Effect of Silicon and Chitosan on Growth and Nutritional Status of Zebda Mango Trees Grown Under Minia Region Conditions

Mohamed A. EL- Sayed[1], Ali A. Gobara[1]; Abbas S. Abdalla[2], and Sadam H.A. Ayed[2]

[1]Hort. Dept. Fac. of Agric. Minia Univ. Egypt.
[2]Tropical Fruit Res. Dept. Hort. Res. Instit., ARC., Giza, Egypt
E. mail: faissalfadel@yahoo.com

Abstract: During 2016 and 2017 seasons, Zebda mango trees grown under Minia region conditions treated with silicon at two sources namely potassium or calcium at 0.05 to 0.2 % twice or thrice and chitosan at 0.1% (thrice). The merit was elucidating the effect of different sources, concentrations and frequencies of application of silicon and chitosan on growth and nutritional status of the trees. Subjecting the trees to silicon via K or Ca sources at 0.05 to 0.2 % twice or thrice and / or chitosan at 0.1% succeeded in stimulating length and thickness of shoot, number of leaves / shoot, length and width and area of leaf, chlorophylls a, b, total chlorophylls, total carotenoids, N, P, K, Mg, Ca, Zn, Fe and Mn relative to the control. The promotion on growth aspects and leaf chemical components were related to the increase in concentrations and frequencies of application of silicon. Using potassium silicate was materially superior than using calcium silicate in this respect. Using silicon was favorable than using chitosan in enhancing growth and leaf chemical components. For stimulating growth and tree nutritional status of Zebda Mango trees grown under Minia region conditions it is suggested to spray the trees three times (at growth start, just after fruit setting and 21 days later) with a mixture of potassium silicate and chitosan together each at 0.1 %.
[Mohamed A. EL- Sayed, Ali A. Gobara; Abbas S. Abdalla, and Sadam H.A. Ayed. **Effect of Silicon and Chitosan on Growth and Nutritional Status of Zebda Mango Trees Grown Under Minia Region Conditions.** *Stem Cell* 2018;9(2):23-30]. ISSN: 1945-4570 (print); ISSN: 1945-4732 (online). http://www.sciencepub.net/stem. 4. doi:10.7537/marsscj090218.04.

Keywords: Silicon, Potassium silicate, Calcium silicate, Chitosan, growth nutritional status, Zebda mango.

1. Introduction

Any attempt made to enhance the tolerance of trees to biotic and abiotic stresses was accompanied with enhancing growth and tree nutritional status consequently improved the yield. Silicon and chitosan were found by many authors to protect the trees from unfavourable effects of all stresses **(Sauvas *et al*, 2002; Lux *et al*, 2003, Gang *et al*, 2003, Hattori *et al*, 2003, Ma, 2004, Taher *et al*, 2006, Eweis *et al*, 2006, Chien and Chou, 2006, Liu *et al*, 2007 and Shao *et al*, 2013).**

Using silicon **(EL – Khawaga and Mansour, 2014, Ibrahim and EL – Wasfy, 2014, Mohamed, 2015, Mohamed *et al*, 2015, Wassel *etal* 2015, Akl *etal* 2015, Mohamed 2016, and Rizk, 2017)** and chitosan **(Gornik *etal*, 2008, Meng *etal*, 2010, El-Miniawy *et al.*, 2013; Hadwiger, 2013, Xing *etal*, 2015, Hassain and Iqbal, 2016, Tayel *et al*, 2016 and Khafagy, 2018)** had an announced promotion on growth and leaf chemical components in different horticultural crops.

The target of this experiment was examining the effect of single and combined applications of silicon and chitosan on growth and nutritional status

2, Materials and Methods

This investigation was conducted during the two consecutive seasons of 2016 and 2017 on sixty 11-years old Zebda mango trees onto Succary mango rootstock. The trees are grown in a private mango orchard located at Mallawy district, Minia Governorate. The uniform in vigour trees of Zebda mango (60 trees) were planted at 7 x 7 meter apart. The soil texture of the tested orchard is silty clay with a water table depth not less than two meters. Surface irrigation system was followed using Nile water.

Table (1): Mechanical, physical and chemical analysis of the tested orchard soil.

