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YIELD AND FRUIT QUALITY OF BERTIMODA DATE PALM IN RELATION TO ABSCISIC ACID (ABA) APPLICATION

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ABSTRACT: Bertimoda is classified as one of the finest class dry date palm varieties in Aswan Governorate, has good taste and excellent flavour. (**Hussien, 2005 and Ibrahim, 2011**). In last decade a remarkable decrease in yield and fruit some quality characteristics of Bertimoda *cv*. under Aswan Governorate conditions were observed (**Al-Bakry 2020**). In order to study the response of Bentimoda palms (*Phoenix dactylifera* L.) to spraying abscisic acid (ABA) at 150, 300 and 450 ppm on leaves mineral content, fruit set and retention%, yield (kg/palm), and fruit physic-chemical properties. A field experiment was conducted in two successive seasons (2018 and 2019) at a private farm located at Edfo, Aswan Governorate was take place. The obtained results confirmed that all ABA concentrations (150, 300 and 450 ppm) used has a positive effect on 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%) rather than untreated ones. While, the total acidity% and crude fibers % were significantly decreased rather than untreated palms. For all physic-chemical properties of fruit, non-significant differences were observed between the two highest concentrations (300 ppm and 450 ppm). Then, it is recommended to foliar spray Bertimoda date palm grown under Aswan governorate conditions with ABA at 300 ppm in order to improve nutritional state, yield/palm, fruit physical and chemical properties. leaves mineral contents

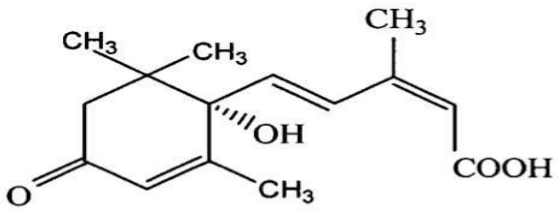
Key words: Bentimoda palms, abscisic acid, yield, phytochemical, fruit retention%, leaves mineral contents

INTRODUCTION

Date palm belongs to family Palmaceae. Which include the genus Phoenix and genera dactylifera. This genus includes all known date palm varieties (**Zaid & Wet, 2002**). Date palm is one of the widely cultivated fruits in Egypt (**Hussien, 2005**). Its cultivation dates back to the early Pharaonic civilization. (**Hussien, 2005** and **Haider *et al.*, 2013**). Among all Egyptian Governorate, Aswan rank the fourth position after Behaira, Sharkia and New Valley. However, dry dates covered all the acreage area.

Bertimoda cultivar is classified as one of the finest class dry date palm varieties cultivated in Aswan region. It is also called Antimode or Bertimoda. Bertimoda date has good taste and excellent flavour. The fruit has a large size ranging between 50 to 60 mm in long and 21 mm in diameter. Fruit color in bisir stage is orange, mottled with red. Then turning to light brown in Tamr stage. Fruit pulp has a light, soft and non-sticky texture pulp **(Hussien, 2005)**.

Abscisic Acid (ABA) is also known as abscisin II, its chemical molecular formula is $C_{15}H_{20}O_4$. Abscisic Acid 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 phasic acid by the enzyme named (+)-Abscisic acid 8-hydroxylase.



Abscisic acid is an inhibitory hormone in plant that helps a plant adapt to stress. It also plays a key role in the closure of the plants stomata, bud development and seed dormancy.

A remarkable decrease in yield (kg/palm) and fruit quality characteristics of Bertimoda date palm under Aswan Governorate conditions were observed during the previous ten years (**Al-Bakry 2020**). Then, the present investigation focused on the role of ABA treatments on nutritional status, yield and fruit quality of Bertimoda date palm under Aswan Governorate.

MATERIAL AND METHODS

Date palm (*Phoenix dactylifera* L.) cultivar Bertimoda trees grown in private orchard located at Edfu, Aswan Governorate (Egypt), where the soil texture is loamy clay and well drained, were used in the present investigation. This investigation was conducted during two consecutive seasons 2018 and 2019 on sixteen derived offshoots Bertimoda date palms. The chosen palms were uniform in vigor, free from insects and diseases. The palms were ten years and irrigated through surface system using Nile water and were planted at 8 X 8 meters apart. Palms 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**).

