	11.5	11.2	2.3	2.3	2.25	2.30	0.22	0.23
Potassium + selenium at 50 ppm	35.2	34.4	7.7	7.4	4.4	4.6	12.1	12.0	2.5	2.6	2.35	2.41	0.23	0.25
Boron + potassium + selenium at 50 ppm	36.3	35.5	8.0	7.7	4.5	4.7	12.5	12.4	2.7	2.8	2.45	2.50	0.25	0.27
Boron + Si + Se	41.1	40.3	9.4	9.1	5.2	5.4	14.6	14.5	3.5	3.6	2.80	2.87	0.33	0.34
Potassium + Si + Se	42.0	41.3	9.7	9.3	5.5	5.7	15.2	15.0	3.6	3.8	2.87	2.96	0.35	0.37
Boron + potassium + Si + Se	43.3	42.5	10.0	9.7	5.7	5.8	15.7	15.5	6.0	4.2	2.93	3.01	0.37	0.40
New L.S.D at 5 %	1.1	0.9	0.3	0.2	0.2	0.3	0.3	0.4	0.2	0.2	0.05	0.06	0.02	0.02

Table (3): Effect of silicon and selenium applied with boron and potassium on the percentages of K and Mg in the leaves, yield as well as some physical characters of the fruits of Valencia orange trees during 2011/ 2012 and 2012/ 2013 seasons.

Treatments	Leaf K %		Leaf Mg %		No. of fruits/ tree		Yield/ tree (kg.)		Fruit weight (g.)		Fruit diameter (cm.)		Fruit height (cm.)	
	2011/ 2012	2012/ 2013	2011/ 2012	2012/ 2013	2011/ 2012	2012/ 2013	2011/ 2012	2012/ 2013	2011/ 2012	2012/ 2013	2011/ 2012	2012/ 2013	2011/ 2012	2012/ 2013
Control	1.11	1.15	0.41	0.38	300	280	42	39.5	140.0	141.0	6.41	6.51	7.92	7.81
Boric acid at 0.05 % (boron)	1.20	1.27	0.45	0.51	311	320	46.5	47.4	149.5	148.0	6.46	6.36	7.99	7.90
Potassium sulphate at 0.5 % (potassium)	1.25	1.32	0.50	0.55	322	332	50.6	51.5	157.0	155.0	6.52	6.42	8.10	8.01
Boron + potassium	1.30	1.37	0.53	0.60	331	341	54.0	54.9	163.0	161.0	6.59	6.49	8.21	8.11
Boron + silicon at 0.1 % (S)	1.52	1.59	0.71	0.77	380	390	65.4	66.3	172.0	170.0	6.81	6.71	8.55	8.44
Potassium + silicon at 0.1 %	1.57	1.64	0.74	0.81	391	401	70.4	71.0	180.0	177.0	6.92	6.81	8.61	8.51
Boron + potassium + silicon at 0.1 %	1.63	1.70	0.79	0.85	405	416	75.3	76.5	186.0	184.0	7.01	6.91	8.67	8.56
Boron + selenium at 50 ppm (Se)	1.35	1.42	0.59	0.65	341	351	53.5	54.4	157.0	155.0	6.66	6.55	8.30	8.21
Potassium + selenium at 50 ppm	1.41	1.48	0.63	0.71	355	366	57.9	58.9	163.0	161.0	6.72	6.60	8.39	8.29
Boron + potassium + selenium at 50 ppm	1.46	1.53	0.66	0.73	366	376	62.6	63.2	171.0	168.0	6.71	6.61	8.45	8.35
Boron + Si + Se	1.71	1.80	0.84	0.91	382	392	66.9	67.0	175.0	171.0	7.07	7.00	8.81	8.71
Potassium + Si + Se	1.75	1.86	0.87	0.94	394	404	71.7	72.7	182.0	180.0	7.14	7.11	8.92	8.82
Boron + potassium + Si + Se	1.79	1.92	0.91	0.97	407	420	78.5	77.3	190.0	187.0	7.21	7.19	8.97	8.89
New L.S.D at 5 %	0.04	0.05	0.03	0.03	9.0	9.9	2.9	3.1	5.1	6.0	0.05	0.04	0.05	0.06

Table (4): Effect of silicon and selenium applied with boron and potassium on some physical and chemical characteristics of the fruits of Valencia orange trees during 2011/ 2012 and 2012/ 2013 seasons.

