Effect of Foliar application of Boron and IAA on some Quantitative and Qualtative of Barhi Date Palm

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Abstract

A field study was carried out in a date palm orchard located at Basrah governorate, Iraq, to study the impact of foliar application of boron and IAA on the fruit set, yield and some physical and chemical attributes of Barhi date palm fruits. The experiment was carried out using 27 uniform and productive palms in a 3 × 3 factorial experiment in Randomized Complete Block Design (RCBD) with three replications. The treatments were three levels (0, 100 and 150 mg L^{-1}) both of boron and IAA. The results showed that increasing the boron and IAA concentrations had an overall positive effect on fruit set and yield and a negative effect on the developing of parthenocarpic fruits. The highest fruit set (86.00%) was obtained with the combined application of 150 mg L^{-1} boron and 150 mg L^{-1} IAA along with lowest parthenocarpic fruits (13.00%). This was also the treatment that gave the heaviest bunch (14.26 kg) and total output (85.56 kg $palm^{-1}$). The physical attributes of fruit were enhanced with highest length, diameter, volume and weight of 3.29cm, 2.64cm, 11.62cm^3 and 11.18g, respectively. The most highest total sugars (67.10%), dry matter (69. 61%), boron concentration (34.19 mg kg^{-1}) and IAA level (36.30 µg g^{-1}) were also observed in the same treatment. In summary, the best treatment to enhance reproductive, yield and fruit quality of Barhi date palm under the present study conditions was the combined application of B and IAA at150 mg L^{-1} each.

Keywords: Foliar application, Fruits set, Growth regulator, Date palm.

Introduction

The date palm *Phoenix dactylifera* L. has been recognized as one of the essential fruit trees in arid and semi-arid regions for centuries due to its high nutritional, economic, and social value. It is a strategic crop for many countries in the Middle East and North Africa and its resilience to harsh environmental conditions is exceptional. In addition, the fruits contain a high concentration of sugars, vitamins, minerals and phenolic compounds with nutraceutical and health promoting properties and have a leading position in the group of tropical and subtropical fruit crops [2].

The Barhi date cultivar is known to be the best local Iraqi cultivar in terms of fruit quality and flavor, and its fruit can be eaten at all stages of maturity (Khalal, Rutab, and Tamar). Its propagation has been disseminated to other countries through tissue culture thereby turning it from a local cultivar to a main commercial cultivar [12]. Due to its superior fruit quality, ability to eat at the Khalal and Rutab stage, high value and higher acceptance by consumers Barhi is the most wanted commercial cultivar in the world. The increasing demand for healthy and genetically uniform plants of some species

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has stimulated the expansion of its propagation through tissue culture [12].

That is notwithstanding the excellent tissue culture production to date of the date palm, there are physiological problems and yield constraints associated with certain cultivars (notably Barhi) including low fruit set percentage, high percentage of parthenocarpic fruits (Shiis) and low yield when compared with the traditionally propagated offshoots [16]. It is suggested that this phenomenon may be a result of physiological, hormonal, and environmental factors affecting pollination, fertilization, embryonic development and fruit growth [4]. .Parthenocarpic fruit: fruit that develops due to fertilization failure or incomplete seed development, which makes it small, deformed, seedless and sometimes does not reach normal maturity. This is because the date palm's production in quantity and quality has declined, making it economically impossible to sustain commercial production [6].

Boron is a vital micro-nutrient for plant growth, having a key function in cell wall structure and stability. It is also involved in pollen germination, pollen tube growth, and fertilization, and in the formation of boron-sugar complexes that enable the translocation of photosynthate from leaves to the growing organs. This has a positive effect on the improvement of fruit set % and fruit development and quality [6, 16, 22]. Boron enhances the level of potassium, which plays a vital role in the osmotic pressure and cofactor of enzymatic processes in plants. It decreases the accumulation of Na and Cl and increases stability of membrane and activity of peroxidase enzyme in leaves particularly under saline stress, resulting in higher fruit set %, ripening %, total dry matter, and the total yield of palm [10]. There is now evidence for boron and auxin metabolism interaction as boron deficiency alters the expression of genes involved in auxin biosynthesis and transport and, therefore, the plant growth and development [15]. Among auxins, a natural auxin, indole-3-acetic acid (IAA), is one of the most important plant hormones involved in fruit set and development, among other processes. They promote cell division and elongation, facilitate ongoing ovarian growth after fertilization, and inhibit abscission-zone development, thus lessening flower and young-fruit falling. This activity enhances fruit set and fruit growth in many fruit crops [24, 9]. It was reported that a number of studies, on foliar application of some micronutrients mainly boron and zinc, showed that it helped in increasing the fruit set percentage and yield and quality of date palm productions in terms of fruit physical and chemical nature, which will definitely reflect on the fruit quality and crop production for the better[19].

