EFFECT OF SPRAYING SILICON AND SELENIUM ON GROWTH, VINE NUTRITIONAL STATUS, BERRY SETTING, YIELD AND BERRIES QUALITY OF SUPERIOR GRAPEVINES GROWN UNDER SANDY SOIL CONDITIONS

I- THE EFFECT ON GROWTH AND VINE NUTRITIONAL STATUS

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ABSTRACT

This study was carried out during 2014 and 2015 seasons to examine the effect of spraying potassium silicate at 0.125 to 0.5% and/or selenium at 50 to 200 ppm on growth and vine nutritional status of Superior grapevines grown under sandy soil.

Treating the vines three times with potassium silicate at 0.125 to 0.5% and/or selenium at 50 to 200 ppm was very effective in stimulating main shoot length, number of leaves/shoot, leaf area, wood ripening coefficient, pruning wood weight/vine and cane thickness, chlorophylls a & b, total chlorophylls, total carotenoids, leaf total carbohydrates %, N, P, K, Mg (as %), Zn, Mn and Fe (as ppm) of Superior grapevines over the control treatment.

Carrying out three sprays of a mixture of potassium silicate at 0.25% and selenium at 100 ppm gave the best results with regard to growth and vine nutritional status of Superior grapevines grown under sandy soil.

Keywords: Silicon, Selenium, Superior grapevines, growth, vine nutritional status.

INTRODUCTION

An outstanding effect on growth and vine nutritional status was noticed in different grapevine cvs grown under sandy soil due to using silicon and selenium. This is due to the positive effects of both silicon and selenium on alleviating the adverse effects of salinity and drought on growth and vine nutritional status.

Silicon, (Si) has not yet received the title of essential nutrient for higher plants, as its role in plant biology is poorly understood. However, various studies showed that Si application enhanced plant growth considerably. The beneficial effects of Si are more prominent when plants were subjected to multiple stresses including biotic and abiotic stresses (**Rodrigues *et al.*, 2003; Ma, 2004 and**

Tahir, *et al.*, 2006). Silicon is also known to increase drought tolerance in plants by maintaining plant water balance, photosynthetic activity, erectness of leaves and structure of xylem vessels under high transpiration rates (**Melo *et al.*, 2003**). Silicon is responsible for improving water economy and leaf water potential under water stress conditions. The previous authors suggested that a silicon cuticle double layer formed on leaf epidermal tissue is responsible for this higher water potential. The results of **Lux *et al.*, (2003)** suggested that Si plays an important role in water transport and root growth under drought conditions. **Ma, (2004)** stated that Si inhibits powdery mildew in grapes.

Selenium was found by many authors to enhance the activities of enzymes such as glutathione peroxidase, the tolerance of trees to abiotic and biotic stresses and the biosynthesis of carbohydrates and proteins. It also reduces reactive oxygen species (ROS) and protects plant cells from aging and death (**Seppanen *et al*., 2003; Nowak-Barbara, 2008 and Jakovljevic *et al*., 2011**).

Previous studies showed that silicon (**Abd El-Hameed, 2012; Ibrahiem and Al-Wasfy, 2014; El-Khawaga, 2014; Wassel *et al*., 2015; Nagy-Dina, 2016; Akl *et al*., 2016, Farahat, 2017 and Youssef, 2017**) and selenium (**Al-Wasfy, 2014; Gad El-Kareem *et al*., 2014 and Uwakiem, 2015**) had an announced promotion on growth and deferent nutrients and pigments of the vines especially these grown under unsuitable environmental conditions.

The target of this study was examining the effect of single and combined applications of silicon and selenium on vegetative growth aspects and vine nutritional status of Superior grapevines grown under sandy soil.

MATERIAL AND METHODS

This study (1st part) was carried out during 2014 and 2015 seasons on sixty uniform in vigour 8-years old Superior grapevines. The selected vines are grown in a private vineyard located at Gerga district, Souhag Governorate where the texture of the soil is Sandy (Table 1). Soil analysis was done according to the procedures that outlined by **Piper (1950) and Black. (1965).**

The selected vines are planted at 2 x 3 meters apart (700 vines/fed.). The chosen vines were trained by cane pruning system leaving 72 eyes/ vine (six fruiting canes x 10 eyes plus six renewal spurs / two eyes) using Gable supporting method. Winter pruning was carried out at the first week of Jan. during both seasons. Drip irrigation system was followed using well water containing 500 ppm salinity.

