Renewable
Journal of the Faculty of Renewable Natural Resources,
University of Ibadan, Ibadan, Nigeria
Volume 4, December, 2024
https://journals.ui.edu.ng/index.php/ren/index
ISSN: 2971-5776 (Prints)
2971-5784 (Online)
pp. 21-26

Influence of Temperature on Early Growth of *Pterocarpus santalinoides* L'Hérit. ex DC.

Fredrick, C.[1]*, Ofodile, E. A. U.[1], Basiru, A. O.[2] and Omokhua, G. E.[1]
[1]Department of Forestry and Wildlife Management, Faculty of Agriculture, University of Port Harcourt, P.M.B. 5323, Choba, Rivers State, Nigeria
[2]Department of Forestry and Wildlife Management, College of Environment Resources Management, Federal University of Agriculture, Abeokuta, Ogun State, Nigeria.
*Corresponding Author: charity.fredrick@uniport.edu.ng

Abstract

This study evaluated the effect of temperature on the early growth of Pterocarpus santalinoides seedlings. In a completely randomized experiment, 80 randomly selected seedlings were subjected to four temperature regimes namely: 20/27±3°C, 22/30±3°C, 25/33±3°C and 27/35±3°C. Initial measurements of seedling growth variables were done, four months after sowing and bi-monthly thereafter for twelve months. Variables such as seedling height, stem collar diameter, number of leaves, root length, shoot and root fresh and dry weights, moisture content, total weight and root to shoot ratio were monitored. Data were analysed using Analysis of Variance and Duncan Multiple Range Test was used to separate significantly different means. There were significant differences in the height, collar diameter, number of leaves, root length and biomass of Pterocarpus santalinoides seedlings grown at different temperatures. After four months, the highest height (35.05 cm) was observed for 22/30±3°C treatment, while lowest (28.11cm) was for 27/35±3°C. From 6 to 12 months, the highest heights: 31.37 cm, 38.04 cm, 45.15 cm and 50.51 cm, respectively, were observed for 25/33±3°C treatment, while the lowest (31.37 cm, 38.04 cm, 45.15 cm and 50.51 cm) were for 20/27±3°C treatment. Highest collar diameters (5.34 mm, 6.88 mm, 8.65 mm, 9.83 mm and 10.48 mm) were observed at 27/35°C±3°C and lowest 3.82 mm, 4.42 mm, 5.86 mm, 6.61 mm and 8.61 mm) at 20/27°C±3°C, from 4 to 12 months. The longest (44.88 mm) and least (30.58 mm) root lengths were observed at 25/33°C±3°C and 20/27°C±3°C, respectively. Pterocarpus santalinoides seedlings grew at all tested temperature regimes, with better growth observed at 25/33°C and 27/35°C.

Keywords: *Pterocarpus santalinoides,* Temperature variation, Early growth, Seedling biomass.

Introduction

Pterocarpus santalinoides L'Herit ex DC. is a leguminous tree species in the Fabaceae family (Orwa *et al.,* 2009). It is commonly called Red Sandal Wood or "Nturukpa" in Igbo language (Keay, 2011; Offor *et al.,* 2015). The species is distributed throughout tropical Africa, from Senegal to the Central African Republic and Democratic Republic of Congo. It is also widely distributed in South America (Lemmens 2008; Organ, 2004; Offor *et al.,* 2015). It grows in well-drained soils and regions with medium rainfall (1600 mm/year) at elevations between 270 and 2700 m and at an average temperature of 26°C (Orwa *et al.,* 2009).

The species is used as a shade tree in agroforestry systems, where it helps to control soil erosion, fixes nitrogen, produces litter and protects arable crops (Lemmens, 2008; Eze *et al.,* 2012).