Treatments	Peel %		Fruit peel thickness (cm.)		T.S.S %		Total acidity %		Reducing sugars %		Total sugars %		V. C content (mg/ 100 ml juice)	
	2011/2012	2012/2013	2011/2012	2012/2013	2011/2012	2012/2013	2011/2012	2012/2013	2011/2012	2012/2013	2011/2012	2012/2013	2011/2012	2012/2013
Control	22.2	22.0	0.39	0.40	11.8	11.7	1.475	1.463	3.1	3.0	7.0	6.9	41.1	42.0
Boric acid at 0.05 % (boron)	21.8	22.3	0.36	0.37	12.1	12.2	1.441	1.433	3.3	3.2	7.1	7.0	41.7	42.6
Potassium sulphate at 0.5 % (potassium)	21.4	21.7	0.33	0.33	12.2	12.3	1.400	1.391	3.6	3.5	7.3	7.2	42.9	43.8
Boron + potassium	21.0	21.3	0.29	0.30	12.5	12.5	1.371	1.362	3.8	3.7	7.4	7.3	44.9	45.8
Boron + silicon at 0.1 % (S)	18.0	18.4	0.23	0.24	13.1	13.2	1.271	1.263	4.5	4.4	8.0	8.0	49.9	50.8
Potassium + silicon at 0.1 %	17.5	17.8	0.22	0.22	13.3	13.4	1.268	1.260	4.6	4.7	8.2	8.1	51.0	52.0
Boron + potassium + silicon at 0.1 %	17.0	17.3	0.21	0.21	13.5	13.6	1.260	1.250	4.7	4.8	8.3	8.3	52.2	53.1
Boron + selenium at 50 ppm (Se)	20.5	20.9	0.30	0.30	12.8	13.0	1.340	1.331	4.0	4.0	7.5	7.3	46.2	47.1
Potassium + selenium at 50 ppm	20.0	20.0	0.27	0.28	13.0	13.0	1.310	1.300	4.1	4.2	7.7	7.5	48.0	49.0
Boron + potassium + selenium at 50 ppm	19.5	19.8	0.26	0.27	13.1	13.1	1.281	1.271	4.3	4.3	8.0	7.8	48.8	49.9
Boron + Si + Se	16.0	16.4	0.22	0.23	13.5	13.6	1.251	1.241	4.6	4.5	8.5	8.4	53.0	54.0
Potassium + Si + Se	15.5	15.9	0.20	0.21	13.7	13.8	1.241	1.231	4.7	4.8	8.7	8.6	53.5	55.5
Boron + potassium + Si + Se	15.0	15.4	0.20	0.20	14.0	14.1	1.231	1.221	4.8	4.9	9.0	8.9	54.2	56.9
New L.S.D at 5 %	0.3	0.4	0.2	0.3	0.2	0.2	0.031	0.032	0.2	0.2	0.2	0.3	0.5	0.4

References

1. Abdalla, A.A. (2008): Behaviour of Zaghoul date palms to some pollen carriers and boron. M. Sc. Thesis Fac. of Agric. Minia Univ. Egypt.
 2. 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.
 3. Abd- El- Latief, M.A. (2002): Studies on potassium fertilization of Balady mandarin trees. M.Sc. Thesis Fac. of Agric. Minia. Univ., Egypt.
 4. Abd El- Migeed, M. M. M.; Saleh, M. M. S.; Mostafa, E. A. M. and Abou Raya, M. S. (2002): Influence of soil and foliar applications of boron on growth, fruit set, mineral status, yield and fruit quality of Picual olive trees. Egypt J. Agric. Sci. 17: 261 – 272.
 5. Abdel- Nasser, G. and Harhash, M. M. (2001): Response of Manzanillo olive cultivar to irrigation regime and boron fertigation under Siwa Oasis conditions 1- Vegetative growth and leaf constituents. Proc. of the Ann. Conf. "Sustainable Agric. Development" 28 – 30 March, 305 – 318.
 6. Ahmad, W.; Niaz, A.; Kanwal, S. and Rahmatullah, A. (2009): Role of boron in plant growth. A Review J. Agric. Res. 47 (3): 329 – 338.
