Behavior of Balady Mandarin Trees to Spraying Silicon and Salicylic Acid

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Abstract: During 2013 and 2014 seasons Balady mandarin trees treated three times with potassium silicate at 0.05 to 2.0% and / or salicylic acid at 0.05 to 200 ppm as a trial for improving productivity of the trees. Subjecting the trees three times to potassium silicate at 0.05 to 0.2% and/ or salicylic acid at 50 to 200 ppm succeeded in improving growth characters, nutritional status of the trees, fruit retention, yield and fruit quality over the check treatment. The promotion was proportional to the increase in concentrations of each material. Treating Balady mandarin trees three times with a mixture of potassium silicate at 0.1 % and salicylic acid at 100 ppm gave the best results with regard to yield and fruit quality.

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1. Introduction

Recently, many attempts were established for improving yield and fruit quality of Balady mandarin trees grown under Middle Egypt conditions.

The beneficial effects of Salicylic acid and Silicon on enhancing the tolerance of the trees to biotic and abiotic stresses, diseases and drought encouraged most workers for carrying out more trials to elucidate these roles (**Tahr *et al.*, 2006; Janda *et al.*, 2007 and Alvarez and Datnoff, 2011**).

Previous studies showed that using salicylic acid (**Eshmawy, 2010; Ahmed *et al.*, 2010; Kassem *et al.*, 2011; Ahmed, 2011; Karmi *et al.*, 2012; Osman, 2014 and Abd El- Megeed , 2015**) and Silicon (**Al-Wasfy, 2014; El- Khawaga and Mansour, 2014; Ibrahiem and Al- Wasfy, 2014; Mohamed, 2015 and Abd El- Wahab, 2015**) was very effective in improving growth, yield and fruit quality of fruit crops.

The target of this stuffy was examining the effect of different concentrations of potassium silicate and salicylic acid on growth and fruiting of Balady mandarin trees growth under Minia region conditions.

2. Material and Methods

This study was conducted during 2013 and 2014 seasons on 48 nearly uniform and similar in vigour 12- years old Balady mandarin trees (*Citrus reticulata L.* Blanco) budded on sour orange rootstock in a private vineyard located at El- Shorafa village at eastern bank of Minia city, 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 4x4 meters apart. Surface irrigation system was followed. Horticultural practices was carried out as usual.

Analysis of the tested soil at 0.0 to 90 cm depth was carried out according to the procedures that outlined by **Chapman and Pratt (1965)** and the obtained data are shown in Table (1).

Table (1): Analysis of the tested soil:

Constituents	Values
Particle size distribution	
Sand %	4.7
Silt %	60.0
Clay %	35.3
Texture %	Silty clay
pH (1: 2.5 extract)	7.92
E.C. (1: 2.5 extract) mmhos/ cm/ 25^{o}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

The present experiment included the following sixteen treatments from two factors (A & B). The first factor (A) comprised from four concentrations of potassium silicate namely a_1) 0.0%; a_2) 0.05% a_3) 0.1% and a_4) 0.2 %. The second factor (B) contained four concentrations of salicylic acid namely b_1) 0.0 ppm, b_2) 50 ppm, b_3) 100 ppm and b_4) 200 ppm. Therefore, this experiment included sixteen treatments. Each treatment was replicated three times, one tree per each. Spraying was done three times at growth start (1st week of March), just after fruit setting (last week of April) and at two months later (last week of June). Triton B as a wetting was added to all

solutions of potassium silicate and salicylic acid. Untreated trees received water containing Triton B.

Randomized complete block design in split plot arrangement was followed. The four concentrations of potassium silicate occupied the whole plots and the four concentrations of salicylic acid ranked the subplots.

During both seasons the following measurements were recorded:

1- Shoot length (cm.) and leaf area (cm^2) (**Ahmed and Morsy, 1999**) in the Spring growth cycle.

2- Leaf pigments namely chlorophylls a & b, total chlorophylls , total carotenoids (mg/ 100 g F.W.) (**Von – Wettstein, 1957** and **Hiscox and Isralstam , 1979**) and total carbohydrates (**A.O.A.C., 2000**).

3- Percentages of N, P, K and Mg (**Chapman and Pratt, 1965; Peach and Tracey, 1968; Summer, 1985 and Wilde *et al.,* 1985**).

4- Percentages of initial fruit setting and fruit retention

5- Yield expressed in weight (kg.) and number of fruits / tree.

6- Fruit quality characters namely weight, diameter and height of fruit (cm.), fruit peel weight %, fruit peel thickness (cm.); T.S.S. %, total and reducing sugars (**Lane and Eynon, 1965 and A.O.A.C., 2000**), T.S.S./acid, total acidity % (as g. citric acid / 100 ml juice) and vitamin C content (mg/ 100 ml juice (**A.O.A.C., 2000**).

Statistical analysis was done (**Mead *et al.,* 1994**). Treatment means were compared using new L.S.D. at 5%.

