



Impact of spraying algae extract and antioxidants on the yield and fruit physical and chemical properties of Barhee date palms

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Abstract

The purpose of the study is to evaluate the influence of spraying algae extract, salicylic and ascorbic acids on the yield and fruit properties of Barhee date palms. This experiment was carried out during 2018 and 2019 growing seasons. The inflorescences were sprayed three times (the first at one day before pollination, the second at the beginning of Kimri stage and the third at the beginning of fruit colour break) with algae extract at 1 and 2%, salicylic acid at 500 ppm and 1000 ppm, also ascorbic acid at 500 ppm and 1000 ppm as individual applications or in combination between them. Generally, when compared to the control treatment, spraying date palm inflorescences with algae extract at 2% + salicylic acid at 1000 ppm + ascorbic acid at 1000 ppm had a significant influence on the yield, fruit physiochemical characteristics of Barhee date palms. However, the positive effect was indirect proportional to the increment of the concentration of the three materials. Spraying Barhee date palms three times with high doses of the combined treatment (2% algae extract + 1000 ppm salicylic acid + 1000 ppm ascorbic acid) was the superior concerning yield and both fruit physical and chemical properties in the two experimental seasons of the study.

Keywords: Barhee date palm; Algae extract; Ascorbic acid; Salicylic acid; Yield; Fruit quality.

1. Introduction

Date palm (*Phoenix dactylifera* L.) is one of the most important fruit species grown in Egypt. The total number of the female palms reached about 12.261 million, producing about 1.31 million tons of fruits with an average of 106 kg/palm, the number of date palms in the old lands is about 9.998 million palms, producing 1.14 million tons of fruits with an average of 115.17 kg/palm, while in the new lands (sandy soils), the number of the date palms is about 2.362 million producing 227.82 thousand tons of fruits with an average of 69.45 kg fruits per palm [1]. Date palms grown on sandy soil have a low yield, which is a huge problem faces the growers.

Lately, many efforts have been made to determine the optimal horticultural strategies for increasing the yield and fruit quality of Barhee date palms growing under sandy soil conditions.

Using algae extract (AE), salicylic acid (SA) and ascorbic acid (AsA) are considered as more effective treatments for solving the problem of poor fruit set and yield especially in the new reclaimed lands [2].

Algae extract (AE) as a new bio fertilizer containing many minerals (N, P, K, Ca, Mg, S, Fe, Zn, Mn, Cu and Mo), some growth regulators, vitamins and polyamines is applied to improve nutritional status, vigour of vegetative growth, which eventually leads to increase the yield in terms of quantity and quality in different orchards [3, 4, 5, 6, 7, 8].

Salicylic acid (SA) is a clear phenolic compound and it is identify as plant growth regulator based on its external application for affecting many plant growth physiological processes. In addition, SA inhibits the ethylene synthesis [9]. Furthermore, it is essential for motivate systemic resistance against some pathogenic infections in a certain extent [10, 11], as well as SA has been shown to increase the activity of the alternative oxidase enzyme inside mitochondria, which is helped in stress alleviation and the enhancement of particular secondary metabolites in plants [12].

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Spraying SA enhances yield and fruit quality of numerous fruit crops [13, 14]. Spraying orange trees with SA at the rate of 300 mg L⁻¹ increased growth, fruit set, and yield [15].

Although, ascorbic acid (AsA) is a vital primary metabolite in plants that plays as antioxidant, enzyme cofactor and a cell signalling modulator in a wide array of crucial physiological processes, stress tolerance, cell division and growth [16], it has a synergistic effect on improving growth, flowering, yield and quality of fruit crops [17].

The physiological effects of AsA included stimulation the activity of lipase, catalase and peroxidase. Moreover, it has an impact on the metabolism of gibberellic acid [18].

Antioxidants such as amino acids, citric acid, ascorbic acid and vitamins may play a especial role on solving the poor yield problems, through enhancing growth nutritional status productivity and fruit quality of many evergreen fruit crops particularly date palms [19, 20, 21].

