

Article

Effect of Spraying Algae Extract and Potassium Nitrate on the Yield and Fruit Quality of Barhee Date Palms

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Abstract: The effect of foliar spray with algae extract and/or potassium nitrate on the quantity and quality of Barhee date palm yields was investigated during the 2017 and 2018 seasons. Inflorescences of Barhee date palms were sprayed twice, after pollination (1st April of each season) and one month later, with algae extract at concentrations of 0.5% and 1.0% and with potassium nitrate at concentrations of 1% and 2% applied individually or in combinations. The obtained results showed that all of the sprayed treatments enhanced the yield and fruit properties when compared to the controls. Spraying inflorescences of Barhee date palms with algae extract and/or potassium nitrate had a significant effect on the yield and on the physical and chemical properties of the fruit when compared with the untreated palms. The increase in yield and qualitative properties was associated with increasing concentrations of both materials (algae extract and potassium nitrate). The best results were detected with spray containing high rates of combined treatment (1% algae extract + 2% potassium nitrate) applied twice in both seasons studied because this treatment resulted in the highest value of fruit and bunch weight, increased the yield per palm compared to the control by about 60.2%, and improved the fruit physical properties (fruit length, fruit diameter, fruit shape index, flesh weight, and seed weight) and fruit chemical properties (total soluble solids (TSS); acidity; TSS/acid ratio; tannins; and reducing, nonreducing, and total sugars) of the Barhee date palm given the experimental conditions.

Keywords: Barhee date palm; yield; fruit properties; algae extract; potassium nitrate



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1. Introduction

This experiment was conducted in two successive seasons to study the effect of foliar sprays using algae extract and potassium nitrate (in different concentrations, applied either individually or in combinations) on the fruit yield and yield per palm as well as the fruit physical and chemical properties of the Barhee date palms grown in a private orchard located 63 km from Cairo on Alex Desert Road, Egypt. The date palm (*Phoenix dactylifera* L.), a monocotyledonous and dioecious species belonging to the *Palmaceae* family, is widely cultivated in arid and semiarid regions. Seaweed extract, which is organic and biodegradable, is considered an important source of nutrition for sustainable agriculture [1]. Seaweeds contain various trace elements (Fe, Cu, Zn, Co, Mo, Mn, and Ni), vitamins, amino acids, and plant growth hormones (IAA, IBA, and cytokinins), which have many beneficial effects on plant growth and development [2]. In this regard, El-Motty [3] showed that spraying Keitte mango trees once at full bloom with 2% algae plus 0.2% yeast solution was very effective at improving fruit set, fruit retention, and the number of fruits per tree (kg/tree); at increasing fruit length (cm), fruit width (cm), fruit weight (g), and pulp/fruit percentage; and at

