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Growth Evaluation of Northern Black Wattle (*Acacia auriculiformis Cunn. ex. Benth*) Seedlings under Varied Watering Intervals in the Nursery

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ABSTRACT

Water stress has a strong sway on the physiological functions of tree crops which adversely affects the growth and yield of tree plants. Drought and soil fertility are one of the major factors that influence seedling survival and growth in arid areas, thus it is of paramount importance to create optimum water requirements for tree seedlings in order to promote growth. In line with this, an investigation was carried out to assess growth behaviors of *Acacia auriculiformis* when exposed to varied watering intervals in the Kurumi Bomo nursery. Two weeks old seedlings in polythene bag containing the standard potting mixture as growing media were used for the experiments. Seedlings were exposed to 4 different watering intervals (once daily, once after 4, 8 and 16 days) and 230ml of water was administered per each seedling based on the watering frequency for 12 weeks. Twelve seedlings were allocated per watering frequency and replicated 5 times in a Completely Randomized Design (CRD). Data was collected on stem height, collar diameter, number of leaves and seedlings dry weights. Net assimilation rate, relative growth rate and absolute growth rate were also calculated. Data were subjected to analysis of variance and the significantly different means were separated with Duncan Multiple Range Tests ($p<0.05$). The results shown a significant ($P<0.05$) effect of water stress on seedlings growth of *Acacia auriculiformis* where seedlings that received water once daily produced stem height (7.61cm); Stem diameter (0.28mm); Number of leaves (5.52); LDW (1.60g); SDW (1.44g); RDW(2.89g); TDW (5.86g); L A (7.80cm^2); NAR (0.01028); RGR (0.01472) and AGR (0.05138) while the seedlings that received once after 4 days recorded stem height (7.23cm); Stem diameter (0.30mm); Number of leaves (4.85); LDW (1.52g); SDW (0.98g); RDW(2.36g); TDW (4.72g); L A (8.60cm^2); NAR (0.00874); RGR (0.01668) and AGR(0.04866). Thus, the two treatments (water once daily and water once after 4 days) produced utmost growth in all the variables measured.

Keywords: Water stress, *Acacia auriculiformis*, Regeneration, Seedling growth, Nursery,

Introduction

Water accessibility is the most imperative environmental factor known to have strong influence on tree species and distribution in the tropics. However, the supply of water in an ecosystem is greatly prejudiced by the seasonality of its distribution and the length of dry period which may vary from a dry spell of a few days in humid wet forests to a dry season of up to 7 to 8 months in dry monsoon forests. (Bongers *et al.*, 2004; Olajuyigbe *et al.*, 2012). Water stress is said to affect the physiological functions of a

tree crop, thereby influencing growth and yield (Simon *et al.*, 2011; Sale, 2015). Water requirement of any tree depends on the botanical characteristics of the plant, its stage of growth and weather conditions (Mukhtar, 2016a) Drought and soil fertility are the major factors that influence seedling survival and growth in the dry land areas (Abraham, 2014; Obalum *et al.*, 2017). However, to promote sustainable use of water in the nurseries, optimal water requirements for tree seedlings which will help in reducing the cost of planting stock production in commercial nurseries is paramount. (Simon *et al.*, 2011).

Acacia auriculiformis A. Cunn ex. Benth (family - Fabaceae) is a leguminous and multipurpose tree which is found in many tropical zones of Southeast Asia, Africa and Latin America (Das and Alam, 2001; Simons and Leakey, 2004). This plant species grows very fast, with the ability to fix nitrogen, thrive on infertile, acid, alkaline, saline and waterlogged soils (Hossain *et al.*, 1997). Successful use of *A. auriculiformis* in agro-forestry programme in Africa and Bangladesh has been reported owing to its rapid growth, short rotation and ability to thrive on degradable soil (Amin *et al.*, 1995). *A. auriculiformis* is a potential plant for erosion control, water conservation and also a source of biomass for fuel generation (Hossain *et al.*, 2009).

A sustained propagation and utilization of *A. auriculiformis* is paramount and in line with this, there is need to determine the extent to which the species will respond to drought at early stage to enhanced growth and development.

Materials and Methods

The study was conducted in Savanna Forestry Research Station nursery situated in Institute for Agricultural Research (I.A.R) farm Samaru in Kurumi Bomu village. Located at Latitude 12°13’and 11°11$^{'}$ N / Longitude 8°39’ and 7°38$^{'}$ E and 686m above sea level (Figure 1). It is located in Sabon – gari Local Government Area of Kaduna State. The vegetation in the local Government Area is the Northern Guinea Savannah woodland type, characterized by short scattered drought resistant trees with undergrowth of grass that serves as fuel for bushfires in the long dry season with mean annual rainfall of 1000mm – 1500mm, temperature of 25.6^{o}C (78.1^{o}F), precipitation of 1,117.6mm and humidity of 69% respectively (Sodimu *et al.*, 2021).

