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The Impact of Silicon on Growth and Fruiting of Zaghloul Date Palms

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Abstract

This study was carried out during 2015 and 2016 seasons to investigate the effect of different concentrations (0.05, 0.1 and 0.2%) and frequencies of application of (once, twice or thrice) potassium silicate on vegetative growth aspects and nutrients in the leaves as well as yield and fruit quality of Zaghloul date palms. Randomized complete block design was adopted.

Treating the palms once, twice or thrice with potassium silicate at 0.05 to 0.2% had an announced effect on improving all growth traits, leaf chemical components, bunch weight, yield and fruit quality over the check treatment. The promotion on these parameters was in proportional to the increase in concentrations and frequencies of application. Meaningless improvement on these parameters was recorded among the higher two concentrations (0.1 & 0.2%) and frequencies of application (twice & thrice).

For improving yield and fruit quality of Zaghloul date palms, it is necessary to spray the palms twice before hand pollination and again just after fruit setting with potassium silicate at 0.1%.

Keywords: *Zaghloul date palms, silicon, concentrations, frequencies of application, yield, fruit quality.*

Introduction

More efforts have been established to improve the production of Zaghloul date palms grown under Behera environmental conditions by using new cultural practices especially silicon nutrition. Silicon is necessary for fruit crops species especially those grown under sandy soil, since it enhances the tolerance of these crops to salinity and drought. Previous studies showed that using silicon was beneficial for alleviating the unfavorable effects of all stresses on the production. It is also responsible for enhancing photosynthesis process, cell division and water uptake. It is an important antioxidant prevents the adverse effects of reactive oxygen species (ROS) from destroying plant cells. (Epstein, 1999; Mengel *et al*., 2001; Alvarez and Datnoff, 2001; Aziz *et al.,* 2002; Kanto, 2002; Ma, 2004, Hattori *et al.,* 2005 and Marshner, 2012).

Silicon nutrition is very essential for stimulating growth aspects, nutritional status of the trees, yield and both physical and chemical characteristics of the fruits of date palms (Al-Wasfy, 2013; Ahmed *et al.,* 2013; Gad El- Kareem, 2012 and Badran, 2016) as well as Abdelaal and Oraby-Mona, (2013) on Ewaise mangos; Ibrahim and Al-Wasfy, (2014) on Valencia oranges; El-Khawaga and Mansour, (2014) on Navel oranges; Aly, (2015) on Balady mandarins; Mohamed *et al.,* (2015) and Abd El-Wahab, (2015) on Succary mangoes and Mahmoud, (2016) on Balady mandarins.

The goal of this study was examining the effect of various concentrations and frequencies of application of potassium silicate on fruiting of Zaghloul date palms. Adjusting the optimum concentration and frequency of application of potassium silicate for improving yield is considered another target.

Materials and Methods

This study was carried out 2015 and 2016 seasons in a private orchard situated at Rashid city, Behera Governorate on thirty 11-years old Zaghloul date palms. Soil texture is sandy and the palms are planted at 6 x 6 meters apart. The selected palms were irrigated through surface system. Pruning was carried out to maintain leaf bunch ratio at 8:1. Number of female spathes per each palm was adjusted to ten spathes. Artificial pollination was achieved by inserting five male strands into the female bunch using known high activity pollen source throughout 2-3 days after female spathe cracking followed by bagging. Each selected palm received the common horticultural practices that are already applied in the orchard except those dealing with the application of potassium silicate.

Table 1. Analysis of the tested soil (according to Wilde *et al*., 1985)

Content	Value
Sand %	80.0
Silt %	14.0
Clay%	6.0
Texture	Sandy
O.M. %	0.25
pH (1: 2.5 extract)	7.6
EC (1: 2.5 extract) dsm^{-1})	1.00
Calcium carbonate %	4.1
Total N%	0.03
Available P (Olsen, ppm)	1.2
Available K (ammonium acetate, ppm)	15.0
EDTA extractable micronutrients (ppm)	
Fe	0.5
Mn	0.4
Zn	0.5
Cu	0.2

This experiment included the following ten treatments:

1. Control (unsprayed with water palms).
2. Spraying potassium silicate once two weeks beforehand pollination (last week of Feb.) at 0.05%.
3. Spraying potassium silicate twice two weeks hand pollination and again just after fruit setting (middle of April) at 0.05%.
4. Spraying potassium silicate thrice as previously mentioned dates and at one month later at 0.05%.