Bertimoda dare palm were subjected to regular horticulture practices that were commonly applied in the orchard including fertilization, irrigation and hoeing as well as pest management.

Soil characters

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/25C	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 effect of different concentration of ABA on Bertimoda date palm, three doses namely; 150 ppm, 300 ppm and 450 ppm were examined. This study included the following four treatments of ABA; Control (0.0 ppm ABA) sprayed the palms with tap water, Spraying Bertimoda palms with ABA at 150 ppm; 300 ppm and 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 spraying solutions. The treatments were arranged complete randomized design (RCBD).

Different determinations

The following characters leaf mineral contents, fruit setting and fruit retention, yield as well as physic-chemical characters of fruits were determined during the two experimental seasons.

1- Leaf mineral contents (N, P, K, Mg, Zn and Fe): 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 Bertimoda date palm were picked at the commercial harvesting time under Aswan region conditions. 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 and the % of flesh % was calculated. Fruit dimensions (height and diameter in 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, 1989)**. Crude fiber % by using acetic acid glacial and nitric acid at 10:1 solution (**according to A.O.A.C., 2000**).

Statistical analysis of data

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

RESULTS AND DISCUSSION

Effect of spraying ABA on leaf mineral contents

Leaf macro nutrients contents (NPK)

Data in Table (2) shows that, leaves content in macro nutrients; nitrogen, phosphorus and potassium of Bertimoda date palm were significantly enhanced as a result of spraying ABA at 150, 300 and 450 ppm compared to untreated palms, the results were true in both experimental seasons. Moreover, the leaf mineral increases were positively correlated 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 highest concentration of ABA, which gave higher and significant leaf potassium content rather than untreated once. Bertimoda palms received ABA at 450 ppm present highest nitrogen (1.99 & 2.33 %), phosphorous (0.27 & 0.27 %) and potassium (1.36 & 1.42 %) percentages in their leaflets, during both experimental seasons respectively.

On the contrary, untreated palms (control) present the lowest N (1.59 & 1.60 %), P (0.15 & 0.14 %), K (1.19 & 1.21 %) percentages in there leaves, the data were true during the two seasons.

Leaf micro nutrients contents

Data illustrated in Table (2) shows the effect of spraying ABA at 150, 300 and 450 ppm on Bertimoda leaf Fe, Zn and Mn ppm during 2018 and 2019 seasons. it is clear from this table that, all the three micronutrients significantly enhanced during the two experimental seasons as a result of ABA application. However, this increment was parallel to increasing ABA concentration. The palms received ABA at higher concentration (450 ppm) present the higher contents in the three micro-nutrients (70 & 79 ppm for Fe; 44 & 43 ppm for Zn and 48 & 49 ppm for Mn contents), during the two experimental seasons respectively. On the opposite side, untreated palms present the lowest Fe, Zn and Mn, during both seasons respectively.

These results are in harmony with those obtained by; **Solar (2003); Al-Absi** and

Archbold (2016); Barickman *et al.* (2019); Dawuda *et al.* (2020) and **Mahmoud (2021**). The promotion in Bertimoda leaflet contents in macro (nitrogen and phosphorous %) and micro nutrients (Fe, Zn and Mn) 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 (**Peuke *et al.*, 2007; Hirayama & Shinozaki 2007; Marschner 2012;** and **Barickman *et al.*, 2014 a&b**). The indirect role of ABA in controlling stomatal closure has been extensively studied. ABA cab activate the efflux of Cl ion efflux throughout ion channels, this can enhancing K ion efflux and inhibit K ions influx channels to promote stomatal closure (**Ruiz *et al.*, 1997**). Furthermore, ABA also regulates the repetitive free Calcium ions elevation in cells (**Ruiz *et al.*, 1997** and **Hirayama & Shinozaki 2007**).

