

Effect of spraying calcium, boron and silicon on growth aspects, tree nutritional status, fruit setting, preharvest fruit dropping, yield and fruit quality of Balady mandarin trees.--I. Effect of spraying calcium chloride, boron and silicon on growth aspects and tree nutritional status of Balady mandarin trees

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Abstract: This study was carried out during 2015, 2016 and 2017 seasons to examine the effect of spraying Balady mandarin trees four times with boric acid at 0.025, 0.05 and 0.1%, potassium silicate and calcium chloride each at 0.05, 0.1 and 0.2% or all together at the medium concentration on some growth aspects, leaf photosynthetic pigments, total carbohydrates, N, P, K, Mg, Ca, Fe, Zn, Mn, Cu and C/N in the leaves. The trees received four sprays before bloom, full bloom, just after fruit setting and at one month later. Subjecting Balady mandarin trees four times with boric acid at 0.025 to 0.1% and both potassium silicate and calcium chloride each at 0.05 to 0.2% or all together at the medium concentration (0.05% for boric acid and 0.1% for both potassium silicate and calcium chloride) considerably enhanced main shoot length, leaf area and number of leaves/shoot in the spring growth cycle, chlorophylls a & b, total chlorophylls, total carbohydrates, N, P, K, Mg, Ca, Fe, Zn and Mn and had no effect on the leaf content of Cu and C/N compared to the check treatment. The promotion effect of these parameters was materially related to using calcium chloride, potassium silicate and boric acid, in ascending order. Four sprays of a mixture of boric acid at 0.05% and both acid potassium silicate and calcium chloride each at 0.1% was suggested to be beneficial for enhancing growth and tree nutritional status of Balady mandarin trees.

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1. Introduction

Recently, many attempts were conducted to use boron, silicon and calcium for promoting growth, tree nutritional status, fruit setting, yield and fruit quality of Balady mandarin trees.

Boron deficiencies can result in poor set, since it plays a main role in early season shoot growth and pollen growth and tube generation which is needed for fertilization process and fruit set (Mengel *et al.*, 2001 and Marschner, 2012).

Silicon is also known to increase drought tolerance in plants by maintaining plant water balance, photosynthetic activity and erectness of leaves and structure of xylem vessels under high transpiration rates (Melo *et al.*, 2003 and Hattori *et al.*, 2005).

Previous studies showed that application of Ca was accompanied with improving yield and fruit quality as well as extending shelf life of fruits and facilitating transportation of fruit to markets (Dood *et al.*, 2010).

The promoting effect of boron on growth and tree nutritional status of Balady mandarin trees was supported by the results of Sourour (2000) on Valencia oranges, Hassan – Al- Sayda (2004) on Balady mandarin, Abd- Allah (2006) on Washington

Navel oranges, Ahmad *et al.*, (2009) on Valencia oranges, Ibrahiem and Al- Wasfy (2014) and Hassan– Huda (2014) on Valencia oranges, Refaai (2014) on Zaghoul date palms as well as Mahmoud (2015) and Wassel *et al.*, (2015) on Ewaise mangoes.

The promotive effect of silicon on growth and tree nutritional status of Balady mandarin trees are in agreement with those obtained by El- Khawaga and Mansour (2014) on Washington Navel oranges, Aly (2015) on Balady mandarins, Gad El- Kareem (2012) on Taimour mangoes; Abdelaal and Oraby- Mona (2013) on Ewaise mangoes, Ahmed *et al.*, (2013a) on Zaghoul date palms, Ahmed *et al.*, (2013 b) on HindyBisinnara mangoes, Gad El- Kareem *et al.*, (2014) on Zaghoul date palms, Abd El- Wahab (2015) and Mohamed *et al.*, (2015) on Succary mangoes, Omar (2015) on Al- Saily date palms and Wassel *et al.*, (2015) on Ewaise mangoes.

