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# COMPARATIVE STUDIES ON SOME FAST-GROWING TIMBER TREES SEEDLINGS SPECIES UNDER DIFFERENT IRRIGATION TREATMENTS

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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, during the two seasons 2019 and 2020, aiming to determine the best growth characters for three species of timber trees viz. *Populus nigra*, *Paulownia* hybrid T121 and *Cedrela odorata* irrigated under three irrigation rates 30, 45 and 60 % of the available soil moisture depletion (ASMD). The obtained results from the combined analysis of two seasons illustrate that the *Populus nigra*, *Paulownia* hybrid T121 and *Cedrela odorata* achieved the highest significant seedling height, stem diameter at 30% followed by 45% meanwhile 60% was the least. Also, *Paulownia* hybrid T121 recorded the highest significant of seedling height, stem diameter and biomass fresh weight followed by *Populus nigra* meanwhile *Cedrela odorata* was the last one at different (ASMD). On the other hand, *Populus nigra* significantly gave the longest root length and *Cedrela odorata* was the intermediate, whilst *Paulownia* hybrid T121 deduced the shortest one at 60 % (ASMD). *Populus nigra* significantly produced the highest values of dry biomass followed by *Cedrela odorata* meanwhile *Paulownia* hybrid T121 achieved lowest values at the different (ASMD). Moreover, *Cedrela odorata* significantly exhibited the highest values of carbohydrates while *Paulownia* hybrid T121 was the least and *Populus nigra* was in between in case of irrigating the seedlings at 45 and 60 % depilation. *Paulownia* hybrid T121 had taken more irrigation water applied and water consumption followed by *Populus nigra* while *Cedrela odorata* was the least at different (ASMD). As for that, *Populus nigra* seedlings recorded significantly highest water productivity and water use efficiency (WUE) followed by *Cedrela odorata* while *Paulownia* hybrid T121 recorded the least especially at 60 % depletion followed by 45 % and 30 % respectively.

It is worthily to notice also that, at different (ASMD) declared one liter of water applied produced 1.34, 1.00 and 1.29 gm biomass dry weight for *Populus nigra*, *Paulownia* hybrid T121 and *Cedrela odorata* respectively.

Therefore, it could be recommended from the herein results that, unadvisable a forestation *Paulownia* spp. under condition of Egypt in which it needs the greater amount of water used awing to less water productivity, less biomass dry weight causing reduce of WUE. So advises substitution anther types of object high economic recurrent such as *Populus nigra* or *Cedrela odorata* under or similar condition of this study.

**Key words:** *Populus nigra*, *Paulownia* hybrid T121 and *Cedrela odorata*- water depletion rates - Biomass fresh and dry weight –water productivity- water use efficiency.

## INTRODUCTION

In the last few years, there are a shortage in the water resources in Egypt and some other countries in Africa because of the climatic changes and no enough water for irrigation, human and industrial needs are available (Aiello *et al*., 2007).

The poplar trees (*Populous* spp.) are belonging to Salicaceae family. It is many benefits and can be used for sustainable development (Isebrands and Richardson, 2014). In many countries, also tolerate a certain degree of drought (Kang *et al*., 1996; Yin *et al*., 2005 a & b and Mao *et al*., 2008).

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Poulownia plants is one of the member of scrophlariaceae family, the tree consume about 2000 liters of water to reach a production of 4.3 ton/ha during the first cut (Francico Antonio *et al*., 2014). *Paulownia* spp. showed a great adaptation to a wide range of soils (pH ranging from 5.0 to 8.9 and it is sensitive to soil salinity (Zhu *et al*., 1986).

*Cedrela odorata* is a deciduous ornamental and forest tree under meliacene family, it grows well in caleareaus, sandy and soils rich in organic matter, it has many uses because of its hard wood (Niembra, 2010).

Therefore, the aim of this study was to determine seedlings growth of three trees species i.e., *populous nigra*, *poulownia* hybrid T121 and *Cedrela odorata* under three irrigation treatments in newly reclaimed soils.

## MATERIALS AND METHODS

A pot experiment was conducted during two season's 2019 and 2020 at El-Qanater Horticultural Research Station ($31^0$ 11' longitude, $30^0$ 28' latitude, and 14 m altitude above mean sea level), El-Qalubia Governorate, Egypt. Monthly average agro-meteorological data at the experimental site for the two growing seasons are presented in Table (1).

The soil physical, chemical properties and soil-moisture constants were taken from ground surface layer at 0-60 depth at the experimental site, determined according to Page *et al*. (1982) and Klute (1986), are listed in Tables 2 and 3.

