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Research Article

Impact of different irrigation programs on enzymatic activities in leaves, and fruit ripening enzymes of two date palm cultivars of Sayer and Halawi

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Abstract

The current study aimed to estimate the activities of the two antioxidant enzymes viz. catalase and peroxidase in fronds and ripening enzymes (invertase and cellulose) in fruits of two date palm cultivars, viz. Sayer and Halawi at Khalal stage subjected to irrigation interval periods. The treatments include irrigating by amount 150 L. with different interval periods. The results showed that antioxidant enzymes activity increased by increasing interval period, where treatment 3 recorded the highest concentrations of the catalase and peroxidase, while ripening enzymes decreased with increasing water deficit period**.**

Keywords: Antioxidant enzymes, Ripening enzymes, Cultivar.

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Introduction

Date palm *Phoenix dactylifera* L. is one of the economically important trees in arid and semiarid areas (Yaish & Kumar 2015). It faces different multi abiotic stress, which decreases palm productivity and also affects tree plantation, in addition, it reduces genetic diversity (El Rabey et al. 2015; Du et al. 2018; Hazzouri et al. 2020). Water plays an important role in the socio-economic growth of the world. As a result, the freshwater demands for agricultural and other uses are rising, while resources availability is limited. Thus, it is predicted that around two-thirds of the world population will be living in water-shortage areas by the year 2025 (Khan & Prathapar 2012). Hence, we need to design economic strategies for different purposes uses of water for especially agricultures.

Water stress affects directly plant growth, especially cell division, cell enlargement, and cell differentiation (Yaish et al. 2017). These events affecting on the various physiological and biochemical processes in the plant such as photosynthesis, respiration, ion uptake, carbohydrate in addition to nutrient metabolisms (Hsiao 1973). Under these conditions, plants can survive by changes in their development and physiology (Konno et al. 2008).

Date palm (s one of the successful fruit trees that can withstand different abiotic stress in the arid and semiarid zones. Date palm possesses a variety of morphological and physiological traits that help it to survive and it has also the potential to produce a yield under such conditions. Moreover, this tree has a deep root network which helps to successfully cultivate across different range soils. Nevertheless, underground water depth, soil characteristics, and

date palm genotype play a role in root growth and spreading. (Zaid & de Wet 2002). In spite of such adaptive features, the tree needs a plenteous water supply for the production in commercial-grade (Alhammadi & Kurup 2012). Even though, long periods of drought negatively affect date palm yield by reducing fruit quality (Elshibli et al. 2016).

The application of irrigation schedules for date palm trees for crop establishment and productivity are very crucial, especially there is variation in water requirements between different cultivars. In addition, the ecological factors around the cultivated orchards are also different. Therefore, the present study aimed to estimate the enzymatic activity in fronds as well as ripening enzymes in fruits of two date palm cultivars, viz. Sayer and Halawi under different irrigation programs in Basrah city.

Materials and Methods

The experiment was carried out in a date palm orchard located in Shatt-Al-Arab, North-East of Basrah, during the season (2018-2019). Two cultivars of date palm of Sayer and Hallawi were selected for this study. To study the effect of water deficit on plant development, productivity, and fruit quality, date palm trees were exposed to different irrigation regimes (Table 1).

Estimation of the peroxidase enzyme activity: The fresh samples of plant materials fruits (fruits at Khalal stage) and leaves (at the end of the fruiting season) were collected. About 1g of fresh samples were grounded separately with phosphate buffer-oxalic acid solution (0.25-0.5; pH=7.5). The extracted solutions were centrifuged at 4°C at 21000rpm for 30min, and the supernatant was used to estimation of peroxidase activity. The enzymatic activity was estimated according to Whitaker & Bernhard (1967).

Estimation of the Catalase enzyme activity: 1g of the fruit and leaves were grounded separately with buffer solution (potassium phosphate 0.1 M, pH =7.8) in a ratio of 2:1 w:v. The extracted solutions were centrifuged at 1200rpm for 30min. Then the catalase activity was estimated according to Goth (1991).

Estimation of the activity of inverses and cellulose enzymes: The two enzymes were evaluated in fruits and the estimation process was carried out according to Al-Bakir & Whitaker (1978).