Although there are many reports on the boron or growth regulators effect separately applied to the date palm for enhancement of growth and productivity, but the interaction effect of boron and the auxin IAA on tissue culture raised date palm trees, especially the Barhi cultivar is scarce. Hence the present investigation was carried out to study the effect of boron and IAA applications via foliar spray on fruit set %, some physical, chemical and yield attributes of tissue culture Barhi date palm fruits.

Material and Methods

The study was carried out in a date palm orchard located in Abu Al-Khaseeb District, southern Basrah Governorate, Iraq, to study the impact of foliar application of boron and the plant growth regulator indole-3-acetic acid (IAA) on fruit set and some physical and chemical traites of Barhi date palm fruits. Twenty-seven healthy, mature and consistently productive Barhi date palm trees were

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selected according to their homogeneity in vegetative growth and size. The chosen trees received similar levels of culture practices including irrigation, pruning and pest control throughout the period of the study. All the chosen trees were pollinated equally using pollen powder of the male cultivar (Ghannami Akhdar) from 25 to 30 March after opening of the first female flower to guarantee thorough pollination of all inflorescences. The number of inflorescences was fixed at six per tree. Immediately after pollination, the inflorescences were bagged with paper bags to avoid pollution by wind pollens and maintain homogeneity.

A 3 × 3 factorial combination of boron concentrations (0, 100, and 150 mg L^{-1}) and IAA concentrations (0, 100, and 150 mg L^{-1}) was used. Therefore, the experiment consisted of nine treatment combinations. The treatments were carried out as foliar applications in three stages: the first one was applied before inflorescence emergence, the second when the inflorescences started to be open, and the third application at five days after inflorescence opening. Spraying was carried out in the early morning to wetting and runoff of the treated surfaces.To all spray solutions as surfactant for retarding surface tension, facilitating spray spread on leaf and flower surfaces and for increasing the efficiency of the foliar application. Control treatment was treated with distilled water containing the equal concentration. Samples of fruit were taken 30 day after pollination at the Hababouk stage. Fruit set and parthenocarpic (unfertilized) fruit (%) was assessed at this stage, along with the concentration of boron and IAA in the fruit tissues. Additional fruit samples were harvested at the Khalal stage to analyze the physical and chemical traits of the fruits. Bunch weight and total yield per palm were assessed at the Tamar stage. Prior to the commencement of experiment, soil samples (n= 5) were collected from the depth of 0–60 cm of the experimental orchard and analyzed for some physical and chemical characteristics relevant to the study for determining the baseline soil status. Results of the soil test are shown in Table 1.

Studied traits:

Fruit Set (%)

Fruit set was assessed by counting the number of fruits and empty fruit scars 30 days after pollination[20] . Ten strands were randomly chosen from each bunch, and the proportion of fruit set was determined as follows:

$$Fruit\ Set\ (\%) = \frac{Number\ of\ set\ fruits}{Number\ of\ Set\ \ Fruits\ +\ Total\ Number\ of\ Empty} \times 100$$

Percentage of Parthenocarpic Fruit (%)

This was determined with the following equation:

$$Parthenocarpic\ fruit\ (\%) = \frac{Quantity\ of\ parthenocarpic\ fruits}{Total\ \ fruit\ number} \times 100$$

Volume, Length, Diameter and Weight of the Fruit

Ten fruits were randomly taken from each experimental replicate for fruit physical traits determination. The fruit volume was measured by the water displacement method. A known volume of water was placed in a graduated cylinder, and the volume of fruit was measured as the difference in the levels of water before and after the immersion of fruit. The average volume of the fruits was obtained by dividing the total displaced volume by the number of fruits. Fruit length and diameter were taken by a Vernier caliper, and the average of the ten sampled fruits was used. The fresh weight of fruit was

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measured by an electronic balance with high precision, mean fruit weight was computed by dividing the total fruit weight (g) on number of fruits.

