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EFFECT OF SPRAYING SILICON AND SOME NUTRIENTS ON GROWTH, PALM NUTRITIONAL STATUS, YIELD AND FRUIT QUALITY OF ZAGHLOUL DATE PALMS.
II. EFFECT OF SPRAYING SILICON AND SOME NUTRIENTS ON YIELD AND FRUIT QUALITY OF ZAGHLOUL DATE PALMS

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ABSTRACT

This study (2nd part) was undertaken during 2015 and 2016 seasons to examine the effect of spraying silicon, N, P, K, Mg, Zn, Fe, Mn, Cu and B on yield and fruit quality of Zaghloul date palms.

Subjecting the palms three times with silicon as well as some macro (N, P, K, Mg) and micro nutrients (Zn, Fe, Mn, Cu and B) either alone or in combinations had an announced promotion on the yield, bunch weight as well as physical and chemical characteristics of the fruits relative to the control treatment. Using nutrients was preferable than using silicon in this respect. Using all nutrients with silicon gave the best results compared to using nutrients alone.

***Conclusively,** the best results with regard to yield and fruit quality of Zaghloul date palms were obtained by spraying a mixture of silicon and nutrients (N, P, K, Mg, Zn, Fe, Mn, Cu and B) three times.*

Keywords: Zaghloul date palms, Si, N, P, K, Mg, Zn, Fe, Mn, Cu, B, yield and fruit quality.

INTRODUCTION

Silicon has many functions in plant nutrition. It has many regulatory roles in enhancing the tolerance of plants to biotic and abiotic stresses, water retention, photosynthesis, plant pigments and building of carbohydrates and natural growth regulators (Gang *et al*., 2003; Lux *et al*., 2003; Ma, 2004 and Hattori *et al*., 2005). Macro and micronutrients are responsible for promoting cell division and the biosynthesis of plant pigments, organic foods, antioxidants, vitamins, amino acids and natural hormones (Marschner, 1995).

Previous studies showed that silicon (Gad El-Kareem *et al*., 2014; Omar, 2015 and Youssef, 2017) and different nutrients (Desouky *et al*., 2007; Shahin, 2007; Abdalla, 2008 and Mohamed and Mohamed, 2013) were favourable in enhancing yield and fruit quality in various date palm cvs.

The target of this study was elucidating the effect of silicon as well as some macro and micro nutrients on yield and fruit quality of Zaghloul date palms.

MATERIALS AND METHODS

This study was conducted during 2015 and 2016 seasons in a private date palm orchard situated at Dahmro village, Maghagha district, Minia Governorate on twenty-four 19-year old Zaghloul date palms. These palms produced through conventional propagation by offshoots as well as characterized by regular bearing. The selected palms are uniform in vigour, healthy, good physical conditions, free from insects, diseases and damages. They are planted at 10 x 10 meters apart (42 palms/ feddan). The selected palms were irrigated with Nile water through surface irrigation system.

The objective of this study was examining the effect of foliar application of silicon as well as some macro and micro nutrients on leaf chemical composition, yield as well as some physical and chemical characteristics of the fruits of Zaghloul date palms grown under middle Egypt conditions.

Hand pollination of all the selected palms was achieved by inserting ten fresh male strands into the center of one female spathae (according to Hussein *et al*., 1987 using the same source of pollens (Zaghloul date palms males) to avoid residues of metaxenia. Pollination was carried out throughout two days after female spathes cracking at the day time of afternoon. Every bunch was bagged after pollination by white paper bags which were tied at the ends using a piece of cotton for aeration and the bags were shaken lightly to ensure pollens distribution and they were removed after one month (Musa, 1981). Number of bunches per palm was adjusted to ten bunches and leaf bunch ratio was maintained at 8: 1.

The texture of soil is clay. Physical and chemical properties of the experimental soil at 0.0 – 90 cm depth are presented in Table 1 according to the procedures of Black *et al* (1965) and Carter (1993).

