Improving Productivity and fruit Quality of Barhee date Palm by Foliar Application of GA_3 and NAA

Samy El-Kosary, Ayman Shabaan and AbdelRahamn Hasseb*

Pomology Department, Faculty of Agriculture, Cairo University, Giza 12613, Egypt

Corresponding author Email : abdelrahman.m.mahmoud@agr.cu.edu.eg

DOI: https://doi.org/10.36077/kjas/2025/v17i1.13730

Received date: 27/10/2023

Accepted date: 1/3/2024

Abstract

The field experiment was designed to evaluate tested treatments to select which suitable treatment should be recommended to be used for Barhee date palm trees grown at Alexandria desert road near El-Sadat city, Egypt. GA_3 and NAA were used in concentrations (25, 50 and 75 $mg.L^{-1}$) individually and the mixture of each equal doses. Experimental design was Randomized Complete Block Design (RCBD). The obtained results revealed that the treatment GA_3 + NAA (75 $mg.L^{-1}$) was distinguished in the yield components (Bunch weight, retained fruits, fruit weight, yield /palm) and physical properties of the fruits (fruit weight, flesh weight, fruit length and width). In addition, application of GA_3 + NAA at 75 $mg.L^{-1}$ showed the highest values in physical characteristics of shees fruits (shees fruit weight, length and width). However, low fruit chemical properties of seeded fruits (TSS, TSS/Acidity ratio and sugar content, carotenoids) were observed in bunches treated with GA_3 + NAA at 75 $mg.L^{-1}$.

Keywords: Gibberellic acid, Naphthalene acetic acid, fruit characteristics, Date palm.

Introduction

Date palm (*Phoenix dactylifera* L.) has been cultivated worldwide, especially in North Africa and West Asia (18). Date palms survive for long periods under adverse conditions such as drought and salt stress (23).

In 2020, the global dates production volumes 9.45 million metric tons. Egypt recorded the first rank among countries in date's production with 1, 747, 7 tons in 2021 representing 18% of the world production (15).

Plant growth regulators (PGR) regulate various physiological processes in a plant such as improving fruit set, decreasing fruit drop, and increase the fruit retention quality (2, 24 and 26). Using PGR to increase yield has become important in agriculture today with enhancing vegetative growth and fruit production quantity and quality (9 and 19).

Many researches describe the utility of PGRs in enhancing agricultural practice. Choudhary *et al*. (12) explained that the foliar application of gibberellic acid on four cultivars of palm trees including Barhee had positive impacts on fruit weight, length, diameter and volume. Spraying Gibberellic acid and humic acid three times: 1) three hours before pollination, 2) four weeks after pollination and 3) eight weeks after pollination increased yield and quality of Salmy dates (17).

Using Ghannami ahmer as pollen source with spraying of naphthalene acetic acid-NAA (50 mgL^{-1}) significantly improved the fruit set, fruit size and weight (3). Also, there was a significant increase in bunch weight in Rutab stage was observed when using Khukri pollen grains with application of NAA at concentration 100 $mg.L^{-1}$ (10).

Application of gibberellins (GA_3 at 100 $mg.L^{-1}$ enhanced germination of date palm pollen grains by increasing velocity of germination rate and growth of pollen tube which reflected on fertilization efficiency. Spraying of GA_3 (100 $mg.L^{-1}$) during pollination period resulted in highest fruit set at Khelal stage and pollen tube growth; which suppose a relationship between GA_3 quantity in pollen grains and its role in fertilization (6). GA_3 has direct on raising cell division and enlargement as well as fruit size (21) through entrance of water into the cell (25). Using NAA enhanced vegetative growth parameters, yield and fruit quality of some fruit trees (1).

Therefore, this investigation aimed to study the effect of growth regulators on Barhee date palm yield and fruit quality of the seeded fruits and shees (parthenocarpy) using phytohormones GA_3 and NAA.