Average bunch weight

Bunches were harvested at the Tamar stage and weighed individually using a field balance. The average bunch weight was expressed in kilograms (kg) per bunch.

Total yield

Total yield per palm was calculated by multiplying the average bunch weight by the number of bunches retained on each palm.

Total sugars (%)

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Total sugars in the date fruit samples were determined by the Lane and Eynon titrimetric method using Fehling's solution with methylene blue as an indicator, following the procedure described by [14].

Dry matter (%)

The dry matter of the fruit was determined by drying a known weight of fresh fruit tissue to a constant weight [1]. The following equation was used to calculate the dry matter content:

$$Dry\ matter\ (\%) = \frac{Dry\ weight\ of\ sample}{Fresh\ weight\ of\ sample} \times 100$$

Determination of boron concentration in fruits

Boron concentration in the fruit tissues was determined using the colorimetric method based on the reaction with Azomethine-H, following the procedure described by [21]. The results were expressed as mg kg^{-1} fresh fruit weight.

Significant Difference (LSD) test at 5% level of significance.

Determination of IAA concentration in fruits

Fruit samples were washed, gently dried using paper towels, immediately frozen in liquid nitrogen, and stored at −80°C until analysis. A 1 g fresh-weight sample was ground in liquid nitrogen, extracted, and used for IAA determination. The IAA concentration was quantified according to the method described by [25].

Statistical analysis

The experimental data were subjected to ANOVA using GenStat statistical package. Means of treatment were compared by Least. Significant Difference (LSD) test at 5% level of significance [5].

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Table 1: Some physical and chemical properties of the study soil field (0–60 cm depth).

Property	Unit	Value
PH	1:1	7.67
Ec	Ds/m	10.94
$CaCo_3$	g/kg	48.24
Organic Matter	g/kg	24.28
Available Nitrogen	g/kg	6.25
Available Phosphorus	g/kg	0.80
Soil Separates		
Sand	%	4.6
Silt	%	47.3
Clay	%	48.1
Soil Texture	Silty Clay	

Results and Discussion

Effect of boron and IAA treatments on the physical of date palm fruits

The application of boron and indole-3-acetic acid (IAA), either individually or in combination, markedly affected the physical characteristics of Barhi date palm fruits (Table 2). Fruit length, diameter, volume, and weight generally increased with increasing concentrations of both boron and IAA. The lowest values for fruit length (2.72 cm), diameter (1.82 cm), volume (7.20 cm^3), and weight (5.64 g) were recorded in untreated fruits (0 mg L^{-1} boron + 0 mg L^{-1} IAA). Increasing IAA concentration from 0 to 150 mg L^{-1} at the corresponding boron levels resulted in a progressive increase in all measured fruit characteristics. At 100 mg L^{-1} boron, the increase in IAA concentration from 0 to 150 mg L^{-1} led to an increase (2.76–2.90 cm) in fruit length, fruit diameter (1.91–2.37 cm), fruit volume (8.13–10.25 cm^3) and fruit weight (7.17–9.33 g) The largest values were mostly found when 150 mg L^{-1}B was foliar applied together with 150 mg L^{-1} income, then the resulting fruits were 3.29 cm in length, 2.64 cm in diameter, has a volume of 11.62 cm3 and a weight of 11.18 g. These were an increase of around 21.0%, 45.1%, 61.4% , and 98.2%, respectively, over the untreated control. The main effects of the two growth-promoting treatments followed a similar pattern. Mean length, diameter, volume, and weight of fruit increased as the IAA concentration increased at all boron levels, and the values reached to 3.05 cm, 2.57 cm, 11.15 cm^3, and 10.72 g, respectively at 150 mg L^{-1} IAA. In case of IAA concentrations, fruit length, diameter and weight increased significantly with increasing boron concentration; the highest mean values were observed at 150 mg L^{-1} boron.

