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EFFECT OF SPRAYING SOME GROWTH REGULATORS; SALICYLIC ACID; CALCIUM AND BORON ON YIELD AND FRUIT QUALITY OF BARHEE DATE PALMS

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ABSTRACT: The present study was conducted during two successive seasons of 2015 and 2016 on 10-years-old Barhee date palms (*Phoenix dactylifera* L.) grown in sandy soil under drip irrigation system in a private orchard located at El-Saddat District, Menoufia Governorate, Egypt. Bunches of the experimental palms were sprayed with six treatments as follows: water (control); gibberellin (GA_3) and Naphthalene acetic acid (NAA) (each at 50, 100 and 50 ppm); salicylic acid (at 50, 50 and 100 ppm) boric acid and calcium/boron, each at (2000, 1500 and 1000 ppm). All the previous treatments were sprayed three times, the 1st was at one day before pollination, the 2nd was at the beginning of kimri stage and the 3rd was at the beginning of fruit color break (khalal or bisr stage), respectively. All the spraying solutions were supplied with 0.25% urea. Generally, NAA and GA_3 treatments gained the highest value of each yield/palm; weight/bunch and number of fruits/spikelet without significant differences between them in most cases in both seasons. While spraying catro calcium (calcium + boron) gained the highest value of each yield/palm and weight/spikelet in the two seasons compared to the control, which recorded the lowest value for each of all the tested characteristics in both seasons. In addition, GA_3 and NAA treatments produced the highest value for each of all fruit physical characteristics without significant differences between them except for the fruit dimensions in the two seasons. The highest seed weight was recorded for boric acid treatment in the two seasons, without significant difference with the control and salicylic acid treatments in the second season only. Moreover, the control treatment gained the lowest value for each of all physical fruit characteristics except seed weight in the second season. GA_3 and NAA treatments achieved the highest value of each TSS% and TSS/acid ratio and the lowest content of peel carotene in the two seasons. While each of the control, boric acid and salicylic acid treatments recorded the highest percentage of fruit acidity in the two seasons. The highest chlorophyll content in the fruit peel was recorded for salicylic acid treatment.

Key words: Date palm, *Phoenix dactylifera*, GA_3, NAA, calcium, boron, salicylic acid, yield and fruit quality.

INTRODUCTION

The date palm fruits (*Phoenix dactylifera* L.) are highly demanded and consumed throughout the world, especially in the Middle East. According to the Statistics of the total cultivated area of palms reached 99.17 thousand faddans (51.11 thousand faddans in the old lands and the rest 48.06 thousand faddans in the new lands). The total number of female palm trees reached about 12,261 million palms producing about 1.31 million tons of fruits with an average of 106 kg per palm, The number of date palm trees in the old lands is 9.898 million palm trees, producing 1.14 million tons of fruits with an average of 115.17 kg fruits per palm, while in the new lands, the number of date palms is 2.362 million producing 227.82 thousand tons of fruits with an average of 96.45 kg fruits per palm. The fruitful number of palm trees in the ancient land