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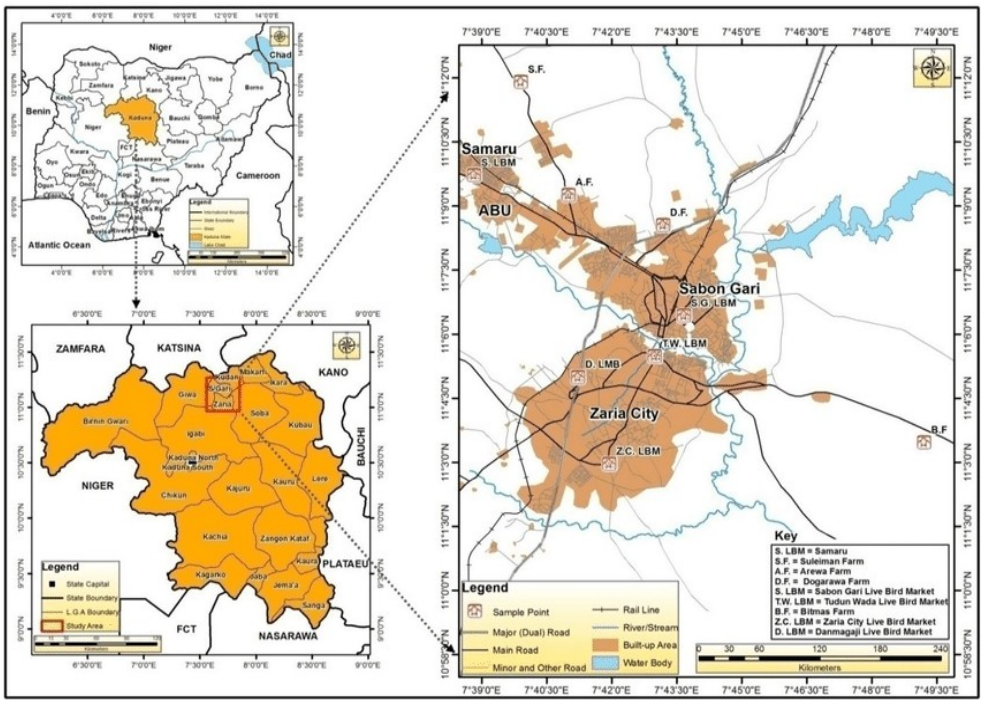

The experiment was carried out in Kurumi Bomo nursery where two (2) weeks old seedlings in standard nursery potting mixture (River sand; Top soil and Cow dung in ratio 3:2:1) were randomly selected and subjected to four (4) different watering regime of once daily, once after 4, 8 and 16days. However, twelve (12) seedlings were allocated per watering frequency and were replicated five (5) times, making 60 seedlings each per watering frequency and a sum total (60 x 4) of 240 seedlings in all. The experiment is laid out in a Completely Randomized Design (CRD) and each seedling is planted in a nursery black polythene pots of size 20cm × 25cm × 25cm, filled with 800g of nursery potting mixture, given 230ml of water based on the watering frequency in the morning.

The growth variables assessed include: seedling stem height, collar diameter and number of leaves. Metre rule was used to measure height, micrometer screw gauge for collar diameter and number of leaves was counted fortnightly for twelve (12) weeks. Seedlings dry weight was assessed at six week's interval (6th and 12th weeks after emergence) through destructive method adopted from Mukhtar, (2016b). Seedlings were sampled and separated into root, stem and leaves. The Leaf area was obtained by linear measurement of leaf length and leaf width as described by Ugese *et al.* (2008) in the formula below:

$$LA=4.41 +1.14LW$$

Where: LA = Leaf area

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

Fresh weight of root, stem and leaves were measured before they were oven dried for 24h at 80°C to constant weight.

The dry weight and leaf area were used to calculate the Relative Growth Rate (RGR), Net Assimilation Rate (NAR) and Absolute Growth Rate using the following formula by Mukhtar (2016a):

$$NAR = \frac{w2-w1 \times LnA2-LnA1}{A2-A2 \times T2-T1}$$

Where: W_1 and W_2 are biomass at time T_1 and T_2

A_1 and A_2 are leaf area at time T_1 and T_2

LnA_1 and LnA_2 are natural logarithm of leaf area at time T_1 and T_2.

$$RGR = \frac{LnW2 - LnW}{T1 - T2}$$

Where:

LnW_2 and LnW_1 are natural logarithm of biomass at time T_1 and T_2

$T_2 - T_1$ is time interval between first and second harvest

$$AGR = \frac{W2 - W1}{T2 - T1}$$

Where:

W_1 and W_2 are biomass at time T_1 and T_2

$T_2 - T_1$ is time interval between first and second harvest.

