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ORIGINAL ARTICLE

EFFECT OF BRASSINOSTEROID ON SOME OF THE PHYSICO-CHEMICAL CHARACTERISTICS OF DATE PALM FRUITS (*PHOENIX DACTYLIFERA* L.) CV. BARHI UNDER DROUGHT STRESS

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Abstract: Date palm (*Phoenix dactylifera* L.) is one of the most economically important plants worldwide. The dates' quality and quantity were affected by several stresses, especially drought. Brassinosteroid (BR) is a new class of hormones that can be used with many plants in different stages of life to resist or overcome the effects of abiotic stresses such as drought. This study aims to study the BR effect on some physico-chemical characteristics of date palm fruits at two stages (Chimri and Khalal) under drought stress. Four concentrations of the BR (0, 0.2, 0.5 and 1 µmol) were studied, interacting with three irrigation times (once every 1, 2 and 3 weeks). The studied characteristics of the date fruit are the fresh and dry weight, dry weight percentage, water content, TSS and total acidity. The randomized complete block design was used for the field experiment and the SPSS program was used as a statistical program to analyze the experimental data. The interacting effects of Brassinosteroid with irrigation periods showed significant increases in fresh weight, dry weight, dry matter, TSS, and date length and diameter. On the other hand, significant decreases in the water content and total acidity, especially at BR concentrations of 0.5 and 1 µmol gave the highest significant differences. The results proved that BR is a key factor in drought stress on date palm fruits at the Chimri and Khalal stages.

***Key words*:** Date Palm, Hormone, Khalal stage, Irrigation times, Tolerance, Water content.

Cite this article

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1. Introduction

Date palm (*Phoenix dactylifera* L.) is a monocotyledon, monosexual and dioecious plant that belong to the Arecaceae family. It was previously called the Tree of Life; it is considered one of the oldest worldwide trees. Date palm fruits are the main food for people in the desert also, palm trees give a high-value nutrient food. There are hundreds of palm varieties worldwide, but only more than 500 cultivars are known in Iraq. The Barhi cultivar is considered one of the most significant commercial date cultivars, as it was first found and propagated in Basrah governorate in Iraq, from which it spread to the rest of the world [Ibrahim *et al*. (2021)]. This cultivar is characterized by its sweet taste and is eaten in all stages of the fruit (Khalal, Rateb and Tamer) because it is free of astringent tannins. Barhi is a late flowering and ripening cultivar, the palm yield about 80-120 kg/tree and produces 6-8 offshoots during its life cycle [Idder-Ighili *et al*. (2015)]. Date palm is classified as an abiotic tolerant tree, which makes it an essential candidate to survive in arid and semi-arid regions. It can withstand between 4 to 18 $dS.m^{-1}$ of (EC) the salinity levels of soil and irrigation water [Ibrahim (2010), Clouston (2013)].

Drought is one of the most significant abiotic factors that negatively affect plant development and growth, especially in arid and semi-arid areas [Mutlak (2019)]. Drought is a term that refers to the insufficient soil water that is available to the plant and this negatively

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affects the plant's metabolism [Hussain and AL-Taey (2020)]. The serious damages of drought stresses are; undermining water relations, reducing the efficiency of irrigation water use and destroying the natural growth of the plant [Mahmood *et al*. (2020)]. Drought affects plants at different levels depending on the plant species and variety, the period of exposure to stress, and the stages of growth. Drought resistance is a necessary trait for plants, and this trait must be developed through appropriate breeding methods or use modern biotechnologies techniques [Fathi and Tari (2016), Kumar *et al*. (2018)].

Phytohormons are considered the most important endogenous substances for modulating physiological and molecular responses, a critical requirement for plant survival as sessile organisms, Phytohormons act either at their site of synthesis or elsewhere in plants following their transport [Altaey and Majid (2018)].

Plant growth regulators (PGRs) are the essential factor to stimulate plant growth and increase its stress tolerance [Hamza and AL-Taey (2020)]. These PGRs are giving the required responses from the explants. Previously, there were five well-known of PGRs nowadays; some new PGRs are discovered such as Brassinosteroids (BRs). BR as PGRs can use with many plants in different stages of life to resist or overcome the effects of abiotic stresses such as drought, salinity, and other stresses [Al-Asadi *et al*. (2019)].