The aim of this study was to investigate the effect of spraying algae extract (AE), salicylic acid (SA) and ascorbic acid (AsA) either alone or their combinations on yield and fruit physical and chemical properties of Barhee date palms grown under sandy soil conditions .

2. Materials and methods

The current study was conducted during two consecutive seasons of 2018 and 2019 on 12 years old Barhee date palms grown on sandy soil planted at 6×6 meters apart under drip irrigation system in a private orchard situated located at point of 63 km from Cairo-Alexandria desert road, Beheira governorate. The experimental palms were selected to be healthy, nearly similar in vigor and uniform; the palms received the normal horticultural practices which applied in the commercial orchard except for the tested treatments. All palms were pollinated with the same male pollen source in both seasons. Moreover, the number of spathes per palm was adjusted to 10 bunches for each palm, and the leaves were thinned to eight leaves per bunch rate (8:1 leaf-to-bunch ratio).

Palms were subjected to nine spraying treatments with three replicates per each (9 treatments × 3 replicates = 27 palms). Treatments were arranged in a randomized complete block design (RCBD) 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 colour break stage, respectively. The spraying treatments were as follows:

- T₁. Water spray only (control).
- T₂. Algae extract at 1%.
- T₃. Algae extract at 2%.
- T₄. Salicylic acid at 500 ppm.
- T₅. Salicylic acid at 1000 ppm.
- T₆. Ascorbic acid at 500 ppm.
- T₇. Salicylic acid at 1000 ppm.
- T₈. Algae extract 1% + Salicylic acid at 500 ppm + ascorbic acid at 500 ppm.
- T₉. Algae extract 2% + Salicylic acid at 1000 ppm + ascorbic acid at 1000 ppm.

Spraying was conducted by small hand gun sprayer until runoff. Tween 20 at the rate of 1% was applied with spraying solution as a wetting agent. Fruits were harvested at full mature stage (Mid of September) according to skin colour (the whole colour at the fruit should be yellow and the yellowish green area shouldn't be more than 10%) [22].

The following measurements were carried out:

Yield/palm (kg):

At harvest time (Mid-September) in both seasons, bunches were harvested and weighed, then the total yield/palm was estimated.

Average bunch weight (kg):

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

Fruit physical properties:

Samples contained 30 fruits per each treatment (10 fruits from each bunch as a replicate) were used to determine the weight of fruit, flesh and seed (g), fruit length and diameter (cm), fruit shape index L/D and fruit volume (cm³).

Fruit chemical properties:

After harvest, fruit chemical properties were determined, since total soluble solids percentage (TSS) was measured using a hand refractometer, acidity percentage was determined by titration against 0.1 NaOH [23].

Sugar contents%:

Total, reducing and non-reducing sugars were determined [23].

The obtained data were subjected to statistical analysis of variances (ANOVA) [24] using CO-STAT program, and means separation was done at 5% level.

3. Results

3.1. Fruit weight, flesh weight, bunch weight and yield/palm:

Results in table (1) clear that all treatments increased significantly fruit weight and flesh weight as compared to the control which gave the lowest values during the two seasons of the study.

Applying salicylic acid (SA) at 1000 ppm (T₅) recorded the highest fruit weight (14.9 & 15.1 g) and flesh weight (13.6 & 13.9 g) during the two experimental seasons, respectively, followed by T₉ (algae extract at 2% + salicylic acid 1000 ppm + ascorbic acid at 1000 ppm) which gave 14.9 & 14.6 g for fruit weight and 13.7 & 13.3 g for flesh weight then T₈ (algae extract 1% + SA 500 ppm + ascorbic acid at 500 ppm) which exhibited 14.0 & 14.3 g for fruit weight and 12.8 & 13.0 g for flesh weight in the 1st and 2nd seasons, respectively.

Regarding seed weight, results in table (1) illustrate that all treatments decreased seed weight as compared to the control in the two experimental seasons.

