Impact of Drought (Irrigation Intervals) on Anatomical Structure of Root and Leaf for Sunflower (*Helianthus annuus* L.) Plant

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Abstract: A field experiment was performed, during the summer season of 2007 to study the effect of four irrigation intervals, i.e. 4, 8, 12 and 16 days on root and leaf structures of sunflower (*Helianthus annuus* L.). Sunflower cultivars viz., Sakha 53 and Giza 102 were grown to maturity in a sandy soil. Extending the irrigation interval (drought) increased xylem arm length and average number of xylem vessels bundle^{-1} in the root. However, an opposite trend was observed true with epidermis thickness, cortex thickness, and average row number of cortex and thickness of biggest xylem vessel. In the cross sections of root the effect on Sakha 53 cultivar was more significant than that with Giza 102 cultivar in all studied characters. Extending the irrigation interval (drought) increased some anatomical characters of leaf such as the thickness of upper epidermis+ palisade tissue, lower epidermis+ spongy tissue, average number of xylem arms bundle $^{-1}$ and number of xylem vessels bundle $^{-1}$. Concerning the cultivar effect, Sakha 53 significantly excelled Giza 102 for the thickness of each of mesophyll, upper epidermis + palisade tissue and collenchymatous tissue lower vascular bundle. But the reverse was correct with the thickness of collenchymatous tissue upper vascular bundle and number of xylem arms bundle in leaves.

Keywords: sunflower cultivars, drought, anatomical structures

INTRODUCTION

Sunflower (*Helianthus annuus* L.), is an important member of the family Asteraceae and is one of the major oilseed crops grown for edible oil in the world. Sunflower seeds contain 40- 50% oil and 23% protein and constitute excellent source of unsaturated fats, crude protein and fiber and important nutrients like vitamin E, selenium, copper, zinc and B-complex vitamin (AfzaL *et al.*, 2010).

Plants have different life strategies to cope drought stress, like drought avoidance and drought tolerance. The ability of plants to delay harmful decrease in the water potential of the protoplasm is considered as avoidance of desiccation. Desiccation tolerance means that plants have ability to maintain their normal functions even at low tissue water potentials. A wide diversity of drought tolerance mechanisms, both morphological and physiological have been developed in plants (Blum, 1996).

Loreto *et al.* (1992) reported that in avocado, palisade and total thickness of water- stressed leaves were lower than in controls. Furthermore, an increased density of spongy cells and a 35-45% decrease of intercellular spaces were also evident. The dense arrangement of spongy cells may result in reduction of diffusion conductance in water stressed avocado leaves. These results supported the idea that a direct relationship between leaf porosity and mesophyll conductance exists.

Also, Syvertsen *et al.* (1995) showed that the mesophyll density was inversely correlated with the conductance through the liquid phase only.

Furthermore, Chartzoulakis *et al.* (2002) found that cross sections of avocado leaves show that the palisade parenchyma is composed of two successive and distinctive layers, the first one being in contact with upper epidermis and the other with the spongy parenrchyma. There were significant changes in leaf anatomical characteristics induced by water stress. In particular, water stress resulted in a significant decrease of the thickness of almost all histological components of the mesophyll, as well as, of the entire lamina thickness. In stressed plants of avocado the chlorenchyma cells were denser than those in well irrigated ones.

The aim of this work is to study the effect of drought (irrigation intervals) on root and leaf structures of sunflower.

MATERIALS AND METHODS

A field experiment was performed, during 2007 season at the Experimental Farm of the Faculty of Agriculture, Suez Canal University, Ismailia. The objective of the study was to detect the effect four irrigation intervals (drought) i.e 4, 8, 12 and 16 days on root and leaf structures of sunflower. Sunflower cultivars Sakha 53 and Giza 102 were obtained from Oil Crop Research Institute, Agricultural Center Research, Ministry of Agriculture, Giza Egypt.

