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Study some of Morphological and Physiological Traits of Kurrajong *Brachychiton populneus* (Schott & Endl.) Seedlings Planted under Water Stress Conditions

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Abstract: In this study, *Brachychiton populneus* seedlings were subjected to drought stress for 90 Days and physiological and morphological characters analyzed to determine their response to water deficit. The growth characters including, height and diameter of shoots, the dry weight of shoots and roots as well as photosynthetic pigment and the leaves content of relative water content were measured to evaluate the effects of drought in the physiological growth of plant. The lowest means; 59 cm and 8 mm of shoot height and diameter respectively were recorded at 30% of water holding capacity of soil (WHC). Drought treated seedlings at both 60% and 30% WHC had lower dry weight of shoots; 9.54 and 8.24 g plant^{-1} respectively compared to the control. Consequently, the increase of drought conditions led to enhancement the growth of roots and roots to shoots ratio. The highest increase in the dry weight of roots and roots to shoots ratio were25.96 g plant^{-1} and 3.19 recorded under severe drought stress condition. Lowest amount of chlorophyll a; 2.94 mg g^{-1} F W recorded under 30% SWHC. It is found also the total content of chlorophyll in the leaves decreased significantly; 5.86 and 7.88 mg g^{-1} F W under both levels. While the highest ratio of chlorophyll a: b was 1.59 recorded at 60% SWHC. However, the lowest leave relative water content LRWC%; 86% was recorded under 30% SWHC. These findings may explain the characters of the early growth and physiological responses of, *Brachychiton populneus* to dehydration and facilitate the selection of drought-resistant tree families.

Keywords: *Brachychiton populneus*, Height, Chlorophyll, Carotenoids, LRWC%.

Introduction

Drought is the major abiotic stresses determining a global vegetation distribution in the forestry and agricultural sector. The shifts in rainfall patterns in arid and semi-arid regions and increase temperatures associated with climate change are likely to cause widespread forest decline in regions where droughts are predicted to increase in duration and severity (Choat *et al*., 2012). *Brachychiton populneus* is predominantly belongs to an Australian genus of the family Sterculiaceae. It is considered a native to eastern Australia which has a widespread distribution, and has great value in cultivation (Guymer, 1988). It is easy to propagate and possess many interesting features. It is modest size evergreen, broad domed tree 10–20 m in height, 12 to 15m in crown diameter generally with a stout trunk. In addition, it has an important role in contemporary urban landscapes. Historically, the fiber of the bark was used by Aborigines for making cordage and nets, while early explorers and settlers roasted and ground the seeds to make a pleasant beverage (Buist *et al*., 2000). Under water deficit growth and development of woody species growth characters including seedling height, stem diameter, plant biomass and leaf area are reduced under drought stress. As well as the leaf's metabolism changes lead to change in water potential, gas exchange, chlorophyll fluorescence, organic solute contents and photosynthetic pigment (Frosi *et al*., 2017). Some species decrease their photosynthetic pigments and accumulate organic solutes without showing a faster recovery of the photosynthetic activity, while other species show the opposite action (Souza *et al*., 2010).

The hydraulic status of plants under water deficit condition has more attention recently. Under water deficit, the ability of plants to supply water to leaves for photosynthetic and gas exchanges is reduced as well as a few water movement through the xylem under tension during transpiration that can be ultimately result in desiccation and mortality. Therefore, high transpiration rate during the drought season led to increases the risk of xylem cavitation (Steudle, 2001).

B. populneus seedlings were brought to the Kurdistan region during the years 2006-2007 and used as ornamental trees widely in the city of Erbil. It has been identified at the herbarium center in Department of Biology, College of Education, University of Salahaddin. As the afforestation projects took large allowance of the government's interest; it's noteworthy to study the growth performance of *B. populneus* seedlings under moisture tension in Kurdistan region, Iraq.

