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Yield and fruit quality of Barhee date palms as affected by gibberellic acid, boron and active dry yeast sprays

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Abstract

The present investigation was conducted over two consecutive seasons on 15-year-old Barhee date palms (*Phoenix dactylifera* L.) cultivated in an exclusive orchard 63 kilometers along the Cairo-Alexandria Desert Road in sandy soil under a drip irrigation system. For three times, bunches of the tested palms were misted with GA3, boric acid, or active dry yeast: once a day before pollination, once a month after fruit set, and once a month before harvest. GA3 was sprayed at the previous dates with 50, 100, and 50 ppm, respectively, while boric acid was sprayed at the same dates with 2000, 1500, and 1000 ppm. Similarly, active dry yeast was sprayed at the same dates with 250, 500, and 250 ppm. The investigated treatments were compared with untreated palms. The findings indicate that all spraying treatments improved fruit properties, both chemical and physical, and boosted fruit set and yield compared to the control. In general, the most effective treatment to increase fruit set, production, and the physical and chemical properties in both seasons was the procedure of spraying inflorescences with active dry yeast three times (250, 500, and 250 ppm).

Keywords: Active dry yeast, Boron, Barhee date palm, Fruit quality, Gibberellic acid, Yield.

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Contents

Contribution of this paper to the literature
Comparing active dry yeast as a bioactive material with two chemical agents (GA3 and boron) may provide an opportunity for dry yeast to be used as an alternative treatment, especially if it produces distinctive results concerning fruit set, yield, and fruit properties of one of the most economical date palm cultivars.

1. Introduction

The oldest fruit crop grown domestically in the Middle East is the date palm, and many people rely heavily on its fruits for their nutritional needs. The Ministry of Agriculture and Land Reclamation has released statistics showing that Egypt is one of the top ten countries in the world for date production. There are approximately fifteen million fruitful female palms (14,955,331) planted on 115,610 feddans, yielding 1,684,917 metric tonnes of dried, semi-dry, and fresh dates [1].

In all agricultural systems, increasing crop yield through the effective use of fertilizers is a key objective. Researchers are motivated to develop more effective methods of fertilizer application because excessive nutrient loss from agricultural land causes public concern. The benefits of foliar fertilization include homogeneous fertilizer distribution, rapid nutritional response, and lawful application rates. Furthermore, it is simple to control concealed hunger [2, 3].

When applied topically, plant growth regulators are the most effective means for controlling growth, flowering, yield, and quality of fruit, particularly its size, as well as the maturation of the fruit. The growth regulators' capacity to expand date cell size and promote fruit development makes them well-known [4].

With GA3 spray at 100 or 150 ppm after 50 days of pollination, Sakkoty dates' fruit weight, flesh percentage, fruit dimensions, and moisture percentage all increased significantly compared to untreated ones. Total sugars were somewhat lower with GA3 than in the control [5].

When compared to the control, the chemical and physical characteristics of the Barhee cultivar were enhanced by spraying salicylic acid (SA), benzyl adenine (BA), gibberellic acid (GA3), and naphthalene acetic acid (NAA). Growth regulator treatments generally improved the shelf life of Barhee date palms [6].

It has been demonstrated that date palms benefit from boron spray application in terms of fruit set and quality because it affects a variety of plant functions, including hormone transition, flowering, pollen tube growth, and cell membrane functions. It also regulates the production of proteins, carbohydrates, and phenols, as well as the transportation of sugars from areas of production to places for growth and storage [7].

Fruit growth, setting, retention, yield, and quality are all positively impacted by micronutrients [8-10].

A number of functions, including protein synthesis, glucose metabolism, and sugar transport, depend on boron [11].

Certain microelements, such as boron, appear to significantly influence date palm yield and fruit quality, aiding in achieving proper fruit set and quality [12, 13].