5. Spraying potassium silicate once as previously mentioned at 0.1%.
6. Spraying potassium silicate twice as previously mentioned at 0.1%.
7. Spraying potassium silicate thrice as previously mentioned at 0.1%.
8. Spraying potassium silicate once as previously mentioned at 0.2%.
9. Spraying potassium silicate twice as previously mentioned at 0.2%.
10. Spraying potassium silicate thrice as previously mentioned at 0.2%.

Each treatment was replicated three times, one palms per each. Therefore, the total uniform in vigour palms that selected to achieve this experiment was 30 palms. Triton B as a wetting agent was added to all solutions at 0.05% and spraying was done till runoff (10-20 L/tree according to the date of spraying). Randomized complete block design (RCBD) was adopted.

During both seasons, the following parameters were measured:

1. Vegetative growth aspects namely leaflet area, number of leaflet/leaf, leaf area $(cm)^2$, number of spine/leaf, length of spine (cm) and total surface area/palm (Ahmed and Morsy, 1999).

2. Leaf pigments namely chlorophylls a & b, total chlorophylls and total carotenoids (mg/100gF.W) (Von-Wettstine, 1957).

3. Percentages of N, P, K and Mg in the driedleavesaccording to (Cottenie *et al*., 1982; Summer, 1985 and Wilde *et al*., 1985).

4. Bunch weight (kg.).

5. Yield/ palm (kg.) at the first week of September. (By multiplying number of bunches by bunch weight)

6. Some physical and chemical characteristics of the fruits namely weight (g.) and dimensions (length and width, cm.) as well as percentages of pulp and seeds, pulp/seed was also calculated, total soluble solids %, total reducing and non-reducing sugars % (A.O.A.C, 1995), total acidity (as g malic acid/100g pulp) accordingfiber crude % and total solubletannins% (A.O.A.C, 2000).

All the obtained data were tabulated and subjected to the proper statistical analysis according to Gomez and Gomez, (1984) and New L.S.D. test at 5% was used to differentiate among the various treatment means.

Results and Discussion

1- Vegetative growth aspects:

It is noticed from the data in Table (2) that treating Zaghloul date palms once (beforehand pollination), twice (beforehand pollination and again just after fruit setting) or thrice (beforehand pollination, just after fruit setting and at one month later) with potassium silicate at 0.05 to 0.2% significantly stimulated the six growth aspects namely leaflet area, number of leaflet per leaf, leaf area, total surface area per palm, number of spines/ leaf and spine length relative to the control treatment. A gradual stimulation on these growth parameters was observed with increasing concentrations from 0.05 to 0.2% and frequencies of application from once to thrice of potassium silicate. Increasing concentrations from 0.1 to 0.2% and frequencies of application from twice to thrice failed significantly to show any promotion on these growth traits. The maximum values were recorded on the palms that received three sprays of potas-

sium silicate at 0.2%. The lowest values were recorded on the untreated palms. There results were true during both seasons.

2- Leaf chemical components:

It can be stated from the data in Tables (3&4) that spraying potassium silicate once, twice or thrice at 0.05 to 0.2% significantly enhanced chlorophylls a & b, total chlorophylls, total carotenoids, N, P, K, Mg, Ca, S, Zn and Fe in the leaves over the control treatment. The promotion was related to the increase in concentrations and frequencies of applications. Significant differences on these pigments and nutrients were observed among all concentrations and frequencies of application except among the higher two concentrations (0.1 & 0.2%) and frequencies of application (twice or thrice). Treating the palms with potassium silicate at 0.2% thrice gave the maximum values. The untreated palms produced the lowest values. These results were true during both seasons.

