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Leaf and root anatomical changes of date palm *Phoenix dactylifera* L. Khadrawi cultivar under abiotic stress

Hussein J. Shareef* **Sajda Y. Sweed**

Date Palm Research Center, University of Basrah

Basrah, Iraq

*Correspondence author: hussein.shareef@uobasrah.edu.iq

Abstract

Thermal stress, associated with salinity or drought stress is more damaging to the anatomical characteristics of the plant than the single factor. Leaves and roots from annual young date palm offshoots used as experimental materials. The results showed that the drought decreased thickness of blade, mesophyll, and vascular bundle in July and September. Whereas the irrigation with fresh water on September increased blade, mesophyll, and vascular bundle thickness. The salinity increased upper epidermal of the leaflet in July whereas the freshwater decreased upper epidermal of the leaflet in September. The lower epidermal affected with salinity in May and July. However, drought increased cuticle thickness in July compared to other treatments. The drought, salinity and thermal stress caused the damage roots of the date palm. The freshwater increased epidermis and the cortical thickness at all months. Whereas drought and salinity decreased epidermis and cortical thickness. However, the drought increased endodermis and sclerenchyma thickness, and vascular thickness compared to fresh water. The critical factor in the effect of drought stress associated with thermal stress is drought stress, and recovery of the tissue does not occur with the presence of drought stress despite the removal of thermal stress.

Keywords: Cuticle; Drought; Mesophyll; Salinity; Thermal stress

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Introduction

Date palm (*Phoenix dactylifera* L.) plants generally faced many problems of abiotic stress, particularly in arid zones. Date palm exposure to the various factors of abiotic stress in the south of Iraq such as salinity, drought, and thermal stress to change their development and formative procedures to lessen the amount of damage brought about by the environmental stress (Shareef *et al.*, 2020). These progressions are regularly transient and reversible, and their enlistment level is dictated by the introduction time to a specific natural factor (Abbas *et al*., 2015). Furthermore, the date palm offshoots growth decreased from May to September because of the high level of salinity, water scarcity and high temperature (Jasim *et al.*, 2016).

In nature, abiotic stress conditions like drought and salinity seldom take place in isolation and accompanied by various stresses is typically not predictable through single-factor analyses as a result of synergistic, antagonistic, or overlapping effects will occur (Valladares and Pearcy, 1997). Along these lines the naturally created difference in the water powered design of monocot leaves may cause an adjustment in nearby development rates (Baum *et al*., 2000).

Morphological and anatomical change of plant compounds occurs when exposed to irrigation deficiency, and the temperature associated with adaptation to severe conditions (Bañon *et al*., 2004). Environmental influences usually induce many mutations of plant structure to determining the effects of these extreme factors, including salinity (Dolatabadian *et al*., 2011).

The tolerant varieties of plant the saltiness jumps out at have an anatomical change in the roots and leaves, for example, an expansion in the thickness of the cuticle layer (Bijanzadeh and Emam 2015). To survival the plant against drought and salinity factors, it should develop specific structures in leaves and roots to adapt against these factors. The tolerant plants of saline described as an expansion of endodermis and lignified wall of cortical parenchyma (Sánchez-Aguayo *et al.*, 2004).

There are few studies on the composition of date palm roots because the roots contain lignified tissues and their complex diffusion in the soil (Fisher and Jayachandran, 1999). In particular, the chance to measure the responses of the plant stress *in vivo* is becoming increasingly important. In this work, we investigated anatomical characteristics of leaf and root to date palm Khadrawi cultivar in nature, in order to determine the critical factor, responses plant and recovery ability to change of temperature which accompanies the salinity and drought factors stress.