Materials & Methods

This study was conducted at a lath house at College of Agriculture, Erbil. Local *Brachychiton populneus* seedlings were subjected to two levels of water holding capacity for 90 days. The water holding capacity of the soil was determined by saturating the soil in pots, covering the tops with aluminum foil. Regular daily weighing after 24, 48 and 72 hours until a constant weight obtained. On this base 1500 mL, 1000 mL and 500 mL water added respectively as; 90%, 60% and 30 % soil water holding capacity (SWHC %) levels (Qadir *et al*., 2016).

Experimental parameters

Morphological Characteristics:

Seedling height (cm) and seedling diameter (mm).

Biomass characters

Biomass characters were measured after separating the seedling to shoot and root and dried in an oven at 72°C until the constant weight obtained (Paliwal *et al*., 1998).

The shoot dry weight g plant^{-1}, root dry weight g plant^{-1}, seedling dry weight g plant^{-1} and root to shoot ratio was calculated.

Photosynthetic pigments

Pigments extracted in 95% ethanol and spectrophotometric determination absorbance taken at 663.2, 646.8 and 470 nm. Chlorophylls and carotenoid contents were calculated using the following formulas as described by Sumanta *et al*. (2014).

Chlorophyll a =13.36A664 – 5.19 A649

Chlorophyll b=27.43A649 – 8.12 A664

Total chlorophyll = Chlorophyll a + Chlorophyll b

Carotenoids = (1000A470 –2.13Ca- – 97.63Cb)/209

Leaf relative water content (LRWC)

Leaf relative water content of seedlings was measured by sampling two similar fully expanded leaves per plot. Leaf samples were sealed in plastic, placed above ice in cooler and transported to the lab to obtain fresh weight. Then leaves floated on water for 24 hours to saturate and obtain the turgid weight. Turgid leaves dried at 70°C until constant weight was reached (Schon-feld *et al*., 1990). LRWC were calculated according to the formula:

RWC= [(FW-DW) / (TG-DW)] ×100

FW =Sample fresh weight

TW = Sample turgid weight

DW = Sample dry weight

Experimental design and data analysing

The Complete Randomized based to design (CRD) the study in the nature of three SWHC% levels repeated four times. The mean values were compared using Duncan's multiple range test DMRT IBM SPSS Statistics version 25 was used to analyze the data.

Results & Discussion

To evaluate the growth of *B. populneus* seedlings subjected to drought stress, shoot heights and stem diameter were measured on the last (90^{th}) day of drought treatment (Fig. 1). There were significant decreases recorded in the shoot height and stem diameter. The lowest means; 59 cm and 8 mm of shoot height and stem diameter were recorded in drought-treated 30% WHC of the soil as compared to their control treatment 90% SWHC. That might be belongs to reduction in cell division and enlargement (Frosi *et al*., 2017). According to Lecoeur *et al.* (1995) during growing plants for a period of time in soils with low water potential, smaller leaves