Table 1 : Analysis of the tested soil:

Constituents	Values
Particle size distribution	
Sand %	8.5
Silt %	21.0
Clay %	70.5
Texture	Clay
pH (1: 2.5 extract)	8.0
EC (1 : 2.5 extract) mmhos/ 1 cm 25^{o}cm	0.75
Organic matter %	1.9
Total $CaCO_3$ %	1.9
Total N %	0.09
P ppm (Olsen	3.3
K ppm	410.0
Available micronutrients (ppm):	
Fe	2.9
Zn	3.1
Mn	1.9
Cu	0.7

All the selected Zaghloul date palms received program of fertilization consists of 10 kg plant compost (2.5 % N), 5.0 kg ammonium sulphate, (20.6 % N) 1.5 kg triple calcium superphosphate (37.5 % P_2O_2) and 1.5 kg potassium sulphate (48 % K_2O) for each palm. Plant compost was added once at the middle of Jan. Ammonium sulphate was added at three equal doses in first week of March., May and July.

Phosphate fertilizer was splitted into two equal batches. The first was added at the middle of January and the second one was applied just after fruit setting (last week of April). Potassium sulphate was applied twice before pollination (last week of Feb.) and just after fruit setting (last week of April). Another horticultural practices such as irrigation, pruning, hoeing and pest management were carried out as recommended by Ministry of Agriculture and Land Reclamation. The study included the following eight treatments as following: -

1- Control (palms sprayed with water)
2- Spraying Potassium silicate at 0.1 %
3- Spraying Zn + Fe + Mn + Cu + B
4- Spraying N + P + K + Mg
5- Spraying Si + Zn + Fe + Mn + Cu + B

6- Spraying Si + N + P + K + Mg
7- Spraying Zn + Fe + Mn + Cu + B +N + P + K + Mg
8- Spraying all nutrients (N+ P + K+ Mg + Zn + Fe + Cu + B + Si).

Each treatment was replicated three times, one date palm per each. Macronutrients namely N, P, K and Mg were foliage sprayed in the sources of urea (46.5 % N), orthophosphoric acid (85 % P_2O_2), potassium sulphate (48 % K_2O) and magnesium sulphate (9.6 % N) each at 0.5 % (5 g/L), respectively. Micronutrients namely Zn, Fe and Mn were applied in the chelated form (13 % of each element) at 0.05 % (0.5 g/ L). Cupper was added in the copper sulphate form at 0.025 % (0.25 g / L). Boron was added in the form of boric acid (17 % B) at 0.025 % 0.25 g/L. Potassium silicate liquid (25 % Si+ 10 % K_2O) was used as source of silicon. The selected palms received three sprays of each treatment started two weeks before hand pollination (before spathe cracking, last week of Feb.), just after fruit setting (1st week of Apr.) and at one month later (1st week of May). Triton B as a wetting agent was added to all treatments.

Randomized complete block design (RCBD) was followed in which this experiment included eight treatments and each treatment replicated three times, one palm per each. During the two seasons, the following measurements were recorded:

1- Yield and bunch weight:

Bunches (ten) of Zaghloul date palms were picked at the optimum commercial harvesting time under Maghagha – Minia conditions (mid of Sept.) in the two experimental seasons. The yield of each palm was recorded in terms of weight per palm (kg) by multiplying the average bunch weight (kg) by total number of bunches per palm (ten bunches).

2- Quality parameters:

Samples of fifty dates from the yield of each palm were taken randomly and the following physical and chemical characteristics were measures:

Weights of fruit seed and flesh (g) and fruit dimensions (height and diameter in cm) were recorded. Percentages of seed and flesh were estimated by dividing weights of seed and fresh by the whole weight of fruit and multiplying the product by 100.

Total soluble solids % (T.S.S. %)

The fruit fresh was well minced with an electric blender and past was squeezed and the total soluble solids % was measured by using hand refractometer according to A.O.A.C.(2000).

Total and reducing sugars:

The percentages of total and reducing sugars were determined according to Lane and Eynon (1965) volumetric method that outlined in A.O.A.C. (2000).