 7. Ahmed, F. F and Morsy, M. H. (1999): A new method for measuring leaf area in different fruit species. Minia. J. Agric. Res. & Dev. 19: 97 – 105.
 8. Alvarez, J. and Datnoff, L. E. (2001): The economic potential of silicon for integrated management and sustainable rice production. Crop Prot. 20: 43 – 48.
 9. Al- Wasfy, M. M. (2013): Response of Sakkoti date palms to foliar application of royal jelly, silicon and vitamins B. J. of Amer. Sci. 9 (5): 315 – 321.
- A. O. A. C. (2000): Official Methods of Analysis 17th Ed, U.S.A. ISBN: 0- 935584 – 42 – 0.

10. Arnon, D. L. (1949): Copper enzymes in isolated chlorophyll polyphenol oxidase in *Beta vulgaris*. *Plant physio*, 24: 1-15.
11. Atalla, A. M.; Etman, A. A.; El- Kobbia, A. M. and El- Nawam, S. M. (2007): Influence of flower boron spray and soil application with some micronutrients in calcareous soil on 2- Yield, quality and mineral content of Zaghloul dates in Egypt. 4th Symp. on Date Palm in Saudi Arabia (Challenges of Processing, Marketing and Pests Control). Date Palm Res. Center, King Faisal Univ., Al- Hassa 5 – 8 May, Abstracts Book pp 73.
12. Aziz, T.; Gill, M. A. and Rahmatullah, R. (2002): Silicon nutrition and crop production: A review. *Pak. J. Agric. Sci.* 39 (3): 181 – 187.
13. Carter, M. R. (1993): *Soil Sampling and Methods of Analysis*. Canadian Soc. Soil Sci. Lewis Publishers, London, Tokyo, ISBN – 10 0873718615.
14. Dayer, R.; Fischer, B. B.; Eggen R. I. L. and Lemaire, S. D. (2008): The peroxidase and glutathione peroxidase families in *Chlamydomonas reinhardtii*. *Genetics*, 179: 41 – 57.
15. Desouky, I. M.; El- Hamady, A.; Hassan, A. and Abdel- Hamid, A. (2007): Effect of spraying Barhee flower with potassium sulphate and boric acid on fruit set, productivity and date properties. 4th Symp. on Date Palm in Saudi Arabia (Challenges of Processing, Marketing and Pests Control). Date Palm Res. Center, King Faisal Univ., Al- Hassa 5 – 8 May, Abstracts Book pp 76.
16. Ebeid- Sanaa, A. (2007): The promotive effect of seaweed extract and boron on growth and fruiting of Hindy Bisinnara mango trees. *Minia J. of Agric. Res. & Develop.* Vol. (27) No. 3 pp 579 – 594.
17. Ebrahiem, T.A.; Ahmed, F.F. and Assy, K.G. (2001): Behaviour of Balady mandarin trees (*Citrus reticulata L.*) grown in sandy soil to different forms and concentrations of potassium foliar sprays. *Assiut J. Agric. Sci.* Vol. 24, 30:215-27.
18. El- Sayed- Esraa, M. H. (2007): Response of Ewaise mango trees to foliar application of boron. M. Sc. Thesis Fac. of Agric. Minia Univ. Egypt.
19. El- Sayed- Esraa, M. H. (2010): Behaviour of Ewaise mango trees to foliar application of some nutrients and seaweed extract Ph. D. Thesis Fac. of Agric. Minia Univ. Egypt.
20. El-Sherif, A.A.; Saeed, W.T, and Nouman, V.F. (2000): Effect of foliar application of potassium and zinc on behaviour of Montakhab El- Kanater guava trees. *Bull. Fac. Agric. Cairo Univ.* 51 (1): 73 – 84.
21. Epstein, E. (1999): Silicon. *Annl. Rev. Plant Physiol. Plant Mol. Biol.* 50: 641 – 664.
22. Epstein, E. and Bloom, A. J. (2003): *Mineral Nutrition of Plant, Principles and Perspectives*. 2nd Ed. John Wiley & Sons, New York pp 1 – 120.