The effect of calcium on stimulating growth and tree nutritional status of Balady mandarin trees was confirmed by the results of Young-Ho and Myung (1999); Bonan (2001); El-Shafey, *et al.*, (2002); Chakerolhosseini, *et al.*, (2016); Young-Ho *et al.*, (2004); Abd-Allah (2006); Yassen and Manzoor

(2010), El- Tanany *et al.*, (2011) and Habasy-Randa *et al.*, (2017).

The target of this study was examining the effect of single and combined applications of boric acid, potassium silicate and calcium chloride on vegetative growth characteristics and tree nutritional status of Balady mandarin trees grown under Minia region conditions.

2. Materials and Methods

This study was conducted during 2015, 2016 and 2017 seasons on 33 nearly uniform and similar vigour 25- years old Balady mandarin trees (*Citrus reticulata* L. Blanck) budded on sour orange rootstock in a private orchard located at El-Rayramon village, Mallawy district, Minia Governorate where the soil is silty clay and well drained and with a water table not less than two meters deep. The selected trees planted at 5x5 meters apart. Surface irrigation system was followed.

The target of this study was examining the effect of spraying calcium chloride, boric acid and potassium silicate on vegetative growth characteristics and tree nutritional status of Balady mandarin trees growing under Minia region.

Table (1): Analysis of the tested soil:

Constituents	Values
Particle size distribution	
Sand %	4.7
Silt %	60.0
Clay %	35.3
Texture %	Silt clay
pH (1: 2.5 extract)	7.92
E.C. (1: 2.5 extract) mmhos/ cm/ 25°C	1.72
O.M. %	1.42
CaCO ₃ %	2.22
Total N %	0.09
Available P (ppm, Olsen)	5.2
Available K (ppm, ammonium acetate)	402.2

Horticultural practices such as fertilization with 10 tons F.Y.M., 600 kg ammonium nitrate (33.5 % N), 600 g potassium sulphate (48 % K₂O) and 600 g calcium superphosphate (15.5 % P₂O₅), irrigation, hoeing as well as pest and fungi control were carried out as usual. Farmyard manure (F.Y.M.) was added at the mid. of Jan. Mineral N was divided into three equal batches applied at the first week of March, May and July. Potassium fertilizer was added at two equal batches before first bloom (mid. Mar.) and just after fruit setting (mid. May). The trees received two equal additions of phosphate fertilizer, the first with F.Y.M. and the second just after fruit setting (mid. May).

Analysis of the tested soil at 0.0 to 90 cm depth was carried out according to the procedures that outlined by **Wilde *et al.* (1985)** and the obtained data are shown in **Table (1)**.

This experiment included the following eleven treatments from single and combined applications of boric acid, potassium silicate and calcium chloride arranged as follows:

- 1- Control (untreated trees).
- 2- Spraying boric acid at 0.025% (0.25 g/l).
- 3- Spraying boric acid at 0.05% (0. 5 g/l).
- 4- Spraying boric acid at 0.1% (1.0 g/l).
- 5- Spraying potassium silicate at 0.05% (0. 5 g/l).
- 6- Spraying potassium silicate at 0.1% (1.0 g/l).
- 7- Spraying potassium silicate at 0.2% (2.0 g/l).
- 8- Spraying calcium chloride at 0.05% (0. 5 g/l).
- 9- Spraying calcium chloride at 0.1 % (1.0 g/l).
- 10- Spraying calcium chloride at 0.2% (2.0 g/l).
- 11- Spraying boric acid at 0.05% + potassium silicate at 0.1%+ calcium chloride at 0.1 %.

Each treatment was replicated three times, one tree / each. The total number of trees selected for achieving this study was 33. Boric acid (**17 % B**), potassium silicate (**25% Si+ 10 % K₂O**) and calcium chloride (**30% Ca**) were sprayed four times before bloom (**growth start at last week of Feb.**), at full bloom (**last week of Mar.**), just after fruit setting (**2nd week of Apr.**) and at one month later (**2nd week of May.**) Triton B as a wetting agent was added to all solutions at 0.05 % and spraying was done till runoff. The untreated trees received water containing Triton B.

