RESEARCH ARTICLE

SABRAO Journal of Breeding and Genetics
57 (2) 870-877, 2025
http://doi.org/10.54910/sabrao2025.57.2.43
http://sabraojournal.org/
pISSN 1029-7073; eISSN 2224-8978

# DATE PALM (*PHOENIX DACTYLIFERA* L.) RESPONSE TO MINERAL FERTILIZER AND GROWTH REGULATOR

**Q.M.A. AL-MAWLA* and H.M.A. AL-TAMIMI**

Department of Horticulture and Landscape Engineering, University of Kerbala, Kerbala, Iraq
*Corresponding author's emails: kahtanalmwla@gmail.com
Email address of co-author: Harith.mhmod@uokerbala.edu.iq

## SUMMARY

The beneficial study aimed to determine the effects of the compound chemical fertilizer and growth regulator brassinolide on the qualitative and productive traits of the date palm Barhi cultivar, carried out in 2023 at the Kerbala Agriculture Directorate, Iraq. The experiment layout had a randomized complete block design (RCBD) with two factors and three replications. The first factor was adding the compound chemical fertilizer at three levels (0, 1000, and 1500 g palm$^{-1}$), while the second factor included foliar application of the growth regulator brassinolide with four concentrations (0.0, 0.3, 0.6, and 0.8 mg L$^{-1}$). The results showed the date palm variant with compound chemical fertilizer (1500 g palm$^{-1}$) was superior in fruit length, diameter, weight, set, bunch weight, and total fruit yield, with average values of 3.079 cm, 2.517 cm, 10.741 g, 74.710%, 14.729 kg bunch$^{-1}$, and 117.830 kg palm$^{-1}$, respectively. According to the foliar application of brassinolide, it was evident that brassinolide at 0.8 mg L$^{-1}$ performed better and excelled for the fruit's yield-related traits, with average values of 3.208 cm, 2.531 cm, 11.153 g, 76.060%, 15.667 kg bunch$^{-1}$, and 125.330 kg palm$^{-1}$, respectively. The interaction effects between the factors were significant for all traits.

**Keywords:** Date palm (*Phoenix dactylifera* L.), compound chemical fertilizer, brassinolide, qualitative traits, fruit yield traits

**Key findings:** The results showed superiority of the mineral fertilizer 1500 g palm$^{-1}$ and foliar application of the growth regulator brassinolide 0.8 mg L$^{-1}$ for the fruit's yield-related traits in the date palm (*P. dactylifera* L.).

Communicating Editor: Dr. A.N. Farhood

Manuscript received: March 07, 2024; Accepted: April 21, 2024.


**Citation:** Al-Mawla, Al-Tamimi (2025). Date palm *(Phoenix dactylifera L.)* response to mineral fertilizer and growth regulator. *SABRAO J. Breed. Genet.* 57(2): 870-877. http://doi.org/10.54910/sabrao2025.57.2.43.

## INTRODUCTION

The date palm (*Phoenix dactylifera* L.) belongs to the family Arecaceae, with its cultivation widespread in tropical and subtropical regions worldwide. The said fruit has considerable economic importance in Iraq and the Arab world. It is distinctive by the fact that its fruit has the highest nutritional and economic values, which contributes to increasing the country's national income (Sadek *et al.,* 2024).

It seemed that Southern Iraq and the Arabian Gulf regions are the original home of this blessed tree, then it spread to the rest of the countries globally (Ibrahim *et al.,* 2021). In Iraq, the palm trees have estimates of about 11,018,783, with a fruit productivity rate of 735,353 tons annually (CSO, 2020). Iraq comprises more than 600 date palm cultivars, with the Barhi cultivar considered one of the crucial commercial cultivars, widely cultivated in the central and southern regions of Iraq. It is a late-flowering and maturing cultivar; its fruits show characteristics of lacking astringent tannins, which distinguish them from the rest of the date palm cultivars, eaten with khalal, tamr, and rutab (Hamza and Al-Hashimi, 2023).

Recently, the signs of mineral elements' deficiency were prevalent in the date palm fruits as a result of neglecting agricultural service operations, especially fertilization, causing a significant decrease in the dates' productivity and quality (Salman *et al.,* 2017). Given the importance of chemical fertilization and its role in improving its date production with good quality, it was necessary to assess the effects of adding macro- and micronutrients in appropriate quantities and timings. This will develop a fertilization program to improve the quantitative and qualitative production of date palm trees (Ghazzawy *et al.,* 2023).