Titratable acidity %:

Twenty-five grams of flesh were mixed with 100 ml distilled water in an electric blender, the extract was filtered and twenty ml of juice was titrated against 0.1 N sodium hydroxide using phenolphthalein as an indicator according to A.O.A.C., (2000). Total acidity % was determined as g % or g malic acid per 100 g pulp.

Total soluble tannins:

The tannin content was determined using the Indigo Carmen indicator according to Balbaa (1981). Titration was carried out using 0.1 N potassium permanganate solution. Tannins (%) as fresh weight were calculated according to the following equation:

1 ml potassium permanganate (0.1 N) = 0.00416 g tannins.

Crude fibers content:

Determination of crude fibers content was achieved using glacial acetic acid and nitric acid at 10: 1 solution according A.O.A.C., (2000).

Thereafter, the obtained data during the two seasons were collected, tabulated and subjected the expermint design of variance method reported by Gomez and Gomez (1984) and Mead *et* al., (1993). The differences between treatment means were differentiated using New L.S.D at 5% parameter.

RESULTS AND DISCUSSION

1- Average bunch weight:

It is obvious from the obtained data in Table 2 that treating the palms three times with silicon alone had a slight and insignificant promotion on the average bunch weight over the control treatment. However, treating the palms with macro and/or micronutrients besides the applications of silicon significantly succeeded in improving the average bunch weight over the control treatment. A great promotion on the average bunch weight was observed when the application of nutrients was accompanied with silicon compared to nutrients alone. Treating the palms with silicon and all nutrients together gave the maximum bunch weight (14.0 & 14.7 kg) while the lowest

Table (2): Effect of spraying applications of silicon alone or combined with some macro and micro nutrients on average bunch weight, yield and some physical characteristics of Zaghloul fruit date palms during 2015 and 2016 seasons

Treatments	Av. bunch weight (kg.)		Yield/palm (kg.)		Average fruit (g.)		Average fruit length (cm)		Average fruit diameter (cm)	
	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
Control	9.9	10.3	99.0	103.0	26.1	27.2	5.41	5.55	1.95	2.02
Potassium silicate at 0.1 %	10.6	10.7	106.0	107.0	27.6	27.9	5.55	5.64	2.07	2.07
Zn + Fe + Mn + Cu + B	11.2	11.3	112.0	113.0	28.1	28.5	5.57	5.75	2.10	2.15
N + P + K + Mg	11.9	11.8	119.0	118.0	29.0	29.1	5.69	5.90	2.18	2.23
Si + Zn + Fe + Mn + Cu + B	12.4	12.8	124.0	128.0	29.7	30.0	5.74	6.00	2.26	2.23
Si + N + P + K + Mg	13.0	13.5	130.0	135.0	30.1	90.9	6.25	6.19	2.35	2.37
Zn + Fe + Mn + Cu + B + N + P + K + Mg	13.3	14.1	133.0	141.0	30.8	31.8	6.09	6.29	2.42	2.60
Si + Zn + Fe + Mn + Cu + B + N + P + K + Mg	14.0	14.7	140.0	147.0	31.7	32.3	6.41	6.47	2.48	2.71
New L.S.D at 5%	1.0	1.0	9.6	9.8	0.5	0.6	0.06	0.05	0.09	0.08

values (9.9 & 10.3 kg) were recorded on untreated palms during both seasons, respectively. The percentage of increment in average bunch weight due to application of silicon and all nutrients over the control treatment reached 41.4 and 42.7 % during both seasons, respectively. These results were true during both seasons.

2- Yield / palm:

It can be seen from the obtained data in Table 2 that yield per palm was insignificantly promoted by using silicon alone compared to the control treatment. Spraying macro and/or micronutrients as well as mixtures of nutrients and silicon had significant promotion on the yield per palm relative to the control treatment. Sparaying separated or combine was significantly preferable than using different nutrients alone (without silicon) in improving the yield per palm. The best result with regard to yield/palm was obtained by sparaying Zaghloul date palms three times with a mixture of silicon and all nutrients. Under such promised treatment yield per palm reached 140 & 147 kg/palm., while the untreated palms produced 99.0 & 103.0 kg/palm during both seasons, respectively. The percentage of increment in the yield per palm due to application of the previously promised treatment over the control treatment reached 41.4 and 42.7% during 2015 and 2016 seasons, respectively. These results were true during both seasons.

