The Synergistic Effects of Using Silicon with Some Vitamins on Growth and Fruiting of Flame Seedless Grapevines

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Abstract: Flame seedless grapevines treated during 2012 and 2013 seasons with potassium silicate at 250 ppm either singly or in various combinations with vitamins K & E & D & A & B_{12} each at 50 ppm and C at 500 ppm as an attempts for promoting berry weight and colouration of clusters. Each vine was sprayed four times. Spraying silicon and or these vitamins was superior than the control treatment in improving growth, yield and quality of the berries. Using vitamins was favourable than using silicon in this respect. Using silicon in combined with these vitamins surpassed the use of vitamins alone in this respect. A remarkable promotion on both berry weight and cluster colouration was observed with using silicon and/ or vitamins. Carrying out four sprays of a mixture of vitamins K & E & D & A & B_{12} each at 50 ppm and C at 500 pm besides potassium silicate at 250 ppm is suggested to be beneficial for promoting berry weight and cluster colouration of Flame seedless grapevines.
Therefore, the composting processes could be optimized by the application of the developed simulation model.
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Key words: Silicon, vitamins, yield and fruit quality.

1. Introduction

Small berries and uneven colouration of clusters of Flame seedless grapevines grown under Upper Egypt conditions are considered serious problems facing the consumption and marketing of such grape cv. Recently, public health and environmental safety encourage the use of vitamins and silicon as a replacement of different chemicals for enhancing production of fruit crops.

Nowadays, there is a widespread use of vitamins as antioxidants. They are very effective in protecting plant cells from senescence and disorders (**Robinson, 1973**) as well as enhancing cell division, the biosynthesis of natural hormones such as IAA, GA_3 and cytokinins, nutrient and water uptake, photosynthesis, biosyntehsis of plant pigments and proteins as well as the biosynthesis of alpha keto glutaric acid which is united with amino to form amino acids and proteins (**Oretili, 1987 and Samiullah *et al.*, 1988**).

Previous studies showed that using silicon in fruit orchards under unsuitable conditions was accompanied with alleviating the adverse effects of these conditions on fruiting of fruit crops. This is happened by maintaining plant water balance, photosynthesis activity, water transport and organic foods (**Levitt, 1980; Kanto, 2002; Aziz *et al.*, 2002; Epstein and Bloom, 2003 and Qin and Tian, 2004**).

Using vitamins (**Farahat, 2008; Ahmed and Selem- Basma, 2008; Abada and Abd El- Hameed, 2009; Abd El- Kariem, 2009; El- Sawy 2009; Mahmoud, 2009; Abada and Abd- El- Hameed, 2010; El- Kady- Hanaa, 2011; Madian and Refaai, 2011; Bondok- Sawsan *et al.*, 2011; Ahmed *et al.*, 2011; Uwakiem, 2011, El- Hanafy, 2011; Wasel *et al.*, 2011; Mohamed- Ebtesam, 2012; Mekawy, 2012; Ahmed *et al.*, 2012; Ibrahiem – Rehab, 2012; Abdelaal, 2012; Abdelaal and Abd El-Rahman, 2013 and Abdellaal *et al.*, 2013**) and Silicon (**Gad El- Kareem, 2012; Abd El- Hameed, 2012 and Abdelaal and Oraby- Mona, 2013**) was found to enhance growth and fruiting of fruit crops.

The target of this study was promoting yield and quality of Flame seedless grapevines by using some vitamins and silicon.

2. Material and Methods

This study was carried out during 2012 and 2013 seasons on forty – eight uniform in vigour 10-years old Flame seedless grapevines growth in a private vineyard located at Armant district, Luxor Governorate. Vines were spaced at 2 x 3 m apart and grown in a clay soil. Spur pruning method with Gable shape supporting system was followed. Pruning was made in the middle of Jan. leaving 72 eyes/ vine (on the basis of 15 fruiting sprays x four eyes + six replacement spurs x two eyes). Surface irrigation system, using Nile water was adopted

The experiment included the following eight treatments:

1- Control (untreated vines).
2- Spraying potassium silicate at 250 ppm.
3- Spraying vitamins K, E, D& A each at 50 ppm.
4- Spraying vitamin C at 500 ppm + B_{12} at 50 ppm.

5- Spraying vitamins K, E, D, A & B_{12} each at 50 ppm + C at 500 ppm.
6- Spraying vitamins K, E, D, A & B_{12} each at 50 ppm + potassium silicate at 250 ppm.
7- Spraying vitamin C at 500 ppm + B_{12} at 50 ppm + potassium silicate at 250 ppm.
8- Spraying all vitamins + potassium silicate at 250 ppm.