The experimental design was randomized complete block with eleven treatments, with three replicates, one tree per each.

Methodology as has been reported in this experiment for different investigated characteristics in response to various plant extract treatments was carried out as follows:

1 Measurements of vegetative growth characters:

Sixteen new shoots from Spring growth cycle were chosen on the four labeled branches on the four main directions on the bases of four shoots/ branch for measuring shoot length (cm) and number of leaves/ shoot and then averages were estimated., Twenty mature leaves were taken from the middle parts of the shoots to measure the leaf area according to **Ahmed and Morsy (1999)** using the following formula.

Leaf area (cm)² = 0.46 (maximum length of leaf x maximum width of leaf) + 1.81

2- Measurement of leaf chemical analysis:

2-1 Measurements of plant pigments:

Samples of five mature fresh leaves from Spring growth cycle (last week of August) per each replicate were taken. The leaves were cut at small pieces,

homogenated and extracted by 25 % acetone in the presence of a little amount of Na₂ CO₃ and silica quartz then filtered through central glass funnel G₄.

The optical density of the filtrate was determined using Carlzeis spectrophotometer at the wave length of 662, 644, and 440 nm to determine chlorophylls (a & b) and carotenoids, respectively. Content of each pigment was calculated by using the following equations (according to Von –Wettstein, 1957).

$$\text{Chl. A} = (9.748 \times E \ 662) - (0.99 \times E \ 644) = \text{mg/ L}$$

$$\text{Chl. B} = (21.426 \times E \ 644) - (4.65 \times E \ 662) = \text{mg/ L}$$

Total carotenoids = $(4.965 \times E \ 440 - 0.268 \text{ (chlorophyll a+ chlorophyll b)})$ where E = optical density at a given wave length.

The chlorophylls a and b as well as total carotenoids were calculated as mg/ 100 g fresh weight of leaves. Also total chlorophylls was estimated (mg/ 100 g F.W.) by summation of chlorophylls a and b.

2-2 Measurements of total carbohydrates in the leaves:

The same leaves taken for measuring leaf area were cut into small pieces, oven dried at 70°C for 72 hours and ground. In the samples accurate 0.1 g dried material, total; carbohydrates was determined colourmetrically at 490 nm wave length using the phenol sulfuric acid method (A.O.A.C., 2000). It was calculated as g glucose /100 g leaf dry weight using glucose standard curve. C.N in the leaves was estimated by dividing total cholar by N%.

2-3 Measurements of leaf chemical composition:

To determine the percentage of N, P and K, Mg, Ca, Zn, Fe, Mn and Cu in the leaves, fifty mature leaves 6 months age from non- fruiting shoots in the Spring growth cycle (1st week of Sept.) were taken (according to Summer,1985). The 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, K, Mg, Ca, Zn, Fe, Mn and Cu on dry weight basis were determined according to the following procedures that outlined by Wilde *et al.*, (1985).

a- Total nitrogen percentage was measured by using the micro- Kjeldahl methods was described by Wilde *et al.*, (1985).

b- Phosphorus percentage was determined by using the method of Wilde *et al.*, (1985).

c- Potassium percentage was determined by using Flame photometer according to the method of (Wilde *et al.*, 1985).

d- Magnesium and calcium were determined by using atomic absorption according to the procedure (Wilde *et al.*, 1985).

e- Micronutrients namely Zn, Fe, Mn and Cu were determined by using atomic absorption according to the procedures of Peach and Tracey (1968).

All the obtained data during the course of this study in the three successive seasons, 2015 and 2016 and 2017 were tabulated and statistically analyzed. The differences between various treatment means were compared using new L.S.D. parameters at 5% (according to Snedecor and Cochran (1980) and Mead *et al.*, (1993).

3. Results and Discussion

1- Vegetative growth characteristics.