3. Results and Discussion

1-Shoot length and leaf area:

It is clear from the data in Table (2) that treating Balady mandarin trees with potassium silicate at 0.05 to 0.2% and/ or salicylic acid at 50 to 200 ppm significantly was followed by enhancing shoot length and leaf area in the Spring growth cycle over the check treatment. There was a gradual stimulation on such two traits with increasing concentrations of each material. Increasing concentrations of potassium silicate from 0.1 to 0.2 % and salicylic acid from 100 to 100 ppm failed to show significant promotion on such two growth characters. The maximum values were recorded on the trees that received three sprays of potassium silicate at 0.2% plus salicylic acid at 200 ppm. Untreated trees produced the minimum values. Similar results were announced during both seasons.

2- Leaf chemical composition:

It is clear from the data in Tables (3 to 7) that subjecting the trees to potassium silicate at 0.05 to 0.2% and / or salicylic acid at 20 to 200 ppm significantly enhanced chlorophylls a & b , total chlorophylls, total carotenoids, N, P, K, Mg and total carbohydrates in the leaves over the check treatment. The promotion was related to the increase in the concentrations of each material. No significant differences on these chemical characters were observed with increasing concentrations of potassium silicate form 0.1 to 0.2 % and salicylic acid from 100 to 200 ppm. The maximum values were recorded on the trees that received both materials together at the higher concentrations. These results were true during both seasons.

3- Fruit setting and yield / tree:

Data in Tables (7 to 9) clearly show that supplying the trees with potassium silicate at 0.05 to 0.2% and / or salicylic acid at 50 to 200 ppm significantly was accompanied with improving the percentages of initial fruit setting and fruit retention as well as yield expressed in weight and number of fruits / tree rather than non- application. There was a gradual promotion on these measurements with increasing concentrations of potassium silicate and salicylic acid. No significant differences on these parameters were observed among the higher two concentrations of each material. Therefore, the recommended concentrations of potassium silicate were 0.1 % and 100 ppm for salicylic acid. From economical point of view, using potassium silicate at 0.1% plus salicylic acid at 100 ppm gave the best results with regard to yield. Yield under such promised treatment reached 51.8 and 52.1 kg during both seasons, respectively comparing with the yield of the untreated trees that reached 19.8 and 19.9 kg during the two seasons, respectively. These results were true during both seasons.

4- Fruit quality:

It is clear from the data in Tables (9 to 14) that spraying the trees three times with potassium silicate at 0.05 to 0.2% and/ or salicylic acid at 50 to 200 ppm significantly was very effective in enhancing fruit quality in terms of increasing weight , height and diameter of fruit , T.S.S. /acid and vitamin C and decreasing fruit peel weight and thickness and total acidity % over the check treatment. The promotion on fruit quality was related to the increase in concentrations of each compound. No significant differences on fruit quality were observed among the higher two concentrations of each material. The best results on fruit quality from economical point of view were obtained due to treating the trees with potassium silicate at 0.1% plus salicylic acid at 100 ppm. Untreated trees produced unfavourable effects on fruit quality. These results were true during both seasons.

Table (2): Effect of different concentrations of potassium silicate and salicylic acid on the shoot length and leaf area in the Spring growth cycle of Balady mandarin trees during 2013 & 2014 seasons

Salicylic acid conc. (B)	**Shoot length in Spring growth cycle**									
	2013					2014				
	Potassium silicate conc. (A)									
	a_1 0.0%	a_2 0.05%	a_3 0.1%	a_4 0.2%	Mean (A)	a_1 0.0%	a_2 0.05%	a_3 0.1%	a_4 0.2%	Mean (A)
b_1 salicylic acid at 0.0 ppm	40.0	42.0	44.0	44.3	**42.6**	39.0	42.3	45.0	45.3	**42.9**
b_2 salicylic acid at 50 ppm	42.9	44.0	46.0	46.3	**44.8**	44.0	45.0	47.0	47.2	**45.8**
b_3 salicylic acid at 100 ppm	44.1	45.9	48.0	48.6	**46.7**	46.0	47.3	49.1	49.2	**47.9**
b_4 salicylic acid at 200 ppm	44.2	46.0	48.6	49.0	**47.0**	46.3	47.5	49.2	49.3	**48.1**
Mean (B)	**42.8**	**44.5**	**46.7**	**47.1**		**43.8**	**45.5**	**47.6**	**47.8**	
New L.S.D. at 5%	A	B	AB			A	B	AB		
	1.0	1.0	2.0			1.0	0.9	1.8		
Character	**Leaf area in Spring growth cycle**									
b_1 salicylic acid at 0.0 ppm	8.0	8.9	9.9	10.0	**9.2**	8.1	9.1	10.2	10.3	**9.4**
b_2 salicylic acid at 50 ppm	9.1	10.0	10.9	11.0	**10.3**	9.3	10.4	11.5	11.6	**10.7**
b_3 salicylic acid at 100 ppm	10.0	11.0	11.9	12.0	**11.2**	10.4	11.7	12.8	13.0	**12.0**
b_4 salicylic acid at 200 ppm	10.3	11.1	12.0	12.0	**11.4**	10.5	11.8	12.9	13.1	**12.1**
Mean (B)	**9.4**	**10.3**	**11.2**	**11.3**		**9.6**	**10.8**	**11.9**	**12.0**	
New L.S.D. at 5%	A	B	AB			A	B	AB		
	0.4	0.5	1.0			0.4	0.4	0.8		