The main objective of this research is to study the interaction effect between the BR and irrigation periods on the physic-chemical properties in the fruits of date palm cultivar Barhi during the Chimri and Khalal stages.

2. Materials and Methods

The experiment was carried out in a private date palm orchard in Basrah governorate in south Iraq. All date palm trees are Barhi cultivars; they are eight years old and produced using tissue culture technology. The BR was sprayed on the leaves in two periods: the first time before flowering and the second time after the fruit set. BR was sprayed with four concentrations (0, 2, 5 and 1 μmol) with three irrigation periods: (watering once every 1, 2 and 3 weeks). The experiment followed a randomized complete block design, and the SPSS 25 version program was used to analyze the results. The dates were harvested at two stages (Chimri and Khala).

The fresh weight (FW) for dates was calculated by weighing ten dates randomly from each replicate, and then the fresh weight for each date was calculated by dividing the whole weight by the number of dates with the unit of (gm). The dry weight (DW) of the fruit dates was calculated by weighing the flesh of ten dates randomly from each replicate and then drying in a Vacuum Oven at 70°C for 72 hours. Then the DW% and WC% for each date were calculated according to the equations

$DW\% = (DW/FW) \times 100$ and $WC\% = (FW-DW) / FW \times 100$

The date length and diameter were calculated by measuring ten dates randomly from each replicate by Vernier and dividing the total by the number of dates with the unit of (cm).

The TSS of date was determined according to the Horwitz method [Chemists and Horwitz (1975)]. The total soluble acidity of date was determined according to AOAC (1970).

3. Results and Discussion

3.1 Fresh Weight (FW)

Fig. 1A showed significant increases in the fresh weight of date at the Chimri stage with the BR treatments at all concentrations (0.2, 0.5, and 1 μmol) with the level of irrigation once every three weeks compared with unsprayed treatments (7.84 g). The values rates of the fresh weight were 10.09, 10 and 9.92 g, respectively. The rest of the BR treatments under drought stress also had an increasing effect compared with unsprayed treatments, but it was not significant.

Also, there were significant increases in the fresh weight of date at the Khalal stage with the BR treatments at all concentrations of 0.2, 0.5 and 1 μmol with the level of watering once every three weeks compared with unsprayed treatments 8.01 g. The values rates of the fresh weight were 10.11, 10.71 and 10.68 g, respectively. The rest of the BR treatments also had an increasing effect compared with unsprayed treatments, but it was not significant (Fig. 1B).

The decrease in the fresh weight of date in different stages of irrigation is a normal response under drought conditions. The results are consistent with what Ratnakumar and Vadez (2011) have explained exposing the plant to a lack of water in critical stages such as flowering and fruiting leads to a decrease in yield and fresh weight [Ratnakumar and Vadez (2011), Elshibli

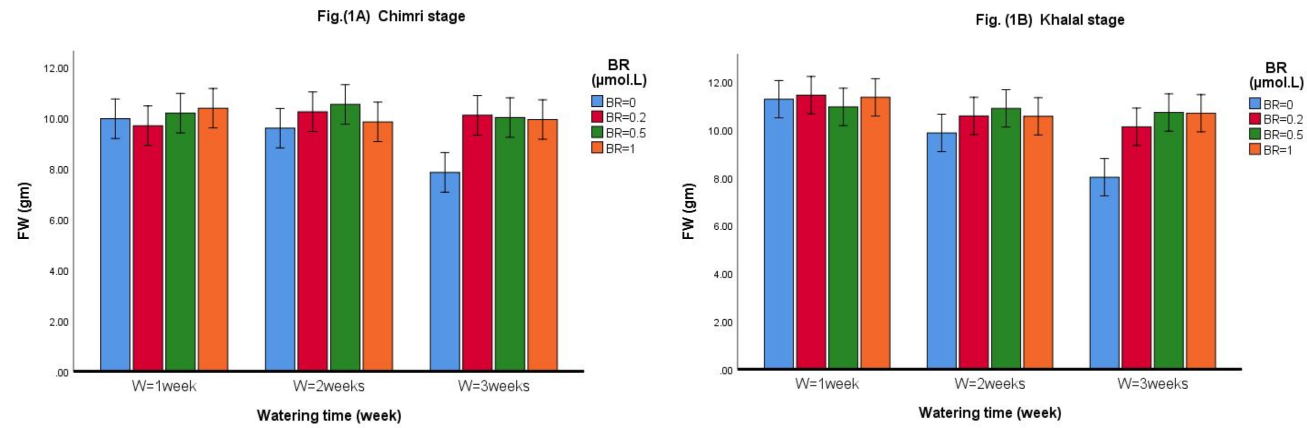

Fig. 1: The interaction effect between BR and the irrigation time on the date fresh weight (gm) at the (A) Chimri (LSD 1.11) and (B) Khalal stages (LSD 1.15)