23. Etman, A. A. Atalla, A. M.; El- Kobbia, A. M. and El- Nawam, S. M. (2007): Influence of flower boron spray and soil application with some micronutrients in calcareous soil on 1- Vegetative growth and leaf mineral content of date palm cv. Zaghloul in Egypt. 4th Symp. on Date Palm in Saudi Arabia (Challenges of Processing, Marketing and Pests Control). Date Palm Res. Center, King Faisal Univ., Al- Hassa 5 – 8 May, Abstracts Book pp 72.
24. Fouad-Amera, A.; Khalil- Fekrya, M.; Ahmed, A.M. and Abdalla, A.S. (2003): Response of Mabrouka mango trees grown in sandy soil to potassium fertilization. *Annals Agric. Sci. Moshtohor*, 41 (2) : 100- 120.
25. 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.* Vol. 32 No. 2 pp 161 – 180.
26. Gissel- Neilsen, G.; Gupta, U. C.; Lamand, M. and Westermarck, T. (1984): Selenium in soils and plants and its importance in livestock and human nutrition. *Adv. Agron.* 37, 398 – 453.
27. Govind, S. and Singh, I.P. (2003): Effects of the foliar application of NPK on the growth of Khasi mandarin seedlings. *Indian J. of Hort.*, 60 (3) 232- 235.
28. Gupta, U. C.; Gupta, S. C. and Gupta, M. D. (2000): Selenium in soils and crops, its deficiencies in livestock and humans, implication for management. *Commun. Soil Sci. Plant Anal.* 31, 1791 – 1807.
29. Hanson, B.; Garifullina, G. F.; Lindblom, S. D.; Wangeline, A.; Ackley, A.; Kramer, K.; Norton, A. P.; Lawrence, C. B. and Pilon- Smits, E. A. H. (2003): Selenium accumulation protects Brassica juncea from invertebrate herbivory and fungal infection. *New Phytologist*, 159: 461 – 469.
30. Hanson, B.; Lindblom, S. D.; Loeffler, M. L. and Pilon- Smits, E. A. H. (2004): Selenium protects plants from phloem- feeding aphids due to both deterrence and toxicity. *New Phytologist*, 162: 655 – 662.
31. Harhash, M.M. and Abdel- Nasser, G. (2001): Response of Manzanillo olive cultivar to irrigation regime and boron fertigation under Siwa oasis conditions. 1- Yield, Oil Percent and fruit quality. *Proc. of the Ann. Conf. Sustainable Agric. Develop.*, 28 – 30 March, 319 – 334.
32. Harhash, M. M. and Abdel- Nasser, G. (2010): Impact of spraying the date palm Khalas cv. Bunches with potassium and boron on fruit set, yield, fruit quality and nutrient content. *Aust. J. Basic. Applied Sci.* 4 (9): 4164 – 4172.
33. Hartikainen, M. and Xue, T. (1999): The promotive effect of selenium on plant growth as triggered by W Harviolet radiation. *J. of Environ. Quality*, 28: 1372 – 1375.
34. 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.
35. Hattori, T.; Inanaga, S.; Araki, H.; An, P.; Mortia, S.; Luxova, M. and Lux, A. (2005): Application of

- silicon enhanced drought tolerance in sorghum bicolor. *Physiolgia Plantarum*. 123: 459 – 466.
36. Hulme, A.C. (1971): The mango, *Biochemistry of Fruits and Their Products*. Vol. 1 London, pp. 95-103.
 37. Jakovljevic, M.; Licina, V.; Antic- Mladenov, S. and Velickovic, M. (2011): The effects of selenium application on replant soil and its content in apple leaves and fruits. *Acta Hort*. 477: IV Inter. Sym. on Replant Proplems P.1.
 38. 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.
 39. Khayyat, M.; Tafazoli, E.; Eshghi, S. and Rajaei, S. (2007): Effect of nitrogen, boron, potassium and zinc on yield and fruit quality of date palm. *Amer. Eurasian J. Agric. & Environ. Sci*. 12 (3): 289 – 296.
 40. Kim, W. S.; Jo, J. A. and Chung, J. S. (2005): Effect of selenium supply by trunk injection on fruit quality of Niitaka Asian Pear. *Hort. Sci*. Vol. 40 No. 4: 1083 – 1084.
