Available online free at www.futurejournals.org

The Future Journal of Agriculture

Print ISSN: 2687-8151 Online ISSN: 2687-8216

Future Science Association

Future J. Agric., 4 (2021) **1-9** **OPEN ACCES**

DOI: 10.37229/fsa.fja.2021.11.01

RESPONSE OF SAKKOTI DATE PALM TO SPRAYING ABSCISIC ACID

Abd El-Hamied, M.M. Wassel; Hamdy I.M. Ibrahim* and Ahmed H. Abobakr

Horticulture Department, Faculty of Agriculture, Minia University, **Egypt.**

***Corresponding author:** hamdy_france@yahoo.com **Received:** 1 Oct. 2021 **; Accepted:** 1 Nov. 2021

ABSTRACT: Sakkoti cultivar is one of the most important and wide dry variety in Aswan Governorate. (**Hussien Fathy, 2005 and Ibrahim, 2011**). A remarkable decrease in yield (kg/palm) and fruit quality characteristics of Sakkoti under Aswan Governorate conditions were observed in last decade (**Al-Bakry 2020**). In order to study the effect of spraying abscisic acid (ABA) at different concentration on leaves mineral content, yield, and fruit physical and chemical properties of Sakkoti date palm trees (*Phoenix dactylifera* L), a field experiment was conducted in two successive seasons (2018 and 2019) at a private farm located at Edfo, Aswan Governorate. The obtained results confirmed that spraying Sakkoti date palm with ABA at 150, 300 and 450 ppm significantly enhanced leaves mineral contents (i.e. nitrogen%, phosphorus%, potassium%, iron ppm, Zinc ppm and manganese ppm), yield (kg)/tree and bunch weight (kg), as well as fruit physical and chemical properties (i.e. fruit length (cm), fruit dimensions (cm), TSS%, total and reducing sugars%), compared to untreated palms. However, the total acidity% and crude fibers % were significantly decreased rather than untreated palms. The maximum values in above mentioned parameters were observed when the palms received ABA at 450 ppm three times yearly. Furthermore, increasing ABA concentration from 300 ppm to 450 ppm failed to enhance some studied parameters significant. The results of the present work showed that spraying ABA at 450 ppm plays a remarkable role in improving leaf mineral contents, yield kg/palm and fruit physical and chemical properties of Sakkoti date palm under Aswan Governorate conditions.

Key words: Date palm, abscisic acid, crude fibers, fruit quality, mineral contents.

INTRODUCTION

Date palm belongs to order of Palmae, and family Palmaceae. Which include the genus *Phoenix* and genera *dactylifera*. This genus includes all known date palm varieties (**Zaid & Wet 2002)**. The date palm is one of the old fruits trees as old as agriculture. The date palm considered as one of the tropical and subtropical region fruits (**Zaid & Wet 2002; Hodel & Johnson 2007**). Date palm is one of the widely cultivated fruits in Egypt (**Hussien-Fathy 2005)**. Its cultivation dates back to the early Pharaonic civilization Era. The inscriptions on pharaonic temples indicate its cultivation, as well as the artificial pollination of trees and some industries based on it are cited (**Hussien-Fathy 2005 and Haider *et al.*, 2013)**. Among all Egyptian Governorate, Aswan rank the fourth position after Behaira, Sharkia and New Valley. The total number of female palms reached 113220 feddans planted with 14093265 palms produce 1563687 ton yearly. However, dry dates covered all the acreage area. Number of Sakkoti female palms reached 143347 palms produce 12201 tons, and Bentimoda female palms reached 12305 which produce 10321 tons yearly (Annual Reports of statistical Institute of Agric. Economic Res., Ministry of Agric. and Reclamation 2018). Sakkoti considered as the most important cultivars in Aswan rejoin, it is one of the most important and wide dry varieties in Aswan Governorate. It is also called Barakawi or Ibremi, in reference to the Ibrem village, ancient Nubia region. Sakkoti fruit is medium-sized, irregular, pointed top. The fruit has a smooth peel, dark yellow color in bisir stage, which turns to brown close to red in the tamer stage. Fruit flesh is sweet taste. Fruit length

ranges from 40 to 60 mm. Seed is small size, thin, pointed at the top and rounded at the base (**Hussien Fathy, 2005**).

Abscisic Acid (ABA), also known as abscisin II, its chemical molecular formula is $C_{15}H_{20}O_4$. ABA considered as one of the most famous growth regulators, it can regulate plant growth and also are termed plant hormone. It can be degraded into phaseic acid by the enzyme named (+)-Abscisic acid 8-hydroxylase. ABA is an inhibitory hormone in plant that helps a plant adapt to stress, it plays a key role in the closure of the plants stomata, bud development and seed dormancy.