Additionally, bio-fertilization is recommended as a safe fertilization technique to boost the productivity and quality of numerous fruit varieties. Certain strains, such as fixing bacteria and yeasts, are used as biological fertilizers to dissolve silicate, phosphorus, and nitrogen, making bio-fertilizers commercially accessible. Many advantages and benefits of employing active dry yeast as a bio-fertilizer are attributed mainly to the stimulation of photosynthesis, increased levels of vitamins, and cytokinin (a naturally occurring plant hormone) [14].

Active bread yeast was sprayed on Valencia orange trees once in March or August, or twice, to improve fruit set, growth, number, weight, and volume, as well as the yield and other fruit quality parameters [15].

When Sukary date palms were sprayed with yeast at 4% and 8%, the amount of soluble solids and total sugars was reduced [16].

The aim of this research is to investigate the impact of applying gibberellic acid, boron, and yeast to the inflorescences of Barhee date palms on fruit yield and quality.

2. Materials and Methods

This study examined the results of foliar spraying with GA3, boric acid, and active dry yeast on fruit set, yield, and quality over two consecutive seasons on 15-year-old, uniform Barhee date palms (*Phoenix dactylifera* L.) cultivated in a private orchard located 63 kilometers along the Cairo-Alexandria desert road.

With the exception of the tested treatments, the experimental palms were given the standard horticultural procedures used in the commercial orchard after being chosen as healthy, uniform, and almost identical in vigor.

In both seasons, the same male pollen was used to pollinate every palm. A drip irrigation system was employed to irrigate the palms. The palms underwent four spraying treatments, each consisting of three replicates and three bunches (4 replicates × 3 replicates × 3 bunches = 36 bunches on 12 palms). The treatments were arranged in a randomized complete block design, and the experimental bunches were sprayed with GA3, boric acid, or active dry yeast three times: once a day before pollination, once a month after fruit set, and once a month before harvest. GA_3 was sprayed at the specified dates with 50, 100, and 50 ppm, respectively, while boric acid was applied at the same dates with 2000, 1500, and 1000 ppm. Similarly, active dry yeast was sprayed at the same dates with 250, 500, and 250 ppm, respectively.

In this manner, the treatments were sprayed with:

1. Water only (Control).
2. GA_3 at 50, 100, and 50 ppm, respectively, at the three dates.
3. Boric acid at 2000, 1500, and 1000 ppm, respectively, on the three dates.
4. Active dry yeast at 250, 500, and 250 ppm, respectively, on the three dates.

A 6:1 carbon to nitrogen supply was used to activate the dry, pure yeast powder, according to Barnett et al. [17].

Urea at 0.25% was added to the spraying solution for each treatment. A small handheld sprayer was used to apply the spray until runoff. The spraying solution was mixed with Tween 20 (1%) as a wetting agent. Fruits were harvested in early October when they were fully ripe, indicated by the color of their skin, which should turn yellow entirely.

The following measurements were carried out:

Fruit set percentage: Ten strands per spath were measured for both abnormal and normal fruit set. The following calculation was used to determine the percentage of fruit setting:

Fruit set % = (Total number of normal fruit set - Number of abnormal fruit set) / Total number of fruits × 100.

2.1. Yield /Palm (Kg)

Weighting bunches at harvest (early October in both seasons) allowed us to determine the overall production per palm.

2.2. Average Bunch Weight

The number of bunches per palm was divided by the total yield per palm to determine the average bunch weight.

2.3. Average Fruit Number/Strand

The number of fruits on ten randomly chosen strands was counted to establish the average number of fruits per strand.

2.4. Fruit Physical Properties

Ten fruits were randomly selected from each bunch (as a replication), and thirty fruits per treatment were used to assess the fruit weight, flesh, and seed weight (g), as well as the fruit length and diameter (cm).

2.5. Fruit Chemical Properties

Fruit chemical characteristics were assessed at harvest by measuring the percentage of total soluble solids and calculating the percentage of acidity by titrating against 0.1 NaOH, in accordance with the Association of Official Agricultural Chemists [18].

Using the Welbur method, the amounts of carotene and total chlorophyll (mg/100g peel fresh weight) were determined [19].

2.6. Statistical Analysis

According to Snedecor and Cochran [20], analysis of variance was conducted on the data gathered for both seasons, and the means were separated at the 5% level using the Duncan multiple range test [21].

