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Response of *Parkia biglobosa* (Jacq) Seedlings to Reduced Water Supply in the Nursery at Aliero, Kebbi State, a Semi-Arid Region of Nigeria.

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Abstract

Parkia biglobosa is a multipurpose tree species with numerous benefits and one of the preferred species for Agroforestry but its population is threatened as a result of increasing human pressure and inability to regenerate under natural condition caused by environmental factors like drought. It is therefore useful to ascertain specific water requirements of the species in the nursery for optimum growth and reduced cost of seedlings production. In line with this, an investigation was carried-out to study water requirement for early growth of *P. biglobosa* in semi-arid region of Nigeria. Two weeks old seedlings were randomly selected and allocated to four different water regime treatments (once in a day, once after 3, 7 and 14 days) and 200 ml of water were applied to each seedling-based watering intervals. Ten seedlings were allocated per treatment and replicated five times. A completely randomised design was used and data were collected fortnightly for 12 weeks on stem height, collar diameter, number of leaves and seedlings dry weight. Net assimilation rate, relative growth rate and absolute growth rate were calculated. Data were analysed with analysis of variance and significantly different means were separated with Duncan multiple range test ($p<0.05$). The result revealed a significant ($p<0.05$) influence of watering regimes on early growth of *P. biglobosa* where once in a day produced the highest growth in all the parameters assessed. Seedlings of *P. biglobosa* that received water once in 7 days produced very low growth with total mortality recorded from once in 14 days. Watering once in a day with 200ml of water was recommended for optimum growth of *P. biglobosa* in the nursery.
Keywords: watering regime, growth, *P. biglobosa,* seedlings, nursery

Introduction

Parkia biglobosa (Jacq.) known as African locust bean is a perennial deciduous tree of *Fabaceae* family preferred for agroforestry with numerous benefits, which include edible fruit pulp, seeds which are fermented to make a local food condiment that is rich in protein and vitamins and ability to fix atmospheric nitrogen (Gideon and Verinumbe, 2013). Also, it plays a vital ecological role in nutrient cycling (Gbadamosi, 2005; Udobi *et al*., 2010). It is a valuable source of food, especially the seeds which serve as useful spices for cooking (Oluwafemi *et al*., 2014).

Parts of the tree are used for medicine, glaze for ceramic pots, fodder, firewood and charcoal production (Olorunmaiye *et al*., 2011). But despite the economic potentials of this important tree, the sustained provision of its benefits is doubtful because of the threat of extinction coupled with inability to regenerate under natural condition as a result of increasing human pressure, drought and other environmental factors which hinder its regeneration (Falerama *et al.,* 2014).

Water has a strong influence on tree species richness and distribution in the tropics (Bongers *et al.,* 2004; Mukhtar *et al.,* 2016). In spite of the essential influence of water to tree growth and development, the water requirements of tree species vary depending on the species, state of growth and prevailing environmental factors as even provenance was found to have a significant influence on seedlings growth of the same species as regard to their water requirements (Mukhtar *et al.,* 2016). Also, water requirement of a plant species is dependent on the botanical characteristics of the crop, its stage of growth and weather conditions (Mukhtar *et al.*, 2016). Thus, water stress is said to affect physiological functions of a tree crop, thereby influencing growth and yield. The amount of water required by the tree crops depends on the type of species, growth stage and season. Therefore, it is necessary to establish the water requirement of each tree species (Simon *et al*., 2011; Mukhtar *et al.,* 2016), which will reduce the cost of production in commercial nurseries and promote sustainable use of water.

Materials and Methods

This research was conducted in Aliero, Kebbi State (Latitude 12°16′42″N and Longitude 4°27′6″E) with estimated area of 350 km^2 inhabited mostly by agrarians with a tropical continental climate that is largely controlled by tropical maritime and tropical continental winds, blowing from the Atlantic and the Sahara desert respectively. The wet season comes in five months and spans May to September while the dry season lasts for the remaining period of the year with mean annual rainfall of about 800 mm and 26 ^oC (temperature) (Mukhtar, 2016).

Seeds were sown in the germination bed (top soil) and allowed to germinate and at two weeks after emergence seedlings were randomly selected and subjected to watering at four different intervals (Once daily, once in 3, 7 and 14 days) (Mukhtar, 2016). Ten seedlings were allocated to each watering regime in five replications using a completely randomized design, with 200 ml of water administered to each seedling at the tested intervals.