Table 2. Leaf mineral contents of Bertimoda 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	1.59	1.60	0.15	0.14	1.19	1.21	42	46	37	33	36	37
ABA 150 ppm	1.77	1.79	0.19	0.21	1.28	1.29	62	79	42	41	43	49
ABA 300 ppm	1.91	1.95	0.24	0.26	1.30	1.37	85	89	47	45	52	52
ABA 450 ppm	1.99	2.03	0.27	0.27	1.36	1.42	92	102	50	50	57	59
Mean	**1.82**	**1.84**	**0.21**	**0.23**	**1.28**	**1.33**	**70**	**79**	**44**	**43**	**48**	**49**
LSD $_{0.05}$	**0.07**	**0.09**	**0.06**	**0.05**	**0.12**	**0.18**	**13**	**15**	**5**	**6**	**7**	**8**

Fruit sett%, fruit retention %, bunch weight (kg) and yield (kg/palm)

Fruit set and fruit retention %

Both fruit setting % and fruit retention % of Bertimoda date palm were significantly increase in both experimental seasons, due to spraying ABA at different concentration (Table 3). Such increment in both traits was gradual parallel to the gradual increase of ABA concentration with the highest values being given due to the high ABA concentration (450 ppm). Furthermore, Bertimoda date palms received ABA at higher concentration (450 ppm) give the highest fruit sett % (61.1% & 62.4%) and fruit retention (36.3% & 37.2%), in both experimental seasons respectively. Contrary, the lowest percentages of fruit sett (51.7% & 51.3 %) and fruit retention (28.5 & 29.1 %) were obtained from untreated palms.

Enhancing fruit setting% and fruit retention % as a result of spraying ABA was also reported by **Greene *et al.* (2011)** on apples cultivars Macintosh and Dilip; **Chung–Ruey (2013)** on wax apple and **Tomoko *et al.* (2018)** on satsuma mandarin.

The role of ABA in flowering and fruit setting as well as fruit retention of date palm and other fruit trees has mainly been studied and reviewed by **Greene *et al.* (2011).** ABA is generally enhancing fruit sett and fruit retention % in apple cultivars Macintosh and Fuji. Where the authors explained this positive effect of ABA on fruit sett and retention by the role of ABA on several physiological events in trees, similar opinion was already illustrated by **Addicott and Lyon (1969); Gent, and McAvoy (2000)** and **Lakso *et al.* (2006).** Applied ABA might enhance floral initiation and fruit setting by enhancing transport of Indol acetic acid to floral parties, that may be increase fruit setting and retention (**Addicott and Lyon (1969) and Gent, and McAvoy (2000)**. It has also been suggested that ABA effect indirectly by delaying floral bud formation and its role en enhancing nutritional statue of fruit trees (**Peuke *et al.*, 2007; Hirayama & Shinozaki 2007; Marschner 2012;** and **Barickman *et al.*, 2014a&b**).

Table 3. Fruit sett %, fruit retention %, bunch weight (kg) and yield (kg/palm) of Bertimoda date palm as affected by spraying ABA at different concentration, during 2018 and 2019 seasons

Treatments	Fruit Setting %		Fruit retention %		Bunch weight (kg)		Yield (kg/palm)	
	2018	2019	2018	2019	2018	2019	2018	2019
Control	51.7	51.3	28.5	29.1	11.0	10.7	110.0	107.0
ABA 150 ppm	57.9	59.3	32.1	33.5	11.8	11.8	118.0	118.0
ABA 300 ppm	59.6	61.2	35.5	35.1	12.3	12.7	123.0	127.0
ABA 450 ppm	61.1	62.4	36.3	37.2	12.9	13.1	129.0	131.0
Mean	**57.7**	**58.6**	**33.1**	**33.7**	**12.0**	**12.1**	**120.0**	**120.8**
LSD $_{0.05}$	**3.1**	**3.7**	**3.9**	**3.5**	**0.9**	**0.7**	**6.0**	**8.0**

Bunch weight (kg) and Yield (kg/palm)

Data illustrated in Table (3) show the effect of spraying different concentrations of ABA on bunch weight (kg) and yield kg/palm of Bertimoda date palm, during 2018 and 2019 seasons. It is clear from the obtained data that, treating Bertimoda cultivar with ABA at 150 to 450 ppm was followed by stimulating bunch weight (kg) and yield/palm (kg) significantly relative to the control treatment, during both experimental seasons (Table 3). This stimulation on these two parameters was gradual and parallel to increasing ABA concentration from 150 to 450 ppm. However, the highest bunch weight (12.9 kg & 13.1 kg) and yield kg/palm (129 kg & 131.0 kg) were obtained due to spraying ABA at 450 ppm. on the opposite side, the lowest bunch weight (11.0 kg & 10.7 kg) were obtained from untreated palms.