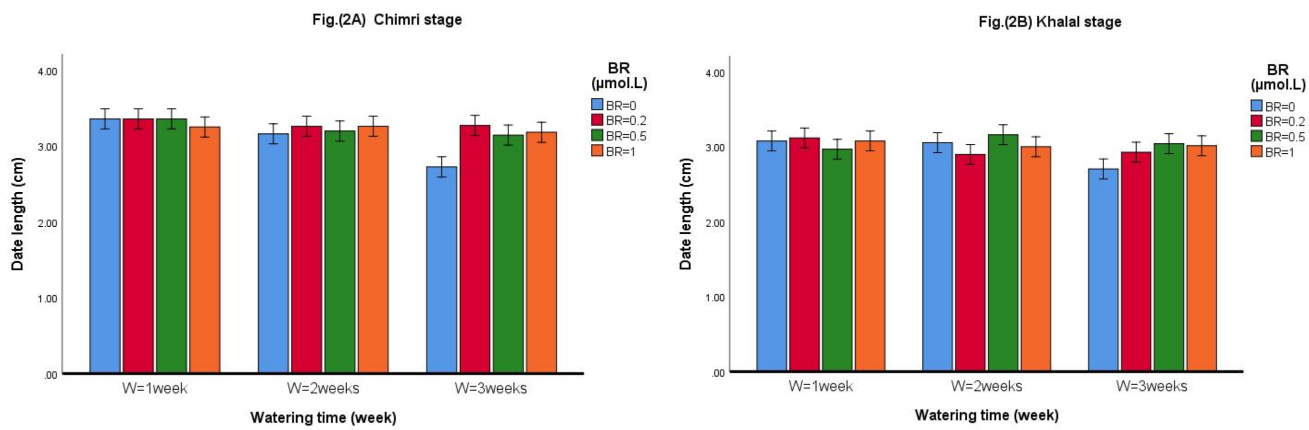

Fig. 2: The interaction effect between BR and the irrigation time on the date length (cm) at the (A) Chimri (LSD 0.1) and (B) Khalal stages (LSD 0.255)

et al. (2016)]. The increase in the fresh weight of the dates in the BR treatments compared to the unsprayed treatments can be attributed to the essential role of the BR in the various developmental processes, including growth [Divi and Krishna (2009), Kahlaoui *et al*. (2014)]. Also, cell division and elongation are significantly affected by the use of BR in interaction with other growth regulators or alone [Jager *et al*. (2005), Matusmoto *et al*. (2016)].

3.2 Date Length and Diameter

From Fig. 2A, it can be seen that there are significant increases in the length of date fruits in the Chimri stage when treated with BR in all its concentrations (0.2, 0.5 and 1) µmol with the irrigation period once every three weeks compared to the non-sprayed treatments whose average value was 2.72 cm. The average values of date fruit lengths were 3.27, 3.14, and 3.18 cm, respectively. The rest of the BR treatments also had a slight increase in the length of date fruit compared with unsprayed treatments, but it was insignificant.

Fig. 2B shows significant increases in the date length at the Khalal stage with the BR treatments at the concentrations of 0.5 and 1 µmol with the level of watering once every three weeks compared with unsprayed treatments at 2.70 cm. The values rates of the date length were 3.04 and 3.01 cm, respectively. On the other hand, there were slight decreases in the date length value with BR treatments at 0.2 and 1 µmol with the level of irrigation every two weeks compared with unsprayed treatments (3.05 cm).