Table (3): Effect of different concentrations of potassium silicate and salicylic acid on chlorophylls a and b in the fresh leaves (mg/ 100 g F.W.) of Balady mandarin trees during 2013 & 2014 seasons

Salicylic acid conc. (B)	**Chlorophyll a (mg / 100 g F.W.)**									
	2013					2014				
	Potassium silicate conc. (A)									
	a_1 0.0%	a_2 0.05%	a_3 0.1%	a_4 0.2%	Mean (A)	a_1 0.0%	a_2 0.05%	a_3 0.1%	a_4 0.2%	Mean (A)
b_1 salicylic acid at 0.0 ppm	6.1	6.9	8.0	8.1	**7.3**	5.9	7.1	8.2	8.3	**7.4**
b_2 salicylic acid at 50 ppm	7.1	8.2	9.4	9.5	**8.6**	7.1	8.2	9.4	9.6	**8.6**
b_3 salicylic acid at 100 ppm	8.2	9.3	10.5	10.6	**9.7**	8.3	9.4	10.5	10.6	**9.7**
b_4 salicylic acid at 200 ppm	8.3	9.4	10.6	10.7	**9.8**	8.4	9.5	10.6	10.7	**9.8**
Mean (B)	**7.4**	**8.5**	**9.6**	**9.7**		**7.4**	**8.4**	**9.7**	**9.8**	
New L.S.D. at 5%	A	B	AB			A	B	AB		
	0.4	0.5	1.0			0.5	0.5	1.0		
Character	**Chlorophyll b (mg / 100 g F.W.)**									
b_1 salicylic acid at 0.0 ppm	2.1	3.0	4.0	4.1	**3.3**	1.9	2.9	4.1	4.2	**3.3**
b_2 salicylic acid at 50 ppm	3.0	4.1	5.2	5.3	**4.4**	2.9	4.1	5.1	5.2	**4.3**
b_3 salicylic acid at 100 ppm	4.0	5.1	6.1	6.2	**5.4**	4.1	5.3	6.4	6.5	**5.6**
b_4 salicylic acid at 200 ppm	4.1	5.2	6.2	6.3	**5.5**	4.2	5.4	6.5	6.6	**5.7**
Mean (B)	**3.3**	**4.4**	**5.3**	**5.5**		**3.3**	**4.4**	**5.5**	**5.6**	
New L.S.D. at 5%	A	B	AB			A	B	AB		
	0.4	0.4	0.8			0.5	0.4	0.8		

Table (4): Effect of different concentrations of potassium silicate and salicylic acid on total chlorophylls and total carotenoids in the fresh leaves (mg / 100 g F.W.) of Balady mandarin trees during 2013 & 2014 seasons

Salicylic acid conc. (B)	**Total chlorophylls (mg / 100 g F.W.)**									
	2013					2014				
	Potassium silicate conc. (A)									
	a_1 0.0%	a_2 0.05%	a_3 0.1%	a_4 0.2%	Mean (A)	a_1 0.0%	a_2 0.05%	a_3 0.1%	a_4 0.2%	Mean (A)
b_1 salicylic acid at 0.0 ppm	8.2	9.9	12.0	12.1	**10.6**	7.8	10.0	12.3	12.5	**10.7**
b_2 salicylic acid at 50 ppm	10.1	12.3	14.6	14.8	**13.0**	10.0	12.3	14.5	14.8	**12.9**
b_3 salicylic acid at 100 ppm	12.2	14.4	16.6	16.8	**15.0**	12.4	14.7	16.9	17.1	**15.3**
b_4 salicylic acid at 200 ppm	12.4	14.6	16.8	17.0	**15.2**	12.6	14.9	17.1	17.3	**15.5**
Mean (B)	**10.7**	**12.8**	**15.0**	**15.2**		**10.7**	**13.0**	**15.2**	**15.4**	
New L.S.D. at 5%	A	B	AB			A	B	AB		
	0.4	0.4	0.8			0.5	0.5	1.0		
Character	**Total carotenoids (mg / 100 g F.W.)**									
b_1 salicylic acid at 0.0 ppm	1.9	2.9	4.1	4.2	**3.3**	2.0	3.0	4.0	4.1	**3.3**
b_2 salicylic acid at 50 ppm	2.5	4.1	5.1	5.2	**4.2**	3.0	4.0	5.0	5.2	**4.3**
b_3 salicylic acid at 100 ppm	3.5	5.1	6.1	6.2	**5.2**	4.1	5.1	6.1	6.2	**5.4**
b_4 salicylic acid at 200 ppm	3.6	5.2	6.2	6.3	**5.3**	4.2	5.2	6.2	6.3	**5.5**
Mean (B)	**2.9**	**4.3**	**5.4**	**5.5**		**3.3**	**4.3**	**5.3**	**5.5**	
New L.S.D. at 5%	A	B	AB			A	B	AB		
	0.3	0.3	0.6			0.4	0.3	0.6		