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represents about 80.7% of the total fruitful palms in Egypt, Barhee is a certain date palm cultivar which harvested and consumed at the Khalal stage when its fruits reach full maturity (partially-ripe) with yellow color. In this stage, this cultivar is less astringent than other cultivars that are harvested when they are fully ripen. However, once ripened, this cultivar has a short shelf life (**Hong *et al*., 2006**). In the mean time, dates consumers are looking for fruits with greater color and bigger size. The small fruit size of Barhee dates is another limiting factor that influences its marketing. Thus, it would be beneficial to improve quality characters and to prolong the Khalal stage of these cultivar in order to expand their shelf life and marketing ability. Plant growth regulators play an important role in regulating fruit growth and development. Some of these substances were used in controlling ripening date (delayed ripening) as well as improving the fruit quality, which act for increasing the income and the revenue of farmers. Spraying NAA (1-Naphthaleneacetic acid) was found to increase fruit size, weight and delay ripening (**Shabana *et al*., 1998; Al-Juburi *et al*., 2000; Al-Juburi *et al*., 2001a; Aboutalebi and Beharoznam 2006**). Also, gibberellin (GA_3) increased fruit weight and delayed fruit ripening (**Hussein *et al*., 1996; Moustafa and Seif 1996; Moustafa *et al*., 1996 ; Ghazawy *et al.*, 2005**). In addition, Salicylic acid (SA) is a simple phenolic compound and it is recognized as a plant growth regulator, because of its external application effect on many plant growth physiological processes. Salicylic acid was reported to retard ethylene synthesis (**Leslie and Romani, 1988**). Also, it has been recognized that SA is required for inducing systemic resistance against some pathogenic infections (**Gaffney *et al.*, 1993 ; Vernooij *et al*., 1994**). **Sayyari *et al*. (2009)** indicated that SA improved fruit quality during cold storage of pomegranate. Boron levels were ranged between 3 and 8 mg kg^{-1} in soil specimens, and 1–6 mg kg^{-1} in fruits and leaves. Moreover, "off" trees have lower levels of boron in date leaves than in "on" trees in the Bisir stage of development. The Ca/B ratio, in most cases, occurred between 700 and 1500 for leaves, and between 150 and 300 for fruit **(Pillay *et al*., 2005). Omar *et al.* (2015)** found that, spraying date palm bunches twice; 2 hr., before pollination and 4 weeks after pollination, with boric acid (B) alone (1500 ppm) or combined with zinc sulphate (300 ppm), get a positive effect on fruit set, total yield, and fruit quality of "Mnifi" date palm. Calcium plays a fundamental role in plant growth and development. Many extracellular signals and environmental cues including light, abiotic and biotic stress factors, elicit change in the cellular calcium levels, termed as calcium signatures (**Wu *et al*., 2013**). **El-Khawaga (2013)** found that the anti-salinity agents as calcium alleviated the adverse effects of salt stress on growth of Sewy, Zaghloul and Hayany date palm cultivars. In accordance to the previous mentioned, the present study was conducted to investigate the effect of spraying GA_3; NAA; salicylic acid (SA); Ca + boron; and boric acid on improving yield and fruit quality of Barhee dates.

MATERIALS AND METHODS

The present study was conducted during two successive seasons of 2015 and 2016 on 18 healthy, 10-years-old Barhee date palms (*Phoenix dactylifera* L.) grown in El-Banna private date palm orchard located at El-Saddat District, Menoufia Governorate, Egypt. The experimental palms were selected to be healthy, nearly similar in vigor and uniform, the palms received the normal horticulture practices which applied in the commercial orchard except for the tested treatments. All palms were pollinated with the same male pollen palm in both seasons. The palms were grown in sandy soil under drip irrigation system. Palms were subjected to six spraying treatments with three replicates per treatment and three bunches for each replicate (6 treatments × 3 replicates × 3 bunches = 54 bunches on 18 palms), treatments were arranged in a complete randomized design and the experimental bunches were sprayed three times in each season as follows: the 1st spray was carried out one day before pollination, the 2nd spray was done at the beginning of kimri stage and the 3rd spray was carried out at the beginning of fruit color break (khalal or bisr stage), respectively.

The spraying treatments were as follows:

1. Spraying with water (control).
2. Spraying with GA_3 at 50, 100 and 50 ppm, respectively.
3. Spraying with NAA at 50, 100 and 50 ppm, respectively.

4. Spraying with salicylic acid at 50, 50 and 100 ppm, respectively.
5. Spraying with boric acid at 2000, 1500 and 1000 ppm, respectively.
6. Spraying with calcium / boron (catro calcium 10% calcium + 0.5% boron) at 2000, 1500 and 1000 ppm, respectively.

The spraying solutions for all treatments were supplied with 0.25% urea. Spraying was conducted by small hand gun sprayer until run-off. Wetting agent Tween 20 (1%) was applied with spraying solution. Fruits were harvested at full mature stage at the beginning of October, according to skin color (the whole fruit should be yellow, and the yellowish green area should not exceed 10%) and the percentage of soluble solids content (SSC%) greater than 28% (**Hegazy *et al*., 2003**).

The following measurements were carried out:

Yield / palm (kg)

At harvest (beginning of October in both seasons), bunches were separated and weighed, and the total yield/palm was estimated.