It has become evident at present, with scientific progress in the agriculture sector, that plant growth relies on water, light, $CO_2$, and mineral elements, as well as insoluble organic substances called plant hormones. Among these are auxins, gibberellins, cytokinins, abscisic acid, and ethylene, which are considerable sources of vital activities controlling the physiological processes necessary for plant growth (Kumari *et al.,* 2018).

Brassinolide has become one of the essential growth regulators, which include crude fatty acids extracted from the pollen grains of the rape (*Brassica napu*s). It has a primary role in the growth and development of plants by activating various structural and physiological processes. These include cell elongation and division, differentiation of transport vessels, flowering, contraction, aging, stress tolerance, the manufacture of nucleic acids, and proteins (Al-Khafaji, 2014). Therefore, the presented study aimed to determine the optimum added quantity of complex chemical fertilizer and brassinolide concentration and their interaction effects in improving the fruit productivity and quality characteristics of the date palm cultivar Barhi.

## MATERIALS AND METHODS

The practical study commenced in 2023 at the Kerbala Agriculture Directorate, Iraq. The experiment layout was in a randomized complete block design (RCBD) with two factors and three replications. The study selected 36 16-year-old trees of the date palm Barhi cultivar, almost uniform in size and shape, planted on lines with dimensions of 8 m × 8 m. The trees received irrigation through basins (with a radius of 1.5 m around the trunk of the palm tree and a height of 20 cm).

The pollination process occurred manually using the pollen of the cultivar Ghanami Ahmar. All the required field operations proceeded for the selected trees, including pruning, cleaning, removing thorns, and unifying the number of stems by keeping eight stems for each palm tree, distributed evenly around the trunk. The soil samples of the orchard soil, taken randomly at a depth of 30–60 cm, underwent analysis. After drying and grinding, soil-sieving used a sieve with 2-mm holes, and then measuring the soil's physical and chemical properties (Table 1).

**Table 1**. Some physical and chemical traits of orchard soil.

| Trait | | Unit | Value |
|---|---|---|---|
| E.C | | $dSm^{-1}$ | 4.27 |
| pH | | ----- | 7.9 |
| Available phosphorus | | mg $kg^{-1}$ | 12.20 |
| Available potassium | | mg $kg^{-1}$ | 124.08 |
| Available nitrogen | $N\text{-}NH_4$ | mg $kg^{-1}$ | 15.92 |
| | $N\text{-}NO_3^-$ | mg $kg^{-1}$ | 14.17 |
| Available zinc | | mg $kg^{-1}$ | 0.32 |
| Available iron | | mg $kg^{-1}$ | 0.46 |
| Texture | | Loamy Sand | |
| Soil isolates | Clay | % | 9.5 |
| | Sand | % | 69 |
| | Silt | % | 21.5 |

**Experimental design**

The experiment, carried out in a randomized complete block design, was a factorial experiment with two factors and three replications. Each replication contained 12 palm trees, one palm tree for each experimental unit, and the total palm trees were 36. The experiment included two factors, the first comprising the addition of the compound chemical fertilizer with three levels (0, 1000, and 1500 g $palm^{-1}$), being added in four batches with an interval of 30 days from one another. The chemical fertilizer consists of the following elements, i.e., N, P, K, Mg, Fe, Zn, Mn, and Cu, with different proportions, as follows: 23**%**, 8.1**%**, 14**%**, 0.27**%**, 0.25**%**, 0.09**%**, 0.07**%**, and 0.0125**%**, respectively. The second factor included foliar application of the growth regulator brassinolide with four concentrations (0.0, 0.3, 0.6, and 0.8 mg $L^{-1}$). The application of growth regulator brassinolide began early in the morning in three stages (Hababouk, Kimri, and Khalal stages), using a 100-liter sprinkler and adding diffuse material (Al-Zahi) at a concentration of 0.5 ml $L^{-1}$ to reduce the surface tension of water and increase the absorption rate.