3- Bunch weight and yield/palm:

It is clear from the data in Table (5) that bunch weight and yield/palm were significantly improved in response to applications of potassium silicate at 0.05 to 0.2% once, twice or thrice rather than non- application. There was a gradual promotion on bunch weight and yield per palm with increasing concentrations and frequencies of applications. No significant promotion on bunch weight and yield/palm was observed among the higher two concentrations (0.1 & 0.2%) and frequencies of application (twice or thrice). Therefore, from economical point of view, it is suggested to use potassium silicate twice at 0.1%. Under such promised treatment, yield during both seasons reached 129 & 130 kg/palm, respectively. The untreated palms produced 100 & 101 kg during 2015 and 2016 seasons, respectively. The percentage of increment on the yield due to using the previous promised treatment over the control treatment reached 29.0 and 28.7 during both seasons, respectively.

4- Physical and chemical characteristics of the fruits:

It is evident from the datain Tables (5 to 7) that subjecting Zaghloul date palms once, twice or thrice with potassium silicate at 0.05 to 0.2% had significant effect on promoting fruit quality in terms of increasing fruit weight and dimensions (height and diameter) pulp%, pulp/ seed, T.S.S.%, total and reducing sugars% and decreasing seed weight%, total acidity%, total fiber% and total soluble tannins % over the check treatment.the promotion on fruit quality was associated with increasing concentrations and frequencies of application. Meaningless promotion on fruit quality was recorded with increasing concentrations from 0.1 to 0.2% and frequencies of application from twice to thrice. Thereby, from economical point of view, it is preferable to use potassium silicate twice at 0.1% for producing good quality fruits. The untreated tree gave unacceptable effect on fruit quality. Theseresults were true during both seasons.

Discussion:

The outstanding effect of silicon on growth and fruiting of Zaghloul date palms might be attributed to its

positive action on enhancing the tolerance of the plants to all stresses namely biotic and abiotic (drought, salinity, diseases, insects, cold, higher temperature) as well as cell division, photosynthesis and water uptake. The effect of silicon as an antioxidant that responsible for preventing the adverse effects of reactive oxygen species (ROS) on cells is not neglect in this connection (Mengel *et al*., 2001; Ma and Takahashi, 2002; Ma, 2004; Hattori *et al*., 2005 and Marschner, 2012).

The present promoting effect of silicon on growth, nutritional status of the trees, fruit retention, yield and fruit quality was supported by the results of Gad El-Kareem, (2012); Al-Wasfy, (2013); Abdelaal and Oraby-Mona, (2013); Ibrahim and Al-Wasfy, (2014); El-Khawaga and Mansour, (2014); Aly, (2015); Mohamed *et al*., (2015); Abd El-Wahab, (2015) and Mahmoud, (2016).

Conclusion:

Carrying out two sprays of potassium silicate (two weeks beforehand pollination and again just after fruit setting) at 0.1% gave the best results with regard to yield and fruit quality of Zaghloul date palms.

Table 2. Effect of different concentrations and application frequencies of potassium silicate on some vegetative growth characteristics of Zaghloul date palms during 2015 and 2016 seasons.

Treatment	Leaflet area $(cm)^2$		No. of leaflet/leaf		Leaf area $(m)^2$		No. of spines/leaf		Spine length (cm)		Total surface area/palm m^2	
	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
Control (unsprayed trees)	59.1	58.8	160.0	159.0	0.95	0.93	29.0	30.0	10.0	10.4	95.0	93.0
K-silicate at 0.05 % once	59.9	59.3	164.0	166.0	0.98	0.98	31.0	32.0	20.5	20.9	98.0	98.0
K-silicate at 0.05 % twice	61.4	60.7	168.0	170.0	1.00	1.00	33.0	34.0	21.0	21.5	100.0	100.0
K-silicate at 0.05 % thrice	61.6	60.8	168.0	171.0	1.00	1.01	33.0	34.0	21.1	21.6	100.0	101.0
K-silicate at 0.1 % once	61.9	61.8	171.0	174.0	1.06	1.08	35.0	36.0	22.0	22.7	110.0	108.0
K-silicate at 0.1 % twice	62.4	62.3	175.0	177.0	1.10	1.10	37.0	38.0	22.7	23.5	110.0	110.0
K-silicate at 0.1 % thrice	62.5	62.4	176.0	178.0	1.10	1.10	37.0	38.3	22.8	23.6	110.0	110.0
K-silicate at 0.2 % once	61.0	66.0	171.0	174.0	1.06	1.08	35.0	36.0	22.2	22.8	106.0	108
K-silicate at 0.2 % twice	62.5	62.4	176.0	178.0	1.10	1.11	37.0	38.0	22.9	23.6	110.0	111.0
K-silicate at 0.2 % thrice	62.6	62.5	176.0	179.0	1.10	1.12	37.0	38.6	22.9	23.7	110.0	112.0
New L.S.D at 5%	**0.3**	**0.3**	**1.2**	**1.1**	**0.02**	**0.02**	**1.0**	**1.0**	**0.4**	**0.4**	**2.0**	**2.0**