The experimental design was a split with three replicates. The seeds were sown in plots each consisted of 4 ridges, 5 meter in length and 60 cm in width, after farm yard manure (FYM) had been applied at a rate of 20 m^3 fed^{-1} . Sunflower seeds were sown on 15 th of April (2007) at a rate of 5 seeds $hill^{-1}$. N- fertilizer was applied to all plots at a rat of 300 kg fed^{-1} as ammonium nitrate (33.5%) in two equal split dressings after 15 and 45 days from sowing. P- fertilizer was applied before sowing to all plots at a rate of 150 kg fed^{-1} as superphosphate (15.5 % P_2O_5). K- fertilizer was applied to all plots at a rate of 50 kg fed^{-1} as potassium sulfate (48% K_2O) in two equal split dressings after sowing and after 20 days from sowing.

In 2007 season, the plant samples were collected after 55 days from sowing (before flowring). Killing and fixation in 70% F. A. A. solution, dehydration and

clearing with ethyl-alcohol and xylene, infiltration and embedding in pure parafine wax (M. P. 56-58 °C) were carried out as described by (Willey 1971).

Using a rotary microtome, sections (15µ) were obtained and stained with safranin (1% solution in 50% ethanol) and light green before being mounted in Canada balsam. Sections, in such cases were microscopically examined by light microscope.

Data were statistically analyzed according to procedures outlined by Snedecor and Cochran (1982). Means followed by the same alphabetical letters are not statistically different according to Duncan' s Multiple Range Test at 5% level of significance (Duncan, 1955).

RESULTES AND DISCUSSION

Root Structure: Data in Table 1 and plate 1 pointed out the effect of four irrigation intervals on root structure. The root cross sections were taken at 55 days from sowing for the two cultivars of sunflower.

It is clear that the thickness of epidermis, cortex, biggest xylem vessel and row number of cortex were significantly decreased as a result of increasing the irrigation intervals as compared with the controls. Increasing irrigation intervals caused lower in the thickness of the root anatomy characters. On the other hand, an opposite trend was shown with xylem arm length and number of xylem vessels bundle^{-1}. All of the studied anatomical characters pertaining the cultivar Sakha 53 proved to exceed significantly those obtained with the cultivar Giza 102. These results are in harmony with those reported by Rogers *et al.* (1984), Freundl *et al.* (1998) and Robertson *et al,* (2005).

Table (1): Impact of irrigation intervals (drought) on some anatomical characters of two cultivars (Sakha53 ,Giza 102) of sunflower roots at 55* days from planting during 2007 season (field experiment)

Root anatomy / Treatment	Epidermis Thickness (mµ)	Cortex Thickness (mµ)	Row number of cortex	Xylem arm length (mµ)	Number of xylem (vessels bundle^{-1})	Thickness of biggest xylem vessel (mµ)
Sakha 53	6.00 ^{a}	43.0 ^{a}	7.88 ^{a}	13.4 ^{a}	16.1 ^{a}	6.25 ^{a}
Giza 102	4.29 ^{b}	36.1 ^{b}	7.63 ^{b}	10.4 ^{b}	14.8 ^{b}	5.75 ^{b}
Drought (Control)	6.75 ^{a}	47.5 ^{a}	9.00 ^{a}	9.50 ^{c}	11.8 ^{d}	8.75 ^{a}
8 days	5.50 ^{b}	43.3 ^{b}	8.00 ^{b}	12.5 ^{b}	15.5 ^{c}	6.75 ^{b}
12 days	4.59 ^{c}	38.8 ^{c}	7.50 ^{c}	10.8 ^{bc}	16.5 ^{b}	4.50 ^{c}
16 days	3.75 ^{d}	28.8 ^{d}	6.50 ^{d}	14.8 ^{a}	18.0 ^{a}	4.00 ^{d}

Means followed by the same letter in each column are not significantly different at p= 0.05.
* Before flowering.