enhancing total soluble solids (TSS). Moreover, it reduced the fruit drop and the weight of peels and seeds (g) compared to the control. On the other hand, many investigators such as Khan [4] on grapevines, Ahmed [5] on mangos, Faissal [6] on date palms, Hikal [7] on oranges, Ibrahim [8] on mangos, and Thanaa [9] on apples found that spraying seaweed extract at different concentrations enhanced growth; enhanced the content of different nutrients; increased fruit set, fruit retention, and yield; and improved both the physical and chemical fruit properties. Foliar fertilization with potassium has the advantage of low application rates, uniform distribution of fertilizer materials, and a quick response to applied nutrients [10]. Potassium is an important solute for expanding cells, and growth is very sensitive to potassium deficiency. Potassium is also needed for the enlargement of fruits, activates the enzymes involved in sugar biosynthesis, and aids in the translocation of sugars [11]. High amounts of potassium are needed during the critical period of growth and development of date palm fruits; thus, foliar application of potassium is an efficient way to meet the trees' needs during this period [12]. Many investigators have studied the effect that spraying potassium has on fruit set, yield, and quality of fruit crops. Al-Hamoudi [13] reported that spraying Barhee date palms with potassium sulfate significantly increased fruit retention and the physical and chemical fruit parameters. Desouky [14] showed that the highest percentage of TSS, total sugars, reducing sugars, and nonreducing sugars were recorded when date palm cv. Barhee was sprayed with 0.4% potassium sulfate compared to untreated palms. Hegazi [15] reported that a foliar spray of potassium nitrate (4%) resulted in the highest values of fruit length, fruit diameter, and flesh weight of Picual olives. Additionally, Awad [16] indicated that the foliar spray of potassium sulfate increased the fruit and flesh weight, length, and diameter of the Seweda date palm. El-Assar [17] indicated that potassium as a foliar spray at 500 and 1000 ppm improved both the percentage of TSS and total sugars while decreasing the percentage of fruit juice acidity and soluble tannins when compared to untreated date palms. Mohamed [18] found that spraying a 2% solution of potassium citrate decreased the tannins of date palm fruit cv. Amhat. Omar [19] reported that spraying date palm cv. Mnifi with potassium sulfate in 1%–2% solutions increased total TSS and reducing and nonreducing sugars. Baiea [20] showed that spraying Hindi mango trees four times—at full bloom, after fruit set, during fruit growing, and before the harvesting with 2% monopotassium phosphate, 2% dipotassium phosphate, and 2% potassium nitrate—was very effective at improving fruit retention and yield, as defined by the number of fruits or weight (kg/tree); at increasing fruit weight and pulp weight; and at enhancing the percentage of total soluble solids (TSS), total sugars, and ascorbic acid content. In addition, it reduced fruit acidity compared to the control. Spraying also improved the vegetative parameters as well as the nitrogen, phosphorus, and potassium contents in the leaves. Esam [21] showed that the foliar application of Sword® (Union for Agricultural Development, 7 B Ebn Gahdam St., Helipolis, Cairo, Egypt) (contains 25% K₂O) had a positive effect on the performance of Medjool date palms and added that there was a direct relation between increases in most of the quality and quantity parameters, and increasing rates and duration of Sword® application. The best results were obtained by spraying 2% Sword® three times, which revealed that it was a promising treatment for increasing fruit set and fruit retention, maximizing the bunch weight and yield per palm, and improving the physical characteristics (such as fruit weight, length, and diameter) as well as the chemical characteristics of date fruits such as increased TSS and total sugars and reduced acidity. Merwad [22] used K-feldspar (a natural K-bearing source) as a source of potassium, which resulted in the highest values concerning leaf mineral content, vegetative growth, yield, and fruit characteristics when compared with potassium sulfate. Moreover, plants treated with 100% K-feldspar took a shorter time to reach bunch shooting, bunch maturation, and the cropping cycle for the two seasons of the study. Rasmia [23] clarified that all bunches sprayed with 0.4% potassium sulfate and trees subjected to soil fertilizer treatments showed increases in fruit physical parameters and resulted in the highest fruit and flesh weight (g), fruit length, and diameter. The aim of this work is to determine the suitable concentration of algae (0.5 or 1.0%) and potassium (1.0 or 2.0%) to be used as a

foliar spray individually or in combination to reach a high yield and to support the best fruit quality of date palm cv. Barhee when grown under sandy soil conditions.

2. Materials and Methods

This work was carried out during two successive seasons (2017 and 2018) at a private orchard 63 km from Cairo on Alex Desert Road, Egypt (this area is characterized by high humidity and moderate temperature). The effect of using algae extract and potassium nitrate as a foliar spray on the yield and fruit quality of Barhee date palms is the main target of this study. Twenty-eight female Barhee palms (12 years old) that were uniform in growth and free from insect damage and diseases were selected and subjected to the same management and practices and the fertilizing program was applied using a fertigation system. The palms were planted 7×6 m apart under a drip irrigation system in sandy soil as described in the soil analysis (Table 1). A hand sprayer containing active pollen grains (1:3 pollen-to-talc powder ratio) from the same parent was used to achieve pollination 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). Six foliar application treatments were compared with the control and were arranged in a randomized complete block design with four replicates (1 replicate = 1 palm) per treatment (i.e., $7 \times 4 \times 1 = 28$ palms).