Data were collected on stem height, collar diameter and number of leaves by the use of metre rule, micro-meter screw gauge and physical counting respectively. The dry weight was assessed at the 4^{th} and 10^{th} weeks when seedlings were sampled and separated into root, stem and leaves. Graph sheet was used to trace leaf area covered by pinnules of the compound leaves, and the root, stem and leaves were oven dried at 80 ^oC to constant weight. Relative growth rate, net assimilation rate (NAR) and absolute growth rate were calculated based on the dried weight and leaf area using the following formula:

Net Assimilation rate (NAR)

$$NAR = \frac{w_2 - w_1 \, X \, LnA_2 - \, LnA_1}{A_2 - \, A_{12} \, X \, t_2 - \, t_1}$$

where, w_1 and w_2 = biomass at time t_1 and t_2

A_1 and A_2 = leaf area at time t_1 and t_2
LnA_1 and LnA_2 = natural logarithm of leaf area at time t_1 and t_2
Relative Growth Rate (RGR)

$$RGR = \frac{Lnw_2 - Lnw_1}{t_2 - t_1}$$

where, Lnw_2-Lnw_1 = natural logarithm of biomass at time t_1 and t_2
t_1 and t_2 = time interval between first and second harvest
Absolute Growth Rate (AGR)

$$AGR = \frac{w_2 - w_1}{t_2 - t_1}$$

where, w_1 and w_2 = biomass at time t_1 and t_2
t_1 and t_2 = time interval between first and second harvest
Data were analyzed using descriptive statistics and Analysis of Variance and where there was significant difference, Duncan Multiple Range Test was used to separate the means using SPSS package (Version 20).

Results

Stem Height
A significant effect (p<0.05) was observed on seedlings stem height (Table 1) and seedlings that were watered once daily had higher stem height (14.02 cm) and were significantly different (p<0.05) from watering at 3, 7 and 14-day intervals (Table 1).
Diameter
Watering regime was found to be significantly (p<0.05) effective on seedlings collar diameter with the largest diameter (4.30 mm) obtained from seedlings that received water once daily. This significantly differed (p<0.05) from seedlings that received water once in 3 days (2.58mm) (Figure 1).
Number of leaves
There was a significant effect of watering regime on seedlings leaf production. Figure 2 shows mean number of leaves produced by seedlings under different watering regime. Plants watered once daily had the highest number of leaves (40) and was significantly different from plants watered once after 14 days.

Table 1: Effect of watering regime on seedlings height of *P. biglobosa*

	Stem Height (cm)				
Treatment	**2WAE**	**4WAE**	**6WAE**	**8WAE**	**10WAE**
Once daily	5.43^a	8.74^a	9.98^a	11.67^a	14.02^a
Once in 3 days	4.10^b	7.36^b	7.79^b	8.94^{bc}	7.41^b
Once in 7 days	3.97^b	7.98^{ab}	8.55^b	9.59^b	8.94^b
Once in 14 days	3.52^b	7.70^{ab}	8.35^b	8.52^c	0.58^c
S.E	0.210	0.202	0.243	0.306	1.141
Significance	*	*	*	*	*