According to the results in table (1), all the investigated treatments increased significantly bunch weight, consequently total yield when compared to the control in both seasons of the study.

Applying algae extract at 2% + salicylic acid at 1000 ppm + ascorbic acid at 1000 ppm (T₉) recorded the heaviest bunch weight (11.7 & 12.0 kg) and yield/palm (117.6 & 120.0 kg/palm) during the two experimental seasons, respectively, followed by T₈ (algae extract 1% + salicylic acid at 500 ppm + ascorbic acid at 500 ppm) which gave 11.4 & 11.7 kg and 114 & 118 kg/palm for yield per palm in the two seasons. Meanwhile, the lowest bunch weight (8.9 & 9.2 kg) and yield /palm (89 & 92 kg/palm) were obtained from the control treatment during the two seasons of the study.

Table 1 The effect of algae extract and some antioxidants on yield and some fruit physical properties and yield of Barhee date palms.

Treatments	Fruit weight (g)		Flesh weight (g)		Seed weight (g)		Bunch weight (kg)		Yield/palm (Kg)	
	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
T ₁ Control	10.03e	9.80h	8.73f	8.46g	1.30a	1.36a	8.9g	9.2e	89.0g	92.0e
T ₂ Algae extract 1% (AE)	12.6d	12.50g	11.36e	11.20f	1.23abc	1.30ab	9.2f	9.4e	92.6f	94.3e
T ₃ Algae extract 2% (AE)	13.5c	13.70de	12.36cd	12.70cd	1.13cde	1.03c	9.7e	10.2d	97.0e	102.0d
T ₄ Salicylic acid 500 ppm (SA)	12.6d	13.03f	11.50e	11.90e	1.06de	1.20b	10.6cd	10.9c	106.0cd	109.3c
T ₅ Salicylic acid 1000 ppm (SA)	14.9a	15.10a	13.60a	13.90a	1.23abc	1.20a	10.7c	11.2c	107.6c	112.0c
T ₆ Ascorbic acid 500 ppm (AsA)	13.4c	13.70e	12.13d	12.50d	1.26ab	1.20b	10.5d	10.9c	105.0d	109.3c
T ₇ Ascorbic acid 1000 ppm (AsA)	13.7b	14.00cd	12.50bc	12.70cd	1.20abcd	1.30ab	11.3b	11.7b	113.0b	117.0b
T ₈ AE 1% + SA 500 ppm + AsA 500 ppm	14.0b	14.30bc	12.80b	13.00bc	1.20abcd	1.30ab	11.4b	11.8ab	114.0b	118.0ab
T ₉ AE 2% + SA 1000 ppm + AsA 1000 ppm	14.9a	14.60b	13.70a	13.30b	1.16bcd	1.30ab	11.7a	12.0a	117.6a	120.0a

3.2. Fruit physical properties

The obtained results in table (2) show that spraying date palms with AE, SA and AsA each alone or in combination caused an increase in fruit length, fruit diameter, and fruit volume when compared to the control during both experimental seasons of the study.

In other words, using a combination of algae extract at 2% + salicylic acid at 1000 ppm + ascorbic acid at 1000 ppm (T₉) caused a significant promotion on fruit length, diameter and volume over than control and other treatments.

The lowest values of fruit (length, diameter and volume) were obtained from the control which gave 2.8 & 3.1 cm for fruit length, 2.4 & 2.4 cm for fruit diameter and 10.5 & 10.3 cm³ for fruit volume in the two experimental seasons, respectively.

The highest fruit volume was recorded from T₇ (ascorbic acid at 1000 ppm) which gave 15.46 and 15.4 cm³ followed by T₈ (algae extract 1% + salicylic acid at 500 ppm + ascorbic acid 500 ppm), which produced 14.3 and 14.8 cm³ and T₉ (algae extract at 2% + salicylic acid at 1000 ppm + ascorbic acid at 1000 ppm) which exhibited 14.2 and 14.4 cm³ during the first and second seasons of the study.