Table 1. Some physical and chemical properties of the experimental soil.

Particle Size Distribution (%)			Soil Texture	Ec dsm ^{−1}	pH	Available Nutrients (Cation)					Available Nutrients (Anion)			
Sand	Silt	Clay				N%	P%	K%	Ca mg/L	Mg mg/L	CO ₃	HCO ₃ mg/L	Cl [−]	SO ₄
90	5	5	sandy	1.5	8.2	Trace	0.44	0.57	2.65	2040	-	3.85	53	55.6

2.1. Treatments

T1: Control (sprayed with water only).

T2: Algae at 0.5%.

T3: Algae at 0.1%.

T4: Potassium nitrate (KNO₃) at 1%.

T5: KNO₃ at 2%.

T6: Algae at 0.5% + KNO₃ at 1%.

T7: Algae at 0.1% + KNO₃ at 2%.

All treatments were sprayed twice, after pollination (1st April of each season) and one month later. Sprays were applied with a small handgun sprayer until run-off occurred. A wetting agent (Tween 20 at 1%) was applied with the spraying solution. Algae extract formulation: Algae extract (oligo-x) was obtained from the Arabian Group for Agricultural Service (AGAS) with the following composition, as described in Table 2.

2.2. Measurements

2.2.1. Yield/Palm (kg)

At harvesting time (mid-September in both seasons), each bunch was weighed (TY/palm = sum of the weight of all bunches) for each palm in the experiment.

2.2.2. Fruit Physical Properties

Samples of 40 fruits per palm (4 bunches \times 10 fruits from each bunch as a replicate) were taken randomly to determine fruit weight (g), flesh weight (g), seed weight (g), and fruit dimension (length and diameter in mm). The shape index was calculated by dividing fruit flesh weight by fruit weight.

2.2.3. Fruit Chemical Properties

Total soluble solids (TSS%): the percentage of TSS was determined in fruit flesh juice using a Carl-Zeiss hand refractometer according to chemists [24]. Fruit acidity (%): fruit acidity was determined according to the method described in chemists [24]. TSS/acid ratio (%) was calculated by dividing TSS% with the total acidity values of fruit juice. The total, reducing, and nonreducing sugars were determined according to the method described by Dubois [25] as fresh weight. Tannins were determined according to the method described by Sulieman [26]. Statistical analysis: the data were subjected to statistical analysis of variance and means separation according to Duncan [27] at a 5% significance level.

Table 2. Composition of the algae used in the spray.

Algae Composition		Concentration
Oligosaccharide		3%
Alginic acid		5%
Phytin		0.003%
Menthol		0.001%
Natural growth regulators	Cytokinin	0.001
	Indole acetic acid	0.0002%
	Pepsin	0.02%
Minerals	Potassium oxide	12%
	Phosphorus oxide	0.5%
	N	1%
	Zn	0.3%
	Fe	0.2%
	Mn	0.1%

3. Results

3.1. Yield and Its Components

The results obtained in Table 3 indicate that spraying palms with algae and potassium individually or in combination had a significant effect on fruit weight, bunch, and yield per palm compared to unsprayed palms in both seasons. The combination of algae extract at 1% concentration + potassium nitrate (KNO_3) at 2% concentration resulted in the highest values of both fruit and bunch weight per palm for both seasons, followed by the combination of algae extract at 0.5% + KNO_3 at 1%. On the other hand, the lowest values of these parameters were recorded in the control treatment (spraying with water only) in both seasons. The relative increases in yield per palm were about 30.7% and 31.8% using the 1% algae + 2% KNO_3 treatment when compared to the control in the first and second seasons, respectively.

