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EFFECT OF WATERING REGIMES ON THE GROWTH AND NUTRIENT UPTAKE OF CITRUS TANGELO J. W. SEEDLINGS GROWN IN A MIXTURE OF SAND AND PULVERIZED *Jacaranda mimosifolia* D. Don LEAVES

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ABSTRACT

There is dearth of quantified information on water requirement of crops growth in the soil amended with leaf litters of agro-forestry trees. In this light, a completely randomized design with five replicates was laid down to assess the effect of watering regimes on the growth of Citrus tangelo seedlings in the screen house of Federal College of Forestry Mechanization, Afaka, Kaduna State. C. tangelo seedlings were subjected to 200 mL of water at five watering regimes (1, 2, 3, 4 and 5 day's interval). Tissue analysis was carried out to determine the nutrient uptake in seedlings. Watering significantly (P<0.05) influences seedling growth and nutrient uptake. Significant height (9cm), number of leaves (8), leaf area-(22.65 cm^2) and phosphorus uptake (18.11 mg/100 g) were recorded for C. tangelo planted in Jacaranda mimosifolia soil and subjected to daily watering regime. Daily watering of C. tangelo enhances its growth and nutrient uptake. Daily watering of C. tangelo is recommended for its mass production for agro-forestry programmes.

Key words: Watering regimes, leaf litters, seedling growth, nutrient uptake, Agro-forestry

INTRODUCTION

Agro-forestry system is an aspect of farm forestry that encourages the deliberate integration of woody perennials with agricultural crops and/or animals on the same management unit, with the aim of enhancing soil fertility and increasing farmers' income through the use of economic trees (Akubuili, 2013). Successful integration of trees and crops in an agro-forestry system which manifest through excellent nutrient uptake that leads to growth and development does not depend only on the present of nutrient, species types, age of the plant, soil rhizosphere, (Capps and Wolf, 2000, Raţić *et al.*, 2005 and Brataševec, 2013) but also on soil-pH and the availability of water (Keller, 2005).

Water is an important natural resource that supports life and growth of plants, but there is a growing concern on water availability (Goyne and McIntyre, 2003). The availability of permanent water supply has been one of the major challenges in fruit tree nursery establishment and management, especially in the drier regions of the tropics and sub-tropics (Daba and Tadese, 2017). There is growing concern about water availability particularly in dry land forestry and nursery raised seedlings (Oboh and Igharo, 2017). Water is the major constituent of any living organisms which is involved in the important biochemical processes (Oboh and Igharo, 2017). Water is of great importance to the growth of plants because it controls the rate of transpiration which in turn, has effect on the inflow nutrient solutions (Aderounmu *et al.*, 2017). Growth and biomass production is directly proportional to the supply and use of water in plant (Cao, 2000; Olajuyigbe *et al.*, 2012). Water is an important factor in the growth, development and productivity of plant (Gbadamosi, 2014; Ogidan *et al.*, 2018). Water availability is the most important environmental factor known to have strong influence on tree species and distribution in the tropics (Bongers *et al.*, 2004).

Isah *et al.* (2013) and Gbadamosi (2014) stated that water is required by plants for the manufacture of carbohydrates and as a means for transportation of foods and mineral elements. Hence water is vital to success of seedling production especially when large quantities are required for afforestation and reforestation programmes (Oboh and Igharo, 2017). Daba and Tadese (2017) stated that sufficient quantity and quality of water is extremely important for the production of tree seedlings at nursery site. Mng'omba *et al.* (2011) stated that for tree nurseries, regular watering is necessary to produce good quality seedlings. This is because any stagnation in seedling growth or subsequent mortality translates into economic loss to a nursery operator (Mhango *et al.*, 2008, Mng'omba *et al.*, 2011, Oboh and Igharo, 2017). Mng'omba *et al.* (2011) reported that this loss can be huge because seedlings take long to reach appropriate size for grafting and transplanting or for sale. Scarcity of water leads to economic loss but the plant water requirement also varies.