Most plants experience heat stress at different times of their life cycles due to temperature variations (Iloh *et al.,* 2014). Climate change has been predicted to increase global temperatures and affect future plant species distribution. This may influence the ability of individual species to survive (Dove, 2010). Hatfield and Prueger (2015) and Koger *et al.* (2004) noted that temperature is a primary factor affecting plant growth and development. Each plant species has an optimal temperature at which it thrives and a base temperature beyond which it would not, with extreme temperatures having detrimental effects on productivity (Salisbury and Ross, 1992; Iloh *et al.,* 2014). When evaluating a species' growth traits or its potential for establishment, knowledge of how temperature affects species might be helpful.

Therefore, research is needed on the temperatures that affect the growth and development of *P. santalinoides*. The early development of the seedlings may aid in promoting its propagation and establishment. Understanding its response to temperature, during early growth is essential, to improve seedling quality, especially under challenging field conditions. Therefore, this study determined the effect of different temperature regimes on early growth of *P. santalinoides* seedlings.

Materials and Methods

Study Area

The study was conducted at the Research and Experimental Nursery of the Department of Forestry and Wildlife Management, Faculty of Agriculture, University of Port Harcourt Rivers State, Nigeria. The University is located in the Choba community, which is in the Obio/Akpor Local Government Area of Rivers State, Nigeria. It is geographically located along latitudes 04°52'30"N to 04°55'0"N and longitudes 6°54'0"E to 6°55'30"E (Chima *et al.,* 2017). The annual rainfall in the region is estimated to be 2400 mm, while the dry season temperature ranges from 25°C to 38°C (Wokoma, 2008).

Seed Collection

Mature fruits of *P. santalinoides* were obtained from mature trees in Eziama Ntigha Autonomous Community in Isi-Alangwa North Local Government Area, Abia State, Nigeria. A viability test was conducted to determine seed health, using the floatation method, which involved soaking the seeds for three hours. Seeds that floated were discarded, while seeds that sank were considered to be viable and used in the study.

Experimental Design

The experiment was set up in a completely randomized design, with 20 randomly selected seedlings for each of four temperature regimes. Two months after sowing, young seedlings were transplanted into 15 cm x 15 cm x 20 cm polypots, filled with topsoil. The polypots were placed in propagators at various temperatures, including 20/27±3°C, 22/30±3°C, 25/33±3°C and 27/35±3°C, simulating night/day temperature fluctuations. With the aid of a thermometer, the temperatures of the propagators were repeatedly recorded. The mean was utilized as the propagators' real temperature. During the experiment, weeding was done frequently and polypots watered, once daily.

Biomass Determination

After 12 months, five seedlings were carefully selected and their root systems were exposed by gently washing off the soil. Excess moisture was then blotted from the plants using absorbent paper. These seedlings were divided into their shoot and root parts by cutting at the collar. The root length, fresh weight of the shoot (including the leaves), and roots were measured before oven drying for 72 hours at 70°C.

Data Collection and Analysis

Initial measurements of seedling growth variables were done, four months after sowing (two months after transplanting) and then bi-monthly for twelve months. Data were collected on seedling height, collar diameter, number of leaves and root length.

Seedling total weight (TW), root to shoot ratio (RSR) and moisture content (MC) were estimated using the equations below;

1. Total Weight (TW) = Shoot weight + Root weight
2. Moisture Content (MC) = Fresh weight – Dry weight
3. Root to Shoot Ratio (RSR) = Root weight ÷ Shoot weight

Analysis of Variance was used to analyse the data and significantly different means at $P \leq 0.05$ were separated using Duncan Multiple Range Test (DMRT).

Results

There were significant variations in the height of *P. santalinoides* seedlings. After 4 months, seedlings exposed to 22/30°C±3°C (35.05 cm) had the highest height, followed by 25/33°C±3°C (33.25 cm) and 27/35°C±3°C (30.98 cm). From 6 to 12 months, highest height was observed at 25/33°C±3°C (33.25±1.20cm, 82.39 cm, 86.66 cm and 89.24 cm, respectively). On the other hand, the lowest height was observed at 20/27°C±3°C (28.11 cm, 31.37 cm, 38.04 cm, 45.15 cm and 50.51cm) (Table 1).

