

(Original Article)



Yield and Fruit Quality of Sewy Date Palm in Response to Foliar Spray with Silicon and Salicylic Acid

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Abstract

This investigation was conducted at private orchard located at new Assiut city, Assiut, Egypt, during 2020 and 2021 seasons on Sewy date palm grown in sandy soil, to investigate the effect of spraying silicon (potassium silicate) at (2 and 3 cm³/L) and salicylic acid at (2 and 3 g/L) on yield and some physical and chemical fruit properties. The foliar spraying for all treatments were done three times during the season, the first spray was done at beginning of spathes appearing. The second one was applied after fruit setting finally the third one was applied after one month later. The control was sprayed with tap water. The results indicated that spraying silicon (potassium silicate) and salicylic acid was very effective on increasing yield, bunch weight and some physical and chemical fruit characteristics compared to the control. The enhancing associated with the high concentration of such spraying substance. Moreover, Salicylic acid was superior to Silicon in this respect which gave the best results of this study compared with the other investigated treatments.

Keywords: Silicon, Salicylic acid, Potassium, Sewy date, Yield

Introduction

The date palm is one of the oldest fruit trees in the world, and its cultivation is widespread in the tropics, and because palm cultivation is historically linked to the Arab, so the Arab world is the original home of the Arab date palm according to the production of dates. There are many reasons responsible for decreasing yield and quality of fruits like unsuitable environmental conditions and stresses. Nowadays, many studies on silicon and salicylic acid were investigated in this respect for increasing yield and fruit quality.

Silicon (Si) was useful for alleviating the unfavorable effects of water stress on vegetative growth, yield and fruit quality of plants (Epstein, 1999 and Matichenkov *et al.*, 2000). Also, silicon enhancing drought tolerance in plants by increasing photosynthesis activity and maintaining plant water balance, Also, Silicon responsible for stimulate root growth and water transport and antioxidants defense system under unsuitable conditions (Neumann and Zur- Nieden, 2001; Kanto, 2002; Aziz *et al.*, 2002; Melo *et al.*, 2003).

Salicylic acid (SA) known as a natural plant defender and one of the phenolic derivatives widely spread in plant species. It is considered one of the endogenous plant hormones that work on regulating most physiological processes in plants like immune systems and hormones (Popova, 1997 and Waseem *et al.*, 2006). It was also found that Salicylic acid have the ability to improve protection of plants from disease, it can be used to reduce the application of chemical fungicides by inhibiting the enzyme catalase, which subsequently increases hydrogen peroxide H_2O_2 and this increase in plant biosynthesis is a fungicide. (Raskin, 1992; Dihazi *et al.*, 2003; Cao *et al.*, 2006; Babalar *et al.*, 2007). Salicylic acid encourage or inhibit physiological processes in fruits and increment the protein within the plant cells so increased the capability to tolerant of salt stress (Kumer *et al.*, 1999). Spraying 50 mg/ml of salicylic acid at the beginning of the khalal stage in Barhi date palm cultivar led to an improvement in the physical properties of the fruits (Al- Obeed, 2010).

The aim of this experiment was to examining the effect of foliar spraying of Silicon and Salicylic acid on yield and fruit quality of Sewy date palm grown in sandy soil.

Materials and Methods

This experiment was carried out during 2020 and 2021 season on Sewy date palm grown in sandy soil, at private orchard situated at new Assiut city, Assiut, Egypt. Fifteen palms of Sewy date palms 20 years old were selected randomly to examine the effect of silicon and salicylic acid on yield, physical and chemical fruit characteristics. The selected palms were nearly similar in vigor and subjected to the same horticulture managements and pruning to maintain leaf/bunch ratio at 8:1 and 10 bunches was maintained. Artificial pollination of the experimental palms was uniformly performed using the same source of pollen, to avoid residues of xinia and metaxinia.

Randomized complete block design (RCBD) was used in this investigation with three replications. The palm trees were divided into five treatments each treatment was included three replicates, one palm per each replicate.