Table (5): Effect of different concentrations of potassium silicate and salicylic acid on the percentages of N and P in the leaves of Balady mandarin trees during 2013 & 2014 seasons

Salicylic acid conc. (B)	**Leaf N %**									
	2013					2014				
	Potassium silicate conc. (A)									
	a_1 0.0%	a_2 0.05%	a_3 0.1%	a_4 0.2%	Mean (A)	a_1 0.0%	a_2 0.05%	a_3 0.1%	a_4 0.2%	Mean (A)
b_1 salicylic acid at 0.0 ppm	1.50	1.70	1.80	1.81	**1.70**	1.55	1.71	1.82	1.83	**1.73**
b_2 salicylic acid at 50 ppm	1.61	1.80	1.90	1.91	**1.81**	1.62	1.82	1.92	1.93	**1.82**
b_3 salicylic acid at 100 ppm	1.71	1.90	1.99	2.00	**1.90**	1.73	1.92	2.01	2.02	**1.92**
b_4 salicylic acid at 200 ppm	1.72	1.91	2.00	2.01	**1.91**	1.74	1.93	2.02	2.03	**1.93**
Mean (B)	**1.64**	**1.83**	**1.92**	**1.93**		**1.66**	**1.85**	**1.94**	**1.95**	
New L.S.D. at 5%	A	B	AB			A	B	AB		
	0.06	0.06	0.12			0.05	0.05	0.10		
Character	**Leaf P %**									
b_1 salicylic acid at 0.0 ppm	0.15	0.18	0.21	0.22	**0.19**	0.15	0.19	0.22	0.23	**0.20**
b_2 salicylic acid at 50 ppm	0.18	0.22	0.25	0.25	**0.23**	0.19	0.23	0.26	0.27	**0.21**
b_3 salicylic acid at 100 ppm	0.21	0.25	0.29	0.30	**0.26**	0.22	0.26	0.29	0.30	**0.27**
b_4 salicylic acid at 200 ppm	0.22	0.25	0.29	0.30	**0.27**	0.23	0.27	0.30	0.31	**0.28**
Mean (B)	**0.19**	**0.23**	**0.26**	**0.27**		**0020**	**0.24**	**0.27**	**0.28**	
New L.S.D. at 5%	A	B	AB			A	B	AB		
	0.02	0.02	0.04			0.02	0.02	0.04		

Table (6): Effect of different concentrations of potassium silicate and salicylic acid on the percentages of K and Mg in the leaves of Balady mandarin trees during 2013 & 2014 seasons

Salicylic acid conc. (B)	**Leaf K %**									
	2013					2014				
	Potassium silicate conc. (A)									
	a_1 0.0%	a_2 0.05%	a_3 0.1%	a_4 0.2%	Mean (A)	a_1 0.0%	a_2 0.05%	a_3 0.1%	a_4 0.2%	Mean (A)
b_1 salicylic acid at 0.0 ppm	1.50	1.59	1.69	1.70	**1.62**	1.51	1.60	1.71	1.72	**1.64**
b_2 salicylic acid at 50 ppm	1.59	1.70	1.79	1.80	**1.72**	1.60	1.71	1.82	1.83	**1.74**
b_3 salicylic acid at 100 ppm	1.69	1.80	1.88	1.89	**1.82**	1.69	1.81	1.92	1.93	**1.84**
b_4 salicylic acid at 200 ppm	1.70	1.81	1.89	1.90	**1.83**	1.71	1.82	1.93	1.94	**1.85**
Mean (B)	**1.62**	**1.73**	**1.81**	**1.82**		**1.63**	**1.74**	**1.85**	**1.86**	
New L.S.D. at 5%	A	B	AB			A	B	AB		
	0.04	0.05	0.10			0.05	0.05	0.10		
Character	**Leaf Mg %**									
b_1 salicylic acid at 0.0 ppm	0.48	0.55	0.61	0.62	**0.57**	0.50	0.59	0.66	0.67	**0.61**
b_2 salicylic acid at 50 ppm	0.53	0.61	0.69	0.70	**0.63**	0.55	0.66	0.71	0.72	**0.66**
b_3 salicylic acid at 100 ppm	0.58	0.71	0.79	0.80	**0.72**	0.60	0.71	0.80	0.81	**0.73**
b_4 salicylic acid at 200 ppm	0.59	0.72	0.80	0.81	**0.73**	0.61	0.72	0.81	0.82	**0.74**
Mean (B)	**0.55**	**0.65**	**0.72**	**0.73**		**0.57**	**0.67**	**0.75**	**0.76**	
New L.S.D. at 5%	A	B	AB			A	B	AB		
	0.03	0.03	0.06			0.03	0.03	0.06		

Table (7): Effect of different concentrations of potassium silicate and salicylic acid on the percentages of total carbohydrates and initial fruit setting of Balady mandarin trees during 2013 & 2014 seasons

