Growth and Vine Nutritional Status of Red Globe Grapevines As Affected With Some Silicon and Summer Pruning Treatments

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Abstract: This study was carried out during 2016 and 2017 seasons to test the effect of spraying silicon and summer pruning practices on growth and vine nutritional status of Red Globe grapevines grown under Minia region conditions. The study consisted from nine treatments namely application of silicon in the form of K-Silicate at 0.1 % with or without three summer pruning treatments (pinching the main shoots, removing all leaves under clusters and removing all laterals on the main shoots). Summer pruning was carried out once just after berry setting. Potassium silicate was sprayed thrice at growth start, just after berry setting and one month later. Treating the vines with K-Silicate at 0.1 % either alone or with any summer pruning treatment (pinching the main shoots, removing all leaves under clusters and removing all laterals on the main shoots) considerably stimulated the five growth traits namely number of leaves/shoot, leaf area, wood ripening coefficient, cane thickness and pruning wood weight, chlorophylls a & b, total chlorophylls, total carotenoids, N, P, K, Mg, Ca, Zn, Fe and Mn in the leaves relative to the control treatment. The promotion on these parameters was associated with removing laterals on the main shoots, removing all leaves under clusters and pinching the main shoots, in descending order. Using silicon besides any summer pruning treatments was measurably superior than using silicon alone in enhancing these parameters. Using more summer pruning treatments was obviously superior than using one summer pruning practice. The maximum values were recorded on the vines subjected to silicon and all summer pruning treatments. Carrying out three sprays of K-Silicate at 0.1 % besides pinching the main shoots, removing all leaves under clusters and removing all laterals on the main shoots gave an acceptable yield and good berries quality of Red Globe grapevines.

[Faissal F. Ahmed, Mohamed A.M. Abada and Wael B.M.M. Farrag. **Growth and Vine Nutritional Status of Red Globe Grapevines As Affected With Some Silicon and Summer Pruning Treatments.** *N Y Sci J* 2018;11(6):24-29]. ISSN 1554-0200 (print); ISSN 2375-723X (online). http://www.sciencepub.net/newyork. 3. doi:10.7537/marsnys110618.03.

Keywords: Silicon, Red Globe grapevines, summer pruning practice, growth, vine nutritional status.

1. Introduction

The outstanding effect of silicon on growth and vines nutritional status of various fruit crops is mainly attributed to its essential roles in enhancing the tolerance of fruit crops to biotic (pests) and abiotic (climatic and soil environmental conditions) stresses, the biosynthesis of organic foods (proteins, fats and carbohydrates), uptake of water and essential nutrients, plant organ strength, plant development, enzyme activities and the retained water**.** The beneficial effects of silicon on forming double layers on plant tissues could explain its effect on protecting the trees from higher transpiration rate and the incidence of different disorders**.** Previous studies supported the important roles of silicon as antioxidant on protecting the plant cells from aging and senescence through chelating free radicals namely OH and O_3 as well as preventing the formaction of reactive oxygen species (ROS) from destroying the permeability of cell walls. Consequently, oxidation process is stopped **((Melo *et al*., 2003; Ma, 2004 and Tahir *et al*., 2006).**

Using silicon was found by many authors to improve growth and vine nutritional status in different grapevines cvs (**Abd El- Hameed, 2012**; **Al-Wasfy, 2014; El- Khawaga, 2014; Uwakiem, 2015**; **Wassel *et al*., 2015**; **Nagy-Dina, 2016; Akl *et al*., 2016; Farahat, 2017 and Masoud, 2017).**

It is worth mentioning that, the majority of grape growers in Egypt either do not apply summer pruning practices in their vineyards or carry out them incorrectly or at the improper time with the result of which most of the current season shoots do not ripen well, perhaps due to the consumption of assimilates manufactured in the leaves for the continuity of shoot growth instead of being stored in the shoots possibly required as canes for the subsequent winter pruning (**Silvestroni *et al*., 1994**).

Light plays an exceptionally important role in the life of fruit trees. Light is indispensable for the synthesis of organic substances in leaves, acts as an activator and determines the speed of the growth and development of plant organs. Light is an important ecological factor. As light intensity increases photosynthesis rate in fruit trees considerably increases. Most fruit trees are light-lovers. With inadequate light their growth and bearing are impaired. The aim of summer pruning is principally arranged as follows to according to **Campostrini and Seriana (2003)**.

These results might be attributed to the following merits of summer pruning.

1- Reducing competition on mineral and organic nutrients for the remaining shoots.

2- The promotion on the growth of the remaining shoots.