3- Some physical characteristics of the fruits:

3-1-Averages weight and dimensions:

It is clear from the obtained data in Table 2 that treating Zaghloul date palms three times with potassium silicate, macro and micronutrients either singly or in different combinations had significant promotion on weight, height and diameter of fruit relative to the control treatment. Macro, micronutrients and silicon, in descending order were responsible for enhancing fruit weight and dimensions. Combined applications of silicon and/or different nutrients were significantly preferable than using each alone in improving these physical characteristics. Using silicon with both macro and micronutrients was significantly superior to using macro and micronutrients alone in this respect. The heaviest fruits were borne on the palms that received silicon and all macro and micronutrients together. Under such promised treatment, average fruit weight reached 31.7 & 32.3 g, fruit height 6.41 & 6.47 cm and fruit diameter 2.48 & 2.71 cm, during both seasons, respectively. The lowest values of fruit weight (26.1 & 27.2 g), fruit

height (5.41 & 5.55 cm) and fruit diameter (1.95 & 2.02 cm) were recorded on untreated palms.

3-2- Percentages of flesh and seed of fruits:

It is noticed from the obtained data in Table 3 that subjecting the palms to silicon as well as macro and micronutrients either alone or in combinations were significantly promoting flesh % and reducing seed % relative to the control treatment. Using macronutrients was significantly superior to using micronutrients or silicon in enhancing flesh % and reducing seed %. A significant promotion on flesh % and a reduction on seed % were observed when the application of macro and/or micronutrients were accompanied with using silicon. The highest values of flesh % (87 & 88.4 %) and the lowest values of seed % (13 & 11.6 %) were recorded on the palms that received three sprays of a combination of silicon and all macro and micronutrients during both seasons, respectively. The untreated palms produced the lowest values of flesh % (78.9 & 80 %) and the highest seed % (21.1 & 20%) during both seasons, respectively.

4- Some chemical characteristics of the fruits:

4-1- Percentage of total soluble solids:

It is obvious from the obtained data in Table 3 that using macro and /or micronutrients in combined with silicon had significant promotion on the percentage of total soluble solids relative to the control treatment. Treating the palms with silicon alone gave insignificant promotion on such chemical characteristic compared with control. Combined application of silicon with macro and /or micronutrients was significantly favourable in enhancing total soluble solids than using each group alone. The highest values (29.8 & 30.4 %) were recorded on the fruits harvested from palms that treated with combine of silicon and all nutrients together during 2015 and 2016 seasons, respectively. The lowest values (25.2 & 26.0 %) were recorded on the fruits that harvested from untreated palms during both seasons, respectively.

4-2- Percentages of total, reducing and non-reducing sugars:

It is worth to mention from the obtained data in Tables (3 & 4) that single and combined applications of silicon as well as macro and micronutrients were significantly very effective in enhancing total and reducing sugars in the fruits of Zaghloul date palms relative to the control treatment. Using macronutrients was significantly preferable than using micro ones in enhancing such two chemical characteristics. Using silicon

Table (3): Effect of spraying applications of silicon alone or combined with some macro and micro nutrients on some physical and chemical characteristics of Zaghloul fruit date palms during 2015 and 2016 seasons

Treatments	Fruit flesh %		Fruit seed %		T.S.S. %		Total sugars %		Reducing sugars %	
	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
Control	78.9	80.0	21.1	20.0	25.2	26.0	19.0	19.7	13.0	13.2
Potassium silicate at 0.1 %	80.0	81.2	20.0	18.8	25.8	26.5	19.7	20.5	14.0	14.0
Zn + Fe + Mn + Cu + B	81.0	83.0	19.0	17.0	26.6	27.1	20.1	21.3	14.5	14.7
N + P + K + Mg	82.0	84.5	18.0	15.5	27.3	27.8	20.6	22.0	15.0	15.5
Si + Zn + Fe + Mn + Cu + B	84.0	85.5	16.0	14.5	28.3	28.5	21.1	22.4	15.5	16.5
Si + N + P + K + Mg	85.0	86.9	15.0	13.1	29.0	29.0	22.0	22.8	16.0	17.0
Zn + Fe + Mn + Cu + B + N + P + K + Mg	86.0	87.5	14.0	12.5	29.4	29.7	22.4	23.3	17.0	17.4
Si + Zn + Fe + Mn + Cu + B + N + P + K + Mg	87.0	88.4	13.0	11.6	29.8	30.4	22.7	23.6	18.0	18.0
New L.S.D at 5%	1.77	0.83	0.86	0.80	1.1	0.9	0.4	0.5	1.0	0.8