Salicylic acid conc. (B)	**Leaf total carbohydrates %**									
	2013					2014				
	Potassium silicate conc. (A)									
	a_1 0.0%	a_2 0.05%	a_3 0.1%	a_4 0.2%	Mean (A)	a_1 0.0%	a_2 0.05%	a_3 0.1%	a_4 0.2%	Mean (A)
b_1 salicylic acid at 0.0 ppm	14.9	15.9	17.1	17.2	**16.3**	15.0	16.2	17.3	17.4	**16.5**
b_2 salicylic acid at 50 ppm	16.0	17.1	18.2	18.2	**17.4**	16.1	17.3	18.4	18.5	**17.6**
b_3 salicylic acid at 100 ppm	17.2	18.2	19.2	19.3	**18.5**	17.3	18.5	19.5	19.6	**18.7**
b_4 salicylic acid at 200 ppm	17.3	18.2	19.2	19.3	**18.5**	17.4	18.6	19.6	19.7	**18.8**
Mean (B)	**16.4**	**17.4**	**18.4**	**18.5**		**16.5**	**17.7**	**18.7**	**18.8**	
New L.S.D. at 5%	A	B	AB			A	B	AB		
	1.0	1.0	2.0			1.0	1.0	2.0		
Character	**Initial fruit setting %**									
b_1 salicylic acid at 0.0 ppm	3.1	4.4	5.5	5.6	**4.7**	3.2	4.4	5.6	5.6	**4.7**
b_2 salicylic acid at 50 ppm	4.3	5.5	6.6	6.7	**5.8**	4.3	5.6	6.7	6.8	**5.9**
b_3 salicylic acid at 100 ppm	5.4	6.6	7.6	7.7	**6.8**	5.5	6.6	7.8	7.9	**7.0**
b_4 salicylic acid at 200 ppm	5.5	6.7	7.7	7.8	**6.9**	5.5	6.7	7.9	8.0	**7.0**
Mean (B)	**4.6**	**5.8**	**6.9**	**7.0**		**4.6**	**5.8**	**7.0**	**7.1**	
New L.S.D. at 5%	A	B	AB			A	B	AB		
	1.1	1.0	2.0			1.0	1.0	2.0		

Table (8): Effect of different concentrations of potassium silicate and salicylic acid on the percentage of fruit retention and number of fruits / tree of Balady mandarin trees during 2013 & 2014 seasons

Salicylic acid conc. (B)	**Fruit retention %**									
	2013					2014				
	Potassium silicate conc. (A)									
	a_1 0.0%	a_2 0.05%	a_3 0.1%	a_4 0.2%	Mean (A)	a_1 0.0%	a_2 0.05%	a_3 0.1%	a_4 0.2%	Mean (A)
b_1 salicylic acid at 0.0 ppm	0.81	0.90	0.97	0.98	**0.92**	0.82	0.92	1.00	1.01	**0.94**
b_2 salicylic acid at 50 ppm	0.88	0.98	1.05	1.06	**0.99**	0.90	1.00	1.07	1.08	**1.01**
b_3 salicylic acid at 100 ppm	0.96	1.05	1.15	1.16	**1.08**	0.99	1.08	1.18	1.19	**1.11**
b_4 salicylic acid at 200 ppm	0.97	1.06	1.16	1.17	**1.09**	1.00	1.09	1.19	1.20	**1.12**
Mean (B)	**0.91**	**1.00**	**1.08**	**1.09**		**0.93**	**1.02**	**1.11**	**1.12**	
New L.S.D. at 5%	A	B	AB			A	B	AB		
	0.05	0.05	0.10			0.04	0.05	0.10		
Character	**Number of fruits / tree**									
b_1 salicylic acid at 0.0 ppm	200.0	240.0	280.0	282.0	**250.5**	201.0	241.0	281.0	282.0	**251.3**
b_2 salicylic acid at 50 ppm	230.0	285.0	319.0	321.0	**288.8**	233.0	286.0	320.0	321.0	**290.0**
b_3 salicylic acid at 100 ppm	271.0	321.0	345.0	346.0	**320.8**	273.0	322.0	347.0	348.0	**322.5**
b_4 salicylic acid at 200 ppm	272.0	322.0	346.0	347.0	**321.8**	274.0	323.0	348.0	349.0	**323.5**
Mean (B)	**243.3**	**292.0**	**322.5**	**324.0**		**246.5**	**293.0**	**324.0**	**325.0**	
New L.S.D. at 5%	A	B	AB			A	B	AB		
	20.0	19.0	38.0				18.5	17.0		

Table (9): Effect of different concentrations of potassium silicate and salicylic acid on the yield / tree (kg.) and fruit weight of Balady mandarin trees during 2013 & 2014 seasons

