

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.--II. Effect of spraying calcium, boron and silicon on fruit setting, preharvest fruit dropping, yield and fruit quality 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 the percentages of initial fruit setting, fruit retention and preharvest fruit dropping, yield and fruit quality. 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 the percentages of initial fruit setting and fruit retention, yield expressed in weight (kg) and number of fruits/tree and both physical and chemical characteristics of the fruits relative to the check treatment. Using boric acid occupied the first position in enhancing these parameters. The investigated treatments had no effect on fruit shape and non-reducing sugars%. Preharvest fruit dropping was greatly controlled by the present boron, silicon and calcium treatments. The reduction was associated with using calcium chloride, boric acid and potassium silicate, in descending 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 improving yield and fruit quality of Balady mandarin trees. [Moawad A. Mohamed; Ramadan A. Sayed and Hassan, S. H. Ismail. **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.--II. Effect of spraying calcium, boron and silicon on fruit setting, preharvest fruit dropping, yield and fruit quality of Balady mandarin trees..** *N Y Sci J* 2017;10(12):78-85]. ISSN 1554-0200 (print); ISSN 2375-723X (online). <http://www.sciencepub.net/newyork>. 9. doi:[10.7537/marsnys101217.09](https://doi.org/10.7537/marsnys101217.09).

Keywords: Boric acid, potassium silicate, calcium chloride, initial fruit setting, fruit retention, preharvest fruit dropping, yield, physical and chemical characteristics fruit quality, Balady mandarin trees

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 yield and fruit quality 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 yield and fruit quality 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 improving yield and fruit quality 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 yield and fruit quality 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 yield and fruit quality of Balady mandarin trees growing under Minia region.

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).

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

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. Percentages of initial fruit setting and fruit retention;

Percentages of initial fruit setting in the four labeled of branches calculated by dividing number of fruits just after fruit setting by total number of flowers and multiplying the product x 100. Just before harvesting, total number of fruits in the same previous four branches was calculated and divided by total number of flowers and multiplied the product x 100 for calculating percentages of fruit retention.

2. Measurements of yield and fruit quality:

Harvesting was achieved during the regular harvesting time prevailing under Minia region conditions (1st Dec.) during eth two seasons when T.SS./ acid reached at least 8:1 Yield per tree

expressed in weight (kg.) and number of fruits per tree was recorded.

To determine the following physical and chemical characters of the fruits, ten fruits at picking date were taken at random from constant height and from all directions of each tree.

1- Fruit weight (g.) and dimensions (height and diameter in cm.) and then fruit shape was estimated by dividing height by diameter.

2- Percentages of fruit peel weight and juice

3- Fruit peel thickness (cm.)

4- Percentages of total soluble solids by handy refractometer.

5- Percentages of total acidity (as a citric acid/ 100 ml juice) by titration against 0.1 N sodium hydroxide using phenolphthalein as an indicator (A.O.A.C., 2000) T.S.S./ acid was estimated.

6- Percentages of total and reducing sugars according to Lane and Eynon (1965) volumetric method (A.O.A.C, 2000).

7- L- ascorbic acid content (as mg/ 100 ml juice) by using 2.6 dichlorophenol indophenol dye (A.O.A.C., 2000).

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

1. Percentages of initial fruit setting and fruit retention

Table (2) show the effect of single and combined applications of boric acid, potassium silicate and calcium chloride on the percentages of initial fruit setting and fruit retention of Balady mandarin trees during 2015, 2016 and 2017 seasons.

One can state from the obtained data that single and combined applications of boric acid, potassium silicate and calcium chloride were responsible for improving the percentages of initial fruit setting and fruit retention relative to the control treatment. Increasing concentrations of the three materials was followed by a gradual promotion on such two parameters. Increasing concentrations of boric acid from 0.05 to 0.1%, potassium silicate from 0.1 to 0.2% and calcium chloride from 0.1 to 0.2% had negligible promotion. Using boric acid was significantly preferable in enhancing such two parameters than using potassium silicate and calcium chloride. Potassium silicate occupied the second position followed by calcium chloride which ranked the last position. Using all materials together at the medium concentration gave the best findings. Under such

promised treatment initial fruit setting reached **9.0 & 9.1 and 9.3%** and fruit retention were **0.72 & 0.75 and 0.76 %** during the three seasons. The untreated trees produced the lowest values of initial fruit setting (**4.1 & 4.2 and 4.4 %**) and fruit retention (**0.61 & 0.61 and 0.59%**) during 2015, 2016 and 2017 seasons, respectively. These results were true during the three seasons.