Data in Table (2) show the effect of single and combined applications of boric acid, potassium silicate and calcium chloride on main shoot length, leaf area and number of leaves/ shoot of Balady mandarin trees during 2015, 2016 and 2017 seasons.

It is clear from the obtained data that subjecting Balady mandarin trees four times with boric acid at 0.025% to 0.1%, potassium silicate at 0.05 to 0.2% and calcium chloride at 0.05 to 0.2% or all at the medium concentrations (boric acid at 0.05% and both potassium silicate and calcium chloride at 0.1%) significantly stimulated the three growth aspects namely main shoot length, leaf area and number of leaves/ shoot comparing to the control treatment. The promoting effect of these growth traits was significantly attributed to using calcium chloride, potassium silicate and boric acid, in ascending order. Varying materials and their concentrations caused significant effect with one exception was observed among the higher two concentrations of each material. Using boric acid at 0.05%, potassium silicate at 0.1% and calcium chloride at 0.1% was significantly superior than using each material alone in enhancing these growth aspects. The maximum main shoot length (41.1 & 42.6 and 42.3 cm), leaf area (8.19 & 8.17 and 7.30 cm²) and number of leaves/shoot (41.3 & 41.0 and 41.0 leaf) were recorded on the trees received three sprays of boric acid at 0.05%+ potassium silicate at 0.1%+ calcium chloride at 0.1% during 2015, 2016 and 2017 seasons, respectively. The untreated trees produced the lowest values. Similar trend was noticed during the tree seasons.

2- Leaf chemical composition.

Data in Tables (3 to 6) show the effect of single and combined applications of boric acid, potassium silicate and calcium chloride on chlorophylls a & b, total chlorophylls, total carotenoids, total carbohydrates N, P, K, Mg, Ca, Fe, Zn, Mn, Cu and C/N in the leaves of Balady mandarin trees during 2015, 2016 and 2017 seasons.

It is evident from the obtained data that supplying the trees via leaves with boric acid at 0.025% to 0.1%, potassium silicate at 0.05 to 0.2% and calcium chloride at 0.05 to 0.2% either alone or in combined applications at the medium concentrations of each material (boric acid at 0.05% and both

potassium silicate and calcium chloride at 0.1%) significantly was accompanied with enhancing chlorophylls a & b, total chlorophylls, total carotenoids, total carbohydrates N, P, K, Mg, Ca, Fe, Zn, Mn, Cu and C/N in the leaves relative to the control treatment. The investigated treatments had no significant effect on the leaf content of Cu and C/N above the control. There was a gradual stimulation on these chemical components with increasing concentrations of boric acid from 0.0 to 0.1 %, potassium silicate from 0.0 to 0.2% and calcium chloride from 0.0 to 0.2%. Using boric acid, potassium silicate and calcium chloride, in descending order was significantly favourable in enhancing these chemical components. Combined applications of these three materials at medium concentration gave the maximum

values of chlorophyll a (8.3 & 8.6 and 8.8 mg/1g FW), chlorophyll b (3.6 & 3.8 and 3.7 mg/1g FW), total chlorophylls (11.9 & 12.4 and 12.5 mg/1g FW), total carotenoids (4.7 & 4.9 and 5.0 mg/1g FW), total carbohydrates (17.0 & 17.0 and 17.1%), N (19.95 & 1.98 and 2.04%), P (0.221 & 0.214 and 0.220 %), K (1.71 & 1.72 and 1.74 %), Mg (0.87 & 0.86 and 0.91 %), Ca (2.94 & 3.00 and 3.06%), Fe (72.3 & 74.1 and 75.1 ppm), Zn (76.0 & 76.3 and 77.0 ppm), Mn (80.0 & 81.2 and 81.2 ppm) were recorded on the trees that received three sprays of boric acid at 0.05%+ potassium silicate at 0.1 % and calcium chloride at 0.2%. The lowest values of these chemical components were recorded on untreated trees. These results were true during the three seasons.