3. Results

3.1. Yield

Both bunch weight and the earliest fruit set are considered indicators of yield. The results in Table 1 demonstrate how GA3, boron, and active dry yeast sprays affected the percentage of fruit set and bunch weight of Barhee date palms during the two seasons. Throughout the two seasons under study, it was found that the outcomes followed a similar pattern.

Compared to the untreated palms (Control), it was evident from the statistics that all treatments significantly increased the fruit set percentage, bunch weight, and yield per palm. The application of active dry yeast produced the highest yield per palm (149 & 155 kg), the heaviest bunch weight (14.96 & 15.50 kg), and the highest percentage of fruit set (70.30% & 71.56%) during the two seasons studied.

In terms of the average number of fruits per strand, Table 1 demonstrates that the GA3 treatment produced the maximum number of fruits (22.6 & 23.1 fruits/strand), followed by the active dry yeast treatment (22.0 & 22.53 fruits/strand).

On the other hand, the control treatment gained the lowest fruit set (58% & 59%), bunch weight (11.8 & 12.2 kg), yield per palm (118 & 122 kg), and fruit number per strand (19.2 & 19.6 fruit/strand) in both seasons of the study, respectively.

Table 1. Effect of spraying GA_3, boron, and active dry yeast on fruit set, bunch weight, yield per palm, and fruit number per strand of Barhee date palms during two seasons.

Treatments		Fruit set%		Bunch weight (kg)		Yield/palm (kg)		Fruit number/strand	
		1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
T1	Control	58.00d	59.53c	11.80b	12.20d	118.00c	122.00d	19.20d	19.63c
T2	GA_3	65.00c	68.00b	14.00a	13.43c	140.00b	134.30c	22.00b	22.53a
T3	Boric acid	67.60b	69.00ab	14.16a	14.50b	141.66b	145.40b	21.06c	21.63b
T4	Active dry yeast	70.30a	71.56a	14.96a	15.50a	149.66a	155.00a	22.60a	23.06a

Note: Means having the same letters within a column are not significantly different at 5% level.

3.2. Fruit Quality

3.2.1. Physical Properties

Results from both seasons indicate that spraying inflorescences with different treatments had a substantial impact on the fruit dimensions, fruit weight, flesh weight, and seed weight of Barhee date palms when compared to the control Table 2.

In the first and second seasons, respectively, foliar spraying with active dry yeast produced the largest fruit length (3.6 and 3.7 cm) and fruit diameter (2.76 and 2.73 cm). Spraying GA3 produced fruit lengths of 3.57 and 3.56 cm and fruit diameters of 2.7 and 2.8 cm in both study seasons.

Throughout the two study seasons, the control treatment produced the smallest fruit dimensions, measuring 3.1 and 3.2 cm for fruit length and 2.3 and 2.36 cm for fruit diameter.

The highest fruit weight (22.4 & 22.9 g) and flesh weight (20.96 & 21.33 g) were recorded in the first and second seasons, respectively, by foliar spray with active dry yeast. This was followed by foliar spray with boron, which produced fruit weights of 21.2 & 21.9 g and flesh weights of 19.60 & 20.26 g in both study seasons. The control treatment produced the lowest fruit and flesh weights, weighing 18.06 and 19.0 g for fruit and 16.66 and 17.46 g for flesh throughout the two experimental seasons.

In terms of seed weight, the foliar spray containing boron produced the maximum seed weight (1.60 & 1.63 g), followed by the foliar spray containing active dry yeast (1.46 & 1.56 g) across the two study seasons. The foliar spray with GA3 yielded the lowest seed weight, weighing 1.16 and 1.26 g in both study seasons.

Table 2. Effect of spraying GA_3, boron, and active dry yeast on fruit dimensions, fruit weight, flesh weight, and seed weight of Barhee date palms during two seasons.