2. Percentage of preharvest fruit dropping.

Table (2) show the effect of single and combined applications of boric acid, potassium silicate and calcium chloride on the percentage of preharvest fruit dropping of Balady mandarin trees during 2015, 2016 and 2017 seasons.

It is clear from the obtained data that percentage of preharvest fruit dropping was significantly controlled by treating the trees singly or in combinations with boric acid, potassium silicate and calcium chloride relative to the control treatment. The reduction on such trait was depended to the increase in concentrations of each material. Significant reduction on such undesirable phenomenon was observed among the three materials and concentrations except among the higher two concentrations. The beneficial of these materials on controlling preharvest fruit dropping could be arranged as follows, in descending order, boric acid, potassium silicate and calcium chloride. Using the three materials together at the medium concentration gave the lowest values of preharvest fruit dropping (**18.0 & 17.7 and 16.8%**) during the three seasons, respectively. The values of preharvest fruit dropping percentage in the untreated trees reached **40.0 & 39.1 and 41.1%** during the three seasons, respectively. These results were true during the three seasons.

3. Number of fruits/ tree and yield/tree (kg).

Data in Tables (2 & 3) show the effect of single and combined applications of boric acid, potassium silicate and calcium chloride on the yield expressed in number of fruits/ tree and weight (kg) of Balady mandarin trees during 2015, 2016 and 2017 seasons.

Treating the 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% singly or in combination had significant promotion on the yield expressed in number of fruits/ tree and yield (kg) relative to the control treatment. The promotion was significantly associated with using boric acid, potassium silicate and calcium chloride, in descending order. There was a gradual increase on the yield with increasing concentrations of each material. Increasing concentrations from 0.05 to 0.1% of boric acid as well as from 0.1 to 0.2% of potassium silicate and from 0.1 to 0.2% of calcium chloride had meaningless promotion on the yield. Using the three materials together at the medium concentration gave the

maximum yield (55.2 & 55.7 and 56.8 kg) while, the untreated trees produced 27.0 & 27.9 and 27.5 kg during 2015, 2016 and 2017 seasons, respectively. The percentage of increment on the yield due to using the promise treatment (Using the three materials together at the medium concentration) over the check treatment reached 1.04 & 99.6 and 1.07% during the three seasons, respectively. These results were true during the three seasons.

4. Physical and chemical characteristics of the fruits.

Data in Tables (3 to 6) show the effect of single and combined applications of boric acid, potassium silicate and calcium chloride on weight, height and diameter of fruit, fruit shape index, fruit peel thickness and percentages of fruit peel and pulp weights, fruit juice, T.S.S, total acidity, total, reducing and non-reducing sugars, T.S.S/acid and vitamin C of the fruits of Balady mandarin trees during 2015, 2016 and 2017 seasons.

Table (2): Effect of single and combined applications of boric acid, potassium silicate and calcium chloride on the percentages of initial fruit setting, fruit retention, preharvest fruit dropping and number of fruits/ tree of Balady mandarin trees during 2015, 2016 and 2017 seasons.