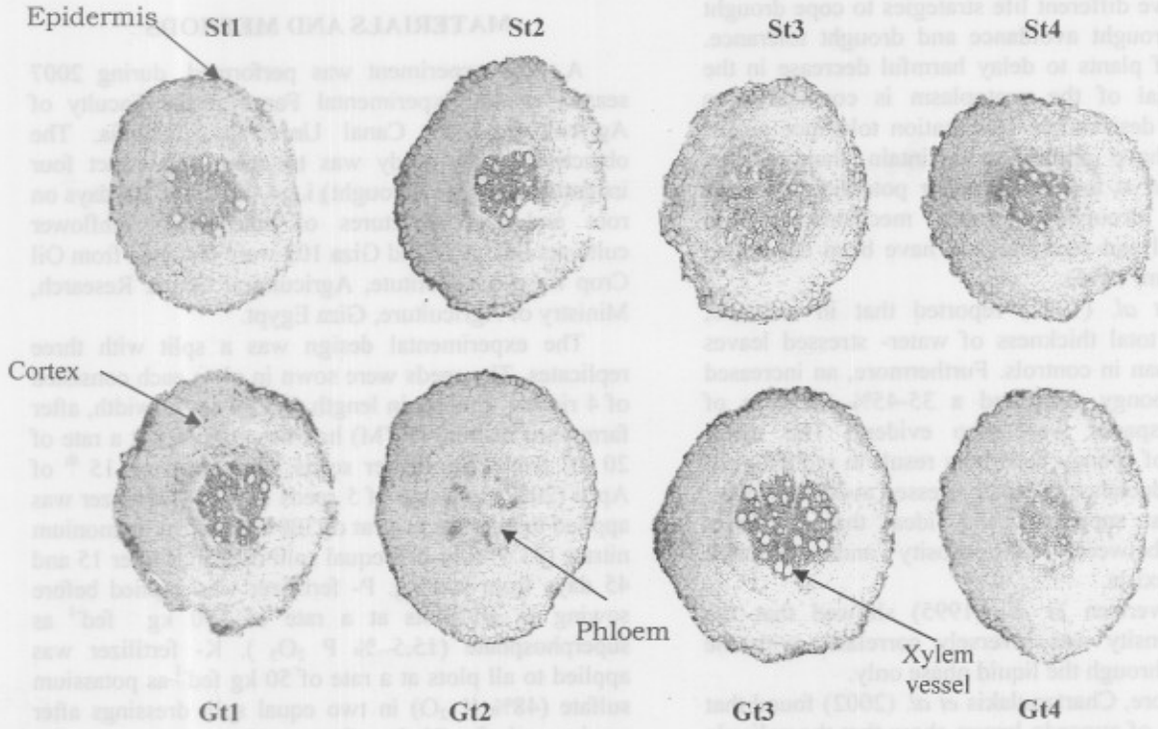

Plate (1): Transverse section showing the impact of irrigation intervals (drought) on some root anatomical characters of two sunflower cultivars (Sakha53, Giza 102) at 55 days from sowing. X= 160
- S refers to Sakha 53 and G refers to Giza 102.
- t1, t2, t3 and t4 refer to irrigation intervals 4, 8, 12 and 16 days, respectively.

Leaf Structure: Data in Table 2a , 2b and plate 2 pointed out the effect of four irrigation intervals (4, 8, 12 , 16 days) on leaf structure of two cultivars (Sakha 53, Giza102). Leaf samples were taken after 55 days form sowing.

It is clearly shown from these Tables that the thickness of upper epidermis + palisade tissue , lower epidermis+ spongy tissue , number of xylem arms bundle^{-1} and number of xylem vessels bundle^{-1} were increased by increasing the irrigation interval and this was particularly clear at 16 days irrigation interval as compared with the controls. On the other hand, an opposite trend is shown with thickness of mesophyll, midrib, collenchymatous tissue upper vascular bundle, collenchymatous tissue lower vascular bundle, vascular bundle and biggest xylem vessel in comparison with the controls.

Concerning the cultivar effect, Sakha 53 significantly excelled Giza 102 for the thickness of mesophyll, upper epidermis + palisade tissue thickness and thickness of collenchymatous tissue lower vascular bundle. But the reverse was correct with thickness of collenchymatous tissue upper vascular bundle and number of xylem arms bundle. Otherwise, no significant differences were obtained between the two cultivars in this concern. These results are in harmony with those reported by Syvertsen *et al.* (1995) and Chartzoulakis *et al.* (2002). However, Stoyanova *et al*, (2002) showed that the gradual depletion of soil moisture does not provoke substantial histological changes. They found that analysis of the leaf ultrastucture reveals that the water deficit (at 40% of soil moisture content) caused a typical destruction of thylakoids in the mesophyll chloroplasts. Chloroplasts in the bundle sheath showed greater structural plasticity and stability in maize.