There were significant differences in the collar diameter as temperature increased. The mean collar diameter of seedlings from 4 to 12 months varied from 4.62 mm to 9.58 mm. Highest seedling collar diameter was at 27/35°C±3°C from 4 to 12 months (5.34 mm, 6.88 mm, 8.65 mm, 9.83 mm and 10.48 mm, respectively). However, 20/27°C±3°C had the lowest collar diameter (3.82 mm, 4.42 mm, 5.86 mm, 6.61 mm and 8.61 mm, respectively) (Table 2).

The number of leaves significantly varied across temperatures, with the mean increasing from 11.75 (at 4 months) to 40.67 (at 12 months). Highest number of leaves was found in seedlings grown at 27/35°C±3°C at 4, 10 and 12 months (14.9, 44.0 and 50.3 respectively) and at 25/33°C±3°C in months 6 and 8 (23.5 and 38.4 respectively), while lowest number of leaves was observed at 20/27°C±3°C from 4 to 12 months (8.0, 13.0, 17.9, 25.1 and 29.1 respectively) (Table 3).

The root length of *P. santalinoides* seedlings was significantly influenced by temperature (Figure 1) and varied from 30.58 cm to 44.88 cm. Seedlings under 25/33°C±3°C treatment had the highest root length, followed by those exposed to 22/30°C±3°C, while seedlings exposed to 20/27°C±3°C had the lowest root length (Figure 1).

Table 1: Seedling height, collar diameter and number of leaves of *Pterocarpus santalinoides* exposed to different temperature regimes for 12 months (μ±SE)

Temperature	Seedling Height (cm) (Months)				
	4	6	8	10	12
20/27°C±3°C	28.11±1.95b	31.37±1.93c	38.04±1.78c	45.15±2.60c	50.51±2.32b
22/30°C±3°C	35.05±0.89a	42.64±2.49b	59.44±4.77b	70.15±8.25ab	76.28±8.09a
25/33°C±3°C	33.25±1.20a	56.04±3.39a	82.39±6.70a	86.66±6.61a	89.24±6.59a
27/35°C±3°C	30.98±1.12ab	42.06±3.50b	51.36±4.45bc	66.88±7.32b	71.26±7.59a
Mean	31.85±0.77	43.03±1.98	57.81±3.45	67.21±3.94	71.82±3.86
P	0.006	<0.001	<0.001	0.001	0.002
	Collar Diameter (mm) (Months)				
	4	6	8	10	12
20/27°C ±3°C	3.82±0.12c	4.42±0.22c	5.86±0.20c	6.61±0.23c	8.61±0.23b
22/30°C±3°C	4.49±0.19bc	5.45±0.30b	6.83±0.26bc	7.95±0.23b	9.28±0.36ab
25/33°C±3°C	4.82±0.31ab	6.63±0.22a	7.47±0.29b	8.79±0.34ab	9.95±0.23ab
27/35°C±3°C	5.34±0.38a	6.88±0.28a	8.65±0.54a	9.83±0.67a	10.48±0.81a
Mean	4.62±0.16	5.84±0.20	7.20±0.23	8.29±0.27	9.58±0.25
P	0.003	<0.001	<0.001	<0.001	0.043
	Number of leaves (Months)				
	4	6	8	10	12
20/27°C ±3°C	8.0±0.76c	13.0±0.76b	17.9±1.45b	25.1±1.69b	29.1±1.71b
22/30°C ±3°C	11.4±1.10b	16.4±1.10b	30.4±1.42a	38.4±3.30a	39.4±2.37ab
25/33°C ±3°C	12.7±0.92ab	23.5±1.57a	38.4±3.34a	43.2±2.73a	43.9±2.545a
27/35°C ±3°C	14.9±1.47a	22.1±2.71a	37.8±4.92a	44.0±5.23a	50.3±6.72a
Mean	11.75±0.66	18.75±1.06	31.13±1.92	37.67±2.07	40.67±2.24
P	0.001	<0.001	<0.001	0.002	0.004

Means in the same column with the same alphabet did not differ significantly ($p > 0.05$).