**Data recorded**

Twenty fruits, selected randomly for each treatment and replication, had their traits on fruit diameter and length measured at the Khalal stage using a Vernier caliper. The fruit weight's calculation also took place at the Khalal stage by taking an average of 20 fruits from each experimental unit using a sensitive electric scale. Measuring the percentage of fruit set at the Hababouk stage ensued by randomly selecting five shoots from each fruit bunch in each date palm tree and each replication following the methodology of Ream and Furr (1970), as follows:

$$\text{Fruit set (\%)} = \frac{\text{Number of fruit set}}{\text{Number of fruit set} + \text{Number of empty scars}} \text{x}100$$

Calculating the average of fruit bunch weight (kg fruit $bunch^{-1}$) continued by weighing eight fruit bunches from each palm using a field scale (scale mechanical dial) and then averaged for each date palm tree. The total fruit yield's (kg $palm^{-1}$) measuring also proceeded by weighing the total yield of each palm tree separately using the same field scale and then averaged per date palm.

**Statistical analysis**

All the recorded data for various parameters bore assessment according to the analysis of variance (ANOVA) as per the RCBD. The least significant difference ($LSD_{0.05}$) test used compared and further separated the treatment means (Al-Mohammadi and Al-Mohammadi, 2012). All the statistical analyses employed the computer software GenStat-12.

## RESULTS AND DISCUSSION

### Fruit length

The results revealed adding compound chemical fertilizer caused a significant difference in the average length of date palm fruits (Table 1). The fertilizer treatment (1500 g palm$^{-1}$) showed the highest fruit length average (3.079 cm), while the control treatment (0 g palm$^{-1}$) recorded the lowest average (2.851 cm)**.** This may refer to the positive role of nitrogen, phosphorus, and potassium contained in the chemical fertilizer in stimulating cell division and elongation, forming amino acids, proteins, nucleic acids (DNA and RNA), and accumulating carbohydrates in fruits. Additionally, the role of microelements contributed, especially Zn, considered a key hormone for the formation of IAA, which is responsible for cell division and elongation, as eventually reflecting in fruit length (Al-Tamimi *et al*., 2020; Stanton *et al.,* 2022).

The outcomes further indicated notable differences among the brassinolide spray treatments for the fruit length (Table 2). The brassinolide foliar application (0.8 mg L$^{-1}$) recorded the highest average fruit length (3.208 cm), while the control treatment (0 mg L$^{-1}$) gave the lowest average (2.800 cm)**.** The reason may be due to the positive role of the growth regulator (brassinolide) in stimulating plant hormones responsible for cell division and elongation, especially auxins, and thus increasing fruit length in date palms (Al-Sahaf *et al.,* 2017). The results also displayed significant interaction effects due to the combination of two study factors for fruit length (Table 2). However, the interaction of chemical fertilizer (1500 g palm$^{-1}$) and brassinolide (0.8 mg L$^{-1}$) delivered the extensive fruit length (3.347 cm), with the control treatment recorded with the least average fruit length (2.646 cm) in the date palm.

### Fruit diameter

For the fruit diameter in date palm, the complex chemical fertilizer treatments revealed significant differences (Table 3). The chemical fertilizer treatment (1500 g palm$^{-1}$) recorded the highest average of fruit length (2.517 cm), compared with the control treatment recording the lowest average for the said trait (2.139 cm)**.** Adding chemical fertilizers can help increase the fruit diameter by providing the basic nutrients that the plant needs for good growth and development. Nitrogen promotes the growth of green tissue and enhances the formation of proteins, which cause an enlarged fruit size. Phosphorus also helps in developing the plant's roots and transportation. Energy enhances the plant growth and fruit formation and provides nutrients in a balanced manner and appropriate quantities through the use of chemical fertilizers, helping achieve an ideal growth and thus reflected in increased fruit diameter (Youssef and Hashem, 2023).

The results of the same table also showed spraying treatments with brassinolide caused significant differences in the average fruit (Table 3). The brassinolide treatment (0.8 mg L$^{-1}$) gave the highest average fruit diameter (2.531 cm), while the control treatment showed the lowest average for the trait (2.184 cm). Plant growth regulators play an important role in increasing the fruit diameter by regulating growth and development processes within plants. These growth regulators also affect the regulation of cell division and use of nutrients and increase the efficiency of growth processes, and this may reflect in increased fruit diameter and weight in date palms (Al-Taie and Hashem, 2023). The interactions of both factors also indicated considerable differences for fruit diameter in date palms (Table 3). The fertilizer treatment (1500 g palm$^{-1}$) in interaction with brassinolide (0.8 mg L$^{-1}$) appeared with the broadest average fruit diameter (2.591 cm) compared with control treatments for both factors, recording the least value for the said trait (1.792 cm).