The obtained data concerning the positive effect of ABA on bunch weight (kg) and yield (kg/palm) of Bertimoda date palm was in harmony with those obtained by **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 ABA on yield (kg/palm) and average bunch weight (kg) of Bertimoda 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. Moreover, through ABA role in enhancing the biosynthesis of some antioxidants, which have an essential role in regulation the metabolism and are responsible for physiological processes **(Castellarin *et al.*, 2016; Luo *et al.*, 2013 and Wang *et al.*, 2015).**

Fruit physical properties

Fruit of Bertimoda date palm in terms fruit weight, fruit dimensions (length and diameter) and flesh % (w/w) were significantly enhanced in both experimental seasons, due to spraying ABA at different concentration (Table 3). Such increment in all physical properties was gradual parallel to the gradual increase of ABA concentration with the highest values being given due to the high ABA concentration (450 ppm) as shown in Table (4). Furthermore, Bertimoda palms received ABA at higher concentration (450 ppm) give the highest fruit weight (9.71 g & 9.82 g) and fruit dimensions (4.1 cm & 4.2 cm for length and 2.7 cm & 2.7 cm for diameter) and flesh % (91.0 & 91.4 %) in both experimental seasons respectively, however in this respect non-significant differences were observed between the two highest concentrations (300 ppm and 450 ppm). Contrary, the lowest values of fruit physical properties (8.67 & 8.59 g

for fruit weight; 3.4 & 3.5 cm for fruit length; 1.9 and 1.8 cm for fruit diameter and 86.7 & 86.5 % for flesh %) were obtained from untreated palms.

A good number of authors reached the conclusion that treated fruit trees or other horticulture plants enhanced significantly all fruit physical properties such as: **Tijero *et al.* (2016)** on sweet sherry (Prunus avium L.) cultivar Prime Giant; **Moustakime *et al.* (2017)** on olive trees cultivar Picholine; **Harhash *et al.* (2019)** on Wonderful Punica granatum trees; **Liu *et al.* (2019)** on Prunus persica L. cultivar Dajiubao and **Kumar *et al.* (2020)**, on Kent mangos trees.

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

Treatments	Fruit weight (g)		Fruit height (cm)		Fruit diameter (cm)		Flesh %	
	2018	2019	2018	2019	2018	2019	2018	2019
Control	8.67	8.59	3.4	3.5	1.9	1.8	86.7	86.5
ABA 150 ppm	9.01	9.12	3.8	3.9	2.4	2.5	88.2	88.7
ABA 300 ppm	9.42	9.56	4.0	4.2	2.5	2.6	90.4	90.6
ABA 450 ppm	9.71	9.82	4.1	4.2	2.7	2.7	91.0	91.4
Mean	**9.20**	**9.26**	**3.83**	**3.95**	**2.4**	**2.5**	**89.1**	**89.3**
LSD $_{0.05}$	**0.30**	**0.34**	**0.2**	**0.3**	**0.3**	**0.4**	**1.1**	**1.4**

Fruit chemical properties

Data illustrated in Table (5) indicated the positive effect of ABA at 150, 300 and 450 ppm on chemical properties (in terms of increasing TSS%, total sugars% and reducing sugars% as well as decreasing total acidity% and crude fiber%) of Bertimoda dates in the two seasons. significant differences were existed between such two ABA concentrations treatments, except those between the two higher concentrations, on one hand and both control and anyone of ABA treatment on the other hand. The data were true in both experimental seasons. The data illustrated in Table (5) shows that the palms received the highest ABA concentration (450 ppm) present the best fruit chemical quality properties in terms of highest TSS%, total sugars%, reducing sugars % and non-reducing sugars %, also present the low total acidity % and crude fiber %. Furthermore, non-significant differences were observed between the two higher concentrations. Contrary untreated palms present a negative effect with all chemical parameters, similar results were observed during the two experimental results.

