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Studies on water requirements of *Paulownia* hybrid T121 seedlings

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ABSTRACT:

The present study was conducted at the experimental area of Horticulture Research Station at El-Kanater El-Khayria, Qalyubia Governorate, Egypt, throughout two seasons of 2019 and 2020 to estimate water requirement of *Paulownia* hybrid T121 seedlings irrigated at three regimes each 3, 5 and 7 days intervals .The obtained results indicated that, all parameters of vegetative growth e.i, seedling height , stem diameter , leaves area, biomass fresh and dry weights significantly exceeded when irrigated each 3 days interval followed by 5 days then 7 days was the latest one. Meanwhile root length was the longest at 7 days interval and the shortest was with 3 days. The amounts of irrigation water applied and water consumption (L/seedling) increased under irrigation at 3 days intervals since gave the highest significant water applied and consumption followed by irrigation at 5 days interval, then the latest at 7 days interval. Average of water productivity at 3 days interval declared that, one liter of water applied produced 4.45 and 1.16g biomass fresh and dry weights respectively. While at 5 days it gave 3.99 and 0.98 g in addition, at 7 days interval induced 3.95 and 0.93 g biomass fresh and dry weight during two seasons respectively. Also water use efficiency (WUE) was influenced by different irrigation intervals and the differences between 3 and 5 or 7 days intervals were significant in two seasons due to reduction of biomass fresh or dry weights, furthermore, *Paulownia* hybrid T121 had taken higher amount of water applied and water consumption but the most has been depleted by higher transpiration without using it in metabolism synthesis. Total chlorophyll was influenced by different water regimes it is significantly increased at abundance of water at (3 days) intervals meanwhile total carbohydrate and proline content significantly decreased at same water regimes of (3days) and the opposite occurred at water stress of (7 days).

The obtained results indicated that, it is not preferable mainly to depend upon *Paulownia* spp. in setting up forestation schemes owing to poverty of water resources in Egyptian condition. Therefore it can be recommended that economically can depend on another fast-growing timber trees species in a forestation.

KEY WORDS: *Paulownia* spp. – Water requirements – Growth – Biomass fresh and dry weight –Water productivity- Water use efficiency.

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1. INTRODUCTION:

Paulownia sp. is a deciduous, fast growing, hardwood tree (family Paulowniaceae, previously in the family Scrophulariaceae) comprised of nine species and a few natural hybrids that are native to China **(Freeman et al., 2012)**. Craftsmen have utilized it as revered wood in ceremonial furniture, musical instruments, decorative moldings, laminated structural beams and shipping containers.

The optimization of water use resources is strategic for the long-term competitiveness of the agricultural industry. Water management is considered one of the major challenges of the near future **(Saguy et al., 2013)**. In fact, by 2030, water demand is expected to be 50% higher than today and withdrawals could exceed natural renewal by over 60%, resulting in water scarcity **(Nestlé, 2011).**

The need of water which is a main element for survival of all living beings, is gradually increasing, because, the demand of the population is constantly growing and modern lifestyle promotes excessive consumption of water, and on the other hand, the decrease in water availability due to pollution is affecting the natural water resources. This requires a global intervention to rationalize the use of the mobilized water, especially in agriculture which is a major water consumer, on the other hand, the world faces very serious global warming, which will produce a general warming and significantly increase the evaporative demand and the irrigation requirement for crops. For this reason, irrigation efficiency is becoming increasingly important in arid and semi-arid regions with limited water resources. Therefore, it is necessary to adopt specialized and efficient methods of irrigation, such as drip irrigation. In order to achieve the twin objectives of higher productivity and optimum use of water (**Gercek et al., 2009**). *Paulownia* spp. consumes about 2000 litters of water per tree to reach a production of 4,3 t/ha during the first cut (**Francisco et al., 2014**).

The adequate conditions for the Paulownia cultivation are attained in a height of 200 – 1300 m above the sea level with an average of the annual temperature 15 – 23oC and annual rainfalls 1400 – 2800 mm (**Navroodi, 2013).**

Paulownia spp. has a very large leaf area with a high transpiration rate, and has a well developed root system. Therefore, sufficient moisture is very important for Paulownia growth. However, the annual precipitation in the extensive areas where Paulownia is growing either naturally or cultivated varies greatly, from as low as 500 mm to a maximum of 2,000-3,000 mm as it is in Taiwan.

Although *Paulownia* spp. has showed a great adaptation to a wide range of soils (pH ranged from 5.0 to 8.9) and this genus is sensitive to soil salinity (**Zhu et al., 1986**). Poor drainage (a clay component greater than 25% and porosity of below 50% are not suitable; It is well-known that Paulownia plantations should be managed with intensive regimes with frugality water and nutrient supply (**Barton et al., 2007**).