This investigated included five treatments as follow

- 1-Control (tap water spray) (T1)
- 2-Spraying Silicon (potassium silicate) at 2 cm³/L (T2)
- 3-Spraying Silicon (potassium silicate) at 3 cm³/L (T3)
- 4-Spraying Salicylic acid at 2 g/L (T4)
- 5-Spraying Salicylic acid at 3 g/L (T5)

The foliar spraying for all treatments were done three times, the first spray was applied at beginning of spathes appearing. The second was applied after fruit setting and the third was applied after one month later. The control was sprayed with tap water. Spraying was done till run off all head of palm (leaves and spathes).

Ten strands from three bunches of each palm were marked and then calculated the percentage of fruit setting using equation

$$\text{Fruit set (\%)} = \frac{\text{number of fruit set per strand}}{\text{number of fruit set} + \text{number of total flower scars}} \times 100$$

Before harvesting, the marked strands were collected from each bunch. Then, the percentage of fruit retention was estimated by using equation:

$$\begin{aligned} \text{Fruit retention \%} \\ = \frac{\text{number of settled fruit}}{\text{number of settled fruit} + \text{number of total flower scars}} \times 100 \end{aligned}$$

Finally, all bunches were harvested at first week of October at ripening stage the ripening % was calculated using the equation:

$$\text{Ripening \%} = \frac{\text{number of ripening fruit}}{\text{number of total fruit}} \times 100$$

Bunch weight (kg) was registered. Yield (kg.) was calculated by multiplying bunch weight by 10 (bunches number / palm).

Thirty fruits from each bunch were taken in random to determine the averages of fruit weight (g.), length and width (cm) ,flesh% and seed weight(g) then, T.S.S.% were determined by hand refract meter. Total and reducing sugars and non reducing sugar as well as total acidity % were determined according to A.O.A.C. (1995).

Data were tabulated and statistically analyzed by using Statistix Version 8.1 software. The differences between means were compared using the least significant difference test (LSD) at $P < 0.05$ (Analytical Software, 2005).

Results and Discussion

Fruit set and fruit retention percentages

From the obtained data in Table (1), it's clear that all treatments slightly increased fruit set and retention compared than the control. There are no significant differences found between the treatments on fruit set during both seasons. However, spraying salicylic acid at 3g/L (T5) caused a significant increase in the fruit retention compared with all treatments except (T3). The highest values of fruit set (75.75 and 77.36 %) and fruit retention (54.55 and 54.50 %) were obtained by spraying salicylic acid at 3ml/l (T5) in both seasons, respectively.

Bunch weight and total yield (kg)

Data presented in table (1) show that bunch weight and total yield take the same trend of fruit set and retention, spraying salicylic acid at 3g/L(T5) significantly increased bunch weight and total yield which gave maximum values(13.23 and 14.66 kg) and (132.3 and 146.6) respectively, while the control gave the minimum values. The percentages of increase with using salicylic acid at 3g/L (T5) compared with control were estimated to be (19.08 and 30.89) %during the first and the second seasons, respectively.

Likewise, a positive relationship was found between fruit set and retention on hand and bunch and total yield on the other hand. So, increasing fruit set and retention resulted in increasing the bunch weight and total yield.

Table 1. Effect of Spraying Silicon and Salicylic acid on fruit set % fruit retention %, bunch weight and total yield of Sewy date palm during 2020 and 2021 seasons

Treatments	Fruit set %		Fruit retention%		Bunch weight(kg)		Total yield (kg)	
	2020	2021	2020	2021	2020	2021	2020	2021
T ₁	70.66 a	73.17 a	49.41 c	50.7 4c	11.11c	11.2 c	111.1c	112.0 c
T ₂	72.45 a	73.33 a	51.1 bc	51.80 bc	11.16 bc	11.27 bc	111.6 bc	112.7 bc
T ₃	74.55 a	75.45 a	52.25 ab	53.23 ab	12.73 b	12.94 b	127.3 b	129.4 b
T ₄	73.23 a	74.22 a	51.8 bc	51.86 bc	11.25 bc	11.48 bc	112.5 bc	114.8 bc
T ₅	75.75 a	77.36 a	54.55 a	54.50 a	13.23 a	14.66 a	132.3 a	146.6 a

Control (water spray) (T₁), Spraying Silicon at 2 cm³/L (T₂), Spraying Silicon at 3 cm³/L (T₃), Spraying Salicylic acid at 2 g/L (T₄) Spraying Salicylic acid at 3 g/L (T₅) Si: Silicon SA: Salicylic acid
Values have the same letters inside a column are not significantly different