Aderounmu *et al.* (2017) mentioned that water has significant effects on growth of plants though watering requirements of different species differ. Bargali and Tewari (2004) reported that water use requirements depend on tree species, growth stage and time of the year and the prevailing climatic condition of the growing site (Oboh and Igharo, 2017) and hence, it is necessary to establish this for each tree species as there are differences in growth rates. Our knowledge on optimal water requirements of most indigenous and exotic fruit tree seedlings that thrive in semi arid environments are limited (Mng'omba *et al.,* 2011). This gap in knowledge, constrains ability of nursery operators to make informed management decision about their operation (Mng'omba *et al.*, 2011). There have been limited research studies accomplished to establish the optimal water requirements for fruit tree seedlings as *C. tangelo* to sustain their growth and survival. *Citrus tangelo* productivity needs to be improved for the benefits of Nigerians by subjecting it to appropriate watering regimes. Tangelos are a specific hybrid of mandarin orange and grapefruit or pummelo.

Yuma (2018) stated that tangelos are a hybrid of *Citrus paradisi* and *Citrus reticulate.* Yuma (2018) reported that tangelo trees indicate that the fruit is a cross between the Duncan grapefruit and the Dancy tangerine of the family Rutaceae. Yuma (2018) stated that not only the tangelos are packed with flavour, they are also a great source of vitamins C and A. They are more substantial than tangerines, and this make them a great snack choice (Yuma, 2018). In spite of enormous potentials of *C. tangelo,* the optimal water requirement of it needs to be investigated for sustainable growth and development so as to make Nigerians to have access to its ample benefits. In order to promote sustainable use of water in the nurseries, it is paramount to establish optimal water requirements for tree seedlings growth (Mukhtar *et al.,* 2016) which will help in reducing the cost of planting stock production in commercial nurseries (Mng'omba *et al.*, 2011). In this light, investigation was conducted on watering regimes and nutrient uptake of *C. tangelo* seedlings.

MATERIALS AND METHODS

Study Area

The research was conducted in the screen house of Federal College of Forestry Mechanization, Afaka, Kaduna. The college is located in the Northern Guinea Savannah ecological zones of Nigeria. The college lies within latitude10^o 35′and 10^o34′and longitude 7^o21′and 7^0 20′ (Adelani, 2015). The vegetation is open woodland with tall broad trees, usually with small boles and broad leaves (Otegbeye *et al.*, 2001).

Experimental Design

Pot experiment was conducted in a screen house. A completely randomized design was laid down to assess the effect of watering regimes (1, 2, 3, 4 and 5 day's interval) on the growth of *C. tangelo* seedlings. Seedling assessment was carried out after two weeks of transplanting into 4cm depth of soil to allow the seedlings to be subjected to early establishment. Parameters assessed include: seedling height (using meter rule), number of leaves and collar girth (using Vernier caliper). The number of leaves was counted manually. Leaf area was obtained by linear measurement of leaf length and leaf width as described by Ugese *et al*. (2008) in the formula below:

LA=4.41 +1.14LW …….. 1

Where:

LA = Leaf area

LW= Product of linear dimension of the length and width at the broadest part of the leaf.

Leaf area index was calculated as:

Leaf area index = leaf area/ land area …… 2

The fresh and dry weight of seedlings of *C. tangelo* were determined by the use of Mettler Top Loading Weighing Balance, but dry weight was taken after oven dried the seedlings at 70°C for 72hours according to Umar and Gwaram (2006).

Tissue analysis was done for *C. tangelo* seedlings to determine nutrient uptake

Experimental procedure for the effect of watering regimes on the growth and nutrient uptake of *C. tangelo* seedlings grown in a mixture of sand and pulverized *Jacaranda mimosifolia*

Biomass transfer method that involves the collections of wet leaves was used. The sample of *Jacaranda mimosifolia* leaves was air dried and pulverized. The sample of *J. mimosifolia* leaves weighed (10g) was used. Highest value of nitrogen recorded in *J. mimosifolia* among the litters of nitrogen fixing tree species investigated according to Adelani *et al.* (2018) accounted for the choice of this species. River sand was collected from floor of the dam of Federal College of Forestry Mechanization, Afaka, Kaduna State and sieved with 2mm sieve and soaked in 10% hydrochloric acid for 24hours to remove impurities, organic matter and nutrient residue according to the recommendation of Adelani *et al.* (2014). The sample of sterilized sand was thoroughly mixed with the leaves of *J. mimosifolia* tree (10g) and then packed into polypots of 20x10x10cm^3 dimensions. Sample of pulverized leaves of *J. mimosifolia* was analyzed chemically for nitrogen, phosphorus and potassium (NPK). Distil water was used to water the seedlings. A month old seedlings of *Citrus tangelo* was transplanted into the pots with the prepared mixture of leaf litter of *J. mimosifolia* and sand.