Particle size distribution:	
Sand %	6.1
Silt %	56.7
Clay	37.2
Texture	:Silty clay
pH (1:2.5 extract)	7.35
EC (1: 2.5 extract) (mmhos/1cm/25°C)	0.81
O.M. %	2.39
CaCO3 %	1.45
Total N %	0.18
Available P (ppm, Olsen)	4.1
Available K (ppm/ ammonium acetate)	491.3
Available Mg (ppm)	115.0
Available S (ppm)	7.11
Available EDTA extractable micronutrients (ppm)	
Zn	1.49
Fe	12.11
Mn	9.39

The results of orchard soil analysis (according to Wilde et al., 1985) are shown in Table (1).

The selected trees received a basal recommended fertilizer including the application of 20 m3 farmyard manure (0.35 %N. 0.45 % P_2O_5, and 1.2 % K_2O) added in early December, 200 kg/ fed/ mono calcium superphosphate (15.5 % P_2O_5) added in mid January, 450 kg/ fed ammonium sulphate (20.6% N) added in three equal dressings in February, April and July and 200 kg/ fed potassium sulphate (48 % K_2O) added in two equal dressings applied in mid February and April, in addition to the regular agricultural and horticultural practices which were followed in the orchard including micronutrient application, pruning, hoeing, irrigation with Nile water as well as pathogens, insects and weed control.

This experiment included the following twenty treatments from spraying different sources, concentrations and frequencies of application of silicon and Chitosan:

1) Control (treated with water trees).

2) Spraying potassium silicate at 0.05% twice (growth start and just after fruit setting).

3) Spraying potassium silicate at 0.05% thrice (growth start and just after fruit setting and 21 days later).

4) Spraying potassium silicate at 0.1% twice (growth start and just after fruit setting).

5) Spraying potassium silicate at 0.1% thrice (growth start and just after fruit setting and 21 days later).

6) Spraying potassium silicate at 0.2% twice (growth start and just after fruit setting).

7) Spraying potassium silicate at 0.2 % thrice (growth start and just after fruit setting and 21 days later).

8) Spraying calcium silicate at 0.05% twice (growth start and just after fruit setting).

9) Spraying calcium silicate at 0.05% thrice (growth start and just after fruit setting and 21 days later).

10) Spraying calcium silicate at 0.1% twice (growth start and just after fruit setting).

11) Spraying calcium silicate at 0.1% thrice (growth start and just after fruit setting and 21 days later).

12) Spraying calcium silicate at 0.2% twice (growth start and just after fruit setting).

13) Spraying calcium silicate at 0.2% thrice (growth start and just after fruit setting and 21 days later).

14) Chitosan at 0.1%.

15) Spraying potassium silicate at 0.05% + Chitosan at 0.1%

16) Spraying potassium silicate at 0.1% +Chitosan at 0.1%

17) Spraying potassium silicate at 0.2% + Chitosan at 0.1%

18) Spraying calcium silicate at 0.05% +Chitosan at 0.1%

19) Spraying calcium silicate at 0.1% +Chitosan at 0.1%

20) Spraying calcium silicate at 0.2% +Chitosan at 0.1%

Therefore, the experiment evolved twenty treatments. Each treatment was replicated three times, one tree per each. When silicon in both forms was applied in combined with chitosan both were applied three times at growth, just after fruit setting and 21 days later. Spraying was done till runoff (about 25 L solution). The untreated trees sprayed with water containing Triton B.

This study was statistically analyzed using Randomized complete block design (RCBD) in which the experiment included twenty treatments and each treatment was replicated three times, one tree per each.

Generally, the following measurements were recorded during the two seasons of study.

1-Measurements of some vegetative growth characteristics in the Spring growth cycle namely main shoot length and thickness of main shoot length, number of leaves/shoot, length, width (cm), and area of leaves. (**Ahmed and Morsy, 1999).**

2- Measurements of plant pigments namely chlorophylls a, b and total chlorophylls and total carotenoids (mg/g F.W) **(von Wettstein, 1957).**

3- Measurements of leaf content of N, P, K, Mg, Ca (as %), Zn, Fe and Mn (as ppm) (**Cottenie *et al.*, 1982 and Summer, 1985).**

All the obtained data during the course of this study in the two successive seasons, 2016 and 2017 were tabulated and statistically analyzed. The difference between various treatments means were compared using new L.S.D. parameter at 5% (according to **Mead *et al*., 1993)**

3. Results and Discussion

1- Vegetative growth characteristics.