The increment in fruit set and consequently bunch weight and total yield by salicylic acid application may be due to its effect on enhancing photosynthetic activity in the leaves and translocation photo assimilates to fruits and stimulates cell division and increased tolerance of plants to any stresses like salt stress, water, diseases and protects the cells from oxidation caused by the free radicals (Raskin, 1992; Lee *et al.*, 1995 and Shah, 2003). These results are in harmony with those obtained by (Singh *et al.*, 2003 and Ngullie *et al.*, 2014) and (Ahmed *et al.*, 2015a and Rahmani *et al.*, 2017) indicated that application of salicylic acid at 2.5 g/l recorded the highest fruit retention, number of fruits and total yield per tree. Spraying Zaghoul and Samany date palms significantly increased fruit retention bunch weight and total yield (Badran *et al.*, 2015).the increasing on bunch weight and yield may be due to the role of silicon on stimulating plant growth and increasing of nutrient transport and uptake (Elawad *et al.*, 1982).

Fruit ripening %

Data illustrated on Tables (2, 3) showed that spraying the palms with Salicylic acid and silicon delayed the ripening percentage of fruits compared to control(decreasing the ripening of total yield), especially spraying salicylic acid at 3g/L (T₅) this decrement may be lead to a decrease in the production of ethylene, which is the plant hormone responsible for the ripening of fruits, by inhibiting ethylene and increasing the activity of antioxidants, (Khan *et al.*, 2003; El-Tayeb *et al* 2006 Joseph *et al.*, 2010).

Table 2. Effect of Spraying Silicon and Salicylic acid on ripening%, fruit length, diameter of Sewy date palm during 2020 and 2021 seasons

Treatments	Ripening%		Fruit length (cm)		Fruit diameter (cm)	
	2020	2021	2020	2021	2020	2021
T ₁	53.40 a	54.50 a	4.20 c	4.22 b	2.16 d	2.19 b
T ₂	48.55 a	49.20 b	4.21 bc	4.22 b	2.18 cd	2.19 b
T ₃	43.32 c	43.50 b	4.25 ab	4.27 ab	2.20 ab	2.22 ab
T ₄	39.00 c	38.50 c	4.21 bc	4.23 b	2.19 bc	2.23 a
T ₅	31.22 d	29.50 d	4.27 a	4.31 a	2.21 a	2.24 a

Control (water spray) (T₁), Spraying Silicon at 2 cm³/L (T₂), Spraying Silicon at 3 cm³/L (T₃), Spraying Salicylic acid at 2 g/L (T₄), Spraying Salicylic acid at 3 g/L (T₅) Si: Silicon SA: Salicylic acid
Values have the same letters inside a column are not significantly different

Table 3. Effect of Spraying Silicon and Salicylic acid on fruit, flesh% and seed weight of Sewy date palm during 2020 and 2021 seasons

Treatments	Fruit weight(g)		Flesh %		Seed weight(g)	
	2020	2021	2020	2021	2020	2021
T ₁	16.90 c	17.24 a	88.40 d	88.45 b	1.96 a	1.99 a
T ₂	17.17 c	18.11 a	88.47 d	89.40 ab	1.98 a	1.92 a
T ₃	18.09 ab	18.29 a	89.11 b	89.72 a	1.97 a	1.88 a
T ₄	17.66 b	18.17 a	88.96 c	89.87 ab	1.95 a	1.84 a
T ₅	18.51 a	18.36 a	89.47 a	89.92a	1.95 a	1.85 a

Control (water spray) (T₁), Spraying Silicon at 2 cm³/L (T₂), Spraying Silicon at 3 cm³/L (T₃), Spraying Salicylic acid at 2 g/L (T₄), Spraying Salicylic acid at 3 g/L (T₅) Si: Silicon SA: Salicylic acid
Values have the same letters inside a column are not significantly different

Fruit physical properties

From data it is clear that spraying with salicylic acid and silicon improved most of the physical parameters of fruits namely fruit dimension (length and diameter), fruit weight, flesh% and seed weight than those of the control. In most cases spraying salicylic acid at 3g/L (T₅) caused a significant promotion on fruit dimension (length, diameter), weight and flesh % compared with the other investigated treatments. On the other hand, fruit weight during second season and seed weight during the two experimental seasons were insignificantly affected by various treatments. The effect of salicylic acid could be attributed to reducing respiration rate through inhibition of ethylene and reducing the losses in fruit weight through the closure of the fruit through (Leslie and Romani, 1988; Zheng and Zhang, 2004).