Table (2): Effect of single and combined applications of boric acid, potassium silicate and calcium chloride on some vegetative growth characteristics of Balady mandarin trees during 2015, 2016 and 2017 seasons.

Treatments	Main shoot length (cm.)			Leaf area (cm ²)			No. of leaves / shoot		
	2015	2016	2017	2015	2016	2017	2015	2016	2017
1- Control (untreated trees)	30.1	30.3	30.9	6.41	6.44	6.45	24.0	24.0	25.0
2- Spraying boric acid at 0.025%	36.3	38.5	36.9	7.60	7.67	7.68	36.0	36.0	37.0
3- Boric acid at 0.05 %	38.0	40.0	38.7	7.89	7.96	7.97	38.0	38.0	39.0
4- Boric acid at 0.1%	38.1	40.1	38.8	7.90	7.97	7.98	38.3	38.3	39.3
5- Potassium silicate at 0.05%	33.7	35.0	34.3	7.12	7.19	7.11	31.0	31.0	32.0
6- Potassium silicate at 0.1%	34.9	37.0	35.5	7.34	7.41	7.41	33.0	33.0	34.0
7- Potassium silicate at 0.2%	35.0	37.3	35.7	7.35	7.42	7.43	33.6	33.6	34.0
8- Calcium chloride at 0.05	31.2	31.5	31.9	6.62	6.69	6.67	26.0	26.0	27.0
9- Calcium chloride at 0.1	32.2	33.0	32.9	6.83	6.90	6.87	28.0	28.0	29.0
10- Calcium chloride at 0.2	32.4	33.3	33.0	6.85	6.92	6.90	28.3	28.6	29.3
11- All at the middle concentrations	41.1	42.6	42.3	8.19	8.17	7.30	41.3	41.0	41.0
New L.S.D. at 5%	0.9	1.1	0.8	0.19	0.17	0.16	1.8	2.0	1.9

Table (3): Effect of single and combined applications of boric acid, potassium silicate and calcium chloride on leaf pigments of Balady mandarin trees during 2015, 2016 and 2017 seasons.

Treatments	Chlorophyll a (mg/ 1.0 g FW.)			Chlorophyll b (mg/ 1.0 g FW.)			Total chlorophyll (mg/ 1.0 g FW.)			Total carotenoids (mg/ 1.0 g F.W.)		
	2015	2016	2017	2015	2016	2017	2015	2016	2017	2015	2016	2017
1- Control (untreated trees)	4.1	4.2	4.3	1.3	1.4	1.4	5.4	5.6	5.7	1.6	1.5	1.4
2- Spraying boric acid at 0.025%	7.0	7.1	7.3	3.0	3.0	3.1	10.0	10.1	10.4	3.6	3.5	3.6
3- Boric acid at 0.05 %	7.5	7.5	7.7	3.3	3.3	3.4	10.8	10.8	11.1	4.0	3.9	4.0
4- Boric acid at 0.1%	7.6	7.7	8.0	3.4	3.5	3.5	11.0	11.2	11.5	4.1	4.0	4.1
5- Potassium silicate at 0.05%	5.7	5.8	6.0	2.2	2.3	2.3	7.9	8.1	8.3	2.6	2.5	2.6
6- Potassium silicate at 0.1%	6.3	6.4	6.6	2.5	2.6	2.6	8.8	9.0	9.2	3.0	2.9	3.0
7- Potassium silicate at 0.2%	6.4	6.5	6.7	2.6	2.7	2.7	9.0	9.4	9.4	3.1	3.0	3.1
8- Calcium chloride at 0.05	4.6	4.7	4.9	1.6	1.8	1.7	6.2	6.5	6.6	1.9	1.9	2.0
9- Calcium chloride at 0.1	5.1	5.1	5.3	1.8	2.0	1.9	6.9	7.1	7.2	2.2	2.2	2.3
10- Calcium chloride at 0.2	5.2	5.3	5.5	1.9	2.1	2.0	7.1	7.4	7.5	2.3	2.3	2.4
11- All at the middle concentrations	8.3	8.6	8.8	3.6	3.8	3.7	11.9	12.4	12.5	4.7	4.9	5.0
New L.S.D. at 5%	0.4	0.5	0.3	0.2	0.3	0.3	0.4	0.5	0.3	0.3	0.2	0.2

Table (4): Effect of single and combined applications of boric acid, potassium silicate and calcium chloride on percentages of total carbohydrates, N, P and K in the leaves of Balady mandarin trees during 2015, 2016 and 2017 seasons.