Results

Stem Height

A significant effect was observed in watering frequencies on stem height (Table 1). Watering once daily had significantly ($p < 0.05$) higher stem height of 7.61cm and this was significantly different with seedlings stem height watered once after 16days which recorded 4.33 cm.

Stem Diameter

There was a significant effect on seedlings diameter exposed to various watering frequencies. Table 1 shows the mean seedlings diameter where watering once daily recorded the highest diameter (0.28 mm) and was followed by seedlings that received water once after 4 days (0.30 mm) which were significantly different with seedlings that were watered once after 8 and 16 days (Table 1).

Number of leaves

A significant effect was observed in watering frequencies on seedlings leaf production (Table 1). Watering once daily had significantly ($p < 0.05$) higher number of leaves (5.52) and the least number of leaves (3.52) was recorded from seedlings that received water once after 16 days.

Table 1: Effect of watering frequency on seedlings growth of *Acacia auriculiformis*

	Stem Height (cm)		Stem Diameter(mm)		Number of Leaves	
Treatment	**2WAE**	**12WAE**	**2WAE**	**12WAE**	**2WAE**	**12WAE**
Once Daily	4.15^a	7.61^a	0.23^b	0.28^a	2.69^a	5.52^a
Once after 4 days	3.20^a	7.23^a	0.28^a	0.30^{ab}	2.35^a	4.85^b
Once after 8 days	5.18^a	5.28^a	0.26^{ab}	0.27^{bc}	2.68^a	4.38^b
Once after 16 days	4.19^a	4.33^b	0.25^b	0.26^c	2.57^a	3.52^c
SE ±	1.35	1.27	0.02	0.01	0.09	1.00
Significance	**ns**	*	*	*	**ns**	*

Means followed by the same letter(s) within a column are not significantly different ($p > 0.05$);
WAE: weeks after emergence

Leaves Dry Weight (LDW)

Table 2 shows the mean seedlings LDW where seedlings that were watered once daily gave the highest LDW (1.60 g) which was similar with seedlings that received watering once after 4 days (1.52 g) but differed significantly ($p < 0.05$) with seedlings that were exposed to watering once after 8 days (0.98 g).

Stem Dry Weight (SDW)

SDW was significantly ($p < 0.05$) influenced by watering frequency (Table 2). Seedlings that received watering once daily yielded significantly higher SDW (1.44 g) and those that received water once after 16 days had the least SDW (0.77 g).

Root Dry Weight (RDW)

There was a significant effect on seedlings' RDW (Table 2) with 2.89g as the highest RDW recorded from seedlings watered once

daily and significantly ($p < 0.05$) different from watering once after 16 days (0.93g) (Table 2).

Total Dry Weight (TDW)

A significant effect was found in seedlings total dry weight exposed to different watering frequencies. Table 2 shows mean TDW where seedlings that received water once daily had significantly higher TDW (5.86g) compared to seedlings that were exposed to watering once after 16 days (1.81g) (Table 2).

Leaf Area

Watering frequency had significant effect on leaf area with the highest leaf area (8.60cm^2) obtained from seedlings that received water once after 4 days which was followed by 7.80cm^2 from seedlings that received daily watering and both were significantly different ($P < 0.05$) from seedlings exposed to watering once after 16 days (2.94cm^2) (Table 2).

Table 2: Effect of Watering Frequency on Seedlings Dry Biomass of *Acacia auriculiformis*

Treatment	LDW(g)	SDW(g)	RDW(g)	TDW(g)	LA (cm^2)
Once Daily	1.60^a	1.44^a	2.89^a	5.86^a	7.80^a
Once after 4 days	1.52^a	0.98^{ab}	2.36^a	4.72^{ab}	8.60^a
Once after 8 days	0.98^b	0.94^{ab}	1.74^{ab}	3.53^b	7.10^a
Once after 16 days	0.45^c	0.77^b	0.93^b	1.81^c	2.94^b
SE ±	1.42	0.093	0.246	0.385	0.657
Significance	*	*	*	*	*

Means followed by the same letter(s) within a column are not significantly different ($p > 0.05$)
LDW: leave dry weight; SDW: stem dry weight; RDW: root dry weight; TDW: total dry weight; LA: leaf area

Net Assimilation Rate (NAR)

A significant effect was found on seedlings NAR between 6th and 12th week after emergence (Table 3). Mean NAR of seedlings under various watering frequencies was higher (0.01028) for seedlings that received watering once daily and was similar with seedlings watered once after 4 days but differed ($p < 0.05$) from seedlings exposed to watering once after 16days (0.01025).

