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Morphological Responses in Two Palm Species Against the Elevation of Ultra Violet Radiation Under Ambient Conditions

Sajeda Y. Swaid[1], Abdulminam H. Ali [2]& Eman M. Abdul Zahra[2]

[1]Date Palm Research Centre, University of Basrah, Basrah, Iraq

[2]Biology Department, Science College, Basrah University, Iraq

Corresponding author e-mail: abdulminamhussienali@gmail.com*

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Abstract: Present study was investigate the effect of different UV-doses on morphological defending system features of two palm species *Phoenix dactylifera* L. and *Washingtonia filifera* (Lindl.) H. Wendl. The results showed that the morphological and biomass traits of both palm species grown for 30 days under UV-B with a rate of 2 hrs.day^{-1} were almost improved. Where, the highest leaf width was recorded (1.1 and 0.7 cm) respectively. Conversely, UV-treatment (4-10 hrs.day^{-1}) has adversely affected on almost morphological and biomass features of both species. Where, the less leaf widths were recorded 0.95, 0.8, 0.73, 0.45, 0.43 and 0.40 cm in both palm species. Besides, results also spotted changes in leaf's surface appearances. However, present investigation concluded that morphological features and biomass of both species were unaffected with low dose of UV-radiation (2 hrs.day^{-1}). But, date palm (*P. dactylifera* L.) was capable to survive at high dose of radiation conditions reaches 8 hrs.day^{-1} for 30 days.

Key words: Arecaceae, *Phoenix dactylifera*, *Washingtonia filifera*, Morphological responses, UV-B.

Introduction

Since plant uses the sunlight for photosynthesis, it exposed to a different spectrum of (UV) radiation. In general, UV Light divide into three types according to wavelength, these are UV- A (320-400 nm), UV –B (280–320 nm) and UV-C (100-280nm). Fortunately, the UV-C and some UV-B radiations are absorbed by the ozone layer located in the stratosphere. But, due to the thinning of the ozone layer, some harmful UV-B rays penetrate the atmosphere and hence it affects the ecosystem in our planet. (Caldwell *et al.*,1989; Hidema & Kumagai, 2006; Kravets *et al*., 2012; Rai & Agrawal, 2017).However, many studies revealed that the exposure of plants to harmful UV radiation induced diverse photomorphogenic responses including: reduction of leaf surface area, curling (folding up) of leaves, yellowing, and growth inhibition. (Stapleton, 1992; Sharma *et al*. 1998; Hollosy, 2002; Frohnmeyer & Staiger, 2003; Ulm & Nagy, 2005; Jenkins, 2009).

For example, Singh *et al*. (2008), reported that the symptoms of leaves exposing to UV-stress are: initially the colour change to bronzy, then leaf folding up and finally glazing. Nevertheless, These symptoms developed when plant stay for

a long period under UV-radiation, where irregular patches on leaf surface start exposed, and ending with brown necrotic spots.

In date palm, Niazwali (2016) studied the impact of high dose UV-B radiation on morphological and biomass parameters and found a notable reduction in shoot height, leaf area, fresh and dry weight. Current study aimed to assess the morphological protection system in two palm species against different doses of UV radiation. Find out strengthens and weakness points in morphological defending system of both species. Therefore, this study also helps us to refinements our understanding about the safe use of the UV-light in plant breeding.

Materials & Methods

The experiment was conducted in the Department of Biology, University of Basrah, Iraq during the season 2017-2018. Two species of Arecaceae family date palm *Phoenix dactylifera* L. cv. 'Barhii' and California fan palm *Washingtonia filifera* (Lindl.) H. Wendl were chosen for this study. Where palms are most economically important plant families. Many foods products derived from palms. Moreover, palms are also used in landscaping. Seeds of date palm cv.'Barhii' were collected on summer season from orchard located in Uosffan, Abu Al-Khaseeb South eastern of Basrah Province. While, California fan palm (*W. filifera*) were collected from the tree cultivated in the Garden of Science College, University of Basrah. Selected viable seeds were washed in tap water for 15 minutes, and then sterilized with 20% sodium hypochlorite for 20 minutes, followed by washing three times with sterilized distilled water. Sterilized seeds then soaked in distilled water under room temperature for 72 hrs. Following, one seed was sown individually in plastic pots sized (12×10.8×8.8 cm), having a mixture of clay, peat moss and vermiculite (1:1:1 v:v). Plants then stored at growth room at30◦C and 50-60% relative humidity. Seedlings irrigated manually every 2-3 days or when the plant needs. Plants watered one time per week with half strength of Hoagland's fertilizer.

Culture conditions (Design of UV-B System)

One UV-B tube light with emission range (30w, λ 280-320 nm) was used as source of harmful electromagnetic ionizing radiation. The UV-tube was fixed between normal white florescent lights. Supplementary white florescent lights or photosynthetic active radiation (PAR) with a rate of 75 μmol. $M^{-2}s^{-1}$ was provided by using 5 fluorescent tubes. A 16.8^{-1}hrs. (light/dark) photoperiod was followed in the current study. The PAR and UV-B light supplementary tubes were fixed on the top of the wooden chamber. Distance between light source and plants were 80 cm. To avoid plant phototropism, walls of a wooden cabinet covered with reflective paper.

