Eco. Env. & Cons. 28 (January Suppl. Issue) : 2022; pp. (S73-S81)
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ISSN 0971–765X

http://doi.org/10.53550/EEC.2022.v28i01s.010

Impact of geographical distribution on the variation of Morphological and biochemical properties in two date Palm cultivars

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(Received 29 July, 2021; Accepted 9 September, 2021)

ABSTRACT

The rationale of the study was to determine the effect of three different locations (Hassa, Kharj, and Qassim) on two date palm (*Phoenix dactylifera* L.) varieties (Khalas and Berhi) to show the effect of the spatial difference affected by weather factors on the quality characteristics of the two types of study. The number of varieties was estimated at 400 varieties distributed in different agricultural areas. Each region was characterized by certain species in the Kingdom. In the proposed study, a series of laboratory studies will be carried out to propose an ideal distribution map for the distribution of varieties in Saudi Arabia in terms of optimum temperature and humidity for growth. It is concluded from the present study that although date palm cultivar Khalas originated from Al-Hassa region however it flourishes well in Qaseem region and produced higher quality fruits. On the other hand, the date palm cultivar Berhi, which was originated from Qaseem geographical location performed well in the same location regarding physicochemical characteristics of the fruit. A detailed future study is suggested to conduct on the soil chemistry and microbiology and in-situ monitoring of crop environment.

Key word : *Phoenix dactylifera L., Dioecious, Qaseem, Fruit quality, Khalas.*

Introduction

Date palm (*Phoenix dactylifera* L.) has had a wide range of agricultural and economical importance throughout human history. It belongs to the family Arecaceae and is considered an icon of life in the desert, as it tolerates water stress, salinity, and high temperatures (Lunde, 1978; Pantuliano and Wekesa, 2008). Also, it is one of the oldest cultivated fruit trees in the world. This statistic illustrates the production of dates worldwide from 2010 to 2018, in million metric tons. In 2018, the global production volume of dates amounted to about 8.53 million metric tons, up from 7.53 million metric tons in 2010(FA0., 2018). It is a prominent crop in arid regions of the Middle East including the Kingdom of Saudi Arabia (FA0, 2019). It can tolerate adverse environmental conditions of desert regions such as high temperature, drought, and salinity (Alhammadi, and Kurup, 2012; Chao and Krueger 2007; Safronov *et al.*, 2017). Date production in Saudi Arabia reached 1539756 tonnes in 2019, up from 117881 Hectares in 2018, whereas the production of the Arab world of dates is about 80% of the total production of the world (FA0., 2018). Its product is used in many things of human as fruits and some other uses as animal feeding, the value of exports jumped by 11.7 % in 2017, and achieving 199.1 million riyals until it reached 222.4 million riyals (Saudi currency) in 2018 (FA0., 2019). The date palm has a distinguished place in many Middle East countries, in general, and particularly in the Kingdom of Saudi Arabia, globally, the Kingdom of Saudi Arabia is considered on the second rank in the world in terms of total goods (Al-Mulhem *et al.,* 2015). There are many varieties of important economic values such as Khalas, Riziz, Shish, Barhee, Ajwa, Anbra, and Mejdol cultivars as an example. For example, it reports the total number of female trees (Khalas cultivar) about (760,476,7) tree, although Trees only produce about approximately (502,886,5) trees. Many factors could affect the dates quality and marketing, such as insect pests, plant diseases, as well as environmental stress factors including drought, salinity, and temperature extremes as a result of climate change, climate change has significant consequences for the agricultural sector due to direct exposure to weather-dependence, both in agriculture and other natural resources (Allbedl *et al.,* 2017).