It is clear from the obtained data (2 and 3) that subjecting Zebda mango Trees to chitosan at 0.1% and / or potassium and calcium silicate each at 0.05% to 0.2% twice or thrice significantly stimulated length and thickens of shoot number of leaves / shoot and length and width and area of leaf relative to the control. Using silicon via potassium silicate was significantly superior than using it through calcium form in stimulating the six growth aspects. The stimulation on these growth aspects was related to the increase in concentration of silicon either applied via potassium or calcium forms. Increasing silicon concentration regardless the form applied from 0.1% to 0.2% had no significant promotion on there growth aspects. Varying frequencies of application of silicon from twice to thrice had meaningless effect on these growth traits. Using silicon was significantly superior than using chitosan in this respect. Combined application of silicon in any form and chitosan significantly stimulated all growth parameter than using each alone. The maximum values were recorded on the trees that received silicon in the form of potassium silicate at 0.1% thrice and chitosan at 0.1%. The worst values were recorded on untreated trees. These results were true during both seasons.

2-Leaf chemical composition

It is clear from the obtained data in Tables (4 to 7) that subjecting Zebda mango trees to silicon in both forms (K or Ca) at 0.05% to 0.2% twice or thrice and / or chitosan at 0.1% significantly was very effective in enhancing chlorophylls a, b, total chlorophylls, total carotenoids, N, P, K, Mg, Ca, Zn, Mn, and Fe relative to the chick treatment. Using silicon at both sources and frequencies of application and concentration was significantly superior than using chitosan in improving theses pigments and nutrients. Using chitosan at 0.1% was significantly favorable than the check treatment in enhancing these chemical components. Using silicon via potassium source was significantly preferable than using in calcium from in enhancing these leaf components. Combined application of silicon and chitosan was significantly superior than using each alone in enhancing these leaf chemical components. There was a relative promotion on these leaf chemical components with increasing concentration of silicon regardless the sources used. Increasing concentration of silicon applied via K or Ca from 0.1% to 0.2% and frequencies of application from twice to thrice had negligible promotion on the leaf chemical components.

The maximum values were recorded on the trees received silicon in the form of potassium silicate each at 0.2% and chitosan at 0.1%. The untreated trees produced the lowest values similar trend was noticed during both seasons. The beneficial effects of silicon and chitosan on nutritional status and enhancing and the trees tolerance to all stresses surely reflected on enhancing pigments and nutrients.

Discussion

Table (2): Effect of chitosan and different sources, concentration and frequencies of silicon application on some vegetative growth aspects of Zebda Mango trees during 2016 and 2017 seasons.

Treatment	Main shoot length (cm)		No. of leaves/shoot		Leaf length (cm.)	
	2016	2017	2016	2017	2016	2017
Control	15.9	16.0	11.0	10.0	23.1	22.9
K.silicate at 0.05 % twice	21.2	21.3	15.0	14.0	26.0	25.8
K.silicate at 0.05 % thrice	21.3	21.4	15.0	14.0	26.1	25.9
K.silicate at 0.1 % twice	23.0	23.1	16.0	15.0	26.6	26.4
K.silicate at 0.1 % thrice	23.2	23.3	16.0	15.0	26.7	26.5
K.silicate at 0.2 % twice	23.1	23.1	16.0	15.0	26.7	26.5
K.silicate at 0.2 % thrice	23.3	23.3	16.0	15.0	26.8	26.6
Ca.silicate at 0.05% twice	18.0	18.1	13.0	12.0	24.5	24.3
Ca.silicate at 0.05% thrice	18.1	18.2	13.0	12.0	24.6	24.4
Ca.silicate at 0.1% twice	19.3	19.4	14.0	13.0	25.3	25.1
Ca.silicate at 0.1% thrice	19.4	19.5	14.0	13.0	25.4	25.2
Ca.silicate at 0.2% twice	19.4	19.4	14.0	13.0	25.4	25.2
Ca.silicate at 0.2% thrice	19.5	19.5	14.0	13.0	25.5	25.2
Chitosan at 0.1%	17.0	17.1	12.0	11.0	23.8	23.6
K.silicate at 0.05 % + Chitosan	28.0	28.1	20.0	19.0	29.0	28.8
K.silicate at 0.1 % + Chitosan	30.0	30.4	21.0	20.0	29.5	29.2
K.silicate at 0.2 % + Chitosan	30.3	30.5	21.0	20.0	29.6	29.4
Ca.silicate at 0.05% + Chitosan	25.0	25.1	17.0	16.0	27.3	27.1
Ca.silicate at 0.1% + Chitosan	26.2	26.3	18.0	18.0	28.0	27.8
Ca.silicate at 0.2% + Chitosan	26.3	26.5	18.0	18.0	28.1	28.0
New L.S.D at 5%	1.1	0.9	1.0	1.0	0.5	0.4

Table (3): Effect of chitosan and different sources, concentration and frequencies of silicon application on some vegetative growth traits of Zebda Mango trees during 2016 and 2017 seasons.