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

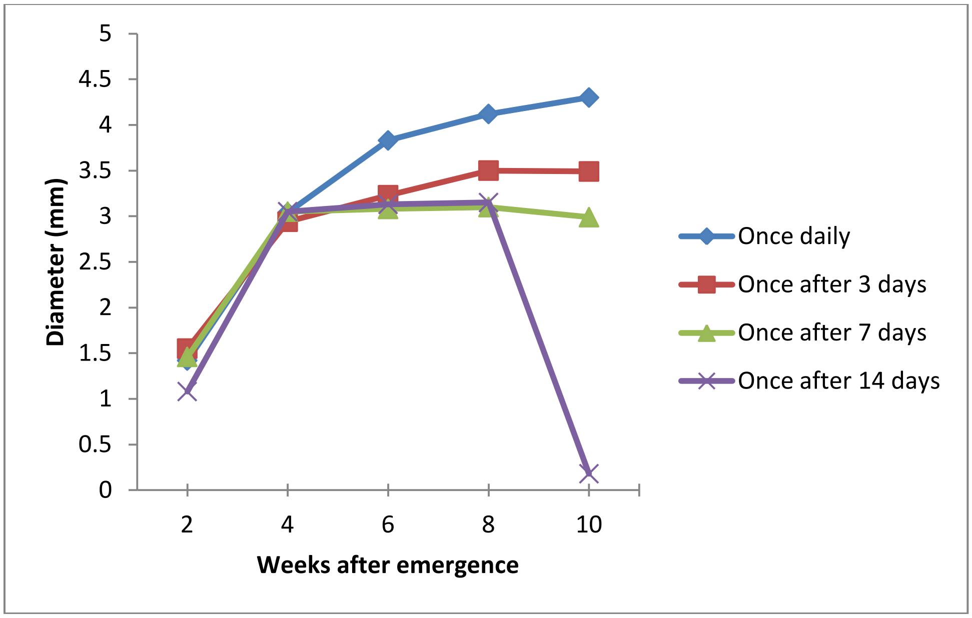

Fig. 1: Effect of watering regime on seedlings diameter of *P. biglobosa*

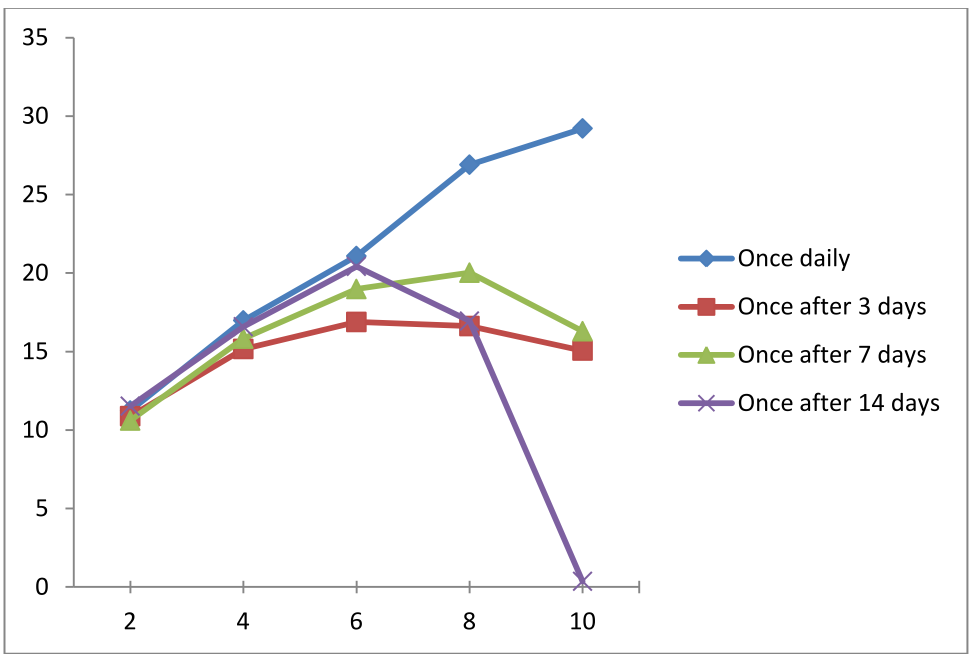

Fig. 2: Effect of watering regime on seedlings leaf production of *P. biglobosa*

Leaf Dry Weight (LDW)

Watering regime had significant effect on LDW as shown in Figure 3 where 3.08 g was the highest LDW obtained from seedlings watered once daily and was significantly ($p<0.05$) different from that of seedlings watered once in 3 days (1.42 g).

Stem dry Weight (SDW)

The SDW was significantly influenced ($p<0.05$) by watering regime and seedlings that received water once daily had significantly higher SDW of 1.02 g which was followed by watering once in 3 days which had 0.42 g (Figure 3).

Root Dry Weight (RDW)

A significant effect ($p<0.05$) was observed on RDW as influenced by watering regime where watering once daily had highest mean RDW of 3.24 g which significantly ($p<0.05$) differed from watering once in 3 days that had 1.48 g (Figure 3).

Total Dry Weight (TDW)

Watering regime was significantly effective on seedlings TDW as shown in Figure 3 where seedlings exposed to watering once daily had significantly highest TDW (7.34 g) (Figure 3).

Leaf Area

Watering regime was significantly ($p<0.05$) effective on leaf area of *P. biglobosa* seedlings with the highest leaf area (40.80 cm^2) obtained from seedlings watered once daily which significantly ($p<0.05$) differed with watering once after 7 and 14 days (Figure 3).