Table (2*a*): Impact of irrigation intervals (drought) on some leaf anatomical characters of two cultivars (Sakha53 , Giza 102) of sunflower at 55 days from planting during 2007 season (field experiment)

Leaf anatomy / Treatment	Thickness of mysophyll (mμ)	Upper epidermis+ palisade tissue thickness (mμ)	Lower epidermis+ spongy tissue thickness (mμ)	Thickness of midrib (mμ)	Thickness of collenchymatous tissue upper vascular bundle (mμ)
Sakha 53	8.55 ^{a}	3.45 ^{a}	4.30 ^{a}	59.6 ^{a}	19.5 ^{b}
Giza 102	7.21 ^{b}	3.15 ^{b}	4.4 ^{a}	57.2 ^{a}	23.0 ^{a}
Drought (Control)	9.30 ^{a}	2.70 ^{c}	3.30 ^{c}	74.5 ^{a}	27.5 ^{a}
8 days	8.40 ^{a}	2.90 ^{c}	4.30 ^{b}	69.4 ^{a}	25.0 ^{b}
12 days	6.81 ^{b}	3.60 ^{b}	4.5 ^{b}	42.8 ^{b}	18.5 ^{c}
16 days	7.00 ^{b}	4.00 ^{a}	5.30 ^{a}	46.9 ^{b}	14.0 ^{d}

Means followed by the same letter in each column are not significantly different at p= 0.05 .
* Before flowering.