Fig. 3A shows significant increases in the date diameter at the Chimri stage with the BR treatments at all concentrations (0.2, 0.5 and 1) µmol with the level of irrigation once every three weeks compared with unsprayed treatments (2.14 cm). The values rates of the date diameter were 2.47, 2.42 and 2.36 cm, respectively. Also, there was a significant increase in the date diameter at the Chimri stage with the BR treatments at 0.5 µmol concentration with the level of irrigation every two weeks compared with unsprayed

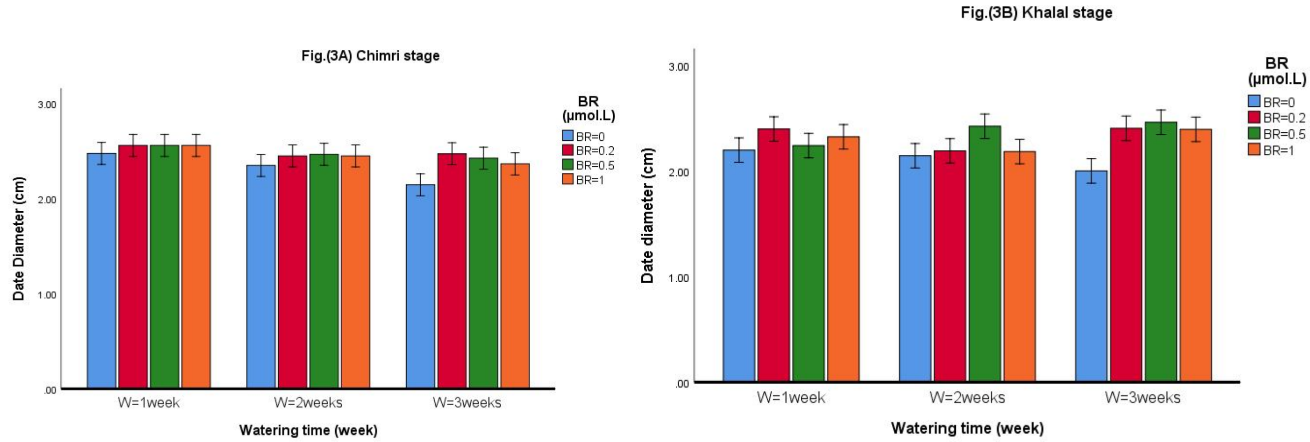

Fig. 3: The interaction effect between BR and the irrigation time on the date diameter (cm) at the (A) Chimri (LSD 0.113) and (B) Khalal stages (LSD 0.210).

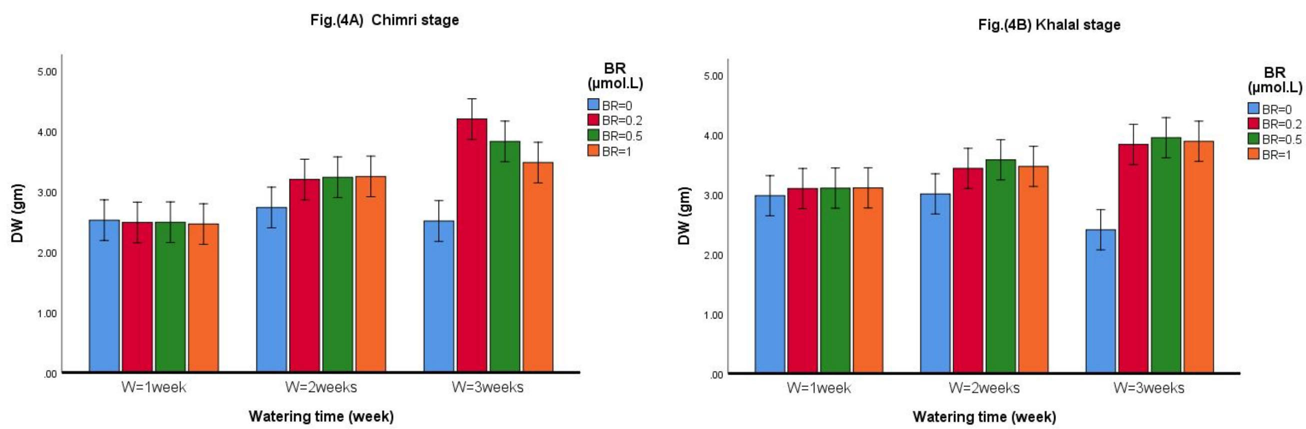

Fig. 4: The interaction effect between BR and the irrigation time on dry weight (gm) of date at the (A) Chimri (LSD: 0.587) and (B) Khalal stages (LSD: 0.368)

treatments (2.34 cm). The value rate of the date diameter was 2.46 cm. The rest of the BR treatments also had a slight increasing effect compared with unsprayed treatments, but it was insignificant.