Data Analysis

Data were collected and subjected to analysis of variance (ANOVA) using SAS (2003). A comparison of significant means was accomplished using Fishers' Least Difference LSD at 5% level of significance.

RESULT

Effect of Watering Regimes on the Height of *C. tangelo* Seedlings

The result of the effect of watering regime on the height of *C. tangelo* is presented in Table 1. Highest height of 9cm was recorded in seedlings subjected to daily watering.

Table 1: Effect of watering regimes on the height of *C. tangelo* seedlings

NFT Species	Watering regime	Weeks					
		2	4	6	8	10	12
J. mimosifolia	1	7.00^b	8.00^{ab}	9.00^a	9.00^a	9.00^a	9.00^a
	2	6.6 0^a	6.80^a	7.40^a	7.40^a	7.40^a	7.40^a
	3	5.80^{ab}	6.40^a	7.40^a	7.40^a	7.40^a	7.40^a
	4	4.80^b	5.60^{ab}	6.60^a	6.60^a	6.60^a	6.60^a
	5	6.80^{ab}	7.00^a	7.80^a	7.80^a	7.80^a	7.80^a
SE±		0.80	0.80	0.80	0.80	0.80	0.80

**Means on the same row having different superscripts are significantly different (P<0.05)*

****NFT -** means nitrogen fixing trees*

Effect of Watering Regimes on the Girth of *C. tangelo* Seedlings

The result of the effect of watering regimes on the girth of *C. tangelo* seedlings is presented in Table 2. There was no significant difference (P <0.05) among the girths of seedlings predisposed to different watering regimes.

Table 2: Effect of watering regimes on the girth of *C. tangelo* seedlings

NFT Species	Watering regime	Weeks					
		2	4	6	8	10	12
J. mimosifolia	1	0.70[a]	0.90[a]	0.90[a]	1.00[a]	1.00[a]	1.00[a]
	2	0.70[a]	0.90[a]	0.90[a]	1.00[a]	1.00[a]	1.00[a]
	3	0.70[a]	0.90[a]	0.90[a]	1.00[a]	1.00[a]	1.00[a]
	4	0.70[a]	0.90[a]	0.90[a]	1.00[a]	1.00[a]	1.00[a]
	5	0.70[a]	0.90[a]	0.90[a]	1.00[a]	1.00[a]	1.00[a]
SE±		0.00	0.00	0.00	0.00	0.00	0.00

**Means on the same row having different superscripts are significantly different (P<0.05)*
****NFT** - means nitrogen fixing trees*

Effect of Watering Regimes on the Number of leaves of *C. tangelo* Seedlings

The result of the effect of watering regimes on the number of leaves of *C. tangelo* seedlings is showed in Table 3. Highest number of leaves of 8 was recorded in seedlings watered daily.

Table 3: Effect of watering regimes on the number of leaves of *C. tangelo* seedlings

NFT Species	Watering regimes	Weeks					
		2	4	6	8	10	12
J.mimosifolia	1	6.00[b]	8.00[a]	8.00[a]	8.00[a]	8.00[a]	8.00[a]
	2	2.20[b]	3.00[ab]	3.20[ab]	4.20[a]	4.40[a]	4.40[a]
	3	2.40[b]	3.40[ab]	3.40[ab]	4.40[a]	4.40[a]	4.40[a]
	4	2.40[b]	3.40[ab]	3.40[ab]	4.40[a]	4.40[a]	4.40[a]
	5	3.00[b]	3.80[ab]	3.80[ab]	4.80[a]	4.80[a]	4.80[a]
SE±		0.34	0.41	0.43	0.44	0.44	0.44

**Means on the same row having different superscripts are significantly different (P<0.05)*
****NFT** - means nitrogen fixing trees*

Effect of Watering Regimes on the Leaf Area of *C. tangelo* Seedlings

The result of the effect of watering regimes on the leaf area of *C. tangelo* seedlings is represented in Table 4. A significant leaf area of 22.65cm^2 was recorded in seedlings subjected to daily watering regimes.