Materials and Methods

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Results and Discussion

Effect of abiotic stress on anatomical characteristics of leaf

The results revealed that drought, salinity, and thermal stress caused the damage leaflet (Fig. 1). The drought decreased blade, mesophyll, and vascular bundle thickness in Jul and Sep. Whereas the irrigation with fresh water on Sep increased blade, mesophyll, and vascular bundle thickness (Fig. 1, a, b, c). The salinity increased upper epidermal of the leaflet in Jul whereas the freshwater decreased upper epidermal of the leaflet in Sep. The lower epidermal thickness increased by salinity in May and Jul. However, drought increased cuticle thickness in Jul compared with other treatments.

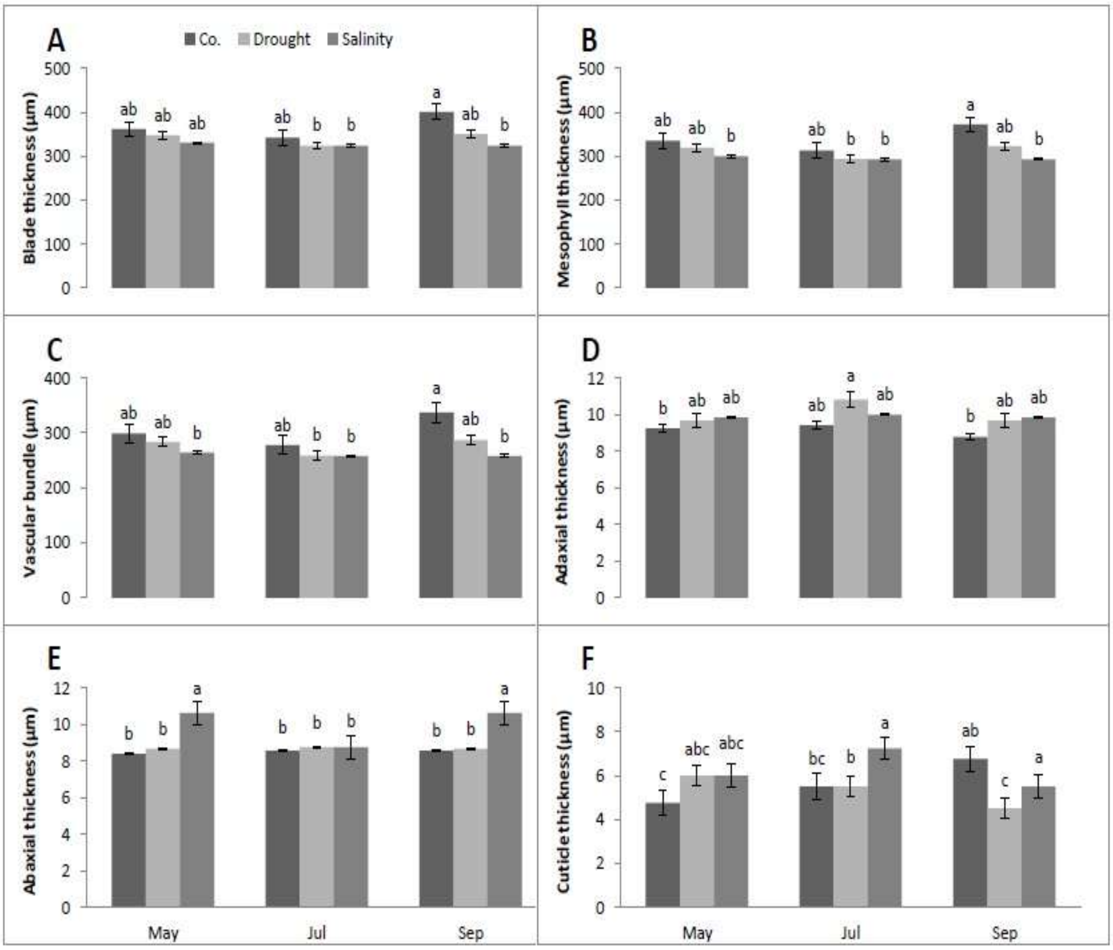


Fig. 1. Changes in the blade (A), Mesophyll (B), Vascular bundle (C), Adaxial (upper epidermal cell) (D), Abaxial (Low epidermal cell) (E) and Cuticle (F) in leaves of Date palm offshoots under different abiotic stresses. Results are means ± SE *(n* = 5*)*. The same letters are not significantly different $p \leq 0.05$ after a Tukey's correction for multiple comparisons.