Cultivars are named by farmers based on fruit color and form or the existence of a certain position (10). In addition, date palms for cultivation are selected based on better fruit (quality and post-harvest life) as cited by (Ahmed *et al.,* 2018). Khalasand Barhiare considered as the important date palm cultivars across Saudi Arabia. Khalas is consumed at both the Rutab and Tamar stages of development, while Barhi is consumed at the Rutabstage (Safronov *et al.,* 2017). Some physical characteristics such as (fruit weight, flesh weight, seed weight, fruit size, moisture percentage in fruits, length and width of the fruit), as well as some chemical characteristics such as (total solids, total sugars, percentage of reduced and non-reducing sugars, acidity in fruits) were studied. The use of phenotypic markers is the easiest and least complex way to distinguish between varieties. The first and oldest method of studying genetic diversity has long been used and is still used for differentiation between varieties. It is based on finding differences in phenotypic floral color and its syphilis, leaf shape and distribution, and the nature of vegetative growth. In the field of date palms, some researchers pointed to the difficulty of distinguishing varieties through their appearance and without the presence of fruits because of the characteristics of vegetative growth affected by the surrounding environmental conditions and service processes. Saudi Arabia is one of those countries that are highly in danger of the bad effects of climate change, due to its arid climate. Normal temperatures are expected to be increased by as much as 6·0 °C by 2100 as a consequence of climate change in Saudi Arabia, so the expected yield of different types of field fruit trees will experience losses that range from 5 to >25% (Allbed, 2017), also the crop irrigation water demands would rise by about 602 and 3122 million m^3 (MCM) at 1 and 5 °C increases. For these reasons, climate change is very likely to have significant impacts on the distribution, quantity, and quality of global agricultural production (Guarino, 1995; Allbedl, 2017). Biotic and nonbiotic factors play an important part in the potential distribution of crops, as an example, the combination of biotic and nonbiotic factors led to a significant improvement in the prediction of the potential distribution of Frankliniella occidentalis in China compared with a prediction by climate variables alone as founded by (Shabani, 2012) who also projected the distribution of date palms for Iran at the national level by using non-climatic parameters such as land use, topography, and soil taxonomy and found that only 220 000 km^2 would be appropriate for date palm cultivation, compared to 610 000 km^2 based on climate suitability. Therefore, it is very important to consider the effect of both climatic and non-climatic parameters when predicting the potential future distribution of the species. In other words, the secret is the inclusion of climatic and non-climatic variables.

The main goal of this study is to obtain some information about the variation of Morphological and biochemical in two date palm cultivars (Khalas and Barhee) under study. The two varieties were investigated and compared between three regions, namely (Alahsa, Qassim, and Al-Kharj) regions conditions. Also, study the soil properties (pH and salinity) for the same regions to draw a map for the distribution of the two date palm cultivars (Al-Ikhlas and Al-Barhi) according to the results obtained in the three different study areas (Al-Ahsa, Al-Kharj, and Al-Qassim) according to environmental factors and their impact on quality characteristics.

Materials and Methods

The present study was carried out at three different locations (Hassa, KHarj, and Qassim) on two date palm (*Phoenix dactylifera* L.) varieties (Khalas and Barhee) during 2018 and 2019 seasons. uniform female date palm trees of cv. Khalas and Barhi were selected for thisstudy as shown in Table 1. All date palm trees were received the same normal agricultural practices. The study was conducted in three locations: 1st in an area Alahsa at the Date Palm Research Center of Excellence Research and Training Station, King Faisal University, Al-Ahsa, Kingdom of Saudi Arabia (Latitude: 25.2608% N, Longitude: 49.7078% E, Altitude: 155 m above sea level), and 2nd in an area Qassim (Buraydah) at farm endowments Saleh bin Abdulaziz Al-Rajhi (Latitude: 26.303994, N, Longitude: 44.141371% E, Altitude: 598 m above sea level) and 3rd in an area Riyadh (Al-Kharj) at farm endowments Mohammed bin Abdulaziz Al-Rajhi (Latitude: 24.703772% N, Longitude: 46.780933% E, Altitude: 610 m above sea level as shown in Table 2. Soil samples were collected from three locations: (Alahsa, Qassim, and Al-Kharj) to study some properties as pH (Allen, 1989) and electrical conductivity ((EC) (Rowell, 1994), then a code number was assigned to each sample as shown in Table 3. This study is based on the description of Thirty-four (34) vegetative traits of the date palm, which were visually observed traits as described in Table 4. These characters have already been reported as a standard descriptor to characterize date palm (Amer, 2000; Rizk, and El Sharabasy, 2004; Rizk *et al.*, 2004). All measurements were performed in triplicate using the measuring tape and different geometrical tools (protractor) to measure the angles.