**Table (1): Monthly average meteorological data of El-Qanater weather station during 2019 and 2020 seasons.**

| Month | T. max | | T. min. | | W.S | | R.H. | | S.S | | R.F | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 |
| January | 18.90 | 19.50 | 6.20 | 8.40 | 2.90 | 2.90 | 50.10 | 65.50 | 12.00 | 12.40 | 2.20 | 20.60 |
| February | 20.90 | 19.80 | 7.30 | 8.30 | 2.50 | 2.70 | 51.70 | 65.00 | 11.90 | 11.80 | 7.70 | 18.00 |
| March | 23.70 | 21.00 | 9.10 | 8.70 | 2.90 | 2.80 | 51.50 | 63.10 | 11.00 | 11.10 | 11.00 | 82.10 |
| April | 28.40 | 22.20 | 12.30 | 9.40 | 3.10 | 2.80 | 43.30 | 61.20 | 10.20 | 10.30 | 12.80 | 103.00 |
| May | 36.80 | 26.30 | 17.90 | 11.50 | 3.40 | 2.80 | 29.60 | 55.50 | 8.80 | 9.50 | 0.04 | 0.10 |
| June | 38.20 | 28.40 | 21.70 | 13.00 | 3.30 | 2.80 | 38.30 | 51.80 | 9.90 | 10.50 | 0.00 | 0.10 |
| July | 39.30 | 34.10 | 22.30 | 17.20 | 3.00 | 3.00 | 38.70 | 44.20 | 9.30 | 10.50 | 0.00 | 0.00 |
| August | 38.90 | 37.40 | 22.70 | 19.80 | 2.60 | 3.00 | 39.80 | 40.70 | 8.30 | 12.40 | 0.00 | 0.00 |
| September | 35.80 | 37.70 | 20.50 | 20.30 | 2.80 | 3.00 | 47.90 | 41.60 | 8.40 | 11.90 | 0.00 | 0.00 |
| October | 32.30 | 37.80 | 18.60 | 21.30 | 2.70 | 2.80 | 53.80 | 44.80 | 9.50 | 11.10 | 16.80 | 0.60 |
| November | 28.40 | 35.30 | 14.80 | 20.00 | 2.40 | 2.70 | 52.00 | 48.10 | 10.40 | 10.30 | 0.11 | 12.70 |
| December | 20.90 | 30.30 | 9.50 | 16.70 | 2.90 | 2.60 | 63.60 | 54.20 | 11.20 | 9.90 | 25.90 | 0.80 |

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 SWERI, ARC*

**Table 2. Particle size distribution and some chemical properties of the soil under study during 2019 and 2020 seasons**

| Seasons | Particle size distribution (%) | | | Texture Class | OM % | E.C (dS/m) | pH | Cations (m mole $L^{-1}$) | | | | Anions (m mole $L^{-1}$) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sand | Silt | Clay | | | | | $Ca^{++}$ | $Mg^{++}$ | $Na^{+}$ | $K^{+}$ | $HCO_3^{-}$ | $Cl^{-}$ | $SO_4^{--}$ |
| 2019 | 77.90 | 10.70 | 11.40 | Sandy | 0.54 | 1.18 | 7.80 | 2.25 | 1.52 | 4.14 | 0.65 | 0.58 | 3.10 | 0.86 |
| 2020 | 77.58 | 10.22 | 12.20 | Sandy | 0.53 | 1.16 | 7.78 | 2.26 | 1.51 | 4.13 | 0.66 | 0.56 | 3.07 | 0.73 |

**Table (3): Some soil water constants and bulk density at the experimental site.**

| Depths | Field capacity (F.C.) % | Wilting point (WP) % | Available water (AW) % | Bulk density (BD) g/cm$^3$ |
|---|---|---|---|---|
| 0-15 | 15.5 | 4.03 | 11.47 | 1.40 |
| 15-30 | 15.1 | 4.0 | 11.1 | 1.43 |
| 30-45 | 14.5 | 3.7 | 10.8 | 1.45 |
| 45-60 | 13.9 | 3.5 | 10.4 | 1.55 |

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

## Seedlings cultural practices

One year-old tree seedlings of *Populus nigra*, *Paulownia* hybrid T121 and *Cedrela odorata* were used in average of 90 to 100 cm., in height and 2 to 2.5 cm., in diameter. The seedlings grown in nursery of Forestry and timber Trees Department, Horticulture Research Station were transplanted individually on the first week of February 2019 and 2020 in polyethylene bags had a diameter of 40 cm., and depth of 60 cm., filled with about 30 kg of soil transported from ("Sadat city") Minufiya Governorate, Egypt.

***Paulownia* hybrid T121**: *Paulownia* e*longata x Paulownia fortunei* 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.

The seedlings were placed in a shade area, after two weeks from transplanting, seedlings were removed outdoors to a sunny area and subjected on thick polyethylene sheets to prevent the penetration of growing roots inside soil.

The seedlings fertilized by 5.0g of Kristalon 19 :19 :19 as a resource NPK and was applied twice with equal doses, the first addition after one month from transplanting (April) and the second one in mid June 2019, then this application was repeated again in the second season 2020 at the same time with the same doses.

## Plant measurements

The vegetative growth parameters were recorded during two seasons 2019 and 2020 and were analyzed of combined two seasons inasmuch as high differences in rainfall (RF mm/month Table 1) between two seasons according to Central Laboratory for Design and Statistical Analysis Research (CLDSAR).

The plant measurements included seedling height, stem diameter, root length (cm), biomass fresh, dry weight (g) and rates of the relative changes (RC) between biomass dry weight and fresh weight:

Rates of the relative changes of the final results (as percent) "RC%" were calculated:

$$RC\ \% = \frac{\text{Biomass f. w} - \text{Biomass d. w}}{\text{Biomass f. w.}} \times 100$$

## Soil-water relations

1- **Applied irrigation water L/bag:** (AIW) Was determined as accumulated amounts of added water to the seedlings at each irrigation during entire growing season under the assessed irrigation intervals.

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

**2- Water consumption use (CU):** 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 consumptive use (CU), values were determined by Time Domain Reflectometry (TDR) sensor which measured the volumetric soil moisture contents in the surface 60 cm depth of soil before and after each irrigation. The TDR is widely used to measure soil water content according to (Cataldo *et al.*, 2011). The CU values were calculated according to Israelsen and Hansen (1962) using the following equation:

$$WCU = \sum_{i=1}^{i=4} \frac{(\theta_2 - \theta_1)}{100} X\ d$$

Where:

WCU= water consumption used 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, (150 mm).

## 3- Water use efficiency (WUE) g/l

Water use efficiency was estimated according to Smith (2002) as follows:

WUE = Biomass dry weight (g) /consumed irrigation water (liter) at the growing season

## 4- Biomass water productivity (WP) g/l

The WP is defined as crop yield (biomass dry weight g) per a unit of applied irrigation water (Zhang, 2003) and is given as follow:

WP = Biomass dry weight (g) /water applied (liter) at the growing season.

