

## Response of Succary Mango Trees to Foliar Application of Silicon and Boron

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**Abstract:** This study was carried out during 2013 and 2014 seasons to examine the effect of single and combined applications of potassium silicate at 0.1 to 0.2% and boric acid at 0.025 to 0.05% on growth, nutritional status of the trees, yield and fruit quality of Succary mango trees grown under Upper Egypt region conditions. Single and combined applications of potassium silicate at 0.1 to 0.2% and boric acid at 0.025 to 0.05 % were very effective in stimulating all growth characters in the Spring, Summer and Autumn growth cycles, chlorophylls a, b, total chlorophylls, N, P, K and Mg in the leaves, yield and fruit quality relative to the control treatment. Using potassium silicate was superior than using boric acid in this respect. Carrying out three sprays of a mixture of potassium silicate at 0.1 % and boric acid at 0.025 % was responsible for improving yield and fruit quality of Succary mango trees grown under Upper Egypt conditions.

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**Key words:** Succary mango trees, boron, silicon, yield and fruit quality

### 1. Introduction

Nowadays, many attempts are established for improving yield and fruit quality of mango trees by using non- traditional methods. Silicon is beneficial on enhancing the tolerance of mango trees to biotic and abiotic stresses, water and nutrients uptake, photosynthesis and water transport. It is very important for reducing the severity of the trees to most disorders through forming a silicon cuticle double layers on the leaf epidermal tissues which is responsible for preventing the penetration of fungal hypha. Also, it is essential for ameliorating the adverse effects of heavy metal toxicity (Mengel *et al.*, 2001; Aziz *et al.*, 2002; Lux *et al.*, 2002 and 2003; Sauvas *et al.*, 2002; Iwaskai *et al.*, 2002 : Gang *et al.*, 2003; Melo *et al.*, 2003 and Tahr *et al.*, 2006).

Boron has an announced impact on fruiting of fruit crops through its important roles in enhancing cell division, biosynthesis and translocation of sugars and hormones, root development, pollens germination, water and nutrients uptake and flower but formation and decreasing dropping of flowers and fruit and the incidence of disorders (Fraguas and Silva, 1998).

Previous studies showed that silicon (Gad El- Kareem, 2012; Ahmed *et al.*, 2013a and 2013b; Abdelaal and Oraby- Mona, 2013, Ibrahiem and Al- Wasfy, 2014; El Khawaga and Mansour, 2014; Gad El- Kareem *et al.*, 2014 and Al- Wasfy, 2014) and boron (Ebeid- Sanaa, 2007; El- Sayed- Esraa, 2007; Ibrahiem *et al.*, 2007; Abdelaal, 2008; Refaai, 2014 and Hassan- Huda, 2014) had an announced promotive effects on growth, yield and fruit quality of different fruit corps.

The target of this study was examining the effect of single and combined applications of silicon and boron at various concentrations on yield and fruit quality of Succary mango trees grown under Upper Egypt region conditions.

### 2. Material and Methods

This study was carried out during 2013 and 2014 seasons on twenty- one uniform in vigour 11- years old Succary mango trees onto seedling mango rootstock. The selected trees are grown in a private orchard located at Keman El- Mataana village, Esna district, Luxor Governorate. The trees are planted at 7x7 meters apart. The texture of the tested soil is clay (Wilde, 1985). The selected trees were kept under the normal horticultural practices that already applied in the orchard except those dealing with the application of potassium silicate and boric acid.

This study included seven treatments arranged as follows:

- 1- Control( treated with water trees).
- 2- Spraying potassium silicate at 0.1%
- 3- Spraying potassium silicate at 0.2%.
- 4- Spraying boric acid at 0.025%.
- 5- Spraying boric acid at 0.05.
- 6- Spraying both at the first concentration.
- 7- Spraying both at the second concentration.

Each treatment was replicated three times, one tree per each. Potassium silicate ( 20% Si + 10% K<sub>2</sub>O) and boric acid (17% B) were sprayed three times at growth start, just after fruit setting and at one month later Triton b as a wetting agent was added to all sprayed solutions at 0.05% and spraying was done till

runoff (50 L water / tree). Randomized completed block design (RCBD) was followed.