The similar healthy germinated seedling of both palm species divided in 5 groups of 10 pots each. UV-B exposure dose was given to 5 groups with different rates as follows: 0, 2, 4, 8 and 10 hrs.day^{-1}. To control the daily UV-exposure time for each group a programmable digital timer type (TS-EE8) had been used. To study the development parameters, plant samples were taken after 30 days of grown under UV-B stress.

Plants growth variables

Shoots and roots length: Shoot height was calculated by the measuring the shoot from the soil level to the tip and indicated in cm, whereas root length was measured from the tip

of the root to the first cotyledonary node and expressed in cm.

Leaves width: width of a leaf was estimated by measuring of the widest region of leaf nearly at half (middle) of the leaf. The centimetres unit expressed the value. Fresh and Dry Weight: Fresh weights of whole plant (shoot and root) measured after seedlings harvest and washed in tap water. After recording the fresh weight, the plant materials were dried by using the oven at 70c for 24 hrs. The fresh and dry weights were determined by utilizing the electronic balance (Sartorius analytical balance model ENTRIS224-1S). Weight values expressed in Grams.

Scanning electron Microscope (SEM) Study

Leaf samples of different treatments were fixed in fixative solution for 4 hours at room temperature or stored in the refrigerator if it will not be processed the following day. Fixative solution was discarded and samples were rinsed twice in 0.1 M buffer solution for 15 min each. For specimen desiccation - critical point drying, samples were transferred into the prechilled critical point dryer chamber after quickly blotting off most alcohol. Samples were transferred to a clean desiccator then samples were mounted onto stubs with double sided tape. Metal coating of the specimen were applied in evaporator or sputter.de Almeida *et al*.(2012). Plant specimens viewed with a scanning electron microscope (SEM) (FESEM Nova 450 Nanosem, Netherlands).

Statistical Analysis

The experiment was randomly designed with two factors. Results were analysed using the analysis of variance (ANOVA). The means were separated, by using the least significant difference (LSD) at 5%. ata represent the means of three replicates for each treatment.

Results

Shoot length changes

Plants are sessile organism needs to adjust their growth properties in order response the environmental changing. Light is one of variable environmental factor, which is necessary for photosynthesis. Plants are enabling to modulate their morphology and metabolism according to seasonal or daytime changes of light. (Kami *et al*, 2010; Vanhaelewyn *et al*., 2016). However, since the end of twentieth centenary, researchers gave a scientific attention on the effect of UV-B on living organisms, and they found that this type of irradiation has a direct impact on plants (Jansen, 2002; Frohnmeyer & Staiger, 2003; Ulm & Nagy, 2005; Jenkins, 2009). But, UV-B stress occur only when plants subjected to high doses of this irradiation (Jenkins, 2009; Jansen & Bornman, 2012).

Present study revealed that the height of the seedlings of *P. dactylifera* L. increased when subjected to UV- stress for 2 and 4 hrs. where the plant height reached 24 and 22cm respectively. Interestingly, the height of date palm seedlings was reduced significantly at high doses of UV- B radiation treatments (8-10 hrs.day^{-1})(see Table 1).In *W. filifer*a the height of the seedling increased at UV- stress for 2 hrs., where the seedling height reached 22.35 cm (Table 1 and Plate 1A). Then, seedlings height slightly reduced to 18.33 cm after 4 hrs. of UV-B stress. Furthermore, the height of the 8 and 10 hrs. treated *W. filifera* seedlings were adversely affected by the UV-B, where it recorded 18.2 and 17 cm respectively (Table1).

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Table (1): Effects of UV radiation on shoot height of *P. dactylifera* and *W. filifera* seedlings grown for 30 days under lab. conditions.

Species	Exposure Time (hrs. day^{-1}) to UV-Radiation					Effect of species
	0	2	4	8	10	
	Shoot height (cm)					
P. dactylifer	21.00±1.73^{bc}	24.00±0.58^{a}	22.00±0.57^{ab}	18.80±0.44^{cde}	16.00±1.16^{e}	20.36±0.98^{A}
W. filifera	20.33±0.88^{bcd}	22.35±1.45^{ab}	18.33±0.88^{cc}	18.20±0.58^{de}	17.00±0.58^{e}	19.24±0.98A
Effect of Time	20.67±0.69^{B}	23.18±0.69^{A}	20.17±0.69^{BC}	18.50±0.69^{C}	16.50±0.69^{D}	
Species: N.S			Time: 1.94		Species and Time: 2.75	

Super scripted Different small letters suffixed on the right side represented a significant difference at 5% level. Super scripted Different capital letters on the right side of third row (Effect of time) represented significant difference of effect of time at 5% level. The effect of UV–stress on two palm species (column on the right side of the table): Super scripted capital letters suffixed on the right side represented significant difference for species at 5% level. The mean values of three replications± SE(Standard Error).

Leaf width changes and others modifications

Results indicated that the leaves of the date palm and California fan palm seedlings subjected to UV-B for twohrs.day^{-1}, showed a significant increasing inwidths (1.1 and 0.7 cm) respectively (Table 2 and Plate 1B). Conversely, UV-treatment (4-10 hrs.day^{-1}) have adversely affected on the leaf width on both palm species under study. Where, leaf widths of both species were recorded 0.95, 0.8, 0.73, 0.45, 0.43 and 0.40 cm (Table 2, Plate-1B; Plate-2 B, D and E and Plate-3A-D).Besides, results spotted changes in leaf's surface appearances (Table 3). First, leaf's surface appearance changed from smoothness to roughness, when UV dose rose from 4 -10 hrs.day^{-1}. Second, a prominent change was recorded specifically in the date palm leaf blade. It is leaf folding (leaf involution) and twisting mechanism (Plate 2 A- F). These types of operation give the leaf more flexibility to avoid the excess exposing to harmful radiation, as well as keep the plant survived until the ended of UV-stress threat . Thus, these mechanisms, let the leaf regulates the daily light (PAR +UV) interception, and resist the high doses of UV stress. Besides, results spotted changes in leaf's surface appearances (Table 3).