Fig. 3B shows significant increases in the date diameter at the Khalal stage with the BR treatments at all concentrations (0.2, 0.5 and 1) µmol with the level of irrigation once every three weeks compared with unsprayed treatments (2 cm). The values rates of the date diameter were 2.40, 2.46 and 2.30 cm, respectively. Also, there was a significant increase in the date diameter value (2.42 cm) with BR treatments at 0.5 µmol with the level of irrigation every two weeks compared with control treatments (2.14 cm). The rest of the BR treatments also had a slight increasing effect compared with unsprayed treatments, but it was insignificant.

The lack of water at critical stages of the plant's life negatively affects plant growth and development. This effect led to a noticeable decrease in the length and diameter of the fruits under drought stress [Ratnakumar and Vadez (2011)]. Exposing the plant to water stress reduces the effectiveness of the photosynthesis process by 33 to 48% [Alleweldt *et al.* (1982)]. Drought stress inhibits photosynthesis by closing stomata in leaves, reducing leaf area, and affecting the activity of dried protoplasmic enzymes [Taiz and Zeiger (1998)]. The photosynthesis inefficiency will lead to a lack of processed food and consequently a decrease in the size and weight of the fruits. The BR application works to increase plant growth, especially in the indicators of physiological characteristics, including the length and diameter of the fruits in conditions of drought stress. This result is consistent with what he found in increasing the physiological characteristics of two apple cultivars that were exposed to the BR under water stress conditions [Kumari and Thakur (2019)]. In addition, many studies

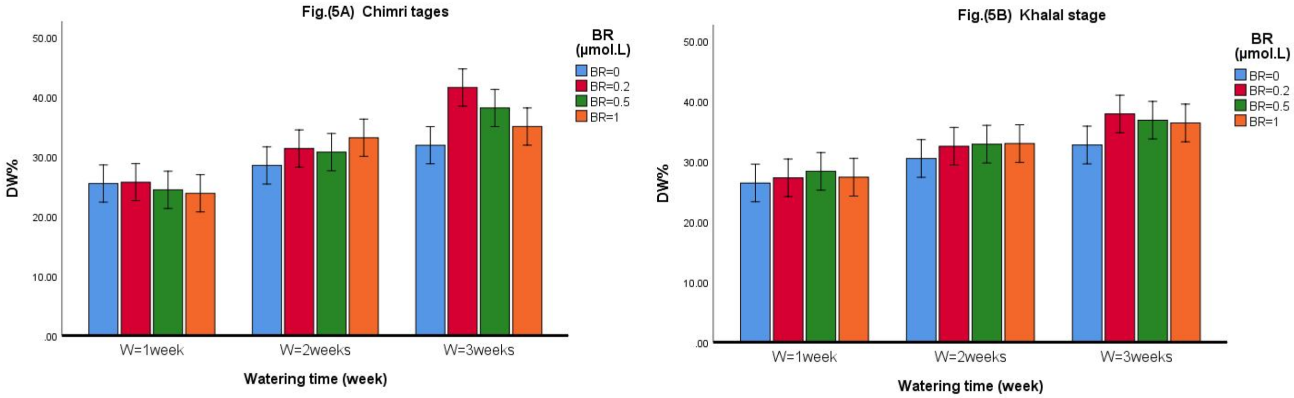

Fig. 5: The interaction effect between BR and the irrigation time on the DW% of date at the (A) Chimri (LSD: 5.2) and (B) Khalal stages (LSD: 3.784)