During the last decades, a remarkable decrease in yield (kg/palm) and fruit quality characteristics of Sakkoti date palm under Aswan Governorate conditions were observed (**Al-Bakry 2020**). Then, the present investigation focused on the role of ABA treatments on nutritional status, yield and fruit quality of Sakkoti date palm under Aswan Governorate.

MATERIAL AND METHODS

The present investigation was carried out during two successive seasons 2017 and 2018 on sixteen derived offshoots Sakkoti date palms, uniform in vigor and free from insects and diseases. The palms were ten years and grown in private orchard located at Edfu, Aswan Governorate where the soil texture is loamy clay and well drained. The orchard was irrigated through surface system using Nile water. The palms were planted at 8 X 8 meters apart. Pruning was performed to maintain leaf/bunch ratio at 8:1. The number of female spathes per palm was adjusted to 10 spathes by removing excess earliest, latest and small bunches. Pollination of the experimental palms was uniformly performed to avoid residues of metaxenia. Pollination was achieved by inserting four male strands into the female bunch using known high activity pollen source throughout 2-3 days after female spathe cracking (**Hussein *et al.*, 1993 and Dammas, 1998**). The pollen grains viability was determined through the following two methods (According to **Mohamed *et al.*, 2014**).

The selected palms are subjected to regular horticulture practices that were commonly applied in the orchard including fertilization, irrigation, hoeing and pest management.

Soil characters: The orchard soil where the present experiment carried out was loamy clay soil (table 2). A composite soil sample was collected and subjected to physical and chemical analysis according to the procedures outlined by **Walsh and Beaton (1986)**, the obtained data are shown in Table (2).

Table 1. Physical and chemical analysis of orchard soils

Constituents	Values
Sand %	8.10
Silt %	52.82
Clay %	39.08
Texture	Silty Clay
EC (1 : 2.5 extract) mmhos / cm / 25 C	0.95
Organic matter %	2.32
pH (1 : 2.5 extract)	7.7
Total CaCO3 %	1.70
N %	0.11
Available P (Olsen, ppm)	6.60
Exch. K^+ (mg/100g)	432.10
Exch. Ca^{++} (mg/100g)	19.8

Experimental work

In order to study the effect and the suitable dose of ABA on Sakkoti date palm, three doses of ABA namely; 150 ppm, 300 ppm and 450 ppm were examined on the present experiment. This study included the following four treatments of ABA; Control (0.0 ppm ABA) sprayed the palms with tap water. Spraying Sakkoti palms with ABA at 150 ppm. Spraying Sakkoti palms with ABA at 300 ppm. Spraying Sakkoti palms with ABA at 450 ppm. The palms were received ABA three times yearly: just after fruit setting, during Kimri stage (one month after fruit setting) and one month later. Each treatment was replicated four times, one palm per each. Wetting agent (Triton B) at 0.05 % was added to all treatments. The treatments were arranged complete randomized design (RCBD).

Different determinations

The following characters i.e. leaf mineral content, yield as well as physic-chemical characters of fruits were determined during the two experimental seasons.

1- Determination of macro and micro elements (N, P, K, Mg, Zn and Fe) in leaves: A six months old labeled leaf per palm was removed (at the first week of August annually) the medium four leaflets were taken according to **Martin-Préval *et al.*, (1984) and Ibrahim (2010).** The samples were washed several times with tap water and rinsed with distilled water and air-dried at 70 °C for 72 hrs. Then, the leaflets grounded, 0.5 g weight was digested using H_2SO_4 and H_2O_2 until clear solution was obtained **(Martin-Préval *et al.*, 1984)**. The digested solution was quantitatively transferred to 100 ml volumetric flask and completed to 100 ml by distilled water. Thereafter, contents of N. P, K, Mg, Zn and Fe for each sample were determined as follows: Nitrogen was determined by the modified microkejldahl method as described by **(Martin-Préval *et al.*, 1984)**. Phosphorus was determined by using colorimetric method, described by **Walsh and Beaton (1986)**. Potassium was flam-photometrically determined by using the method outlined by **Martin-Préval *et al.*, (1984)**, and Mg, Zn and Fe were by determined using atomic absorption method (**Martin-Préval *et al.*, 1984)**

2- Yield and bunch weight: Bunches of Sakkoti date palm were picked at the optimum commercial harvesting time under Aswan region conditions (**Mahmoudm, 2017**). The yield of each palm was recorded in terms of weight in kilograms/palm, by multiplying the average bunch weight (kg) by total number of bunches per palm (ten bunches).