## Chemical measurements

Total carbohydrates (%) in dry stem was estimated using the method recommended by Dubois *et al*., 1956.

## Layout of experiment

The study was layout on a complete randomized block design in split plot with three replications. There were 9 treatments including three irrigation treatments 30, 45and 60% available soil moisture depletion as sub-plots (ASMD) and three seedling species (*Populus nigra, Paulownia* hybrid *T121 and Cedrela odorata*) as main-plots.

The obtained data were subjected to analysis of variance ANOVA according to (Snedecor and Cochran, 1980). The means were compared by Duncan's multiple range test described by (Duncan, 1955) at 5% properly between means of various treatments.

# RESULTS AND DISCUSSIONS

**Effect of different ayailable soil depletion (ASMD) and three seedlings species on vegetative growth during combined analysis of two seasons (2019 and 2020)**

## 1-Seedling height, stem diameter and root length

The adopted irrigation treatments exerted significant influence on seedling height, stem diameter and root length traits of *Populus nigra, Paulownia* hybrid T121 *and Cedrela odorata* during combined analysis of two seasons (2019 and 2020). Results in Table (4) illustrate that the highest values of seedling height and stem diameter were recorded with irrigation at 30 % of available soil moisture depletion (ASMD) which reached to 255.2 and 7.14 cm, respectively. Moreover, height growth and stem diameter values seemed to be lower under Irrigation at 45 and 60 % (ASMD) by 16.31, 42.90% and 27.95, 76.73%, respectively, comparable with Irrigation at 30 % (ASMD). These results are in agreement with those obtained by Martínez *et al*., (2002), on *pinus leiophlla*, Jones (2004) and Hamad *et al*., (2018) on three species (*Gmelina arborea*, *Khaya senegalensis* and *Tectona grandis*) where the amounts of waste water were similar, except for few instances. The highest amount of irrigation water (A1; 10.3 l tree-1 day-1) gave the tallest seedlings, the wider at DBH, and the greatest BA plant height. In the study of Amin and Al-Atrash (2021) increasing the period between irrigation dates from 4 to 16 days resulted in significant tolerances in seedling

height and stem diameter of *Tipuana speciosa*. Abd El- Latif *et al.* (2012) found that the irrigation at 45% available soil moisture depletion (ASMD) regime resulted in maize plant height and yield components values, comparing with 75% ASMD regime. Furthermore, El-Sayed *et al.* (2010) on some crops and Wenhui *et al.* (2020) on wheat, under irrigation shortage stated that decreasing irrigation water quantity gave a negative effect on plant growth , meanwhile, root length exhibited significantly an adverse trend where the highest value 67.23cm was obtained due to irrigation at 60% (ASMD) whilst, irrigation at 30% or 45 % (ASMD) resulted in shorter roots reached to 58.83 and 64.16 cm. less than that irrigated at 60 % (ASMD), respectively. Such results indicate that under soil moisture stress (irrigation at 60% (ASMD)) the roots extended deeper searching for more soil moisture to complete the plant life cycle. Obtained results agree with Bargali and Tewari (2004) on *Coriaria nepalensis* seedling, Sakran, (2008), on *Eucalyptus gomphocephala* and Al-Atrash (2014) on *Pinus roxbourghii* seedlings. All of them cleared that, the longest roots were correlated with deficit soil moisture content.

Different species were differed significantly as presented in Table (4) where *Paulownia* hybrid achieved the superiority on seedling height, stem diameter and the values were (250.20 and 7.16 cm) followed by *Populus nigra* (229.4 and 5.08 cm) whilst the *Cedrela odorata* showed (173.5 and 4.51 cm) respectively, on the other hand *Populus nigra* achieved the superiority on root length raised up to 67.17cm while the *Cedrela odorata* was 64.28 cm, meanwhile *Paulownia* hybrid T121 recorded the shortest one (58.78 cm).

In this regard, the interaction between the available soil moisture depletion (ASMD) and species was significant for all studied traits. *Populus nigra*, *Paulownia* hybrid T121 and *Cedrela odorata* differently responded to the amount of irrigation (Table 4), *Paulownia* hybrid T121 treated with irrigation at 30 % of available soil moisture depleted (ASMD) gave the highest values in both seedling height (295.3) cm and stem diameter was 9.04 cm also, under the same condition it gave the shortest values in root length (53.12 cm) compared to other treatments 45% or 60 % (ASMD). Similar trend was observed in *Populus nigra* and *Cedrela odorata*.

These findings are similar to those obtained by Shehata (2002) on *Khaya senegalensis* grown under different levels of soil moisture stress, El-Khalil Soha and Abd El-Kader (2011) on *Hibisicus sabdariffa*, El-Tantawy and El-Beik (2007) on cowpea plants, (Sakran 2008), on *Eucalyptus gomphocephala* and Khattab *et al.* (2011) on pomegranate.

These decrement in plant growth characters due to low soil water content (drought stress) may be attributed to low nutrient uptake which reflect reduction in cell division and cell enlargement and subsequent low plant growth Sirag, Amina *et al.* (2005) on (*Citrus aurantifolia* L.) seedlings.