Effect of abiotic stress on anatomical characteristics of root

The drought, salinity and thermal stress caused the damage roots of date palm (Fig. 2). The fresh water increased epidermis and the cortical thickness at all months. Whereas, drought and salinity decreased epidermis and cortical thickness (Fig. 2, a,b). The drought increased endodermis and sclerenchyma thickness compared with fresh water (Fig. 2, c, d). However, drought and salinity increased vascular bundle thickness compared with fresh water (Fig. 2, e). Abiotic factors were no significate effect on pith area (Fig. 2, f).

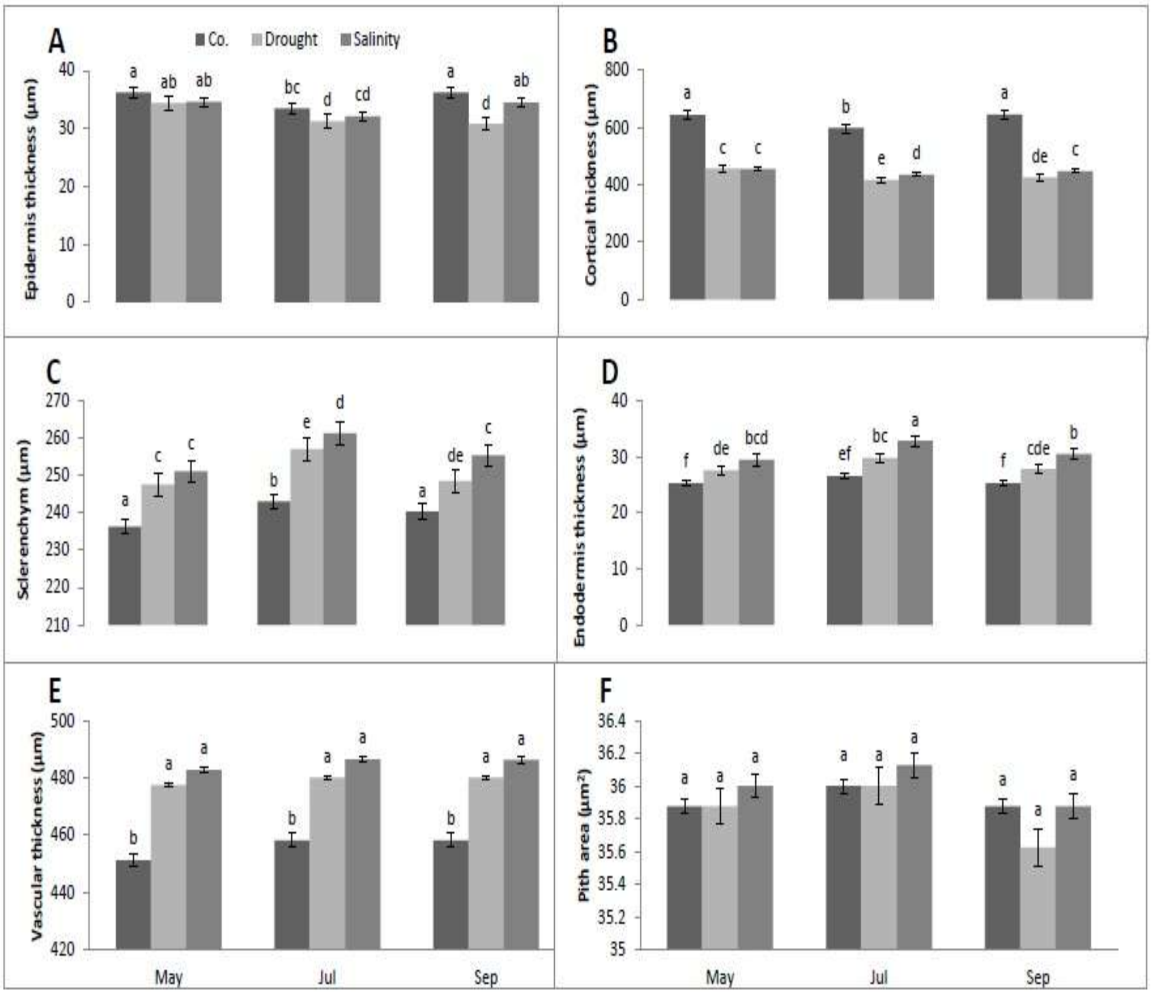


Fig. 2. Changes in Epidermis (A), Endodermis (B), Cortical (C), Sclerenchyma (D), Vascular (E) and Pith area (F) in roots of Date palm offshoots under different abiotic stress. Results are means ± SE *(n* = 5*)*. The same letters are not significantly different $p \leq 0.05$ after a Tukey's correction for multiple comparisons.

Transverse sections to both leaflet and root of date palm (Fig. 3, 4) indicate that there were significant changes in a leaflet and root anatomical characteristics induced by salinity and drought accompanied to high temperature. These led to a significant decrease in the thickness of almost all anatomical components.

The high salts prompt the plant to make some adjustments to the tissues in order to maintain the most significant water content within the tissues and reduce the process of evaporation by increasing the thickness of upper and low epidermal (Hameed *et al.*, 2013). Moreover, increasing the number of epidermis cells or decline in the mesophyll is due to carry the tissue inside the leaf damaged which reduces the length and diameter of the cells and the water potential on the one side and the reduction of construction on the other (Atabayeva *et al.