3.2. Fruit Physical Properties

The resulting effects of the different studied treatments on various fruit properties are presented in Table 4 for the two seasons. The results for both seasons show significant increases in fruit length, diameter, and flesh weight compared to the control, but they are not significant with respect to fruit shape index and seed weight. The palms sprayed with the mixture of algae extract at 1% and KNO_3 at 2% showed a significant increase in all of the mentioned fruit physical properties in both seasons and recorded the highest values.

Table 3. Effect of algae and potassium as foliar sprays on yield and its components of Barhee date palm.

Treatments	Fruit Weight (g)	Bunch Weight (kg)	Yield/Palm (kg)	Relative Increase in Yield
	Season 1			
Control	11.93 g	10.20 e	102.2 d	00.0
Algae (0.5%)	12.30 f	10.73 d	107.33 d	4.9
Algae (1%)	12.70 e	10.93 d	109.3 d	6.9
KNO ₃ (1%)	13.40 d	11.56 c	115.6 c	13.1
KNO ₃ (2%)	13.73 c	12.46 b	124.5 b	21.8
Algae (0.5% + KNO ₃ 1%)	14.33 b	12.70 b	127.0 ab	24.2
Algae (1% + KNO ₃ 2%)	15.40 a	13.36 a	133.6 a	30.7
LSD at 0.05 level	0.23	0.29	7.43	–
Treatments	Season 2			
Control	11.90 f	10.26 e	102.67 e	00.0
Algae (0.5%)	12.33 e	10.80 d	108.00 de	5.2
Algae (1%)	12.66 d	11.00 d	110.00 de	7.2
KNO ₃ (1%)	13.40 c	11.70 c	117.00 cd	14.0
KNO ₃ (2%)	13.60 c	12.50 b	125.00 bc	21.8
Algae (0.5% + KNO ₃ 1%)	14.30 b	12.76 b	127.60 ab	24.3
Algae (1% + KNO ₃ 2%)	15.00 a	13.53 a	135.30 a	31.8
LSD at 0.05 level	0.32	0.26	10.28	–

Means within a column followed by different letter(s) are statistically different at the 5% significance level.

Table 4. Effect of algae and potassium as foliar sprays on fruit physical properties of the Barhee date palm.

Treatments	Fruit Length (cm)	Fruit Diameter (cm)	Fruit Shape Index	Flesh Weight (g)	Seed Weight (g)
	Season 1				
Control	3.00 e	2.20 d	1.36 a	9.76 g	2.16 a
Algae (0.5%)	3.33 d	2.36 c	1.41 a	10.06 f	2.23 a
Algae (1%)	3.60 c	2.50 b	1.44 a	10.36 e	2.33 a
KNO ₃ (1%)	3.70 c	2.56 b	1.44 a	11.06 d	2.33 a
KNO ₃ (2%)	4.00 b	2.83 a	1.41 a	11.46 c	2.26 a
Algae (0.5% + KNO ₃ 1%)	4.16 ab	2.86 a	1.45 a	12.10 b	2.23 a
Algae (1% + KNO ₃ 2%)	4.33 a	2.90 a	1.49 a	13.10 a	2.30 a
LSD at 0.05 level	0.18	0.12	NS	0.21	NS
Treatments	Season 2				
Control	2.96 f	2.20 f	1.34 a	10.33 g	1.56 a
Algae (0.5%)	3.26 e	2.40 e	1.36 a	11.00 f	1.33 a
Algae (1%)	3.56 d	2.56 d	1.38 a	11.40 e	1.26 a
KNO ₃ (1%)	3.76 c	2.70 c	1.39 a	11.86 d	1.53 a
KNO ₃ (2%)	4.06 b	2.93 b	1.38 a	12.30 c	1.30 a
Algae (0.5% + KNO ₃ 1%)	4.13 b	2.96 b	1.39 a	12.90 b	1.40 a
Algae (1% + KNO ₃ 2%)	4.43 a	3.13 a	1.41 a	13.63 a	1.36 a
LSD at 0.05 level	0.12	0.13	NS	0.19	NS

Means within a column followed by different letter(s) are statistically different at the 5% significance level.

