

The Synergistic Effects of Using Silicon and Selenium on Fruiting of Zaghoul Date Palm (*Phoenix dactylifera* L.)

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Abstract—During 2011 and 2012 seasons, Zaghoul date palms received four sprays of silicon (Si) at 0.05 to 0.1% and selenium (Se) at 0.01 to 0.02%. Growth, nutritional status, yield as well as physical and chemical characteristics of the fruits in response to application of silicon and selenium were investigated. Single and combined applications of silicon at 0.05 to 0.1% and selenium at 0.01 to 0.02% was very effective in enhancing the leaf area, total chlorophylls, percentages of N, P and K in the leaves, yield, bunch weight as well as physical and chemical characteristics of the fruits in relative to the check treatment. Silicon was superior to selenium in this respect. Combined application was favorable than using each alone in this connection. Treating Zaghoul date palms four times with a mixture of silicon at 0.05% + selenium at 0.01% resulted in an economical yield and producing better fruit quality.

Keywords—Date Palms, Zaghoul, Silicon, Selenium, leaf area.

I. INTRODUCTION

MANY attempts have been conducted to improve the yield and fruit quality of Zaghoul date palms grown under Minia region conditions by using new cultural practices especially fertilization with silicon and selenium [34], [9].

Various studies showed that using silicon was beneficial for counteracting the adverse effects of water stress on growth and nutritional status of the plants. It is also known that silicon increases drought tolerance in plants by maintaining plant water balance, photosynthesis activity, erectness of leaves and structure of xylem vessels under higher transpiration rates. Also, it is responsible for encouraging water transport and root growth under unfavorable conditions and antioxidants defense system [22], [9], [2], [7], [24], [16]. Previous studies showed that using silicon in fruit orchards under drought conditions were accompanied with alleviating the adverse effects of drought on growth, plant pigments as well as nutritional status of the Plants [21], [18], [20], [27], [10], [3], [4].

Many trials to supply selenium to fruit orchards have been carried out since tests have confirmed selenium's role as a medical substance and must be added for its positive action on fruiting. Selenium as an element chemically similar to sulfur has received considerable attention as an essential micronutrient for human, animals and some species of microorganisms. It functions in the active site of a large

number of selenium dependent enzymes such as glutathione-peroxidase and in anticancer and other physiological functions.

A lower selenium level in body is reported to be responsible for high incidence of cancer and disease [12]. It also influences the nutrient balance in the plants [28]. Selenium (Se) is an important element associated with the enhancement of antioxidant activity in plants, animals and humans [31]. Beneficial effects of Se were reported explored in terms of plant protection against abiotic stress [15], plant protection against reactive oxygen compounds, activator of the protective mechanism that reduces oxidation stress for example in chloroplasts [33], phloem-feeding aphids and herbivorous caterpillars [13], and fungal diseases [14]. Selenium has a positive effect also on potato carbohydrate accumulation and possibly on yield formation [35], [36].

The theoretical explanation for the antioxidative effects of Se on plants is the increased activity of the enzyme glutathione-peroxidase (GSH-Px) in selenium-treated plants. However, no Se-containing GSH-Px was identified in plants, in contrast to animals [8]. Reference [33] discovered that Se reduced the activity of superoxide dismutase (SOD) and in some cases the amount of tocopherols. Previous studies showed that application of selenium (Se) was very effective in enhancing growth, yield and fruit quality of fruit crops and other horticultural crops [26], [11], [34], [19], [12], [15], [39], [28], [17]. The target of this study was examining the beneficial effects of using silicon and or selenium on growth and fruiting of Zaghoul date palms grown under Minia region.

II. MATERIALS AND METHODS

This study was carried out 2011 and 2012 seasons in a private orchard situated at Maghagha district, Minia Governorate on twenty one 20- years old Zaghoul date palms. Soil texture is silty clay and the palms are planted at 7 × 7 meters apart. The selected palms were irrigated through surface system. Pruning was carried out to maintain leaf bunch ratio at 8: 1 according to [32]. 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 activating pollen source throughout 2-3 days after female spathe creaking followed by bagging [29]. Each selected palm received the common horticultural practices that are already applied in the orchard except those dealing with using silicon and selenium.

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This experiment included the following seven treatments:

- 1- Foliar application of silicon and selenium each at 0.0%.
- 2- Foliar application of silicon at 0.05%.
- 3- Foliar application of silicon at 0.1%.
- 4- Foliar application of selenium at 0.01%.
- 5- Foliar application of selenium at 0.02%.
- 6- Foliar application of both at low concentrations.
- 7- Foliar application of both at high concentrations.

Each treatment was replicated three times, one palm per each. Randomized complete block design was followed. Silicon and selenium were sprayed in the forms of potassium silicate (25% Si + 10 % K₂O) and sodium selenite (20% Se) (Na₂SeO₃, 5H₂O), respectively. Each palm received four sprays at growth start, just after fruit setting and at one month intervals. Triton B as a wetting agent was added to all materials at 0.05 %. Spraying was done till runoff.