In Mediterranean climate, Paulownia production is affected negatively by evapotranspiration, (**Durán et al., 2013**). Application of water and fertilizer results in considerably enhanced forest plantation growth but the influencing effect of water depends primarily on soil fertility and water availability (**Campoe et al., 2013**). However, abundance supply of water is essential to paulownia growth and the size of individuals of a given species can vary several folds in response to variation in moisture level **(Bargali and Tewari, 2004).**

Therefore, the objective of this study was to investigate the water requirements of *Paulownia hybrid (T121)* seedlings grown in sandy loam soil as reclaimed soils.

2. MATERIALS AND METHODS:

The present investigation has been carried out at an experimental farm of Horticultural Research Station of El-Kanater

El-Khyria, Qaluobeia Governorate, Egypt, in the two seasons, 2019 and 2020.

The seedlings were irrigated up to field capacity after that, the seedlings were divided into three treatments of water irrigation intervals namely 3 days, soil moisture content ranged of field capacity (100-70%) , 5 days, soil moisture content ranged of field capacity (100-55%) and 7 days, soil moisture content ranged of field capacity (100-40%) represented, non-water stress, medium and stressed soil moisture content respectively.

The seedlings were irrigated by limited average 4 liter of Nile water for every interval throughout the summer months of April, May, June, July, August, and September, while average 2.5 liter were used during October, November, December, January, February and March.

Seedlings of a *Paulownia* hybrid (T121) three months old. A uniform seedlings, 25.0 cm height and 0.5 cm diameter at soil surface produced from tissue culture research lab., Horticulture Res. Instit., Agricultural Research Center, Giza. Ex vitro acclimatization was carried out at green house appendix to the lab.

ORIGIN: Paulownia (T121) Hybrid of *Paulownia elongata x Paulownia fortunei.*

Bio Tree LTD 7 Shose Bankya str Shose Bankya str www.biotree.bg;www. paulowniatree.eu.

Particle size distribution, some chemical properties and soil-moisture content, of the bag soil were determined according to **Klute** and **Dirksen (1986)** and **Ryan *et al.*, (1996)** are listed in Tables (1 and 2), respectively.

Table 1. Field capacity wilting point, available water and bulk density of soil at various depths.

Depths	Field capacity (F.C.) %	Wilting point (WP) %	Available water (AW) %	Bulk density (BD) g/cm^3
0-20	15.90	2.54	13.36	1.63
20-40	14.56	2.53	12.03	1.65
40-60	13.83	2.50	11.33	1.67

FC: moisture at 33 kPa moisture tension. WP: moisture at 1.5 MPa moisture tension.
AW = FC – WP

Table 2. Physical and chemical properties of the used soil under study during 2019 and 2020 seasons.

Season	Practical size distribution (%)								Cations (meq/L)				Anions (Meq/L)			
	Coarse sand	ine san	Silt	Clay	Soil texture	pH soil: water susp., 1:2.5	F.C. 1/3 bar%	EC, dSm-1 soil: water ext., 1:2.5	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO_3^{--}	HCO_3^{-}	Cl^{-}	SO_4^{--}
2019	22.10	35.30	25.10	17.50	Sandy loam	7.75	15.9%	1.60	2.20	1.70	4.1	0.4	-	2.32	3.5	2.54
2020	22.13	35.32	25.08	17.47		7.72	15.5%	1.68	2.22	1.71	4.1	0.4	-	2.30	3.6	2.55

E.C. = Electrical conductivity. F.C. = Field capacity. Meq/L – Milie equivalent per liter.

The monthly averages of weather factors for El-Kanater El-Khyria, Qaluobeia Governorate during two seasons, 2019 and 2020 are recorded in Table (3). Meteorological data for the Agricultural Research Station are shown in Table (3

Table 3. Meteorological data in 2019 and 2020 seasons.

Month	2019						2020					
	T.max	T.min.	W.S	R.H.	S.S	R.F	T.max	T.min.	W.S	R.H.	S.S	R.F
February	20.4	6.8	2.2	62.6	8.1	5.1	22.8	10.1	2.0	57.0	8.2	5.1
March	24.8	10.4	2.7	51.3	8.2	32.5	28.7	11.7	2.5	42.3	8.5	5.5
April	28.9	12.4	3.0	45.4	9.2	9.6	30.8	14.2	2.6	41.0	9.4	28.3
May	34.5	17.4	3.1	37.1	10.2	1.9	35.6	19.2	3.1	38.0	10.3	1.2
June	38.0	20.3	3.2	36.2	11.3	0.0	37.8	21.2	3.1	36.1	11.4	0.0
July	40.1	22.8	3.0	37.6	12.0	0.0	39.0	22.4	3.0	40.8	12.5	0.0
August	38.6	22.8	2.8	42.6	11.8	0.0	38.4	22.6	2.9	45.1	11.6	0.0
September	36.2	19.8	2.8	45.9	11.1	0.0	36.3	21.0	2.7	47.1	11.2	0.0
October	30.4	16.7	2.6	52.2	10.3	14.4	31.7	18.1	2.7	50.8	10.5	4.8
November	24.7	12.5	2.2	62.0	9.0	61.8	26.5	14.2	2.1	55.9	9.4	6.1
December	20.4	10.4	2.1	62.6	8.5	2.4	20.5	9.7	2.6	63.3	8.6	9.0
January	19.1	7.7	2.8	68.3	8.1	29.8	18.8	6.2	2.9	50.1	8.3	2.1