3- physical and chemical characteristics of fruits: samples of one hundred dates from the yield of each palm were taken randomly and the following physical and chemical characteristics were measured:

3-1: Measurement of fruits physical properties: Average weight of fruit estimated using top pan balance of 0.01g sensitivity, flesh weight was recorded ant the % of flesh % were calculated. Fruit dimensions (height and diameter (cm) were measured, using vernier caliper. Edible (flesh weight) to non-edible portions (seed weight) was calculated (flesh/seed) according to **Ibrahim (2010)**.

3-2: Determination of fruits chemical properties: Sample of 100 gram of fruit flesh was added to 100 ml distilled water and stand 4 hours, then the samples minced will with electric blender, the following chemical parameters determination: T.S.S % was determined by using hand refractometer. Total and reducing sugars%, by using Lane and Eynone (**Rangana, 1977).** Then, non-reducing sugars were calculated. Total acidity % by titration against 0.1 NaOH using phenolphthalein as an indicator (**A.O.A.C, 1995)**. Crude fiber % by using acetic acid glacial and nitric acid at 10:1 solution (**according to A.O.A.C., 1995**).

Statistical analysis of data

All the obtained data were tabulated and subjected for the proper statistical analysis; using the statistical package MSTATC Program. Comparisons between means were made by the F-test and least significant differences (L.S.D) at p= 0.05 (**Snedecore & Cochran, 1990 and Rangaswamy, 1995).**

RESULTS AND DISCUSSION

Effect of spraying ABA on leaf mineral contents

Leaf macro nutrients contents (NPK)

Data illustrated in Tables (2) shows that, the leaf contents in nitrogen, phosphorus and potassium percentages of Sakkoti date palm were remarkable increased significantly due to sprayed ABA at 150, 300 and 450 ppm, during the two experimental seasons, rather than untreated palms (control). Moreover, such increase was gradually enhanced parallel to increase in the concentration of ABA from 150 to 450 ppm. While, non-significant differences in potassium contents were observed, except the case of the palms received the highest concentration of ABA. Furthermore, Sakkoti palms received the highest ABA concentration (450 ppm) present the higher nitrogen (1.99 & 1.97%), phosphorous (0.29 & 0.31%) and potassium (1.47 & 1.48%) percentages in their leaflets, during both experimental seasons respectively. on the opposite side untreated palms (control) present the lowest N, P, K percentages in there leaves, these data were true during the two seasons.

Leaves micro nutrients content (Fe, Zn and Mn)

Obtained data in Table (2) show that leaflets contents in Fe, Zn and Mn (ppm) of Sakkoti date palm was significantly increased due to

treated the palms with ABA at 150, 300 and 450 ppm, during the two experimental seasons.

Furthermore, Sakkoti palms received the highest ABA concentration (450 ppm) present the highest Fe (99 & 122 ppm), Zn (56 & 58 ppm) and Mn (67 & 69 ppm) in their leaflets, during both seasons respectively. It is clear from the same table that, regardless the concentration used of ABA any treatment of ABA present high and significant leaflet Fe, Zn and Mn rather than those of untreated palms. Contrary, the lowest values of iron (35 & 37 ppm), Zinc (39 & 38 ppm) and Manganese (42 & 43 ppm) were obtained from untreated palms, during the two experimental seasons respectively.

The promotion in leaves contents in macro (nitrogen, phosphorus & potassium %) and micro nutrients (Fe, Zn & Mn ppm) as a result of spraying ABA at different concentrations in the present investigation may be attributed to the positive effect of ABA as a plant hormone on increasing mineral elements availability, uptake and translocation (**Popova, *et al.*, 1995**; **Ruiz *et al.*, 1997; Peuke *et al.*, 2002; Hirayama and Shinozaki 2007; Marschner 2012** and **Barickman *et al.*, 2014 a&b**). Also, **Hirayama and Shinozaki (2007)** mentioned an indirect role of ABA in controlling stomata closure as well as ABA cab activate the efflux of ions efflux throughout ion channels. This can enhance K ion efflux and inhibit K ions influx channels to promote stomata closure (**Ruiz *et al.*, 1997**). ABA also regulates the repetitive free Calcium ions elevation in cells (**Hirayama and Shinozaki, 2007**).