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Table (2): Effect of Boron and IAA treatments on the physical characteristics of date palm fruits (cv. Barhi)

Boron concentration (mg L^{-1})	IAA concentration (mg L^{-1})	Fruit length (cm)	Fruit diameter (cm)	Fruit volume (cm^3)	Fruit weight (g)
0	0	2.72	1.82	7.20	5.64
	100	2.78	1.92	8.15	7.48
	150	2.87	2.18	9.16	8.37
100	0	2.76	1.91	8.13	7.17
	100	2.85	2.17	9.17	8.43
	150	2.90	2.37	10.25	9.33
150	0	2.94	2.56	10.92	10.47
	100	2.96	2.58	10.94	10.50
	150	3.29	2.64	11.62	11.18
LSD		**0.039**	**0.031**	**0.094**	**0.769**
Boron main effect	0	2.79	1.98	8.17	7.16
	100	2.84	2.15	9.18	8.31
	150	3.05	2.57	11.15	10.72
LSD		**0.022**	**0.018**	**0.054**	**0.444**
IAA main effect	0	2.81	2.10	8.75	7.76
	100	2.85	2.20	9.41	8.80
	150	3.02	2.40	10.34	9.63
LSD		**0.022**	**0.018**	**0.054**	**0.444**

Enhancement in fruit length, diameter, volume and weight by boron application was related with its function in keeping the cell wall, pollen tube elongation, and pollen germination. Boron also participates in the synthesis of boron-sugar complexes which act as carriers for photosynthesis increasing carbohydrate accumulation in developing fruits and improving fruit enlargement and quality [6, 7]. These results are in line with those of [3], who found that foliar application of boron enhanced date palm fruits physical properties and their overall quality. Effect of IAA spraying on fruit physical parameters was attributed to its efficacy as major plant hormone controlling fruit development and growth and its role in cell division and expansion and an ability to promote sink strength by up regulating activities involved in supply of carbohydrates and other nutrients to the fruits that results with faster rates of growth and more dimension and weight. Moreover, early fruit growth and development are modulated by IAA, which promotes fruit persistence and viability [9, 13]. The superiority of the interaction treatments between boron and IAA may be due to a synergistic effect since the beneficial impact of boron on fertilization and nutrient supply is complemented by the IAA-induced stimulation of cell division and elongation. Together, these create ideal physiological conditions for the development of the fruit, thereby bringing about a much more significant improvement in fruit quality than treatment with either agent alone.

Effect of boron and IAA applications on yield characteristics of Barhi date palm

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Boron and IAA treatments significantly influenced all the yield components of Barhi date palm (Table 3). In general, increasing the concentrations of both boron and IAA resulted in a progressive increase in fruit set, bunch weight, and total yield, accompanied by a corresponding decrease in the percentage of parthenocarpic fruits. The lowest percentage of fruit set with the highest percentage of parthenocarpic fruits was recorded in the control (0mg L^{-1} boron + 0 mg L^{-1} IAA) with 30.33% and 67.00%, respectively. Under 0 mg L^{-1} of boron, IAA increased the fruit set at 56.67 and 68.00% for 100 and 150 mg L^{-1} IAA, respectively, whereas the percentage of parthenocarpic fruits reduced up to 41.00 and 30.67%, respectively. A similar pattern was noted with increasing boron levels. At 150 mg L^{-1} boron without IAA the fruit set was 77,00%, while the parthenocarpic fruits fell to 22.67%.

The interaction between boron and IAA produced the most pronounced response. The highest fruit set (%) (86.00) and lowest parthenocarpic fruit (%) (13.00) were observed with the combined application of 150 mg L^{-1} boron and 150 mg L^{-1} IAA. The increase in fruit set was also related to an increase in bunch weight and total yield. From the bunch weight observed in the untreated control (7.32 kg), an increase was observed with the combined foliar application of 150 mg L^{-1} boron and 150 mg L^{-1} IAA with a mean bunch weight of 14.26 kg. Likewise the total yield was greatly improved from 43.90 to 85.56 kg $palm^{-1}$. At 100 mg L^{-1} boron, increasing IAA up to 150 mg L^{-1} enhanced bunch weight from 8.79 to 12.44 kg and total yield from 52.72 to 74.62 kg $palm^{-1}$. The intermediate dose of 150 mgL^{-1} boron + 150 mgL^{-1} IAA giving the highest bunch weight of 14.26 kg, also led to the highest total yield of 85.56 kg per palm.