**Table (1): Analysis of the tested soil:**

Constituents	Values
<b>Particle size distribution :</b>	
Sand %	4.1
Silt %	13.0
Clay %	82.9
Texture	Clay
pH ( 1 : 2.5 extract)	7.11
E.C ( ha 2.5 extract) mmhos/ 1 cm/ 25°C)	0.71
O.M. %	2.50
CaCO <sub>3</sub> %	1.13
Total N %	0.12
Available P ( ppm, olsen)	4.1
Available K (ppm, ammonium acetate)	450

During both seasons the following parameters were recorded, vegetative growth characters namely shoot length (cm.); length and width of leaves (cm.), number of leaves per shoot, shoot thickness (cm.) and leaf area (cm)<sup>2</sup> (Ahmed and Morsy, 1999) in the

three growth cycles (Spring, Summer and Autumn), chlorophylls a & b, total chlorophylls (Von-Wettstein, 1957 and Hiscox and Isralstam, 1979) as mg/100 g F.W., N, P, K and Mg in the leaves (Summer, 1985 and Wilde *et al.*, 1985), percentages of initial fruit setting and fruit retention, yield / tree (kg.), number of fruits / tree, fruit weight (g.) and dimensions (length & width & thickness) (in cm), percentages of pulp, peel and seed weights, edible / non- edible portions, T.S.S. %, total and reducing sugars (A.O.A.C., 2000), total acidity % as g citric acid / 100 g pulp and vitamin C content ( as mg/ 100 g pulp (A.O.A.C., 2000).

Statistical analysis was done and treatment means were compared using new L.S.D. at 5% according to Mead *et al.* (1993).

### 3. Results

#### 1- Growth characters in the three growth flushes:

Table (2): Effect of single and combined applications of potassium silicate and boric acid on some vegetative growth characters in Spring growth cycle of Succary mango trees during 2012 and 2014 seasons.

Treatment	Spring growth cycle											
	Shoot length (cm)		No. of leaves / shoot		leaf length (cm.)		leaf width (cm.)		leaf area (cm <sup>2</sup> )		Shoot thickness (cm.)	
	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014
Control	10.1	11.0	7.0	8.0	14.0	15.0	4.0	4.7	38.14	48.29	0.48	0.50
Spraying K silicate at 0.1 %	13.9	14.8	10.0	11.0	16.9	18.0	5.1	5.8	59.27	72.02	0.57	0.59
Spraying K silicate at 0.2 %	14.0	15.0	10.0	11.0	17.1	18.	5.2	5.9	61.18	74.11	0.61	0.60
Spraying boric acid at 0.025 %	11.9	13.0	8.0	9.0	15.1	16.1	4.5	5.2	46.51	57.54	0.51	0.54
Spraying boric acid at 0.05 %	1.0	13.1	8.0	9.0	15.2	16.3	4.6	5.3	47.88	89.41	0.52	0.55
Spraying both at 1 <sup>st</sup> conc.	16.3	17.5	12.0	14.0	19.0	20.0	6.9	7.6	90.71	105.34	0.67	0.68
Spraying both at 2 <sup>nd</sup> conc.	16.4	17.7	12.0	14.0	19.3	20.6	7.1	7.7	94.88	109.9	0.69	0.69
New L.S.D. at 5%	1.1	0.9	1.0	1.0	0.9	0.9	0.4	0.4	4.99	5.11	0.03	0.03

Table (3): Effect of single and combined applications of potassium silicate and boric acid on some vegetative growth characters in Summer growth cycle of Succary mango trees during 2012 and 2014 seasons.