Results in table (2) clear that all treatments increased fruit shape index significantly when compared with the control in the 1st season, while in the 2nd one whole treatments decreased significantly fruit shape index as compared with the control except T₆ (spraying ascorbic acid at 500 ppm). The highest fruit shape index value was obtained from T₆ (spraying ascorbic acid at 500 ppm) which recorded 1.36 and 1.33 during the two experimental seasons.

Table 2 The effect of algae extract and some antioxidants on some fruit physical properties of Barhee date palms.

Treatments	Fruit length (cm)		Fruit diameter (cm)		Fruit shape index		Fruit volume (cm ³)	
	2018	2019	2018	2019	2018	2019	2018	2019
T ₁ Control	2.8d	3.1c	2.4c	2.40e	1.16f	1.29ab	10.5f	10.3f
T ₂ Algae extract 1% (AE)	3.4bc	3.4b	2.63ab	2.70d	1.29bcd	1.25abc	13.2e	13.0e
T ₃ Algae extract 2% (AE)	3.5abc	3.5ab	2.70ab	2.80d	1.30bc	1.25bcd	13.8d	13.6d
T ₄ Salicylic acid 500 ppm (SA)	3.6a	3.6a	2.70ab	2.93bc	1.33ab	1.22cd	14.63b	14.9b
T ₅ Salicylic acid 1000 ppm (SA)	3.3c	3.4b	2.70a	2.70d	1.20ef	1.23bcd	13.2e	13.2e
T ₆ Ascorbic acid 500 ppm (AsA)	3.5ab	3.6a	2.60b	2.70d	1.36a	1.33a	13.6d	14.2c
T ₇ Ascorbic acid 1000 ppm (AsA)	3.5abc	3.5ab	2.80a	2.96b	1.24de	1.17de	15.46a	15.4a
T ₈ AE 1% + SA 500 ppm + AsA 500 ppm	3.5abc	3.5ab	2.80a	2.80cd	1.25cde	1.25abcd	14.3bc	14.8b
T ₉ AE 2% + SA 1000 ppm + AsA 1000 ppm	3.6a	3.6a	2.80a	3.13a	1.28bcd	1.14e	14.26c	14.4c

3.3. Fruit chemical properties

It is clear from the results in table (3) that spraying the inflorescences with AE, SA and AsA each alone or in combination between them, significantly increased TSS% as compared with the control treatment during the two seasons of the study. Application of algae extract at 2% + salicylic acid at 1000 ppm + ascorbic acid at 1000 ppm (T₉) recorded the highest TSS% since it gave 58.3 and 59.0%, followed by T₈ (algae extract at 1% + salicylic acid at 500 ppm + ascorbic acid at 500 ppm) which exhibited 55.5 and 55.6% during the two seasons of the study. While, the lowest TSS% was found due to the control which produced 35.2 and 35.7% in both seasons, respectively.

In this respect, total acidity percentage was significantly decreased as compared to the palms sprayed with water (control) in the two seasons.

Results in table (3) show that all treatments affected significantly TSS/acid ratio as compared to the control during the two seasons. In this concern, T₉ (algae extract at 2% + salicylic acid at 1000 ppm + ascorbic acid at 1000 ppm) ranked the best TSS/acid ratio, which recorded 275.0 and 239.3, while the lowest TSS/acid ratio was produced from the control which gave 101.6 and 106.0 in the 1st and 2nd seasons, respectively.

According to the results in table (3), sugars content (total, reducing and non-reducing sugars), show that using algae extract at 2% + salicylic acid at 1000 ppm + ascorbic acid at 1000 ppm (T₉) gave the highest sugars content as compared with the control, since, it recorded 50.3 and 51.3% as total sugars, 35.0 and 35.3% as reducing sugars and 1.3 and 16% as non-reducing sugars during the 1st and 2nd seasons, respectively.

Table 3 The effect of algae extract and some antioxidants on chemical properties of Barhee date palms.