Average bunch weight

Average bunch weight was estimated by dividing the total yield/ palm on the number of bunches/ palm.

Average fruit number / strand

The number of fruits on 10 random strands was counted and the average number/strand was calculated.

Fruit physical properties

Samples of 30 fruits per each treatment (10 fruits from each bunch (as a replicate) were randomly taken to determine fruit weight, flesh weight, seed weight (g) fruit length and diameter (cm) and volume cm^3.

Fruit chemical properties

Fruit chemical properties were determined at harvest; total soluble solids percentage was measured by a hand refractometer; acidity percentage was determined by titration against 0.1 NaOH according to **AOAC (1995)**, carotene and total chlorophyll contents (mg/100 g peel fresh weight) were determined by the method of **Welburn (1994)**.

The obtained data were subjected to the statistical analysis of variances (ANOVA) according to **Snedecor and Cochran (1980)** using CO-STAT program. Means separation was done at 5% level.

RESULTS AND DISCUSSION

Effect of Some Foliar Spraying Treatments on Yield (Kg/tree) and Yield Components of Barhee Date Palm

Regarding yield/tree (kg), results in Table 1 show that, yield/ tree was significantly increased by GA_3 treatment at 50, 100 and 50 ppm, respectively recording the highest yield/ tree (165.12 and 180.00 kg/palm in the 1st and 2nd seasons, respectively, without significant differences with both of NAA and Ca + B at 2000, 1500 and 1000 ppm, respectively in the two tested seasons. On the other hand, control treatment (spraying with water) exhibited the lowest yield (152.20 and 164.48 kg/palm) in the 1st and 2nd seasons, respectively. The other tested treatments gained intermediate yields.

As for bunch weight (kg), the same trend was observed, as such, GA_3 treatment produced the heaviest bunches (27.52 and 30.00 kg) in the 1st and 2nd seasons, respectively, without significant differences with those treated by NAA and Ca + Boron in both seasons. Control treatment recorded the lowest bunch weight (25.37 and 27.41 kg) in the 1st and 2nd seasons, respectively. The other tested treatments came in between.

Concerning the average fruit number/strand of Barhee date palm, Table 1 showed that GA_3 treatment produced the highest fruit number/ strand (21.45 and 22.77 fruit/strand) without significant differences with those treated by NAA at 50, 100 and 50 ppm, respectively in both seasons. On the other hand, control treatment gained the lowest fruit number/strand (19.11 and 19.99 fruit/strand) in the 1st and 2nd seasons, respectively.

Generally, NAA and GA_3 treatments produced the highest values of each yield/palm; bunch weight and number of fruits/ strand without significant differences with those treated with Catro calcium (Ca+B) in both seasons compared to control, which achieved the lowest values for all the tested characteristics in both seasons.

Table 1. Effect of some foliar spraying treatments on yield /tree, bunch weight and fruit number/ strand of Barhee date palm (2015and 2016 seasons)

Spraying treatment	First season (2015)			Second season (2016)		
	Yield /tree (Kg)	Bunch weight (kg)	Fruit number/ strand	Yield /tree (Kg)	Bunch weight (kg)	Fruits number/ strand
Water (control)	152.20c	25.37c	19.11c	164.48d	27.41d	19.99c
GA_3 (50, 100 and 50 ppm)	165.12a	27.52a	21.45a	180.00ab	30.00ab	22.77a
NAA (50, 100 and 50 ppm)	163.42ab	27.24ab	21.00a	183.76a	30.63a	22.66a
Boric acid (2000, 1500 and 1000 ppm)	159.64b	26.61b	19.67bc	178.72bc	29.79bc	21.26b
Ca + Boron (2000, 1500 and 1000 ppm)	162.20ab	27.03ab	20.11b	180.02ab	30.00ab	20.56bc
Salicylic acid (50, 50 and 100 ppm)	153.80c	25.63c	19.44bc	174.68c	29.11c	20.34c

Means followed by the same letter (s) within each column are not significantly different.

The obtained results confirm those obtained on date palm since the application of GA_3 at 100 or 150 ppm significantly decreased fruit drop of palm, while NAA had the least effect in this respect (**El-Kassas, 1983 ; Hussein *et al.*, 1993; Tavakkoli *et al.*, 2007; Al-Qurashi *et al.*, 2012**).