Treatment	Leaf width (cm)		Leaf area (cm2)		Shoot thickness (cm.)	
	2016	2017	2016	2017	2016	2017
Control	4.1	3.9	44.57	42.62	0.52	0.50
K.silicate at 0.05 % twice	5.8	5.6	85.01	82.43	0.64	0.62
K.silicate at 0.05 % thrice	5.9	5.7	86.91	84.33	0.69	0.62
K.silicate at 0.1 % twice	6.3	6.1	100.37	97.58	0.67	0.65
K.silicate at 0.1 % thrice	6.4	6.2	102.88	100.62	0.68	0.66
K.silicate at 0.2 % twice	6.5	6.3	104.05	100.81	0.67	0.66
K.silicate at 0.2 % thrice	6.6	6.4	106.59	103.33	0.68	0.66
Ca.silicate at 0.05% twice	4.7	4.5	58.16	55.96	0.58	0.56
Ca.silicate at 0.05% thrice	4.8	4.6	59.76	57.54	0.58	0.56
Ca.silicate at 0.1% twice	5.2	5.0	69.19	66.84	0.60	0.58
Ca.silicate at 0.1% thrice	5.3	5.1	70.91	68.56	0.61	0.59
Ca.silicate at 0.2% twice	5.2	5.0	69.56	66.14	0.60	0.58
Ca.silicate at 0.2% thrice	5.4	5.2	72.65	69.92	0.61	0.59
Chitosan at 0.1%	4.4	4.2	51.30	49.21	0.55	0.54
K.silicate at 0.05 % + Chitosan	7.8	7.6	151.82	148.43	0.84	0.83
K.silicate at 0.1 % + Chitosan	8.2	8.0	171.14	169.18	0.88	0.86
K.silicate at 0.2 % + Chitosan	8.3	8.1	174.98	171.88	0.89	0.87
Ca.silicate at 0.05% + Chitosan	7.0	6.8	121.44	118.42	0.75	0.73
Ca.silicate at 0.1% + Chitosan	7.3	7.1	132.82	129.65	0.78	0.76
Ca.silicate at 0.2% + Chitosan	7.4	7.1	135.17	130.65	0.79	0.77
New L.S.D at 5%	0.2	0.3	3.0	2.9	0.02	0.03

Table (4): Effect of chitosan and different sources, concentration and frequencies of silicon application on chlorophylls a & b and total chlorophylls in the leaves of Zebda Mango trees during 2016 and 2017 seasons.

Treatment	Chlorophyll a (mg/g F.W)		Chlorophyll b (mg/g F.W)		Total Chlorophylls (mg/g F.W)	
	2016	2017	2016	2017	2016	2017
Control	4.1	4.0	1.1	1.0	5.2	5.0
K.silicate at 0.05 % twice	6.0	5.9	2.5	2.4	8.5	8.3
K.silicate at 0.05 % thrice	6.1	6.0	2.6	2.5	8.7	8.5
K.silicate at 0.1 % twice	6.6	6.5	3.0	2.9	9.6	9.4
K.silicate at 0.1 % thrice	6.7	6.6	3.1	3.0	9.8	9.6
K.silicate at 0.2 % twice	6.6	6.5	3.0	2.9	9.6	9.4
K.silicate at 0.2 % thrice	6.7	6.6	3.1	3.0	9.8	9.6
Ca.silicate at 0.05% twice	4.9	4.8	1.7	1.7	6.6	6.5
Ca.silicate at 0.05% thrice	5.0	4.9	1.8	1.8	6.8	6.7
Ca.silicate at 0.1% twice	5.4	5.3	2.1	2.1	7.5	7.4
Ca.silicate at 0.1% thrice	5.5	5.4	2.2	2.2	7.7	7.7
Ca.silicate at 0.2% twice	5.5	5.4	2.1	2.1	7.6	7.5
Ca.silicate at 0.2% thrice	5.5	5.5	2.2	2.2	7.7	7.7
Chitosan at 0.1%	4.5	4.4	1.0	1.4	5.9	5.8
K.silicate at 0.05 % + Chitosan	9.0	8.9	3.3	3.2	12.3	12.1
K.silicate at 0.1 % + Chitosan	9.3	9.2	3.6	3.5	12.9	12.7
K.silicate at 0.2 % + Chitosan	9.4	9.3	3.7	3.6	13.1	12.9
Ca.silicate at 0.05% + Chitosan	8.1	8.0	2.6	2.5	10.7	10.5
Ca.silicate at 0.1% + Chitosan	8.6	8.5	3.0	2.9	11.6	11.4
Ca.silicate at 0.2% + Chitosan	8.7	8.6	3.1	2.9	11.8	11.5
New L.S.D at 5%	0.3	0.2	0.2	0.3	0.3	0.4