where: T.max., T.min.= maximum and minimum temperatures °C; W.S = wind speed (m/ sec); R.H.= relative humidity (%); S.S= actual sun shine (hour) and RF = rainfall (mm / month).

[Data were obtained from the agro meteorological Unit at Soils, Water and Environ. Res. Inst., Agriculture Research Center]

Seedlings were carefully selected as being healthy and approximately uniform in their vigor, shape , size and planted individually in 1st week of March 2019 and 2020 into plastic bags 40cm diameter and 60 cm depth filled with 25 kg of sandy loam soil as reclaimed soils transported from Belbiese desert in El-Sharkia Governorate, Egypt.

The seedlings were fertilized by 5.0g of Kristalon 19 :19 :19 as a resource of NPK and was applied twice with equal doses, the first addition after one month from transplanting (April) and the second one in mid June in the two seasons.

The seedlings were placed in shade area and after one month from cultivation ,the seedlings were subjected outdoors to sunny area above sheets of thick polyethylene to prevent penetrate the growing roots into soil outer bags.

A. Determination of vegetative growth:

1. Seedling height (cm).

2. Stem diameter (cm) was determined at ground surface by vainer Caliper.

3. Leaf area (cm^2): leaf area was recorded at the end of both seasons where samples of leaves from the medium part of stem have taken and measured photometrically using a digital leaf area meter (LI –3000 Portable Area Meter), (L I- COR, LINCOLN, NEBRASKA, USA).

4. Root length (cm) plants of each treatment were accurately up rooted from the bag and roots were washed carefully to preserve the hairs root. Length of main root was determined from soil surface to the farthest point of root.

5. Fresh and dry weights biomass.

Fresh weight of roots, stems and leaves were estimated by weighing each portion individually, then the fresh weight of whole plant (fresh biomass) accounted.

The fresh portions of seedlings were subjected in oven dry at 70 °C until constant weight, then the dry weight of each portion, (roots, stems and leaves) were recorded and the dry weight of whole plant (dry biomass) was estimated for each treatment in both seasons.

B. Water determinations:

1-Transpiration rate: Transpiration rate was determined (mg/g fresh weight of plant /hour by weighing method **(Rawat et al. 1985).**

2- Applied irrigation water (AIW) L/seedling: Was determined as accumulated amounts of added water to the seedlings at each irrigation during entire growing season under the assessed irrigation intervals according to the equation given by **Vermeiren and Jopling (1984**) as:

$$\textbf{Applied irrigation water (AIW)} = \frac{\text{Water consumption use (CU)}}{\text{Ea}}\ \text{LR}$$

AIW = applied irrigation water depth (liters/day).
CU = sum of depletion soil moisture in each soil layer (60 cm)
Ea = irrigation efficiency
LR = leaching requirements

3- Water consumption use (CU) L/seedling: was determined as accumulated amounts of added water to the seedlings at each irrigation to attain field capacity point during the entire growing season under the assessed irrigation intervals. Water consumption use (CU), values were determined according to **(Cataldo *et al.*, 2017).** The CU values were calculated according to **Israelsen and Hansen (1962)** using the following equation:

$$CU = \sum_{i=1}^{i-4} \frac{\theta 2 - \theta 1}{100} \times d$$

Where:
CU = water consumption use or actual evapotranspiration, ETa (mm).
i = number of soil layer.
θ2 = soil moisture content after irrigation, (%, by volume).
θ1 = soil moisture content just before irrigation, (%, by volume).
d = depth of soil layer, (mm).

4- Water productivity (WP): : Water productivity was estimated according to (**Zhang, 2003**) as follow:

$$\textbf{W.P} = \frac{\text{Biomass (g)/plant}}{\text{Water applied (W.A)}}$$

5- Water use efficiency (W.U.E) gm/l: Water use efficiency was estimated according to **Smith (2002)** as follows:

$$\text{W.U.E} = \frac{\text{Biomass (g)/plant}}{\text{Water consumption use (CU)}}$$

C. Chemical Analysis.

The following data were analyzed chemically at the end of September in both seasons (2019 and 2020)

1- **Total chlorophylls (mg/g fresh weight of leaves)**:were extracted with dimethyl formamide solution according to **Mornai (1982)**
2- **Proline determination:** Proline mg/100g.f. w. determined as described by **Bates et al., (1973)**.
3- **Total carbohydrate %:** in stems were determined as percentage described by **Dubasit et al. (1956)**.