Treatments	Initial fruit setting %			Fruit retention %			Preharvest fruit dropping %			Number of fruits / tree		
	2015	2016	2017	2015	2016	2017	2015	2016	2017	2015	2016	2017
1- Control (untreated trees)	4.1	4.2	4.4	0.61	0.61	0.59	40.0	39.1	41.1	251.0	253.0	255.0
2- Spraying boric acid at 0.025%	7.6	7.6	8.0	0.90	0.92	0.93	31.0	30.8	30.0	315.0	317.0	317.0
3- Boric acid at 0.05 %	8.2	8.3	8.5	0.94	0.95	0.97	29.0	28.2	27.4	330.0	331.0	333.0
4- Boric acid at 0.1%	8.3	8.4	8.6	0.95	0.95	0.97	28.6	28.4	27.6	331.0	333.0	336.0
5- Potassium silicate at 0.05%	5.8	5.9	6.1	0.77	0.80	0.81	38.1	37.8	37.0	288.0	291.0	293.0
6- Potassium silicate at 0.1%	6.3	6.4	6.7	0.83	0.87	0.89	35.0	34.8	34.0	300.0	302.0	305.0
7- Potassium silicate at 0.2%	7.0	7.1	7.4	0.84	0.88	0.90	34.7	34.5	33.7	301.0	303.0	306.0
8- Calcium chloride at 0.05	4.6	4.7	5.0	0.66	0.69	0.70	26.0	25.8	25.0	263.0	265.0	267.0
9- Calcium chloride at 0.1	5.2	5.3	5.6	0.71	0.74	0.75	22.0	21.8	21.0	275.0	278.0	280.0
10- Calcium chloride at 0.2	5.3	5.4	5.7	0.72	0.75	0.76	21.9	21.6	20.8	276.0	279.0	281.0
11- All at the middle concentrations	9.0	9.1	9.3	0.99	1.04	1.05	18.0	17.7	16.8	345.0	350.0	355.0
New L.S.D. at 5%	0.4	0.5	0.4	0.04	0.03	0.03	1.0	0.8	0.9	11.1	12.0	11.4

Table (3): Effect of single and combined applications of boric acid, potassium silicate and calcium chloride on yield/ tree (kg) and some physical characteristics of the fruits of Balady mandarin trees during 2015, 2016 and 2017 seasons.

Treatments	Yield/ tree Kg			Fruit weight (g)			Fruit height (cm)			Fruit diameter (cm)		
	2015	2016	2017	2015	2016	2017	2015	2016	2017	2015	2016	2017
1- Control (untreated trees)	27.0	27.9	27.5	106.1	107.1	107.9	5.01	5.09	5.11	6.11	6.14	6.16
2- Spraying boric acid at 0.025%	49.0	49.5	49.1	155.0	156.0	155.0	5.50	5.49	5.51	6.64	6.67	6.69
3- Boric acid at 0.05 %	52.0	51.9	52.3	156.0	157.0	157.0	5.59	5.58	5.60	6.75	6.78	6.80
4- Boric acid at 0.1%	52.0	52.3	53.1	156.3	157.2	158.0	5.60	5.59	5.61	6.76	6.80	6.82
5- Potassium silicate at 0.05%	39.0	39.5	39.6	135.0	137.0	135.0	5.30	5.29	5.31	6.42	6.46	6.48
6- Potassium silicate at 0.1%	43.5	44.1	43.9	145.0	146.0	144.0	5.37	5.38	5.40	6.53	6.57	6.59
7- Potassium silicate at 0.2%	43.6	44.3	44.2	145.0	146.3	144.3	5.38	5.38	5.40	6.54	6.57	6.59
8- Calcium chloride at 0.05	30.5	31.0	30.9	116.0	117.0	116.0	5.11	5.11	5.13	6.21	6.24	6.26
9- Calcium chloride at 0.1	34.7	34.8	35.0	126.0	126.2	125.0	5.18	5.18	5.20	6.31	6.35	6.37
10- Calcium chloride at 0.2	34.9	35.3	35.2	126.3	126.4	125.3	5.19	5.19	5.21	6.32	6.36	6.38
11- All at the middle concentrations	55.0	55.7	56.8	160.0	159.0	160.0	5.71	5.74	5.75	6.90	6.91	6.91
New L.S.D. at 5%	1.8	1.6	2.1	9.0	8.8	8.7	0.07	0.05	0.06	0.08	0.07	0.06