Treatment	Summer growth cycle											
	Shoot length (cm)		No. of leaves / shoot		leaf length (cm.)		leaf width (cm.)		leaf area (cm <sup>2</sup> )		Shoot thickness (cm.)	
	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014
Control	5.1	6.0	6.0	5.9	13.0	13.1	3.8	4.5	33.52	40.21	0.42	0.44
Spraying K silicate at 0.1 %	8.9	9.8	9.0	9.0	15.1	15.2	4.9	5.6	50.73	58.52	0.55	0.57
Spraying K silicate at 0.2 %	9.0	10.0	9.0	9.0	15.2	15.3	5.0	5.7	52.14	59.99	0.56	0.58
Spraying boric acid at 0.025 %	6.3	7.4	7.3	7.2	14.0	14.1	4.2	5.0	40.1	48.29	0.47	0.49
Spraying boric acid at 0.05 %	6.4	7.5	7.5	7.3	14.1	14.2	4.3	5.1	41.38	49.63	0.48	0.50
Spraying both at 1 <sup>st</sup> conc.	11.9	12.9	4.0	11.2	16.9	17.0	6.5	7.2	75.84	84.62	0.64	0.66
Spraying both at 2 <sup>nd</sup> conc.	12.0	13.0	4.3	11.5	17.0	17.1	6.6	7.3	77.48	86.32	0.65	0.67
New L.S.D. at 5%	1.0	1.0	1.0	1.0	0.9	0.9	0.4	0.4	3.92	3.98	0.03	0.04

Table (4): Effect of single and combined applications of potassium silicate and boric acid on some vegetative growth characters in Autumn growth cycle of Succary mango trees during 2012 and 2014 seasons.

Treatment	Autumn growth cycle											
	Shoot length (cm)		No. of leaves / shoot		leaf length (cm.)		leaf width (cm.)		leaf area (cm <sup>2</sup> )		Shoot thickness (cm.)	
	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014
Control	4.7	5.5	5.0	4.9	12.5	12.6	3.5	4.1	59.57	53.10	0.40	0.44
Spraying K silicate at 0.1 %	8.5	9.3	8.0	8.0	14.5	14.5	4.6	5.2	45.63	51.72	0.53	0.55
Spraying K silicate at 0.2 %	8.6	9.5	8.0	8.0	14.6	14.7	4.7	5.3	46.97	53.48	0.54	0.56
Spraying boric acid at 0.025 %	5.9	6.9	6.8	6.9	13.6	13.7	3.9	4.6	36.07	43.05	0.45	0.48
Spraying boric acid at 0.05 %	6.0	7.0	7.0	7.0	13.8	13.8	4.0	4.6	37.58	44.34	0.46	0.49
Spraying both at 1 <sup>st</sup> conc.	11.5	12.3	7.0	7.3	15.6	15.7	6.0	6.8	63.92	73.67	0.61	0.63
Spraying both at 2 <sup>nd</sup> conc.	11.6	12.4	7.1	7.4	15.6	16.0	6.1	6.9	65.55	76.22	0.62	0.64
New L.S.D. at 5%	0.9	0.9	1.0	1.0	0.8	0.7	0.3	0.3	3.55	3.79	0.03	0.04

It is clear from the data in Tables ( 2, 3 & 4) that single and combined application of potassium silicate at 0.1 to 0.2% and boric acid at 0.025 to 0.05% significantly was accompanied with stimulating shoot length, length and width of the leaves, number of leaves/ shoot, leaf area and shoot thickness in the three growth cycles comparing with the check treatment. Using potassium silicate was superior than using boric acid in this respect. Combined application of such two materials surpassed the application of each material alone in enhancing these growth traits. Increasing concentrations of potassium silicate from 0.1 to 0.2% and boric acid from 0.02 % to 0.05% failed significantly to show any stimulation on these growth traits. The highest values were recorded on the trees that received three sprays of a mixture of potassium silicate at 0.2% and boric acid at 0.05 %. The control trees produced the minimum values. Similar results were announced during both seasons.