Table (4): Effect of spraying applications of silicon alone or combined with some macro and micro nutrients on some chemical characteristics of Zaghloul fruit date palms during 2015 and 2016 seasons

Treatments	Non-reducing sugars %		Titratable acidity %		Total crude fibre %		Total soluble tannins %	
	2015	2016	2015	2016	2015	2016	2015	2016
Control	6.0	6.5	0.397	0.360	0.76	0.69	0.71	0.67
Potassium silicate at 0.1 %	5.7	6.5	0.360	0.329	0.71	0.65	0.65	0.64
Zn + Fe + Mn + Cu + B	5.6	6.6	0.353	0.301	0.67	0.59	0.60	0.59
N + P + K + Mg	5.6	5.5	0.305	0.274	0.61	0.54	0.54	0.54
Si + Zn + Fe + Mn + Cu + B	5.6	5.9	0.240	0.254	0.55	0.49	0.49	0.47
Si + N + P + K + Mg	6.0	5.8	0.257	0.231	0.50	0.44	0.40	0.40
Zn + Fe + Mn + Cu + B + N + P + K + Mg	5.4	5.9	0.221	0.210	0.45	0.37	0.33	0.37
Si + Zn + Fe + Mn + Cu + B + N + P + K + Mg	4.7	5.6	0.201	0.194	0.39	0.31	0.30	0.30
New L.S.D at 5%	**NS**	**NS**	**0.034**	**0.012**	**0.06**	**0.07**	**0.08**	**0.05**

combined with macro and/or micronutrients significantly surpassed the application of nutrients alone in this respect. The maximum values of total sugars (22.7 & 23.6%) and reducing sugars (18.0 & 18.0 %) were recorded on the fruits harvested from palms received silicon combines with all nutrients during both seasons, respectively. The untreated palms produced fruits had lower of total sugars (19.0 & 19.7 %) and reducing sugars (13.0& 13.2 %) during both seasons, respectively. The present treatments had no significant effect on the percentage of non-reducing sugars. These results were true during both seasons.

4-3- Percentages of titratable acidity, total fibre and total soluble tannins in the fruits:

One can be stated from data in Table 4 that subjecting Zaghloul date palms three times with single and combined applications of silicon and/or macro and micronutrients were significantly very favourable in reducing the percentages of titratable acidity, total fibre and total soluble tannins relative to the control treatment. The reduction on these chemical characteristics was significantly related to application of silicon, micro and macronutrients, in ascending order. Using silicon incorporated with macro and/or micronutrients had significant reduction on these chemical characteristics relative to application of silicon alone. The lowest values of titratable acidity (0.201 & 0.194 %), total fibre (0.39 & 0.31 %) and total soluble tannins (0.30 & 0.30 %) were recorded on the fruits harvested from palms received silicon and all nutrients together during 2015 and 2016 seasons, respectively. The highest values of titratable acidity (0.397 & 0.360 %), total fober % (0.76 & 0.69 %), and total soluble tannins (0.71 & 0.67 %) were recorded on the fruits from palms that did not supply with any nutrients or silicone treatment (control)during both seasons, respectively.

DISCUSSION:

The outstanding effect of silicon on growth, palm nutritional status, yield and fruit quality might be attributed to its positive action on enhancing the tolerance of plants to biotic and abiotic stresses (Ma, 2004), water retention; separated and water economy (Gang *et al*., 2003 and Hattori *et al*., 2005), water transport, root development (Lux *et al*., 2003 and Hattori *et al*., 2005). The great strength on the plant tissues due to using silicon surely reflected on increasing the resistance to several disorders (Marschner, 1995).