Materials and Methods

Experimental site and plant material

This experiment was established on seven years old Barhee date palm cultivar during the 2020 and 2021 seasons. Ten palms were selected for the experiment treatments within each palm there were four bunches chosen as replicate. The chosen palms were produced all through tissue culture procedure. They were uniform in size and grown in a private orchard where it is located in Alexandria desert road near El-Sadat city, Egypt (30°15'47.0"N

30°40'19.3"E) which cultivated in sandy soil under drip irrigation system.

Selection of bunches

The selected bunches were uniform and pollinated by the same male source through March and April and just after pollination bunches were covered by perforated paper bags to prevent any foreign pollen grains, palm load was adjusted to be 10 bunches on each palm after 5 weeks from pollination (the end of Hababouk stage) Bunches were sprayed by the treatments as following: Control (water), GA_3 (25, 50 or 75 $mg.L^{-1}$) , NAA (25, 50 or 75 $mg.L^{-1}$), GA_3 (25 $mg.L^{-1}$) + NAA (25 $mg.L^{-1}$), GA_3 (50 $mg.L^{-1}$) + NAA (50 $mg.L^{-1}$) and GA_3 (75 $mg.L^{-1}$) + NAA (75 $mg.L^{-1}$). A surfactant agent (1 cm/liter) was added to all spraying treatments until runoff.

Fruit set parameters

Ten strands were randomly chosen (at Khalal stage) from each replicate to determine the retained fruit (%), fertilized fruit (%) and unfertilized fruit (%) using the following equations:

Retained fruit (%) =

$$\frac{no.\, of retained\ fruits/bunch}{Total\ scares\ no.\, per\ bunch} \times 100$$

$$\frac{no.\, of\ fertilized\ fruits/bunch}{Total\ scares\ no.\, per\ bunch} \times 100$$

Fertilized fruit (%) =

Unfertilized fruit (%) =

$$\frac{no.\, of\ seedless fruits/bunch}{Total\ scares\ no.\, per\ bunch} \times 100$$

Yield and Bunch weight

At harvesting time (through August and September) each bunch was weighed individually to determine the bunch weight in Kg then the yield per palm was estimated (Kg) for each treatment.

Fruit physical characteristics

Fifteen fruits were picked randomly from each replicate (one bunch for each treatment) to determine fruit physical characteristics as following:

Fruit samples were weighted then flesh and seed were separated and weighted individually using digital balance. Fruit Flesh/seed ratio was estimated by dividing fruit flesh weight by seed weight. Vernier caliper was used to measure fruit dimensions length (L) and diameter (D). Shape index (L/D) was calculated by dividing length by diameter.

Fruit chemical characteristics:

Total Soluble Solids (TSS Brix):

After collecting and mincing a sample of fruit flesh, the paste was squeezed out. A hand refractometer was used to measure the TSS (7).

Total acidity (%):

It was estimated by the titration process the fruit juice samples. The titratable acidity was done by titrating the known volume of juice with NaOH using phenolphthalein as indicator then calculated as malic acid (8)

TSS/Acidity ratio:

It was calculated through dividing TSS by acidity percentage.

Total sugars:

Total sugars of fruit content ($mg.g^{-1}$) were determined as described by Dubois (13).

Total Carotenoids:

Total carotenoids content ($\mu g.g^{-1}$ fresh weight) in dates was calculated from the absorbance at 480 and 510 nm according to Jensen (20).

Statistical analysis:

Experimental design was Randomized Complete Block Design (RCBD). Analysis of variance (ANOVA) was performed using the ‘‘GLM’’ procedure - SAS software (version 9.0; SAS Institute, Cary, NC). Significant differences between treatments were determined by Duncan's multiple range tests (14) at $P \leq 0.05$.

Results and Discussion

Fruiting and yield components:

From the data, results in Table 1 cleared that the usage of GA_3 + NAA (50 $mg.L^{-1}$) and NAA (75 $mg.L^{-1}$) alone gave the highest values of fertilized fruit percentage (53.9 %, 53.2 %, respectively) with low significant differences between them. While, control treatment gave the lowest values (39.2 %) followed by GA_3 at 25 $mg.L^{-1}$ (42.9 %).