Table 2. Leaf mineral nutrients of Sakkoti date palm as affected by spraying ABA at different concentration, during 2018 and 2019 seasons

Treatments	N%		P%		K%		Fe (ppm)		Zn (ppm)		Mn (ppm)	
	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
Control	1.51	1.52	0.15	0.14	1.18	1.19	35	37	39	38	42	43
ABA 150 ppm	1.79	1.68	0.23	0.25	1.30	1.31	78	82	48	47	59	61
ABA 300 ppm	1.84	1.89	0.26	0.28	1.36	1.40	92	104	51	51	60	66
ABA 450 ppm	1.91	1.97	0.29	0.31	1.47	1.48	99	122	56	58	67	69
Mean	1.76	1.77	0.23	0.25	1.33	1.35	76	86	49	49	57	60
$LSD_{0.05}$	0.28	0.26	0.07	0.07	0.24	0.25	19	20	10	9	12	17

Effect of spraying ABA on yield and bunch weight

Data illustrated in Table (3) shows the effect of spraying different concentrations of ABA on yield and average bunch weight of Sakkoti cultivar, during 2018 and 2019 seasons. It is clear from the obtained data that, treating Sakkoti cultivar with ABA at 150, 300 and 450 ppm was followed by stimulating bunch weight (kg) and yield/palm (kg) significantly relative to the control treatment, during the two experimental seasons. This stimulation concerning the two parameters was positively related to increasing ABA concentrations from 150 to 450 ppm. However, the data show that ABA especially at 300 ppm and 450 ppm was capable to increase significantly the bunch weight (kg). Spraying Sakkoti palms with any one of ABA concentration was capable to increase bunch weight (kg) and yield kg/palm. However, the palms received the highest concentration (450 ppm) present the highest bunch weight (13.1 & 13.4 kg) and yield/palm (131 & 134 kg/palm). Contrary, untreated palms present the lowest bunch weight and yield/palm (11. & 11.1 kg for bunch weigh and 111.0 & 111.0 kg/palm), similar trend was noticed during both seasons.

The obtained data concerning the positive effect of ABA on bunch weight (kg) and yield (kg/palm) of Sakkoti date palm are in harmony with those obtained in other fruit trees such as; **Iamsub *et al.* (2007)** on apple trees *cvs.* Tsugaru Yataka and Fuji and peach trees *cv.*

Akatsuki**; Greene *et al.*, (2011)** on apple trees *cvs.* McIntosh and Fuji; **Omran (2011)** on Redglobe grapevines and **Khalil (2020)** on Flame seedless grapevines.

The positive effect of abscisic acid on yield (kg/palm) and average bunch weight (kg) of Sakkoti date palm might be attributed to their role in protecting the palm from biotic and abiotic stress, enhancing the cell to building of some organic acids and the biosynthesis of carbohydrates and enhance nutrients uptake and localization (**Hazzouri *et al.*, 2020**). In addition, ABA enhancing some plant antioxidants biosynthesis which are responsible for enhancing biosynthesis of some plant enzymes, (**Abo-bakre, 2021**).

Table 3. Bunch weight, yield/palm and fruit physical properties of Sakkoti date palm as affected by spraying ABA at different concentration, during 2018 and 2019 seasons

Treatments	Bunch weight (kg)		Yield (kg/palm)		Fruit weight		Fruit length (cm)		Fruit diameter (cm)		Flesh (%)	
	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
Control	11.1	11.1	111.0	112.0	9.01	9.08	3.8	3.8	1.9	1.9	88.4	88.2
ABA 150 ppm	12.7	12.2	127.0	129.0	9.43	9.27	4.2	4.4	2.3	2.3	90.0	89.7
ABA 300 ppm	12.9	13.1	129	131.0	9.87	9.91	4.6	4.8	2.4	2.5	91.9	91.8
ABA 450 ppm	13.1	13.4	131.0	134.0	10.11	10.22	4.7	4.9	2.4	2.5	92.1	92.9
Mean	12.5	12.7	124.5	126.5	9.61	9.64	4.4	4.5	2.3	2.3	90.6	90.7
$LSD_{0.05}$	0.8	0.9	9.5	9.9	0.5	0.4	0.3	0.4	0.2	0.2	1.2	1.3

Effect of spraying ABA on fruit physic chemical properties

Effect on fruit physical properties

Data concerning the effect of spraying ABA at different concentrations (0.0, 150, 300 and 450 ppm) on fruit weight (g) dimensions (cm) and flesh % of Sakkoti date palm trees during 2018 and 2019 seasons are shown in Tables (3). It is obvious from this Table that subjected Sakkoti date palm to three sprays of ABA (at 0.0 to 450 ppm) was significantly accompanied with enhancing all physical properties of fruit i.e. fruit weight (g), fruit length (cm), fruit diameter (cm), and flesh % relative to the control treatment, during the two experimental seasons.