Table (5): Effect of chitosan and different sources, concentration and frequencies of silicon application on total carotenoids and percentages of N and P in the leaves of Zebda Mango trees during 2016 and 2017 seasons.

Treatment	Total carotenoids (mg/g FW)		Leaf N%		Leaf P%	
	2016	2017	2016	2017	2016	2017
Control	1.0	0.9	1.56	1.53	0.210	0.208
K.silicate at 0.05 % twice	2.6	2.5	1.87	1.84	0.261	0.259
K.silicate at 0.05 % thrice	2.7	2.5	1.88	1.85	0.262	0.260
K.silicate at 0.1 % twice	3.0	2.9	1.94	1.90	0.272	0.270
K.silicate at 0.1 % thrice	3.1	3.6	1.95	1.91	0.273	0.271
K.silicate at 0.2 % twice	3.0	2.9	1.94	1.90	0.273	0.271
K.silicate at 0.2 % thrice	3.1	3.0	1.96	1.93	0.274	0.272
Ca.silicate at 0.05% twice	1.6	1.5	1.70	1.67	0.232	0.230
Ca.silicate at 0.05% thrice	1.7	1.6	1.71	1.68	0.233	0.231
Ca.silicate at 0.1% twice	2.0	1.9	1.77	1.73	0.244	0.242
Ca.silicate at 0.1% thrice	2.1	2.0	1.78	1.74	0.245	0.243
Ca.silicate at 0.2% twice	2.0	1.9	1.78	1.74	0.245	0.243
Ca.silicate at 0.2% thrice	2.1	2.0	1.79	1.75	0.246	0.244
Chitosan at 0.1%	1.4	1.2	1.63	1.59	0.221	0.219
K.silicate at 0.05 % + Chitosan	4.7	4.6	2.16	2.13	0.312	0.310
K.silicate at 0.1 % + Chitosan	5.0	4.9	2.22	2.19	0.325	0.323
K.silicate at 0.2 % + Chitosan	5.0	4.9	2.23	2.26	0.326	0.324
Ca.silicate at 0.05% + Chitosan	4.0	3.9	2.02	1.99	0.286	0.284
Ca.silicate at 0.1% + Chitosan	4.2	4.1	2.09	2.06	0.300	0. 298
Ca.silicate at 0.2% + Chitosan	4.3	4.2	2.10	2.07	0.301	0.299
New L.S.D at 5%	0.2	0.3	0.05	0.06	0.010	0.090

Table (6): Effect of chitosan and different sources, concentration and frequencies of silicon application on the percentages of K, Mg, and Ca in the leaves of Zebda Mango trees during 2016 and 2017 seasons.