Relative Growth Rate (RGR)

Watering frequency had significantly influenced seedlings RGR between 6th and 12th week after emergence (Table 3). The highest RGR (0.01472) was obtained in seedlings that received watering once daily

Absolute Growth Rate (AGR)

The AGR was significantly ($p < 0.05$) influenced by watering frequency. Table 3 shows mean AGR of seedling between 6th and 12th week after emergence where seedlings watering once daily yielded the highest AGR of 0.05138 which was significantly ($p < 0.05$) different with watering once after 16 days (0.00979).

Table 3: Effect of Watering Frequency on Seedlings NAR, RGR and AGR of *Acacia auriculiformis*

Treatment	NAR	RGR	AGR
Once Daily	0.01028^a	0.01472^{ab}	0.05138^a
Once after 4 days	0.00874^a	0.01668^{ab}	0.04866^a
Once after 8 days	0.00955^a	0.02173^a	0.03851^a
Once after 16 days	0.00187^b	0.01025^b	0.00979^b

SE ±	0.00138	0.00167	0.00428
Significance	*	*	*

Means followed by the same letter(s) within a column are not significantly different (p > 0.05)
NAR: Net assimilation rate, RGR: Relative growth rate, AGR: Absolute growth rate

Discussion

Seedlings growth was significantly enhanced by watering frequency where watering once daily and once after four (4) days yielded higher growth than watering once after eight (8) and sixteen (16) days. Seedlings that received water once after eight (8) days and those watered once after sixteen (16) days had lower growth rate but the species was able to withstand the water stress. The lower growth observed is in consonance with the work of Mukhtar, (2012) that plant - water status has a strong influence on plant growth and biomass production through its effect on leaf and root expansion. This further confirmed by the work of Sale, (2015) that growth and biomass production is directly proportional to the supply and use of water for optimum growth and development. Deciduousness was observed in seedlings watered once after eight (8) and sixteen (16) days which is an important drought tolerant strategy which deemphasize leaf production under low water supply (Cao, 2000 and Olajuyigbe *et al.* 2012).

The result advocates that seedlings of *Acacia auriculiformis* require average watering to enhanced growth and development. However, to reduced cost of production and optimum growth of *Acacia auriculiformis*, seedlings should be given 230 ml of water once after four (4) days in the nursery. The good seedling growth obtained from watering once after four (4) days was also confirmed by observation recorded in Isah *et al.* (2013) on *Acacia senegal* seedlings. Their findings shown high growth in seedlings watered once after three (3) days over those watered once daily, twice a day and once after two days. The only variance being that seedlings of *Acacia auriculiformis* watered once daily had the highest growth although was similar to once after four (4) days. However, these findings relatively disagreed with the result of Sale (2015) who recorded highest growth of *Parkia biglobosa* seedlings that were watered once in five (5) days over seedlings watered once daily and once in four (4) days. This variation could be due to species characteristics as stated by Cao (2000). The results, however, is in agreement with the work of Akinyele (2007) where higher growth was recorded in stem height and collar diameter from seedlings of *Buchholzia coreacea* that were watered once daily. Suberu (2014) and Oyun *et al.* (2010) also, reported high growth of seedlings of *Acacia senegal* that were watered once after fourteen (14) days over the same seedlings watered once daily and weekly. Cao (2000) also confirmed in is work that the species is said to be tolerant to low water availability with respect to its ability to withstand long period of water stress in spite of the low growth recorded. Lawlor (2002) opined that biomass production determines plant productivity. There have been other reports of greater biomass production of tree species in water use efficiency under limited supply as compared to well-watered or irrigated conditions (Lazaridou *et al*., 2003; Abbate *et al.*, 2004). However, growth and biomass are said to be directly related to the supply and use of water which could be attributed to the species water requirement, environment, season of growth and state of the seedlings. This is corroborated with the reports of Olubode *et al.* (2018) who stated that there was a corresponding increase in plant biomass with increase in applied moisture content and vice versa

Conclusion

Acacia auriculiformis is tolerant to water stress, highest growth in nursery could be achieved by watering the seedlings once daily which is as better as once after four (4) days in standard nursery potting mixture for improve growth and development. However, it could be recommended for Northern savannah afforestation programmes especially in some water deficit areas.

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