Treatments		Fruit length (cm)		Fruit diameter (cm)		Fruit weight (g)		Flesh weight (g)		Seed weight (g)	
		1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
T1	Control	3.1d	3.20c	2.30b	2.36b	18.06d	19.0d	16.66d	17.46d	1.40b	1.56a
T2	GA_3	3.5b	3.56b	2.70a	2.80a	20.03c	20.53c	18.86c	19.26c	1.16c	1.26b
T3	Boric acid	3.3c	3.50b	2.73a	2.86a	21.20b	21.90b	19.60b	20.26b	1.60a	1.63a
T4	Active dry yeast	3.6a	3.73a	2.76a	2.73a	22.43a	22.90a	20.96a	21.33a	1.46ab	1.56a

Note: Means having the same letters within a column are not significantly different at 5% level.

3.2.2. Chemical Properties

Table 3 presents the results of GA3, boron, and active dry yeast sprays on various chemical characteristics of Barhee fruits over two seasons. These qualities include total soluble solids, acidity percentage, total sugars percentage, and TSS/acid ratio.

GA3, boron, and active dry yeast sprays significantly enhanced the dates' chemical composition by increasing the percentages of total soluble solids, total sugars, and TSS/acid ratio, while decreasing the percentages of total acidity compared to untreated samples.

The results might simply show that the total soluble solids were equal to the amount of sugar, and the overall acidity content was the opposite.

In general, spraying active dry yeast resulted in the highest total soluble solids (32.53 & 32.90%), TSS/acid ratio (89.56 & 88.83), and total sugars (53.06 & 55.06%) during the two seasons of the study, respectively, followed by foliar spray with GA_3, which recorded 31.2 & 32% for TSS and 86.66 & 84.93 for TSS/acid ratio. The second highest for total sugars (50.50 & 52.66%) was observed when boric acid was sprayed. The lowest percentages of TSS, TSS/acid ratio, and total sugars were obtained with the control treatment, which recorded 28.83 & 29.3% for TSS, 58.03 & 57.43 for TSS/acid ratio, and 42.56 & 42.80% for total sugars in the first and second seasons, respectively.

According to the results in Table 3 over the two study seasons, the water spray treatment (Control) had the highest fruit acidity percentages (0.49% and 0.51%, respectively). However, both GA3 and active dry yeast had the lowest overall acidity percentages (0.36% and 0.37%) for both seasons, respectively.

Table 3. Effect of spraying GA_3, boron and active dry yeast on TSS, acidity, TSS/acid ratio and total sugars of Barhee date palms during the two seasons.

Treatments		TSS%		Acidity%		TSS/acid		Total sugars%	
		1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
T1	Control	28.83c	29.30c	0.49a	0.51a	58.03c	57.43d	42.56d	42.80d
T2	GA_3	31.20b	32.00b	0.36c	0.37c	86.66a	84.93b	46.46c	48.56c
T3	Boric acid	28.73c	28.70c	0.43b	0.41b	65.16b	70.00c	50.50b	52.66b
T4	Active dry yeast	32.53a	32.90a	0.36c	0.37c	89.56a	88.83a	53.06a	55.06a

Note: Means having the same letters within a column are not significantly different at 5% level.

All treatments significantly increased both reducing and non-reducing sugars throughout the duration of the two study seasons when compared to the control, as shown by the results in Table 4. The highest percentages of reducing and non-reducing sugars, 40.86% and 42.66%, and 12.03% and 12.4%, respectively, were produced by the palms sprayed with active dry yeast in both seasons. The control yielded the lowest results, with reducing sugars at 32.3% and 32.36%, and non-reducing sugars at 9.36% and 10.1% during the two study seasons. The other treatments recorded intermediate results.

According to the results in Table 4, the total chlorophyll content in the fruit peel was significantly increased by spraying inflorescences with active dry yeast. The highest content (6.44 and 6.53 mg/100g in fresh peel) was recorded in the first and second seasons, respectively, followed by foliar spraying with boric acid, which produced 6.27 and 5.80 mg/100g in the fresh peel across the two seasons. During both study seasons, the control treatment's fresh peel had the lowest total chlorophyll concentration, registering 2.44 and 2.64 mg/100g.