According to Shees fruit percentage, data revealed that there were no significant differences among the majority of the treatments except GA_3 + NAA (25 $mg.L^{-1}$), and GA_3 + NAA (75 $mg.L^{-1}$).

Whatever, the least shees fruit percentage (0.1 %) was obtained by application of GA_3 + NAA (50 $mg.L^{-1}$). The most retained fruit percentage (54.9 %) was recorded by using NAA (75 $mg.L^{-1}$) then followed by GA_3 + NAA (50 $mg.L^{-1}$). While least percentage (41.1%, 45.1%) was obtained by the control treatment and GA_3 (25 $mg.L^{-1}$).

Barhee date palm sprayed with GA_3 + NAA (75 $mg.L^{-1}$) recorded the highest bunch (23.1 k.g) weight followed by GA_3 (75 mgL^{-1}) and GA_3 at (50 $mg.L^{-1}$) with no significant differences. While the lightest one was detected with control treatment (9 kg). Concerning palm yield, data revealed was associated strongly to bunch weight, data showed revealed the average yield of Barhee date. Yet, the treatment with GA_3 + NAA (75 $mg.L^{-1}$) gave the highest yield (231.3 kg /palm) as compared to the control treatment (90.6 kg/palm) which led to the lowest yield detected.

The optimization of date palm yield using growth regulators were agreed with the findings reported by Awad and Al-Qurashi (11) who conducted that spraying GA_3 at different concentrations (50, 100 and 150 $mg.L^{-1}$) increased the weight of Barhee date bunches compared to the control. Moreover, spraying inflorescences of

Barhee after twenty days of pollination by growth regulator mixture (50 $mg.L^{-1}$ GA_3, 100 $mg.L^{-1}$ NAA, and 1000 $mg.L^{-1}$ ethephon) increased yield and flesh percentage of dates (5).

Fruit physical characteristics:

Considering the data shown in Table 2 it's clear that the highest fruit weight (20.4 g , 19.5 g) was conducted by GA_3 + NAA (75 $mg.L^{-1}$) and GA_3 + NAA (25 $mg.L^{-1}$) compared to control which recorded the lowest fruit weight (10.9 g). Regarding to seed weight, the highest value (1.7 g) was observed by NAA (75 $mg.L^{-1}$) followed by NAA (50 $mg.L^{-1}$), while the lowest value (1.0 g) was recorded by GA_3 at 50 ppm. With regard to the flesh weight, it could be observed that using GA_3 + NAA (75 $mg.L^{-1}$) ppm showed the highest flesh weight (19.0 g) followed by using GA_3 (75 $mg.L^{-1}$). While control gave the lowest flesh weight (9.8 g) followed by NAA (25 $mg.L^{-1}$) and NAA (50 $mg.L^{-1}$) with no significant differences.

Table 1. Effect of GA_3 and NAA on fruiting and yield components of Barhee date palm (Average of the two seasons)

Treatment	Fertilized Fruit %	Shees Fruit %	Retained Fruit %	Bunch weight (Kg)	Yield (Kg/palm)
Control	39.2g	1.9a	41.1f	9.0f	90.6f
GA_3 (25 $mg.L^{-1}$)	42.9fg	2.1a	45.1fe	13.1e	131.4e
GA_3 (50 $mg.L^{-1}$)	44.4ef	1.6a	46.0de	19.9abc	199.9abc
GA_3 (75 $mg.L^{-1}$)	46.5def	1.6a	48.1cde	20.9ab	209.2ab
NAA (25 $mg.L^{-1}$)	43.7ef	2.4a	46.1de	12.1ef	121.2ef
NAA (50 $mg.L^{-1}$)	48.6cde	2.3a	50.9abc	14.3de	143.5de
NAA (75 $mg.L^{-1}$)	53.2ab	1.6a	54.9a	18.2bc	182.6bc
GA_3 + NAA (25 $mg.L^{-1}$)	49.0bcd	1.1ab	50.1bcd	17.1cd	171.1cd
GA_3 + NAA (50 $mg.L^{-1}$)	53.9a	0.1b	54.1ab	19.4bc	194.8bc
GA_3 + NAA (75 $mg.L^{-1}$)	51.4abc	1.1ab	52.5abc	23.1a	231.3a