### Fruit weight

The compound chemical fertilizer treatments significantly affected the fruit weight in date palms (Table 4). The fertilizer treatment (1500 g palm$^{-1}$) gave the supreme

**Table 2.** Effect of adding compound chemical fertilizer and foliar application of the growth regulator brassinolide and their interaction on fruit length in date palms.

| Compound chemical fertilizer (g palm$^{-1}$) | Brassinolide (mg L$^{-1}$) | | | | Means (cm) |
|---|---|---|---|---|---|
| | 0.0 | 0.3 | 0.6 | 0.8 | |
| 0 | 2.646 | 2.800 | 2.887 | 3.071 | 2.851 |
| 1000 | 2.829 | 2.885 | 3.000 | 3.206 | 2.980 |
| 1500 | 2.924 | 2.947 | 3.097 | 3.347 | 3.079 |
| Means (cm) | 2.800 | 2.877 | 2.995 | 3.208 | |
| $LSD_{0.05}$ Fertilizer: 0.070, Brassinolide: 0.081, Interaction: 0.141 | | | | | |

**Table 3.** Effect of adding a compound chemical fertilizer and spraying with the growth regulator brassinolide and their interaction on the fruit's average diameter in date palms.

| Compound chemical fertilizer (g palm$^{-1}$) | Brassinolide (mg L$^{-1}$) | | | | Means (cm) |
|---|---|---|---|---|---|
| | 0.0 | 0.3 | 0.6 | 0.8 | |
| 0 | 1.792 | 1.935 | 2.378 | 2.452 | 2.139 |
| 1000 | 2.323 | 2.409 | 2.439 | 2.550 | 2.431 |
| 1500 | 2.438 | 2.454 | 2.585 | 2.591 | 2.517 |
| Means (cm) | 2.184 | 2.266 | 2.467 | 2.531 | |
| $LSD_{0.05}$ Fertilizer: 0.041, Brassinolide: 0.047, Interaction: 0.082 | | | | | |

**Table 4.** Effect of adding a compound chemical fertilizer and spraying with the growth regulator brassinolide and their interaction on the fruit's average weight in date palms.

| Compound chemical fertilizer (g palm$^{-1}$) | Brassinolide (mg L$^{-1}$) | | | | Means (g) |
|---|---|---|---|---|---|
| | 0.0 | 0.3 | 0.6 | 0.8 | |
| 0 | 7.481 | 8.799 | 9.725 | 10.414 | 9.105 |
| 1000 | 9.305 | 9.493 | 10.455 | 11.438 | 10.173 |
| 1500 | 10.102 | 10.132 | 11.123 | 11.608 | 10.741 |
| Means (g) | 8.963 | 9.475 | 10.434 | 11.153 | |
| $LSD_{0.05}$ Fertilizer:0.305, Brassinolide: 0.353, Interaction: 0.611 | | | | | |

average of fruit weight (10.741 g), compared with the control treatment (9.105 g). The reason for the increase in fruit weight may refer to the addition of the complex chemical fertilizer, which contains the basic nutrients needed by the plant. Plants receiving sufficient nutrients become more capable of producing the energy and materials necessary for growing larger fruits in date palm fruits (*P. dactylifera* L.) (Hussain *et al.,* 2020). Significant differences also emerged with the foliar application of brassinolide treatments in the average fruit weight of the date palm (Table 4). The brassinolide treatment (0.8 mg L$^{-1}$) recorded the premier average (11.135 g), compared with the control treatment exhibiting the lowest average (8.963 g)**.**

The rise in the average fruit weight was a result of the growth regulator stimulating the enzymes responsible for elasticity in cell walls (pectinase) and, thus, increasing the flow of water and mineral elements into the fruits (Sebastian *et al.,* 2019). The brassinolide also stimulates the photosynthesis of enzymes, boosting the accumulation of manufactured carbohydrates in fruits, as reflected in their weight gain (Wang *et al.*, 2019). The interactions between both factors also revealed significant differences for fruit weight (Table 4). The chemical fertilizer treatment (1500 g palm$^{-1}$) in interaction with brassinolide (0.8 mg L$^{-1}$) showed the highest average fruit weight (11.608 g), compared with the control treatment recording the lowest average for the said trait in date palms (7.481 g).