Table 3. Effect of different concentrations and application frequencies of potassium silicate on leaf pigments and percentages of N and P in the leaves of Zaghloul date palms during 2015 and 2016 seasons.

Treatment	Chlorophyll a (mg/100gF.W)		Chlorophyll b (mg/100gF.W)		Total chlorophylls (mg/100gF.W)		Total carotenoids (mg/100gF.W)		Leaf N %		Leaf P %	
	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
Control (unsprayed trees)	2.1	2.3	1.0	1.0	3.1	3.3	0.9	0.9	1.60	1.54	0.10	0.09
K-silicate at 0.05 % once	2.4	2.6	1.3	1.3	3.7	3.9	1.2	1.3	1.67	1.60	0.13	0.12
K-silicate at 0.05 % twice	2.8	3.0	1.6	1.6	4.4	4.6	1.5	1.6	1.75	1.69	0.15	0.14
K-silicate at 0.05 % thrice	2.9	3.1	1.7	1.7	4.6	4.8	1.6	1.6	1.77	1.70	0.16	0.15
K-silicate at 0.1 % once	3.4	3.6	2.1	2.1	5.5	5.7	2.0	1.9	1.84	1.86	0.19	0.18
K-silicate at 0.1 % twice	3.9	4.0	2.4	2.5	6.3	6.5	2.3	2.2	1.91	1.94	0.22	0.21
K-silicate at 0.1 % thrice	4.0	4.1	2.5	2.6	6.5	6.7	2.4	2.3	1.92	1.95	0.23	0.22
K-silicate at 0.2 % once	3.5	3.7	2.2	2.2	5.7	5.9	2.1	2.0	1.85	1.87	0.20	0.19
K-silicate at 0.2 % twice	4.0	4.1	2.5	2.6	6.5	6.7	2.4	2.3	1.92	1.95	0.22	0.22
K-silicate at 0.2 % thrice	4.1	4.2	2.6	2.6	6.7	6.8	2.5	2.3	1.93	1.96	0.23	0.23
New L.S.D at 5%	**0.3**	**0.3**	**0.2**	**0.2**	**0.3**	**0.3**	**0.2**	**0.2**	**0.05**	**0.05**	**0.02**	**0.02**

Table 4. Effect of different concentrations and application frequencies of potassium silicate on leaf content of K, Mg, Ca and S (as %) and Zn and Fe (as ppm) in the leaves of Zaghloul date palms during 2015 and 2016 seasons.

Treatment	Leaf K %		Leaf Mg %		Leaf Ca %		Leaf S %		Leaf Zn %		Leaf Fe %	
	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
Control (unsprayed trees)	0.66	0.69	0.45	0.49	1.55	1.62	0.06	0.07	150.0	149.9	84.0	86.3
K-silicate at 0.05 % once	0.73	0.74	0.49	0.53	1.63	1.70	0.11	0.12	155.0	155.9	87.0	89.0
K-silicate at 0.05 % twice	0.80	0.79	0.54	0.56	1.72	1.77	0.16	0.16	161.0	160.0	91.9	92.9
K-silicate at 0.05 % thrice	0.81	0.80	0.55	0.57	1.73	1.78	0.17	0.17	162.9	160.9	92.0	93.0
K-silicate at 0.1 % once	0.91	0.87	0.61	0.62	1.81	1.86	0.22	0.23	167.0	169.0	95.9	96.0
K-silicate at 0.1 % twice	0.97	0.94	0.66	0.66	1.90	1.95	0.27	0.30	171.9	173.3	99.9	98.3
K-silicate at 0.1 % thrice	0.98	0.95	0.67	0.67	1.91	1.96	0.28	0.31	172.0	173.9	101.0	99.0
K-silicate at 0.2 % once	0.92	0.88	0.62	0.63	1.82	1.87	0.23	0.24	167.6	169.3	96.0	96.1
K-silicate at 0.2 % twice	0.98	0.95	0.67	0.67	1.91	1.96	0.28	0.31	172.0	173.6	100.0	98.6
K-silicate at 0.2 % thrice	0.99	0.96	0.68	0.68	1.92	1.97	0.29	0.32	172.3	174.0	101.3	99.3
New L.S.D at 5%	**0.05**	**0.05**	**0.03**	**0.03**	**0.07**	**0.07**	**0.04**	**0.04**	**2.9**	**3.0**	**2.1**	**1.9**