Layout of experiment:

45 seedlings for this study divided to 3 treatments, each treatment includes 3 seedling and 5 replicates, which were arranged in a complete randomized block design.

All the obtained data during this study was subjected to analysis of variance method according to **Snedecor and Cochran (1989)**. The means were compared using Least Significant Difference LSD at 5 % probability level according to **Waller and Duncan (1969).**

3. RESULTS AND DISCUSSION:

Effect of irrigation intervals on vegetative growth of *Paulownia* hybrid (T121) seedlings during 2019 and 2020 seasons.

1- Seedling height, stem diameter and leaf area:

Data presented in Table (4) indicated that, seedling height, stem diameter and leaf area decreased in a descending order as the irrigation intervals were 3, 5 and 7 days, which the values were (119.0,87.0and 64.0 cm) for seedling height,(5.01, 2.04 and 1.80 cm) for stem diameter and (473.5, 258.17 and 201.40 cm^2) for leaf area, all for the first season.

In the second one the data take the same trend for the same studied traits. It means that seedlings of *Paulownia* hybrid T121 grew higher under non water stressed . The differences between 3 and 5 or 7 days were significant while the differences between 5 and 7 days intervals were insignificant in two seasons.

Table 4. Effect of irrigation intervals, on seedling height, stem diameter, leaf area of *paulownia* hybrid (T121) seedlings during (2019)and (2020) seasons.

Irrigation intervals	Seedling height (cm)	Stem diameter (cm)	Leaf area (cm^2)
		1st season (2019)	
3day	119.00	5.01	473.50
5day	87.00	2.04	258.17
7day	64.00	1.80	201.40
L.S.D. at 5 % =	**5.70**	**1.10**	**10.30**
		2nd season (2020)	
3day	133.00	5.20	481.00
5day	98.00	2.13	263.00
7day	73.00	1.82	212.00
L.S.D. at 5 % =	**6.0**	**1.12**	**11.13**

These findings go parallel with those obtained by **Khalil and Abd El-Kader (2011)** on *Hibisicus sabdariffa* and **Khattab et al. (2011)** on pomegranate they stated that, a positive response due to increased water supply and was essentially in vegetative growth. Whereas, **Sebastiani et al., (2012),** mentioned that, different irrigation levels significantly modified plant physiological conditions and vegetative growth of olive cultivars and **Garofalo and Rinaldi (2013)** on sorghum reported that, reduction of green leaf area index (GAI) in sweet sorghum, as a result to reduction in water supply.

The reduction in plant growth under low soil moisture condition may be due to water stress caused losses in plant tissue which reduced turgor pressure in the cell, thereby inhibited enlargement and division of cells and caused a reduction in the uptake of nutrient elements thus causing disturbance in the physiological processes needed for plant growth.

2- Root length, biomass fresh and dry weight:

Data in Table (5) indicated that, root length exhibited an adverse trend where the longest root (59.80 and 60.00 cm) was obtained due to irrigation at 7 days interval whilst, irrigation at 3 or 5 days intervals resulted in shortest roots reached (48.40 and 49.50 cm) and (53.12 and 54.16 cm), in two seasons respectively. The differences among of irrigation intervals, on root length were significant. Such results could be justified that, under soil moisture stress (irrigation at 7days interval) the roots can deeper searching for more soil moisture to complete the plant life cycle. In connection, **El-Sayed et al. (2010)**, on some crops, **Abd El-Latif et al., (2012)** on maize plant and **Al-Atrash** and **Abd El-Latif (2014)** on *Dalbrgia sisso* seedlings. All of them reported that as the irrigation level was sloping down ward the longest root system was found, while the longest roots correlated with the deficit soil moisture content, in agreement with the finding of **Shehata (2002)** on *Khaya senegalensis* also **Moroni et al., (2003).** On *Ecalyptus globules* where they confirmed that root length were greater in drought than those abundance of soil moisture.

Data in Table (5) obviously cleared that, biomass fresh and dry weight affected by different water irrigation intervals since the plants subjected to water stress irrigated every 7 days had the inferior values of (610.0 and 615.0 g.) and (150.20 and 153.00g.) while, those subjected to non-water stress irrigated every 3 days had the superior values of (1620.0 and 1631.0 g) and (420.0 and 425.0 g) followed by those irrigated every 5 days interval in which the fresh and dry weight of biomass were intermediate which gave (870.0 and 877.0 g) and (211.0 and 217.0 g) in first and second seasons respectively, however the differences among 3, 5 and 7 days interval were significant in two seasons.