Treatments	Total carbohydrates (%)			Leaf N %			Leaf P %			Leaf K %		
	2015	2016	2017	2015	2016	2017	2015	2016	2017	2015	2016	2017
1- Control (untreated trees)	13.1	13.2	13.2	1.41	1.44	1.47	0.140	0.136	0.141	1.14	1.13	1.16
2- Spraying boric acid at 0.025%	16.0	16.1	16.3	1.80	1.84	1.89	0.192	0.188	0.193	1.51	1.52	1.55
3- Boric acid at 0.05 %	16.5	16.6	16.8	1.86	1.90	1.95	0.209	0.205	0.210	1.61	1.63	1.66
4- Boric acid at 0.1%	16.6	16.7	16.8	1.87	1.91	1.96	0.210	0.205	0.210	1.62	1.64	1.67
5- Potassium silicate at 0.05%	14.6	14.7	14.9	1.61	1.65	1.70	0.171	0.167	0.172	1.34	1.37	1.41
6- Potassium silicate at 0.1%	15.2	15.3	15.5	1.67	1.71	1.77	0.181	0.177	0.182	1.40	1.44	1.48
7- Potassium silicate at 0.2%	15.3	15.3	15.4	1.69	1.73	1.78	0.182	0.178	0.183	1.41	1.44	1.49
8-Calcium chloride at 0.05	13.5	13.6	13.8	1.47	1.51	1.56	0.148	0.144	0.150	1.20	1.27	1.33
9- Calcium chloride at 0. 1	14.0	14.1	14.2	1.54	1.58	1.64	0.159	0.150	0.156	1.27	1.39	1.34
10- Calcium chloride at 0.2	14.1	14.2	14.3	1.55	1.59	1.65	0.160	0.151	0.157	1.28	1.40	1.40
11- All at the middle concentrations	17.0	17.1	17.1	1.95	1.98	2.04	0.221	0.214	0.220	1.71	1.72	1.74
New L.S.D. at 5%	0.3	0.4	0.3	0.04	0.05	0.05	0.003	0.004	0.004	0.04	0.04	0.04

Table (5): Effect of single and combined applications of boric acid, potassium silicate and calcium chloride on the leaf content of Mg and Ca (as %) and Fe & Zn (as ppm) of Balady mandarin trees during 2015, 2016 and 2017 seasons.

Treatments	Leaf Mg (%)			Leaf Ca %			Leaf Fe (ppm)			Leaf Zn (ppm)		
	2015	2016	2017	2015	2016	2017	2015	2016	2017	2015	2016	2017
1- Control (untreated trees)	0.51	0.51	0.53	2.11	2.16	2.17	48.3	49.0	49.0	54.1	54.3	55.0
2- Spraying boric acid at 0.025%	0.75	0.77	0.80	2.61	2.66	2.66	66.0	66.7	66.8	69.3	69.6	70.3
3- Boric acid at 0.05 %	0.81	0.83	0.86	2.71	2.76	2.76	68.5	69.2	69.3	72.2	72.5	73.2
4- Boric acid at 0.1%	0.82	0.84	0.87	2.84	2.90	2.90	68.6	69.3	69.3	72.3	72.6	73.3
5- Potassium silicate at 0.05%	0.64	0.67	0.70	2.40	2.45	2.45	58.3	59.0	59.3	63.3	63.6	64.3
6- Potassium silicate at 0.1%	0.68	0.71	0.75	2.50	2.56	2.57	62.3	63.0	63.2	66.0	66.4	66.7
7- Potassium silicate at 0.2%	0.69	0.74	0.75	2.51	2.56	2.58	62.4	63.1	63.1	66.3	67.2	68.0
8-Calcium chloride at 0.05	0.55	0.59	0.64	2.19	2.25	2.27	51.0	51.7	51.8	57.0	57.3	58.0
9- Calcium chloride at 0. 1	0.59	0.64	0.69	2.29	2.35	2.37	54.0	54.8	55.0	60.0	60.6	61.3
10- Calcium chloride at 0.2	0.60	0.64	0.70	2.30	2.36	2.39	54.6	55.0	55.1	60.3	60.6	61.3
11- All at the middle concentrations	0.87	0.86	0.91	2.94	3.00	3.06	72.3	74.1	75.1	76.0	76.3	77.1
New L.S.D. at 5%	0.03	0.03	0.02	0.06	0.06	0.06	1.6	1.7	1.9	1.9	2.1	1.8