*, 2013). The tissue leaf had suffered some cracking in high saline concentration, and this may be due to increased differences in tissue cells (Fig. 3,4). These results correspond to previous reports that extreme environmental conditions lead to changes in the composition and function of plant cells (Herna and Almansa, 2002). The presence of high salinity has led to a significant reduction in the thickness of the epidermis with a lack of epidermis cells of the upper and lower epidermis and thus decrease the thickness of the leaf (Duarte *et al*., 2013). There was also a decrease in the thickness of the leaf as well as a decrease in the mesophyll part of the number and volume (Bast *et al*., 2004). A decrease in the diameter of vascular bundles is directly related to reduced xylem vessel area, which is responsible for nutrient delivery (Ortega *et al.*, 2006). However, increase the thickness of the external cortex of the roots to guide the adaptation of the roots to the surrounding environment (Huang and Fry, 1998).

The narrow and thin leaflet blade for the most part because of shrinkage and decrease in the size and number of cells and mesophyll layers, because of decreased the water uptake and expanded sodium and chloride danger in the cells just as decreased photosynthesis. Subsequently, the advancement of mesophyll tissue cells and layers have a primary function in the shape and size of leaflet blades at the tolerance of date palm to abiotic stress, and this shrinkage evacuated step by step with decrease temperature. Salinity associated with high temperature caused damage to the roots and leaflets of the date palm.

This anatomical damage is the result of an osmotic effect, and the toxicity of accumulated ions such as chlorine and sodium in plant tissues. Water scarcity and high concentration of salts in the active root absorption area reduce water stress in the soil (Munns, 2002). Thus, the plant loses the ability to absorb water. The roots then become highly permeable, allowing soil salts to enter the root and thus move to the leaves. Thus, resulting in a toxic effect on both leaves and roots. These damages lead to imbalances in the nutrients within the plant tissue (Hameed et al., 2013).