**Table (4): Effect of different available soil depletion (ASMD) and three seedling species on seedling height, stem diameter and root length during combined analysis of two seasons (2019 and 2020).**

| ASMD / Species | Seedling height (cm) | | | Mean | Stem diameter (cm) | | | Mean | Root length(cm) | | | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 30% | 45% | 60% | | 30% | 45% | 60% | | 30% | 45% | 60% | |
| *Populus nigra* | 275.0b | 227.7d | 185.7g | 229.4B | 6.53c | 4.86f | 3.85h | 5.08B | 63.24d | 68.13b | 70.14a | 67.17A |
| *Paulownia* hybrid | 295.3a | 263.0c | 192.3f | 250.2A | 9.04a | 7.32b | 5.13e | 7.16A | 53.12f | 60.10e | 63.13d | 58.78C |
| *Cedrela odorata* | 195.3e | 167.7h | 157.7i | 173.5C | 5.84d | 4.55g | 3.14i | 4.51C | 60.14e | 64.26c | 68.43b | 64.28B |
| Mean | 255.2A | 219.4B | 178.6C | | 7.14A | 5.58B | 4.04C | | 58.83C | 64.16B | 67.23A | |

ASMD = Available soil moisture depleted.

Values followed by the same capital letters in the same column or rows are not statistically different, small letters for interaction.

## 2-Biomass fresh and dry weight

Data presented in Table (5) indicated that average biomass fresh and dry weight was significantly affected by available soil moisture depletion (ASMD) in the used three species during combined analysis of two seasons. The greatest biomass fresh or dry weight was found as irrigation at 30% (ASMD) while the lowest values, in this respect was recorded when irrigation was at 60% (ASMD). It is evident that biomass fresh or dry weight was more effective due to the different (ASMD) since at 30% level, biomass fresh or dry weight raised up to maximum values 2520 and 1235g /plant followed by 45% which was 2270 and 1118 g/plant meanwhile it reduced at 60% (ASMD) where attained to 2010 and 1054 g/plant, respectively. This was true during combined analysis of two seasons. Generally, in this study the *Paulownia* hybrid T121 seedlings revealed the greatest biomass fresh weight and the value was 2400 g meanwhile *Populus nigra* plants recorded intermediate value 2290 g otherwise, *Cedrela odorat* seedlings recorded the lowest values of fresh biomass weight (2100 g), respectively irrespective to the effect of water depletion. On the other hand, it could be concluded that, the maximum value of biomass dry weight was recorded by *populous nigra* (1180 g) followed by *Cedrela odorat* seedlings (1141 g) meanwhile *Paulownia* hybrid T121 seedlings recorded the inferior value (1087 g) of biomass dry weight. These results are incompatible with those reported by Shehata (2002) on Khaya seedlings, De Pascale *et al.* (2003) on pepper plants and Zhang (2003) who stated that biomass fresh or dry weight is significantly higher as soil moisture stress level decreased. Also, Mehasen *et al.* (2017) on faba bean and Wenhui *et al*. (2020) on wheat as affected by water regimes, they reported that biomass fresh weight of 100 seeds and seed yield/ fed were significantly increased by the shortest irrigation intervals also, fresh and dry weight of Tipuana seedlings were reduced as the period between irrigation increased as mentioned by Amin and Al-Atrash (2021).

Concerning, the interaction among species and Available soil moisture depletion (ASMD), it could be noticed that, *Paulownia* hybrid T121 seedlings revealed the greatest biomass fresh weight when watered at 30% (ASMD)which was (2650g) whereas *Cedrela odorat* produced the lowest values of biomass fresh weight (2380g) then *Populus nigra* seedlings recorded intermediate values which was (2520 g) under the same condition, Vic vicar *Populus nigra* plants recorded the superiority on biomass dry weight in average of (1281g /plant) behind the seedlings of *cedrela odorata* which produced 1248g/plant, then *Paulownia* hybrid T121produced the inferior values which was (1177g) while plants were irrigated at 30% (ASMD). The differences among the three species were significant.

**Table (5): Effect of different available soil depletion (ASMD) and three seedling species on biomass fresh, dry weight (g) and relative changes% during combined analysis of two seasons (2019 and 2020).**

| ASMD / Species | Biomass fresh weight(g) | | | Mean | Biomass dry weight ( g) | | | Mean | RC |
|---|---|---|---|---|---|---|---|---|---|
| | 30% | 45% | 60% | | 30% | 45% | 60% | | |
| *Populus nigra* | 2520ab | 2290cd | 2070e | 2290B | 1281a | 1140d | 1118e | 1180A | 48% |
| *Paulownia* hybrid | 2650a | 2410bc | 2150de | 2400A | 1177c | 1077f | 1007h | 1087C | 55% |
| *Cedrela odorata* | 2380bc | 2120de | 1810f | 2100C | 1248b | 1137g | 1038g | 1141B | 50% |
| Mean | 2520A | 2270B | 2010C | | 1235A | 1118B | 1054C | | |

ASMD = Available soil moisture depleted. RC%= relative changes

Values followed by the same capital letters in the same column or rows are not statistically different, small letters for interaction.

Also, Table (5) showed that there were wide variations within the values of relative changes (RC, %) of same parameters where the lowest RC% rates of biomass dry/ fresh weight which attained to 48% in *Populus nigra* seedlings, followed by *Cedrela odorata* 50% and 55% for *Paulownia* hybrid T121. Such results could be attributed to the favorite soil moisture status, under the frequent irrigation, which exceeds the internal water status in particular at non-water stress resulting higher biomass fresh weight, meaning that *paulownia* hybrid had taken higher amount of water applied and water consumption but the most has been lost and depleted by higher transpiration without using it in metabolism synthesis.