3- Obtaining the highest reserved of organic foods.

4- The stimulation in the assimilation in the remaining leaves.

5- The improvement in the distribute on of photosynthesis products.

6- The great control of fungal and disease attack.

7- The reduction of shade during growth.

8- The increase in light intensities or penetration within the canopy.

Carrying out summer pruning at the optimum time was responsible for enhancing growth and vine nutritional status in different grapevine cvs (**Ibrahiem-Alia *et al*., 2001; Ibrahiem-Asmaa 2001; Marenghi, 2002; Poni *et al*., 2002**; **Valor and Bautista, 2002**; **Petrie *et al*., 2003 and Abada, 2005**.

Thus, this study aimed to examine the effect of silicon and summer pruning on growth and vine nutritional status of Red Globe grapevines grown under Minia region conditions.

2. Materials and Methods

Table (1): Analysis of the tested soil

constituent	Values
Sand %	**5.9**
Silt %	**15.0**
Clay %	**79.1**
Texture	**clay**
O.M. %	**2.49**
pH (1: 2.5 extract)	**7.95**
EC (1:2.5 extract) (mmhos/cm/25^{o}C)	**0.89**
$CaCO_3$%	**2.11**
Total N %	**0.09**
Available P (Olsen method, ppm)	**4.90**
Available K (ammonium acetate, ppm)	**4.90**

This study was carried out during 2016 and 2017 seasons on 54 uniform in vigour 10-years old own-rooted Red Globe grapevines. The selected vines are grown in a private vineyard located at Al- Kessey private vineyard located at Matay district, Minia Governorate, where the texture of the soil is clay (Table 1). Soil analysis was done according to the procedures that outlined by **Wilde *et al*., (1985).**

The selected vines are planted at 1.5 x 3 meters apart. The chosen vines were trained by spur pruning method leaving 66 eyes/ vine (on basis of 18 fruiting spurs x 3 eyes plus 6 replacement spurs/ two eyes) using Gable supporting system. Winter pruning was carried out at the first week of Jan. during both seasons. Surface irrigation system was followed using Nile water.

Except those dealing with the present treatments (application of potassium silicate and summer pruning practices), the selected vines (54 vines) received the usual horticultural practices that are commonly applied in the vineyard.

This study consisted from the following nine treatments:

1- Control treatment.

2- Spraying potassium silicate at 0.1% (g/l) .

3- Spraying potassium silicate at 0.1%+ pinching the main shoots.

4- Spraying potassium silicate at 0.1%+ removing all leaves under clusters.

5- Spraying potassium silicate at 0.1%+ removing all lateral shoots on the main shoots.

6- Spraying potassium silicate at 0.1%+ pinching the main shoots + removing all leaves under clusters.

7- Spraying potassium silicate at 0.1%+ pinching the main shoots+ removing all lateral shoots on the main shoots.

8- Spraying potassium silicate at 0.1%+ removing all leaves under clusters+ removing all lateral shoots on the main shoots.

9- Spraying potassium silicate at 0.1%+ all summer pruning practices (pinching the main shoots, removing all leaves under clusters and removing all lateral shoots on the main shoots

Each treatment was replicated three times, two vines per each. The total vines selected for achieving of this experiment were 54 vines. Pinching the main shoots was carried once by cutting 3 cm from shoot tips. Summer pruning practices were conducted once just after berry setting (middle of May). Potassium silicate (25% Si+ 10% K2O) was sprayed three times at growth start (middle of April), just after berry setting (middle of May) and at one month later (middle of June). Triton B as a wetting agent at 0.1% was added to silicon solutions and spraying was done till runoff.

Randomized complete block design (RCBD) was adopted for carrying out statistical analysis of the obtained data (**Rangaswamy, 1995 and Rao, 2007**), where the present experiment contained nine treatments and each treatment was replicated three times two vines per each.

For realizing the objectives of this study, the following parameters were examined in response to application of the present treatments:

At the last week of June during both seasons, the following parameters were measured as follows:

1. Average leaf area (cm^2) as a result of measuring the diameter of twenty mature leaves from those opposite to the basal clusters on the main shoots (**Balo *et al*., 1985**).

Leaf area (cm^2) was measured using the following equation as outlined by **Ahmed and Morsy (1999)**.

Leaf area (cm^2) = 0.45 ($0.79 \times d^2$) + 17.77, where d is the maximum diameter of leaf, then the average leaf area was registered.

2. Wood ripening coefficient was measured by dividing the length of brownish part of the cane by the total length of cane just before pruning date (1st week of January) (**Bourad, 1966**).