These results are in agreement with those obtained by Gad El-Kareem *et al* (2014) on Zaghloul date palms and Youssef (2017) on Sakkoti date palms.

According Marchner, (1995) the important regulatory effect of N on building of proteins, amino acids, enzymes, natural hormones, vitamins, antioxidants and plant pigments and encouraging photosynthesis and cell division, P in enhancing the biosynthesis of sugars, plant pigments, enzymes, natural hormones, cell division, vitamins, root development and photosynthesis, K in stimulating the biosynthesis and translocation of sugars, plant pigments, cell division, tolerance of fruit crops to biotic and abiotic stresses, water tolerance, root development, Mg in building chlorophylls and enhancing the biosynthesis of sugars, proteins and fats, sugars translocation and amino acid, Fe in building chlorophylls and plant pigments and regulating reduction and oxidants reactions, Mn in enhancing co-enzymes that are responsible for enhancing the activity of respiration and oxidation enzymes and the biosynthesis of organic acids, N metabolism, nitrate reduction and the biosynthesis of IAA, Zn in activating metabolism enzymes, biosynthesis of organic foods, IAA, cell division and enlargement, water absorption and nutrient transport and B in enhancing the biosynthesis of N, proteins, IAA, carbohydrates, water uptake and pallor germination surely reflected on stimulating growth, palm nutritional status, yield and fruit quality of Zaghloul date palms.

These results are in agreement with those obtained by Desouky *et al*., (2007) on Barhee date palms; Shahin (2007) on Khalas date palms; Abdalla (2008) on Zaghloul date palms and Mohamed and Mohamed (2013) on Sewy date palms.

Conclusively, the best results with regard to yield and fruit quality of Zaghloul date palms were obtained due to using a mixture of silicon and nutrients (N, P, K, Mg, Zn, Fe, Mn, Cu and B) three times.

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تأثير رش السيليكون وبعض العناصر الغذائية علي النمو والحالة الغذائية للنخلة وكمية المحصول وخصائص الجودة للثمار في نخيل البلح الزغلول
2- تأثير رش السيليكون وبعض العناصر الغذائية علي كمية المحصول وخصائص الجودة لثمار نخيل البلح الزغلول

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**قسم بحوث الفاكهة الاستوائية – معهد بحوث البساتين – مركز البحوث الزراعية – الجيزة – مصر

أجريت هذه الدراسة (الجزء الثانى) خلال موسمى 2015، 2016 لاختبار تأثير رش السليكيون وبعض العناصر الغذائية (نيتروجين، فوسفور، بوتاسيوم، ماغنسيوم، زنك، حديد، منجنيز، نحاس، بورون) علي كمية المحصول وخصائص الجودة لثمار نخيل البلح الزغلول.

إن رش النخيل ثلاث مرات بالسيليكون وبعض العناصر الكبرى (نيتروجين – بوتاسيوم – فوسفور – بوتاسيوم – ماغنسيوم) والصغرى (زنك – منجنيز – حديد – نحاس –بورون) فى الصورة الفردية والمشتركة كان له تأثير كبير فى تحسين كمية المحصول ووزن السوباطة وكذلك خصائص الجودة الطبيعية والكيميائية للثمار وذلك بالمقارنة بمعاملة الكونترول وكان استخدام العناصر الغذائية افضل من استخدام السيليكون فى هذا الصدد وكان استخدام جميع العناصر الغذائية مع السيليكون أفضل من استخدام العناصر الغذائية بمفردها.

التوصية:أمكن الحصول علي أفضل النتائج بخصوص كمية المحصول وخصائص الجودة لثمار نخيل البلح الزغلول عند رش النخيل ثلاث مرات بخليط من السيليكون والعناصر الغذائية (نيتروجين – فوسفور – بوتاسيوم – ماغنسيوم – زنك – منجنيز – حديد – نحاس - بورون)