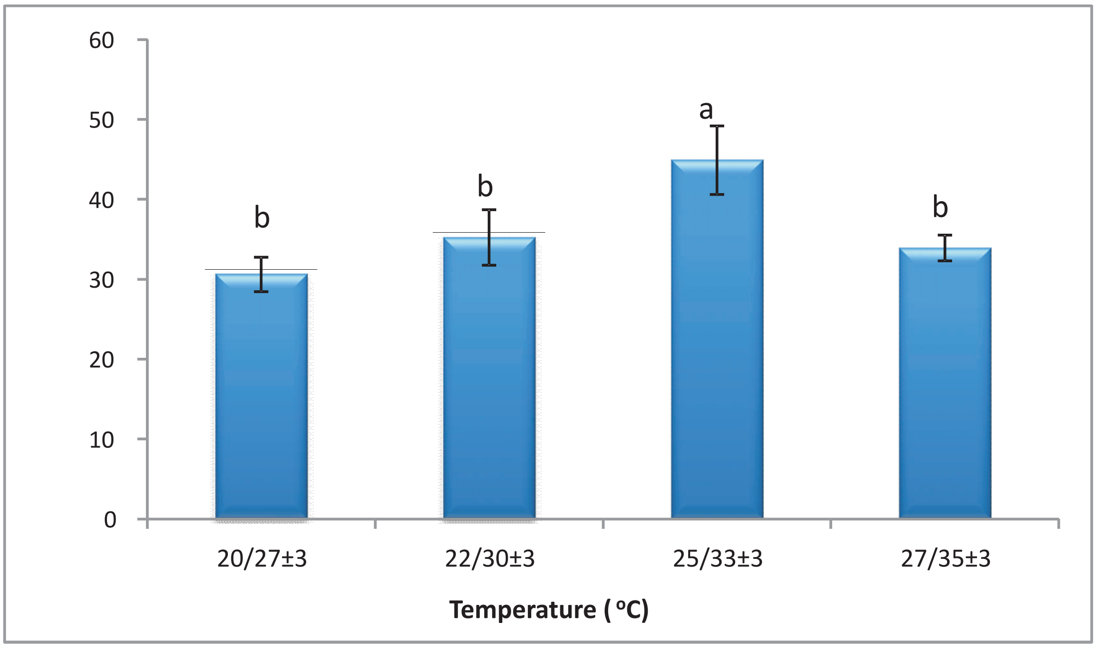

Figure 1: Root length of *Pterocarpus santalinoides* exposed to different temperature regimes. Bars with the same letter (s) did not differ significantly ($p < 0.05$).

Table 2: Biomass of *Pterocarpus santalinoides* seedlings exposed to different temperature regimes for 12 months (μ±SE).

	Temperature (°C)				
Biomass	**20/27±3**	**22/30±3**	**25/33±3**	**27/35±3°**	***P value***
Shoot Fresh Weight (g)	3.16±0.51c	11.00±1.23b	16.80±1.00a	15.04±1.82a	0.000
Shoot Dry weight(g)	1.56±0.22c	4.06±0.49b	7.18±1.01a	7.08±1.02a	0.000
Shoot Moisture Content (g)	1.60±0.33b	6.94±0.76b	9.62±0.38a	7.96±1.07a	0.000
Root Fresh Weight (g)	0.86±0.10b	2.28±0.41b	8.50±0.48a	10.28±1.11a	0.000
Root Dry weight (g)	0.40±0.06c	0.74±0.10c	2.56±0.22b	3.58±0.61a	0.000
Root Moisture Content (g)	0.46±0.05b	1.54±0.31b	5.94±0.32a	6.70±0.60a	0.000
Total Fresh Weight (g)	4.02±0.58c	13.28±1.53b	25.30±1.37a	25.32±2.60a	0.000
Total Dry Weight (g)	1.96±0.24c	4.80±0.54b	9.74±1.10a	10.66±1.37a	0.000
Fresh Root to Shoot Ratio (g)	0.29±0.04c	0.21±0.03c	0.51±0.02b	0.72±0.09a	0.000
Dry Root to Shoot Ratio (g)	0.27±0.14b	0.19±0.11b	0.39±0.20ab	0.53±0.24a	0.014