Table (2): Effects UV radiation on leaf width of *P. dactylifera* and *W. filifera* seedlings grown for 30 days under lab. conditions.

Species	S		Exposure Time (hrs.day^{-1}) to UV-Radiatic			**Effect of Species**
	0	2	4	8	10	
	Leaf Width (cm)					
P. dactylifer	1.00±0.00^{a}	1.10±0.00^{ab}	0.95±0.33 ^{b}	0.80±0.33 ^{c}	0.73±0.06^{c}	**0.92±0.04^{A}**
W. filifera	0.50±0.00^{d}	0.70±0.06^{c}	0.45±0.03^{d}	0.43±0.07^{d}	0.40±0.06^{d}	**0.50±0.04^{B}**
Effect of Time	0.75±0.03 ^{B}	0.90±0.03 ^{A}	0.70±0.03 ^{BC}	0.62±0.03 ^{C}	0.57±0.03^{D}	
Species: 0.05			**Time: 0.09**		**Species and Time: 0.12**	

Super scripted Different small letters suffixed on the right side represented a significant difference at 5% level. Super scripted Different capital letters on the right side of third row (Effect of time) represented significant difference of effect of time at 5% level. The effect of UV–stress on two palm species (column on the right side of the table): Super scripted capital letters suffixed on the right side represented significant difference for species at 5% level. The mean values of three replications± SE (Standard Error).

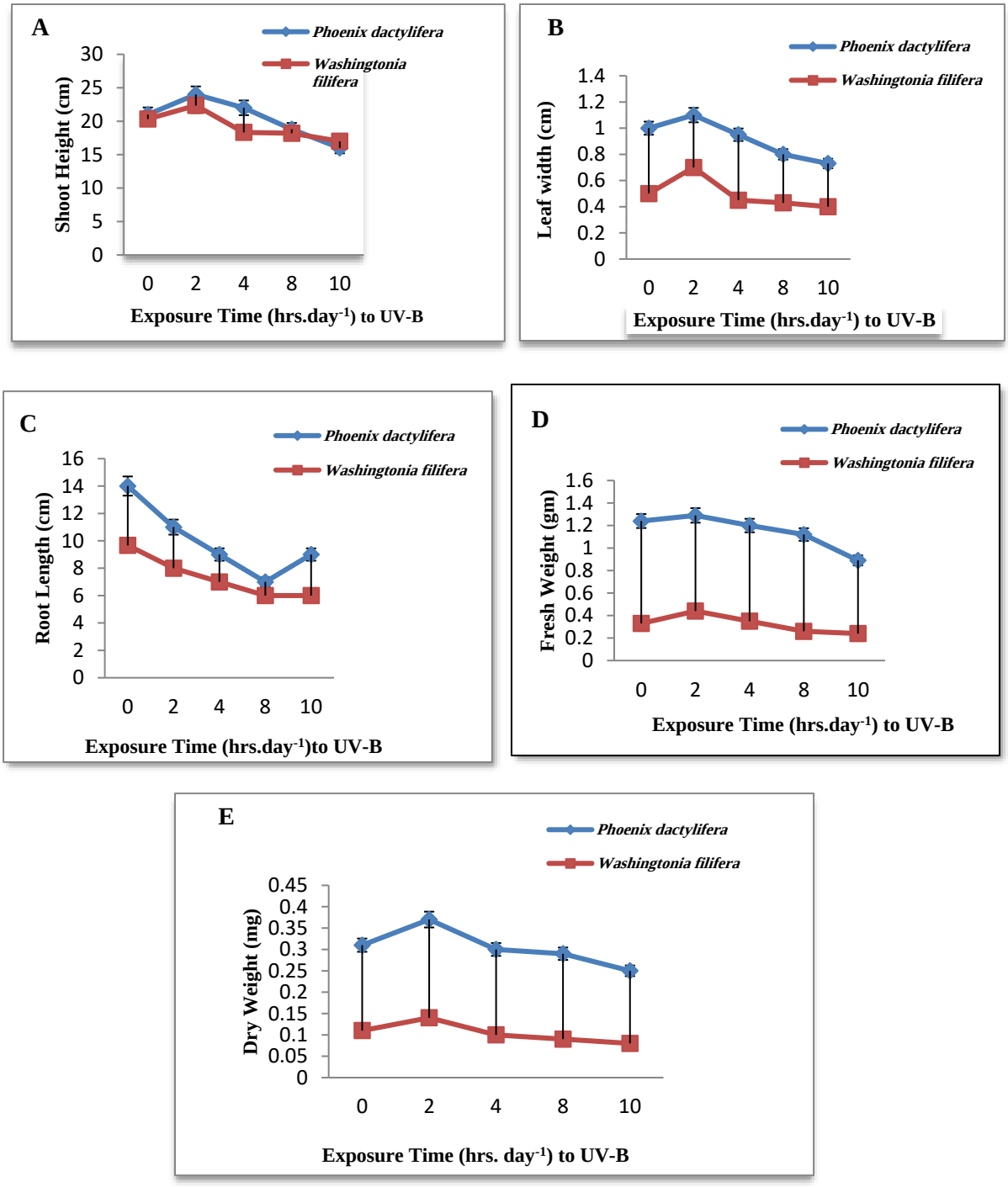


Plate (1): Effect of 30 days of UV-B radiation on growth parameters of both palm species (*P. dactylifera*) *and (W. filifera)*: A– Shoot height growth, B –Leaf width, C-Root length, D- Fresh Weight and E- Dry Weight.