The findings in Table 4 show that the total carotene content in the fruit peel was significantly increased by spraying water only (control), which produced the highest content (8.31 & 8.49 mg/100g) in the first and second seasons, respectively, while the GA3 treatment resulted in the lowest content (3.29 & 4.06 mg/100g) in the two seasons. The other treatments yielded intermediate results.

Table 4. Effect of spraying GA_3, boron and active dry yeast on reducing, non-reducing sugars, total chlorophyll and carotene of Barhee date palms during the two seasons.

Treatments		Reducing sugars%		non-reducing sugars%		Total chlorophyll mg/100g		Carotene mg/100g	
		1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
T1	Control	33.20c	32.36d	9.36d	10.1c	2.44c	2.64c	8.31a	8.49a
T2	GA3	36.03b	37.56c	10.43c	11.00b	2.47c	4.20b	3.29d	4.06d
T3	Boric acid	39.50a	40.66b	11.00b	12.00a	6.27b	5.80a	6.43c	7.05c
T4	Active dry yeast	40.86a	42.66a	12.03a	12.40a	6.44a	6.53a	6.49b	7.14b

Note: Means having the same letters within a column are not significantly different at 5% level.

4. Discussion

The benefits of foliar fertilization include rapid reactions to applied nutrients, consistent fertilizer distribution, and low application rates [2]. Applying zinc and boron to date palms increased their productivity, fruit set percentage, and bunch weight [9].

Another theory is that boron enhances fruit removal force because it is involved in numerous enzymatic processes that control the metabolism of proteins and carbohydrates, which are essential for growth and development [8]. By applying boron and bio-fertilization, date palm fruit quality had improved.

Many processes, including the transport of sugars and the metabolism of carbohydrates and proteins, depend on boron to enhance the weight and dimensions of fruits and to speed up their maturity [11].

Numerous researchers [8-10, 16] found that spraying micronutrients increased fruit yield and quality, and the obtained results were consistent with those findings. In addition to increasing productivity, proper boron nutrition is essential for fruit quality [22].

The obtained results are in line with numerous studies Sarrwy, et al. [8]; Omar, et al. [9]; Mostafa [10]; Khayyat, et al. [13]; Osman [23]; Ashour, et al. [24]; Harhash and Abdel-Nasser [25]; Soliman and Al-Obeed [26]; Zaen El–Daen, et al. [27] and Jabbar and Hassan [28] who found that foliar spray of boron on date palms significantly affected fruit setting.

On the other hand, the GA3 application has a noticeable impact on fruit volume, diameter, and length. This effect may be explained by gibberellic acid's ability to increase cell elongation, as well as the elasticity and permeability of the cell wall, which increases the amount of water and nutrients entering the cells and causes them to swell and enlarge [29, 30].

Our obtained results agree with those observed in many experiments [24, 28, 31-33].

The presence of yeast is advantageous for fruit development, since applying 0.2% yeast solution to Keitte mango trees once during full bloom resulted in the development of fruits, increasing their weight and quantity per tree, as well as fruit length, width, and weight. Additionally, it improved the pulp-to-fruit ratio and increased total soluble solids [34]. With its abundance of cytokinins and nutritional components, yeast is a natural (safe and non-polluting) component. Additionally, it is rich in reducing sugars, enzymes, minerals, amino acids, and vitamins B1, B2, B3, and B12, all of which improve the chemical and physical properties of the fruits [35, 36]. This may be the reason for the effects of yeast extract. Additionally, yeast contains proteins and cytokinins that promote cell growth and division [17].

Regarding the impact of active dry yeast on the fruit's physical and chemical properties, the results obtained are consistent with those found in other studies [10, 16, 37, 38].

5. Conclusion

Overall, it can be said that applying GA3, boric acid, and active dry yeast to the inflorescences of Barhee date palms one day prior to pollination, one month after fruit set, and one month before harvest, respectively, has a favorable impact on fruit set and fruiting. The active dry yeast spray outperformed the boric acid and GA3 sprays in both study seasons.

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