## 2- Leaf chemical composition

Data in Table (5) clearly show that chlorophylls a & b, total chlorophylls, N, P, K and Mg in the leaves of Succary mango trees were significantly enhanced in response to single and combined applications of potassium silicate and boric acid rather than non-application. Application of potassium silicate was significantly superior than using boric acid in this connection. Insignificant promotion on these parameters was detected with increasing concentrations of potassium silicate from 0.1 to 0.2% as well as boric acid from 0.025 to 0.05%. Using potassium silicate plus boric acid was significantly preferable than using each alone in enhancing these nutrients. A significant promotion was observed owing to using potassium silicate relative to using boric acid. Carrying out three sprays of a mixture of potassium silicate at 0.2 % plus boric acid at 0.05 % gave the maximum values. These results were true during both seasons.

Table (5): Effect of single and combined applications of potassium silicate and boric acid on chlorophylls a &amp; b, total chlorophylls and percentages of N, P, K and Mg in the leaves of Succary mango trees during 2012 and 2014 seasons.

Treatment	Chlorophyll a (mg/ 100 g F.W.)		Chlorophyll b (mg/ 100 g F.W.)		Total chlorophylls (mg/ 100 g F.W.)		Leaf N %		Leaf P %		Leaf K %		Leaf Mg %	
	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014
Control	4.1	4.3	3.1	3.3	7.2	7.6	1.64	1.70	0.15	0.16	1.31	1.29	0.51	0.52
Spraying K silicate at 0.1 %	6.1	6.5	4.9	5.3	11.0	11.8	1.84	1.89	0.23	0.24	0.49	1.39	0.60	0.63
Spraying K silicate at 0.2 %	6.2	6.6	5.0	5.4	11.2	12.0	1.86	1.90	0.24	0.25	0.50	1.40	0.61	0.64
Spraying boric acid at 0.025 %	5.0	5.5	3.5	4.0	8.5	9.5	1.72	1.80	0.19	0.20	0.41	1.37	0.55	0.58
Spraying boric acid at 0.05 %	5.1	5.6	3.7	4.1	8.8	9.7	1.73	1.81	0.19	0.21	0.42	1.38	0.56	0.59
Spraying both at 1 <sup>st</sup> conc.	8.3	9.0	6.0	6.3	14.3	15.3	1.95	1.97	0.27	0.28	0.59	1.47	0.79	0.82
Spraying both at 2 <sup>nd</sup> conc.	8.4	9.1	6.1	6.4	14.5	15.5	1.96	1.98	0.28	0.29	0.60	1.48	0.80	0.83
New L.S.D. at 5%	0.3	0.3	0.3	0.3	0.4	0.4	0.05	0.06	0.03	0.03	0.05	0.04	0.03	0.03

## 3- Percentages of initial fruit setting and fruit retention and yield / tree:

Data in Table (6) obviously reveal that spraying potassium silicate at 0.1 to 0.2% and/ or boric acid at 0.025 to 0.05 % significantly improved percentages of initial fruit setting and fruit retention, yield and number of fruits / tree comparing with the check treatment. A significant promotion on these parameters was observed due to using potassium

silicate rather than using boric acid in improving fruit setting and yield/ tree. Combined application of potassium silicate and boric acid was significantly preferable than using each alone in improving fruit setting and yield / tree. No significant promotion was attributed to increasing concentrations of potassium silicate from 0.1 to 0.2%, therefore, the recommended concentration of both potassium silicate and boric acid was 0.1 % and 0.025%, respectively. From

economical point of view, the best results were obtained owing to spraying potassium silicate at 0.1% plus boric acid at 0.025 % three times. Under such promised treatment yield/ tree reached 57.6 and 58.7 kg/ tree during both seasons, respectively. Untreated trees produced 31.0 and 31.3 kg during 2013 and 2014 seasons, respectively. The percentage of increase on the yield due to using such promised treatment over the control treatment reached 85.8 and 87.5% during both seasons, respectively.