Table (3): Effects UV radiation on morphological parameters of leaf of both palm species grown for 30 days in ambient conditions.

Species	Leaf Traits	Exposure Time (hrs.day^{-1}) to UV-Radiation				
		0	2	4	8	10
P. dactylifera	Surface Type	Smooth	smooth	smooth	rough	Rough
	Discolouration (Photo bleaching)	-	-	-	-	+
	Curling	-	-	-	+	++
W. filifera	Surface Type	Smooth	smooth	smooth	rough	Rough
	Discolouration (Photo bleaching)	-	-	+	++	++
	Curling	-	-	+	+	++

In contrast, the (*W. filifera*) interact differently with the high doses of UV -B. where a thick waxy layer as well as a non-oriented appendages accumulated on the leaf surface (Fig-3F). Interestingly, the photo bleaching appeared at the started on seedlings leaf grown under moderate dose of UV (4 hrs.day^{-1}), and next chlorosis increased dramatically with the UV-B elevation (Table 3 and Plate 3G and H). In date palm, it seems that it has different strategies to face against the elevations of UV-B. However, leaf discolouration or (chlorosis) was noted in seedlings irradiated for 10 hrs.day^{-1}(Plate-2GandH).

Interestingly, the scanning electron microscope revealed a deformation on the stomata apparatus of leaves subjected to high doses of UV-B in both palm species as a result of deposited a thick waxy cuticle on surface (Plate 2I and J; Plate 4A-D). Furthermore, in date palm the waxy material emerged prominently as scales on the surface (Plate 2I and J). In (*W. filifera*), it was noted that a cluster of non-oriented silica had gathered on leaf surface as well as thick epicuticular wax (Plate 3 E, F and Plate 4 C-E). But no such materializes were spotted on the leaf surface of date palm.

Root length

Results showed that the root length in both species of palms was decreased dramatically and according to the time of radiation exposing (14-9cm) and (9-6cm). Details were summarized in (Table 4 and Plate-1C).

Fresh and dry weight

The fresh and dry weight of both palm species were not affected with low dose of UV- stress (2 hrs.day^{-1}), rather increased significantly.

In date palm the plants' fresh and dry weight were not much influenced with high doses of UV- light (4-8 hrs.day^{-1}) (1.12gm) (Table 5 and 6, Plate-1D and E). But, in the desert palm(*W. filifera*), fresh and dry weights of plants were influenced effectively when plant subjected to 4-10 hrs.$^{day-1}$ of UV-radiation (0.35-0.24gm) (Table-5 and 6, Plate-1D and E).

Table (4): Effects UV radiation on root length of *P. dactylifera* and *W. filifera* seedlings grown for 30 days under lab. conditions.

Species	Exposure Time (hrs.day^{-1}) to UV-Radiation					Effect of Species
	0	2	4	8	10	
	Root Length (cm)					
P. dactylifer	14.00±0.58^{a}	11.00±0.58^{b}	9.00±1.16^{bd}	7.00±1.16^{de}	9.00±0.58^{bd}	**10.00±0.72^{A}**
W. filifera	9.67±0.33^{bc}	8.00±0.58^{cde}	7.00±0.58^{de}	6.00±0.58 ^{e}	6.000.58± ^{e}	**7.33±0.72^{B}**
Effect of Time	11.50±0.51^{A}	9.50±0.51 ^{B}	8.50±0.51^{BC}	6.30±0.51^{C}	7.50±0.51 ^{C}	
	Species: 0.94		**Time: 1.49**			**Species and Time: 2.11**

Super scripted Different small letters suffixed on the right side represented a significant difference at 5% level. Super scripted Different capital letters on the right side of third row (Effect of time) represented significant difference of effect of time at 5% level. The effect of UV–stress on two palm species (column on the right side of the table): Super scripted capital Letters suffixed on the right side represented significant difference for species at 5% level. The mean values of three replications± SE (Standard Error).