**Effect of different available soil depletion (ASMD) and three seedling species on water relations during combined analysis of two seasons (2019 and 2020).**

## 1-Applied irrigation water (AIW)

The average total amounts of applied irrigation water (L/bag) through combined two seasons for the tree species of seedlings (*Populus nigra*, *Paulownia* hybrid T121 and *Cedrela odorata*) were measured for all treatments. Results presented in Table (6) and Fig (1) obviously cleared that the values of (AIW) significantly increased under irrigation at 30% of available soil moisture depletion ASMD (1206 L/bag) followed by irrigation at 45% (940 L/bag) then the late one exhibited at 60% of (ASMD), which gave 779 L/bag. Also, results revealed that irrigation at 30%, it could increase water quantity percentage about 28.3 % and 54.9% of the applied water, over with irrigation at 45% and 60% of (ASMD), respectively.

Concerning, the interaction between the available soil moisture depletion (ASMD) and species was significant for (AIW), *Populus nigra*, *Paulownia* hybrid T121 and *Cedrela odorata* differently responded to the amount of (AIW), it could be noticed that, *Paulownia* hybrid T121 seedlings revealed the greatest amount of (AIW) when watered at 30% (ASMD)which gave 1440.0 l/bag whereas *Cedrela odorat* produced the lowest values of (AIW) (1030.0 l/bag) then *Populus nigra* seedlings recorded intermediate values which was (1150 l/bag) under the same condition. Generally, *Populus nigra* seedlings revealed the lowest amount of (AIW), the values were 850 and 720 l/bag meanwhile *Cedrela odorat* plants recorded intermediate value 890 and 750 l/bag otherwise, *Paulownia* hybrid T121 seedlings recorded the greatest amount of (AIW), which values (1081 and 867) l/bag at 45 and 60% (ASMD), respectively.

In their study on pine plant used for forest areas, Campoe *et al*., (2013) found that, more water applide increasing plant growth.

**Table (6): Applied irrigation water (AIW) (L/bag) and water consumptive use (CU) as affected by different available soil depletion (ASMD)on three seedling species (combined analysis of two seasons 2019 and 2020).**

| ASMD / Species | Applied irrigation water (AIW) (L/bag) | | | Mean | Water consumption use (CU) (L/bag) | | | Mean |
|---|---|---|---|---|---|---|---|---|
| | 30% | 45% | 60% | | 30% | 45% | 60% | |
| *Populus nigra* | 1150.0b | 850.0f | 720.0h | 906.7B | 1080.0b | 764.9g | 684.0i | 843.0B |
| *Paulownia* hybrid | 1440.0a | 1081.0c | 867.0e | 1129.3A | 1296.0a | 972.9c | 780.3f | 1016.4A |
| *Cedrela odorata* | 1030.0d | 890.0d | 750.0g | 890.0C | 927.0d | 850.1e | 698.0h | 825.0C |
| Mean | 1206.7A | 940.3B | 779.0C | | 1101.0A | 862.3B | 720.8C | |

ASMD = Available soil moisture depleted.
Values followed by the same capital letters in the same column or rows are not statistically different, small letters for interaction.

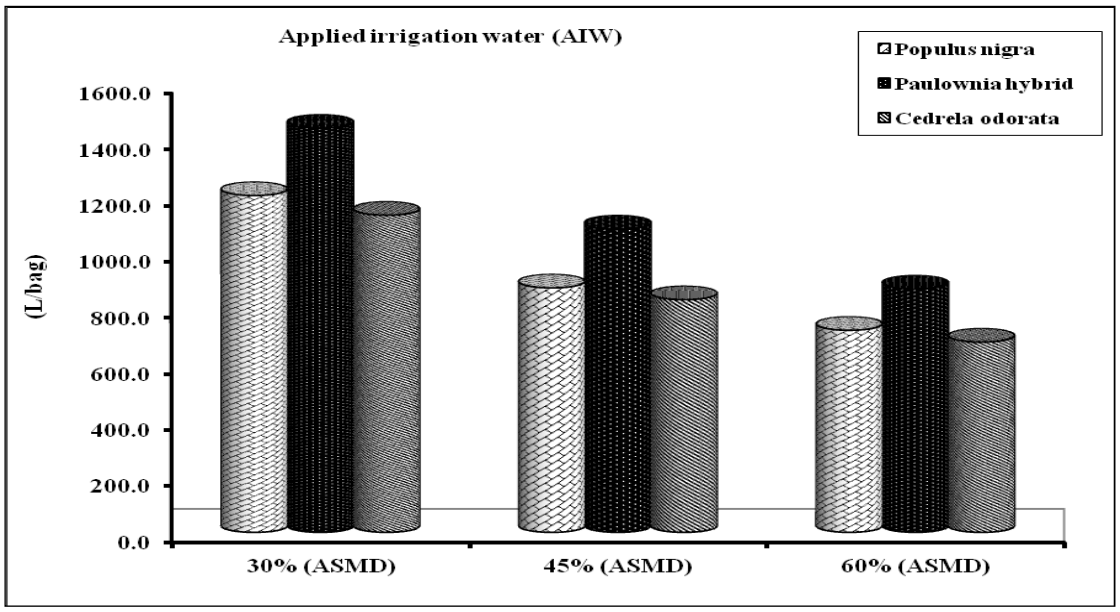


**Fig. 1: Effect of irrigation treatments on applied irrigation water for different species.**

In this respect, the obtained results declared that, AIW values of 1129.3, 906.7 and 890.0 (L/bag) were recorded for *Paulownia* hybrid T121, *Populus nigra* and *Cedrela odorata* respectively, and the differences were significantly, furthermore the reduction in AIW value for *Populus nigra* and *Cedrela odorata* seedlings attained to 24.6% and 26.9%, respectively less than *Paulownia* hybrid T121. Supply of water to *Paulownia* hybrid tree is essential to its growth and the size in response to the variation in moisture level (Bargali and Tewari 2004).