During both seasons, the following parameters were carried out:-

- 1- Leaf area (m²) [1].
- 2- Total chlorophylls (a+b) as (mg/ g-1 F.W) [6], [25], [37].
- 3- Percentages of N, P, K and Mg in the dried leaves according To [30], [38].
- 4- Bunch weight (kg).
- 5- Yield/ palm (kg.) at the first week of September.
- 6- Some physical and chemical characteristics of the fruits namely fruit weight (g.) and dimensions (length and width, cm.) as well as percentages of pulp and seeds, pulp/ seed, total soluble solids %, total and non- reducing sugars % [5], total acidity % (as g malic acid/ 100g pulp) according to [5]; fibre crude % and total soluble tannins % were determined [5].

All the obtained data were tabulated and subjected to the proper statistical analysis using new L.S.D at 5% according to [23].

III. RESULTS AND DISCUSSION

A. Leaf Area and Its Content of Total Chlorophylls and N, P and K

It is clear from the obtained data in Table I that single and combined applications of silicon (Si) at 0.05 to 0.1% and Se at 0.01 to 0.02% significantly was followed by a great stimulation on the leaf area and its content of total chlorophylls and N, P, and K in relative to the control treatment. Using Si at 0.05 to 0.1% was superior than spraying Se at 0.01 to 0.02% in improving leaf area and its chemical composition. Using Si and Se together gave the best results comparing with using each compound alone. No significant differences were obtained on these parameters among the higher two concentration of Si (0.05 and 0.1%) and Se (0.01 and 0.02%). The maximum values were recorded on the palms that received Si and Se together at the low concentrations (0.05% for Si and 0.01% for Se). The untreated palms produced the minimum values. These results were true during both seasons.

B. Bunch Weight and Yield Per Palm

It is evident from the data in Tables I&II that both bunch weight and yield per palm were significantly improved in response to single or combined application of Si from 0.05 to 0.1% and Se from 0.01 to 0.02% comparing with the control treatment. Using Si at 0.05 to 0.1% was preferable than using Se at 0.01 to 0.02% in promoting bunch weight and yield per palm. Using Si incorporated with Se significantly enhanced bunch weight and yield/ palm in relative to using each nutrient alone. Meaningless promotion was detected on bunch weight and yield/ palm between the higher two concentrations of Si and Se. Therefore, from economical point of view, it is suggested to use Si at 0.05% and Se at 0.01% together. In this treatment, yield per palm reached 190.1 and 190.4kg while in the control treatment reached 145.6 and 148kg during both seasons, respectively. The percentage of yield increase due to application of the promised treatment over the control treatment reached 30.8 and 28.6% during both seasons, respectively. These results were true during both seasons.

C. Physical and Chemical Characteristics of the Fruits

Tables II & III show that treating Zaghoul date palms four times with Si at 0.05 to 0.1% or Se at 0.01 to 0.02% either singly or in combinations significantly improved physical and chemical characteristics of the fruits in terms of increasing fruit weight and dimensions, pulp %, pulp/ seed, T.S.S %, total and reducing sugars % and decreasing seed %, total acidity %, total soluble tannins % and total crude fibre % in relative to the check treatment. A significant promotion on fruit quality was observed with using both elements together rather than application of each alone. Spraying Si at 0.05 to 0.1% was preferable in improving fruit quality than using Se at 0.01 to 0.02%. Meaningless stimulation on fruit quality was observed with increasing concentrations of each element from the low (0.05% for Si and 0.01% for Se) to the high (0.1% for Si and 0.02% for Se). The best results from economical point of view were obtained with spraying Si at 0.05% and Se at 0.01% together. Untreated palms produced unfavorable effects on fruit quality. These results were true during 2011 and 2012 seasons.

The essential roles of silicon (Si) and selenium (Se) on promotion growth and fruiting of Zaghoul date palm might be attributed to the effect of Si in enhancing the tolerance of the trees to all stresses, uptake and transport of water and different nutrients, root development and antioxidant defense systems [16] as well as the effect of Se in increasing activities of enzymes such as glutathione-peroxidase, antioxidant activities, protections plants from abiotic and biotic stresses, biosynthesis of carbohydrates as well as it reduces reactive oxygen species [35], [36].

These results are in harmony with those obtained by [10], [3], [4], [11], [12].

IV. CONCLUSION

Carrying out four sprays of a mixture of silicon at 0.05% plus selenium at 0.01% proved to be very effective for

improving yield and fruit quality of Zaghoul date palms grown under Minia region.