Statistical analysis: The experiment was designed under a completely randomized design (C.R.D.) with two factors (variety and irrigation treatments) in Genestats 0.7 program to determine the RLSD between the mean of the treatments.

Results and Discussion

Catalase and peroxidase enzyme activities: Date palm trees need good irrigation programs, which means utilizing the right amount of water at the right time. Strictly speaking, making sure water is available when the tree needs it. From the biochemical aspect, water shortage plays important role in plant growth and productivity. In two cultivars of date palm studied in this work i.e. Sayer and Halawii, irrigation treatments were significantly affected the enzymatic activity (catalase and peroxidase) of fronds and fruits. Where high catalase and peroxidase activities were recorded at treatments 3 and 4 (150 L/once every 20 and 30 days, respectively) in fronds and fruits (Table 2).

Catalase and peroxidase activities have increased as the interval water irrigation period increased, where treatment 3 showed the highest peroxidase and catalase activity in fruit and fronds of both date palm cultivars under study (as 54677 and 116.4, and 27906 and 44.5unit.mg^{-1}, respectively (Table 2). While the less peroxidase and catalase activity scored in treatment 0 and 1 in fruits and fronds of both cultivars. The results also revealed that the interaction between two cultivars for catalase and peroxidase activity is not significant in fronds and significant in fruits. Where concentration average for both catalase and

Table 1. Different irrigation regimes exposed to date palm trees in the current study.

Treatment	Water quantity 150 L/interval period (days)
0 (control)	Once a week
1	Once every 10 days
2	Once every 20 days
3	Once every 30 days

Table 2. The effect of variety and irrigation treatments on the content of antioxidant enzymes in leaves and fruits.

		Vari. / Irr. Tre.	irr. Tre.0	Irr. Tre.1	Irr. Tre.2	Irr. Tre3	Mean of variety
1	Catalase enzyme in frond (unit/mg)	Al-Sayer	18206	29001	39384	47241	33458
		Al-Halawi	26897	36198	54355	62112	44890
		Mean of irrigation	22552	32599	46869	54677	
		Variety: L.S.D Irri. 4834.5: : 9668.9 : Interaction 6837					
2	Peroxidase enzyme frond(unit/mg)	Al-Sayer	49.1	68.5	77.2	127.8	80.6
		Al-Halawi	61.3	66.8	78.1	105.0	77.8
		Mean of irrigation	55.2	67.6	77.6	116.4	
		10.44: Variety: L.S.D Irri. :14.76 Interaction 20.87 :					
3	Catalase enzyme in fruits (unit/mg)	Al-Sayer	2168	2656	7134	18957	7729
		Al-Halawi	5746	10298	24403	36856	19326
		Mean of irrigation	3957	6477	15769	27906	
		L.S.D :Variety : 2630.2 Irri. : 3719.7 Interaction : 5260.4					
4	Peroxidase enzyme in fruits (unit/mg)	Al-Sayer	3.7	6.6	16.7	30.5	14.4
		Al-Halawi	4.9	9.8	14.2	58.4	21.8
		Mean of irrigation	4.3	8.2	15.4	44.5	
		Variety: L.S.D : 6.06 Irri. : 8.58 Interaction: 12.13					

peroxidase in two cultivars under study Sayer and Halawii were 44890 and 33458, and 19326 and 7729unit.mg^{-1}, respectively. While, the mean of the catalase and peroxidase activities of fruits were 80.6 and 77.8, and 21.8 and 14.4unit.mg^{-1}, respectively, in Sayer and Halawii cultivars.

With respect to interaction between two cultivars and water shortage stress, the activities of two antioxidant enzymes (catalase and peroxidase) were measured under control and water irrigation period. The results showed that the interaction between two date palm cultivars and water shortage stress was recorded in the third irrigation treatment. Where high catalase and peroxidase activity was scored in the fronds of the Hellawii cultivar, whereas a high level of the same enzymes was recorded in the fruit of the Sayer cultivar (Table 2).