Table 1. Locations (Latitude and Longitude) of the samples.

No	Codes & Locations	Latitude	Longitude
1	KH_AH_1	25.267927"N	49.708493"E
2	KH_KH_2	24.23126 "N	47.14113"E
3	KH_QS_3	25.5457.8"N	44.03357"E
4	BR_AH_4	25.267927"N	49.708493"E
5	BR_KH_5	24.23126"N	47.14113"E
6	BR_QS_6	25.5457.8"N	44.03357"E

Table 2. Sample code number (Cultivar - Region – Number)

No	Sample code number	The definition
1	KH_H_1	Cultivar - Region - Number
2	KH_K_2	Cultivar - Region - Number
3	KH_Q_3	Cultivar - Region - Number
4	BR_H_4	Cultivar - Region - Number
5	BR_K_5	Cultivar - Region - Number
6	BR_Q_6	Cultivar - Region - Number

Fig. 1. Map of the Date Palm Research Center of Excellence Research and Training Station, King Faisal University, Al-Ahsa, mentioned by abbreviations.

Fig. 2. Map showing the three study locations under study

Table 3. Cultivars and names of locations with their corresponding abbreviations

No	Sex	Cvs	Cvs abbr	Locations	Loc. abbr	Code
1	Female	Khalas	Kh	Alahsa	AH	KH_AH_1
2	Female	Khalas	Kh	Al-Kharj	KH	KH_KH_2
3	Female	Khalas	Kh	Qassim	QS	KH_QS_3
4	Female	Barhee	Br	Alahsa	AH	BR_AH_4
5	Female	Barhee	Br	Al-Kharj	KH	BR_KH_5
6	Female	Barhee	Br	Qassim	QS	BR_QS_6

Plant material and measurements

Morphological attributes part

Some Vegetative Attributes were studied as follows in the table bellows:

A total of 1170 samples representing two varieties of date palm in Saudi Arabia were collected and checked for specific attributes during the 2018 and 2019 seasons. The attributes were collected from the three locations as mentioned below. The attributes were gathered and screened to formulate a system of descriptors for date palm agrobiodiversity. The collected attributes for date palm description included those used by (Amer, 2000; Rizk, and El Sharabasy, 2004; Rizk *et al.,* 2004).. The analysis was carried out on 5 randomly selected healthy date palm trees of the same-named variety of the same age. Leaf attributes were measured and scored from 25 well-developed mature leaves. Fruit attributes were scored at the full maturation of the date fruit. Samples of one hundred fruits were picked randomly from each cultivar for fruit characterization. The terminology used for morphological attributes follows (Bennaceur, 1991). A multi-score system was used to characterize the date palm attributes. The bi-state characters were scored as absent/present. The expression of quantitative multi-state characters was recorded on a scale of 1-9. The types of data used by gene banks are passport data, eco-geographical data, ethnobotanical data, characterization data, evaluation data, and management data as cited by (Bennaceur, 1991; Rizk *et al.,* 2004).

Fig. 3. Map of the Endowments Farmer Sheikh Muhammad bin Abdulaziz Al-Rajhi (Al-Kharj), mentioned by abbreviations.

Fig. 4. Map of the Agricultural Administration in the Department of Endowments Saleh bin Abdulaziz Al-Rajhi (Buraidah),mentioned by abbreviations.

•Characterization data: • Characterization is important to identify the cultivars under study (Table 4).

Results

Morphological attributes part

Data are related to the attributes that are highly heritable and can be observed easily as shown in Table 4.