## 2-Water consumption use (CU)

The average total amounts of (CU) through combined two seasons for the three species of seedlings (*Populus nigra, Paulownia* hybrid T121and *Cedrela odorata*) are presented in Table (6) and Fig. (2). It is obvious that, the consumption used augments as the irrigation applications increased. Irrigation treatment (30%) gave the highest significant value of water consumption, followed by (45%) and (60%) was the lowest of (ASMD) respectively. water consumption used for (L/bag) were; 1101, 862.3 and 720.8 for irrigation treatments. It is evident that, at the stressed water condition of 60% (ASMD) the water consumption diminished by 52.74 and 19.63% less than those of 30 and 45% (ASMD), respectively. Generally, water consumption (CU) value increased as (ASMD) decreased.

The results in Table (6) and Fig. (2) show also that, *Paulownia* hybrid T121 achieved the superiority regarding water consumption (CU) where the value was (1016.4 l/bag) followed by *Populus nigra* (843.0 L/bag) while *Cedrela odorata* was (825.0L/bag) respectively.

In this regard, the interaction among species and available soil moisture depletion (ASMD), it could be observed that, *Paulownia* hybrid T121 seedlings revealed the greatest Water consumption use (CU) (L/bag) when watered at 30% (ASMD)which was (1296 l/bag) whereas *Cedrela odorat* produced the lowest values of (927.0 l/bag) then *Populus nigra* seedlings recorded intermediate values which was (1080.0 l/bag) under the same condition ,Vic vicar *Populus nigra* plants recorded the inferior on (CU) in average of (764.9 and 684.0 l/bag) behind the seedlings of *cedrela odorata* which produced (850.1 and 698.0 l/bag) then *Paulownia* hybrid T121produced the superiority values which was (972.9 and 780.3 l/bag) while plants were irrigated at 45 and 60% (ASMD). The differences among the three species were significant.

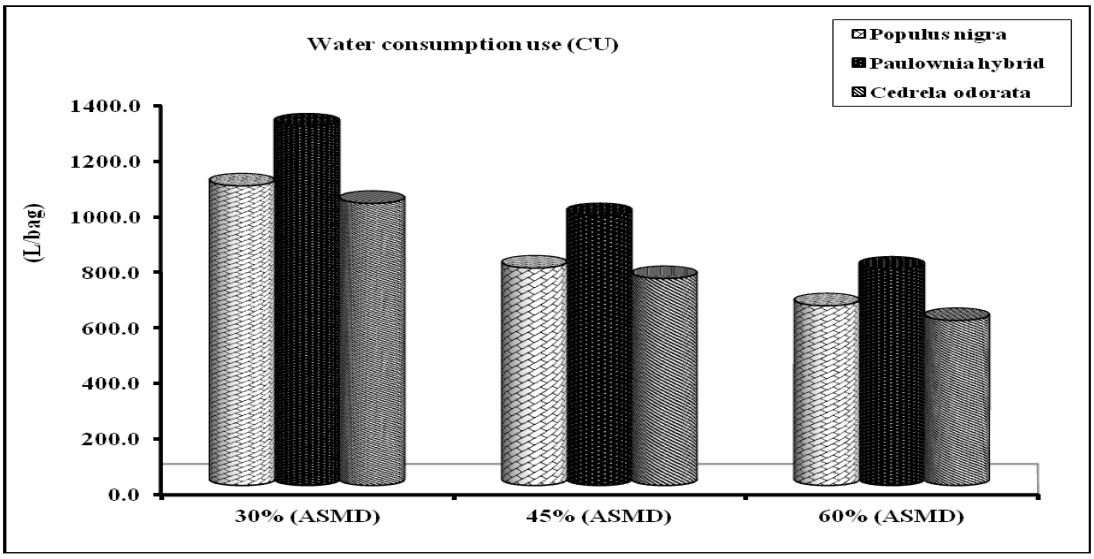


**Fig.2: Effect of irrigation treatments on Water consumption use (CU) for different species.**

Higher water use value was increased due to frequent irrigation practice, which led to more absorbed soil moisture by the plant roots and simultaneously higher evaporative demands from the soil surface. These results were supported by Kirnak and Demirtas (2006) and Abd El- Latif *et al*. (2012) on Maize plants who stated that, the irrigation treatments insignificantly affected water consumption however, higher values were noticed due to irrigation at 30% comparable to 45 or 60% available soil moisture depletion regime and Al-Atrash *et al*., (2014) on *Dalbergia sisso* seedlings who found that the highest water consumptive use (CU) depressed as water stress increased and the opposite occurred with increasing soil moisture content, also Levitt *et al*., (1995) stated that more frequent irrigation events provide high evaporation opportunity from the relatively wet rather than dry soil surface.

## 3-Water productivity (WP)

Water productivity (WP) there is the amount of biomass dry weight produced by one liter of irrigation water applied for seedling. Data presented in Table (7) revealed that this trait was markedly profitable under medium and low soil moisture. Values of (WP) were higher significantly under irrigation at 60 and 45% compared with 30 % of (ASMD), it recorded 1.37, 1.21 and 1.05 g biomass dry weight L/bag respectively. These results are harmony with the findings of Zeng *et al*. (2009), on *Cucumis melo* L. On wheat Wenhui *et al*. (2020), concluded that decreasing irrigation water amount particularly in the first growth period increase water productivity due to high basic shooting under low irrigation which enable the plants to give more shoots compare with high irrigation. In this regard, *Populus nigra* seedlings had achieved increasable significant values of water productivity (1.34g/l) followed *Cedrela odorata* seedlings which attained (1.29 g/l). On the other hand, the *Paulownia* hybrid T121 gave the least effect which was 1.00g/l during combined the average two seasons. Concerning the interaction, it could be concluded that *Populus nigra* plants recorded the highest significant effect of water productivity (WP) 1.55 g/l recorded when watered at 60% meanwhile, *Paulownia* hybrid T121 plants achieved inferior values of 0.82 and 1.00 although they were irrigated at 30 and 45 % (ASMD), respectively. The higher WP value in case of *Populus nigra* or *Cedrela odorata* may be due to increases biomass dry weight yield comparable to *Paulownia* hybrid T121. Water productivity at different (ASMD) declared that one liter of water applied produced 1.34, 1.00 and 1.29 gm biomass dry weight for *Populus nigra*, *Paulownia* hybrid T121 and *Cedrela odorata* respectively. Meaning that, *paulownia* hybrid T121 had taken higher amount of water applied but the most of it has been lost and depleted by higher consumption use without using it in biomass synthesis.