* Values shown are average of replications, within each column, different letters imply significant differences as defined by the means of Duncan's multiple range tests ($P < 0.05$).

Table 2. Effect of GA_3 and NAA on fruit weight (g), seed weight (g) and flesh weight (g) of Barhee date palm (Average of the two seasons)

Treatment	Fruit weight (g)	Seed Weight (g)	Flesh weight (g)	Fruit volume (cm^3)
Control	10.9e	1.1ef	9.8e	9.6e
GA_3 (25 mg.L^{-1})	15.5c	1.3cd	14.2c	10.5de
GA_3 (50 mg.L^{-1})	15.7c	1.0f	14.7c	12cde
GA_3 (75 mg.L^{-1})	17.4b	1.3c	16.1b	15.6bc
NAA (25 mg.L^{-1})	13.6d	1.1de	12.4d	16.6b
NAA (50 mg.L^{-1})	14.5d	1.5b	13.0d	13.8bcde
NAA (75 mg.L^{-1})	15.6d	1.7a	13.8c	17b
GA_3 + NAA (25 mg.L^{-1})	19.5a	1.2cd	18.2a	16.8b
GA_3 + NAA (50 mg.L^{-1})	14.0d	1.3c	12.7d	15bcd
GA_3 + NAA (75 mg.L^{-1})	20.4a	1.3dc	19.0a	21.3a

* Values shown are average of replications, within each column, different letters imply significant differences as defined by the means of Duncan's multiple range tests ($P < 0.05$).

According to fruit volume, data indicated that the highest fruit volume (21.3 cm^3) was conducted by the usage of GA_3 + NAA (75 mg.L^{-1}) followed by NAA (75 mg.L^{-1}), while least fruit volume (9.6 and 10.5 cm^3) was resulted by control and GA_3 (25 mg.L^{-1}) treatments.

The obtained results were nearly in the same line as reported by Ghazzawy (16) who reported that spraying GA_3 and NAA significantly effected in increasing fruit weight, length, and pulp weight than control, also using GA_3 at 75 mg.L^{-1} and NAA at 75 mg.L^{-1} improve fruit parameters such as fruit weight, volume, and dimensions (22).

Enhancement in fruit physical properties by spraying of different PGR might be due to their effect in broadening cell size and strengthening of carbohydrate sink which led to an enhancement of fruit size and weight (21 and 25).

From the shown data in Table 3 it could be concluded that the impact of GA_3 and NAA treatments on fruit length, diameter, fruit shape index (L/D) of Barhee date palm.

Regarding fruit length, the highest value (41.6 mm) was exhibited significantly by using GA_3 + NAA (75 mg.L^{-1}) followed by GA_3 + NAA (50 mg.L^{-1}), GA_3 + NAA (25 mg.L^{-1}) and GA_3 (75 mg.L^{-1}).

Concerning the fruit diameter, the treatments GA_3 + NAA (75 mg.L^{-1}) and GA_3 + NAA (25 mg.L^{-1}) gave the highest fruit diameter (32.5 and 31.8 mm) with no significant differences followed by GA_3 (75 mg.L^{-1}), while the least fruit diameter (25.1 and 27.3 mm) was obtained by control and NAA (25 mg.L^{-1}) treatments.