Soil analysis

Soil samples were collected from three locations, (Alahsa, Qassim, and Al-Kharj) and the pH and EC were determined as follow:

Physical properties

Table 6 indicated a statistically significant (Pd"0.05) difference in cv. Khalas has grown at three different geographical locations (Al-Ahsa, Kharj, and Qassim) regarding fruit weight, seed weight, flesh weight, fruit length, fruit diameter, fruit moisture content, and fruit volume. Maximum fruit weight (14.38 g), seed weight (1.04 g), flesh weight (11.68 g), fruit length (3.21 cm), fruit diameter (2.45 cm), fruit moisture content (20.55%), and fruit volume (10.15 cm3) were measured when the cv. Khalas was grown in the Qassim location. The same cultivar grown at its originated location (Al-Ahsa) ranked as the second-best and indicated fruit weight (8.76 g), seed weight (0.88 g), flesh weight (8.02 g), fruit length (2.85 cm), fruit diameter (2.15 cm), fruit moisture content (17.63%) and fruit volume (9.53 cm3). These physical fruit characters were minimum when the same cultivar was grown in Kharj that is fruit weight (6.39 g), seed weight (0.74 g), flesh weight (5.51 g), fruit length (2.51 cm), fruit diameter (2.14 cm), fruit moisture content (16.20%) and fruit volume (8.54 cm3). However, there was a statistically non-significant difference between Al-Ahsa and Kharj geographical locations regarding fruit weight and fruit diameter parameters as cited by (35, 36, 37).

Table 4. Character used for (Khalas and Barhee) date palm cultivars identification.

Vegetative Attributes	Khalas			Barhee		
	Alahsa	Al-Kharj	Qassim	Alahsa	Al-Kharj	Qassim
Trunk width (1. homogenous, 2. base broader than above)	1	1	1	1	1	1
Crown shape (1. dense, 2. moderate dense, 3. loose and open from the middle)	2	1	1	2	1	1
Leaf length (cm)	295	304	500	312	315	520
Leaf width (at the middle) (cm)	3.2	3.2	3.4	3.8	3.2	3.8
Colors of leaf (1. dark green, 2. green)	1	1	1	2	1	1
Midrib color (1. dark green, 2. glossy green, 3. light green)	1	1	1	2	1	1
Leaf curvature (1. high curved, 2. moderately curved, 3. slightly curved)	2	1	1	2	1	1
Leaf curvature point (l. at the middle of the blade, 2. at the second half of the blade, 3. at all blade)	2	1	1	2	1	1
Petiole length (cm)	67	71	74	80	72	72
Petiole thickness at the middle (cm)	5	5	5	4	5	5
Petiole width at the middle (cm)	10	8	9	8	8	8
Petiole shape (1. slender, 2. base stout than above)	2	2	2	2	2	2
Leaf base width at the attachment point (cm)	14	14	20	11	14	14
Color of leaf base abaxial surface (l. dark green, 2. light green)	1	1	1	2	1	1
Blotches on leaf base abaxial surface (1. small reddish-brown blotches, 2. absent)	2	1	1	1	1	1
Blade length (cm)	227	302	500	231	300	460
Number of pinnate	132	155	190	167	171	184
Pinnate density (1. dense, 2. lax, 3. very lax)	1	1	1	1	1	1
Pinnate length (cm)	49	48	50	39	44	52
Pinnate width (cm)	4.0	4.0	4.2	3.5	3.8	3.6
Pinnate shape (1. lanceolate, 2. linear)	2	2	2	2	2	2
Pinnate apex (1. acute, 2. soft end)	2	2	2	2	2	2
Pinnate nature (1. semi-drooping, 2. non-drooping, 3. semi-erect)	3	2	3	2	2	3
Pinnate-rachis angle (°)	57.5	58	55	60	49	49
Valley angle (1. small, 2. large, 3. absent)	2	2	2	2	2	1
Spine area length (cm)	66	68	68	81	67	77
Spine shape (1. pyramids, 2. pyramids with longitudinal fold, 3. mixed)	2	2	2	1	2	2
Shorter spine length (cm)	9.4	11	14	6	10	12
Longer spine length (cm)	24.5	24	26	17	18	20
Spine base (l. not raised, 2. raised, 3. raised and pulvinus)	3	2	3	2	2	2
Spine type (1. single, 2. di, 3. mixed)	1	1	1	1	1	1
Spin color (1. dark green, 2. light green, 3. yellowish-green)	1	1	1	3	1	2
Spine nature (1. flexible, 2. rigid)	2	2	2	2	2	2
Spine rachis angle (°)	55.0	48.0	47.5	40.0	47.5	43.8