Each treatment was replicated three times, two vines per each. Vitamins K, E, D& A were dissolved in few drops of ethyl alcohol before application. Vitamin B_{12} and potassium silicate (25 % SiO_2 and 10% % K_2O) were easily soluble in water. They were sprayed four times at growth start (last week of Feb. (just before flowering start (2^{nd} week of Mar.), just after berry setting (last week of April) and at three weeks later (2^{nd} week of May). Triton B as wetting agent was added at 0.05 % to all spraying solutions. Untreated vines were sprayed with water containing Triton B. Randomized complete block design was followed.

During both seasons, the following parameters were measured:-

1-Leaf area, (cm_2) **(Ahmed and Morsy, 1999)** and main shoot length (cm).

2- Leaf nutrient content in the dried leaves namely N, P, K, Mg and Zn, Fe and Mn (ppm) (according to **Balo *et al.*, 1988 and Chapman and Pratt, 1965**).

3-Plant pigments in the fresh leaves namely chlorophylls a & b, total chlorophylls and total carotenodis (as mg/ 100 g F.W) (according to **Wettstein, 1957**).

4-Yield expressed in weight (kg.) and number of clusters per vine.

5- Cluster weight and colouration %.

6-Berries quality namely berry weight (g.), T.S.S. %, total sugars (according to **Lane and Eynon, 1965, A.O.A.C., 1995**) and total acidity % (as g tartaric acid/ 100 ml juice, **A.O.A.C., 1995**).

All the obtained data were tabulated and subjected to the proper statistical analysis using new L.S.D. test at 5% (according to **Mead *et al.*, 1993**).

3. Results and Discussion

1-Growth and Leaf composition:

Data in Tables (from 1 to 3) clearly show that single and combined applications of silicon (s) at 250 ppm, vitamins K, E.D, & A each at 50 ppm, vitamin C at 500 ppm, and B_{12} at 50 ppm were significantly effective in improving the leaf area and main shoot length as well as nutrients namely N, P, K, Mg, Zn, Mn and Fe and plant pigments namely chlorophylls a, b, total carotenoids and total chlorophylls in the leaves in relative to the control treatment. Application of vitamins K, E, D, A & B_{12} each at 50 ppm and C at 500 ppm was superior in promotion these growth, nutrients and plant pigments than using silicon at 250 ppm alone. Using all vitamins was significantly favourable than using each vitamin group alone in this connection. The beneficial effects of all vitamins on growth and leaf components were significantly enhanced with using silicon in combined with these vitamins. Using vitamin C at 500 ppm plus B_{12} at 50 ppm surpassed the application of vitamins K, E, D & A each at 50 ppm in this respect. The maximum leaf area (118.9 and 120.3 cm^2) main shoot length (107.8 and 109.3 cm), N(2.21 and 2.31 %), P (0.31 and 0.30%), K (1.69 and 1.65%), Mg (0.66 and 0.70%), Zn (71.0 and 72.5 % ppm); Mn (71.9 and 73.1 ppm), Fe (70.0 and 72.2 ppm), total chlorophylls (15.3 and 15.3 mg/ 100 g F.W) and total carotenoids (3.7and 3.5 mg/ 100 g F.W) were observed on the vines that received four sprays of a mixture of vitamins containing vitamins K, E, D, A & B_{12} each at 50 ppm, besides C at 500 ppm and silicon at 250 ppm during both seasons, respectively. The untreated vines produced the minimum values. These results were true during both seasons.

2- Yield, as well as cluster weight and colouration:

It is evident from the data in Tables (3 & 4) that yield expressed in number of clusters / vine and weight as well as cluster weight and colouration were significantly improved in response to single and combined applications of vitamins and silicon rather than the check treatment. Using vitamins was significantly favourable than using silicon alone. Combined applications of vitamins besides silicon was superior in promoting yield and cluster weight than using each alone. Using all vitamins together was better than using each vitamin group alone in this respect. Treating the vines with all vitamins (K, E, D, A & B_{12} each at 50 ppm and C at 500 ppm) besides silicon at 250 ppm gave the maximum yield (8.3 and 13.1 kg), cluster weight (394 and 396 g) and cluster colouration % (79.9 and 80.3%) during both seasons, respectively. Number of clusters in the first season of study did not alter significantly with the present treatments. These results were true during both seasons.

3- Berries quality:

Data in Table (4) obviously reveal that using vitamins and silicon either alone or in various combinations significantly was accompanied with improving quality of the berries in terms of increasing fruit weight, T.S.S. %, and total sugars and reducing total acidity % in relative to the check treatment. The promotion was significantly associated with using silicon with vitamins. Using vitamins alone was significantly responsible for enhancing fruit quality compared with the single use of silicon. Using all vitamins surpassed the application of each vitamin group alone in this connection.

Table (1): Effect of single and combined applications of some vitamins and silicon on the leaf area, main shoot length and percentages of N and K in the leaves of Flame seedless grapevines during 2012 & 2013 seasons.