Effect of some Foliar Spraying Treatments on Physical Characteristics of Barhee Date Fruits

Results in Table 2 indicate that spraying bunches with different treatments had a significant effect on the average fruit weight and volume of Barhee date palms in both seasons. Foliar spray with GA_3 recorded the maximum fruit weight (14.36 and 11.92 g) and volume (13.77 and 11.98 cm^3) in the 1st and 2nd seasons, respectively, without significant differences with those treated by NAA in both tested seasons. On the other hand, control treatment exhibited the lowest fruit weight (9.63and 9.84 g) and volume (8.65 and 7.53 cm^3) in both seasons, respectively. The other tested treatments came in between.

Moreover, spraying bunches with GA_3 recorded the maximum values of fruit length (3.60 and 3.20 cm) and diameter (2.69 and 2.37 cm) in the 1st and 2nd seasons, respectively, without significant differences with those treated by NAA in fruit length.

In addition, foliar spray with GA_3 recorded the maximum fruit flesh weight (13.20 and 10.48 g) in the 1st and 2nd seasons, respectively, without significant differences with those treated by NAA and Catro calcium (Ca + B) in the second season only. Control treatment gained the lowest fruit flesh weight (8.24 and 8.47 g) in the two seasons, respectively. The other tested treatments recorded intermediate values.

Spraying bunches with boric acid at 2000, 1500 and 1000 ppm, respectively. recorded the highest seed weight (1.72 and 1.56 g) in the 1st and 2nd seasons, respectively, without significant differences with those treated by NAA in both seasons, and almost all tested treatments, except those treated by Ca + B in the second season. Whereas, the lowest seed weight was recorded for GA_3 treatment (1.16 g) without significant differences with control and each of Ca + B and salicylic acid treatments in the first season, while, in the second season, the lowest seed weight (1.20 g) was recorded for Ca + B without significant differences with all tested treatments except boron treatment .

As a general, GA_3 and NAA treatments achieved the highest values for all fruit physical characteristics, except seed weight in the first season for GA_3 and fruit dimensions of the first season and the fruit diameter in the second season

Table 2. Effect of some foliar spraying treatments on physical characteristics of Barhee date fruits (2015 and 2016 seasons)

Spraying treatment	First season (2015)						Second season (2016)					
	Fruit weight (g)	Fruit volume (cm^3)	Fruit length (cm)	Fruit diameter (cm)	Flesh weight (g)	Seed weight (g)	Fruit weight (g)	Fruit volume (cm^3)	Fruit length (cm)	Fruit diameter (cm)	Flesh weight (g)	Seed weight (g)
Water (control)	9.63d	8.65d	2.29d	2.04f	8.24d	1.39bc	9.84d	7.53d	2.04d	1.80f	8.47 c	1.37ab
GA_3 (50, 100 and 50 ppm)	14.36a	13.77a	3.60a	2.69a	13.20a	1.16c	11.92a	11.98a	3.20a	2.37a	10.48a	1.44ab
NAA (50, 100 and 50 ppm)	13.61ab	13.50a	3.44ab	2.65b	11.98bc	1.63ab	11.84a	11.75a	3.07ab	2.33b	10.43a	1.41ab
Boric acid (2000, 1500 and 1000 ppm)	12.91bc	10.26c	3.30b	2.44d	11.18c	1.72a	11.23b	8.93c	2.94b	2.15d	9.67b	1.56a
Ca+Boron (2000, 1500 and 1000 ppm)	13.44abc	12.15b	3.28b	2.50c	12.10b	1.34c	11.69a	10.57b	2.92b	2.20 c	10.49a	1.20b
Salicylic acid (50, 50 and 100 ppm)	12.91bc	9.95c	3.02c	2.30e	11.10c	1.41bc	10.85c	8.66c	2.69c	2.02e	9.41b	1.44 ab

Means followed by the same letter (s) within each column are not significantly different.

for NAA. Boric acid treatment gained the highest seed weight in the two seasons, without significant difference with the control and salicylic acid treatments in the second season only. Control treatment gave the lowest values for all physical fruit characteristics except seed weight in the second season.