The positive effect of adjusting the temperature of photosynthesis in Sep. alleviated the damage on leaflet and root anatomical characteristics as mesophyll thickness, and vascular bundles diameter may be attributed to the recovery of the membrane stability and activate photosynthesis and consequently improving the mechanism of tolerance to environmental conditions. In this case, removed shrinkage of the cell contents, improve the development of tissues, balanced nutrition, recover stable of the membrane. The high temperature reduces the metabolism of the roots, the composition of proteins (Valladares and Pearcy, 1997). Thus, it can reduce the mass of the root, which leads to damage to the roots, and low absorption capacity (Giri, 2013). The effect of salinity and drought on decreasing the thickness of vascular bundles may be due to the efficiency of adaptation to the absorption and transport of water and nutrients from the roots, associated with increasing the tolerance of the plant to the environmental stress (Céccoli *et al*., 2011).

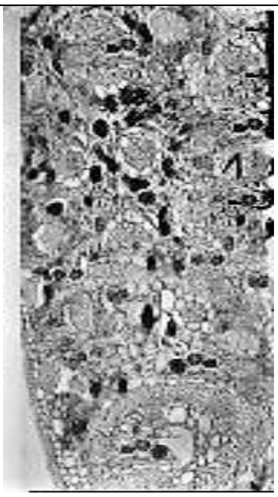
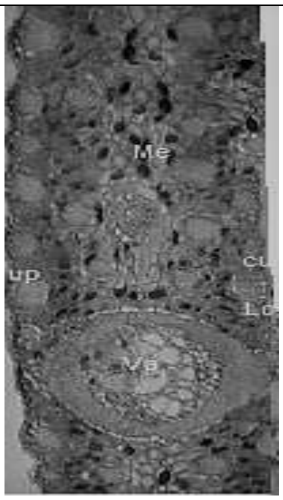
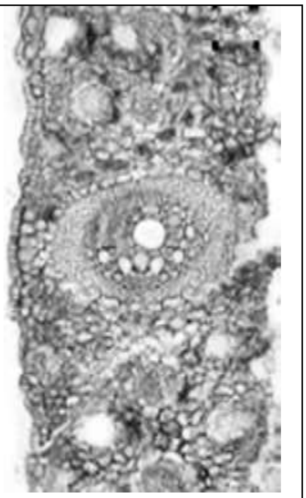
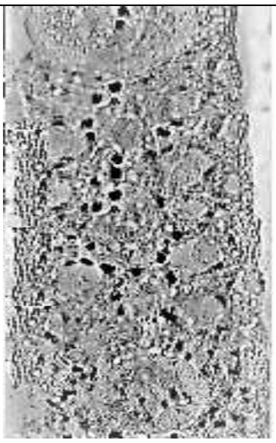
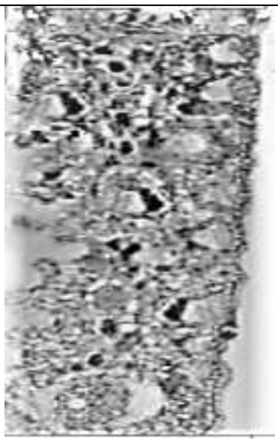
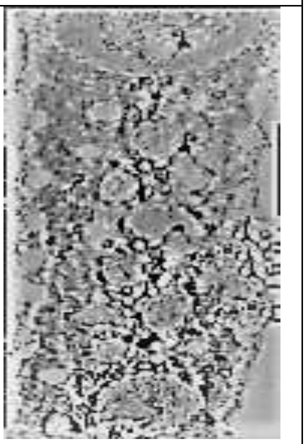
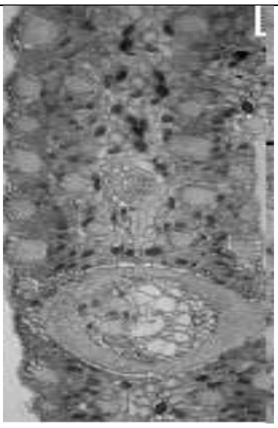
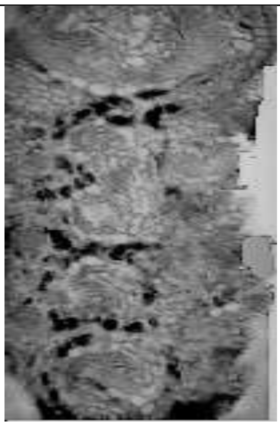
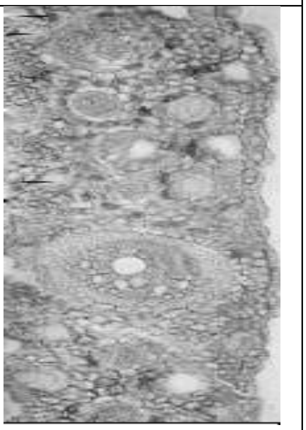
May **(37 ºC)**			
July **(43 ºC)**			
September **(35 ºC)**			
	Control	**Drought**	**Salinity**