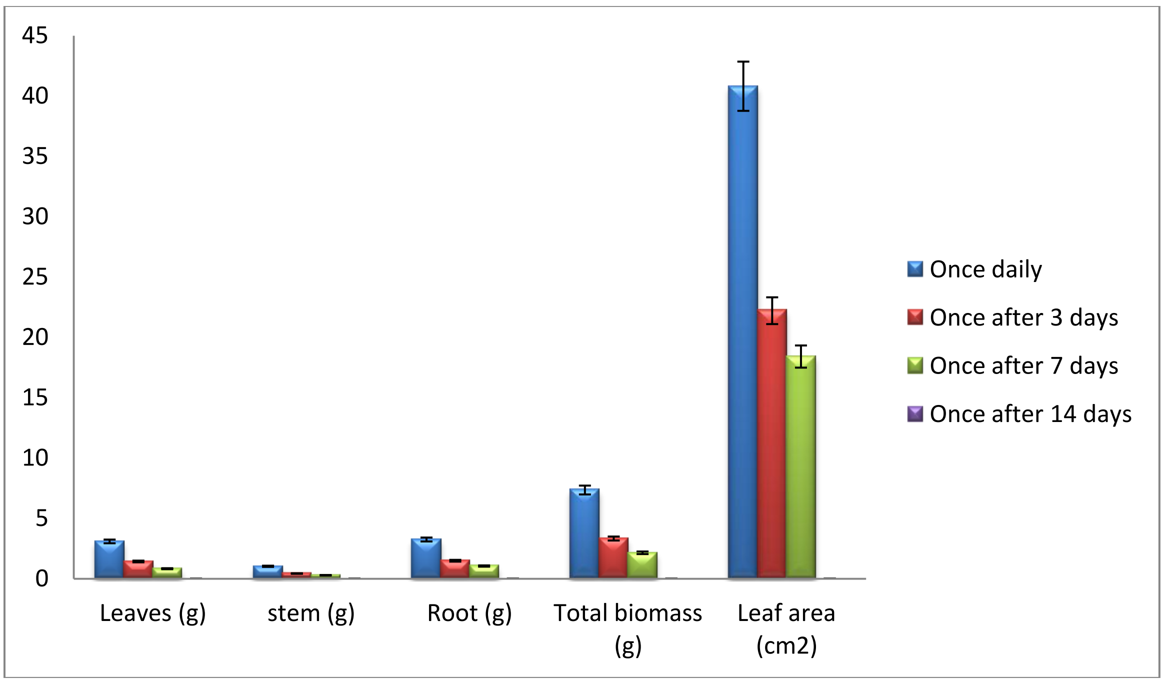

Fig. 3: Effect of watering regime on dry biomass of *P. biglobosa* seedlings

Net Assimilation Rate (NAR)

Watering regime was significantly effective in enhancing seedlings NAR between 4th and 10th week after emergence where watering once daily had significantly highest NAR (0.00452) (Table 2).

Relative Growth Rate (RGR)

No significant ($p>0.05$) effect was observed in watering intervals on seedlings RGR between 4th and 10th week after emergence where seedlings that received water once daily had RGR of 0.26 but was not significantly different from watering frequencies (Table 2)

Absolute Growth Rate (AGR)

A significant effect was observed on AGR between 4th and 10th week after emergence where seedlings that were watered once daily had significantly higher AGR (0.09) (Table 2).

Table 2: Effect of watering regime on seedlings NAR, RGR and AGR of *P. biglobosa*

Treatment	NAR	RGR	AGR
Once daily	0.00452[a]	0.02600	0.09428[a]
Once in 3 days	0.00309[b]	0.02267	0.04178[b]
Once in 7 days	0.00209[b]	0.01863	0.02535[b]
Once in 14 days	0.00000[c]	0.00000	-0.01214[c]
S.E	0.00042	0.00256	0.00919
Significance	*	*ns*	*

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 of *P. biglobosa* was significantly improved by watering regime where watering once daily had the highest growth (stem height, collar diameter, leaves and biomass). Low growth was recorded in seedlings that were watered once in 3 and 7 days, while mortality was observed in seedlings exposed to watering once in 14 days. These agreed with Mukhtar *et al.* (2016) that water status strongly influenced plant growth and biomass production and in particular through its effects on leaf and root expansion. This implies that, growth and biomass production is directly proportional to the supply and use of water (Akinyele, 2007; Mukhtar *et al.*, 2016). The higher growth in seedlings that were watered once daily disagreed with Isah *et al*. (2013) who recorded highest growth in seedlings of *A. senegal* that received water once after 3 days over once daily, twice a day and once in two days. This might be due to the differences in genetic potentials of the species but the findings confirmed Sale (2015) and Simon (2011) who wrote on water requirements of a plant species to be dependent on the botanical characteristics of the crop, its stage of growth, weather condition and water availability (stress) which are said to affect physiological functions of tree crops, thereby influencing growth and yield. The findings however disagreed with the result of Sale (2015) who evaluated the effect of watering regime and pot size on seedlings growth of *P. biglobosa* where highest growth was recorded in seedlings watered once after five days over watering once daily and once after three days. The weakness in Sale (2015) is non specification of the amount of water used. Furthermore, the findings agreed with Akinyele (2007) where seedlings of *B. coreacea* that received water once daily had the highest growth over seedlings that were either flooded, watered once every three days or five days. Total mortality was observed after some time in seedlings exposed to watering once after fourteen days which could be due to inability of the species to withstand drought/water stress which has to do with species characteristics (Cao, 2000; De Smedt *et al*., 2011; Olajuyigbe *et a*l., 2012; Lawanson *et al*., 2014). The result suggests that *P. biglobosa* is a water loving species at early stage for growth and thus, the seedlings should be watered at least once daily for enhanced growth.

Conclusion

Reduced water supply had a significant influence on early growth of *P. biglobosa* and application of 200 ml of water daily to a seedling greatly improved the growth of *P. biglobosa* seedlings in the nursery.

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