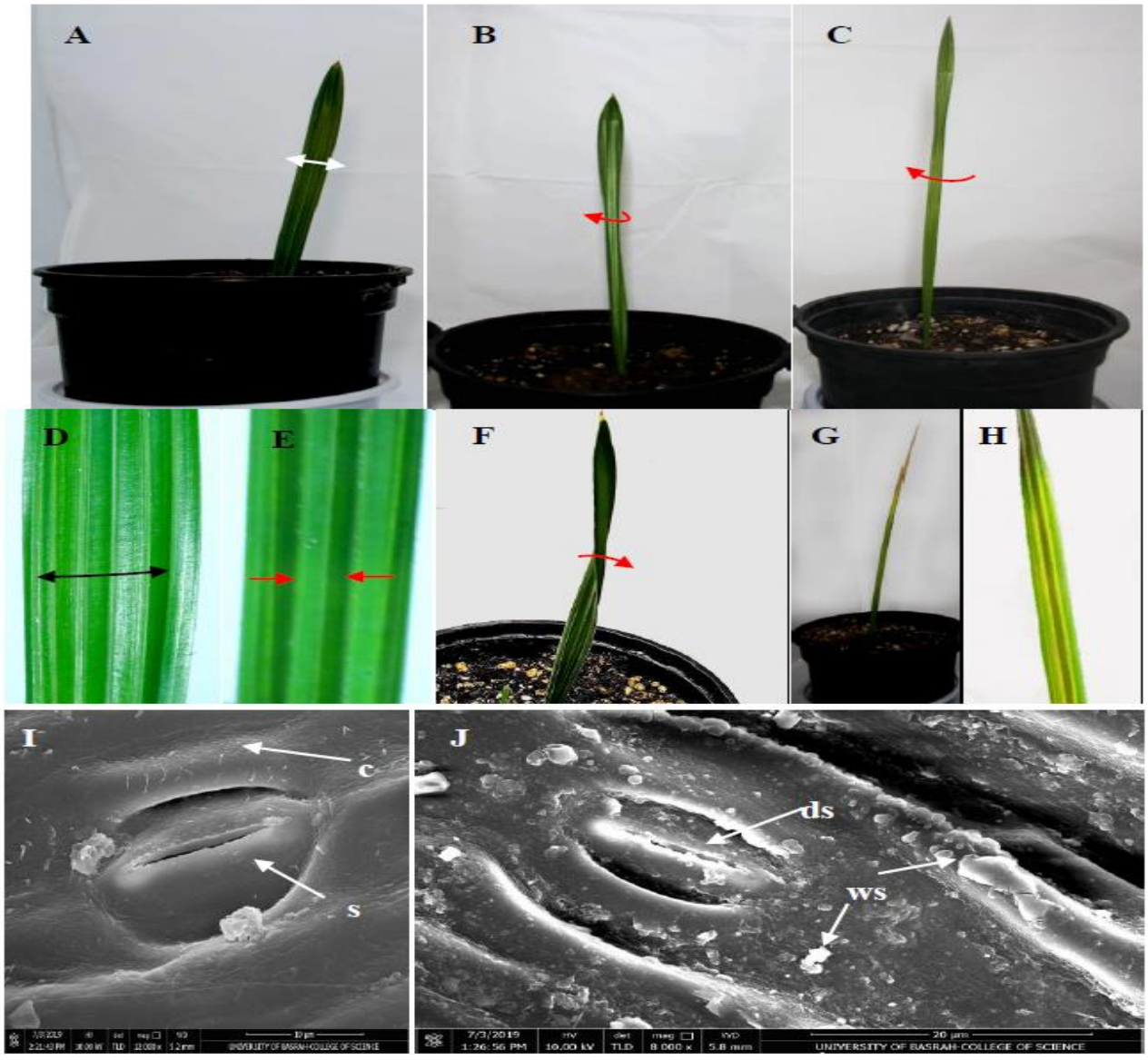


plate (2) (A): Date palm seedling grown on PAR light only. normal leaf with fully expanded surface (note the white arrows). (B-C) seedling subjected to PAR+UV-B 8-hrs./day. Note the reduction on leaf's surface area by rolling mechanism (observe the red arrows). (D) Digitally magnified photograph (40 times) for leaf at the normal condition. (E) Digitally magnified photograph (40 times) showing curling of leaf exposed to high dose of UV. (F)Twisting mechanism (note the red arrow) in seedling leaf subjected to high dose of UV stress(8-hrs. day^{-1}). (G and H) leaf discolouration or (chlorosis) on date palm seedlings irradiated to UV-B for 10 hrs.(I) Scanning electron microscopy of leaf of (*P. dactylifera*) after 30 days of growth under normal condition. Note the normal cuticle (c) and stomata (s), (Scalebar=10µm). (J) Scanning electron microscopy to leaf grown under UV stress. Observe the abnormal deposited waxy scales (ws) on the cuticle layer and deformed stomata (ds), (Scale bar=10µm).

Table (6) Effects UV radiation on dry weight of *P. dactylifera* and *W. filifera* seedlings grown for 30 days under lab. conditions. Super scripted Different small letters suffixed on the rightside represented a significant difference at 5% level.

Species	Exposure Time (hrs. day^{-1}) to UV-Radiation					Effect of Species
	0	2	4	8	10	
	Dry Weight (gm)					
P. dactylifer	0.31±0.05^{b}	0.37±0.01^{a}	0.30±0.02^{b}	0.29±0.01^{b}	0.25±0.01^{c}	**0.30±0.02^{A}**
W. filifera	0.11±0.02^{de}	0.14±0.01^{d}	0.10±0.00^{e}	0.09±0.01^{e}	0.08±0.01^{e}	**0.10±0.02^{B}**
Effect of time	0.21±0.01^{b}	0.25±0.01^{a}	0.20±0.01^{b}	0.19±0.01^{b}	0.17±0.01^{c}	
Species: 0.02			**Time:0.04**		**Species and Time: 0.05**	

Super scripted Different capital letters on the right side of third row (Effect of time) represented significant difference of effect of time at 5% level. The effect of UV–stress on two palm species (column on the right side of the table): Super scripted capital Letters suffixed on the right side represented significant difference for species at 5% level. The mean values of three replications± SE(Standard Error).