**Fruits set**

The compound chemical fertilizer treatments disclosed remarkable variations for fruit setting percentage in the date palm (Table 5). The fertilizer treatment (1500 g palm$^{-1}$) gave the highest average fruit setting (74.710%), while the control treatment recorded the lowest average (70.120%)**.** This may be due to the positive role of microelements contained in the chemical fertilizer, such as Zn and B, which are essential in increasing the rate of fruit setting. Thereby, stimulating pollen tube growth and cell division and enriching the hormonal content of female flowers (Jain, 2017).

Moreover, the results showed significant differences among the foliar application of brassinolide treatments in the percentage of fruit set (Table 5). The brassinolide treatment (0.8 mg L$^{-1}$) exhibited the highest average (76.060%), compared with the control treatment (69.900%)**.** This has attributes to the positive role of brassinolide in stimulating flowering and fruiting, which causes an increased number of flowers and the fruits' setting in date palms (Hosny *et al.,* 2022). Likewise, the interaction effects of the chemical fertilizer and the growth regulator brassinolide revealed prominent differences for date palm fruit setting (Table 5). A significant interaction between the two study factors in the percentage of fruit set signified the supreme fruit setting percentage was evident with the interaction of chemical fertilizer (1500 g palm$^{-1}$) and brassinolide (0.8 mg L$^{-1}$) with an average of 79.16**0**%. Meanwhile, the lowest values resulted in the control treatment (66.64**0**%).

**Bunch weight**

The findings detailed that the compound chemical fertilizer treatments had a marked effect on average fruit bunch weight in date palms (Table 6). The fertilizer treatment (1500 g palm$^{-1}$) recorded the highest average (14.729 kg bunch$^{-1}$), compared with the control treatment, with the lowest average of the said variable (11.208 kg bunch$^{-1}$). The increase in bunch weight may be due to an enhancement in the fruit length and fruit diameter, as well as the fruit weight (Tables 2, 3, and 4), with the said improvement in other fruit traits positively reflecting in the raised bunch weight. The brassinolide treatments with foliar application also showed the significant effect on the average fruit bunch weight (Table 6). The brassinolide (0.8 mg L$^{-1}$) treatment indicated the utmost average (15.667 kg bunch$^{-1}$) versus the control treatment, which recorded the lowest average (10.500 kg bunch$^{-1}$).

Growth regulators play a crucial role in increasing the rate of fruit bunch weight by improving environmental factors and providing appropriate conditions for growth, through providing nutrients. Growth regulators also contribute to appropriate nutrient utilization, ensuring the availability of essential nutrients, i.e., nitrogen, phosphorus, potassium, and magnesium. This helps to improve plant growth, which eventually enhances the size and weight of the fruit bunch in date palms (Al-Sahaf *et al.,* 2017). Similarly, the interactions between the two study factors have significantly affected the average fruit bunch weight (Table 6). The interaction of the chemical fertilizer treatment (1500 g palm$^{-1}$) with brassinolide (0.8 mg L$^{-1}$) revealed an average of 16.417 kg bunch$^{-1}$, while the lowest value for the said trait appeared in the interaction of both control treatments (8.583 kg bunch$^{-1}$).

**Fruit yield**

The results indicated adding complex chemical fertilizer notably influenced an increase in the total fruit yield in date palms (Table 7). The chemical fertilizer treatment (1500 g palm$^{-1}$) recorded the maximum average fruit yield (117.830 kg palm$^{-1}$), while the control treatment provided the minimum average (90.170 kg palm$^{-1}$)**.** The increase in total fruit yield of the date palm could be due to enhancements in its fruit length, diameter, and weight (Tables 2, 3, and 4). These yield components collectively reflected in boosting fruit yield per palm tree. The same may also be because of an increase in the percentage of fruit set (Table 5), as reflected positively in an

**Table 5.** Effect of adding compound chemical fertilizer and spraying with the growth regulator brassinolide and their interaction on the percentage of fruit set in date palms.