Table 5. Effect of irrigation intervals, on Root length (cm), biomass fresh and dry weight of *Paulownia* hybrid (T121) seedlings during (2019)and (2020) seasons.

Irrigation intervals	Root length (cm)	Biomass fresh weight (g)	Biomass dry weight (g)
		1st season (2019)	
3day	48.40	1620.00	420.00
5day	53.12	870.00	211.00
7day	59.80	610.00	150.20
L.S.D. at 5 % =	**2.5**	**12.35**	**9.10**
		2nd season (2020)	
3day	49.50	1631.00	425.00
5day	54.16	877.00	217.00
7day	60.00	615.00	153.00
L.S.D. at 5 % =	**2.12**	**13.31**	**9.17**

The aforementioned results showed that, irrigating the seedlings at water stress resulted in markedly reduction in biomass fresh and dry weight, while the opposite occurred when seedlings were subjected to nun-water stress and **Hassan and Seif (1999)** on Apricot trees reported that, yield increased with increasing soil moisture content. **Wiesław et al**., **(2017)** on *Paulownia* hybrid Shan Tong found that biomass fresh weight was significantly increased with increasing the irrigation plus rainfall. **Rinaldi et al., (2014),** on tomato the well watered regimes actual evapotrnspireation (ET125 and ET100) provided for a greater biomass accumulation (+17%) and yield (+20%) in term of fresh weight if compared with the deficit regimes (ET75 and ET50), **Garofalo and Rinaldi** (**2013)** on sorghum reported that, a fewer advantage in term of fresh and dry matter of biomass sorghum in drought conditions**.**

Water determinations:

- Effect of irrigation intervals, on water relations of *Paulownia* hybrid (T121) seedlings during (2019) and (2020) seasons.

1- Transpiration rate (mg/g fresh weight /hour):

As shown in Table (6) obviously cleared that, transpiration rate affected by different water irrigation intervals since the seedlings subjected to water stress irrigated every 7 days had the values of 160 mg/g fresh weight

/hour while, those subjected to non-water stress irrigated every 3 days had the superior values of 230 mg/g fresh weight /hour due to the effect of amended the water status in internal tissues of plants, followed by those irrigated every 5 days interval in which the transpiration rate was intermediate 200 mg/g fresh weight/ hour in the first season. Also the mean values were 226, 186 and 153 mg/g fresh weight/hour when the plants were irrigated at 3, 5 and 7 days in the second season, respectively. The differences among the irrigation intervals were significant during 1st and 2nd season. The previous results showed that, irrigating the seedlings at water stress resulted in slightest reduction in transpiration rate in this case, while the contrast occurred when seedlings were subjected to non-water stress. These results are in harmony with those reported by **Cochard et al., (2002)** and **Scheiber et al. (2008)** on *Solenostemon scutellarioides* (coleus). All of them cleared that, transpiration rate increased as irrigation intervals decreased.

Table 6. Effect of irrigation intervals, on Transpiration rate (mg/g f. w./hour, irrigation water applied (L/bag) and Water consumption use (L/seedling) of *Paulownia* hybrid (T121) seedlings during (2019) and (2020) seasons.

Irrigation intervals	Transpiration rate (mg/g f.w /hour)	Applied irrigation water (L/seedling)	Water consumption use (L/seedling)
		1st season (2019).	
3 day	230.0	365.0	271.0
5day	200.0	219.0	162.0
7day	160.0	156.0	115.0
L.S.D. at 5 % =	**6.9**	**8.40**	**7.80**
		2nd season (2020).	
3 day	226.0	366.0	275.0
5day	186.0	218.0	164.0
7day	153.0	158.0	117.0
L.S.D. at 5 % =	**6.2**	**8.51**	**7.91**

2- Applied irrigation water (AIW) L/seedling:

Data presented in Table (6) clearly showed that, the values of water applied increased under irrigation at 3 days intervals since gave the highest significant water applied of 365.0 L/bag as a results to frequency irrigation regimes followed by irrigation at 5 days interval, which gave 219.0 L/bag then the latest at 7 days interval 156.0 L/seedling. Also, results revealed that irrigation at 7 days treatment could reduce about 134 % of the applied water compared with irrigation at 3 days treatment in 1st season whereas in the second one the seedlings irrigated at 3 or 5 days period revealed excessive values to the maximum of 366.0 and 218.0 L/seedling respectively more than those irrigated at 7 days which recorded 158.0 L/seedling and the differences were significant in among them . These results are in coincided with those reported by **Malidarreh (2010)** on *Triticum aerstivum* L, **Badel et al. (2013)** on wheat, **El-Agrodi et al. (2016)** *Triticum aestivum* L and **Khalifa (2016)** on wheat they stated that obtained results are in the same direction with that reported by **Chen et al**., (**2014)** on wheat**,** water applied (WA) was increased with decreasing number of irrigation periods.