Means in the same row with the same alphabet did not differ significantly ($p < 0.05$).

The shoot biomass varied significantly, with the highest fresh and dry weight observed for seedlings exposed to 25/33°C±3°C, while lowest was for those in the 20/27°C±3°C temperature regime. Highest shoot moisture content was found at 25/33oC±3°C, while the lowest was at 20/27°C±3°C (Table 4).

The total and root biomass were significantly different with highest fresh and dry weights recorded for 27/35°C±3°C treatment and lowest for 20/27°C±3°C (Table 4). The root to shoot ratio varied across treatments with the highest observed for 27/35°C±3°C, while the lowest was for 22/30°C±3°C.

Discussion

Temperature regimes influenced growth parameters (seedling height, collar diameter, number of leaves, root length and biomass) and plays a crucial role in early growth and development (Gairola *et al.,* 2015). For example, Kamani *et al.* (2011) observed significant variations in the growth of *Arabidopsis thaliana,* due to temperature effects.

The highest seedling heights, shoot biomass and root lengths were at 25/33°C suggesting suitability of this temperature for early growth. This agrees with

Kulkarni *et al.* (2005), who reported that seedlings of *Albuca pachychlamys* and *Drimia robusta* should be grown at 25°C to ensure seedling vigour and health. Rezazadeh *et al.* (2018) noted that potted red firespike plants reached maximum height at 25°C, while higher temperatures led to shorter plants. Nordli *et al.* (2011) also observed enhanced total shoot length in *Hydrangea macrophylla* at 24°C.

The highest seedling collar diameter, number of leaves, root biomass, total weight and root to shoot ratio were observed at 27/35°C. This confirmed that 27/35°C was beneficial to the growth of *Pterocarpus santalinoides* although height and root length reduced at this temperature regime. Muhl *et al.* (2011) observed that the highest temperature regime was most suitable for the growth of *Moringa oleifera*.

Growth and development of *P. santalinoides* seedlings at 20/27°C was greatly restricted, suggesting that the species requires a higher temperature for improved growth. Plant growth and development depend on the surrounding temperature, with species preferring specific ranges, represented by a minimum, maximum and optimum level (Kulkarni *et al.,* 2005; Hatfield and Prueger, 2015).

Conclusion

Pterocarpus santalinoides seedlings grew at different temperature regimes, but the most suitable ranges were 25/33°C and 27/35°C. These temperature regimes supported increased growth for height, collar diameter, number of leaves, root length, and biomass. This threshold could be used during large scale propagation of the species.

References

Chima, U. D., Etuk, E. C. and Fredrick, C. (2017). Effects of sowing depths on the germination and early seedling growth of different seed sizes of *Annona muricata* L. *African Journal of Agriculture, Technology and Environment* 6(2): 134-144.

Dove, N. (2010). The effect of increasing temperature on germination of native plant species in the north woods' region. *University of Vermont* (Doctoral dissertation, Thesis).

Eze, S. O., Cornelius, C. and Okereke, H. C. (2012). Phytochemical and antimicrobial analysis of the stem bark of *Pterocarpus santalinoides* (Nturu Ukpa). Asian *Journal of Natural and Applied Sciences* 1(3): 26-32.