| Compound chemical fertilizer (g palm$^{-1}$) | Brassinolide (mg L$^{-1}$) | | | | Means (%) |
|---|---|---|---|---|---|
| | 0.0 | 0.3 | 0.6 | 0.8 | |
| 0 | 66.640 | 68.730 | 71.690 | 73.440 | 70.120 |
| 1000 | 70.720 | 72.210 | 73.140 | 75.580 | 73.910 |
| 1500 | 72.330 | 72.930 | 74.440 | 79.160 | 74.710 |
| Means (%) | 69.900 | 71.290 | 73.090 | 76.060 | |
| $LSD_{0.05}$ Fertilizer: 1.464, Brassinolide: 1.690, Interaction: 2.927 | | | | | |

**Table 6.** Effect of adding a compound chemical fertilizer and spraying with the growth regulator brassinolide and their interaction on the fruit bunch weight in date palms.

| Compound chemical fertilizer (g palm$^{-1}$) | Brassinolide (mg L$^{-1}$) | | | | Means (kg bunch$^{-1}$) |
|---|---|---|---|---|---|
| | 0.0 | 0.3 | 0.6 | 0.8 | |
| 0 | 8.583 | 9.750 | 12.167 | 14.333 | 11.208 |
| 1000 | 10.333 | 12.583 | 14.167 | 16.250 | 13.333 |
| 1500 | 12.583 | 14.417 | 15.500 | 16.417 | 14.729 |
| Means (kg bunch$^{-1}$) | 10.500 | 12.250 | 13.945 | 15.667 | |
| $LSD_{0.05}$ Fertilizer: 0.3715, Brassinolide: 0.4290, Interaction: 0.7430 | | | | | |

**Table 7.** Effect of adding compound chemical fertilizer and spraying with the growth regulator brassinolide and their interaction on the average total yield in date palms.

| Compound chemical fertilizer (g palm$^{-1}$) | Brassinolide (mg L$^{-1}$) | | | | Means (kg palm$^{-1}$) |
|---|---|---|---|---|---|
| | 0.0 | 0.3 | 0.6 | 0.8 | |
| 0 | 68.670 | 78.000 | 99.330 | 114.670 | 90.170 |
| 1000 | 82.670 | 100.670 | 113.330 | 130.000 | 106.670 |
| 1500 | 100.670 | 115.330 | 124.000 | 131.330 | 117.830 |
| Means (kg palm$^{-1}$) | 84.000 | 98.000 | 112.220 | 125.330 | |
| $LSD_{0.05}$ Fertilizer: 3.146, Brassinolide: 3.633, Interaction: 6.292 | | | | | |

elevation in the total fruit in date palms (Youssef and Hashem, 2023).

The findings further showed significant differences among the foliar application treatments of the growth regulator brassinolide for fruit yield (Table 7). The brassinolide treatment (0.8 mg L$^{-1}$) provided the highest average fruit yield (125.330 kg palm$^{-1}$), compared with the control treatment, which recorded the lowest average fruit yield (84.000 kg palm$^{-1}$)**.** Plant growth regulators, including brassinolide, are vital in boosting fruit yield by regulating growth processes more effectively, causing better distribution of nutritional resources and, thus, improving the growth and ripening of date palm fruits (Hosny *et al.,* 2022). Table 7 also shows substantial interaction effects between the two factors for total fruit yield. The interaction of chemical fertilizer (1500 g palm$^{-1}$) with brassinolide (0.8 mg L$^{-1}$) demonstrated an utmost average fruit yield of 131.330 kg palm$^{-1}$, while the treatment recorded with control for both factors has the least interaction effect and average fruit yield in date palms (68.670 kg palm$^{-1}$).

## CONCLUSIONS

The results revealed that the compound chemical fertilizer has a prominent role in improving the quantity and quality traits of date palms. The chemical fertilizer at 1500 g palm$^{-1}$ showed better results than the other two levels. The foliar application of brassinolide (0.8 mg L$^{-1}$) also has a remarkable role in increasing the plant's ability to exploit available resources and enhance the total fruit yield in date palms.

## REFERENCES


Al-Khafaji MA (2014). Plant Growth Regulators, Application and Utilization in Horticulture. Ministry of Higher Education and Scientific Research, University of Bagdad. Al-Dar Al-Jammia for Press and Publishing. pp. 327.