Different letters in the same column means significantly different at 5% level of probability

Table 5. pH and EC for the three locations, (Alahsa, Qassim, and Al-Kharj), EC measurement =mS/cm (milli-Siemen per centimeter) or dS/m (deci-Siemen per meter), and 1 mmho/cm = 1 mS/m = 1 dS/m.

Sample number	PH	EC
KH_H_1	8.36	599 µS/cm
KH_K_2	7.54	2.61 mS/cm
KH_Q_3	7.80	1018 µS/cm
BR_H_4	7.80	576 µS/cm.
BR_K_5	7.37	5.28 mS/cm
BR_Q_6	7.75	296 µS/cm

Data related to total soluble solids, total soluble sugars, reducing soluble sugars, non-reducing sugars, and acidity of cv. Khalas showed statistically significant (Pd"0.05) effects of different geographical locations such as Al-Ahsa, Kharj, and Qassim (Table 7). Total soluble solids (71.61 Brix), total soluble sugars (58.23%), reducing soluble sugars (37.45%) were significantly higher when cv. Khalas was grown in the Qassim location whereas acidity (0.237%) was lower. Non-reducing sugars were non-significant statistically at all three geographical locations i.e. 18.94% (Kharj), 19.79% (Al-Ahsa), and 21.78% (Qassim). The same cultivar grown in the Al-Ahsa environment contained total soluble solids (69.55 Brix), total soluble sugars (56.39%), reducing soluble sugars (36.45%), and acidity (0.245%). Similarly, these parameters were estimated at least when cv. Khalas was grown in Kharj location i.e. total soluble solids (58.72 Brix), total soluble sugars (55.46%), reducing soluble sugars (35.67%) however acidity (0.247%) was higher than other locations as cited by (38, 39, 40, 41).

Data presented in Table 8 revealed a statistically significant (Pd"0.05) difference in fruit weight, seed weight, flesh weight, fruit length, fruit diameter,

Table 6. Response of date palm cv. Khalas grown at three different geographical locations of Kingdom of Saudi Arabia.

Locations	Fruit weight (g)	Seed Weight (g)	Flesh Weight (g)	Fruit Length (cm)	Fruit diameter (cm)	Fruit moisture (%)	Fruit volume (cm^3)
Hassa-Khalas	8.76 b	0.88 b	8.02 b	2.85 b	2.15 b	17.63 b	9.53 b
Kharj-Khalas	6.39 b	0.74 c	5.51 c	2.51 c	2.14 b	16.20 c	8.54 c
Qaseem-Khalas	14.38 a	1.04 a	11.68 a	3.21 a	2.45 a	20.55 a	10.15 a
LSD 0.05	3.7897	0.1251	0.0262	0.0262	0.0112	0.1178	0.0131

Similar letter(s) in a column are non-significant statistically at 5% level of probability.

Table 7. Response of date palm cv. Khalas grown at three different geographical locations of Kingdom of Saudi Arabia.

Locations	Total soluble solids (%)	Total soluble sugars(%)	Reducing soluble sugars(%)	Non-reducing sugars (%)	Acidity (%)
Hassa-Khalas	69.55 b	56.39 b	36.45 b	19.79 a	0.245 a
Kharj-Khalas	58.72 c	55.46 c	35.67 c	18.94 a	0.247 a
Qaseem-Khalas	71.61 a	58.23 a	37.45 a	21.78 a	0.237 b
$LSD_{0.05}$	0.0262	0.0151	0.0965	14.352	2.390

Similar letter(s) in a column are non-significant statistically at 5% level of probability.