Table 5. Effect of different concentrations and application frequencies of potassium silicate on bunch weight, yield and some physical characteristics of the fruits of Zaghloul date palms during 2015 and 2016 seasons.

Treatment	Bunch weight (kg.)		Yield/palm (kg)		Fruit weight (g.)		Fruit height (cm)		Fruit diameter (cm)		Seed weight %	
	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
Control (unsprayed trees)	10.8	10.1	108.0	101.0	20.0	19.9	5.0	4.9	2.6	2.4	18.0	18.2
K-silicate at 0.05 % once	10.9	10.7	109.0	107.0	21.9	21.9	5.3	5.4	2.9	2.6	17.1	17.7
K-silicate at 0.05 % twice	11.5	11.3	115.0	113.0	23.9	23.9	5.6	5.7	3.1	3.0	16.5	17.0
K-silicate at 0.05 % thrice	11.6	11.4	116.0	114.0	24.0	24.0	5.7	5.8	3.2	3.1	16.4	16.9
K-silicate at 0.1 % once	12.2	12.3	122.0	123.0	25.4	25.9	6.0	6.1	3.6	3.5	16.0	16.4
K-silicate at 0.1 % twice	12.9	13.0	129.0	130.0	27.0	27.1	6.2	6.4	3.9	3.9	15.6	16.0
K-silicate at 0.1 % thrice	13.0	13.1	130.0	131.0	27.1	27.2	6.3	6.5	4.0	4.0	15.5	15.9
K-silicate at 0.2 % once	12.3	12.4	123.0	124.0	25.5	26.0	6.1	6.2	3.6	3.6	15.9	16.3
K-silicate at 0.2 % twice	13.0	13.1	130.0	131.0	27.1	27.2	6.3	6.5	4.0	4.0	15.5	15.9
K-silicate at 0.2 % thrice	13.1	13.2	131.0	132.0	27.2	27.3	6.4	6.6	4.1	4.1	15.4	15.7
New L.S.D at 5%	**0.5**	**0.5**	**4.0**	**4.0**	**1.1**	**1.2**	**0.2**	**0.2**	**0.02**	**0.02**	**0.04**	**0.05**

Table 6. Effect of different concentrations and application frequencies of potassium silicate on some physical and chemical characteristics of the fruits of Zaghloul date palms during 2015 and 2016 seasons.

Treatment	Pulp weight %		Pulp/seed		T.S.S. %		Total sugars %		Reducing sugars %		Non-reducing sugars %	
	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
Control (unsprayed trees)	82.0	81.8	4.6	4.5	26.0	25.8	20.0	19.7	13.0	12.9	7.0	6.8
K-silicate at 0.05 % once	82.9	82.3	4.8	4.6	26.9	26.3	20.6	20.4	13.4	13.4	7.2	7.0
K-silicate at 0.05 % twice	83.5	83.0	5.1	4.9	27.1	27.3	21.0	20.8	14.0	14.1	7.0	6.7
K-silicate at 0.05 % thrice	83.6	83.1	5.1	4.9	27.2	27.4	21.2	20.8	14.1	14.2	7.1	6.8
K-silicate at 0.1 % once	84.0	83.6	5.3	5.1	28.0	28.3	21.6	21.00	14.7	14.9	6.9	6.8
K-silicate at 0.1 % twice	84.4	84.0	5.4	5.3	28.6	29.0	22.0	21.7	15.3	15.5	6.7	6.6
K-silicate at 0.1 % thrice	84.5	84.1	5.5	5.3	28.7	29.2	22.1	22.2	15.4	15.6	6.7	6.6
K-silicate at 0.2 % once	84.1	83.7	5.3	5.1	28.2	28.4	21.7	21.8	14.8	15.0	6.9	6.8
K-silicate at 0.2 % twice	84.5	84.1	5.5	5.3	28.7	29.1	22.1	22.2	15.4	15.5	6.7	6.7
K-silicate at 0.2 % thrice	84.6	84.3	5.5	5.4	28.8	29.3	22.2	22.3	15.5	15.7	6.7	6.6
New L.S.D at 5%	**0.9**	**0.6**	**0.2**	**0.2**	**0.3**	**0.3**	**0.3**	**0.3**	**0.4**	**0.4**	**NS**	**NS**