It is revealed from the obtained data that treating 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% singly or in combination was significantly very effective in improving quality of the fruits in terms of increasing weight, height and diameter of fruit, fruit pulp weight %, fruit juice %, T.S.S %, T.S.S/acid, total and reducing sugars % and vitamin C and decreasing fruit peel weight %, peel thickness and total acidity %

relative to the check treatment. Fruit shape and percentage of non-reducing sugars were significantly unaffected by the present treatments. The promotion on both physical and chemical characteristics was significantly associated with using calcium chloride, potassium silicate and boric acid, in ascending order. There was a gradual promotion on both physical and chemical characteristics of the fruits with increasing concentrations of each material. Using the three materials together at the medium concentration was

significant preferable than using each material alone in enhancing fruit quality. Increasing concentrations of boric acid from 0.05 to 0.1% as well as potassium silicate and calcium chloride from 0.1 to 0.2% failed

significantly to show any promotion on quality parameters. The untreated trees produced unfavourable effects on fruit quality. Similar findings were observed during the three seasons.

Table (4): Effect of single and combined applications of boric acid, potassium silicate and calcium chloride on some physical characteristics of the fruits of Balady mandarin trees during 2015, 2016 and 2017 seasons.

Treatments	Fruit shape index			Fruit peel weight %			Fruit pulp weight %			Fruit juice %			Fruit peel thickness (cm)		
	2015	2016	2017	2015	2016	2017	2015	2016	2017	2015	2016	2017	2015	2016	2017
1- Control (untreated trees)	0.82	0.83	0.83	25.1	25.0	25.0	74.9	75.0	75.0	50.1	49.9	50.9	0.37	0.36	0.36
2- Spraying boric acid at 0.025%	0.83	0.82	0.82	19.9	20.0	19.9	80.1	80.0	80.1	59.0	58.8	58.9	0.24	0.24	0.24
3- Boric acid at 0.05 %	0.83	0.82	0.82	19.1	19.2	19.2	80.9	80.8	80.8	60.9	60.7	60.8	0.22	0.22	0.22
4- Boric acid at 0.1%	0.83	0.82	0.82	18.0	18.0	17.8	82.0	82.0	82.2	61.0	60.8	61.0	0.21	0.21	0.21
5- Potassium silicate at 0.05%	0.83	0.82	0.82	22.2	22.2	22.1	77.8	77.8	77.9	55.3	55.1	55.3	0.29	0.29	0.29
6- Potassium silicate at 0.1%	0.82	0.82	0.82	21.0	21.1	20.9	79.0	78.9	79.1	57.0	56.9	57.0	0.27	0.27	0.26
7- Potassium silicate at 0.2%	0.82	0.81	0.82	20.9	21.0	20.9	79.1	79.0	79.1	57.3	57.1	57.3	0.26	0.26	0.25
8-Calcium chloride at 0.05	0.82	0.82	0.82	24.0	24.1	24.0	76.0	75.9	76.0	52.5	52.4	52.5	0.35	0.35	0.34
9- Calcium chloride at 0.1	0.82	0.82	0.82	23.3	23.4	23.3	76.7	76.6	76.7	53.6	53.4	53.5	0.33	0.32	0.32
10- Calcium chloride at 0.2	0.82	0.82	0.82	23.2	23.2	23.2	76.8	76.8	76.8	53.8	53.6	53.6	0.32	0.31	0.31
11- All at the middle concentrations	0.83	0.83	0.83	17.1	17.1	16.9	82.9	82.9	83.1	62.3	62.3	62.3	0.19	0.20	0.19
New L.S.D. at 5%	NS	NS	NS	0.07	0.6	0.7	0.6	0.5	0.6	1.1	1.0	0.9	0.02	0.02	0.02

Table (5): Effect of single and combined applications of boric acid, potassium silicate and calcium chloride on some chemical characteristics of the fruits of Balady mandarin trees during 2015, 2016 and 2017 seasons.