3- Water consumption use (CU) L/seedling:

Regarding effect of the assessed irrigation intervals on water consumption use (CU) L/seedling) of *paulownia* hybrid T121 seedlings. Data presented in Table (6) cleared that, the values of (CU) L/g significantly increased under irrigation at 3 days which gave 271.0 L/bag followed by irrigation at

5days which gave 162.0 L/ seedling then the latest one exhibited at 7 days , which gave 115.0 L/seedling. Also, data revealed that irrigation at 3 days, could increase water quantity percentage about 67 % and 136% of (CU) L/seedling , over with irrigation at 5 and 7 days, in the first season respectively. .On the other hand, the results of second season were similar to those of the first one and appeared significant differences among the treatments. Higher water use value increased due to frequent irrigation practice, which led to more absorbed moisture by the seedling roots. These results were in harmony with those obtained by **Yasin et al. (2003)** and **Mady (2004)** on some rice cultivars stated that, more frequent irrigation events provide high evaporation opportunity from the relatively wet rather than dry soil surface. **Mahmoud and Abd El-Monem (2017)** on rice crop they found that water consumption use (CU) depressed as water stress increased and the opposite occurred with increasing soil moisture content**,** **Amer et al., (2016)** on wheat and sunflower they found that, the highest water consumption use (CU) occurred when irrigation was done upon reaching the soil moisture content to 35 or 50 % of available soil moisture depletion more than 65 % depletion of available soil moisture. This effect of irrigation treatments on water consumption use might be attributed to the increase for water applied. So, the values of water consumption use were decreased as soil available water decreased. These results are in agreement with herein present study**.**

4- Water productivity (WP) g/l:

Data in Table (7) cleared that, water productivity (WP) for biomass fresh or dry weight slightly affected by different water irrigation intervals since the seedlings subjected to non- water stress irrigated every 3 days had the values of 4.43 and 1.15 g /l. followed by irrigated every 5 days had the values of 3.97 and 0.96 g/l. while, those subjected to water stress and irrigated every 7 days gave 3.91and 0.90 g/l in the first season respectively. Similar trend was noticed with the water productivity (WP) for biomass fresh or dry weights in the same order of irrigation intervals treatments in the second one due to lower biomass fresh or dry weight and excessive water use for *Paulownia* hybrid T121 seedlings caused reduction in (WP). However, the differences between 3 and 5 or 7 days were significant while the differences between 5 and 7 days intervals were insignificant in two seasons. These results were in harmony with those recorded by **Goldhamer et al. (2006)** on almond, **El-Souda (2011), Mellisho et al. (2012)** and **Yun et al. (2019)** on apple. They mentioned that, tree productivity was significantly declined by increasing irrigation deficit of different fruit species. **El-Souda et al. (2021)** on Pecan trees found that irrigation level 75% actual evapotranspireation (Etc) decreased vegetative growth, nut weight, yield and water utilization efficiency compared to irrigation levels 100 and 125% ETc.

Table 7. Effect of irrigation intervals, on water productivity (WP) for fresh and dry weight of *paulownia* hybrid (T121) seedlings during (2019)and (2020) seasons.

Irrigation intervals	Water applied (l/seedling)	Water productivity for fresh weight g/l	Water productivity for dry weight g/l
		1st season (2019)	
3day	365.00	4.43	1.15
5day	219.00	3.97	0.96
7day	156.00	3.91	0.90
L.S.D. at 5 % =	**4.30**	**0.27**	**0.07**
		2nd season (2020)	
3day	366.00	4.46	1.16
5day	218.00	4.02	1.00
7day	158.00	3.99	0.96
L.S.D. at 5 % =	**4.00**	**0.25**	**0.07**

5-Water use efficiency (WUE)g/l:

Data in Table (8) illustrated that, water use efficiency (WUE) influenced by different irrigation interval**,** the main effect of irrigation treatments showed that, irrigation at 7 days interval gave the lowest values of WUE which gave 5.30 for fresh weight and 1.30 for dry weight compared with 3 days which gave 5.97 for fresh and 1.55g/l for dry weight, meanwhile 5 days interval gives 5.37 for fresh weight and 1.31g/l for biomass dry weight, in the first season, respectively. The differences betwee3 and 5 or 7 days were significant while the differences between 5 and 7 days intervals were insignificant. In the second season, the results had taken the same trend but the values were different where they were 5.96 & 1.54 g/l, 5.93 & 1.32 g/l and 5.25 & 1.30 g/l for fresh and dry weight in the seedlings irrigated at 3, 5 and 7 days interval respectively. The differences between 3 and 7 days intervals were significant for fresh and dry weight but the differences between 3 or 5 days intervals for fresh weight and 5 or 7 days intervals for dry weight insignificant.