 41. Ma, J. F. and Takahashi, E. (2002): Soil, Fertilizer and Plant. *Silicon Research in Japan*. Elsevier Science, Amsterdam, the Netherlands p 1 – 200.
 42. Matichenkov, V. V.; Calvert, D. V. and Snyder, G. H. (2000): Prospective of silicon fertilization for citrus in Florida. *Proc. Soil and Crop Sci. Soc. of Florida* 5 p: 137 – 141.
 43. Matoh, T.; Murata, S. and Takahashi, E. (1991): Effect of silicate application on photosynthesis of rice plants (in Japanese). *Jpn. J. Soil Sci. Plant Nutr*. 62: 248 – 251.
 44. Mead, R.; Curnow, R. N. and Harted, A. M. (1993): *Statistical Methods in Agricultural and Experimental Biology*. Second Ed. Chapman & Hall London. pp 10 - 44.
 45. Melo, S. P.; Korndorfer, G. H.; Korndorfer, C. M.; Lana, R. M. Q. and Santan, D. G. (2003): Silicon accumulation and water deficit tolerance in grasses. *Scientia Agricola*. 60: 755 – 759.
 46. National Academy of Sciences, National Research Council (1983): (NASNRC): *Selenium in nutrition*, Washington D.C. p 1 – 300.
 47. Neumann, D. and Zur- Nieden, U. (2011): Silicon and heavy metal tolerance of higher plants. *Phytochemistry*, 56, 685 – 692.
 48. Nijjar, G. S. (1985): *Nutrition of Fruit Trees*. Published by Mrs Usha Raj Kumar for kalyani, New Delhi pp. 283-302.
 49. Nowak- Barbara, H. (2008): Effect of selenium on selected macronutrients in maize plants. *J. Elemental*. 13 (4): 513 – 519.
 50. Osman, S. M. (1999): Response of Picual olive trees to soil fertilization with borax and magnesium sulphate. *J. Agric. Res*. Vol. 24 No 1: 277 – 287.
 51. Piper, C. D. (1950): *Soil and Plant Analysis*. Inter. Sci., New York pp 48 – 110.
 52. Rayman, M. P. (2002): The argument for increasing selenium intake. *Proceeding of the Nutrition Society*, 61: 203 – 215.
 53. Saleh, M. M. S and Abd El- Monem- Eman, A. A. (2003): Improving productivity of Fagri Kalan mango trees grown under sandy soil conditions using potassium, boron and sucrose as foliar spray. *Annals Agric. Sci. Ain Shams Univ*. 48: 747 – 756. Egypt.
 54. Seppänen, M.; Turakainen, M. and Harikainen, H. (2003): Selenium effects on oxidative stress in potato. *Plant Science*, 165: 311 – 319.
 55. Sima, P. and Gissel- Neilsen, G. (1985): Spraying crops with selenium. *Acta Agric. Second*. 35: 161 – 164.
 56. Summer, M. E. (1985): *Diagnosis and Recommendation Integrated System (DRIS) as a Guide to Orchard Fertilization*. *Hort. Abst*. 55 (8): 7502.
 57. Turakainen, M.; Hartikainen, H. and Sepänen, M. (2004): Effect of selenium treatments on potato (*Solanum tuberosum* L.) growth concentration of soluble sugars and starch. *Journal of Agricultural and Food Chemistry*, 52: 5378 – 5382.
 58. Turakainen, M.; Hartikainen, H.; Ekholm, P., Seppänen M. M. (2006): Distribution of selenium in different biochemical fractions and raw darkening degree of potato (*Solanum tuberosum* L.) tubers supplemented with selenate. *Journal of Agricultural and Food Chemistry*, 54: 8617 – 8622.
 59. Wettstein, D. V. C. (1957): Clatale und der Sumbmikro Skopisne Formwechsel de Plastids. *Experimental Cell Research*, 12: 427.
 60. Whanger, P. D. (2002): Selenium pounds in plants and animal and their biological significance. *J. of the Amer. College and Nutrition* 21: 223 – 232.
 61. Wilde, S. A.; Corey, R. B.; Layer, J. G. and Voigt, G. K. (1985): *Soils and Plant Analysis for Tree Culture*. 3rd Ed. Oxford and IBH publishing Co., New Delhi, India. pp. 529 – 546.