Table (1): Analysis of the tested soil

Constituent	Values
Sand %	76.2
Silt %	12.1
Clay %	11.7
Texture	Sandy
O.M. %	0.11
pH (1: 2.5 extract)	7.69
EC (1 :2.5 extract) (mmhos/cm/25^{o}C)	1.01
$CaCO_3$%	3.00
Total N %	0.005
Available P (Olsen method , ppm)	1.1
Available K (ammonium acetate , ppm)	31.0

Common horticultural practices such as fertilization twice hoeings, irrigation, pinching and pest management were carried out as usual.

This study consisted from the following ten treatments:

1- Control vines (sprayed with water).
2- Spraying potassium silicate at 0.125% (1.25 g/l).
3- Spraying potassium silicate at 0.25% (2.5 g/l).
4- Spraying potassium silicate at 0.5% (5.0 g/l).
5- Spraying selenium at 50 ppm (50 g/l).
6- Spraying selenium at 100 ppm (100 mg/l).
7- Spraying selenium at 200 ppm (200 mg/l).
8- Spraying potassium-silicate at 0.125% + selenium at 50 ppm.
9- Spraying potassium-silicate at 0.25% + selenium at 100 ppm.
10- Spraying potassium-silicate at 0.5% + selenium at 200 ppm.

Each treatment was replicated three times, two vines per each. Both potassium silicate (25% Si and 10% K) and selenium (100% Se) were sprayed three times at growth start (1st week per Mar.), just after berry setting (last week of April) and three week later (3rd week of May). Triton B as a wetting agent was added to all spraying solutions at 0.05%. Spraying was done till runoff (1.2 L/ vine according to the date of spraying).

Randomized complete block design (RCBD) was adopted for carrying out statistical analysis of this study.

During both seasons, the following measurements were recorded:

1. Vegetative growth characteristics namely main shoot length (cm), number of leaves/shoot, leaf area (cm^2) **(Ahmed and Morsy, 1999),** wood ripening coefficient (**Bourad, 1966**), wood weight (kg.) and cane thickness (cm).

2. Leaf chemical components namely chlorophylls a & b, total chlorophylls, total carotenoids (mg/ 100 g F.W.) (**Von-Wettstein**, **1957**), total carbohydrates %

(**A.O.A.C**, **2000**), N, P, K, Mg (as %), Zn, Mn and Fe (as ppm) in the leaves (**Cottenie *et al,* 1982 and Summer, 1985)**.

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

RESULTS AND DISCUSSION

1- Vegetative growth characteristics:

It is clear from the obtained data in Table (2) that single and combined applications of potassium silicate at 0.125 to 0.50 % and selenium at 50 to 200 ppm significantly were accompanied with stimulating the six growth characteristics namely main shoot length, number of leaves/shoot, leaf area, wood ripening coefficient, pruning wood weight/vine and cane thickness relative to the check treatment. The stimulation on these growth traits was associated with increasing concentrations of potassium silicate from 0.125 to 0.5% and selenium from 50 to 200 ppm. Unsignificant promotion on these growth aspects was observed among the higher two concentrations of potassium silicate namely 0.25 and 0.50% and selenium namely 100 and 200 ppm. Combined applications of silicon and selenium significantly was superior than using each alone in enhancing these growth aspects. Using potassium silicate at 0.125 to 0.5 % was superior to using selenium at 50 to 200 ppm in this connection. The maximum values of shoot length (149.7 & 147.4); number of leaves/shoot (31.0 & 32.0); leaf area (74.0 & 75.0 cm^2); wood ripening coefficient (0.95 & 0.96 cm), pruning wood weight (3.52 & 3.61 kg) and cane thickness (1.37 & 1.39 cm) during both seasons, respectively were observed on the vines that received three sprays of potassium silicate at 0.5 % and selenium at 200 ppm. The lowest values were recorded on untreated vines. These results were true during both seasons.