Table 4: Effect of watering regimes on the leaf area of *C. tangelo* seedlings

N.FT Species	Watering regimes	Weeks					
		2	4	6	8	10	12
J. mimosifolia	1	18.10[b]	16.83[b]	20.87[ab]	22.65[a]	22.65[a]	22.65[a]
	2	7.49[a]	7.49[a]	9.65[a]	9.88[a]	9.88[a]	9.88[a]
	3	6.80[b]	6.80[b]	8.74[ab]	10.56[a]	10.56[a]	10.56[a]
	4	6.23[a]	6.23[a]	7.83[a]	9.20[a]	9.20[a]	9.20[a]
	5	6.23[a]	7.97[a]	7.97[a]	8.74[a]	8.74[a]	8.74[a]
SE±		0.78	0.66	0.78	1.13	1.13	1.13

**Means on the same row having different superscripts are significantly different (P<0.05)*
****NFT** - means nitrogen fixing trees*

Effect of Watering Regimes on the Leaf Area Index of *C. tangelo* Seedlings

The result of the effect of watering regimes on the leaf area index of *C. tangelo* seedlings is presented in Table 5. Highest leaf area index of 1.54 was recorded in seedlings watered at 4 days' interval.

Table 5: Effect of watering regimes on the leaf area index of *C. tangelo* seedlings

NFT Species	Watering Regimes	Weeks 2	4	6	8	10	12
J.mimosifolia	1	0.76^{a}	0.76^{a}	0.73^{a}	0.71^{a}	0.71^{a}	0.71^{a}
	2	1.42^{a}	1.42^{a}	1.06^{a}	0.96^{a}	0.96^{a}	0.96^{a}
	3	1.75^{a}	1.75^{a}	1.19^{a}	0.98^{a}	0.98^{a}	0.98^{a}
	4	1.97^{a}	1.97^{a}	1.20^{a}	1.54^{a}	1.54^{a}	1.54^{a}
	5	1.52^{a}	1.52^{a}	1.09^{a}	1.24^{a}	1.24^{a}	1.24^{a}
SE±		0.43	0.33	0.29	0.24	0.24	0.24

**Means on the same row having different superscripts are significantly different (P<0.05)*

***NFT** - means nitrogen fixing trees*

Effect of Watering Regimes on the Fresh and Dry Weight of *C. tangelo* Seedlings

The result of effect of watering regimes on the fresh and dry weight of *C. tangelo* seedlings is presented in Table 6. A significant fresh weight and dry weight of 5.55g and 1.75g respectively were recorded in seedlings subjected to 5 days' watering interval.

Table 6: Effect of watering regimes on the fresh and dry weight of *C. tangelo* seedlings

NFT Species	Watering regimes	Fresh weight L	S	R	T FW	Dry weight L	S	R	TDW
J. mimosifolia	1	0.40^{b}	0.10^{c}	0.70^{a}	1.20^{e}	0.10^{b}	0.10^{c}	0.20^{a}	0.30^{d}
	2	0.85^{b}	0.35^{c}	1.45^{a}	2.65^{d}	0.20^{b}	0.10^{c}	0.30^{a}	0.60^{c}
	3	0.95^{b}	0.30^{c}	1.85^{a}	3.10^{c}	0.20^{b}	0.10^{c}	0.45^{a}	0.75^{c}
	4	1.60^{b}	0.55^{c}	2.20^{a}	4.35^{b}	0.60^{b}	0.20^{c}	0.60^{a}	1.40^{b}
	5	2.10^{b}	0.45^{c}	3.00^{a}	5.55^{a}	0.60^{b}	0.20^{c}	0.95^{a}	1.75^{a}
SE±		0.10	0.10	0.10	0.31	0.07	0.07	0.07	0.21