It is noticed from the obtained data that the promotion of physical properties was parallel with increasing ABA concentrations from 150 to 450 ppm. Numerically, increasing the concentration of ABA from 0.0 ppm to 450 ppm caused a remarkable promotion on fruit weight (12.2 & 12.5%), fruit length (23.7 & 28.9%), fruit diameter (26.3 & 31.8%) and only by 4.2 & 5.8% for flesh%. However, the palms received the highest concentration of ABA (450 ppm) present the highest fruit weight (10.11 & 10.22 g), length (4.7 & 4.9 cm), fruit diameter (2.4 & 2.5 cm) and flesh/fruit ratio (92.1 & 92.4 %), during the two seasons respectively. on the opposite side, untreated palms present the lowest fruit weight (9.01& 9.08 g), fruil length (3.8 & 3.8 cm), fruit diameter (1.9 & 1.9 cm) and flesh % (88.4 & 88.2%), during the two seasons respectively.

The obtained data concerning fruit physical properties were in harmony with those obtained by other authors on different fruit trees, such as: **Tijero *et al.* (2016)** on sweet sherry (*Prunus avium* L.) cultivar Prime Giant; **Moustakime *et al.* (2017)** on olive trees cultivar Picholine; **Setha (2012)** and **Harhash *et al.* (2019)** on Wonderful *Punica granatum* trees; **Liu (2019)** on *Prunus persica* L. cultivar and **Kumar *et al.* (2020)** on Kent mangos trees.

Effect on fruit chemical properties

Data concerning the effect of ABA concentration on TSS%, reducing sugars and total sugars% total acidity% and crude fibers%

in Sakkoti date palm fruits during 2018 and 2019 seasons are shown in Table (4).

1: Effect of ABA on fruit TSS and Sugars %

It is clear from the obtained data in Table (4) that spraying the Sakkoti date palm with ABA three times yearly at 150, 300 and 450 ppm significantly was responsible for improving the fruit TSS%, total sugars%, and reducing sugars%, rather than untreated palms. This promotion was associated with increasing concentration of ABA from 0.0 to 450 ppm, the data were true during the two seasons.

It is clear from the obtained data that treating Sakkoti date palm with ABA at 450 ppm presents the highest total soluble solids (70.9% & 71.4%), highest total sugars (71.9% & 72.2%) and reducing sugars (14.8% & 14.9%), during the two seasons respectively. On the opposite side, unfavorable effect on fruit TSS% and sugars contents were observed on untreated trees, however, the lowest values were obtained in untreated plants (67.9 & 68.0 % for TSS; 65.4 & 65.5% for total sugars and 13.1 & 13.3% for reducing sugars), during 2018 and 2019 seasons respectively.

2: Effect of ABA on total acidity % and crude fiber %

Obtained data illustrated in Table (4) concerning the response of Sakkoti date palm during the present study revealed that the total acidity % and crude fibers % decreased gradual and significant as a result of increasing ABA concentrations from 0.0 ppm to 450 ppm, during 2018 and 2019 seasons.

Furthermore, spraying Sakkoti date palm with 450 ppm gave the lowest percentages of total acidity (0.291 & 0.281 %) and crude % (1.29 & 1.31 %) followed by those received 300 ppm (0.291% & 0.281% for total acidity and 1.29% & 1.31% for crude fiber). On the opposite side, untreated palms present the highest total acidity (0.393% & 0.381%) and crude fiber (1.99 % & 1.95 %), during the two experimental seasons respectively.

Table 4. Fruit chemical properties of Sakkoti date palm as affected by spraying ABA at different concentration, during 2018 and 2019 seasons

Treatments	TSS %		Total Sugars %		Reducing sugars %		Total acidity %		Crude fiber %	
	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
Control	67.9	68.0	65.4	65.5	13.0	13.3	0.393	0.381	1.99	1.95
ABA 150 ppm	70.6	70.1	68.0	67.6	13.9	13.9	0.352	0.322	1.55	1.49
ABA 300 ppm	72.1	72.7	69.8	70.2	14.1	14.6	0.302	0.309	1.31	1.41
ABA 450 ppm	73.3	74.8	71.9	72.2	14.8	14.9	0.291	0.281	1.29	1.31
Mean	70.9	71.4	68.7	68.9	14.0	14.2	0.353	0.323	11.54	1.54
LSD $_{0.05}$	1.2	1.1	1.0	1.1	0.8	0.9	0.042	0.031	0.20	0.29