Increasing peroxidase and catalase enzymes activities resulting from irrigation treatments can be due to oxidative stress as well as an increase in ROS levels where plants have two defense systems against ROS, enzymatic and non-enzymatic systems (Racchi 2013). The increase in the activity of the antioxidant enzymes under drought stress in the current study is because the plants produce a variety of antioxidants that counteract the generation of reactive oxygen species (ROS) in response to drought stress (Wang et al. 2009). Our results are in agreement with the findings of Haider et al. (2013) and Haider et al. (2014), who indicated that date palm cultivars differ for the enzymatic activity of peroxidase and catalase in leaves and fruits, and Ati (2016) who noticed that increase in antioxidant enzymes activity has occurred when a foliar spray of some environmental stress compounds on date palm leaves. In addition, Sakran et al. (2018) found an increase in peroxidase, catalase, and polyphenol oxidase in date palm leaves and seedlings under drought stress.

Ripening enzymes activity during irrigation

Table 3. The effect of variety and irrigation treatments on the content of invetase and cellulase enzymes in fruits at the Khala stage.

		Vari. / Irri. Tre.	irri. Tre.0	Irri. Tre.1	Irri. Tre.2	Irri. Tre.3	Mean of variety
1	Invertase enzyme (unit/k.g/min.	Al-Sayer	2862	2801	2567	2224	2613
		Al-Halawi	2906	2807	2585	2272	2642
		Mean of Irrigation	2884	2804	2576	2248	
L.S.D Variety: 80.0: Irri. : 113.1 interaction : 160.0							
2	Cellulase enzyme (unit/k.g/min	Al-Sayer	2289	2189	2134	1113	1931
		Al-Halawi	2321	2177	2179	1117	1949
		Mean of Irrigation	2305	2183	2156	1115	
Variety: L.S.D 85.3: Irri. : 120.7 Interaction :170.6							

shortage: Date palm fruit development and ripening pass through a complex biological process that undergoes gradual switches from cell division to energy, nutrient storage during cell expansion, and starch degradation during ripening (Mortazavi et al. 2015). The results of the treatments exposed to the water shortage caused not many disturbances in ripening enzymes activity (Table 3); where the highest invertase and cellulose enzyme activities were recorded in Hallawi cultivar at Khalal stage (2642 and 1949unit.Kg^{-1}.min^{-1}).

Based on the results, the invertase and cellulase activities decreased as the interval water irrigation period increased, where treatment 3 recorded the lowest invertase and cellulase activities in fruit at the Kalal stage of both cultivars (2248 and 1115 unit. Kg^{-1}.min^{-1}) (Table 3). With respect to interaction between two cultivars and water shortage stress, the activities of two ripening enzymes, the low invertase, and cellulase activities in the fruit of both cultivars were measured in treatment 3, where, the mean of two enzymes were 2224 and 1117unit.Kg^{-1}.min^{-1} for Hallawi followed by Sayer as 2272 and 1113unit. Kg^{-1}.min^{-1}. Date palm fruits contain a group of ripening enzymes, such as pectin methylesterase, invertase, cellulase, polyphenoloxidase, and polygalacturonase (Rastegar et al. 2012). Invertase is one of the important enzymes in the date palm fruits because of its effect on fruits quality and consistency, as it works to convert disaccharides (sucrose) into monosaccharides (glucose and fructose), and is related to ripening processes, while cellulose works on the softness of the cell wall of the fruit cells. It is produced to break down the cellulose in the cell walls, which leads to their softening (Abdul-Wahid 2017).

Abdul-Wahid & Abd (2004) indicated that invertase enzyme in Halawi fruits appeared at a high level in the Khalal stage and decreases in the same path that the sucrose followed, while the cellulase enzyme increased to the Khalal stage, followed by a rapid decrease in level as the fruit advanced growth and until maturity. Our result is in agreement with Abdul-Wahid (2017) that showed a significant decrease in the activity of ripening enzymes as a result of salt stress. This result agrees with Alpresem & Alamery (2019) in the study of water stress effects on the enzymatic activity of invertase and cellulase in date palm fruits cv. Barhi and Hallawi. Environmental stress reduces the enzymatic activity of invertase (Fotopoulos 2005).

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