3.3. TSS, Acidity, TSS/Acid Ratio, and Tannins

The results presented in Table 5 clearly indicate that all treatments of algae extract or potassium nitrate used individually or in combination had a significant effect on TSS, acidity, TSS/acid ratio, and tannins in the fruits when compared to the untreated palms in both seasons. Furthermore, it is clear that TSS% and the TSS/acid ratio significantly increased with the combination treatment of algae extract at 1% and KNO₃ at 2%, which were recorded as 27.66 and 28.00 for TSS and 36.42 and 38.26 for TSS/acid ratio in the first

and second seasons, respectively. This treatment also recorded the lowest acidity values (0.76% and 0.73%) and tannins (0.210% and 0.200%) in both seasons, whereas the highest values for these qualities were recorded in the control treatment.

Table 5. Effect of algae and potassium as foliar sprays on TSS, acidity, and tannins of Barhee date palm fruits.

Treatments	TSS (%)	Acidity (%)	TSS/acid Ratio	Tannins %
	Season 1			
Control	22.66 f	0.80 c	28.33 c	0.240 a
Algae (0.5%)	23.50 e	0.81 ab	28.77 c	0.226 b
Algae (1%)	24.33 d	0.82 a	29.43 c	0.226 b
KNO ₃ (1%)	26.00 c	0.80 c	32.50 b	0.210 c
KNO ₃ (2%)	26.66 bc	0.81 bc	32.92 b	0.203 c
Algae (0.5% + KNO ₃ 1%)	27.00 ab	0.77 d	35.07 a	0.206 c
Algae (1% + KNO ₃ 2%)	27.66 a	0.76 d	36.42 a	0.210 c
LSD at 0.05 level	0.77	0.02	1.35	0.011
Treatments	Season 2			
Control	22.66 f	0.82 a	27.41 f	0.246 a
Algae (0.5%)	23.66 e	0.79 b	29.83 e	0.240 b
Algae (1%)	25.00 d	0.78 bc	31.92 d	0.240 b
KNO ₃ (1%)	26.66 c	0.77 c	34.34 c	0.230 c
KNO ₃ (2%)	27.00 bc	0.77 c	34.92 c	0.220 d
Algae (0.5% + KNO ₃ 1%)	27.66 ab	0.75 d	36.56 b	0.220 d
Algae (1% + KNO ₃ 2%)	28.00 a	0.73 e	38.36 a	0.200 e
LSD at 0.05 level	0.91	0.01	0.92	0.038

Means within a column followed by different letter(s) are statistically different at the 5% significance level.

3.4. Sugars

The results presented in Table 6 show that all of the foliar spray treatments with algae extract and potassium nitrate used individually or in combination demonstrated a significant increase in the percentage of total and reducing sugars as well as TSS in the fruit in comparison to the untreated palms in both seasons. Moreover, the combination of 1% algae extract and 2% KNO₃ gave the best results: 36.33% and 36.66% for reducing sugars and 49.00% and 49.00% for total sugars in the first and second seasons, respectively. At the same time, the lowest values for reducing sugars (30.33% and 31.00%) and for total sugars (42.00% and 43.00%) in the first and second seasons, respectively, were recorded in the control treatment. On the other hand, there were significant differences among all of the tested treatments on the non-reducing sugars of the fruits in both seasons.

Table 6. Effect of algae and potassium as foliar sprays on fruit sugar contents of Barhee date palm.

Treatments	Reducing Sugars (%)	Nonreducing Sugars (%)	Total Sugars (%)
	Season 1		
Control	30.33 d	11.66 a	42.00 d
Algae (0.5%)	31.00 d	12.00 a	43.00 d
Algae (1%)	30.66 d	11.66 a	42.33 d
KNO ₃ (1%)	34.33 c	11.00 a	45.33 c

Table 6. Cont.