The increase in fruit dimensions could be attributed to the effect of gibberellic acid since it stimulate both cell division and cell enlargement. Similar observation was reported by many investigators who found that fruit dimensions were increased when fruits received gibberellic acid spraying (**Hussein *et al.*, 1993; Kamal 1995; Abo-El-Ez *et al*., 2002**). Moreover, these results are in harmony with those recorded on date palms since spraying GA_3 increased average fruit weight, flesh weight, fruit length and fruit diameter (**Al-Juburi *et al*., 2001 a and b; Tavakkoli *et al*., 2007 ; Hesami and Abdi, 2010 ; Ahmed *et al*., 2010**).

Effect of some Foliar Spraying Treatments on Chemical Characteristics of Barhee Date Fruits

Results in Table 3 show that foliar spraying treatments caused a significant effect on some fruit chemical characteristics of Barhee dates during the two seasons. As such, the highest total soluble solids percentage (33.30 and 29.64%) was obtained with the NAA treatment in the 1st and 2nd seasons, respectively, without significant differences with those treated with GA_3 in both seasons. While the lowest percentage was obtained with the foliar spray with boric acid (27.30 and 24.30%) in the 1st and 2nd seasons respectively, without significant differences with the other treatments.

Results in Table 3 indicate that water spray (control) gave the highest fruit acidity percentage (0.50 and 0.44%) in the 1st and 2nd seasons, respectively, without significant differences with those treated with boric acid and salicylic acid in both seasons. While GA_3 treatment gained the lowest total acidity percentage (0.35 and 0.30%) in the 1st and 2nd seasons, respectively, without significant differences with those treated with NAA in both seasons. The other tested treatments recorded intermediate percentages.

Concerning TSS/acid ratio, the results in Table 3, show that foliar spray with GA_3 recorded the highest TSS/acid ratio (90.57 and 93.23) in the 1st and 2nd seasons, respectively, without significant differences with those treated

Table 3. Effect of some foliar spraying treatments on chemical characteristics of Barhee date fruits (2015 and 2016 seasons)

Spraying treatments	First season (2015)					Second season (2016)				
	TSS (%)	Total acidity (%)	TSS/ acid ratio	Total chlorophyll (mg/100g fruit peel)	Carotene (mg/ 100 g fruit peel)	TSS (%)	Total acidity (%)	TSS / acid ratio	Total chlorophyll (mg/ 100g fruit peel)	Carotene (mg/ 100 g fruit peel)
Water (control)	28.45bc	0.50a	57.14b	2.46f	8.29 a	25.32bc	0.44a	57.79b	2.67f	8.43a
GA_3 (50, 100 and 50 ppm)	31.70ab	0.35 d	90.57a	3.49e	3.29f	28.21ab	0.30 d	93.23a	4.13e	4.06f
NAA (50, 100 and 50 ppm)	33.30a	0.40 cd	83.25a	4.61d	4.57e	29.64a	0.35cd	84.36a	4.86d	4.69e
Boric acid (2000, 1500 and 1000 ppm)	27.30c	0.45abc	61.26b	6.27b	6.41c	24.30c	0.40abc	61.96b	6.40b	7.02c
Ca + Boron (2000, 1500 and 1000 ppm)	27.65c	0.42bc	66.86b	5.38c	5.43d	24.61c	0.37bc	67.62b	5.60c	5.85d
Salicylic acid (50, 50 and 100 ppm)	29.00bc	0.47ab	62.05b	7.31a	7.45b	25.81bc	0.41ab	62.76b	7.54a	7.89b

Means followed by the same letter (s) within each column are not significantly different.

with NAA in both seasons. Other tested treatments came in the second rank without significant differences among them.

These results are in harmony with those of **Ahmed *et al*. (2010)** who reported that spraying date palms by GA_3 at 150 ppm increased fruit total soluble solids and total sugars percentages.

Results in Table 3 clear that spraying bunches with salicylic acid at 50, 50 and 100 ppm, respectively significantly increased total chlorophyll content in the fruit peel recording the highest content (7.31 and 7.54 mg/100 g fresh peel) in the 1st and 2nd seasons, respectively. The other treatments recorded descending lower values of total chlorophyll content until they reached the lowest value with the control treatment (2.46 and 2.67 mg/100 g fresh peel) in the 1st and 2nd seasons, respectively.