Table (2): Effect of single and combined applications of silicon and selenium on some vegetative growth characteristics of Superior grapevines during 2014 and 2015 seasons.

Treatments	Main shoot length (cm.)		Number of leaves/shoot		Leaf area (cm^2)		Wood ripening coefficient		Pruning wood weight / vine (kg.)		Cane thickness (cm)	
	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
Control	130.1	129.3	19.0	20.0	91.3	92.0	0.66	0.64	2.11	2.20	0.99	1.00
K-Silicate at 0.125%	138.0	137.0	25.0	26.0	98.8	99.5	0.81	0.80	2.74	2.83	1.14	1.15
K-Silicate at 0.25%	141.9	140.0	27.0	28.0	99.9	100.6	0.86	0.85	3.00	3.09	1.19	1.20
K-Silicate at 0.5%	142.0	140.6	27.0	29.0	100.0	100.8	0.87	0.86	3.05	3.14	1.20	1.21
Selenium (Se) at 50 ppm	132.3	131.7	21.0	22.0	93.0	93.7	0.71	0.69	2.30	2.40	1.04	1.05
Selenium at 100 ppm	134.3	134.0	23.0	24.0	94.9	95.6	0.75	0.74	2.50	2.59	1.08	1.10
Selenium at 200 ppm	135.0	134.7	23.0	24.0	95.0	95.7	0.76	0.74	2.52	2.61	1.09	1.11
K-Silicate at 0.125% + Se at 50 ppm	145.0	143.9	29.0	30.0	102.0	102.7	0.91	0.90	3.33	3.42	1.28	1.30
K-Silicate 0.25% + Se at 100 ppm	149.0	147.0	31.0	32.0	103.9	104.6	0.95	0.95	3.50	3.60	1.36	1.38
K-Silicate 0.5% + Se at 200 ppm	149.7	147.4	31.0	32.0	104.0	105.0	0.95	0.96	3.52	3.61	1.37	1.39
New L.S.D. at 5%	**1.4**	**1.7**	**1.0**	**1.0**	**1.1**	**1.4**	**0.03**	**0.05**	**0.11**	**0.14**	**0.03**	**0.03**

2- Leaf chemical composition:

It is evident from the obtained data in Tables (3 & 4) that the twelve leaf chemical components namely chlorophylls a & b, total chlorophylls, total carotenoids, total carbohydrates, N, P, K, Mg, Zn, Fe and Mn were significantly varied among the nine silicon and selenium treatments. They were significantly enhanced with using potassium silicate and/or selenium relative to the control treatment. There was a gradual promotion on these leaf chemical components with increasing concentrations of silicon and selenium. Increasing concentrations of potassium silicate from 0.25 to 0.50% and selenium from 100 to 200 ppm failed to show significant promotion on these chemical constituents. Using silicon was significantly superior to using selenium in enhancing these chemical components. Combined applications of silicon and selenium were significantly favorable for enhancing these chemical components relative to using each alone. The maximum values of chlorophyll a (10.0 & 10.1 mg/100g F.W.), chlorophyll b (3.2 & 3.3 mg/100g F.W.), total chlorophylls (13.2 & 13.4 mg/100g F.W.), total carotenoids (2.6 & 2.7 mg/ 100g F.W.), N (2.02 & 2.08%), P (0.34 & 0.36%), K (1.61 & 1.67%), Mg (0.86 & 0.89%), Zn (65.6 & 66.3 ppm), Fe (64.3 & 65.0 ppm), Mn (73.0 & 73.3 ppm) and total carbohydrates (20.6 & 21.1%) during both seasons, respectively were observed on the vines that received a mixture of potassium silicate at 0.5 % and selenium at 200 ppm. The untreated vines produced the minimum values. These results were true during both seasons.

Table (3): Effect of single and combined applications of silicon and selenium on leaf pigments and percentages of total carbohydrates and N in the leaves of Superior grapevines during 2014 and 2015 seasons.