Table 8. Response of date palm cv. Berhi grown at three different geographical locations of Kingdom of Saudi Arabia.

Locations	Fruit weight (g)	Seed Weight (g)	Flesh Weight (g)	Fruit Length (cm)	Fruit diameter (cm)	Fruit moisture (%)	Fruit volume (cm^3)
Hassa-Berhi	9.90 b	1.08 b	8.82 b	2.96 b	1.97 b	65.37 c	9.63 ab
Kharj-Berhi	8.62 c	1.01 c	7.61 c	2.88 c	1.88 c	67.12 b	8.54 b
Qaseem-Berhi	10.24 a	1.12 a	9.12 a	3.11 a	2.21 a	69.45 a	9.84 a
$LSD_{0.05}$	0.0680	0.0227	0.2546	0.0262	0.0125	0.0262	0.1120

Similar letter(s) in a column are non-significant statistically at 5% level of probability.

fruit moisture, and fruit volume of date palm cv. Berhi has grown at three different geographical locations (Al-Ahsa, Kharj, and Qassim). Like cv. Khalas, maximum fruit weight (10.24 g), seed weight (1.12 g), flesh weight (9.12 g), fruit length (3.11 cm), fruit diameter (2.21 cm), fruit moisture content (69.45%) and fruit volume (9.84 cm^3) was observed in cv. Berhi when grown inthe Qassim region. Although, fruit volume of cv. Berhi was highest when grown at Qassim however it was closely followed by the Al-Ahsa region (9.63 cm^3). Other parameters such as fruit weight (9.90 g), seed weight (1.08 g), flesh weight (8.82 g), fruit length (2.96 cm), and fruit diameter (1.97 cm) were ranked second when date palm cv. Berhi was grown in Al-Ahsa region. These physical characteristics were minimum when the same cultivar was grown in the Kharj region i.e. fruit weight (8.62 g), seed weight (1.01 g), flesh weight (7.61 g), fruit length (2.88 cm), fruit diameter (1.88 cm), fruit volume (8.54 cm^3) whereas fruit moisture content (65.37%) was lowest at Al-Ahsa geographical location.

Data regarding total soluble solids, total soluble sugars, reducing soluble sugars, non-reducing sugars, and acidity indicated a statistically significant ($P \leq 0.05$) response of date palm cv. Berhi when grown at different geographical locations viz. Al-Ahsa, Kharj, and Qassim (Table 9). Date palm cv. Berhi grown in the Qassim region exhibited higher total soluble solids (38.83 Brix), total soluble sugars (29.33%), reducing soluble sugars (20.45%), and non-reducing sugars (8.88%), and lowest acidity (0.352%). The same cultivar grown in the Al-Ahsa region had 34.00 Brix total soluble solids, 27.35% total soluble sugars, 19.75% reducing soluble sugars, 8.29% non-reducing sugars, and 0.321% acidity. On the other hand, the lowest total soluble solids (33.00 Brix), total soluble sugars (25.94%), reducing soluble sugars (17.65%), non-reducing sugars (7.60%), and highest acidity (0.376%) were observed when cv. Berhi was grown in the Kharj location.

Discussion

Plants have particular locations where they prefer to live. When they are introduced to an altered location, they either adopt it or perish. Plant adaptation strategies include changes in morphological, and biochemical characterization (Bennaceur, 1991; Ould *et al.*, 2011; Ould *et al.*, 2008).

The adaptive response of plants mainly depends on their resilient nature to thrive against the changing climatic conditions (24, 25). Climate has a great impact on date palm production. At present, some regions that are climatically suitable for the cultivation of date palm will become unsuitable in the future due to climatic change and vice versa. Accordingly, countries that are dependent on date fruit production and its export will expose to economic falloff. Therefore, the introduction of plants to different geographical locations can be one of the best adaptation policies for sustainable crop production.