3. Just after carrying out winter pruning, the weight removal of 1-year old pruning wood per each vine was recorded (kg/ vine).

4. For each vine five canes were selected just before Winter pruning (1st week of January) for measuring the cane thickness (mm) by using Vernier caliper.

1- Measurements of leaf pigments:

Plant pigments namely chlorophylls a & b and total carotenoids were determined as mg/ 100 g F.W. The same fresh leaves chosen for measuring the leaf area were out into small pieces and a known sample (0.5 g) from each sample was taken, homogenized and extracted using 25% acetone with the assistance of little amounts of Na_2CO_3 and clean sand. Filtration was conducted and the residue was washed several times with acetone till the filtrate was colorless. Acetone was used as a blank. The optical density of the filtrate was determined using spectrophotometer at the wave length of 662, 644 and 440 nm to determine chlorophylls a and b and total carotenoids, respectively. The following equations were used for determination of the three plant pigments. Concentration of each pigment was calculated by using the following equations according to (according to **Hiscox and Isralastam, 1979**).

Chl.a = (9.784 × E 662) – (0.99 × E644) = mg II

Chl. b =(21.426× E 644) – (4.65× E662) = mg II

Total carotenoids = (4.965 x E440- 0.268 (chl.a + chl.b)

Where E = optical density at a given wave length. Total chlorophylls was calculated by summation of chl. a and chl. b. These plant pigments were calculated as (mg/g F.W.)

2- Measurements of leaf content of N, P, K, Mg, Ca, Zn, Fe and Mn

Petioles of the same leaves that were taken for measuring the leaf area were oven dried at 70°C and grinded then 0.5 g weight of each sample was digested using H_2SO_4 (**Balo *et* al., 1988)** and H_2O_2 until clear solution

In the digested solutions, leaf content of N, P, K, Mg, Ca, Zn, Fe and Mn were determined **(Cottenie *et al.*, 1982)**.

Statistical analysis:

The proper statistical analysis was done. Treatment means were compared using new L.S.D. at 5% (according to **Mead *et al.*, 1993**).

3. Results and Discussion

Effect of silicon and some summer pruning treatments on certain vegetative growth aspects:

Data in Table (2) show the effect of silicon and some summer pruning treatments on the number of leaves/shoot, leaf area, wood ripening coefficient, cane thickness and pruning wood weight of Red Globe grapevines during 2016 and 2017 seasons.

It is clear from the obtained data that treating the vines with silicon in the form of potassium silicate at 0.1 % alone or with any summer pruning practices (removal of laterals in the main shoots or leaves under clusters or pinching the main shoots) significantly stimulated the five growth traits namely number of leaves/shoot, leaf area, wood ripening coefficient, cane thickness and pruning wood ripening relative to the control. Treating the vines with K-silicate in combined with any summer pruning treatments was significantly superior than using silicon alone in enhancing these growth traits. Carrying out summer pruning by removing laterals, leaves under cluster and pinching, in descending order was significantly very favourable in enhancing these growth attributes. Combined applications of summer pruning was significantly preferable than using any summer pruning practice alone in stimulating these growth characteristics. Significant differences on these growth traits were observed among all silicon and summer pruning treatments. The maximum values of number of leaves (36 & 36 leaf), leaf area (128.0 & 129.9 cm^2), wood ripening coefficient (0.93 & 0.93), cane thickness (1.71 & 1.74 cm) and pruning wood weight (3.20 & 3.18 kg) were observed due to treating the vines with K-silicate plus the three summer pruning treatments namely the removal of lateral on the main shoots and leaves under clusters and pinching the main shoot during both seasons, respectively. The lowest values were recorded on untreated vines. These results were true during both seasons.

Leaf chemical components:

Data un Tables (3 & 4) show the effect of silicon and summer pruning treatments on chlorophylls a & b, total chlorophylls, total chlorophylls, N, P, K, Mg, Ca, Zn, Fe and Mn in the leaves of Red Globe grapevines during 2016 and 2017 seasons.