Treatments	Chlorophyll a (mg/100g F.W.)		Chlorophyll b (mg/100 g F.W.)		Total chlorophylls (mg/100 g F.W.)		Total carotenoids (mg/100 g F.W.)		Leaf total carbohydrates %		Leaf N%	
	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
Control	5.1	5.0	1.2	1.1	6.3	6.1	0.9	1.0	14.1	14.1	1.60	1.57
K-Silicate at 0.125%	7.0	6.9	2.1	1.9	9.1	8.8	1.8	2.0	17.3	17.4	1.81	1.85
K-Silicate at 0.250%	8.0	7.9	2.4	2.3	10.4	10.2	2.0	2.2	18.3	18.4	1.86	1.90
K-Silicate at 0.5%	8.1	8.0	2.4	2.3	10.5	10.3	2.0	2.2	18.4	18.4	1.87	1.91
Selenium (Se) at 50 ppm	5.6	5.5	1.4	1.4	7.0	6.9	1.1	1.3	15.0	15.0	1.67	1.71
Selenium at 100 ppm	6.1	6.0	1.6	1.6	7.7	7.6	1.4	1.6	16.0	16.1	1.75	1.79
Selenium at 200 ppm	6.2	6.1	1.7	1.7	7.9	7.8	1.5	1.7	16.2	16.1	1.76	1.79
K-Silicate at 0.125%+ Se at 50 ppm	8.9	8.9	2.8	3.0	11.7	11.9	2.3	2.5	19.5	19.8	1.95	2.00
K-Silicate 0.25% + Se at 100 ppm	9.9	10.0	3.1	3.2	13.0	13.2	2.5	2.7	20.5	20.9	2.01	2.07
K-Silicate 0.5% + Se at 200 ppm	10.0	10.1	3.2	3.3	13.2	13.4	2.6	2.7	20.6	21.0	2.02	2.08
New L.S.D. at 5%	**0.4**	**0.5**	**0.2**	**0.2**	**0.5**	**0.4**	**0.2**	**0.2**	**0.9**	**0.7**	**0.05**	**0.04**

Table (4): Effect of single and combined applications of silicon and selenium on leaf content of P, K and Mg as (%) and Zn, Fe and Mn (as ppm) of Superior grapevines during 2014 and 2015 seasons.

Treatments	Leaf P%		Leaf K%		Leaf Mg%		Leaf Zn (ppm)		Leaf Fe (ppm)		Leaf Mn (ppm)	
	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
Control	0.16	0.15	1.14	1.17	0.50	0.47	49.5	50.0	51.7	52.0	52.9	53.0
K-Silicate at 0.125%	0.25	0.25	1.31	1.35	0.68	0.70	57.5	58.0	58.3	58.6	62.9	63.0
K-Silicate at 0.250%	0.28	0.29	1.36	1.40	0.73	0.75	60.0	60.4	60.4	60.7	66.0	66.1
K-Silicate at 0.5%	0.28	0.30	1.37	1.41	0.74	0.76	60.6	61.1	61.0	61.3	66.6	66.8
Selenium (Se) at 50 ppm	0.18	0.18	1.18	1.22	0.55	0.58	52.0	52.5	53.8	54.1	56.0	56.1
Selenium at 100 ppm	0.21	0.21	1.23	1.27	0.60	0.62	54.9	55.4	55.9	56.4	59.0	59.1
Selenium at 200 ppm	0.22	0.22	1.24	1.29	0.61	0.62	55.0	55.5	56.0	57.0	59.3	59.4
K-Silicate at 0.125%+ Se at 50 ppm	0.31	0.33	1.53	1.58	0.79	0.81	63.0	63.6	62.0	62.6	70.0	70.1
K-Silicate 0.25% + Se at 100 ppm	0.33	0.35	1.60	1.66	0.85	0.88	65.0	66.0	64.0	64.7	72.9	73.0
K-Silicate 0.5% + Se at 200 ppm	0.34	0.36	1.61	1.67	0.86	0.89	65.6	66.3	64.3	65.0	73.0	73.3
New L.S.D. at 5%	0.02	0.03	0.04	0.03	0.03	0.04	1.7	1.9	1.8	1.9	2.0	2.2