Table 7. Effect of different concentrations and application frequencies of potassium silicate on some chemical characteristics of the fruits of Zaghloul date palms during 2015 and 2016 seasons.

Treatment	Total acidity %		Total fibre %		Total soluble tannins %	
	2015	2016	2015	2016	2015	2016
Control (unsprayed trees)	0.503	0.509	0.89	0.91	0.80	0.82
K-silicate at 0.05 % once	0.470	0.480	0.84	0.85	0.74	0.75
K-silicate at 0.05 % twice	0.441	0.458	0.80	0.79	0.68	0.69
K-silicate at 0.05 % thrice	0.439	0.456	0.79	0.78	0.67	0.68
K-silicate at 0.1 % once	0.411	0.433	0.71	0.70	0.60	0.59
K-silicate at 0.1 % twice	0.383	0.415	0.64	0.64	0.55	0.54
K-silicate at 0.1 % thrice	0.382	0.410	0.63	0.63	0.54	0.53
K-silicate at 0.2 % once	0.410	0.431	0.70	0.69	0.59	0.58
K-silicate at 0.2 % twice	0.382	0.414	0.63	0.63	0.54	0.54
K-silicate at 0.2 % thrice	0.380	0.409	0.62	0.62	0.53	0.52
New L.S.D at 5%	**0.018**	**0.019**	**0.04**	**0.05**	**0.04**	**0.04**

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تأثير السيليكون علي النمو الخضرى والاثمار فى نخيل البلح الزغلول

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الملخص

أجريت هذه الدراسة خلال موسمى ٢٠١٥، ٢٠١٦ لبيان تاثير التركيزات (٠,٠٥ إلي ٠,٢%) وعدد مرات الرش (واحدة – اثنان أو ثلاث مرات) المختلفة لمادة سيليكات البوتاسيوم علي صفات النمو الخضرى والصبغات والعناصر الغذائية فى الورقة، وزن السوباطة وكمية محصول النخلة وخصائص الجودة للثمار فى نخيل البلح الزغلول. وكان التصميم الاحصائى المستخدم لتحليل نتائج هذه التجربة هو القطاعات الكاملة العشوائية.

كان هناك تحسن ملحوظ فى جميع صفات النمو الخضرى والمكونات الكيميائية للورقة ووزن السوباطة وكمية المحصول وخصائص الجودة للثمار عند المعاملة بمادة سيليكات البوتاسيوم مرة، مرتان أو ثلاث مرات بتركيز ما بين ٠,٠٥ ، ٠,١ و ٠,٢% وذلك بالمقارنة بمعاملة الكونترول. وكان التحسن فى هذه الصفات متناسبا مع زيادة التركيز وعدد مرات الرش ولم تكن هناك فروق تذكر علي هذه الصفات فيما بين التركيزين الأعلي (٠,١، ٠,٢%) وعدد مرات الرش الأعلي (مرتان وثلاث مرات).

لأجل تحسين كمية المحصول وخصائص الجودة للثمار فى نخيل البلح الزغلول فإنه يكون من الضرورى رش النخيل مرتان قبل عملية التلقيح الصناعى بأسبوعين وبعد مرحلة عقد الثمار مباشرة بسيليكات البوتاسيوم بتركيز ٠,١%.

الكلمات الدالة: نخيل البلح الزغلول–السيليكون– التركيزات– عدد مرات الرش – كمية المحصول – خصائص الجودة للثمار.