Also, salicylic acid caused stimulating the enzymes it responsible for the process of photosynthesis, which led to the accumulation of manufactured food in the plant and thus an increase in the weight of the fruit (AL-Obeed, 2010).

Moreover, the role of silicon on enhancing physical characters of Sewy date palm could be lead to its effect in increased antioxidant defense systems, transport and uptake of nutrients and water, development of root and increasing tolerance of

the trees to the all stresses (Hattori *et al.*, 2005). These results are in same line with those observed by Al- Wasfy (2013), Gad El- Kareem (2014) decided that spraying of Zaghloul date palms with silicon very effective for enhancing yield and the fruit quality. Rahmani *et al.*, (2017) salicylic acid at 2500 ppm improved physical parameters of fruit quality of mango Kesar cv.

Chemical characteristics

Table (4) shows that spraying silicon (potassium silicate) and salicylic acid insignificant decreased the total acidity compared to the control. Concerning to TSS and sugar content (total, reducing and non reducing sugar) data showed that using Silicon and Salicylic acid increased previous characters compared with control. This increment was significant in most cases during the two seasons. In general treatment of spraying Salicylic acid at 3g/L (T5) gave the highest values compared with control and the other investigation treatments during the two seasons.

These results are accordance with this finding by Gad El- Kareem (2014) who found that spraying Silicon on Zaghloul date palm decreasing total acidity % and increasing T.S.S %, total and reducing sugars % compared to the control treatment. Wassel *et al.* (2015) studied that the foliar spraying of potassium silicate significantly increased TSS in Pomegranate Wonderful cultivar. Ngullie *et al.*, (2014) in mango found that spraying salicylic acid at 2000 ppm gave the highest total soluble solids and reducing sugar (%). On the other hand this results not agreement with Muntaha *et al.*, (2012) stated that spraying salicylic acid on Hilliawi date palm reduced the total soluble solids.

Table 4. Effect of Spraying Silicon and Salicylic acid on acidity, TSS, total sugars, reducing and Non red-sugars of Sewy date palm during 2020 and 2021 seasons

Treatments	Acidity (%)		TSS (%)		Reducing sugar%		Non reducing sugar %		Total sugar %	
	2020	2021	2020	2021	2020	2021	2020	2021	2020	2021
T ₁	0.21 a	0.21 a	51.52b	52.84 c	28.18 b	28.77 c	19.73 b	19.71 d	47.91 c	48.44 b
T ₂	0.20 a	0.19 a	52.23b	53.91 c	28.42 b	29.30 bc	20.87 ab	20.61 c	49.29 bc	49.91 b
T ₃	0.19 ab	0.18 a	55.13 a	58.02 ab	30.03ab	30.51 ab	21.08ab	21.44 b	50.97 a	51.95 a
T ₄	0.19 ab	0.18 a	54.83 a	56.51 b	28.62b	30.33 ab	20.94ab	21.37 b	49.7 a	51.70 a
T ₅	0.18 a	0.17 a	56.28 a	59.91 b	31.09 a	31.23 a	21.75 a	22.54 a	52.84 a	53.77 a

Control (water spray) (T₁), Spraying Silicon at 2 cm³/L (T₂), Spraying Silicon at 3 cm³/L (T₃), Spraying Salicylic acid at 2 g/L (T₄), Spraying Salicylic acid at 3 g/L (T₅) Si: Silicon SA: Salicylic acid
Values have the same letters inside a column are not significantly different

Conclusion

Spraying Sewy date palm with silicon (potassium silicate) and salicylic acid very effective on increasing yield and improving most of fruit physical and chemical characteristics compared with unsprayed trees. Spraying Salicylic acid at 3g/L considered the best treatment under condition of this study.