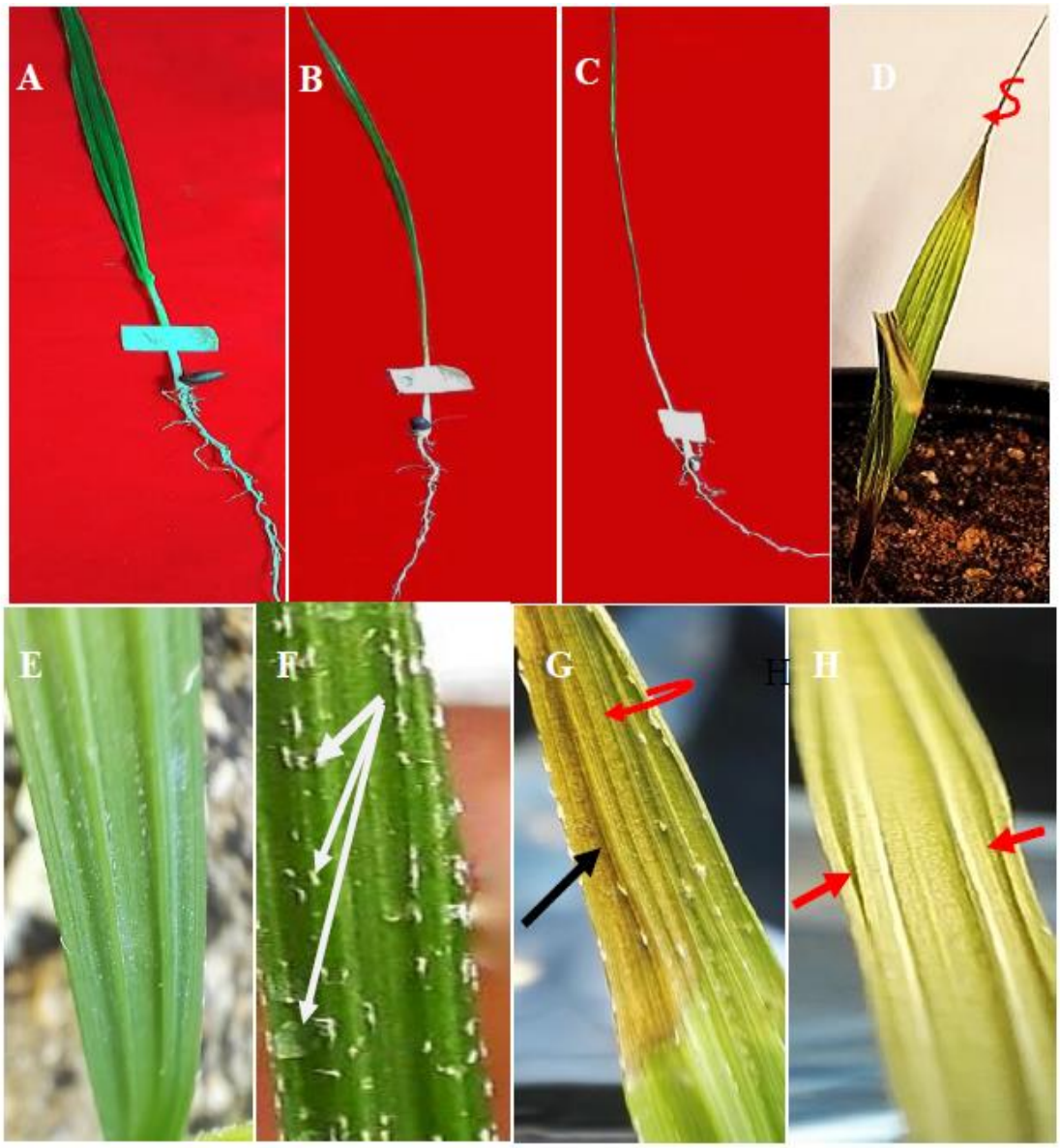
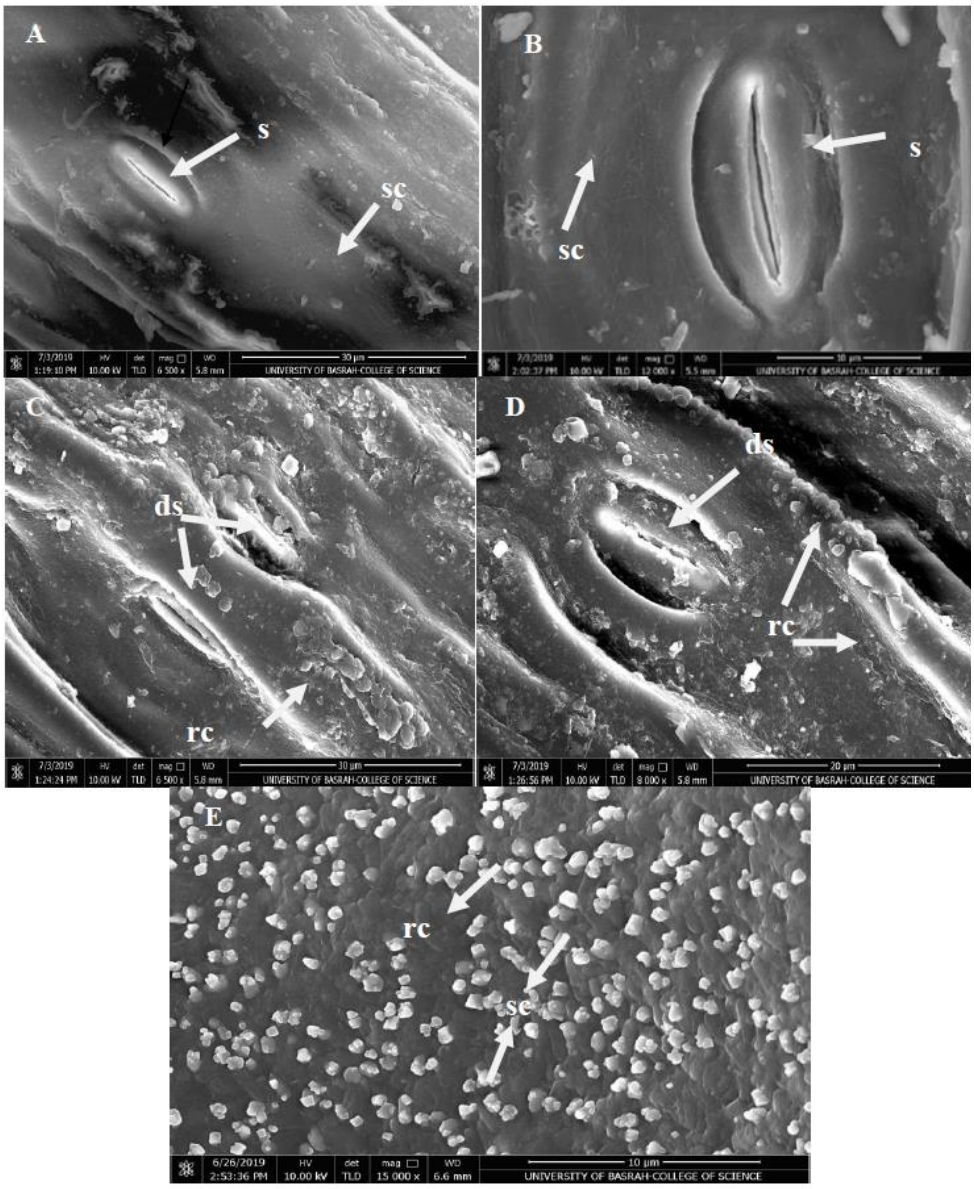