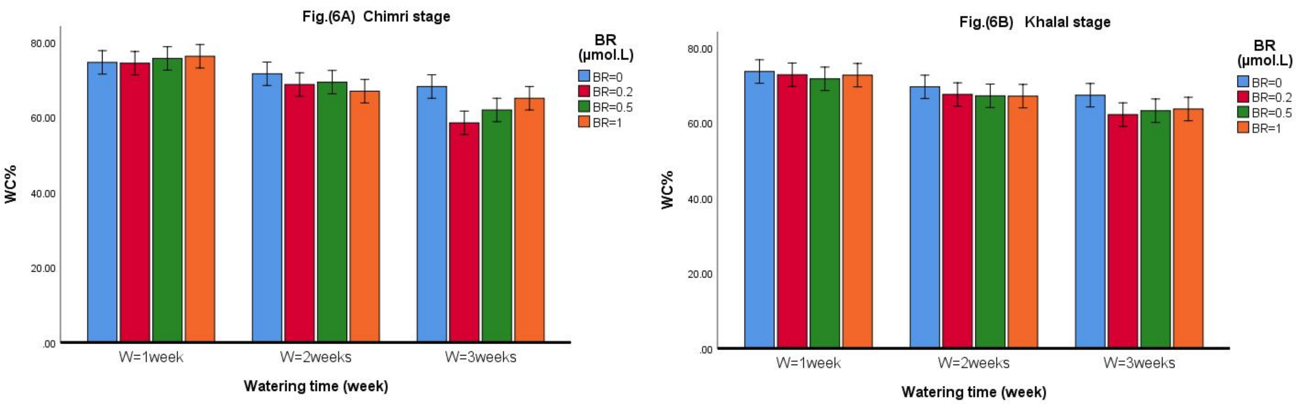

Fig. 6: The interaction effect between BR and the irrigation time on the WC% of date at the (A) Chimri (LSD: 5.2) and (B) Khalal stages (LSD: 3.78)

have indicated that cell division and elongation are significantly affected by the use of BR in interaction with other growth regulators, or alone [Jager *et al.* (2005), Matusmoto *et al*. (2016)].

3.3 Dry Weight (DW) and DW% and water content (WC %)

Fig. 4A showed significant increases in the dry weight of date at the Chimri stage with the BR treatments at all concentrations (0.2, 0.5 and 1) µmol with the level of irrigation once every three weeks compared with unsprayed treatments at 2.50 g. The values rates of the dry weight were 4.19, 3.82 and 3.47 g, respectively. The rest of the BR treatments also had a slight increasing effect compared with unsprayed treatments, but it was not significant.

The dry weight of date fruits at the Khalal stage had significant increases with the BR treatments at all concentrations (0.2, 0.5 and 1 µmol) and the level of irrigation (once every three weeks) compared with unsprayed treatments, in which the rate value was 2.40 g. The values rates of the dry weight were 3.83, 3.94, and 3.88 g, respectively. Also, there were significant increases in the dry weight of date at the Khalal stage with the BR treatments at all concentrations (0.2, 0.5 and 1 µmol) with the level of irrigation once every two weeks compared with unsprayed treatments of 3 g. The values rates of the dry weight were 3.43, 3.57 and 3.46 g, respectively (Fig. 4B).

Fig. 5A showed significant increases in the DW% of date at the Chimri stage with the BR treatments at the concentrations of (0.2, 0.5 and 1) µmol with the level of irrigation once every two weeks compared with control treatments (25.46%). The value rates of the dry weight ratio were 31.32, 30.7 and 33.11%, respectively. Also, there were significant increases in the DW% of date at the Chimri stage with the BR treatments at the concentrations of (0.2, 0.5 and 1) µmol with the level of irrigation once every three weeks compared with control treatments (26.39%). The value rates of the dry weight ratio were 41.53, 38.10 and 35%, respectively.

The Khalal stage in date fruits also had significant increases in the percentage of dry matter (%DW) when treated with BR at all its concentrations (0.2, 0.5 and 1) µmol with an irrigation level (once every three weeks) compared with the control treatment whose average value was 25.45%. The dry weight ratio value rates were 32.49, 32.83 and 32.93%, respectively. Also, there were significant increases in the DW% of date at the Khalal stage with the BR treatments at the concentrations of (0.2, 0.5 and 1) µmol with the level of irrigation once every three weeks compared with control treatments 26.39%. The value rates of the dry weight ratio were 37.84, 36.8, and 36.35%, respectively (Fig. 5A).

Fig. 6A significant decreases in the WC% in the date at the Chimri stage with the BR treatments at the concentrations of 0.2 and 0.5 µmol with the level of irrigation once every three weeks compared with unsprayed treatments (68.12%). The value rates of the WC% were 58.46 and 61.89%, respectively. Also, there was a slight decrease in the WC% of date at the Chimri stage with the BR treatments at all concentrations with the level of irrigation once every two weeks compared with unsprayed treatments, but it was not significant.