References

- Ahmed, F.F., Mansour, A.E.M., Merwad, M.A. (2015). Physiological studies on the effect of spraying salicylic acid on fruiting of 'Sukkary' mango trees. *International Journal of Chem Tech Research* 8:2142-2149
- Al-Obeed, R.S. (2010). Improving fruit quality, marketability and storagability of barhee date palm .*World Applied Sciences Journal* 9(6) : 630 – 637.
- Al- Wasfy, M.M. (2013). Response of Sakkoti date palms to foliar application of royal jelly, silicon and vitamins B. *J. of Amer. Sci.* 9 (5): 315 – 321.
- A. O. A. C. (1995). *Official Methods of Analysis* 16th Ed, A.O.A.C Benjamin Franklin Station, Washington, D.C, U.S.A. pp 490 – 510.
- Aziz, T., Gill, M.A and Rahmatullah, R. (2002). Silicon nutrition and crop production: A review. *Pak. J. Agric. Sci.* 39 (3): 181 – 187.
- Babalar, M., Asghari, M., Talaei, A and Khosroshahi, A. (2007). Effect of pre- and postharvest salicylic acid treatment on ethylene production, fungal decay and overall quality of selva strawberry fruitv. *Food Chemistry* 105(2):449-453.
- Badran, M.A.F.; Aly, H.S.H.; Khalil O.A. and Ahmed, A.Y.M. (2015). Improving fruit quality and yield of Zaghoul and Samany date cultivars by spraying with Silicon nutrient. *Assiut J. Agric. Sci.*, 46(6):57-66
- Cao, J., Zeng, K and Jiang, W. (2006). Enhancement of postharvest disease resistance in Ya Li Pear (*Pyrus bretschneideri*) fruit by salicylic acid sprays on the trees during fruit growth . *European Journal of plant pathology* 114(4) ; 363-370.
- Dihazi, A., Jaiti, F., Zouine, J., EL Hassni, M. and EL- Hadrami, I. (2003). Effect of salicylic acid on phenolic compounds related to date palm resistance to *Fusarium oxysporum* f.sp. *albedinis*. *Phytopathologia mediterranea* 42(1) .
- Elawad, S.H.; Gascho, G.J. and Street, J.J (1982). Response of sugarcane to silicate source and rate on growth and yield .*Agronomy Journal*,74: 481-484
- El-Tayeb, M.A., El-Enany, A.E and Ahmed, N.I. (2006). Salicylic acid induced adaptive response to copper stress in sunflower (*Helianthus annuus* L.) *Int. J. Bot.*, 2: 372-379.
- Epstein, E. (1999). Silicon. *Annl. Rev. Plant Physiol. Plant Mol. Biol* 50: 641 – 664.
- Gad El- Kareem, M.R., Abdel Aal, A.M.K and Mohamed, A.Y. (2014). The Synergistic Effects of Using Silicon and Selenium on Fruiting of Zaghoul Date Palm (*Phoenix dactylifera* L.). *International Scholarly and Scientific Research & Innovation* 8(3): 259-262.
- Hattori, T., Inanaga, S., Araki, H., An, P., Mortia, S., Luxova, M. and Lux, A. (2005). Application of silicon enhanced drought tolerance in sorghum bicolor. *Physiologia Plantarum*. 123: 459-466.
- Joseph, B., Jini, D and Sujatha, S. (2010). Insight into the role of salicylic acid on plants grown under salt environment. *Asian J. Crop Sci.*, 2: 226-235.
- Kanto, T. (2002). Research of silicate of improvement of plant defense against pathogens in Japan. *Abstract of Second Silicon in Agriculture Conference* p. 22 – 26.
- Khan, W., Prithviraj, B and Smith, D.L. (2003). Photosynthetic response of corn and soybean to foliar application of salicylates. *J. Plant Physiol.*, 160:485-492.