Treatment	Leaf K %		Leaf Mg %		Leaf Ca %	
	2016	2017	2016	2017	2016	2017
Control	1.17	1.21	0.51	0.53	2.76	2.66
K.silicate at 0.05 % twice	1.40	1.45	0.72	0.74	3.00	2.99
K.silicate at 0.05 % thrice	1.41	1.45	0.73	0.75	3.02	3.01
K.silicate at 0.1 % twice	1.46	1.50	0.77	0.79	3.08	3.07
K.silicate at 0.1 % thrice	1.47	1.51	0.78	0.80	3.09	3.08
K.silicate at 0.2 % twice	1.46	1.50	0.77	0.79	3.09	3.08
K.silicate at 0.2 % thrice	1.47	1.51	0.78	0.80	3.10	3.09
Ca.silicate at 0.05% twice	1.27	1.31	1.60	0.62	2.83	2.83
Ca.silicate at 0.05% thrice	1.28	1.32	0.61	0.63	2.84	2.84
Ca.silicate at 0.1% twice	1.33	1.38	0.66	0.68	2.90	2.89
Ca.silicate at 0.1% thrice	1.34	1.39	0.67	0.69	2.91	2.90
Ca.silicate at 0.2% twice	1.33	1.38	0.66	0.68	2.90	2.89
Ca.silicate at 0.2% thrice	1.34	1.39	0.67	0.69	2.91	2.91
Chitosan at 0.1%	1.22	1.26	0.56	0.58	2.75	2.74
K.silicate at 0.05 % + Chitosan	1.67	1.71	0.92	0.94	3.31	3.30
K.silicate at 0.1 % + Chitosan	1.72	1.76	0.95	0.97	3.39	3.38
K.silicate at 0.2 % + Chitosan	1.73	1.77	0.96	0.98	3.40	3.39
Ca.silicate at 0.05% + Chitosan	1.53	1.57	0.53	0.85	3.17	3.16
Ca.silicate at 0.1% + Chitosan	1.60	1.64	0.87	0.89	3.23	3.22
Ca.silicate at 0.2% + Chitosan	1.61	1.65	0.88	0.90	3.24	3.23
New L.S.D at 5%	0.04	0.05	0.03	0.04	0.06	0.08

Table (7): Effect of chitosan and different sources, concentration and frequencies of silicon application on the leaf content of Zn, Mn and Fe in the leaves of Zebda Mango trees during 2016 and 2017 seasons.

Treatment	Leaf Zn (ppm)		Leaf Mn (ppm)		Leaf Fe (ppm)	
	2016	2017	2016	2017	2016	2017
Control	62.3	63.0	49.1	49.0	55.2	55.3
K.silicate at 0.05 % twice	70.3	70.4	56.0	55.9	62.0	61.9
K.silicate at 0.05 % thrice	70.4	70.5	56.2	65.1	62.1	62.0
K.silicate at 0.1 % thrice	72.0	72.1	58.0	57.9	64.0	63.9
K.silicate at 0.1 % thrice	72.1	72.2	58.3	58.2	64.3	64.4
K.silicate at 0.2 % twice	78.0	78.1	58.0	57.9	64.1	64.0
K.silicate at 0.2 % thrice	72.1	72.2	58.3	58.2	64.4	64.5
Ca.silicate at 0.05% twice	66.0	66.1	52.0	51.9	58.1	58.2
Ca.silicate at 0.05% thrice	66.6	66.7	52.2	52.1	58.2	58.3
Ca.silicate at 0.1% twice	68.2	68.3	54.0	53.9	60.0	59.9
Ca.silicate at 0.1% thrice	68.3	68.4	54.3	55.0	60.1	60.0
Ca.silicate at 0.2% twice	68.3	68.4	54.0	53.9	60.0	59.0
Ca.silicate at 0.2% thrice	68.4	68.5	54.4	54.5	60.1	60.1
Chitosan at 0.1%	64.0	64.1	50.6	50.5	56.7	56.6
K.silicate at 0.05 % + Chitosan	78.0	78.1	63.0	62.9	71.1	71.0
K.silicate at 0.1 % + Chitosan	80.0	79.9	65.0	64.9	73.0	72.9
K.silicate at 0.2 % + Chitosan	80.3	80.4	65.2	65.3	73.3	73.3
Ca.silicate at 0.05% + Chitosan	74.0	73.9	60.0	59.9	66.6	66.7
Ca.silicate at 0.1% + Chitosan	76.0	75.9	61.2	61.3	69.0	68.9
Ca.silicate at 0.2% + Chitosan	76.2	76.3	61.3	61.4	69.3	69.2
New L.S.D at 5%	1.6	1.4	1.2	1.4	1.3	1.4

The promoting effect of silicon on growth and nutritional trees of Zebda mango trees might be attributed to its positive action on enhancing the tolerance of the trees to biotic and abiotic stresses, balancing plant water, enhancing photosynthesis, root development, water transport and reducing transpiration rate through forming silicon cuticle double layers on leaf epidermal tissues and various disorders, **Sauvas *etal*, (2002), Lux *etal*, (2003) Gany *etal*, (2003), Hattori *etal*, (2003), Ma, (2004) and Tahir *etal*, (2006)**

The results of **EL-Khawaga and Mansour (2014), Ibrahim and AL- Wasfy (2014), Mohamed (2015), Mohamed *etal* (2015), Wassel *etal* (2015), Akl *etal* (2015), Mohamed (2016) and Rizk (2017)** supported the present results regarding the effect of silicon on stimulating growth aspects of different fruit crops.