Plate (3): (A) California fan palm seedling grown on PAR light only. Note the fully expanding leaf surface. (B) Seedling exposed to 4 hrs.day^{-1}**UV-B. Observe the reduction in leaf area. (C) Plant grown under high UV-stress (8hrs.**day^{-1}**). See the leaf's surface was reduced as a result of rolling mechanism. (D) Seedling subjected to (10 hrs./day) of UV-light. Note the irreversible curling leaf (red twisted arrow). (E) Digitally magnifying photograph (40 times) for leaf of control plant, Note the fully expanded leaf with very smooth surface. (F) Digitally magnifying photograph (40 times) for leaf of plant grown under 4hrs./day UV-stress for 30 days. Note the rough leaf surface and non-oriented appendages (white arrows). (G and H) Note the photo bleaching (black arrow), and leaf folded or irreversible curling (red arrows) on plant leaf exposed to UV-B for 8-10hrs.**day^{-1}.



Plate(4): Scanning electron microscopy for normal and UV-stressed leaf of (*W. filifera*) after 30 days of growth and development under Lab. conditions. (A) Note the normal smooth cuticle layer (sc) and regular stomata (s), Scale bar=30µm. (B) Magnifying part of normal smooth cuticle (sc) showed no silica crystals, Scale bar=10µm. (C) Scanning electron microscopy for UV-stressed leaf, note the deformed stomata, thick rough cuticle (rc) and non-oriented silica crystals deposited on the cuticle layer, Scale bar=30µm. (D) Magnifying part of same part, Scale bar=20µm.(E) Magnifying part of leaf surface exhibited a thick cuticle wax cover or rough cuticle (rc) and non-oriented silica crystals (sc), Scale bar=10µm.

Discussion

Data extracted from the present study indicated that both palm species have a morphological defence system that able to faces the UV-stress, but not equal. Therefore, under low dose of UV-B (2 hrs.$^{-1day}$), both species showed a significant increasing in some morphological traits. These findings are in line with Kumari & Agrawal (2010), who obtained the same results in lemongrass (*Cymbopogon*

citrates) where, the morphological features of plants were unaffected with low doses of UV-B. Klem *et al*. (2019) reported that in barley (*Hordeum vulgare*), the growth and photosynthetic performance were enhanced, when plant exposed to a combination of lights consist of red, blue, far-red, and UV-A. Jansen & Bornman (2012) suggested that the low dose of UV-B induced photomorphogentic acclimation in plant without any signs of acclimation.

Also, current findings are in harmony with a results obtained by Niazwali (2016) who reported that date palm seedlings was able to resisted and tolerate the UV-B stress up to 8 hrs.day^{-1}. Where, most desert plant able to develop special strategies to attenuate different environmental stress including the ionizing radiations. In contrast, California fan palm showed deterioration in most of growth parameters. and ultimately plants died.