DISCUSSION

The favorable effects of silicon on growth and nutritional status of trees seem to originate from its positive action on enhancing the tolerance of plants to biotic and abiotic stresses and drought tolerance. This is attributed to its essential role in maintaining plant water balance, photosynthetic activity, erecting the structure of xylem vessels. Previous studies explained these benefits to the formation of silica cuticle double layers formed on leaf epidermal tissue. Silicon also is responsible for water transport and root development as well as increasing the tolerance of plants to mildew. The mechanical strength provided by silicon to the plant tissues increases their resistance to diseases and insects and reducing the adverse effects of heavy metal toxicity (**Lux *et al.*, 2003; Rodrigues *et al.*, 2003; Ma, 2004 ; and Tahir *et al.*, 2006**).

The promoting effect of silicon on growth and vine nutritional of Superior grapevines was emphasized by the results of **Abd El-Hameed (2012); Al-Wasfy (2014); El-Khawaga (2014); Wassel *et al* (2015); Nagy-Dina (2016); Akl *et al* (2016) , Farahat, (2017) and Youssef, (2017).**

The beneficial effects of selenium on growth and vine nutritional of Superior grapevines might be attributed to its positive action on enhancing the tolerance of the trees to biotic and abiotic stresses and the biosynthesis of carbohydrates and proteins. It is effective in reducing reactive oxygen species (ROS) since it considered as an important antioxidant protects the plant cells from death. Thereby, it is responsible for producing healthy trees able to produce more fruits (**Nowak-Barbara, 2008 and Jakovljevic *et al*., 2011**). These results are in harmony with those obtained by **Ibrahiem and Al-Wasfy (2014); Gad El-Kareem *et al* (2014) and Uwakiem (2015).**

CONCLUSION

Carrying out three sprays of a mixture of potassium silicate at 0.25% and selenium at 100 ppm gave the best results with regard to growth and vine nutritional status of Superior grapevines grown under sandy soil conditions.

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الملخص العربي

تأثير رش السيليكون والسيلينيوم علي النمو الخضرى والحالة الغذائية للكرمة وعقد الحبات وكمية المحصول وخصائص الجودة للحبات فى كرمات العنب السوبيريور النامية فى التربة الرملية
١- التأثير علي النمو والحالة الغذائية للكرمة

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أجريت هذه الدراسة خلال موسمى ٢٠١٤، ٢٠١٥ لاختبار تأثير سيليكات البوتاسيوم بتركيز ٠.١٢٥ إلي ٠.٥ % مع أو بدون السيلينيوم بتركيز ٥٠ إلي ٢٠٠ جزء فى المليون علي النمو والحالة الغذائية للكرمة فى العنب السوبيريور النامى فى التربة الرملية.
ادى معاملة الكرمات ثلاث مرات بسيليكات البوتاسيوم بتركيز ٠.١٢٥ إلي ٠.٥% مع أو بدون السيلينيوم بتركيز ٥٠ إلي ٢٠٠ جزء فى المليون إلي حدوث تحسن واضح فى طول الفرخ الرئيسى وعدد الأوراق التى عليه ومساحة الورقة ومعامل نضج الخشب ووزن خشب التقليم الكرمة وسمك القصبة وكلوروفيل أ، ب والكلوروفيل والكارتين الكلى والكربوهيدرات الكلية والنيتروجين والفوسفور والبوتاسيوم والماغنسيوم والزنك والمنجنيز والحديد وذلك مقارنة بمعاملة الكونترول.
أمكن الحصول علي أفضل النتائج بخصوص النمو والحالة الغذائية للكرمات فى العنب السوبيريور النامى فى التربة الرملية عند رش الكرمات ثلاث مرات بمخلوط يتكون من سيليكات البوتاسيوم بتركيز ٠.٢٥% مع السيلينيوم بتركيز ١٠٠ جزء فى المليون.

الكلمات الدالة: السيليكون – السيلينيوم - كرمات العنب السوبريور –النمو – الحالة الغذائية للكرمة