The remarkable favorable effect of spraying ABA on Sakkoti date palms fruit quality could be explained by its high positive effect on photosynthsis activity and improving effect of plant tolerances to abiotic stress that may be lead to more carbohydrates productions and accumulations in fruits. Thus, can be explained its major effect on enhancing fruit chemical properties (**Gent and Mc-Avoy, 2000**). The higher concentration of ABA may be cause enhancement of vitamins, amino acids as well as antioxidant biosynthesis, these can play an important role in improve fruit chemical properties, i.e. decreasing of total acidity% and crude fiber %. ABA has been indicated as a ripening promoter in many non-climacteric fruits, such as strawberry (**Jia *et al.*, 2011; Li *et al.*, 2015 and Jia *et al.*, 2016**) grape berries; **Luo *et al.*, 2014** on sweet cherry; **Zhang *et al.*, 2014** on citrus fruits; **Forlani *et al.* (2019)** on pear trees; **Yuan and Huang (1988)** and **Singh *et al.* (2014)** on litchi, also on climacteric fruits, such as peach and mango by **Jiang *et al.* (2000**) on banana . Moreover, the direct role of ABA in fruit ripening was mentioned in strawberry fruits by suppressing the expression of the key ABA biosynthetic gene, blocking ABA biosynthesis and leading to partly uncolored

strawberry fruits that could be rescued by exogenous ABA (**Jia *et al.*, 2011**).

Similar results concerning the effect of ABA on fruit chemical properties were obtained by: **Hartmann and Wisler (1968)** on olive trees; **Singh *et al.* (2014)** on litchi fruits; **Tijero *et al.* (2016)** on (*Prunus avium* L.) Prime Giant Sweet cherry; **Villalobos-Gonzalez (2016)** on Carmenere grapevines; **Rehman *et al.* (2018)** on Navel orange M7; **Harhash *et al.* (2019)** on Wonderful pomegranate and **Kumar *et al.* (2020)** on mango trees cultivar Kent. **Hazzouri *et al.* (2020)** on Date palm trees.

Conclusion: It is strongly recommended to spray Sakkoti date palms grown under Aswan Governorate conditions and resembling conditions with abscisic acid (ABA) at 450 ppm three times at just after fruit sett, at kamary stage and one month later, in order to improve the nutritional status, yield and fruit physic–chemical properties.

REFERENCES

Abo-Bakr, A.H. (2021). Effect of spraying Abscisic acid (ABA) on growth and fruit quality of Sakkoti and Bentimoda date palms. Ph.D. Thesis, Horti. Depart. Fac. of Agric. Minia Univ. El-Minia – Egypt.

Al-Bakry, I.M. (2020). Response of Sakkoti date palms to foliar application of seaweed extract. B.Sc. Fac. Of Agric. Minia Univ. 2015.

A.O.A.C. (1995). Association of Official Agricultural: Chemists. Official Methods of Analysis. 12th Ed., Benjamin Franklin station, Washington D.C., U.S.A., pp: 490-510.

Barickman, T.C.; Kopsell, D.A. and Sams, C.E. (2014 a). Abscisic acid increases carotenoid and chlorophyll concentrations in leaves and fruit of two tomato genotypes. J. Amer. Soc. Hort. Sci., 139(3): 261–266.

Barickman, T.C.; Kopsell, D.A. and Sams, C.E. (2014 b). Exogenous foliar and root applications of abscisic acid increase the influx of calcium into tomato fruit tissue and decrease the incidence of blossom. HortScience, 49: 1397–1402.

Dammas, M.O. (1998). Fruit growth and receptivity of pistillate flowers pollination in two date palm cultivars (*Phoenix dactylifera L.*) M.Sc. Thesis Fac. Enviro. & Arid land Agric. King Abdel Aziz Univ., pp: 50-57.

Forlani, S.; Masiero, S. and Mizzotti, C. (2019). Fruit ripening: the role of hormones, cell wall modifications, and their relationship with pathogens. J. Exp. Bot. 70, 2993–3006. doi: 10.1093/jxb/erz112

Gent, M.P.N. and Mc-Avoy, R.J. (2000). Plant growth retardants in pomology horticulture: A critical appraisal, p. 89–145. In: Basra, A.S. (ed.). Plant growth regulators in agriculture and horticulture: Their role and commercial uses. The Haworth Press, Inc., Binghamton, NY.