The water content percentage in date fruits at the Khalal stage was significantly decreased in the BR treatments at the concentrations of 0.2 and 0.5 µmol with the level of irrigation once every three weeks compared with unsprayed treatment, which was 67.30%. The value rates of the WC% were 62.15 and 63.19%, respectively. Also, there were slight decreases in the WC% of date at the Khalal stage with the BR treatments at all concentrations 0.2, 0.5, and 1 µmol with the level of irrigation once every three weeks compared with unsprayed treatments, but it was not significant (Fig. 6A).

The differences in the date dry weight are due to the difference in their fresh weight. The dry weight decreases are reflected in its fresh weight decrease whenever the plant is exposed to water stress. The dry weight percentage in dates increases when the plant is exposed to water stress. This increase is considered logical as a result of the decrease in the water content of the dates due to drought. There is an inverse relationship between DW% and WC% [Karim *et al.* (2020), Castañeda-Murillo *et al.* (2022)]. BR also increases the dry matter content of the dates and reduces the water content [Kumari and Thakur (2019)]. The decrease in the water content percentage and the increase in the dry matter percentage in the plant grown under drought stress conditions (compared to the control treatments) is related to the essential role of BR in the process of adjusting osmosis in the plant, and this, in turn, leads to the promotion of the accumulation of total soluble solids [Khamsuk *et al.* (2018), Pérez-Borroto *et al.* (2021)].

3.4 Total Soluble Solids (TSS) and Total Acidity in Date Fruits

Fig. 7A showed significant increases in the TSS% in the date at the Chimri stage with the BR treatments at all concentrations (0.2, 0.5 and 1) µmol with the level of irrigation once every two weeks compared with control treatments (22.66%). The value rates of the TSS% were 32, 32 and 29%, respectively. Also, there were significant increases in the TSS of date at the Chimri stage with the BR treatments at all concentrations (0.2, 0.5 and 1) µmol with the level of irrigation once every three weeks compared with control treatments (22.66%). The value rates of the TSS% were 35, 32 and 34%, respectively.

TSS% in date fruits at the Khalal stage was significantly increased in the BR treatments at the concentrations of 0.2, 0.5 and 1 µmol with the irrigation level (once every two weeks) compared with control treatment, which was 31.66%. The value rates of the TSS% were 47, 48 and 46%, respectively. Also, there were significant increases in the TSS of date at the Khalal stage with the BR treatments at all concentrations (0.2, 0.5 and 1) µmol with the level of irrigation once every three weeks compared with control treatments at 31.66%. The value rates of the TSS% were 53, 55 and 50%, respectively (Fig. 7B).

Fig. 8A showed a significant decrease in the Acidity% in the date at the Chimri stage with the BR treatments at the concentration of 0.5 µmol with the levels of irrigation once every two weeks compared with control treatments 0.32% and the value rate of the Acidity% was 0.27%. The rest of the BR treatments also had a slight decreasing effect compared with control and unsprayed treatments, but they were not significant.

At the Khalal stage of date fruits noticed the acidity percentage had significantly decreased with the BR treatments at all concentrations (0.2, 0.5 and 1) µmol with the irrigation level (once every two weeks) compared with unsprayed treatments, which was