TABLE I
EFFECT OF SINGLE AND COMBINED APPLICATIONS OF SILICON AND SELENIUM ON THE LEAF AREA, TOTAL CHLOROPHYLLS, PERCENTAGES OF N, P AND K IN THE LEAVES AND BUNCH WEIGHT OF ZAGHLOUL DATE PALMS DURING 2011 AND 2012 SEASONS

Treatments	Leaf area (m ²)		Total chlorophylls (mg/ g ⁻¹ F.W)		Leaf N %		Leaf P %		Leaf K %		Bunch weight (kg.)	
	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012
Silicon (Si) + selenium (Se) at 0.0%	1.95	2.00	9.41	9.52	1.69	1.71	0.14	0.15	1.29	1.33	18.2	18.5
Si at 0.05%	2.11	2.16	9.77	9.89	1.84	1.86	0.24	0.25	1.44	1.47	21.9	22.0
Si at 0.1%	2.13	2.17	9.80	9.91	1.85	1.87	0.25	0.26	1.45	1.48	22.0	22.2
Se at 0.01%	2.03	2.08	9.66	9.77	1.75	1.76	0.18	0.19	1.36	1.40	20.0	20.2
Se at 0.02%	2.04	2.09	9.67	9.78	1.77	1.78	0.19	0.20	1.37	1.41	20.3	20.5
Si + Se at the low conc.	2.25	2.30	10.96	11.06	1.93	1.94	0.29	0.30	1.55	1.61	23.8	23.8
Si + Se at the high conc.	2.26	2.31	10.97	11.07	1.94	1.96	0.30	0.31	1.51	1.62	24.0	24.1
New L.S.D at 5%	0.04	0.05	0.05	0.06	0.04	0.05	0.02	0.03	0.04	0.05	1.0	1.1

Si = Silicon & Se = Selenium

TABLE II
EFFECT OF SINGLE AND COMBINED APPLICATIONS OF SILICON AND SELENIUM ON YIELD AND SOME PHYSICAL CHARACTERS OF THE FRUITS OF ZAGHLOUL DATE PALMS DURING 2011 AND 2012 SEASONS

Treatments	Yield/ palm (kg.)		Fruit weight (g.)		Fruit length (cm.)		Fruit width (cm.)		Pulp %		Pulp/ seed	
	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012
Silicon (Si) + selenium (Se) at 0.0%	145.6	148.0	21.1	21.3	5.39	5.44	2.71	2.74	79.0	80.1	3.76	4.30
Si at 0.05%	175.2	176.0	24.5	24.8	5.60	5.65	2.84	2.88	83.0	84.1	4.88	5.29
Si at 0.1%	176.0	177.6	24.7	25.0	5.62	5.67	2.85	2.88	83.1	84.2	4.92	5.33
Se at 0.01%	160.0	161.6	22.9	23.2	5.47	5.52	2.77	2.80	80.5	81.6	4.13	4.43
Se at 0.02%	162.4	164.0	23.0	23.3	5.48	5.53	2.78	2.81	80.6	81.7	4.15	4.46
Si + Se at the low conc.	190.4	190.4	26.1	26.4	5.75	5.80	2.91	2.94	85.0	86.1	5.67	6.19
Si + Se at the high conc.	192.0	192.8	26.2	26.5	5.76	5.81	2.92	2.95	85.3	86.5	5.80	6.41
New L.S.D at 5%	2.5	2.6	1.0	0.9	0.06	0.07	0.03	0.03	1.1	1.1	0.27	0.23

Si = Silicon & Se = Selenium

TABLE III
EFFECT OF SINGLE AND COMBINED APPLICATIONS OF SILICON AND SELENIUM ON SOME CHEMICAL CHARACTERISTICS OF THE FRUITS OF ZAGHLOUL DATE PALMS DURING 2011 AND 2012 SEASONS

Treatments	T.S.S %		Total sugars %		Reducing sugars %		Total acidity %		Total soluble Tannins %		Total crude fibre %	
	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012
Silicon (Si) + selenium (Se) at 0.0%	26.3	26.6	20.6	21.0	13.5	13.8	0.419	0.520	0.71	0.74	0.60	0.58
Si at 0.05%	28.1	28.4	22.0	22.4	14.8	15.2	0.359	0.360	0.59	0.62	0.49	0.47
Si at 0.1%	28.2	28.5	22.1	22.5	14.9	15.2	0.357	0.358	0.58	0.61	0.47	0.45
Se at 0.01%	27.2	27.6	21.2	21.5	14.1	14.3	0.394	0.395	0.66	0.70	0.55	0.53
Se at 0.02%	27.3	27.5	21.3	21.6	14.2	14.5	0.391	0.393	0.65	0.71	0.54	0.52
Si + Se at the low conc.	29.7	30.0	23.0	23.4	15.9	16.2	0.311	0.314	0.39	0.42	0.34	0.32
Si + Se at the high conc.	30.0	30.2	23.2	23.5	16.0	16.3	0.308	0.309	0.38	0.41	0.32	0.30
New L.S.D at 5%	0.6	0.7	0.5	0.6	0.4	0.4	0.018	0.019	0.03	0.04	0.04	0.03

Si = Silicon & Se = Selenium

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