Treatments	TSS (%)		Acidity (%)		TSS/acidity ratio		Total sugars (%)		Reducing sugars (%)		Non reducing sugars (%)	
	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
T ₁ Control	35.20f	35.70f	0.34a	0.33a	101.6f	106.0d	33.6f	35.0f	21.7e	22.5e	11.80d	12.40d
T ₂ Algae extract 1% (AE)	50.83c	51.50c	0.27c	0.25c	184.3d	203.3b	40.3cd	41.6cd	26.3d	27.4cd	14.00bc	14.20bc
T ₃ Algae extract 2% (AE)	52.16c	52.83c	0.25d	0.23c	208.3c	226.0a	42.0c	43.0c	28.3c	28.9c	13.60bc	14.03c
T ₄ Salicylic acid 500 ppm (SA)	46.13e	46.30e	0.31b	0.29b	145.6e	156.0c	35.9e	37.6e	21.2e	22.4e	14.70ab	15.20ab
T ₅ Salicylic acid 1000 ppm (SA)	47.50de	47.50de	0.24d	0.23c	197.6cd	203.0b	35.0ef	36.0ef	21.6e	21.8e	13.30c	14.13c
T ₆ Ascorbic acid 500 ppm (AsA)	48.00d	48.16d	0.31b	0.29b	151.6e	166.0c	39.0d	40.6d	26.0d	26.2d	14.00bc	14.40bc
T ₇ Ascorbic acid 1000 ppm (AsA)	48.50d	49.00d	0.26cd	0.25c	186.3d	193.3b	40.0d	41.0d	26.3d	27.1cd	13.30c	13.90c
T ₈ AE 1% + SA 500 ppm + AsA 500 ppm	55.50b	55.60b	0.24d	0.23c	231.0b	235.0a	47.0b	48.3b	31.6b	32.5b	15.30a	15.80a
T ₉ AE 2% + SA 1000 ppm + AsA 1000 ppm	58.30a	59.00a	0.21e	0.24c	275.0a	239.3a	50.3a	51.3a	35.0a	35.3a	15.30a	16.03a

4. Discussion

The promotive impact of AE on yield and fruit quality may be related to its higher own content of natural plant hormones such as GA₃, cytokinins and IAA which are responsible for the enhancing cell division, also due to its containing of lecithin glutathione, 21 amino acids and vitamins 60 nutrients. Moreover, algae extract plays a major role in the biosynthesis of all organic food antioxidants and plant pigments [4].

The effect of SA on mitigating the effect of salinity on Manzanillo olive tree fruit and yield/tree perhaps referred to an increase in vegetative growth parameters particularly the content of total chlorophyll, which leads to high carbohydrates production through photosynthesis increasing vegetative growth and ultimately improving fruit yield. Additionally, SA has a good effect on increasing organic matter, reducing soil pH and promoting water and nutrients uptake [25] plus enhancing soil fertility [26].

These results are in harmony with those obtained previously [6, 7, 8, 21, 27, 28].

The physiological effect of the nutrients, growth regulators and vitamins is primarily responsible for enhancing the effect of AE on fruit qualities [29] which had an impact on the quality of the fruit. In addition, the increase in leaf total chlorophyll content has a result in an increase in photosynthetic rate and carbohydrate reserves, which had a beneficial impact on fruit quality.

Regarding the effect of antioxidants on the yield and fruit quality of Barhee dates are in a harmony with the findings in earlier studies [8, 20, 21, 28, 30, 31].

5. Conclusions

From the above mentioned results, it could be concluded that foliar spray with the mixture of algae extract at 2% + salicylic acid at 1000 ppm + ascorbic acid at 1000 ppm on date palms three times has a useful impact and provides the best results for rising yield and improving the quality of Barhee date palms fruits under the current study conditions.

6. List of abbreviations

AE: Algae Extract, **SA:** Salicylic Acid, **AsA:** Ascorbic Acid, **TSS:** Total Soluble Solids and **RCBD:** Randomized complete block design.

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