#### 4- Fruit quality:

It is evident from the data in Tables ( 6 to 8) that supplying Succary mango trees with potassium silicate at 0.1 to 0.2 % as well as boric acid at 0.025 to 0.05 % either singly or in combinations was significantly very effective in improving fruit quality in terms of increasing fruit weight and dimensions (length & width & thickness), pulp %, edible / non -

edible portions, T.S.S. %, total and reducing sugars % and vitamin C and decreasing fruit peel weight % and total acidity % rather than non- application. The investigated treatments had no significant effect on the percentage of seeds. Using potassium silicate was significantly favourable than using boric acid in this connection. Application of potassium silicate plus boric acid was significantly superior than using each alone. A slight and insignificant promotion on fruit quality was attributed to increasing concentrations of potassium silicate from 0.1 to 0.2% and boric acid from 0.025 to 0.05%. The best results with regard to fruit quality were observed due to treating the trees three times with potassium silicate at 0.1 % plus boric acid at 0.025%. Unfavourable effects on fruit quality were observed on untreated trees. These results were true during both seasons.

Table (6): Effect of single and combined applications of potassium silicate and boric acid on the percentages of initial fruit setting and fruit retention, number of fruits/ tree, yield / tree and weight and length of fruit of Succary mango trees during 2012 and 2014 seasons.

Treatment	Initial fruit setting %		Fruit retention %		No. of fruits / tree		Yield/ tree (kg.)		Fruit weight (g.)		Fruit length (cm.)	
	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014
Control	2.9	3.0	1.0	0.9	181.0	181.0	31.0	31.3	171.0	173.0	7.8	8.0
Spraying K silicate at 0.1 %	4.5	4.7	1.7	1.6	211.0	214.0	41.1	41.5	195.0	194.0	9.0	8.8
Spraying K silicate at 0.2 %	4.6	4.8	1.7	1.7	212.0	215.0	41.7	41.9	196.7	195.0	9.1	8.9
Spraying boric acid at 0.025 %	3.5	3.6	1.3	1.3	191.0	194.0	34.6	34.9	181.7	180.0	8.2	8.4
Spraying boric acid at 0.05 %	3.6	3.7	1.4	1.4	193.0	196.0	35.3	35.6	183.0	181.5	8.3	8.5
Spraying both at 1 <sup>st</sup> conc.	6.9	7.0	2.1	2.2	249.0	255.0	57.6	58.7	231.3	230.0	10.0	9.9
Spraying both at 2 <sup>nd</sup> conc.	7.0	7.1	2.2	2.3	251.0	256.0	58.6	59.5	233.3	232.5	10.1	10.0
New L.S.D. at 5%	0.2	0.2	0.2	0.2	7.0	6.7	1.5	1.7	4.1	3.9	0.2	0.2

Table (7): Effect of single and combined applications of potassium silicate and boric acid on some physical characters of the fruits of Succary mango trees during 2012 and 2014 seasons.

Treatment	Fruit width (cm.)		Fruit thickness(cm.)		Pulp %		Fruit peel %		Seeds %		Edible / non edible portions	
	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014
Control	5.7	6.0	4.5	4.8	49.0	48.8	25.0	25.9	26.0	25.3	0.96	0.95
Spraying K silicate at 0.1 %	6.5	6.9	6.3	6.7	51.9	52.6	22.0	23.0	26.1	24.4	1.08	1.11
Spraying K silicate at 0.2 %	6.6	7.0	5.4	5.8	52.0	52.8	21.8	22.8	26.2	24.4	1.08	1.12
Spraying K silicate at 0.025 %	6.0	6.4	4.8	5.2	50.5	51.0	23.9	25.0	25.6	24.0	1.02	1.04
Spraying K silicate at 0.05 %	6.1	6.5	4.9	5.3	50.7	51.3	23.8	24.9	25.5	23.5	1.03	1.05
Spraying at 1 <sup>st</sup> conc.	7.3	7.6	6.6	6.9	53.9	54.0	20.0	21.0	26.1	25.0	1.17	1.17
Spraying at 2 <sup>nd</sup> conc.	7.4	7.7	6.9	7.0	54.0	54.0	19.7	20.9	26.3	25.1	1.17	1.17
New L.S.D. at 5%	0.2	0.2	0.2	0.2	0.6	0.7	1.0	1.0	NS	NS	0.05	0.06

Table (8): Effect of single and combined applications of potassium silicate and boric acid on some chemical characteristics of the fruits of Succary mango trees during 2012 and 2014 seasons.