These results, regarding the effect of different concentrations of ABA on Bertimoda date palms fruit quality are in harmony with those obtained by other authors on different fruit trees, such as: **Luo *et al.* (2013)** sweet cherry fruit**; Wang *et al.* (2015**) sweet cherry fruit; **Castellarin *et al.* (2016)** in grapevines**; Tihero *et al.* (2016)** on Sweet cherry (*Prunus avium* L.) cultivar Prime Giant; **Villalobos-Gonzalez (2016)** on Carmenere grapevines; **Rehman *et al.* (2018)** on orange cultivar Navel orange M7; **Harhash *et al.* (2019)** on pomegranate cultivar Wonderful and **Kumar *et al.* (2020)** on mango trees cultivar Kent.

Table 5. Fruit chemical properties of Bertimoda date palm as affected by spraying ABA at different concentration, during 2018 and 2019 seasons

Treatments	TSS %		Total Sugars %		Non reducing sugars %		Reducing sugars %		Total acidity %		Crude fiber %	
	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
Control	66.8	66.8	64.2	63.3	51.5	51.4	12.7	11.8	0.397	0.388	2.01	1.99
ABA 150 ppm	68.9	68.2	66.8	65.5	53.5	52.7	13.3	12.8	0.367	0.331	1.87	1.71
ABA 300 ppm	71.3	72.4	68.5	69.2	54.9	55.4	13.6	13.8	0.311	0.308	1.65	1.50
ABA 450 ppm	72.1	73.1	70.0	70.8	55.4	56.6	14.0	14.2	0.299	0.298	1.44	1.43
Mean	**69.6**	**69.7**	**67.4**	**67.2**	**53.8**	**54.2**	**13.4**	**13.1**	**0.344**	**0.331**	**1.74**	**1.67**
LSD $_{0.05}$	**1.2**	**1.2**	**1.3**	**1.7**	**0.9**	**1.3**	**0.6**	**0.8**	**0.044**	**0.032**	**0.21**	**0.20**

Recommendation

It is strongly recommended to foliar spray Bertimoda date palm grown under Aswan governorate conditions with ABA at 300 ppm three times yearly "just after fruit sett, at the start of Kimri stage and one month later" in order to improve nutritional state, yield/palm, fruit physical and chemical properties.

REFERENCES

Abo-Bakr, A.H. (2021). Effect of spraying Abscisic acid (ABA) on growth and fruit quality of Sakkoti and Bertimoda 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.

Castellarin, S. D.; Gambetta, G. A.; Wada, H.; Krasnow, M. N.; Cramer, G. R.; Peterlunger, E. (2016). Characterization of major ripening events during softening in grape: turgor, sugar accumulation, abscisic acid metabolism, colour development, and their relationship with growth. J. Exp. Bot., 67: 709–722.

Dammas, M.O. (1998). Fruit growth and receptivity of pistillate flowercs 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. Hortscience 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. Agr., 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.; 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.; 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.

Jia, H.F.; Chai,Y-M.; Li, C.L. ; Lu, D. ; Luo, J.J.; Qin, L.; 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.; Li, C.; Chai, Y.; Xing, Y. and Shen, Y. (2013). Sucrose promotes strawberry fruit ripening by stimulation of abscisic acid biosynthesis. Pak. J. Bot., 45: 169–175.

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. and Andrew J. 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, 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. J.; Ren, J.; Zhang, C. X.; Ding, Y.; Li, Z., (2013). The role of ABA in the maturation and post-harvest life of a non-climacteric sweet cherry fruit. J. Plant Growth Regul., 33: 373–383.

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

Ranganna, S. (1977). Manual analysis of fruit and vegetable products. Edition Tata Mc Grow-Hill Publishing Company, New Delhi India, 634 P.

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, 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.

Wang, Y.; Chen, P.; Sun, L.; Li, Q.; Dai, S.; Sun, Y. (2015). Transcriptional regulation of PaPYLs, PaPP2Cs and PaSnRK2s during sweet cherry fruit development and in response to abscisic acid and auxin at onset of fruit ripening. Plant Growth Regul., 75: 455–464.

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. (2011). Foliar Application of Abscisic Acid Induces Dormancy Responses in Greenhouse-grown Grapevines Hortiscience, 46(9):1271–1277.

Zhang, Y.J.; Wang, X.J.; Wu, J.X.; Chen, S.Y.; Chen, H.; 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.