The main-effect means also confirmed the beneficial effect of IAA. At all boron levels, an increase in IAA level from 0 to 150 mg L^{-1} led to an increase in the mean fruit set (from 51.67 to 80.33%), bunch weight (from 9.03 to 13.54 kg), and total yield (from 54.19 to 81.17 kg $palm^{-1}$), and a reduction in the percentage of parthenocarpic fruit (from 46.22 to 18.89%). Also, raising boron level from 0 to 150 mg L^{-1} enhanced mean fruit set from 56.44 to 76.33%, bunch weight from 9.75 to 12.55 kg, and total yield from 58.45 to 75.31 kg $palm^{-1}$, and lowered the incidence of parthencarpic fruit from 41.89 to 22.44%

Table (3): Effect of Boron and IAA treatments on the yield characteristics of date palm fruits (cv. Barhi)

Boron concentration (mg L^{-1})	IAA concentration (mg L^{-1})	Fruit set %	Parthenoc-arpic fruit %	Bunch weight (kg)	Total yield (kg palm)
0	0	30.33	67.00	7.32	43.90
	100	56.67	41.00	8.82	52.92
	150	68.00	30.67	10.96	65.76
100	0	62.00	36.00	8.79	52.72
	100	67.33	31.00	10.89	65.32
	150	75.00	23.67	12.44	74.62

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150	0	77.00	22.67	13.14	78.72
	100	78.00	21.00	13.23	79.23
	150	86.00	13.00	14.26	85.56
LSD		**2.916**	**3.750**	**0.229**	**1.375**
Boron main effect	0	51.67	46.22	9.03	54.19
	100	68.11	30.22	10.70	64.22
	150	80.33	18.89	13.54	81.17
LSD		**1.683**	**2.165**	**0.133**	**0.794**
IAA main effect	0	56.44	41.89	9.75	58.45
	100	67.33	31.00	10.98	65.82
	150	76.33	22.44	12.55	75.31
LSD		**1.683**	**2.165**	**0.133**	**0.794**

The differences in treatment means were large enough to infer significant effects of the treatments on all the yield characteristics under measurement as indicated by the reported LSD values. In general, the best treatment was 150 mg L^{-1} boron + 150 mg L^{-1} IAA, which significantly increased fruit set, bunch weight and total yield and significantly decreased parthenocarpic fruit production. The drastic enhancement in percent fruit set, bunch weight, and total yield along with reduction in parthenocarpic fruit percentage due to the foliar application of boron might be ascribed to its importance in the reproductive functions. Boron is crucial to the pollen germination, tube elongation, and to sustain the stigma receptivity, which contributes to higher fertilization success and seed set. In addition, boron plays a role in cell wall and plasma membrane integrity, promotes the movement of sugars and photosynthates from source to sink (developing organs), which results in better fruit set and persisting growth as well as reducing parthenocarpic fruits, and eventually leads to higher bunch weight and total yield [16]. These results are in line with those of [3, 10, 18], which reported that boric acid spraying enhanced the percentage of fruit setting increased the yield and the quality of date palm fruits comparison with control treatment. The first tendency for nonsense fruit reduction, grain weight, and total yield together with the decrease in parthenocarpic fruit for was positively affected by the application of indole-3-acetic acid (IAA) and this could be due to the action of auxins in the control of early fruit set and development processes. Therefore, auxins promote cell division and expansion in the fruit, enhance the sink strength for the fruit, and facilitate the flow of carbohydrates and mineral nutrients to the fruit [13]. They play a part to prevent the development of the abscission layer at the base of the fruit so delaying premature fall and let hold more fruits till harvest thus an increase in bunch weight and total yield. Moreover, high auxin concentrations in young fruits are an essential signal for their normal growth after fertilization[9, 24]. The outstanding superiority of the combined treatment of boron and IAA especially at the concentration of 150 mg L-1 for each can be explained by the merging effects of boron in enhancing the success of pollination and fertilization, seed development and translocation of photosynthates and auxin in stimulating cell division and elongation and sink strength increase. These conditions are ideal for enhancing fruit set, for reducing parthenocarpic fruit, for increasing fruit growth and for keeping them on the bunch