Treatments	Reducing Sugars (%)	Nonreducing Sugars (%)	Total Sugars (%)
	Season 1		
KNO ₃ (2%)	35.33 bc	12.00 a	47.33 b
Algae (0.5% + KNO ₃ 1%)	36.66 a	12.00 a	48.66 a
Algae (1% + KNO ₃ 2%)	36.33 ab	12.66 a	49.00 a
LSD at 0.05 level	1.05	NS	1.02
Season 2			
Control	31.00 d	12.00 a	43.00 d
Algae (0.5%)	31.00 d	11.66 ab	42.66 de
Algae (1%)	31.00 d	11.00 b	42.00 e
KNO ₃ (1%)	33.33 c	12.00 a	45.33 c
KNO ₃ (2%)	35.33 b	12.33 a	47.66 b
Algae (0.5% + KNO ₃ 1%)	36.33 a	12.00 a	48.33 ab
Algae (1% + KNO ₃ 2%)	36.66 a	12.34 a	49.00 a
LSD at 0.05 level	0.95	NS	0.83

Means within a column followed by different letter(s) are statistically different at the 5% significance level.

4. Discussion

The positive effects of potassium and algae treatments on the yield and its components in this experiment are similar to those obtained by El-Motty [3], Mohamed [5], and Ibrahim [8] on mangos and Khan [4] on grapevines. In this regard, potassium is a mobile nutrient and is well adapted to foliar fertilization because it is rapidly translocated from the leaves to other plant parts and consequently increases yield and its components [28]. Seaweeds contain various trace elements (Fe, Cu, Zn, Co, Mo, Mn, and Ni), vitamins, amino acids, and plant growth hormones (IAA, IBA, and cytokinins) that have many beneficial effects on plant growth and development [2].

The positive effect of potassium on yield and fruit quality was explained by Mirza [29], who reported that potassium plays roles in flowering and pollen germination as well as in seed development and added that potassium activates nitrate reductase (NR), a starch synthetase, and these two enzymes create a balance by producing protein and carbohydrates, respectively. Moreover, potassium plays an imperative role in the photosynthesis process and the subsequent carbohydrate translocation and metabolism, which eventually increase the crop yield [29]. Potassium also regulates the biosynthesis, conversion, and allocation of metabolites, which ultimately increases the yield. Many researchers' works strongly support the notion that K is directly or indirectly responsible for the higher yield of crops. On the other hand, potassium is responsible not only for higher production but also for the improved quality of the harvest. Thus, K ensures high-value crops and benefits to growers. K is sometimes called the "quality element" for its association with better crop production, which is supported by many scientists.

The increases due to potassium and algae applications on fruit diameter, fruit length, and flesh weight could be attributed both to the role of potassium in improving fruit growth and uptake of nutrients that accelerate metabolic processes and to the growth promoters and some macro- and micronutrients present in algae. These observations on date palm were also detected by Harhash [30], who noted that potassium increases the rate of sugar transported to actively growing regions of the palm and to the developing fruits. The results also agreed with those of Ahmed [6], Desouky [14], Mohamed [18], and Elsabagh [31] on date palm and with that of Abd El-Razek [32] on mango. The obtained results on the effect of potassium on TSS% and sugar content may be attributed to the fact that potassium activates the enzymes involved in sugar biosynthesis and aids in the

translocation of sugars [11]. This was confirmed by Al Hamudi [13], who reported that spraying Barhee date palms with potassium sulfate significantly increased fruit retention and the physical and chemical fruit parameters.

On the other hand, the results obtained regarding the effect of algae are consistent with those obtained by El-Sharony [33], who reported that spraying algae on mangos had an obvious effect on enhancing their fruit chemical properties and induced the highest values of the percentage of total soluble solids and total sugars.

5. Conclusions

From the abovementioned results, it can be concluded that spraying date palms with a combination of algae extract and potassium nitrate, especially at higher concentrations (1% algae + 2% potassium nitrite) has a positive effect and affords the best results on increasing yield and improving the fruit quality of Barhee date palm under the current study conditions.

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