Table 8. Effect of irrigation intervals, on Water use efficiency (W.U.E) for fresh and dry weight of paulownia hybrid (T121) seedlings during (2019) and (2020) seasons.

Irrigation intervals	Water consumption (l/seedling)	Water use efficiently for fresh weight (g/l)	Water use efficiently for dry weight (g/l)
		1st season (2019)	
3day	271.00	5.97	1.55
5day	162.00	5.37	1.31
7day	115.00	5.30	1.30
L.S.D. at 5 % =	**7.80**	**0.31**	**0.09**
		2nd season (2020)	
3day	275.00	5.96	1.54
5day	164.00	5.93	1.32
7day	117.00	5.25	1.30
L.S.D. at 5 % =	**7.91**	**0.33**	**0.10**

The previous results were in the same line of those obtained by **Goldhamer et al., (2006)** on almond, **Mellisho et al., (2012)** and **Yun et al., (2019)** on apple. They reported that, WUE depressed as water stress increased and the opposite occurred with increasing soil moisture content, **El-Souda et al., (2021)** on Pecan trees found that irrigation level 75% ETc decreased water utilization efficiency compared to irrigation levels 100 and 125% ETc.

- Effect of irrigation intervals, on chemical composition of *Paulownia* hybried T121 seedlings during (2019) and (2020) seasons.

1- Total chlorophyll (mg/g.f.w.):

Data in Table (9) showed that, total chlorophyll in the 1st and 2nd seasons significantly increased in the leaves of *Paulownia* hybrid (T121) which irrigated at 3 days intervals reached 1.87 mg/g f.w. more than those irrigated at 5 or 7 days which reached 1.79 & 1.66 mg/g f.w. in the first season while the values were in the second one, 1.80, 1.70 and 1.60 mg/g f.w, respectively. These results were in harmony with those obtained by **Ibrahim-Soad (2005)** on Jojoba seedlings and **Azza et al., (2006)** on *Taxodium distichum*. Also **Abd-Elaziz (2000)** on *Azadirachta indica* where they found that, high soil moisture content considerably increased total chlorophyll content, also **Dunisch et al., (2002)** showed that, the net photosynthesis of *Swietenia macrophlla* and *Cedrela odorata* strongly depends on high water of the plants .

2- Total carbohydrate (%):

Data in Table (9) illustrated that, total carbohydrate in stem influenced by different irrigation intervals in which it significantly increased with 7 days interval by average of 11.73% compared with 3 or 5 day intervals which reached 7.83 and 11.04 % respectively, in the first season and reached 7.25, 10.93 and 11.40% respectively, in the second one when the seedlings irrigated at 3,5 and 7 days intervals . The differences among three irrigation intervals were significantly in both seasons.

From the obtained previous results, it can be concluded that, drought stress condition resulted in rising up total carbohydrate in stem and the opposite was occurred in non-water stress. These results were agreement with **El-Tantawy et al. (1993)** on *Eucalyptus camaldulensis*, and **Abd El-Latif et al. (2012)** stated that, the irrigation treatments insignificantly affected total carbohydrate in maize grains contents, however, higher values were noticed due to irrigation at 45% available soil moisture depletion (ASMD) regime compared to 60% (ASMD). All of them declared that, total carbohydrate increased in stem of seedling subjected to reduction of water supply Also, **Al-Atrash, et al., (2015)** on *Pinus roxburghii*, illustrated that, total carbohydrate in stem influenced by different irrigation periods in which it significantly increased with 8 days period compared to 4 or 6 days in both season. It may be due to the abundance of water irrigating at 3 days interval ameliorated vegetative growth parameters used stored carbohydrate of stem in formation and differentiation recent portions which consumed more carbohydrate led to a decreasing it in stem .These results in were agreement with **Hendawy (2008)** on *Plantago arenaria* who indicated that, increased compost tea from 200 to 300 ml/l resulting high soil moisture content, significantly decreased total carbohydrates content.

Table 9. Effect of irrigation intervals, on total chlorophyll mg/g f.w, total carbohydrate %,and Proline of *Paulownia* hybried T121 seedlings during (2019)and (2020) seasons.