Fig. 3. Cross-sections of Khadrawi offshoot pinnae under Abiotic Stress Cu: cuticle, Ad: Adaxial, Ab: Abaxial, Me: mesophyll tissue, and Va: vascular bundles. All Figures X=10

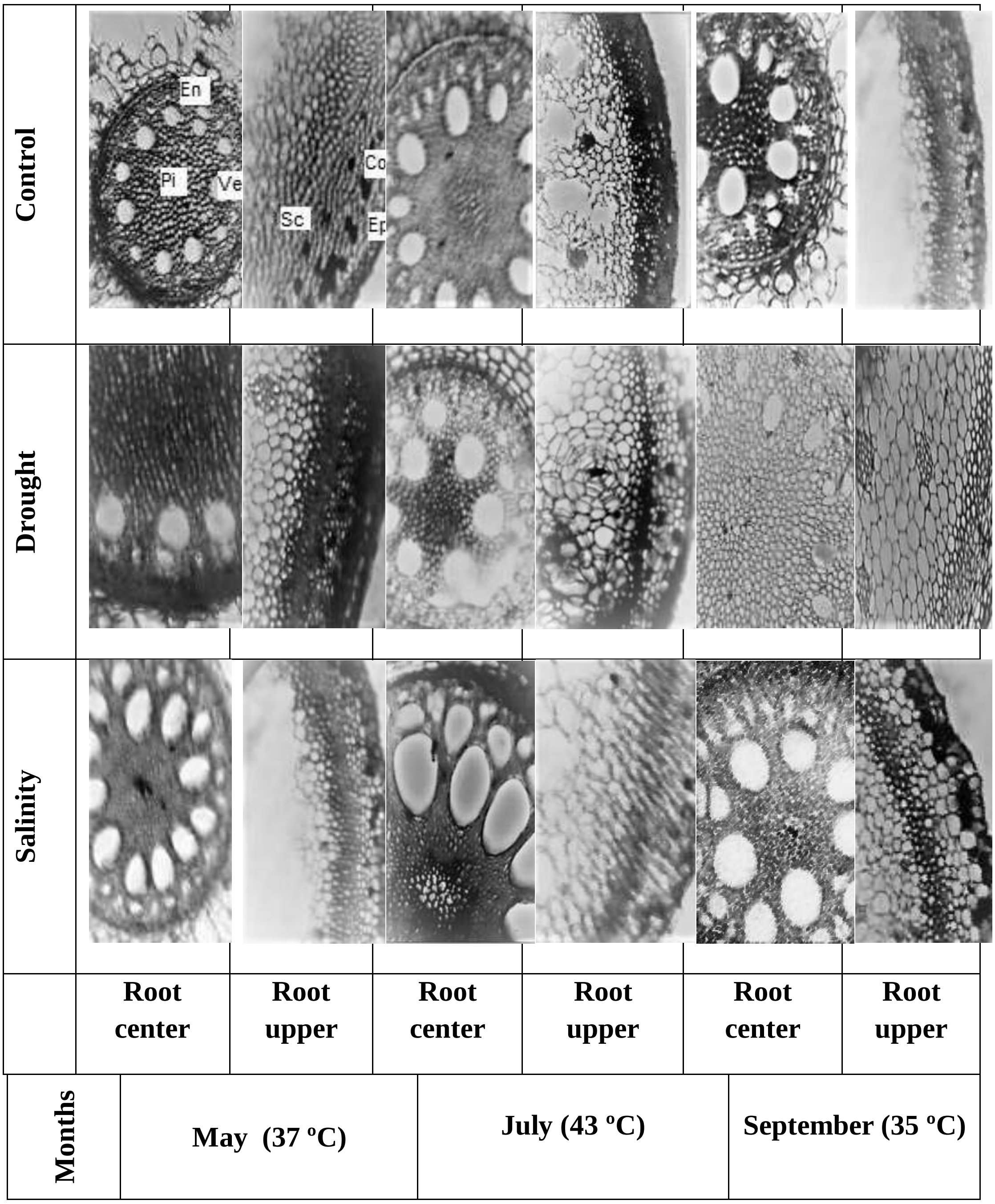


Fig. 4. Transverse sections of Khadrawi offshoot roots under Abiotic stress, Ep: epidermal Co: cortical layer, En: Endodermis, Sc: Sclerenchyma, Va: Vascular bundle and Pi: Pith area. All Figures X=40

Conclusion

Our results allow us to assume that the critical factor in the effect of drought stress associated with high temperature is drought stress and recovery of the tissue does not occur with the presence of drought stress despite the temperature is optimal. A critical factor in the saline stress associated with heat stress is high temperature and the recovery of tissue occurs by removing thermal stress despite the continues of saline stress.

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التغييرات التشريحية لاوراق وجذور نخيل التمر *Phoenix dactylifera* L. صنف الخضراوي تحت الاجهاد اللاحيوي

حسين جاسم شريف **ساجدة ياسين سويد**

مركز أبحاث النخيل، جامعة البصرة، البصرة، العراق

الخلاصة