Greene, D.W.; Schupp, J.R. and Winzeler, H.E. (2011). Effect of abscisic acid and benzyladenine on fruit set and fruit quality of apples. Hortsciece, 46 (4): 604–609.

Haider, M.S.; Khan, I.A.; Naqvi, S.A.; Jaskani, M.J. and Khan, R.W. (2013). Fruit development stage effect on biochemical attributes in date palm. Pak., J. Agric. Sci., 50: 577-583.

Harhash, M.M.; Aly, M.A.M.; Abd El-Megeed, N.A. and Ben Hifaa, A.B.S. (2019). Effect of some growth regulators, nutrient elements and kaolin on cracking and fruit quality of pomegranate Wonderful cultivar. J. Adv. Agric. Res. (Fac. Agric. Saba Basha), 24 (3): 280-297.

Hartmann, H.T.A.J.H. and Wisler, J. (1968). Chemical induction of fruit abscission in olive. Calif. Agric., 22: 14–16.

Hazzouri, K.M.; Flowers, J.M.; Nelson, D.; Lemansour, I.A.; Masmoudi, K. and Amiri, K.M.A. (2020). Prospects for the Study and Improvement of Abiotic Stress Tolerance in Date Palms in the Post-genomics. Frontiers in Plant Sci.,11 (293): 1-13.

Hirayama, T. and Shinozaki, K. (2007). Perception and transduction of abscisic acid signals: Keys to the function of the versatile plant hormone ABA. Trends Plant Sci., 12: 343–351.

Hodel, D.R. and Johnson, D.V. (2007). Imported and American varieties of dates in USA. California Univ., Agric. & Natural Resources 112 pp.

Hussein, F.; El-Kholy. M.H and Abo-Said Ahmed, T.A. (1993). Organic- chemical

constituents of some Egyptian dry date cultivars grown at Aswan. Zagazig J. Agric. Res., 20(4): 1313-1321.

Hussien, Fathy, A.A. (2005). Date palm, life tree, between past, present and future. Arbic version, Arab House for Publishing & Distribution, Cairo – Egupt. Pages 64:66.

Iamsub, Y.; Sekozawa, Y.; Sugaya, S.; Gemma, H. and Kamuro, Y. (2007). Improvement of fruit quality by S-ABA and the fertilizer formulated K, P, Mg, B, Mn containing S-ABA as free harvest application on peaches and apples. ISHS Acta Horti. 804: Europe-Asia Symposium on Quality Management in Postharvest Systems - Eurasia 2007.

Jia, H.F.; Chai,Y-M.; Li, C.L. ; Lu, D. ; Luo, J.J.; Qin, L. and Shen, Y-Y. (2011). Abscisic acid plays an important role in the regulation of strawberry fruit ripening. Plant Physiol., 157(1): 188-199.

Jia, H.; Jiu, S.; Zhang, C.; Wang, C.; Tariq, P.; Liu, Z. (2016). Abscisic acid and sucrose regulate tomato and strawberry fruit ripening through the abscisic acid-stress-ripening transcription factor. Plant Biotechnology J., 14: 2045–2065.

Jiang, Y.; Joyce, D.C.; Andrew J. and Macnish, A.J. (2000). Effect of Abscisic Acid on Banana Fruit Ripening in Relation to the Role of Ethylene. J Plant Growth Regul., 19: 106–111.

Ibrahim, H.I.M. (2010). Plant samples, collection and analyses. 1st Edition, Dar Al Fajr Publishing & Distrib., Cairo – Egypt. P350.

Ibrahim, H.I.M. (2011). Fruit trees production under Sandy Soil conditions. 1st Edition, Dar Al Fajr Publishing & Distrib., Cairo – Egypt. P350.

Kumar, S.U.; Maurer, D.; Feygenberg, O. and Alkan, N. (2020). Improving the red color and fruit quality of 'Kent' mango Fruit by pruning and preharvest spraying of prohydrojasmon or abscisic acid. Agronomy 2020, 10(7), 944; https://doi.org/10.3390/agronomy10070944.

Li, D.; Li, L.; Luo, Z.; Mou, W.; Mao, L. and Ying, T. (2015). Comparative transcriptome analysis reveals the influence of abscisic acid on the metabolism of pigments, ascorbic acid and folic acid during strawberry fruit ripening. *PLoS ONE* 10:e0130037. doi: 10.1371/journal.pone.0130037

Luo, H.; Dai, S.; Ren, J.; Zhang, C.; Ding, Y. and Li, Z. (2014). The role of ABA in the maturation and postharvest life of a nonclimacteric sweet cherry fruit. J. Plant Growth Regul. 33, 373–383. doi: 10.1007/s00344-013-9388-7.