Irrigation intervals	Total chlorophyll (mg/g f.w)	Total carbohydrate (%)	Proline (mg/100g)
		1st season (2019).	
3day	1.87	7.83	0.71
5day	1.79	11.04	0.80
7day	1.66	11.73	1.03
L.S.D. at 5 %	**0.07**	**0.34**	**0.08**
		2nd season (2020).	
3day	1.80	7.25	0.69
5day	1.70	10.93	0.85
7day	1.60	11.40	1.10
L.S.D. at 5 %	**0.08**	**0.28**	**0.09**

3- Proline (mg/100g) fresh leaves.

As shown in Table (9) proline contents in fresh leaves of *Paulownia* hybrid T121 significantly increased in average value of 1.03 and 1.10 mg/100 g f.w in 1st and 2nd season owing to exposed drought stress represented irrigated every 7 days. Meanwhile the seedlings irrigated every 3 days intervals as a result to non-water stress proline contents in leaves reduced to minimum values of 0.71 and 0.69 mg/100g. f. w. On the other hand, exposing seedlings to medium water stress 5 days irrigation period, proline content was intermediate, which reached 0.80 and 0.85 mg/100g f. w. in1st and 2nd seasons, respectively. The differences among different irrigation intervals were significant during 1st and 2nd seasons.

The former obtained results indicated that leaves proline content increased clearly with drought stress conditions causing high osmotic pressure in plant cells consequently associated in drought tolerance. In accordance with the findings of **Shvaleva et al., (2005)** on *Eucalyptus globules*, **Azza et al**. **(2006)** on *Taxodium distichum* and **El-Quesni et al., (2010)** on *Schefflera arboricola*. They observed increases in concentration of proline with drought stress.

CONCLUSIONS :

It can be concluded from the herein results that, unfavorable to depends on *Paulownia* spp. as a forestation under condition of Egypt in which the shortage water supply and it demands the greater amount of water applied and consumption in spite of gives less biomass dry weight causing reduce of water use efficiency (WUE). So advises substitution another types object high economic recurrent such as fast-growing timber trees species in a forestation.

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الملخص العربي

دراسات على الاحتياجات المائية لشتلات هجين البولونيا (T121)

أجريت هذه الدراسة في محطة بحوث البساتين بالقناطر الخيرية، محافظة القليوبية خلال موسمين هما 2019 و2020 لتقدير الاحتياجات المائية لهجين البولونيا ت 121، حيث رويت عند ثلاث فترات ري 3، 5 و7 أيام ، وفيما يلي ملخص لأهم النتائج:-

- جميع القياسات الخضرية هى النمو الطولي والقطر للساق ومساحة سطح الورقه وكذلك وزن الكتلة الحيوية الطازجة والجافة قد زادت عند الري كل 3 أيام يليها الري عند 5 أيام وأقل القيم تم الحصول عليها عند الري كل 7 أيام، في حين زاد طول الجذر عند الري كل 7 أيام وقل عند الري كل 3 أيام.
- كميات المياه المضافه والمستهلكه زادت عند الرى كل 3 أيام يليها 5 أيام وفى الأخير كانت عند الرى كل 7 أيام.
- قل معدل النتح عند فترة 7 أيام بينما زاد عند فترة 3 أيام في حين كان متوسطاً عند الري كل 5 أيام.
- متوسط إنتاجية وحدة المياه خلال الموسمين عند الري كل 3 أيام ان اللتر الواحد من الماء يعطى 4.45 & 1.16 جم/لتر في حين أن الري كل 5 أيام أعطى 3.99 & 0.98.جم /لتر وأن الري كل 7 أيام قد أعطى 3.95 & 0.93. جم/لتر كتلة حيوية طازجة وجافة على الترتيب.
- تأثرت كفاءة استخدام الماء تأثرا معنويا باختلاف فترات الرى حيث تحتاج البولونيا ت 121 كميات كبيره من الماء المضاف والمستهلك حيث يستنفذ هذا الماء عن طريق النتح دون استخدامه فى عمليات البناء.
- زاد الكلوروفيل الكلي معنويا عند توفر المياه حيث الري كل 3 أيام بينما حدث العكس عند تعرض الشتلات للإجهاد المائي عند الري كل 7 أيام، في حين أن الكربوهيدرات الكليه و البرولين زاد معنويا في الشتلات التي تعرضت للجفاف عند الري كل 7 أيام.
- من النتائج السابقة يتضح أنه من غير المفضل الاعتماد على البولونيا في إقامة مشاريع التشجير لاحتياجاتها المائيه العاليه حيث الفقر في مصادر المياه خاصة في المناطق الجافة مثل الظروف المصرية، لذلك يمكن التوصية بالتشجير بأنواع اقتصاديه أخرى من الاشجار الخشبيه سريعة النمو.

الكلمات الداله: البولونيا-الاحتياجات المائيه –الكتله الحيويه الطازجه والجافه – انتاجية المياه –كفاءة استخدام المياه.