Salicylic acid conc. (B)	**Yield / tree (kg.)**									
	2013					2014				
	Potassium silicate conc. (A)									
	a_1 0.0%	a_2 0.05%	a_3 0.1%	a_4 0.2%	Mean (A)	a_1 0.0%	a_2 0.05%	a_3 0.1%	a_4 0.2%	Mean (A)
b_1 salicylic acid at 0.0 ppm	19.8	27.1	35.3	35.8	**29.5**	19.9	27.2	35.7	36.1	**29.7**
b_2 salicylic acid at 50 ppm	25.8	35.9	43.4	44.3	**37.4**	26.6	36.3	44.8	45.3	**38.3**
b_3 salicylic acid at 100 ppm	33.9	43.9	51.8	52.2	**45.5**	35.5	44.4	52.1	52.9	**46.2**
b_4 salicylic acid at 200 ppm	34.3	44.1	52.2	52.7	**45.8**	35.9	44.6	52.5	53.0	**46.5**
Mean (B)	**28.5**	**37.7**	**45.7**	**46.3**		**29.5**	**38.1**	**46.3**	**46.8**	
New L.S.D. at 5%	A	B	AB			A	B	AB		
	3.1	3.3	6.6			35.	3.6	7.2		
Character	**Fruit weight (g.)**									
b_1 salicylic acid at 0.0 ppm	99.0	113.0	126.0	127.0	**116.3**	99.0	113.0	127.0	128.0	**116.8**
b_2 salicylic acid at 50 ppm	112.0	126.0	136.0	138.0	**128.0**	114.0	127.0	140.0	141.0	**130.5**
b_3 salicylic acid at 100 ppm	125.0	136.9	150.0	151.0	**140.7**	130.0	138.0	150.0	152.0	**142.5**
b_4 salicylic acid at 200 ppm	126.0	137.0	151.0	152.0	**141.5**	131.0	138.0	151.0	152.0	**143.0**
Mean (B)	**115.5**	**128.2**	**140.8**	**142.0**		**118.5**	**129.0**	**142.0**	**143.3**	
New L.S.D. at 5%	A	B	AB			A	B	AB		
	10.0	11.0	22.0				11.0	22.0		

Table (10): Effect of different concentrations of potassium silicate and salicylic acid on height and diameter of fruit of Balady mandarin trees during 2013 & 2014 seasons

Salicylic acid conc. (B)	**Fruit height (cm.)**									
	2013					2014				
	Potassium silicate conc. (A)									
	a_1 0.0%	a_2 0.05%	a_3 0.1%	a_4 0.2%	Mean (A)	a_1 0.0%	a_2 0.05%	a_3 0.1%	a_4 0.2%	Mean (A)
b_1 salicylic acid at 0.0 ppm	5.00	5.22	5.39	5.40	**5.25**	4.99	5.25	5.41	5.42	**5.27**
b_2 salicylic acid at 50 ppm	5.14	5.40	5.50	5.51	**5.39**	5.16	5.41	5.55	5.56	**5.42**
b_3 salicylic acid at 100 ppm	5.28	5.52	5.62	5.63	**5.51**	5.31	5.55	5.63	5.64	**5.53**
b_4 salicylic acid at 200 ppm	5.29	5.53	5.63	5.64	**5.52**	5.32	5.56	5.64	5.65	**5.54**
Mean (B)	**5.18**	**5.42**	**5.54**	**5.55**		**5.20**	**5.44**	**5.57**	**5.57**	
New L.S.D. at 5%	A	B	AB			A	B	AB		
	0.07	0.06	0.12			0.6	0.6	0.12		
Character	**Fruit diameter (cm.)**									
b_1 salicylic acid at 0.0 ppm	6.00	6.20	6.40	6.41	**6.25**	6.00	6.21	6.41	6.42	**6.26**
b_2 salicylic acid at 50 ppm	6.16	6.44	6.60	6.67	**6.45**	6.17	6.46	6.62	6.63	**6.47**
b_3 salicylic acid at 100 ppm	6.31	6.60	6.71	6.72	**6.59**	6.33	6.61	6.72	6.72	**6.60**
b_4 salicylic acid at 200 ppm	6.32	6.61	6.72	6.73	**6.60**	6.34	6.62	6.73	6.73	**6.61**
Mean (B)	**6.20**	**6.46**	**6.61**	**6.62**		**6.21**	**6.48**	**6.62**	**6.63**	
New L.S.D. at 5%	A	B	AB			A	B	AB		
	0.06	0.05	0.10				0.05	0.10		

Table (11): Effect of different concentrations of potassium silicate and salicylic acid on the percentage of fruit peel weight and peel thickness of Balady mandarin trees during 2013 & 2014 seasons