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until harvest, so that bunch weight and total palm yield are increased [16]. This result is in accordance with [23], which showed that boron application helped in enhancing hormonal status mainly in case of IAA and thereby promoted natural fruit set in tissue-cultured 'Barhi' date palms, and is also in line with [11] that reported growth regulators application increased fruit set % and some biochemical characteristics of tissue-cultured 'Barhi' fruits.

Effect of boron and IAA applications on some chemical characteristics of Barhi date fruits

The application of boron and indole-3-acetic acid (IAA), either individually or in combination, significantly affected the chemical characteristics of Barhi date fruits, including total sugars, dry matter, boron concentration, and IAA content (Table 4). All measured chemical characteristics generally increased along with the increase of boron and IAA concentrations, and the highest values of most parameters were observed at co-application of 150 mg L^{-1} boron and 150 mg L^{-1} IAA. The highest total sugars (67.10%), dry matter (69.61%), boron concentration (34.19 mg kg^{-1}), and IAA content (36.30 ug g^{-1}), and the minimum were found in untreated control (0 mg L^{-1} boron + 0 mg L^{-1} IAA). Application of IAA at 0, 50, 100 and 150 mg L^{-1} at 0 mg L^{-1} boron rose the levels of total sugars to 49.72, 52.48 and 53.44%, and so the dry matter rose up to 52.58, 54.63 and 58.54%. Fruit boron concentration also rose from 24.87 to 27.25 and 29.16 mg kg^{-1}, and IAA content from 18.13 to 23.07 and 23.67 µg g^{-1}, respectively.

The response was also more pronounced at higher boron levels (100 and 150 mg L−1). In 100 mg L^{-1} boron, the Increasing IAA concentration from 0 to 150 mg L^{-1} enhanced total sugars from 54.95 to 61.07%, dry matter from 54.22 to 65.14%, boron level from 26.86 to 30.06 mg kg^{-1}, and IAA content from 27.37 to 32.70 µg g^{-1}. At 150 mg L^{-1} boron, a similar but weaker increase was also achieved when IAA concentration was raised from 0 to 150 mg L^{-1} resulting in a total sugars raise from 62.85 to 67.10%, dry matter from 67.47 to 69.61%, boron concentration from 31.62 to 34.19 mg kg^{-1}, and IAA content from 34.00 to 36.30 µg g^{-1}. All chemical traits were highest when 150 mg L^{-1} boron in combination with 150 mg L^{-1} IAA was applied. This treatment had given 67.10% total sugars, 69.61% dry matter, 34.19 mg kg^{-1} boron and 36.30 µg g^{-2} IAA. These values were about 35.0, 32.4, 37.5 and 100.2% more as compared to the untreated control, respectively. The increasing fruit B and IAA contents under increasing dosages suggested that the supplied treatments had been effectively sorbed and accumulated in the fruit tissue.

The main-effect means were indicative of the fruit chemical traits positively responding to both the factors. In boron treatments, the increase in IAA concentration from 0 to 150 mg L^{-1} resulted in increased total sugars, dry matter, boron content and IAA content from 51.88 to 65.13%, 55.25 to 68.26%, 27.09 to 32.56 mg kg^{-1} and 21.62 to 35.19 µg g^{-1}, respectively. Similarly, in all IAA treatments, the increase in B concentration from 0 to 150 mg L^{-1} enhanced total sugars from 52.84 to 60.54%, dry matter from 58.09 to 64.43%, B concentration from 27.78 to 31.14 mg kg^{-1} and IAA content from 22.50 to 30.89 µg g^{-1}.