With regard to fruit shape index, the highest value (1.313) was recorded with GA_3 +

NAA (50 mg.L^{-1}) followed by GA_3 + NAA (75 mg.L^{-1}). On the other side, GA_3 + NAA (25 mg.L^{-1}) gave the lowest shape value (1.207). GA_3 has direct on raising cell division and enlargement as well as fruit size (21), GA_3 is reported to induce growth and causing cell elongation through entrance of water into the cell by increasing flexibility of the cell wall and hydrolysis of starch into sugars (25).

Shees fruit characteristics:

Physical characteristics of shees fruit (Parthenocarpic fruits) for Barhee date palm significantly differed according to tested treatments presented in Table 4. The highest shees fruit weight (5.7 g) was obtained by the usage of GA_3 + NAA (75 mgL^{-1}) followed by GA_3 + NAA (50 mg.L^{-1}).Whatever the lightest fruit weight (2.2 g) was obtained by control treatment, when comparing between the highest and lowest value it is clear that the shees fruit weight was nearly doubled which is economically valuable for the total yield income. Regarding shees fruit length, it was quite evident that the highest value (27.5 mm) was detected with GA_3 + NAA (75 mg.L^{-1}) followed by GA_3 + NAA (50 mg.L^{-1}) and GA_3 + NAA (50 mg.L^{-1}) with no significant differences between them. On the contrary, control ranked statistically the lowest value (18.8 mm) in this concern. Shees shape index was influenced by the differential tested treatments. Highest shape index value (1.52) was resulted in NAA (50 mgL^{-1}) treatment, while the lowest value (1.33) conducted by GA_3 + NAA (25 mg.L^{-1}) and GA_3 (50 mg.L^{-1}).

Table 3. Effect of GA_3 and NAA on fruit length (mm), fruit diameter (mm) and fruit shape index (L/D) of Barhee date palm (Average of the two seasons)

Treatment	Fruit length (mm)	Fruit diameter (mm)	Fruit shape index (L/D)
Control	31.4e	25.1f	1.253abc
GA_3 (25 mg.L^{-1})	35.3c	28.3d	1.240bc
GA_3 (50 mg.L^{-1})	35.9c	29.4c	1.220bc
GA_3 (75 mg.L^{-1})	38.3b	30.4b	1.260abc
NAA (25 mg.L^{-1})	34.0d	27.3e	1.243bc
NAA (50 mg.L^{-1})	35.4c	27.9de	1.267abc
NAA (75 mg.L^{-1})	36.0c	29.5bc	1.217bc
GA_3 + NAA (25 mg.L^{-1})	38.5b	31.8a	1.207c
GA_3 + NAA (50 mg.L^{-1})	38.8b	29.5bc	1.313a

GA_3 + NAA (75 mg.L^{-1})	41.6a	32.5a	1.277ab

* Values shown are average of replications, within each column, different letters imply significant differences as defined by the means of Duncan's multiple range tests ($P < 0.05$).

Table 4. Effect of GA_3 and NAA on shees physical characteristics of female Barhee date palm (Average of the two seasons)

Treatment	Shees weight(g)	Shees Length(mm)	Shees width(mm)	Shees Shape index
Control	2.2f	18.8g	13.0d	1.45abc
GA_3 (25 mg.L^{-1})	2.8ef	20.9f	15.1c	1.38bcd
GA_3 (50 mg.L^{-1})	3.4ed	21.6ef	16.2b	1.33d
GA_3 (75 mg.L^{-1})	3.7ed	22.8cd	16.8b	1.36cd
NAA (25 mg.L^{-1})	3.8dc	22.4de	14.9c	1.50ab
NAA (50 mg.L^{-1})	4.1bcd	23.1cd	15.2c	1.52a
NAA (75 mg.L^{-1})	4.1bcd	23.8c	16.2b	1.47abc
GA_3 + NAA (25 mg.L^{-1})	4.7abc	24.8b	18.7a	1.33d
GA_3 + NAA (50 mg.L^{-1})	5.0ab	25.5b	18.6a	1.37cd
GA_3 + NAA (75 mg.L^{-1})	5.7a	27.5a	18.9a	1.45abc

* Values shown are average of replications, within each column, different letters imply significant differences as defined by the means of Duncan's multiple range tests ($P < 0.05$).