Vitamin and silicon treatments	Leaf area (cm^2)		Main shoot length (cm)		Leaf N%		Leaf P%		Leaf K %	
	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013
Control (untreated vines)	105.1	105.0	95.9	97.3	1.66	1.64	0.11	0.10	1.25	1.18
Silicon at 250 ppm	107.7	108.8	97.1	98.0	1.74	1.80	0.13	0.14	1.31	1.33
Vitamins K, E, D & A at 50 ppm	109.4	110.5	98.4	99.3	1.82	1.88	0.16	0.16	1.36	1.38
Vitamins C at 500 ppm + B12 at 50 ppm	111.0	112.1	99.7	100.6	1.90	1.96	0.18	0.19	1.42	1.44
All vitamins at the previous conc.	112.3	113.4	101.0	101.9	1.97	2.03	0.21	0.22	1.50	1.50
Vitamins K, E, D & A + silicon	115.0	116.1	103.0	103.9	2.06	1.12	0.23	0.25	1.56	1.55
Vitamins C + B12+ Silicon	117.5	118.1	105.5	106.5	2.14	1.21	0.26	0.27	1.62	1.60
All vitamins ($KEDACB_{12}$) + silicon	118.9	120.3	107.8	109.3	2.21	2.31	0.30	0.31	1.69	1.65
New L.S.D. at 5%	1.1	1.0	1.1	1.2	0.06	0.05	0.02	0.02	0.04	0.05

Table (2): Effect of single and combined applications of some vitamins and silicon on the leaf content of Mg(0%) and Zn, Mn and Fe (as ppm) and chlorophyll a (mg(100gF.W) of Flame seedless grapevines during 2012 & 2013 seasons.

Vitamin and silicon treatments	Leaf Mg%		Leaf Zn ppm		Leaf Mn ppm		Leaf Fe ppm		Chlorophyll a (mg/100 gF.W)	
	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013
Control (untreated vines)	0.41	0.44	51.5	50.3	52.9	52.0	49.1	44.2	6.9	7.1
Silicon at 250 ppm	0.44	0.48	53.6	55.0	55.0	56.1	52.1	51.9	7.4	7.6
Vitamins K, E, D & A at 50 ppm	0.48	0.52	56.9	58.4	58.5	59.6	55.1	55.0	7.8	8.1
Vitamins C at 500 ppm + B12 at 50 ppm	0.52	0.56	60.0	61.5	60.6	61.7	58.0	58.8	8.2	8.5
All vitamins at the previous conc.	0.55	0.59	62.9	64.5	63.0	64.1	61.1	61.9	9.0	9.0
Vitamins K, E, D & A + silicon	0.59	0.63	65.0	66.5	65.9	67.0	63.7	66.3	9.4	9.4
Vitamins C + B12+ Silicon	0.63	0.67	68.0	69.5	69.0	70.1	66.8	69.2	9.9	9.9
All vitamins ($KEDACB_{12}$) + silicon	0.66	0.70	71.0	72.5	71.9	73.1	70.1	72.2	10.6	10.5
New L.S.D. at 5%	0.03	0.03	1.9	2.0	1.8	1.9	2.0	2.1	0.3	0.3

Table (3): Effect of single and combined applications of some vitamins and silicon on some plant pigments (mg100g F.W) and yield of Flame seedless grapevines during 2012 & 2013 seasons.

Vitamin and silicon treatments	Chlorophyll b (mg/100gF.w)		Total chlorophyll (mg/100gFw)		Total carotenoides (mg/100gFw)		No. of cluster/vine		Yield/vine (Kg.)	
	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013
Control (untreated vines)	2.9	3.1	9.8	10.2	2.1	2.0	20.0	20.0	6.2	6.2
Silicon at 250 ppm	3.1	3.3	10.5	10.9	2.3	2.2	21.0	22.0	6.9	7.3
Vitamins K, E, D & A at 50 ppm	3.4	3.6	11.2	11.7	2.6	2.4	21.0	24.0	7.2	8.4
Vitamins C at 500 ppm + B12 at 50 ppm	3.6	3.8	11.6	12.3	2.8	2.6	21.0	26.0	7.5	9.5
All vitamins at the previous conc.	3.8	4.1	12.8	13.1	3.0	2.8	21.0	28.0	7.9	10.7
Vitamins K, E, D & A + silicon	4.1	4.3	13.5	13.7	3.3	3.0	21.0	30.0	8.0	11.6
Vitamins C + B12+ Silicon	4.4	4.6	14.3	14.5	3.5	3.3	21.0	32.0	8.2	12.5
All vitamins ($KEDACB_{12}$) + silicon	4.7	4.8	15.3	15.3	3.4	3.5	21.0	33.0	8.3	13.1
New L.S.D. at 5%	0.2	0.2	0.3	0.4	0.2	0.2	NS	2.0	0.3	0.4

Table (4): Effect of single and combined applications of some vitamins and silicon on cluster weight(g.), berry weight (g.) and some chemical characteristics of the berries of Flame seedless grapevines during 2012 & 2013 seasons.