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Table (4): Effect of Boron and IAA treatments on the chemical characteristics of date palm fruits (cv. Barhi)

Boron concentration (mg L^{-1})	IAA concentration (mg L^{-1})	Total Sugars (%)	Dry Matter (%)	B mg .kg	IAA µ . g
0	0	49.72	52.58	24.87	18.13
	100	52.48	54.63	27.25	23.07
	150	53.44	58.54	29.16	23.67
100	0	54.95	54.22	26.86	27.37
	100	57.03	58.48	28.22	30.97
	150	61.07	65.14	30.06	32.70
150	0	62.85	67.47	31.62	34.00
	100	65.43	67.69	31.86	35.27
	150	67.10	69.61	34.19	36.30
LSD		**1.167**	**1.381**	**0.779**	**1.389**
Boron main effect	0	51.88	55.25	27.09	21.62
	100	57.68	59.28	28.38	30.34
	150	65.13	68.26	32.56	35.19
LSD		**0.674**	**0.797**	**0.450**	**0.802**
IAA main effect	0	52.84	58.09	27.78	22.50
	100	58.31	60.26	29.11	29.77
	150	60.54	64.43	31.14	30.89
LSD		**0.674**	**0.797**	**0.450**	**0.802**

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The finding of the present study was that foliar application of B significantly enhanced the total sugars, dry matter, B concentration and IAA hormone of the fruit at the rate of 150 mg L^{-1}. This is due to the physiological function of boron in carbohydrate metabolism and the phloem transport of photosynthate. Boron complexes with sugars to boron-sugar complexes which can be transported through the phloem to growing tissues, and this is suggested to increase sugar levels in fruit. In addition, it is involved in the plasma membrane and cell wall integrity that maintains metabolism and photosynthate utilization [6, 16, 7]. The boron may have increased IAA levels in the fruits by boron's influence on auxin metabolism; boron deficiency alters expression of genes related to auxin biosynthesis and transport in the plant [15], and boron nutrition and auxin regulation seem to be closely related. This is consistent with [23] who observed an increase in the content of hormones especially IAA in tissue cultured 'Barhi' date palm after application of boron. These results are in harmony with the finding of [22], who reported that foliar application of boron significantly enhanced total sugars as well as quality of date palm fruit. The IAA spray-induced enhancement in fruit total sugar and dry matter could be explained by the crucial roles played by auxins in growth and development of plants. Auxins promote the sink strength of fruits, as well as favor the translocation of carbohydrates, auxins may also lead to the stimulation of cell division and elongation, they increase the activities of some enzymes related to carbohydrate metabolism, and this is in relation to the fact that more sugars and dry matter are accumulated in the fruits. The higher IAA levels seen in treated fruits is a predictable consequence of exogenous treatment combined with the contribution of continuous fruit growth to its intracellular level [9, 13, 24]. The pronounced enhancement of the between-subject factors boron and IAA on the phytohormone IAA is due to the combined physiological influences of both substances. Boron enhanced photosynthate transport and fruit N production efficiency and IAA promoted cell division and elongation and sink strength. This synergism led to more sugar and dry matter accumulation with higher fruit content of boron and IAA as compared to individual treatments [16. 13]. This finding is in line with [23] who reported the increase in hormonal content (free and conjugated IAA) in boron treated tissue-cultured 'Barhi' fruits and with the results of [11] where the application of growth regulators enhanced some biochemical attributes of tissue-cultured 'Barhi' fruits.

Conclusions

The results of the current investigation confirmed the positive impact of foliar application of boron (B) and indole-3-acetic acid (IAA) alone or combined on fruit set, yield and some physical and chemical properties of Barhi date palm fruits. The effects of increasing levels of boron and IAA on fruit set, fruit size, bunch weight, total yield, and the percentage of parthenocarpic fruits were positively influenced. The treatments were also effective in increasing total sugars, dry matter, and boron and IAA content in fruits. The synergistic treatment of 150 mg L^{-1} boron and 150 mg L^{-1} IAA among all the tested treatments was also the best in most of the fruit quality parameters, followed by converging in few parameters, and resulted the lowest percentage of parthenocarpic fruits. These results suggest that combined foliar application of boron and IAA at 150 mg L^{-1} each is an effective approach to enhance the reproductive performance, yield

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and fruit quality of Barhi date palm under the study condition.

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