Fruit chemical characteristics:

Fruit chemical characteristics for Barhee date palm significantly differed according to tested treatments were shown in Table 5. Fruit TSS was markedly coupled with GA_3 (50 mg.L^{-1}), control and GA_3 (25 mg.L^{-1}) with no significant differences between them. Moreover, GA_3 + NAA (25 mg.L^{-1}) ranked statistically the second in fruit TSS. The reverse was true with NAA (50 mg.L^{-1}), which led to have significantly the poorest fruit (16.6) in their TSS content.

Concerning fruit juice acidity (%) of Barhee date palm as influenced by sprayed treatments, it was quite evident that the highest value (0.35%) was detected with control followed by GA_3 (25 mg.L^{-1}). On the contrary, NAA (50 mg.L^{-1}) ranked statistically the lowest (0.09%) in this concern.

TSS/Acidity ratio was influenced by the tested treatments. GA_3 + NAA (50 mg.L^{-1}) and NAA (50 mg.L^{-1}) were statistically superior (185.9 and 184.7) and showed the greatest values in this concern followed by GA_3 + NAA (25 mg.L^{-1}). On the contrary, control treatment recorded the lowest TSS/Acidity ratio (73.2). Such trend of response could be adequately clarified depending on the paralleled rates of changes exhibited in fruit juice TSS. Regarding total sugars, the highest values (84.4 and 82.7 mg/g) were recorded with GA_3 (25 mg.L^{-1}) and NAA (25 mg.L^{-1}). The reverse was true with GA_3 + NAA (75 mg.L^{-1}) and control which ranked statistically the lowest values (72.7 mg/g) in this concern.

Table 5. Effect of GA_3 and NAA on fruit chemical characteristics of female Barhee date palm (Average of the two seasons)

Treatment	TSS (Brix)	Acidity (%)	TSS/Acidity Ratio	Total Sugars (mg/g)	Carotenoids (mg/g)
Control	25.5a	0.35a	73.2f	72.7e	66.8e
GA_3 (25 mg.L^{-1})	25.1a	0.25b	100.4e	84.4a	29.7h
GA_3 (50 mg.L^{-1})	26.2a	0.20c	133.1d	79.9abc	44.8g
GA_3 (75 mg.L^{-1})	21.9bc	0.14d	155.1bc	78.8bcd	54.7f
NAA (25 mg.L^{-1})	21.5bcd	0.14d	151.9c	82.7ab	134.8a
NAA (50 mg.L^{-1})	16.6f	0.09f	184.7a	76.2cde	103.1c
NAA (75 mg.L^{-1})	18.2ef	0.14d	130.1d	74.7de	75.2d
GA_3 + NAA (25 mg.L^{-1})	22.8b	0.13d	170.6ab	75.1de	72.6d
GA_3 + NAA (50 mg.L^{-1})	20.5cd	0.11e	185.9a	72.9e	130.3ab
GA_3 + NAA (75 mg.L^{-1})	19.8de	0.15d	131.8d	66.0f	126.9b

* Values shown are average of replications, within each column, different letters imply significant differences as defined by the means of multiple Duncan range tests ($P < 0.05$).

Results in Table 5 indicated that carotenoids differed greatly according to the tested treatment. Hence, the highest value in carotenoids was statistically in NAA (25 mg.L^{-1}) followed by GA_3 + NAA (50 mg.L^{-1}), respectively. Using GA_3 (25 mg.L^{-1}) treatment led significantly to the poorest fruit in their carotenoids content. The Previously illustrated results which demonstrate the effect of phytohormones on chemical characteristics of Barhee dates. Kassem *et al.*,(22) reported that the TSS content increased significantly by spraying GA_3 (75 mgL^{-1}) while using NAA (75 mgL^{-1}) decreased the TSS percentage. NAA spray led to a reduction in TSS content and sugar content the lowest value when compared to control treatment (2), spraying NAA or mixture of other PGR reduced significantly TSS (4).