الإجهاد الحراري المرتبط بإجهاد الملوحة أو الجفاف أكثر ضرراً للخصائص التشريحية للنبات من العامل الفردي. تم استخدام اوراق وجذور من فسائل نخيل التمر الفتية كمواد تجريبية. أظهرت النتائج أن اجهاد الجفاف أدى إلى انخفاض سماك النصل، والنسيج الوسطي، والحزم الوعائية في شهري تموز وايلول. في حين أدى الري بالمياه غير مالحة في شهر ايلول إلى زيادة سمك النصل والنسيج الوسطي و الحزم الوعائية. ادى اجهاد الملوحة الى زيادة سمك البشرة العليا للاوراق في تموز بينما ادى الري بالمياه غير المالحة الى خفضها في ايلول. وقد تأثر سمك البشرة السفلي للاوراق بالملوحة في شهري ايار وتموز. ومع ذلك، أدى الجفاف إلى زيادة سمك االكيوتكل في تموز مقارنة بالمعاملات الأخرى. تسبب اجهاد الجفاف والملوحة والاجهاد الحراري في ضرر جذور نخيل التمر. ادى الري بالمياه غير المالحة الى زيادة سمك البشرة والقشرة في جميع الأشهر. بينما أدى الجفاف والملوحة إلى انخفاض سمك البشرة والقشرة. ومع ذلك، أدى الجفاف إلى زيادة سماكة البشرة والطبقة السكلرنشيمية والحزم الوعائية مقارنة بالمياه غير المالحة. العامل الحاسم في تأثير إجهاد الجفاف المرتبط بالإجهاد الحراري هو إجهاد الجفاف، ولا يحدث تعافي للأنسجة مع وجود إجهاد الجفاف على الرغم من إزالة الإجهاد الحراري.

الكلمات المفتاحية: الكيوتكل، النسيج الوسطي، الملوحة ؛ الجفاف؛ الإجهاد الحراري