Liu, N. (2019). Effects of IAA and ABA on the Immature Peach Fruit Development Process. Horticultural Plant J., 5 (4): 145-154

Mahmoud, M.S.Y. (2017). Effect of spraying Silicon on fruiting of Sakkoti date palms. Ms.C. Hortic. Depart. Fac. Agric. Minia Univ. – Egypt.

Marschner, H. (2012). Mineral. Nutrition of Higher Plants, 3rd ed.; Academic Press: London, UK, 2012.

Martin-Préval, P.; Gagnard, J. and Gautier, P. (1984). L'analyse végétale dans le contrôle de l'alimentation des plantes tempères & tropicales. Technique et Documentation – Lavoisier, Paris, France.

Mohamed, S.; Shabana, H.R. and Aziz, F.M. (2014). Investigation on the storage viability and germination of date pollen of different mal cultivars. Palm and Dates Res, Conf. Tech. Bull. No. 1-15 pp.

Moustakime, Y.; Hazzoumi, Z. and Joute, K.A. (2017): Effect of the exogenous application of abscisic acid (ABA) at fruit set and at veraison on cell ripeness of olives *Olea europaea L.* and the extractability of phenolic compounds in virgin olive oil. Chem. Biol. Technol. Agric. (2017) 4:23.

Omran, Y.A.M. (2011). Enhanced yield and fruit quality of Redglobe grapevines by abscisic acid (ABA) and ethanol application. J. Int. Sci. Vigne & Vin., 45(1): 13-18.

Peuke, A.; Jeschke, W.D. and Hartung, W. (2002). Flows of elements, ions and abscisic acid in Ricinus communis and site of nitrate reduction under potassium limitation. J. Exp. Bot. 2002, 53: 241–250.

Rangaswamy, R. (1995). Randomized Complete Block Design. In a Text Book of Agricultural Statistics. New Ager. International Publishers, pp 281-309.

Rehman, M.; Singh, Z. and Khurshid, T. (2018). Pre-harvest spray application of abscisic acid (S-ABA) regulates fruit colour development and quality in early maturing M7 Navel orange. Scientia Horticulturae, 229: 1-9.

Ruiz, D.; Martinez, V. and Cerda A. (1997). Citrus response to salinity: growth and nutrient uptake. Tree Physiology 1997, 17: 141–150.

Snedecor, G.W. and Cochran, W.G. (1990). Statistical Methods, 7th Ed. The Iowa State Univ. Press Ames. pp 80-100.

Setha, S. (2012). Roles of abscisic acid in fruit ripening. Walailak J. Sci. & Tech., 9(4): 297-308.

Singh, S.P.; Saini, M.K.; Singh, J.; Pongener, A. and Sidhu, G.S. (2014). Preharvest application of abscisic acid promotes anthocyanins accumulation in pericarp of litchi fruit without adversely affecting postharvest quality. Postharvest Biol. Technol., 96, 14–22.

Tijero, V.; Teribia, N.; Munoz, P. and Munne-Bosch, S. (2016). Implication of Abscisic Acid on Ripening and Quality in Sweet Cherries: Differential Effects during Pre- and Post-harvest. Frontiers in Plant Sci. volume 7, article 602.

Villalobos-Gonzalez, L.; Pena-Neira, A.; Ibanez, F. and Pastenes, C. (2016). Long-term effects of abscisic acid (ABA) on the grape berry henylpropanoid pathway: gene expression and metabolite content. Plant Physiol & Biochem., 105: 213–23.

Walsh, L.M. and Beaton, J.D. (1986). Soil testing and plant analysis. 6th Edition. Editor, Soil Science Society of America, Inc. pp 489.

Yuan, R. and Huang, H (1988). Litchi fruit abscission: Its patterns, effect of shading and relation to endogenous abscisic acid. Sci. Hort., 36: 281–292.

Zaid, A. and Wet, P.E. (2002). Date palm propagation. FAO plant production and protection. 156: 73-105.

Zhang, Y.J.; Wang, X.J.; Wu, J.X.; Chen, S.Y.; Chen, H. and Chai, L.J. (2014). Comparative transcriptome analyses between a spontaneous late-ripening sweet orange mutant and its wild type suggest the functions of ABA, sucrose and JA during citrus fruit ripening. PLos One 9:e116056. doi: 10.1371/journal.pone.0116056