The favourable effects of chitosan on growth characteristics and nutritional states of Zebda mango trees was attributed to its effect in reducing transpirate rate and enhancing the tolerance of the trees to stress (biotic and abiotic) **Eweis *etal* (2006), Chien and Chou, (2006), Liu *etal* (2007) and Chao *etal* (2015).**

These results regarding the effect of chitosan on growth are in harmong with those obtained by **Gornik *etal* (2008), Meng *etal* (2010), Hadwiger (2013) EL- Miniawy *etal* (2013), Xing *etal* (2015), Hosssain and Iqbal (2016), Tayel *et al* (2016) and Khafagy (2018)**

Conclusion

For stimulating growth and tree nutritional status of Zebda Mango trees grown under Minia region conditions it is suggested to spray the trees three times (at growth start, just after fruit setting and 21 days later) with a mixture of potassium silicate and chitosan together each at 0.1 %.

References

1. Ahmed, F.F. and Morsy, M.H. (1999): A new method for measuring leaf area in different fruit species. Minia J. of Agric. Res. & Develop. Vol. (19)pp. 97-105.
2. Akl, A.M.M.A.; Mohamed, M.A.; Ibrahim, H.I.M and Mohamed, R.H.M. (2015): Productive capacity of Manfalouty pomegranate trees in relation to spraying of silicon and vitamins B. World Rural observations 7(1):108-118.
3. Chien, P. J., and Chou, C. C. (2006): Antifungal activity of chitosan and its application to control post harvest quality and

fungal rotting of Tankan citrus fruit (Citrus tankan Hayata). J. of the Sci. of Food and Agric., 86(12), 1964-1969.