Treatments	T.S.S. %			Total acidity %			T.S.S. / acid			Total sugars %		
	2015	2016	2017	2015	2016	2017	2015	2016	2017	2015	2016	2017
1- Control (untreated trees)	10.7	10.8	10.9	1.390	1.397	1.399	7.7	7.7	7.8	7.41	7.41	7.48
2- Spraying boric acid at 0.025%	12.2	12.2	12.2	1.270	1.274	1.269	9.6	9.6	9.6	7.86	7.80	7.88
3- Boric acid at 0.05 %	12.5	12.5	12.5	1.249	1.253	1.249	10.0	9.9	10.0	7.96	7.91	7.99
4- Boric acid at 0.1%	12.6	12.7	12.6	1.247	1.251	1.246	10.1	10.2	10.1	7.97	7.92	8.00
5- Potassium silicate at 0.05%	11.5	11.6	11.6	1.320	1.325	1.319	8.7	8.8	8.8	7.69	7.64	7.72
6- Potassium silicate at 0.1%	11.8	11.9	11.9	1.300	1.303	1.299	9.0	9.1	9.2	7.75	7.71	7.79
7- Potassium silicate at 0.2%	11.9	12.0	12.0	1.299	1.304	1.298	9.2	9.2	9.2	7.76	7.72	7.79
8-Calcium chloride at 0.05	10.9	11.0	11.0	1.370	1.374	1.369	7.9	8.0	8.0	7.52	7.48	7.55
9- Calcium chloride at 0.1	11.1	11.1	11.1	1.349	1.352	1.348	8.2	8.2	7.9	7.59	7.55	7.62
10- Calcium chloride at 0.2	11.2	11.2	11.2	1.348	1.352	1.347	8.3	8.3	8.3	7.60	7.56	7.63
11- All at the middle concentrations	12.9	13.0	13.1	1.229	1.221	1.229	10.5	10.2	10.7	8.03	8.01	8.11
New L.S.D. at 5%	0.2	0.2	0.2	0.016	0.015	0.017	0.3	0.5	0.4	0.05	0.04	0.06

Table (6):Effect of single and combined applications of boric acid, potassium silicate and calcium chloride on some chemical characteristics of the fruits of Balady mandarin trees during 2015, 2016 and 2017 seasons.

Treatments	Reducing sugars %			Non-reducing sugars %			Vitamin C (mg/100 ml juice)		
	2015	2016	2017	2015	2016	2017	2015	2016	2017
1- Control (untreated trees)	3.11	3.20	3.13	4.30	4.21	4.35	30.1	29.9	30.3
2- Spraying boric acid at 0.025%	3.50	3.60	3.53	4.36	4.20	4.35	37.0	37.6	38.0
3- Boric acid at 0.05 %	3.59	3.69	3.62	4.37	4.22	4.37	38.3	39.0	39.5
4- Boric acid at 0.1%	3.60	3.70	3.63	4.37	4.22	4.37	38.4	39.0	39.6
5- Potassium silicate at 0.05%	3.31	3.41	3.43	4.38	4.23	4.29	33.3	34.0	34.7
6- Potassium silicate at 0.1%	3.40	3.50	3.43	4.35	4.21	4.36	35.0	35.6	36.2
7- Potassium silicate at 0.2%	3.41	3.51	3.44	4.35	4.21	4.35	35.3	36.0	36.6
8-Calcium chloride at 0.05	3.17	3.27	3.20	4.35	4.21	4.35	31.0	31.6	32.2
9- Calcium chloride at 0.1	3.23	3.33	3.26	4.36	4.22	4.36	32.0	32.7	33.3
10- Calcium chloride at 0.2	3.24	3.34	3.27	4.36	4.22	4.36	32.1	32.8	33.4
11- All at the middle concentrations	3.71	3.81	3.81	4.32	4.20	4.30	41.1	41.9	42.3
New L.S.D. at 5%	0.05	0.06	0.06	NS	NS	NS	0.8	0.7	0.6

4. Discussion

The positive action of boron on yield and fruit quality 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 improving yield and fruit quality 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 yield and fruit quality of the three olive cvs is mainly attributed to its essential roles in enhancing the tolerance of fruit crops to biotic (pests) and abiotic (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 yield and fruit quality 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 yield and fruit quality 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 abscission and delays its senescence development.

These results regarding the beneficial effect of calcium on yield and fruit quality 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- Tananyet et al., (2011) and Habasy-Randaet 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 improving yield and fruit quality.

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