Gairola, K. C., Nautiyal, A. R. and Dwivedi, A. K. (2011). Effect of temperatures and germination media on seed germination of *Jatropha curcas* Linn. *Advances in Bioresearch 2*(2): 66-71.

Hatfield, J. L. and Prueger, J. H. (2015). Temperature extremes: Effect on plant growth and development. *Weather and Climate Extremes* 10: 4-10.

Iloh, A. C., Omatta, G., Ogbadu, G. H. and Onyenekwe, P. C. (2014). Effects of elevated temperature on seed germination and seedling growth on three cereal crops in Nigeria. *Scientific Research and Essays* 9(18): 806-813.

Kamani, N., Kim, J. and MacLean, J. (2011). Effect of temperature on the germination and growth rate of Thale Cress (*Arabidopsis thaliana*). *The Expedition* 1: 1-11

Keay, R. W. (1989). *Pterocarpus* species, Trees of Nigeria, Vol III, Clarendon Press, Oxford, 210 pp.

Koger, C. H., Reddy, K. N. and Poston, D. H. (2004). Factors affecting seed germination, seedling emergence, and survival of Texas weed (*Caperonia palustris*). *Weed Science* 52(6): 989-995.

Kulkarni, M. G., Sparg, S. G., Van Staden, J. and Thomas, T. H. (2005). Temperature and light requirements for seed germination and seedling growth of two medicinal Hyacinthaceae species. *South African Journal of Botany,* 71(3-4): 349-353.

Lemmens, R. H. M. J. (2008). *Pterocarpus santalinoides* DC. [Internet] Record from PROTA4U. Louppe, D., Oteng-Amoako, A. A. and Brink, M. (Editors). PROTA (Plant Resources of Tropical Africa / Ressources végétales de l'Afrique tropicale), Wageningen, Netherlands. http://www.prota4u.org/search.asp Accessed 5 August 2016.

Muhl, Q. E., Du Toit, E. S. and Robbertse, P. J. (2011). Temperature effect on seed germination and seedling growth of *Moringa oleifera* Lam. *Seed Science and Technology* 39 (1): 208-213.

Nordli, E. F., Strøm, M. and Torre, S. (2011). Temperature and photoperiod control of morphology and flowering time in two greenhouses grown *Hydrangea macrophylla* cultivars. *Scientia horticulturae* 127 (3): 372-377.

Offor, C. E., Nwankwegu, N. J., Ugwu Okechukwu, P. C. and Aja, P. M. (2015). The effects of ethanol leaf-extract of *Pterocarpus santalinoides* on liver enzymes of albino rats. *American-Eurasian Journal of Agriculture and Environmental Science* 15(5): 920-922.

Organ, M. T. (2004). Trees of Nigeria. J*ournal of Complementary and Integrative Medicin*e 123 (1): 125-129.

Orwa, C., Mutua, A., Kindt, R., Jamnadass, R. and Simons, A. (2009). Agroforestry tree Database: a tree reference and selection guide version 4.0. Retrieved from (http://www.worldagroforestry.org/sites/treedbs/treedatabases.asp).

Rezazadeh, A., Harkess, R. L. and Telmadarrehei, T. (2018). The effect of light intensity and temperature on flowering and morphology of potted red firespike. *Horticulturae* 4(4): 36.

Salisbury, F. B. and Ross, C. W. (1992). *Plant Physiology,* 4th edn. Wadsworth Publishing Company, Belmont, California.

Wokoma, E. C. W. (2008). Preliminary Report on Diseases of Tomato in Choba, Rivers State. *Journal of Applied Sciences and Environmental Management* 12(3): 117-121.

Renewable

Fredrick, C., Ofodile, E. A. U., Basiru, A. O. and Omokhua, G. E
Journal of the Faculty of Renewable Natural Resources,
University of Ibadan, Ibadan, Nigeria
Volume 4, December, 2024
https://journals.ui.edu.ng/index.php/ren/index
ISSN: 2971-5776 (Prints); 2971-5784 (Online)
pp. 21-26