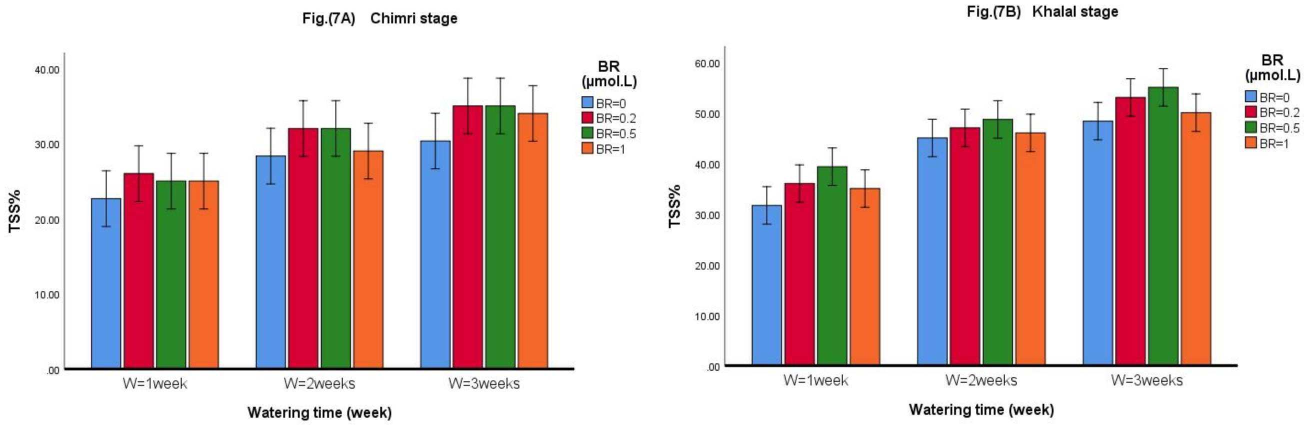

Fig. 7 : The interaction effect between BR and the irrigation time on the TSS% of date at the (A) Chimri (LSD: 3.11) and (B) Khalal stages (LSD: 6.97).

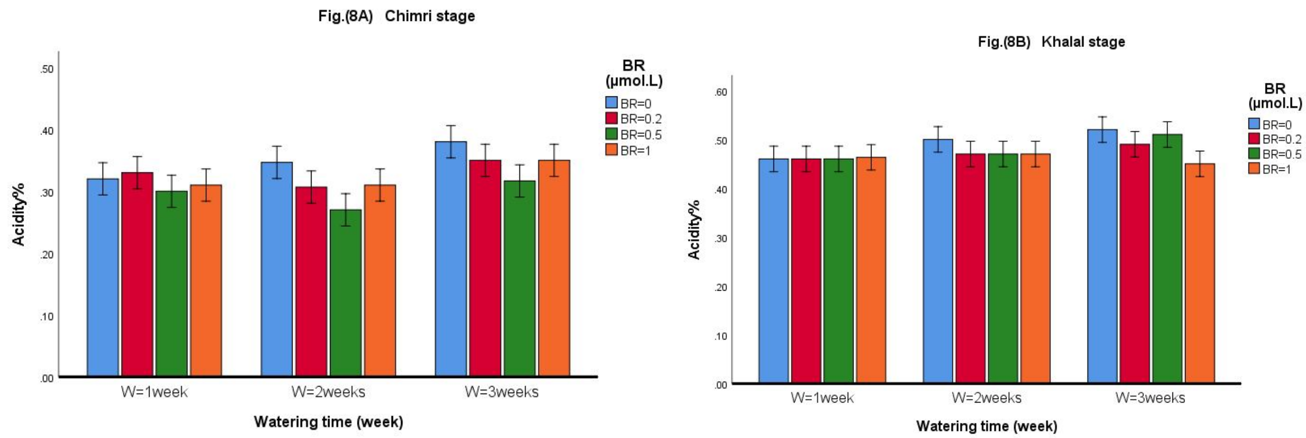

Fig. 8 : The interaction effect between BR and the irrigation time on the Acidity% of date at the (A) Chimri (LSD: 0.044) and (B) Khalal stages (LSD: 0.0297).

0.50%. The value rates of the acidity% were 0.47, 0.47, and 0.47%, respectively. Also, there were significant decreases in the Acidity% of date at the Khalal stage with the BR treatments at all concentrations with the level of irrigation once every three weeks compared with unsprayed treatments (0.52%). The value rates of the Acidity% were 0.49, 0.51 and 0.45%, respectively (Fig. 8B).

The percentage of total soluble solids and acidity has risen with the increase in the period of drought stress, which is an expected trend. This increase is due to drought stress acting as a potential factor for accelerating thermal time that, in turn, encourages more efficient photosynthesis and thus increases solubility [Stöckle *et al*. (2003), Roghabadi and Pakkish (2014)]. Also, BR encouraged an increase in TSS in fruits compared with control treatments. On the other hand, BR worked to inhibit or reduce the effect of drought stress on the fruits by decreasing the acidity in the fruits compared with control treatments [Khatoon *et al*. (2020), Khatoon *et al*. (2021)]. There is a close relationship between BR and the ripening stage onset in the berry plant, as BR act as a promoting factor for the maturation process, TSS and acidity are important indicators of ripening [Symons *et al*. (2006)].

4. Conclusion

Drought stress negatively affects the growth and development of plants, especially in critical stages such as the development and ripening of fruits. BR acted as an inhibited factor of the drought stress, by improving the physical characteristics and water content of date fruits at different stages. BR in concentrations of 0.5 and 1 µmol improved the fruits characteristics of date palms under drought stress.

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