Table (2): Effect of spraying Silicon and some summer pruning treatments on vegetative growth aspects of Red Globe grapevines during 2016 & 2017 seasons

Treatment	No of leaves/shoot		Leaf area (cm)^2		Wood ripening coefficient		Cane thickness (cm)		Pruning wood weight (kg)	
	2016	2017	2016	2017	2016	2017			2016	2017
Control	18.0	15.0	101.0	105.0	0.66	0.64	1.00	1.04	2.11	2.08
K-Silicate at 0.1 %	20.0	17.0	104.0	108.0	0.71	0.68	1.11	1.12	2.22	2.25
K-Silicate + pinching main shoots	22.0	20.0	107.0	111.0	0.75	0.71	1.26	1.27	2.33	2.35
K-Silicate + removal of leaves	25.0	22.0	110.0	114.0	0.78	0.76	1.39	1.41	2.45	2.46
K-Silicate + removal of laterals	27.0	25.0	112.2	116.9	0.81	0.79	1.50	1.52	2.59	2.60
K-Silicate + removal of leaves+ pinching	29.0	28.0	115.0	120.0	0.84	0.82	1.55	1.56	2.71	2.72
K-Silicate + removal of laterals+ pinching	31.0	31.0	118.0	122.5	0.87	0.85	1.64	1.62	2.82	2.84
K-Silicate + removal of laterals and leaves	33.0	34.0	121.1	125.0	0.90	0.88	1.66	1.68	2.95	2.97
K-Silicate + removal of laterals and leaves and pinching	36.0	36.0	128.0	129.9	0.93	0.93	1.71	1.74	3.20	3.18
New L.S.D. at 5%	2.0	2.0	1.9	2.1	0.03	0.03	0.04	0.05	0.10	0.09

Table (3): Effect of spraying Silicon and some summer pruning treatments on leaf chemical components of Red Globe grapevines during 2016 & 2017 seasons

Treatment	Chlorophyll a (mg/g F.W)		Chlorophyll b (mg/g F.W)		Total Chlorophylls (mg/g F.W)		Total Carotenoids (mg/g F.W)		Leaf N %		Leaf P %	
	2016	2017	2016	2017	2016	2017			2016	2017	2016	2017
Control	4.1	4.0	1.4	1.2	5.5	5.2	1.1	1.0	1.59	1.61	0.121	0.119
K-Silicate at 0.1 %	4.6	4.6	1.8	1.5	6.4	6.1	1.4	1.3	1.66	1.68	0.129	0.131
K-Silicate + pinching main shoots	5.1	5.2	2.2	1.8	7.3	7.0	1.7	1.6	1.71	1.73	0.140	0.141
K-Silicate + removal of leaves	5.7	6.0	2.5	2.1	8.2	8.1	2.0	1.9	1.76	1.79	0.155	0.155
K-Silicate + removal of laterals	6.3	6.6	2.8	2.4	9.1	9.0	2.3	2.2	1.82	1,84	0.175	0.177
K-Silicate + removal of leaves+ pinching	7.0	7.2	3.1	2.7	10.1	9.9	2.5	2.5	1.90	1.92	0.190	0.191
K-Silicate + removal of laterals+ pinching	7.5	8.0	3.4	3.0	10.9	11.0	2.8	2.8	1.96	1.99	0.211	0.215
K-Silicate + removal of laterals and leaves	8.0	8.6	3.8	3.3	11.8	11.9	3.0	3.1	2.03	2.05	0.231	0.233
K-Silicate + removal of laterals and leaves and pinching	8.4	9.1	4.1	3.6	12.5	12.7	3.2	3.5	2.10	2.12	0.241	0.246
New L.S.D. at 5%	0.4	0.5	0.3	0.3	0.5	0.6	0.2	0.3	0.05	0.04	0.005	0.007

Table (4): Effect of spraying Silicon and some summer pruning treatments on leaf chemical components of Red Globe grapevines during 2016 & 2017 seasons

Treatment	Leaf K%		Leaf Mg %		Leaf Ca%		Leaf Mn (ppm)		Leaf Zn (ppm)		Leaf Fe (ppm)	
	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
Control	1.09	1.11	0.55	0.55	2.11	2.15	51.1	50.9	52.3	53.9	55.5	55.9
K-Silicate at 0.1 %	1.15	1.18	0.59	0.60	2.21	2.25	53.1	52.9	55.3	56.0	57.6	58.0
K-Silicate + pinching main shoots	1.21	1.24	0.64	0.65	2.31	2.35	55.0	55.0	58.4	59.0	60.0	60.0
K-Silicate + removal of leaves	1.30	1.31	0.71	0.70	2.41	2.45	57.3	57.0	61.5	62.5	62.1	62.2
K-Silicate + removal of laterals	1.36	1.38	0.76	0.76	2.55	2.55	60.1	60.0	63.6	64.9	64.6	65.0
K-Silicate + removal of leaves+ pinching	1.41	1.45	0.81	0.83	2.66	2.66	63.1	61.9	66.0	67.8	67.0	67.0
K-Silicate + removal of laterals+ pinching	1.49	1.51	0.87	0.90	2.79	2.76	66.0	64.0	68.5	70.0	70.0	69.1
K-Silicate + removal of laterals and leaves	1.55	1.59	0.94	0.94	2.90	2.86	69.0	65.6	71.0	72.4	71.9	71.4
K-Silicate + removal of laterals and leaves and pinching	1.62	1.65	0.97	0.98	2.97	2.96	71.2	69.4	73.0	74.4	74.0	73.9
New L.S.D. at 5%	0.04	0.06	0.03	0.04	0.07	0.09	1.1	1.2	1.9	2.0	1.8	1.7