Vitamin and silicon treatments	Cluster weight (g.)		Cluster coloration %		Berry weight (g.)		T.S.S. %		Total sugars %		Total acidity %	
	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013
Control (untreated vines)	310	312	25.5	41.2	2.29	2.33	18.0	17.9	16.0	15.9	0.718	0.715
Silicon at 250 ppm	326	331	52.5	53.2	2.38	2.41	18.3	18.2	16.1	16.1	0.688	0.689
Vitamins K, E, D & A at 50 ppm	342	348	54.0	54.8	2.48	2.50	18.6	18.4	16.3	16.3	0.662	0.660
Vitamins C at 500 ppm + B12 at 50 ppm	358	364	57.0	57.9	2.57	2.57	18.9	18.6	16.5	16.5	0.630	0.631
All vitamins at the previous conc.	374	381	64.0	64.8	2.65	2.66	19.2	19.0	16.7	16.7	0.600	0.600
Vitamins K, E, D & A + silicon	381	387	68.5	69.4	2.73	2.74	19.5	19.2	17.0	17.0	0.570	0.571
Vitamins C + B12+ Silicon	391	392	71.9	72.9	2.83	2.82	19.8	19.4	17.2	17.2	0.550	0.541
All vitamins ($KEDACB_{12}$) + silicon	394	396	79.9	80.3	2.92	2.89	20.1	19.6	17.2	17.5	0.520	0.518
New L.S.D. at 5%	15.0	16.0	1.1	1.0	0.08	0.07	0.3	0.2	0.2	0.2	0.025	0.021

The best results were obtained with using all vitamins and silicon together. Under such promised treatment berry weight reached 2.921 and 2.89 g during both seasons, respectively. T.S.S. values 20.1 and 19.6 % were appeared with using all vitamins with silicon during both seasons, respectively. The low grade of berries quality was observed in the clusters harvested from untreated vines. These results were nearly the same during both seasons.

4. Discussion

The previous beneficial effects of the six vitamins K, E, D, A & B_{12} and ascorbic acid on growth characters, vine nutritional status, yield as well as physical and chemical characteristics of the fruits might be attributed to their positive action on avoiding all active oxygen species from reducing cell senscenses and destroying membranes as well as enhancing cell division, the biosynthesis of plant pigments and organic foods, the resistance of plants to unfavourable conditions beyond the trees, the biosynthesis of natural hormones, building of amino acids and proteins and uptake of water and different nutrients. These merits were happened through the effect of these vitamins on catching the free radicals namely signlet oxygen, superoxide anion, H_2O_2 and hydroxyl and preventing the oxidation of lipids and death of cells (**Robinson, 1973, Oretili, 1987 and Samiullah *et al.*, 1988**).

Silicon is known to reduce the formation of reactive oxygen species that oxidizes photosynthetic pigments, membranes lipids, proteins and nucleic acid. Previous studies showed that silicon increases the activities of antioxidant enzymes in the leaves that protect plant tissues from oxidative damage under unfavourable conditions. Silicon is responsible for maintaining plant water balance as well as stimulating water transport and root growth (**Levitt, 1980; Epstein, 1999; Matichenkov *et al,* 2000; Ma *et al,* 2001; Neumann and Zur- Nieden, 2001; Ma and Takahashi, 2002; Aziz *et al.,* 2002, Kanto, 2002, Epstein and Bloom, 2003 and Qin and Tian, 2004**).

These results regarding the beneficial effects of vitamins on growth, vine nutritional status, yield as well as physical and chemical characteristics of the berries are in harmony with those obtained by **El-Kady – Hanaa (2011); El- Hanafy (2011); Madian and Refaai (2011); Ahmed *et al.,* (2011); Uwakiem (2011); Wasel *et al.* (2011); Mohamed -Ebtesam, (2012); Mekawy, (2012); Abdelaal, (2012) and Abdelaal *et al.,* (2013)**.

The results of **Gad El- kareem (2012); Abd El- Hameed (2012) and Abdelaal and Oraby – Mona (2013)** supported the profits of silicon on growth, yield and fruit quality of fruit crops.

Conclusion:

The best results with regard to growth, yield as well as physical and chemical characteristics of Flame seedless grapes were obtained with treating the vines four times with a mixture of vitamins K, E, D, A and B_{12} each at 20 ppm ascorbic acid at 500 pm besides silicon at 250 ppm.

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