4. Cottenie A; Verloo, M.; Velghe, M. and Camerlynck, R. (1982): Chemical Analysis of Plant and Soil. Ghent, Belgium, Laboratory of Analytical and Agro- chemistry. State Univ. pp. 200 - 210.
5. El-Khawaga, A.S. and Mansour, A.G.M. (2014): Promoting productivity of Washington Navel orange trees by using some crop seed sprout extracts, silicon and glutathione. Middle East Journal of Applied Sciences, 4(3): 779-785.
6. El-Miniawy, S., Ragab, M., Youssef, S., and Metwally, A. (2013): Response of strawberry plants to foliar spraying of chitosan. Res. J. Agric. Biol. Sci, 9(6), 366-372.
7. Eweis, M., Elkholy, S. S., & Elsabee, M. Z. (2006): Antifungal efficacy of chitosan and its thiourea derivatives upon the growth of some sugar-beet pathogens. International Journal of Biological Macromolecules, 38(1), 1-8.
8. Gang, H.J.K.; Chen, K.M.; Chen, G.C.; Wan, S.M. and Zhang, C.L. (2003): Effect of silicon on growth of wheat under drought. H. Plant. Nutr. 26(5):1055-1063.
9. Górnik, K., Grzesik, M., & Romanowska-Duda, B. (2008): The effect of chitosan on rooting of grapevine cuttings and on subsequent plant growth under drought and temperature stress. J. Fruit Ornam. Plant Res, 16, 333-343.
10. Hadwiger, L. A., Klosterman, S. J., & Choi, J. J. (2002): The mode of action of chitosan and its oligomers in inducing plant promoters and developing disease resistance in plants. Advances in chitin science, 5, 452-457.
11. Hossain, M. S., and Iqbal, A. (2016): Effect of shrimp chitosan coating on postharvest quality of banana (Musa sapientum L.) fruits. Inter. Food Res. J. 23(1), 277-283.
12. Hattori, T; Inanaga, S.; araki, H.; An, P.; Martia, S.; Luxova, M. and Lux, A. (2005): Application of silicon enhanced drought tolerance in Sorgham bicolor. Physiologia Plantarum, 123:459-466.
13. Ibrahiem, H.I.M. and Al- Wasfy, M.M. (2014): The promotive impact of using silicon and selenium with potassium and boron on fruiting of Valencia orange trees grown under Minia region conditions. World Rural Observations 6(2):28-36.
14. Khafagy. O. M.M. (2018): The beneficial effects of using chitosan and glutathione on the fruiting of Red Roomy grapevines. Ms.C Thesis Fac. Of Agric Minia Univ.
15. Liu, J., Tian, S., Meng, X., & Xu, Y. (2007): Effects of chitosan on control of postharvest diseases and physiological responses of tomato fruit. Postharvest Biology and Technology, 44(3), 300-306.
16. Lux, A.; Luxova, M.; Abe, J. Tanmoto, E. and Inanaga, S. (2003): The dynamic of silicon deposition in the sorghum root endodermis. New Physiol. 158:437-441.
17. Ma, J.F. (2004): Role of silicon in enhancing the resistance of plants of biotic and abiotic stresses. Soil Scr. Plant Nutr. 50:11-18.
18. Mead, R., Curnow, R. N. and Harted, A. M. (1993): Statistical methods in Agricultural and Experimental Biology. 2nd Ed. Chapman & Hall, London pp. 10-44.
19. Meng, X., Yang, L., Kennedy, J. F., & Tian, S. (2010): Effects of chitosan and oligochitosan on growth of two fungal pathogens and physiological properties in pear fruit. Carbohydrate Polymers, 81(1), 70-75.
20. Mohamed, R.H.M. (2015): Studies on the effect of spraying potassium silicate and vitamin B on fruiting of Manfalouty pomegranate trees. M.Sc. Thesis, Fac. of Agric. Minia Univ. Egypt.
21. Mohamed, M.A.A. (2016): Physiological studies on the effect of some silicon, boron and amino acid treatments on some olive cvs. Ph. D. Thesis Fac. of Agric. Al- Azhar Univ. Assiut, Egypt.
22. Mohamed, M.A.; El- Sayed, M.A. and Abd El-Wahab, H.A.M. (2015): Response of succary mango trees to foliar application of silicon and boron. World Rural observation 7(2):93-98.
23. Rizk, M.N.S. (2017): The beneficial effects of using silicon with some nutrients on fruiting of Zaghloul date palms. Ph. D. Thesis Fac. of Agric. Minia Univ. Egypt.
24. Sauvas, D.; Manos, G.; Kotsiras, A. and Souvaliotis, S. (2002): Effects of silicon and nutrient-induced salinity on yield, flower quality and nutrient uptake of gerbera grown in a closed hydroponic system. J. appl. Bot. 76(5): 153-158.
25. Shao, X., Cao, B., Xu, F., Xie, S., Yu, D., & Wang, H. (2015): Effect of postharvest application of chitosan combined with clove oil against citrus green mold. Postharvest Biol. Technol. 99, 37-43.
26. Summer, M.E. (1985): Diagnosis and Recommendation. Integrated system (DRIS) as a guide to orchard fertilization. Hort. Abst. 55(8): 7502.
27. Tahir, M.A.; Rahmatullah, A.; Aziz, T. Ashraf, M.; Kanwal, S. and Magsood, A. (2006):

Beneficial effects of silicon in wheat (Triticum oestrum L.) under salinity stress. Pak. J. Bot.38(5): 1715-1727.

28. Tayel, A. A., Moussa, S. H., Salem, M. F., Mazrou, K. E., & El‐Tras, W. F. (2016): Control of citrus molds using bioactive coatings incorporated with fungal chitosan/plant extracts composite. Journal of the Science of Food and Agriculture, 96(4), 1306-1312.
29. von Wettstein, D. (1957): Chlorophyll-letale und der submikroskopische Formwechsel der Plastiden. Experimental Cell Research, 12(3): 427-506.
30. Wassel, A.M.M.; Gobara, A.A.; Mohamed, A.Y. and El- Sadek, M.A. (2015): Response of Ewaise mango trees to foliar application of boron and silicon. J. Biol. Chem. Environ. Sci. 10(4): 423-437.
31. Wilde, S. A.; Corey, R. B.; Layer, J. G. and Voigt, G. K. (1985): Soils and Plant Analysis for Tree Culture. Mohan Primlani, Oxford & IBH Publishing Co., New Delhi, India, p 1-142.
32. Xing, K., Zhu, X., Peng, X., & Qin, S. (2015): Chitosan antimicrobial and eliciting properties for pest control in agriculture: a review. Agronomy for Sustainable Development, 35(2), 569-588.

6/18/2018