- Kumar, P., Dube, S.D and Chauhan, V.S. (1999). Effect of salicylic acid on growth, development and some biochemical aspects of soybean (*Glycine max* L. Merrill). Indian Journal of Plant Physiology. 4: 327-330.
- Lee, H.L., Leon, J and Raskin, I. (1995). Biosynthesis and metabolism of salicylic acid. Proceedings of the National Academy of Sciences USA. 92:4076-4079.
- Leslie, C.A., Romani, R.G. (1988). Inhibition of ethylene by salicylic acid. Plant Physiology 88:833-837.
- Matichenkov, V.V., Calvert, D.V and Snyder, G.H. (2000). Prospective of silicon fertilization for citrus in Florida. Proc. Soil and Crop Sci. Soc. of Florida 5 p: 137 – 141.
- Melo, S.P., Korndorfer, G.H., Korndorfer, C.M., Lana, R.M.Q and Santan, D.G. (2003). Silicon accumulation and water deficit tolerance in grasses. Scientia Agricola. 60: 755 – 759.
- Muntaha, A.A., Mu'ayed, F.A., Sabah and AL-Barak, S.H.T. (2012) Effect of spraying salicylic acid on certain fruit characteristic of Hillawi date palm (*Phoenix dactylifera* L.). Basrah j. for date palm research 11 (1):16-38
- Neumann, D. and Zur- Nieden, U. (2001). Silicon and heavy metal tolerance of higher plants. Phytochemistry, 56: 685 – 692.
- Ngullie, C.R., Tank, R.V and Bhanderi, D.R.(2014). Effect of salicylic acid and humic acid on flowering, fruiting, yield and quality of mango (*Mangifera indica* L.) cv. 'Kesar' Advance Research Journal of Crop Improvement 5:136-139.
- Popova, L., Ananieva, E., Hristova, V., Christov, K., Georgieva, K., Alexieva, V and Stoinova, Z. (2003). Salicylic acid and methyl jasmonate induced protection on photosynthesis to paraquat oxidative stress. J. Plant physiol. Special issue, 133-152.
- Rahmani, N., Ahlawat, T., Kumar, S., and Mohammadi, N. (2017). Improving productivity in Mango (*Mangifera indica* L.) cv. Kesar through foliar sprays of silicon and salicylic acid. International Journal of Chemical Studies, 5(6):1440-1443.
- Raskin , I., (1992). Role of salicylic acid in plants . Ann.Rev. Plant physiol . Mol . Biol . 43: 439 - 463 .
- Shah, J. (2003). the salicylic acid loop in plant defense. Plant Biology 6:365-371.
- Singh, B and Usha, K. (2003). Salicylic acid induced physiological and biochemical changes in wheat seedlings under water stress. Plant Growth Regulation 39:137-141.
- Waseem, M., H.U.R. Athar, H.U.R and M. Ashraf, M (2006). Effect of salicylic acid applied through rooting medium on drought tolerance of wheat. Pak. J. Bot., 38(4): 1127-1136.
- Zheng, Y and Zhang, Q. (2004). Effects of polyamines and salicylic acid postharvest storage of Ponkan mandarin. Acta Hort., 632: 317-320.

استجابة محصول وجودة ثمار البلح السيوى للرش بالسيليكون وحامض الساليسليك

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الملخص

أجريت هذه الدراسة على أشجار نخيل البلح السيوى المنزرع في تربة رملية في الوادي الأسيوطي بمحافظة اسيوط وذلك لدراسة تأثير الرش بالسيليكون (سليكات بوتاسيوم) بتركيز 2 و 3 سنتميتر مكعب لكل لتر وايضا الرش بحامض الساليسليك بتركيز 2 و 3 جرام لكل لتر على المحصول الكلى للأشجار وبعض الصفات الفيزيائية والكيميائية للثمار وقد تم إجراء عملية الرش بالمركبات السابقة بمعدل ثلاث راشات في كل موسم وكانت الرشة الاولى في بداية خروج الاغاريض والرشة الثانية بعد العقد والرشة الثالثة بعد شهر من الرشة الثانية، أوضحت النتائج المتحصل عليها ان الرش بالسيليكون(سليكات البوتاسيوم) وحامض الساليسليك أدى إلى زيادة عقد الثمار والذي انعكس بدوره على وزن السوباطة والمحصول الكلى للأشجار وأيضا أدى إلى زيادة وتحسين بعض الصفات الفيزيائية والكيميائية للثمار مقارنة بمعاملة الكنترول (الرش بالماء فقط). كما أوضحت النتائج أن الرش بحامض بالساليسليك كان افضل من الرش بالسيليكون حيث أعطى أفضل النتائج مقارنة بالكنترول وباقي المعاملات تحت ظروف هذه التجربة.