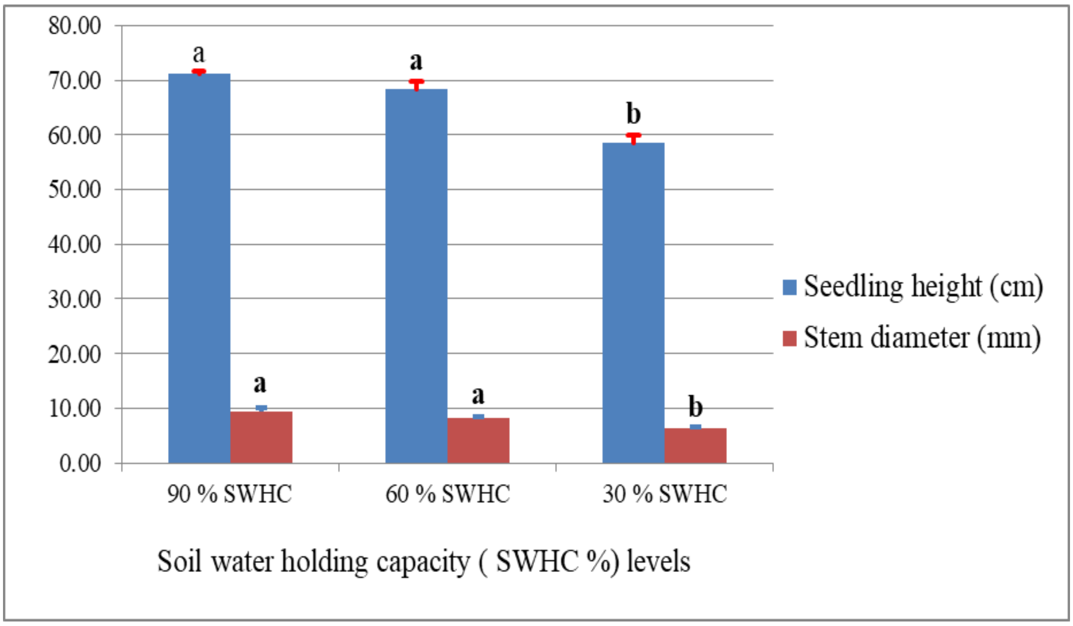

Fig. (1): Seedling height (cm) and stem diameter (mm) of *B. populneus* under different soil water holding capacity levels.

with fewer cells are produced, these explanation recommend that reduced cell formation during water stress may reduce final leaf size. Similar results were observed in *Populus* × *euramericana* clones (Marron *et al*., 2002) and *Celtis caucasica* seedlings (Tabatabaei *et al.*, 2014). Drought treated seedlings at both 60 and 30% WHC had lower shoot dry weights; 9.54 and 8.24 g plant^{-1} than their counterparts control (90 % SWHC); 17.50 g plant^{-1} (Table 1), as previously described by Lim *et al*. (2017).

The dry weight is closely correlated with the seedling collar diameter. Both the dry weight and stem collar diameter significantly influence. Seedling survival and growth (Ritchie, 1984). In dry conditions the plant respond through reduction in leaf area as soil water becomes limiting is achieved through reduction in leaf size, leaf rolling or leaf shedding, thus reducing the transpiring leaf surface, but with significant negative impact on carbon gain and overall plant productivity (Jones, 1992). Leaf fall can be caused by water shortages and reduce the level of transpiration way to resist is dry. This increase in plant adaptation to drought; ethylene produced by stress, such as a secondary messenger for reactions to plant operation (Jalili Marandi, 2010). Consequently, increasing drought conditions may result in enhanced root growth and root to shoot ratio (Noguchi *et al*., 2007). The highest increase in root dry weight and root: shoot ratio 25.96 g plant^{-1} and 3.19 were recorded under severe drought stress condition. This is also recorded in previous studies by Rötzer *et al*. (2017). Thus, water uptake of trees in periods with low water availability can be ensured by carbon allocation to the roots. Because of roots have direct contact with soil and absorb water from the soil. Therefore, roots regarded as good scale for response to drought stress (Leuschner *et al*., 2001).

Table (1): Biomass characters of *B. populneus* seedlings under different soil water holding capacity levels (SWHC %).

Biomass characters	SWHC % levels			
	90 % SWHC	60 % SWHC	30 % SWHC	Mean
Shoot dry weight (g plant^{-1})	17.50 a ±1.67	9.54 b ± 0.24	8.24 b ± 0.49	11.78 ± 1.54
Root dry weight (g plant^{-1})	19.40 b ± 1.12	22.66 ab ± 1.40	25.96 a ± 1.13	22.67 ± 1.13
Seedling dry weight (g plant^{-1})	36.96 a ± 0.57	32.20 b ± 1.16	34.20 ab ± 0.67	34.45 ± 0.81
Root: shoot ratio	1.14 a ± 0.18	2.19 a ± 0.21	3.19 b ± 0.34	2.24 ± 0.32