Our results indicated that date palm cv. Khalas belongs to the Al-Ahsa region was not only established well in the Qassim region but displayed significantly superior physicochemical characteristics. By the look of climatic data, it seems that there was an average increase of 2°C temperature and 11% relative humidity when cv. Khalas was grown in the Qassim region. It indicated that an increase in both environmental factors enhanced the physicochemical characteristics of cv. Khalas fruits. Similarly, when these fruit quality characters were compared between Al-Ahsa and Kharj regions, the same parameters were higher in the Hassa region, regardless of fruit weight, fruit diameter, non-reducing sugars, and acidity as these were non-significant at both locations. The temperature was 1.5 °C higher whereas relative humidity was 2% higher in Al-Ahsa climatic region than in Kharj.

Table 9. Response of date palm cv. Berhi grown at three different geographical locations of Kingdom of Saudi Arabia.

Locations	Total soluble solids (%)	Total soluble sugars(%)	Reducing soluble sugars(%)	Non-reducing sugars(%)	Acidity (%)
Hassa-Berhi	34.00 b	27.35 b	19.75 b	8.29 b	0.321 b
Kharj-Berhi	33.00 c	25.94 c	17.65 c	7.60 c	0.376 a
Qaseem-Berhi	38.83 a	29.33 a	20.45 a	8.88 a	0.352 c
$LSD_{0.05}$	1.6110	0.0151	0.0965	0.1328	0.0485

Similar letter(s) in a column are non-significant statistically at 5% level of probability.

On the other hand, date palm cv. Berhi that is recognized as the Qassim region's cultivar behaved well in the same geographical location. All physicochemical characteristics were significantly higher in the Qassim region. It presumed that the difference in temperature and relative humidity played a significant role to enhance the parameters. The comparison between Al-Ahsa and Kharj region showed that the same date palm cultivar behaved well when grown in the Al-Ahsa region where the temperature and relative humidity was higher compared to the Kharj region regardless of fruit moisture content and fruit acidity as both were higher in the Kharj region than Al-Ahsa.

Date Palm is a thermopile species that withstand large temperature fluctuations in arid and semi-arid regions and can endure high temperatures (56 °C) in summer and low in winter (below 0°C). The optimum growth temperature is considered about 32 °C, however, it continues at a stable rate until the temperature reaches 38/40 °C where it starts decreasing (Van, 1983). (Shabani, 2012) predicted through simulation models that in many date cultivation areas in North Africa will become climatically unsuitable by 2100. However, locations in North and South America such as south-eastern Bolivia and northern Venezuela will become climatically more suitable for date palm cultivation. They also predicted that by 2070, Saudi Arabia, Iraq, and western Iran will show a reduction in climate suitability for this species. (Liu *et al.,* 2018) collected leaf samples of Cyclocarya paliurus trees from five different geographical locations of China to estimate phenolic compounds and antioxidant activities and reported that both were higher when it was grown in Wufeng and Jinzhongshan regions where climatic conditions were more suitable than other locations. Similarly, (Sass, and Lakner, 1998) found a significant difference in the physical and chemical properties of the apple fruits after storage, which were picked from three different geological locations of Hungary at different times of the year. (Abdalla, and Elzebeir, 2014; Stearn, 1973) reported that the physicochemical properties of Ziziphus fruits significantly varied at different geographical localities (Diaz, 2003) stated that the geographical location influenced the number of oxygenated compounds present in lime oil. (Khalid, 2018) concluded that geolocation and agro-ecological conditions have a significant impact on Kinnow fruit quality.

Acknowledgement

The authors would like to thank the Date Palm Research Center of Excellence, King Faisal University, Saudi Arabia for providing financial support for the Project (DPRC-2-2018).

We also thank Dr. Wael Nada for his valuable assistance as a representative of the Arajhi Endowment Farms in Al-Kharj, also many thanks to Abdul Majeed Al-Bahigan, Mubarak Al-Maued for their assistance during this investigation.

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