Conclusion

According to the findings of the current investigation, spraying growth regulators significantly increased yield through improving the fruit retained percentage and enlarging fruit weight. Shees fruits physical properties were also enhanced by increasing fruit weight and dimensions. Foliar spraying of GA_3 + NAA (75 $mg.L^{-1}$) led to the finest results among all the applied treatments.

Conflict of interest

The authors declare no conflict of interest.

References

1- **Abd El-Naby, A., Mohamed, A. A., and El-Naggar, Y. I. M. 2019**. Effect of melatonin, GA3 and NAA on vegetative growth, yield and quality of 'Canino' apricot fruits. Acta Scientiarum Polonorum. Hortorum Cultus, 18(3), 167–174. https://doi.org/10.24326/asphc.2019.3.16

2- **Aftab, T., and Roychoudhury, A. 2021**. Crosstalk among plant growth regulators and signaling molecules during biotic and abiotic stresses: molecular responses and signaling pathways. Plant Cell Reports, 40, 2017–2019. https://doi.org/10.1007/s00299-021-02791-5

3- **Al-Falahy, T. H., and Hasan, A. M. 2020**. Impact of potassium sulphate and naphthalene acetic acid spray on yield and fruit quality of date palm cv. Barhee. Eurasian Journal of BioSciences, 14(2), 4689-4695.

4- **Alhammadi, M. S., and Kurup, S. S. 2012**. Impact of salinity stress on date palm (*Phoenix dactylifera* L.)–a review. Crop production technologies, 9, 169-173.

5- **Aljuburi, H. J., Al-Masry, H. H., and Al-Muhanna, S. A. (2001).** Effect of some growth regulators on some fruit characteristics and productivity of the Barhee date palm tree cultivar (*Phoenix dactylifera* L.). Fruits, 56(5), 325-332. https://doi.org/10.1051/fruits:2001133

6- **Al-Tarawneh, M. S., Al-Absi, K. M., and Al Asasfa, M. A. 2023**. Pollen grain efficiency of two date palm (*Phoenix dactylifera* L.) genotypes as influenced by exogenous application of GA3 and NAA; in vitro and field study. Journal of Survey in Fisheries Sciences, 10(3S), 971-988. https://doi.org/10.17762/sfs.v10i3S.105

7- **AOAC. 1995**. Official methods of analysis (16th Ed.). Association of Official Analytical Chemists. Washington, DC, USA;

8- **AOAC. 2005.** Official Methods of Analysis (18th ed.). Association of Official Analytical Chemists; Arlington, VA, USA.

9- **Ashour, N. E., Mostafa, E. A. M., Saleh, M. A., and Hafez, O. M. 2018.** Effect of GA_3, 6-

benzylaminopurine and boric acid spraying on yield and fruit quality of barhee date palm. Middle East J. Agric. Res, 7(2), 278-286. https://www.curresweb.com/mejar/mejar/2018/278-286.pdf

10- **Aubied, I. A., and Hamzah, H. A. 2019.** Effect of Pollen Grains and Growth Regulator NAA on Some Fruit Characterization of Date Palm *Phoenix Dactylifera* L. cultivar Sultani. Al-Qadisiyah Journal for Agriculture Sciences, 9(1), 136-142. https://doi.org/10.33794/qjas.2019.162663

11- **Awad, M. A., and Al-Qurashi, A. D. 2012**. Gibberellic acid spray and bunch bagging increase bunch weight and improve fruit quality of 'Barhee' date palm cultivar under hot arid conditions. Scientia Horticulturae, *138*, 96-100. https://doi.org/10.1016/j.scienta.2012.02.015

12- **Choudhary, S. K., Kumar, S., Meena, R., Yadav, P. K., and Sudarsan, Y. 2018.** Effect of GA3 on fruit yield and quality of date palm (*Phoenix dactylifera* L.). *Int. J.* Curr. Microbiol. App. Sci, *7*(2), 3448-3456.