The leaf chlorophyll content is directly correlated to the photosynthetic activity under drought stress condition. The chlorophyll content in drought-treated *B. populneus* seedlings significantly differs from that of the controls (Table 2). Lowest amount of chlorophyll a; 2.94 mg.g^{-1} F W recorded under 30% SWHC. Furthermore, the amount of chlorophyll; 3.05 and 2.91 mg g^{-1} F W under moderate and severe drought stress levels. As well as total chlorophyll content decreased significantly; 5.86 and 7.88 mg.g^{-1} F W under the same levels as compared to the control seedlings. While the highest ratio of chlorophyll a: b was 1.59 recorded at 60% SWHC. Similar responses in photosynthetic pigments were present in *Olea europaea* (Guerfel *et al*., 2009) as well as Frosi *et al.* (2017) recorded the same results. Avoiding severe damages strategy might include decrease in photosynthetic pigment could directly affect the photosynthetic machinery, as well as lower CO_2 concentrations inside the chloroplast can be caused by stomatal closure may have an inhibitory effect on photosynthetic machinery (de Lima *et al*., 2015).

Relative water content is the main factor which caused growth reduction in response. Decrease in RWC in plants under drought stress may depend on plant vigor reduction (Alexieva *et al*., 2001).

A significant decrease observed in leaves water content of *Brachychton* sp. under 30% SWHC as compared to control (Fig. 2). In which the lowest LRWC%; 86% was recorded. While moderate treatments did not differ under water deficit, as previously reported by Souza *et al.* (2010).

Cell membrane subjects to an increase in its permeability and decrease in stability during subjecting seedlings under drought stress (Blokhina *et al*., 2003). Due to damaged cleavage in the membrane and sedimentation of cytoplasm content probably, in these conditions, ability to osmotic adjustment is reduced (Blackman *et al*., 1995).

Table (2): Photosynthetic pigments in *B. populneus* seedling leaves under different soil water holding capacity levels (SWHC %).

Photosynthetic pigments	SWHC % levels			
	90 % SWHC	60 % SWHC	30 % SWHC	Mean
Chlorophyll a (mg g^{-1} F W)	5.036 a ± 0.13	4.83 a ± 0.03	2.94 b ± 0.16	4.27 ± 0.34
Chlorophyll b (mg g^{-1} F W)	3.97 a ± 0.08	3.05 b ± 0.16	2.91 b ± 0.13	3.31 ± 0.18
Total chlorophyll (mg g^{-1} F W)	9.01 a ± 0.18	7.88 b ± 0.17	5.86 c ± 0.11	7.58 ± 0.47
Carotenoids (mg g^{-1} F W)	0.54 a ± 0.02	0.55 a ± 0.01	0.39 a ± 0.06	0.49 ± 0.03
Chlorophyll a: b	1.27 ab ± 0.03	1.59 b ± 0.08	1.02 a ± 0.10	1.29 ± 0.10
Chlorophyll: carotenoids	16.83 a ± 0.47	14.22 a ± 0.53	15.69 a ± 2.67	15.58 ± 0.88