Treatment	T.S.S. %		Total sugars %		Reducing sugars %		Total acidity %		Vitamin C content (mg. 100 g. pulp )	
	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014
Control	14.0	13.9	10.5	10.6	3.0	3.1	0.371	0.381	38.3	39.0
Spraying K silicate at 0.1 %	14.9	15.2	11.6	12.0	3.8	4.0	0.301	0.299	41.9	42.6
Spraying K silicate at 0.2 %	15.0	15.3	11.7	12.1	3.9	4.1	0.299	0.298	42.0	42.7
Spraying boric acid at 0.025 %	14.3	14.6	10.8	11.2	3.3	3.5	0.341	0.339	40.3	41.0
Spraying boric acid at 0.05 %	14.4	14.7	10.9	11.3	3.4	3.6	0.339	0.338	40.5	41.1
Spraying both at 1 <sup>st</sup> conc.	16.5	16.9	12.9	13.5	4.5	4.6	0.260	0.258	44.1	45.0
Spraying both at 2 <sup>nd</sup> conc.	16.6	17.0	13.0	13.6	4.6	4.7	0.259	0.257	44.3	45.2
New L.S.D. at 5%	0.3	0.3	0.2	0.2	0.2	0.2	0.021	0.022	1.1	1.2

#### 4. Discussion:

The present positive active of silicon on enhancing growth, nutritional status of the trees, yield and fruit quality was ascribed to the beneficial effects of silicon on enhancing the tolerance of plants to biotic and abiotic stresses as well as drought, water and nutrient uptake, photosynthesis process, water transport and root development. The beneficial effect of silicon on reducing the severity of most diseases through forming a silicon cuticle double layers on leaf epidermal tissues which is responsible for preventing water evaporation and the penetration of fungal hypha into host tissues and ameliorating the adverse effects of heavy metal toxicity could explain the present results (Mengel, 1984; Mengel *et al.*, 2001; Aziz *et al.*, 2002; Lux *et al.*, 2002 and 2003, Sauvas *et al.*, 2002; Iwaskai *et al.*, 2002; Gang *et al.*, 2003; Melo, *et al.*, 2003 and Tahr *et al.*, 2006).

These results regarding the promoting effect of silicon on growth and fruiting of Succary mango trees are in harmony with those obtained by (Gad El-Kareem, 2012; Ahmed *et al.*, 2013a and 2013b; Abdelaal and Oraby- Mona, 2013, Ibrahiem and Al- Wasfy, 2014; El Khawaga and Mansour, 2014; Gad El- Kareem *et al.*, 2014 and Al- Wasfy, 2014) and boron (Ebeid- Sanaa, 2007; El- Sayed- Esraa, 2007; Ibrahiem *et al.*, 2007; Abdelaal, 2008; Refaai, 2014 and Hassan- Huda, 2014).

The outstanding effect of boron on growth, tree nutritional status, yield and fruit quality might be attributed to its essential role in enhancing cell division, biosynthesis and translocation of sugars and hormones, root development, germination of pollens, water and nutrients uptake flower bud formation and reducing the incidence of disorders as well as flowers and fruit dropping (Fraguas and Silva, 1993 and Mengel *et al.*, 2001).

The results with regard to the promoting effect of boron on growth and fruiting of Succary mango trees are in agreement with those obtained by Ebeid-Sanaa, (2007); El- Sayed- Esraa, (2007); Ibrahiem *et al.*, (2007); Abdelaal, (2008); Refaai, (2014) and Hassan- Huda, (2014).

#### Conclusion:

Under Upper Egypt region and the resembling condition, it is advised to foliar application of a mixture of potassium silicate at 0.1% plus boric acid at 0.025 % three times to improve yield and fruit quality of Succary mango trees.

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