**Means on the same row having different superscripts are significantly different (P<0.05) for plant parts*

**Means on the same column having different superscripts are significantly different (P<0.05) for total fresh weight and total dry weight*

Key: NFT-Nitrogen fixing trees; L –leaf, S – stem, R – root, TDW –Total dry weight, TFW –Total fresh weight

Nutrient Uptake in the Watered *C. tangelo*

The nutrient uptake in the watered seedlings of *C. tangelo* is presented in Table 7. Highest nitrogen, phosphorus and potassium uptake of 1.96%, 18.11mg/ 100g and 345mg/ 100g were recorded in seedlings subjected to 4days, 1 day and 5 days' watering intervals, respectively.

Table 7: Nutrient uptake in the watered *C. tangelo*

NFT Species	Watering Regimes	Nutrient N%	Pmg/100g	Kmg/100g
J. mimosifolia	1	1.92	18.11	328.63
	2	1.88	14.32	341.78
	3	1.86	16.83	329.67
	4	1.96	12.73	312.45
	5	1.91	15.67	345.63

***NFT** - means nitrogen fixing trees*

P mg/100g - milligram of phosphorus in 100g of *J. mimosifolia*; Kmg/100g- milligram of potassium in 100g of *J. mimosifolia*

DISCUSSION

Highest number of leaves of *C. tangelo* was recorded in seedlings watered daily. Similar observation has been made by Dauda *et al.* (2009) who stated that the rate of increase in leaf number of vegetables (such as Okra, *Chocorus olitorus, Telferia* spp and *Amaranthus* spp) can be said to be directly proportional to the frequency of watering regime as seedlings watered everyday produced the highest number of leaves (6.75) and the lowest was obtained in seedlings watered once a week (5.75). Various investigators have reported the highest growth parameters in seedlings exposed to regular watering. This is consistent with the reports of Akinyele (2007) on *Buchholzia coreacea* and Oboho and Igharo (2017) on *Pycnanthus angolensis.,* Gbadamosi (2014) on *Persea americana* and Ogidan *et al.* (2018) on *Kigelia africana.* This is in consonance with reports of Antunez *et al.* (2001) as well as that of Asaolu and Asaolu (2002).

Highest number of leaves was recorded in seedlings watered daily can also be traced to nitrogen present in *J. mimosifolia* which easily dissolve in the presence of regular watering and this facilitate the uptake of nutrient than other species investigated. This result is corroborated with the reports of Olubode *et al.* (2018) who stated that there was a corresponding increase in plant nutrient uptake with increase in applied moisture content and vice versa.

A significant leaf area recorded in seedlings subjected to daily watering regimes. Regular watering enhanced the leaf area of the *C. tangelo* seedlings. This is in conformity with the report of Ogunrotimi and Kayode (2018) who stated that *Solanum macrocarpon* might require much water as seedlings watered everyday had the highest leaf area. Regular watering enhanced the leaf area of *C. tangelo* seedlings. This is consonance with the reports of Oboho and Igharo (2017) who stated that leaf size is very crucial in photosynthesis and protoplasm build up hence the higher biomass under the higher watering regime. This is in agreement with the submission of Gonzales *et al*. (2009). The regular watering allows nutrient to dissolve and transport to appropriate area for leaf expansion for photosynthesis. Regular watering also enhanced the nutrient uptake of phosphorus. This is corroborated by the documentation of Olubode *et al.* (2018).

CONCLUSION

Of all the factors affecting nutrient uptake, growth and development of the plant, water is most critical. The success of nutrient up take in agro-forestry that leads to growth and development does not depend alone on present of nutrient, species types, age of the plant, soil rhizosphere, but also on soil ph and the availability of water. Irrespective of the quality and quantity of nutrient present in the soil, only water helps the nutrient to dissolve and form ions for the absorption of the root for plant growth and development. The essentiality of water cannot be over emphasized as its helps in biochemical, physiological and hormonal process in the plants as *C. tangelo*. The result of the investigation on the effect of watering regimes on the growth of *C. tangelo* revealed that daily watering enhances the growth parameters and nutrient uptake of *C. tangelo* except in the dry and fresh weight.

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