Table (6): Effect of single and combined applications of boric acid, potassium silicate and calcium chloride on leaf content of Mn and Cu (as ppm) and C/N in the leaves of Balady mandarin trees during 2015, 2016 and 2017 seasons.

Treatments	Leaf Mn (ppm)			Leaf Cu (ppm)			C/N		
	2015	2016	2017	2015	2016	2017	2015	2016	2017
1- Control (untreated trees)	59.1	60.4	60.5	1.9	1.9	1.9	9.29	9.17	8.98
2- Spraying boric acid at 0.025%	73.0	73.6	74.0	2.0	2.0	2.0	8.89	8.75	8.62
3- Boric acid at 0.05 %	76.0	76.5	76.9	2.0	2.0	2.0	8.87	8.74	8.62
4- Boric acid at 0.1%	76.4	76.6	77.0	2.0	2.0	2.0	8.88	8.74	8.57
5- Potassium silicate at 0.05%	67.0	67.5	68.0	2.0	2.0	2.0	9.07	8.91	8.76
6- Potassium silicate at 0.1%	70.0	70.5	70.9	2.0	2.0	2.0	9.10	8.95	8.76
7- Potassium silicate at 0.2%	70.1	70.6	71.0	2.0	2.0	2.0	9.05	8.84	8.80
8-Calcium chloride at 0.05	61.6	62.0	62.9	2.0	2.0	2.0	9.18	9.01	8.85
9- Calcium chloride at 0. 1	64.0	64.6	65.0	2.1	2.0	2.0	9.09	8.92	8.66
10- Calcium chloride at 0.2	64.1	64.6	65.1	2.1	2.1	2.1	9.10	8.93	8.67
11- All at the middle concentrations	80.0	81.2	81.2	2.1	2.1	2.1	8.71	8.64	8.38
New L.S.D. at 5%	2.0	1.9	1.8	NS	NS	NS	NS	NS	NS

4. Discussion

The positive action of boron on growth and tree nutritional status of the trees might be attributed to the following reasons:

1- It is responsible as an essential nutrient in enhancing uptake of water through roots, controlling water movement within plant tissues, sugar translocation and biosynthesis, cell division and enlargement, pollen grains germination, pollination efficiency, formation of proteins and pectin substances that are responsible for building cellular translocation of the natural hormone namely IAA, the tolerance of fruit crops to various disorders uptake of the essential nutrients namely N, P and Ca, root development, expanding of plant cells and N fixation (**Blevius and Lucassweski, 1998**).

2- Boron is for reducing the incidence of various disease, uptake of Na and Ca, nematode occurrence, polarization of sugars and the efforts needed to movement sugars (**Mengel et al., 2001**).

3- The previous numerous positive action of boron could result in enhancing growth characters, nutritional status of the trees, fruit setting, yield and fruit quality.