**Table (7): Water productivity (WP) (g/L) and Water use efficiency (WUE) as affected by different available soil depletion and three seedling species (combined analysis of two seasons 2019 and 2020).**

| ASMD / Species | water productivity (WP) (g/L) | | | | Water use efficiency (WUE) (g/L/) | | | |
|---|---|---|---|---|---|---|---|---|
| | 30% | 45% | 60% | Mean | 30% | 45% | 60% | Mean |
| *Populus nigra* | 1.11f | 1.34b | 1.55a | 1.34A | 1.19e | 1.49b | 1.63a | 1.44A |
| *Paulownia* hybrid | 0.82h | 1.00fg | 1.16de | 1.00C | 0.91gh | 1.11f | 1.29d | 1.10C |
| *Cedrela odorata* | 1.21d | 1.28c | 1.38b | 1.29B | 1.35c | 1.34c | 1.49b | 1.39B |
| Mean | 1.05C | 1.21B | 1.37A | | 1.15C | 1.31B | 1.47A | |

ASMD = Available soil moisture depleted.
Values followed by the same capital letters in the same column or rows are not statistically different, small letters for interaction.

## 4-Water use efficiency (WUE)

Data presented in Table (7) cleared that, WUE was more affected by different ASMD where increases exhibited with those irrigated 60 % ASMD and had the significant surpassed values of 1.47 (g/L). Whereas the seedlings irrigated at 45% ASMD produced in average of 1.31 (g/L) while at 30% ASMD, had the last one with an average of 1.15 (g/L) during combined analysis of two seasons. Consequently, water use efficiency was significantly affected by the amount of water treatments, in this respect *Populus nigra* declared the superiority on WUE and the value was 1.44 (g/L) followed by *Cedrela odorata* 1.39 (g/L) whilst the last one was the *Paulownia* hybrid T121 which gives 1.10 (g/L) respectively. These results are in agreement with those reported by Costa *et al*., (2007) who mentioned that in some horticultural crops, reduced water addition enhanced WUE specially in tolerant plants to water stress.

As shown in Table (7) it is clear that the interaction between irrigation treatments and three species for WUE indicating that species differed responded to ASMD, where *Populus nigra* under irrigation 60% gave the highest values in WUE (1.63 g/L). On the other hand, *Cedrela odorata* improved under irrigation at 60% ASMD and gave the value of 1.49 g/L) while, *Paulownia* hybrid T121 seedlings recorded the lowest values of WUE at different soil moisture depleted ASMD which produced 0.91,1.11, and 1.29 g/l under 30,45 and 60 % respectively. The differences among treatments were significant.

The results of this study revealed that the behavior of the three species (*Populus nigra*, *Paulownia* hybrid T121 and *Cedrela odorata*) to different amounts of water was different. The highest amount of irrigation water (30% ASMD) gave the tallest seedlings, conversely gives the lowest water use efficiency (WUE). The balance between water and oxygen in root zoon is very important because it's needed for good plant uptake according to the plant requirements for standard growth and production. So, it is advisable to apply such interaction in order to use the already limited water resources efficiently. The obtained results were in agreement with those of Abd El- Latif *et al.* (2012) on Maize crop, Wenhui *et al*. (2020) on wheat, Al-Atrash *et al*., (2014) on *Dalbergia sisso* seedlings and Hamad *et al*. (2018) on three species (*Gmelina arborea*, *Khaya senegalensis* and *Tectona grandis*). All of them reported that WUE increased by higher dry biomass and less water use.

### Effect of different available soil depletion (ASMD) and three seedling species on total carbohydrate (%) during combined analysis of two seasons (2019 and 2020).

Data presented in Table (8) obviously cleared that, total carbohydrates in stem influenced by available soil moisture depletion (ASMD in both three species in which it significantly increased with irrigation at 60% (ASMD) in average of 10.64% comparable with the 45% or 30% (ASMD) which reached to 10.31 and 9.48 % respectively, during the average combined two seasons. These results are similar to Moursi *et al*. (2014) and Mehasen *et al*. (2017) on faba bean, they reported that, carbohydrates % were significantly increased by the shortest irrigation interval.

**Table (8): Effect of different available soil depletion (ASMD) and three seedling species on total carbohydrates % (combined analysis of two seasons 2019 and 2020).**

| ASMD / Species | Total carbohydrates (%) | | | Mean |
|---|---|---|---|---|
| | 30% | 45% | 60% | |
| *Populus nigra* | 10.18d | 10.60c | 9.11ef | 9.96B |
| *Paulownia* hybrid | 8.11g | 9.03f | 10.42cd | 9.19C |
| *Cedrela odorata* | 10.15e | 11.30b | 12.40a | 11.28A |
| Mean | 9.48C | 10.31B | 10.64A | |

ASMD = Available soil moisture depleted.

Values followed by the same capital letters in the same column or rows are not statistically different, small letters for interaction.