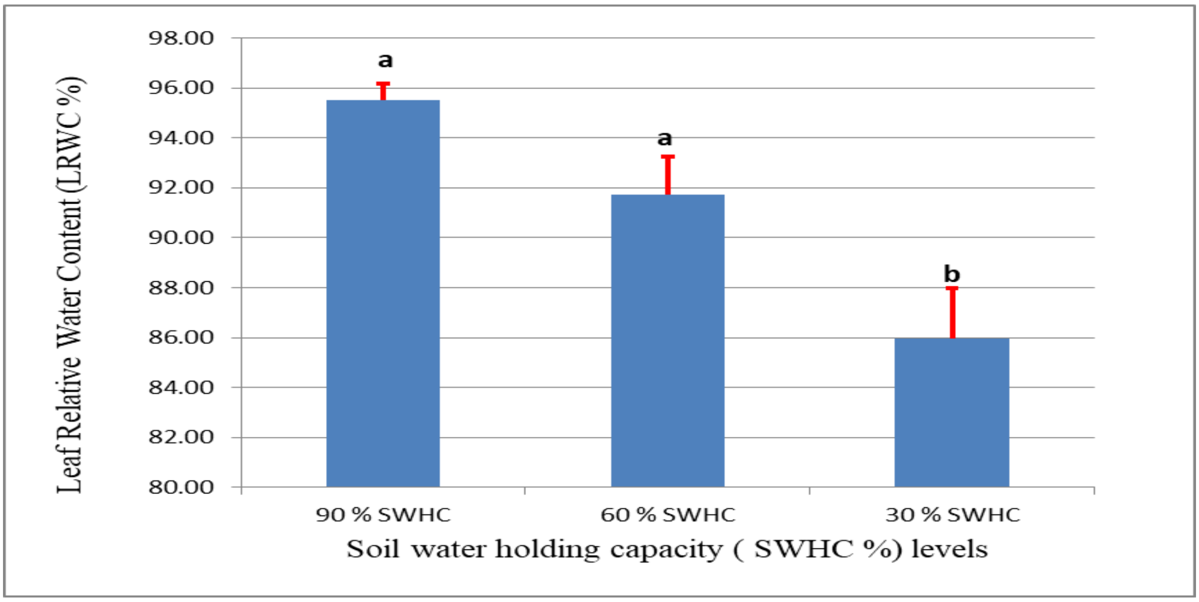

Fig. (2): Leaf relative water content (LRWC %) in *B. populneus* leaves under different soil water holding capacity levels.

Conclusion

The study results may assist in the understanding of the initial growth and physiological responses of *B. populneus* under drought stress and facilitate the selection of drought-resistant tree families. It is resistant plants to drought which is suitable for sowing in dry and hot areas. To increase the green places in the city by planting streets, parks, playgrounds and backyards are lined with trees that create a peaceful, aesthetically pleasing environment.

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Conflicts of interest

The authors-declare-that they-have-no-conflict of interests.

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دراسة بعض الصفات المورفولوجية والفسلجية لشتلات *Brachychiton populneus* (Schott & Endl.) Kurrajong المزروعة تحت ظروف الإجهاد المائي

شيماء عبدالخالق كريم و سروه انور قادر وحلمت ابوبكر صابر

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المستخلص: تعرضت شتلات *Brachychiton populneus* في الدراسة الحالية للجفاف لمدة 90 يومًا وتم تحليل الخواص الفسلجية والمظهرية لتحديد استجابتها لشحة المياه. تم قياس خصائص النمو، بما في ذلك ارتفاع وقطر الشتلات، والوزن الجاف للنمو الخضرى والجذور، وكذلك الصباغ الضوئي ومحتوى الأوراق النسبي من محتوى الماء لتقييم آثار الجفاف على النمو الفسيولوجي للنبات. أدنى قيمه 59 سم و 0.8 سم لارتفاع شتلات وقطره، على التوالي سجلت عند 30 ٪ (SWHC) من قابلية التربة للاحتفاظ بالماء. الشتلات المعالجة بالجفاف على 60 ٪ و 30 ٪ (SWHC) أعطت أقل وزن جاف للنمو الخضرى 9.54 و8.24 غرام نبات $^{-1}$ على التوالي مقارنة مع معاملة المقارنة. نتيجة لذلك، أدت زيادة ظروف الجفاف إلى تعزيز نمو الجذور ونسبة الجذرى إلى المعدل الخضرى. سجلت أعلى زيادة في الوزن الجاف للجذور ونسبة الجذور إلى المعدل الخضرى 25.96 غم نبات $^{-1}$ و3.19 تحت ظروف الجفاف الشديد. أقل كمية من الكلوروفيل 2.94 ملغ $F W^{-1}$ غرام سجلت تحت 30 ٪ (SWHC). وجد أيضا أن المحتوى الكلي للكلوروفيل في الأوراق انخفض بشكل كبير 5.86 و7.88 ملغ $F W^{-1}$ تحت كلا المستويين في حين أن أعلى نسبة للكلوروفيل a:b كانت 1.59 مسجلة بنسبة 60 ٪ من(SWHC). أدنى المستوى محتوى المياه النسبية (LRWC ٪).سجل 86 ٪ تحت 30 ٪(SWHC) . قد تفسر هذه النتائج صفات النمو المبكر والاستجابات الفسيولوجية لشجرة *Brachychiton populneus* للتجفاف وتسهيل اختيار عوائل الأشجار المقاومة للجفاف.