Salicylic acid conc. (B)	**Fruit peel weight %**									
	2013					2014				
	Potassium silicate conc. (A)									
	a_1 0.0%	a_2 0.05%	a_3 0.1%	a_4 0.2%	Mean (A)	a_1 0.0%	a_2 0.05%	a_3 0.1%	a_4 0.2%	Mean (A)
b_1 salicylic acid at 0.0 ppm	20.0	19.0	17.3	17.2	**18.4**	19.9	18.8	17.1	17.0	**18.2**
b_2 salicylic acid at 50 ppm	18.0	17.3	16.0	15.8	**16.8**	18.0	17.0	15.9	15.7	**16.7**
b_3 salicylic acid at 100 ppm	17.0	16.0	15.0	14.9	**15.7**	16.9	15.8	14.8	14.7	**15.6**
b_4 salicylic acid at 200 ppm	16.8	16.0	14.9	14.9	**15.7**	16.7	15.7	14.7	14.7	**15.5**
Mean (B)	**18.0**	**17.1**	**15.8**	**15.7**		**17.9**	**16.8**	**15.6**	**15.5**	
New L.S.D. at 5%	A	B	AB			A	B	AB		
	0.9	1.0	2.0			1.0	1.0	2.0		
Character	**Fruit peel thickness (cm.)**									
b_1 salicylic acid at 0.0 ppm	0.31	0.28	0.24	0.23	**0.27**	0.30	0.28	0.23	0.22	**0.26**
b_2 salicylic acid at 50 ppm	0.28	0.24	0.21	0.20	**0.23**	0.28	0.23	0.20	0.20	**0.23**
b_3 salicylic acid at 100 ppm	0.24	0.21	0.18	0.17	**0.20**	0.24	0.20	0.17	0.16	**0.19**
b_4 salicylic acid at 200 ppm	0.23	0.20	0.17	0.16	**0.19**	0.23	0.19	0.16	0.15	**0.18**
Mean (B)	**0.27**	**0.23**	**0.20**	**0.19**		**0.26**	**0.23**	**0.19**	**0.18**	
New L.S.D. at 5%	A	B	AB			A	B	AB		
	0.02	0.03	0.06			0.02	0.03	0.06		

Table (12): Effect of different concentrations of potassium silicate and salicylic acid on the percentages of total soluble solids and total acidity in the fruits of Balady mandarin trees during 2013 & 2014 seasons

Salicylic acid conc. (B)	**T.S.S. %**									
	2013					2014				
	Potassium silicate conc. (A)									
	a_1 0.0%	a_2 0.05%	a_3 0.1%	a_4 0.2%	Mean (A)	a_1 0.0%	a_2 0.05%	a_3 0.1%	a_4 0.2%	Mean (A)
b_1 salicylic acid at 0.0 ppm	11.0	11.5	12.0	12.1	**11.7**	11.4	11.8	12.2	12.3	**12.0**
b_2 salicylic acid at 50 ppm	11.4	12.0	12.4	12.5	**12.1**	11.8	12.2	12.6	12.7	**12.3**
b_3 salicylic acid at 100 ppm	11.8	12.5	13.0	13.1	**12.6**	12.2	12.6	13.0	13.1	**12.7**
b_4 salicylic acid at 200 ppm	11.9	12.5	13.0	13.1	**12.6**	12.3	12.6	13.1	13.2	**12.8**
Mean (B)	**11.5**	**12.1**	**12.6**	**12.7**		**11.9**	**12.3**	**12.7**	**12.8**	
New L.S.D. at 5%	A	B	AB			A	B	AB		
	0.3	0.3	0.6			0.2	0.3	0.6		
Character	**Total acidity %**									
b_1 salicylic acid at 0.0 ppm	1.396	1.340	1.300	1.299	**1.334**	1.398	1.335	1.295	1.292	**1.330**
b_2 salicylic acid at 50 ppm	1.360	1.310	1.270	1.269	**1.302**	1.335	1.290	1.260	1.259	**1.291**
b_3 salicylic acid at 100 ppm	1.320	1.260	1.240	1.237	**1.264**	1.314	1.255	1.215	1.214	**1.250**
b_4 salicylic acid at 200 ppm	1.318	1.259	1.239	1.236	**1.263**	1.311	1.253	1.213	1.213	**1.248**
Mean (B)	**1.349**	**1.292**	**1.262**	**1.260**		**1.345**	**1.283**	**1.246**	**1.245**	
New L.S.D. at 5%	A	B	AB			A	B	AB		
	0.020	0.019	0.038			0.020	0.018	0.036		

Table (13): Effect of different concentrations of potassium silicate and salicylic acid on T.S.S/ acid and the percentage of total sugars in the fruits of Balady mandarin trees during 2013 & 2014 seasons

Salicylic acid conc. (B)	**T.S.S. / acid**									
	2013					2014				
	Potassium silicate conc. (A)									
	a_1 0.0%	a_2 0.05%	a_3 0.1%	a_4 0.2%	Mean (A)	a_1 0.0%	a_2 0.05%	a_3 0.1%	a_4 0.2%	Mean (A)
b_1 salicylic acid at 0.0 ppm	7.9	8.6	9.2	9.3	**8.8**	8.2	8.8	9.4	9.5	**9.0**
b_2 salicylic acid at 50 ppm	8.4	9.2	9.8	9.9	**9.3**	8.7	9.5	10.0	10.1	**9.3**
b_3 salicylic acid at 100 ppm	8.9	9.9	10.5	10.6	**10.0**	9.3	10.0	10.7	10.8	**10.2**
b_4 salicylic acid at 200 ppm	9.0	9.9	10.5	10.6	**10.0**	9.3	10.1	10.8	10.9	**10.3**
Mean (B)	**8.6**	**9.4**	**10.0**	**10.1**		**8.9**	**9.6**	**10.2**	**10.3**	
New L.S.D. at 5%	A	B	AB			A	B	AB		
	0.4	0.3	0.6			0.4	0.3	0.6		
Character	**Total sugars %**									
b_1 salicylic acid at 0.0 ppm	8.1	8.5	9.0	9.1	**8.7**	7.8	8.5	9.0	9.1	**8.6**
b_2 salicylic acid at 50 ppm	8.5	9.1	9.5	9.6	**9.2**	8.4	9.0	9.6	9.7	**9.2**
b_3 salicylic acid at 100 ppm	9.0	9.6	10.1	10.2	**9.7**	8.9	9.6	10.2	10.3	**9.8**
b_4 salicylic acid at 200 ppm	9.1	9.6	10.1	10.2	**9.8**	9.0	9.7	10.2	10.3	**9.8**
Mean (B)	**8.7**	**9.2**	**9.7**	**9.8**		**8.5**	**9.2**	**9.8**	**9.9**	
New L.S.D. at 5%	A	B	AB			A	B	AB		
	0.3	0.3	0.6			0.3	0.3	0.6		