Regarding the leaf folding up process in plants. This adaptive procedure mostly applied by xerophytic plants to minimizing abiotic stress like (overheating, dehydration and light interception) (Alvarez *et al.,* 2008). Scientist have different explanations of this interesting defence mechanism in plants. Nevertheless, Alvarez *et al*. (2008) described the effect of the hygroscopic pressure changes on bulliform cells (motor cells) associated to avoid light interception by reducing the leaf surface area in *Tristachya leiostachya*. Accordingly, most of the leaf epidermal cells increase their wall thickness during the exposing to UV-stress, and thus it disrupted the stomatal structure. As a result, these cells loses their expansion through the temporary plasmolysis (reducing the hygroscopic turgor pressure of the cell). Thus, motor cells become more flaccid and the leaf enabled to involutes or folding up. Current study supports this allegation, where it was found that the UV-B deposited more epiculticuler wax on leaf surface. This resulted in deformation of stomata structure. Finally, this action deficit the water flow from soil to the leaf. Lastly, these mechanisms may cause a dropped in biomass barometers of both species. On the contrary, Alvarez *et al*. (2008)that the motor cells in some species were not play an active role during the leaf curling process, due to accumulation to large amounts of silicon on their outermost walls. The same effect was recognized in (*W. filifera*) leaf, where leaf folded up irreversibly when plant exposed to high dose of UV-B (8-10 hrs.day^{-1}).

Kakani *et al*. (2003) suggested other path for leaf curling process. Where, they believed that the conversion of Indole-acetic-acid to 3-methylene oxindole, let the curling action or cupping to take place. This suggestion was supported recently by molecular study. Where, Tanaka *et al*. (2014) found, that the over expression of *UGT74D1*gene increases the oxindole-3-acetic acid production that induced the leaf curling. Plants shoot height and root length, is another morphological factors have monitored in the current study. Data indicated that the shoot height, and root length were much affected by high dose treatment of UV in the two palm species. Same results obtained by Liu *et al*. (2013), Rajendiran *et al*. (2015) and Niazwali (2016).

However, with respect to the important factor, that governs the response of plants to UV-B stress. Scientist found a relationship between UVR8 (signaling protein) and triggers of various morphological and physiological changes in plants to stand up against such stress. (Mao *et al*., 2015). In palms, this needs much intensive investigations on the molecular level.

Conclusions

Present study concluded that morphological features and biomass of both species were unaffected with low dose of UV-radiation (2 hrs.day^{-1}) or at least it can withstand for a long period. But, date palm (*P. dactylifera* L.) capable to survived at high dose of radiation conditions reaches 8 hrs.day-1for 30 days. However, UV-B resistance between palm species or date palm cultivars is a crucial factor and needs more investigations. But, the results of the present work open the possibility future work for selecting the palm species that able to survive under UV-B radiation. Moreover, current study invites all research workers to focusing their studies towards the UV-B photoreceptor. Where, this receptor triggers morphological and physiological changes to attenuate the UV radiation.

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Conflict of interest

The authors declare that they have no conflict of interest photographed the samples.

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الاستجابة المظهرية لنوعين من النخيل ضد الارتفاع في الأشعة فوق البنفسجية تحت الظروف المختبرية

ساجده ياسين سويد[1] و عبد المنعم حسين علي[2] وايمان محمد عبد الزهرة[2]

[1]مركز ابحاث نخيل التمر، جامعة البصرة، البصرة، العراق

[2] قسم علوم الحياة، كلية العلوم، جامعة البصرة، العراق

المستخلص: بحثت الدراسة الحالية في تأثير جرعات الأشعة فوق البنفسجية المختلفة على خصائص النظام الدفاعي المظهري لنوعين من النخيل هما نخيل التمر *Phoenix dactylifera* L. و نخيل الواشنطونيا *Washingtonia filifera* (Lindl.) H. Wendl. أظهرت النتائج أن الصفات المظهرية والكتلة الحيوية لكلا النوعين من النخيل التي نمت لمدة 30 يومًا تحت الأشعة فوق البنفسجية-B وبمعدل 2. اليوم $^{-1}$ قد تحسنت تقريبًا. حيث تم تسجيل أعلى عرض للأوراق (1.1 و 0.7 سم) على التوالي. وعلى العكس من ذلك ، فإن المعاملة بالأشعة فوق البنفسجية لمدة 4-10 ساعات. اليوم $^{-1}$ قد أثر سلبًا على الخصائص المظهرية والكتلة الحيوية تقريبًا لكلا النوعين. حيث تم تسجيل أقل عرض للأوراق (0.95 و 0.8 و 0.73 و 0.45 و 0.43 و 0.40 سم) في كلا النوعين من النخيل. إلى جانب ذلك، رصدت النتائج أيضًا تغيرات في مظهر سطح الورقة. ومع ذلك تمخضت الدراسة الحالية إلى أن السمات المظهرية والكتلة الحيوية لكلا النوعين لم تتأثر بالجرعة المنخفضة من الأشعة فوق البنفسجية (2.اليوم $^{-1}$)، ولكن كان نخيل التمر قادرًا على البقاء بالجرعات العالية من الإشعاع تصل إلى 8 ساعة. اليوم $^{-1}$ لمدة 30 يوماً.

الكلمات المفتاحية: العائلة النخيلية، نخيل التمر، نخيل الواشنطونيا، الاستجابات المظهرية، الحساسية للاشعة فوق البنفسجية.