Al-Mohammadi SM, Al-Mohammadi FM (2012). Statistics and Experimental Design. Dar Osama for Publishing and Distribution, Oman, Jordan. pp. 376.

Al-Sahaf FH, Abed YM, Saleh FF, Khierallah HSM (2017). Influence of spraying by some plant growth regulators on date palm salt tolerance enhancement. *Iraqi J. Agric. Sci*. 48(1): 236-241.

Al-Taie IMJ, Hashem AH (2023). Effect of the auxin on the fruit quality and yield of date palm *Phoenix dactylifera* L. Barhi and Sayer cultivars. *Euphrates J. Agric. Sci*. 15(1): 304-310.

Al-Tamimi HMA, Ali AA, Kadhim ZK, Shatti RH (2020). Effect of foliar spraying with grow more and scott on improving some vegetative and root growth characteristics of citrus seedlings Swingle citrumelo. *Biochem. Cell. Arch*. *2*: 4201-4205.

CSO (2020). Dates production report. Directorate of Agricultural Statistics, Ministry of Planning, Baghdad, Iraq. pp: 9-17.

Ghazzawy HS, Alqahtani N, Munir M, Alghanim NS, Mohammed M (2023). Combined impact of irrigation, potassium fertilizer, and thinning treatments on yield, skin separation, and physicochemical properties of date palm fruits. *Plants* 12(5): 1003.

Hamza RS, Al-Hashimi AG (2023). Effect of different drying methods on some mineral elements, amino acids and fatty acids of the fruits of some Iraqi palm cultivars. *Biodivers. J. Biol. Divers.* 24(1): 359-369.

Hosny SS, Madboly EA, El-Kholy MF (2022). Influence of strands thinning and brassinolide spray on yield and economic return of sewi date palm cultivar. *Egyptian Int. J. Palms* 2(1): 24-39.

Hussain MI, Farooq M, Syed QA (2020). Nutritional and biological characteristics of the date palm fruit (*Phoenix dactylifera* L.) A review. *Food Biosci*. 34(6): 2-11.

Ibrahim M, Ali AH, Hashem MS (2021). In vitro effects of cyanobacteria (*Oscillatoria tenuis*) extracellular products on date palm (*Phoenix dactylifera* L. cv. 'Barhee') propagation. *Dysona Appl. Sci.* 2(1): 1-7.

Jain VK (2017). Fundamentals of Plant Physiology. S. Chand Publishing. New Delhi. pp. 736.

Kumari S, Bakshi P, Sharma A, Wali VK, Jasrotia A, Kour S (2018). Use of plant growth regulators for improving fruit production in sub tropical crops. *Int. J. Curr. Microbiol. Appl. Sci*. 7(3): 659-668.

Ream CL, Furr JR (1970). Fruit set of dates as affected by pollen viability and dust or water on stigmas. Date Grower's Inst. *Ann. Rep*. 47: 11-13.

Sadek MG, Abdellah MY, Abdel-Jaber GT (2024). A review on properties, applications and feasibility study of date palm fiber-reinforced polymer composites. *SVU-Int. J. Eng. Sci. Appl*. 5(2): 50-61.

Salman AH, Matar HA, Muhammad IQ, Al-Zahidi HWF (2017). Effect of adding chemical fertilizers on the content of major elements in palm leaves and the yield of three varieties of newly fruiting date palms. *Al-Qadisiyah J. Agric. Sci.* 7(1): 41-48.

Sebastian K, Arya MS, Reshma UR, Anaswara SJ, Thampi SS (2019). Effect of plant growth regulators on fruit production. *Int. J. Curr. Microbiol. Appl. Sci.* 8(2): 800-814.

Stanton C, Sanders D, Krämer U, Podar D (2022). Zinc in plants: Integrating homeostasis and biofortification. *Mol. Plant* 15(1): 65-85.

Wang Y, Fu X, He W, Chen Q, Wang X (2019). Effect of spraying brassinolide on fruit quality of *Citrus grandis* cv. 'Huangjinmiyou' and 'Hongroumiyou'. In *IOP Conf. Ser: Earth Environ. Sci.* 358(2): 1-6.

Youssef RS, Hashem AH (2023). Effect of adding chemical fertilizers at different distances, dates and concentrations on the growth and yield of date palm. *Ann. For. Res.* 66(1): 1311-1321.