Table (14): Effect of different concentrations of potassium silicate and salicylic acid on the percentage of reducing sugars and vitamin C content in the fruits of Balady mandarin trees during 2013 & 2014 seasons

Salicylic acid conc. (B)	Reducing sugars %									
	2013					2014				
	Potassium silicate conc. (A)									
	a_1 0.0%	a_2 0.05%	a_3 0.1%	a_4 0.2%	Mean (A)	a_1 0.0%	a_2 0.05%	a_3 0.1%	a_4 0.2%	Mean (A)
b_1 salicylic acid at 0.0 ppm	3.0	3.3	3.6	3.7	**3.4**	2.9	3.4	3.6	3.7	**3.4**
b_2 salicylic acid at 50 ppm	3.3	3.6	3.9	4.0	**3.7**	3.3	3.7	4.0	4.1	**3.8**
b_3 salicylic acid at 100 ppm	3.6	4.0	4.3	4.4	**4.1**	3.7	4.0	4.3	4.4	**4.1**
b_4 salicylic acid at 200 ppm	3.7	4.1	4.4	4.4	**4.2**	3.8	4.0	4.4	4.5	**4.2**
Mean (B)	**3.4**	**3.8**	**4.1**	**4.1**		**3.4**	**3.8**	**4.1**	**4.2**	
New L.S.D. at 5%	A	B	AB			A	B	AB		
	0.2	0.2	0.4			0.2	0.2	0.4		
Character	**Vitamin C content (mg/ 100 ml juice)**									
b_1 salicylic acid at 0.0 ppm	41.9	44.5	46.9	47.0	**45.1**	42.3	45.0	47.0	47.5	**45.5**
b_2 salicylic acid at 50 ppm	44.0	47.0	49.5	50.0	**47.6**	44.5	47.0	49.0	49.1	**47.4**
b_3 salicylic acid at 100 ppm	46.0	50.0	52.9	53.0	**50.5**	47.3	49.0	50.9	51.0	**49.6**
b_4 salicylic acid at 200 ppm	46.3	50.0	53.0	53.0	**50.6**	47.4	49.0	51.0	51.1	**49.6**
Mean (B)	**44.6**	**47.9**	**50.6**	**50.8**		**45.4**	**47.5**	**49.5**	**49.7**	
New L.S.D. at 5%	A	B	AB			A	B	AB		
	0.9	1.0	2.0			1.0	1.0	2.0		

4. Discussion

The important roles of salicylic acid in enhancing the tolerance of the trees to abiotic stress, the synthesis of protective compounds, the antioxidative capacity of the trees, building of natural hormones, photosynthesis, uptake and transport of nutrients, the tolerance of the trees to pathogens, the inhibition of reactive oxygen species (ROS) namely catalase and ascorbate peroxidade that capable of stimulating ROS accumulation during various biotic and abiotic stresses. Evidence indicates that salicylic acid together with oxygen reactive species which accumulate in the stresses cells are essential signals to trigger local defense response or to activate transpiration of stress defense genes (**Janda *et al.*, 2007**) could explain the promoting effect of salicylic acid on growth and fruiting of Balady mandarin trees.

These results are in harmony with those obtained **Eshmawy (2010) Ahmed *et al.*, (2010); Kassem *et al.*, (2011) Ahmed (2011) , Karmi *et al.*, (2012) Osman (2014) and Abd El- Megeed (2015)**.

The promoting effect of silicon on fruiting of Balady mandarin trees might be attributed to its important roles in enhancing the tolerance of the trees to biotic and abiotic stresses, drought, photosynthesis, leaf water potential, diseases tolerance through forming a silicon cuticle double layers on leaf epideral tissues which preventing water evaporation and the penetration of fungal hypha into host tissues. It is also responsible for enhancing water transport and root growth under drought conditions and emeliorating the adverse effects of heavy metal toxicity (**Tahr *et al.*, 2006 and Alvarez and Datnoff, 2011**).

These results are in agreement with those obtained by **Al- Wasfy (2014); El- Khawaga and Mansour (2014); Ibrahiem and Al- Wasfy (2014); Mohamed (2015) and Abd El- Wahab (2015)**.

Conclusion

Three sprays of a mixture of potassium silicate at 0.1% plus salicylic acid at 100 ppm was necessary for improving yield and fruit quality of Balady mandarin trees grown under Minia region conditions.

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