These results regarding the effect of boron on enhancing growth and tree nutritional status of Balady mandarin trees are in harmony with those obtained by **Sourour (2000)** on Valencia oranges, **Hassan – Al-Sayda (2004)** on Balady mandarin, **Abd- Allah (2006)** on Washington Navel oranges, **Ahmad et al., (2009)** on Valencia oranges, **Ibrahiem and Al- Wasfy (2014)** and **Hassan– Huda (2014)** on Valencia oranges, **Refaai (2014)** on Zaghoul date palms as well as **Mahmoud (2015)** and **Wassel et al., (2015)** on Ewaise mangoes.

The outstanding effect of silicon on growth and tree nutritional status of the three olive cvs is mainly attributed to its essential roles in enhancing the tolerance of fruit crops to biotic (pests) and a biotic (climatic and soil environmental conditions) stresses, the biosynthesis of organic foods (proteins, fats and carbohydrates), uptake of water and essential nutrients, plant organ strength, plant development enzyme activities and the retained water (**Matoh et al., 1991; Bowen et al., 1992, and Reynolds et al., (1996)** The beneficial effects of silicon on forming double layers on plant tissues could explain its effect on protecting the trees from higher transpiration rate and the incidence of different disorders (**Alvarez and Datnoff, 2001, Aziz et al., 2002 and Melo et al., 2003**) previous studies supported the important roles of silicon as an antioxidant on protecting the plant cells from aging and senescence through chelating free radicals namely OH, O₂ as well as preventing the for ROS (reactive oxygen species) from destroying the permeability of cell walls. Consequently, oxidation

process is stopped (**Lux et al., 2003, Rodrigues et al., 2003, Ma, 2004 and Tahir et al., 2006**).

The promotive effect of silicon on growth and tree nutritional status of Balady mandarin trees are in agreement with those obtained by **El- Khawaga and Mansour (2014)** on Washington Navel oranges, **Aly (2015)** on Balady mandarins, **Gad El- Kareem (2012)** on Taimour mangoes; **Abdelaal and Oraby- Mona (2013)** on Ewaise mangoes, **Ahmed et al., (2013a)** on Zaghoul date palms, **Ahmed et al., (2013 b)** on HindyBisinnara mangoes, **Gad El- Kareem et al., (2014)** on Zaghoul date palms, **Abd El- Wahab (2015)** and **Mohamed et al., (2015)** on Succary mangoes, **Omar (2015)** on Al- Saily date palms and **Wassel et al., (2015)** on Ewaise mangoes.

Calcium has many important functions on growth and tree nutritional status of fruit crops. It is responsible in maintaining and modulating various cell functions by increasing membrane stability, cell wall strength and maintaining the cell to cell contact by reducing degradation of middle lamella, this is due to a decrease in the activity 1-minocyclopropane -1-carboxylic acid oxidase. It is very effective in enhancing fruit firmness, stress tolerance, cell division, N fixation, nutrient uptake, enzymes activity, root development and reducing fruit weight loss, respiration rate and decay incidence (**Dodd et al., 2010**). The increase of nutrient uptake due to using Ca was attributed to its effect in stimulating root development. The increase on growth aspects and tree nutritional status surely reflected in enhancing yield. Also, it inhibits fruit a abscission and delays its senescence development.

These results regarding the beneficial effect of calcium on growth and tree nutritional status of Balady mandarin trees were supported by **Young-Ho and Myung (1999); Bonan (2001); El-Shafey, et al., (2002); Chakerolhosseini, et al., (2016); Young-Ho et al., (2004); Abd-Allah (2006); Yassen and Manzoor (2010), El- Tanany et al., (2011) and Habasy- Randa et al., (2017)**.

Conclusion

Under the experimental and resembling conditions, it is recommended to spray Balady mandarin four times, at growth start (at last week of Feb.), at full bloom (last week of Mar.), just after fruit setting (2nd week of Apr.) and at one month later (2nd week of May.) with a mixture of boric acid at 0.05% potassium silicate at 0.1% and calcium chloride at 0.1% for enhancing growth characteristics and tree nutritional status.

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