Subjecting Red Globe grapevines to silicon alone or in combined with any summer pruning treatment (removal of lateral on the main shoots or leaves under clusters and pinching the main shoots) had significant stimulation on chlorophylls a & b, total chlorophylls, total chlorophylls, N, P, K, Mg, Ca, Zn, Fe and Mn in the leaves compared to the control. The promotion in these leaf chemical components was significantly in proportional to carrying out removal of laterals on the main shoots and leaves under clusters and pinching on the main shoots, in descending order. Using silicon besides any summer pruning practices significantly surpassed the application of silicon alone in enhancing these chemical components. Using more summer pruning treatments was significantly superior than using one summer pruning practice in enhancing these leaf chemical components. Treating the vines with silicon and removing laterals on the main shoots and leaves under clusters plus pinching the main shoots gave the maximum values of chlorophylls a (8.4 & 9.1 mg/1g F.W), chlorophylls b (4.1 & 3.6 mg/g F.W), total chlorophylls (12.5 & 12.7 mg/g F.W), total carotenoids (3.2 & 3.5 mg/g F.W), N (2.10 & 2.12 %), P (0.241 & 0.246%), K (1.62 & 1.65 %), Mg (0.97 & 0.98 %), Ca (2.97 & 2.96 %), Mn (71.2 & 69.4 ppm), Zn (73.0 & 74.4 ppm) and Fe (74.0 & 73.9 ppm) during both seasons, respectively. The maximum values were recorded on untreated vines. Similar trend on noticed during both seasons.

4. Discussion

The outstanding effect of silicon on growth and vines nutritional status of various fruit crops is mainly attributed to its essential roles in enhancing the tolerance of fruit crops to biotic (pests) and abiotic (climatic and soil environmental conditions) stresses, the biosynthesis of organic foods (proteins, fats and carbohydrates), uptake of water and essential nutrients, plant organ strength, plant development, enzyme activities and the retained water**.** The beneficial effects of silicon on forming double layers on plant tissues could explain its effect on protecting the trees from higher transpiration rate and the incidence of different disorders**.** Previous studies supported the important roles of silicon as antioxidant on protecting the plant cells from aging and senescence through chelating free radicals namely OH and O_3 as well as preventing the formaction of reactive oxygen species (ROS) from destroying the permeability of cell walls. Consequently, oxidation process is stopped **((Melo *et al*., 2003; Ma, 2004 and Tahir *et al*., 2006).**

These results are in agreement with those obtained by **Abd El- Hameed, (2012)**; **Al-Wasfy, (2014); El- Khawaga, (2014); Uwakiem, (2015)**; **Wassel *et al*., (2015)**; **Nagy-Dina, (2016); Akl *et al*., (2016); Farahat, (2017) and Masoud, (2017)**.

The beneficial effects of summer pruning on growth and vine nutritional status might be attributed to according to (**Silvestroni *et al*., (1994**) **and Campostrini and Seriana (2003)**.

These results might be attributed to the following merits of summer pruning.

1- Reducing competition on mineral and organic nutrients for the remaining shoots.

2- The promotion on the growth of the remaining shoots.

3- Obtaining the highest reserved of organic foods.

4- The stimulation in the assimilation in the remaining leaves.

5- The improvement in the distribute on of photosynthesis products.

6- The great control of fungal and disease attack.

7- The reduction of shade during growth.

8- The increase in light intensities or penetration within the canopy.

The results of **Ibrahiem-Alia *et al*., (2001); Ibrahiem-Asmaa (2001); Marenghi, (2002); Poni *et al*., (2002)**; **Valor and Bautista, (2002)**; **Petrie *et al*., (2003) and Abada, (2005**) confirmed the present results regarding the benefits of summer pruning on growth and vine nutritional status.

Conclusion:

Carrying out three sprays of K-Silicate at 0.1 % besides pinching the main shoots, removing all leaves under clusters and removing all lateral shoots on the main shoots gave on acceptable yield and berries quality of Red Globe grapevines.

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6/2/2018