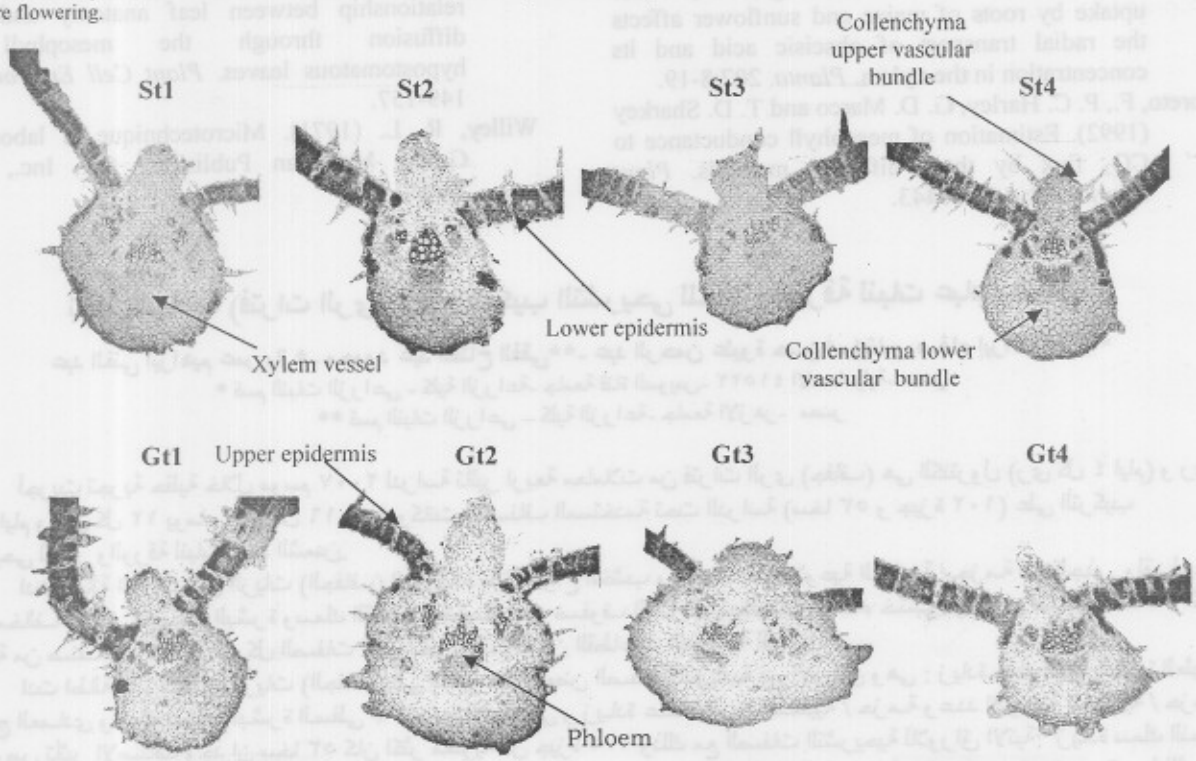

Plate (3): Transverse section showing the impact of irrigation intervals (drought) on some leaf anatomical characters of two sunflower cultivars (Sakha53 , Giza 102) at 55 days from sowing. (X= 160).
- S refers to Sakha 53and G refers to Giza 102.
- t1, t2, t3 and t4 refer to irrigation intervals 4, 8, 12 and 16 days, respectively.

Table (2*b*): Impact of irrigation intervals (drought) on some leaf anatomical characters of two cultivars (Sakha53 , Giza 102) of sunflower at 55 days from planting during 2007 season *(field experiment)*

Leaf anatomy / Treatment	Thickness of collenchymatous tissue lower vascular bundle (mμ)	Thickness of vascular bundle (mμ)	Number of xylem arms bundle^{-1}	Number of xylem vessels bundle^{-1}	Thickness of biggest xylem vessel (mμ)
Sakha 53	20.6 [a]	18.9 [a]	5.50 [b]	19.5 [a]	1.90 [a]
Giza 102	17.6 [b]	17.9 [a]	6.25 [a]	20.8 [a]	1.77 [a]
Drought (Control)	25.5 [a]	23.5 [a]	4.5 [d]	17.0 [b]	2.20 [a]
8 days	22.0 [b]	19.8 [b]	5.00 [c]	18.0 [b]	1.80 [ab]
12 days	14.5 [c]	14.6 [c]	5.50 [b]	19.0 [b]	1.84 [ab]
16 days	14.4 [c]	15.8 [c]	8.50 [a]	26.5 [a]	1.50 [b]

Means followed by the same letter in each column are not significantly different at p= 0.05.
* Before flowering.

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تأثير الجفاف (فترات الرى) على التركيب التشريحى للجذر والورقة لنبات عباد الشمس

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أجريت تجربة حقلية خلال موسم ٢٠٠٧ لدراسة تأثير اربعة معاملات من فترات الرى (جفاف) هى الكنترول (رى كل ٤ ايام) و رى كل ٨ ايام و رى كل ١٢ يوما و رى كل ١٦ يوما وكانت الاصناف المستخدمة تحت الدراسة (سخا ٥٣ و جيزة ١٠٢) على التركيب التشريحى للجذر والورقة لنبات عباد الشمس.

ادت اطالة الفترات بين الريات (الجفاف) الى زيادة طول ذراع الخشب ومتوسط عدد الاوعية الخشبية / حزمة فى الجذر. ولقد لوحظ اتجاه مخالف للسابق مع سمك البشرة وسمك القشرة ومتوسط عدد صفوف القشرة وسمك اكبر وعاء خشبى. وجد ان صنف سخا ٥٣ اكثر معنوية من صنف جيزة ١٠٢ فى كل الصفات التشريحية المأخوذة من القطاعات العرضية للجذر.

ادت اطالة الفترات بين الريات (الجفاف) الى التأثير على بعض الصفات تشريحية فى الاوراق وهى : زيادة سمك نسيج البشرة العليا + النسيج العمادى وسمك نسيج البشرة السفلى + النسيج الاسفنجى و زيادة عدد الاذرع الخشبية / حزمة وعدد الاوعية الخشبية / حزمة. بخصوص تأثير الاصناف وجد ان سخا ٥٣ كان اكثر معنوية من جيزة ١٠٢ وذلك مع الصفات التشريحية للاوراق الاتية: زيادة سمك النسيج المتوسط وسمك البشرة العليا + النسيج العمادى وسمك النسيج الكولنكيمى الموجود اسفل الحزمة الوعائية. ولكن وجد اتجاه معاكس لذلك مع سمك النسيج الكولنكيمى الموجود اعلى الحزمة الوعائية ومتوسط عدد اذرع الخشب / حزمة .