Results in Table 3 reveal also that, spraying bunches with NAA significantly increased total carotene content in the fruit peel gaining the highest content (8.29 and 8.43 mg/100g fresh peel) in the 1st and 2nd seasons, respectively. While the lowest content (3.29 and 4.06 mg/100g fresh peel) was recorded for GA_3 treatment in the 1st and 2nd seasons, respectively. The other tested treatments came in between.

Generally, GA_3 and NAA treatments achieved the highest content of TSS and TSS/ acid ratio and the lowest content of carotene in the two seasons. While, control, boron and salicylic acid treatments gave the highest values of fruit acidity in the two seasons. Salicylic acid treatment also achieved the highest values of total chlorophyll content in the fruit peel.

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تأثير الرش ببعض منظمات النمو، حمض الساليسيلك، الكالسيوم والبورون على محصول و جودة ثمار أشجار نخيل البلح البرحي

أحمد فريد جاسم - أحمد سيد أحمد حسن - رزق عبد الحميد الأشقر - محمد ممتاز جاد

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أجريت هذه الدراسة خلال موسمين ٢٠١٥ و٢٠١٦ على أشجار نخيل البلح برحي عمر ١٠ سنوات نامية في تربة رملية تحت نظام الري بالتنقيط في بستان نخيل خاص فى مركز السادات بمحافظة المنوفية، مصر، تم رش عذوق أشجار التجربة بست معاملات كما يلي: الرش بالماء (كمقارنة)، والرش بمحلولNAA و GA_3 (كلاً منهما بتركيز ٥٠ ، ١٠٠ و ٥٠ جزء بالمليون على التوالي) وحمض الساليسيليك (بتركيز٥٠ و ٥٠ و ١٠٠ جزء في المليون على التوالي) والبورون ثم مركب كاترو كالسيوم (١٠% كالسيوم +٠,٠٥ بورن) (كلاً منهما بتركيز ٢٠٠٠ و١٥٠٠ و ١٠٠٠ جزء في المليون على التوالي)، وتم تزويد جميع معاملات الرش باليوريا ٠,٢٥%، وتم رش هذه المعاملات ثلاث مرات قبل التلقيح بيوم واحد والثانية مع بداية مرحلة الكمري والثالثة مع بداية مرحلة الخلال (البسر) وتم رش كل منها بالثلاثة تركيزات المذكورة على التوالي وفيما يلي أهم النتائج: حققت معاملتي الرش بمحاليل NAA،GA_3 أعلى القيم لكل من محصول/نخلة وزن/عذق وعدد الثمار/شمراخ فى الموسمين، فى حين حققت معاملة الكاترو كالسيوم (الكالسيوم + البورون) أعلى القيم لكل من محصول/نخلة وزن/عذق فى الموسمين بالمقارنة بمعاملة الكنترول التى حققت أقل النتائج فى الموسمين، حققت معاملتي الرش بمحاليل كل من GA_3 و NAA أعلى القيم لكل خصائص الثمار الطبيعية باستثناء وزن النواة فى الموسم الأول و بدون فروق معنوية بينهما فيما عدا أبعاد الثمار في الموسم الأول وقطر الثمرة في الموسم الثانى، حققت معاملة الرش بحمض البوريك أعلى وزن للنواة فى الموسمين وبدون فرق معنوي عن معاملتي المقارنة وحمض الساليسيلك فى الموسم الثانى فقط، وبصفة عامة حققت معاملة المقارنة أقل القيم للصفات الطبيعية للثمار فيما عدا وزن النواة فى الموسم الثانى، حققت معاملتي الـ GA_3، NAA أعلى محتوى من الـ TSS and TSS/acid ratio وأقل محتوى من الكاروتين ونسبة الحموضة فى الموسمين. فى حين حققت معاملات المقارنة ومعاملة الرش بحمض البوريك وحمض الساليسيلك أعلى قيم لحموضة الثمار فى الموسمين، كما حققت معاملة حمض الساليسيلك أعلى قيم لمحتوى قشرة الثمرة من الكلوروفيل.

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