13- **Dubois, M., Gilles, K. A., Hamilton, J. K., Rebers, P. T., & Smith, F. (1956).** Colorimetric method for determination of sugars and related substances. Analytical chemistry, 28(3), 350-356.

14- **Duncan, D. B. (1955).** Multiple range and multiple F tests. *Biometrics*, *11*(1), 1-42.

15- **FAO. 2020**. Food and Agriculture Organization of the United Nations. https://www.fao.org/faostat/en/#data/QCL

16- **Ghazzawy, H. S. 2013**. Effects of some applications with growth regulators to improve fruit physical, chemical characteristics and storage ability of Barhee date palm cultivar. Int. Res. J. Plant Sci, 4(7), 208-213.

17- **Hafez, O. M., Saleh, M. A., Mostafa, E. A. M., and Ashour, N. E. (2022).** Responding Yield and Fruit Quality of Salmy Date Palm Cultivar by Foliar Application of Gibberellic Acid and Humic Acid. Journal of Pharmaceutical Negative Results, 2548-2553. https://doi.org/10.47750/pnr.2022.13.S08.321

18- **Hussain, M. I., Farooq, M., and Syed, Q. A. 2020.** Nutritional and biological characteristics of the date palm fruit (*Phoenix dactylifera* L.)–A review. Food Bioscience, 34, 100509. https://doi.org/10.1016/j.fbio.2019.100509

19- **Jabbar, S. H., and Hassan, Z. A. 2020**. Effect of spraying date of gibberellic acid and boron on some physical charavteristics of palm trees cv. Plant Archives (09725210), 20(1).

20- **Jensen, A. 1978** Chlorophylls and carotenoids. In Handbook of Phycological Methods: Physiological and Biochemical Methods; Hellebust, J.A., Craigie, J.S., Eds.; Cambridge University Press: Cambridge, UK, pp.59–70.

21- **Kassem, H. A., Al-Obeed, R. S., and Ahmed, M. A. (2011).** Extending harvest season and shelf life and improving quality characters of Barhee dates. Advances in Agriculture & Botanics, *3*(1), 67-75.

22- **Kassem, H. A., Al-Obeed, R. S., and Ahmed, M. A. (2012).** Effect of bioregulators preharvest application on date palm fruit productivity, ripening and quality. African Journal of Agricultural Research, *7*(49), 6565-6572. https://doi.org/10.5897/AJAR12.1122

23- **Müller, H. M., Schäfer, N., Bauer, H., Geiger, D., Lautner, S., Fromm, J., and Hedrich, R. 2017**. The desert plant *Phoenix dactylifera* closes stomata via nitrate-regulated SLAC 1 anion channel. New Phytologist, 216(1), 150-162. https://doi.org/10.1111/nph.14672

24- **Sabagh, A. E., Hossain, A., Islam, M. S., Iqbal, M. A., Amanet, K., Mubeen, M., ... and Erman, M. 2021.** Prospective role of plant growth regulators for tolerance to abiotic stresses. Plant growth regulators: signalling under stress conditions, 1-38. https://doi.org/10.1007/978-3-030-61153-8_1

25- **Stern, A. R., Ben-Arie, R., Applebaum, S., and Flaishman, M. 2006.** Cytokinins increase fruit size of ‘Delicious’ and ‘Golden Delicious’ (*Malus domestica*) apple in a warm climate. *The Journal of Horticultural Science and Biotechnology*, *81*(1), 51-56. https://doi.org/10.1080/14620316.2006.11512028

26- **Zahid, G., Iftikhar, S., Shimira, F., Ahmad, H. M., and Kaçar, Y. A. 2023.** An overview and recent progress of plant growth regulators (PGRs) in the mitigation of abiotic stresses in fruits: A review. *Scientia Horticulturae*, *309*, 111621. https://doi.org/10.1016/j.scienta.2022.111621