Significant species differences were showed in Table (8) it can be concluded that total carbohydrates in stem was the maximized and attained by *Cedrela odorata* seedlings (11.28 %) followed by *Populus nigra* seedlings (9.96%) meanwhile, the *Paulownia* hybrid T121 seedlings recorded the lowest values of total carbohydrates (9.19%).

In this respect, the interaction between available soil moisture depletion (ASMD) and species were significant for total carbohydrates % indicating that *Cedrela odorata* treated with irrigation at 60 % of available soil moisture depletion (ASMD) gave the highest values in total carbohydrates% 12.40%) followed by 45% for the same species (11.30%). *Paulownia* hybrid T121 recorded 10.42% alongside irrigation at 60 % of available soil moisture depleted (ASMD), it could be noticed that the lowest values 8.11 was recorded by the *Paulownia* hybrid T121 seedlings at 30%. this may be due to, the treatments ameliorated vegetative growth parameters using stored carbohydrates of stem in formation and differentiation recent portions consumed more carbohydrates led to a decrement in stem .These results were in harmony with those obtained by, Hendawy (2008) on *Plantago arenaria*, Abd El- Latif *et al*. (2012) on maize plants stated that the irrigation treatments insignificantly affected carbohydrates content however, higher values were noticed due to irrigation at 45% compared to 30 % available soil moisture depletion (ASMD) regime and Al-Atrash (2014) on *Pinus roxbourghii* seedlings who stated that total carbohydrates% were significantly better as soil moisture level decreased.

## Conclusion and recommendation

The obtained results of this study indicated that the used three species seedlings differed significantly in their water requirements *Paulownia* hybrid T121 have taken more water followed by *Populus nigra* in spite of the latest was better in biomass dry weight and water use efficiency than *Paulownia* hybrid T121 thus it is preferable to choose *Populus nigra* in a forestation especially in arid and semi arid land such as the Egyptian conditions where scare water and the excess water in soil is determinate to plant growth saving more water in cultivating other crops and it is not substantial to depend on *Paulownia* hybrid T121 in establishment plantation forest under new reclaimed soil conditions and substituted with *Populus nigra* or *Cedrela odorata* to get great dry biomass and saving amount of water irrigation.

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# دراسات مقارنه بعض انواع شتلات الاشجار الخشبية سريعة النمو تحت معاملات رى مختلفة

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## الملخص العربى

اجريت هذه الدراسة بمشتل الاشجار الخشبية والغابات بمحطة بحوث البساتين بالقناطر الخيرية محافظة القليوبية مصر خلال موسمين هما٢٠١٩ و٢٠٢٠ بهدف تقدير افضل صفات النمو لثلاثة انواع من شتلات الاشجار الخشبية سريعة النمو هى الحور الاسود والبولونيا ت١٢١ والسيدريلا عند ثلاث مستويات رى هى٣٠ &٤٥ & ٦٠ % استنفاذ الرطوبة من الماء المتاح.

ويمكن تلخيص النتائج المتحصل عليها خلال موسمين مندمجين كما يلى:

الحور الاسود وهجين البولونيا ت١٢١والسيدريلا سجلت زيادة معنوية فى الطول والقطر للساق عند٣٠٪ يليها ٤٥٪ ثم ٦٠٪ استنفاذ من الماء المتاح كما ان البولونيا ت١٢١ سجلت زيادة معنوية فى الطول والقطر والكتلة الحيوية يليها الحور الاسود وفى الاخير كانت السيدريلا تحت مستويات الرطوبة المختلفة. ومن جهة اخرى سجل الحور الاسود زيادة معنويه فى طول الجذر ثم السيدريلا بينما البولونيا ت١٢١ كانت اقل القيم خاصة عند ٦٠٪ استنفاذ من الرطوبة .

الحور الاسود اعطى زيادة معنويه فى الكتلة الحية الجافه يليه السيدريلا اعطت قيما متوسطه فى حين البولونيا ت ١٢١أعطت اقل القيم عند مستويات الرطوبة المختلفة. ومن جهة اخرى سجلت السيدريلا اعلى القيم فى نسبة الكربوهيدرات بينما البولونيا اقل القيم فى حين اعطى الحور الاسود قيما متوسطه عند مستوى ٤٥ % &٦٠٪ استنفاذ من الماء الميسر.

أوضحت النتائج أيضا ان كمية الماء المضاف والمستهلك زادت معنويا مع البولونيا ت١٢١ يليها الحور الاسود ثم السيدريلا تحت مستويات الرطوبة المختلفة وبخصوص وحدة انتاجية الماء وكفاءة الاستهلاك المائى فقد اشارت النتائج إلى أن الحور الاسود فقد سجل اعلى القيم معنويا يليه السيدريلا واقلهم كانت البولونيا ت ١٢١ خاصة عن ٦٠ % يليه ٤٥ % ثم ٣٠ % استنفاذ من الماء المتاح.

أظهرت وحدة انتاجية المياه كانت ١,٣٤&١,٠٠&١,٢٩ جم كتله حيوية جافه لكل واحد لتر ماء لكل من الحور الاسود والبولونيا والسيدريلا تحت مستويات الرطوبة المختلفة .

بناءا على ما سبق يمكن التوصية بأنه من غير المستحسن التشجير بشتلات البولونيا ت ١٢١ تحت الظروف المصرية نظرا لزيادة الماء المستهلك لتر/شتله وانخفاض وحدة الانتاجية وكفاءة استخدام المياه جرام/لتر لذلك ينصح باستبدالها بانواع اقتصاديه اخرى مثل شتلات الحور الاسود أو السيدريلا تحت نفس الظروف.

**الكلمات الدالة:** الحور الاسود- هجين البولونيا ت ١٢١- السيدريلا - معدلات استنفاذ الماء - الكتلة الحيوية الطازجة والجافة - كفاءة استخدام الماء.