

Comparative study on shading effect of selected avenue trees in University of Port Harcourt, Nigeria

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ABSTRACT

The impact of urbanization process on increase in temperature within urban environment cannot be over emphasised. The main reason for this study was to determine and compare the shading effect of selected tree species within the University of Port Harcourt Park. The study was achieved by measuring tree growth and shading effect parameters, assessing the relationship between these parameters and comparing the shading effect of the tree species studied. Four tree species (*Terminalia mantaly*, *Azadirachta indica*, *Mangifera indica* and *Terminalia catappa*) were selected for the study based on their percentage composition in the study area. Tree growth parameters measured on the studied species were total height, Crown length, Crown diameter and diameter at Breast height Crown Projection area, Air temperature, Relative humidity and Light intensity were the shade parameters measured. There is significant relationship between crown projection area and the entire tree growth variable compared excluding the clear bole height ($p < 0.05$). Also, there is significant difference among the shade parameters measured such as Crown projection area, light, humidity and temperature of the species studied ($p < 0.05$). The result reveals that *A. indica* gave the best indication of tree shade hence is a good species for microclimate mitigation in the environment.

Keywords: Crown, environment, shade, temperature, tree, university, urban forest.

INTRODUCTION

Climatic condition of tropical regions is usually considered hot and humid but the presence of green infrastructures in the urban environment affects the microclimatic condition of the area. University campuses are typical urban setting which is not only used for educational purposes but also for cultural and social activities. Baik *et al.*, (2012) considered the university campus as a micro scale urban environment. Trees may be graded as avenue, ornamental, shade bearing, fragrant, fruit bearing, medicinal or food yielding, wood yielding, nitrogen fixing, venerated, carbon yielding, fibre yielding, multipurpose trees (Seth, 2004). Trees in an urban environment play a major role in micro climate amelioration by

intercepting sunlight with its leaves thereby using the heat for transpiration (Pauleit and Duhme 2000; Leuzinger *et al.*, 2010) and also through the provision of shade. Research have shown that tree-shaded areas of built surface are much cooler than those under the sun (Akbari *et al.*, 2001; Streiling and Matzarakis 2003; Wong *et al.*, 2003).

Urban environment that is rich with green infrastructure enjoys numerous natural, social, and economic benefits. Such benefits could include improved air and water quality, wildlife *habitat*, lower energy costs and higher property values (Bebette de Vera, *et al.* 2018). Lopez-Rodriguez *et al.* (2015) stated that trees can provide significant improvements in the quality of the environment, including their ability to

reduce atmospheric CO₂ emissions and urban pollutant concentrations; as well as reducing noise levels. During the day, shade trees also indirectly reduce heat gain in buildings by altering terrestrial radiation and ultimately reducing ground surface temperatures (Akbari, 2002; Shahidan, *et al.*, 2010). Absence of shade in urban environments can result to higher surface and air temperatures. Therefore, shading by trees is of crucial importance in reducing the ambient and surface temperatures of any artificial surface in urban built-up that will indirectly affect the building energy consumption (Shahidan, *et al.*, 2010).

University of Port Harcourt environment is just like any other urban environment which is characterized by increased amounts of built surfaces and loss of vegetation which is part of urbanization processes causing urban heat island (UHI) as found in every urban setting (Smithson *et al.*, 2002; Kuttler, 2008). Despite the unique and crucial role trees play in climate stabilization, removal of trees in urban environment even within university campuses continues at an alarming rate (Eguakun *et al.*, 2014). Under the changing climate prediction, the frequencies of hot days are set to increase with significant implications for the thermal comfort and health of city dwellers (Kosatsky, 2005). During the day, the built surfaces, such as concrete, asphalt and bricks found in urban areas absorb more heat than the former vegetated surface. The problem of the UHI is likely to get worse with climate change, as mean temperatures are predicted to rise, as are the frequencies of heat waves. The increase in the magnitude and frequency of urban heat waves will potentially cause severe health problems and an increased number of heat related illnesses and deaths. Inclusion of urban tree planning in building plan is needed. UN-Habitat, (2008) stated that more than half of the world is urban and given that three out of five people worldwide are expected to live in an urban environment by 2030 (United Nations,

2010), it is increasingly important to protect these densely-populated areas from the impacts of adverse weather that may stem from current rapid urbanization.

Thermal comfort plays an important role in determining the quality of life in urban environment. For example, there is ample evidence that the thermal comfort of urban pedestrians influences their choice and level of outdoor activities and the utilization of urban space (Huang, *et al.*, 2015; Hwang *et al.*, 2011). The urban thermal environment is influenced by ground cover, including vegetation cover and impervious surfaces, as well as the geometry of street canyons (Johansson, 2006), the shade provision by trees and building blocks (Hwang *et al.*, 2011; Lin *et al.*, 2010). Without modifying the existing built environment, urban greening projects are often considered a preferred method for adaption to the warming climate and urban heat island effects (Klemm *et al.*, 2015). As such, quantitative information on the ecosystem services provided by urban trees, particularly in terms of potential temperature reductions, would provide an important reference for urban greening projects in order to maximize those services.

Although urban trees are particularly effective at providing cooling benefits, the effectiveness of different species is likely to differ. A wide range of species are grown within the university campuses. The radiant energy reduction made by a tree will vary depending on the tree canopy size and density, but as a result of tree shade, a person radiates more energy away than they receive resulting in them feeling cooler (Georgi and Dimitriou, 2010). The main objective of the study was to determine and compare shading effect parameters of selected tree species within the University of Port Harcourt.

MATERIALS AND METHODS

Study area

The study was carried out at the University Park of the University of Port Harcourt, Choba, Rivers State, Nigeria. It was established in 1975 and was known as University College, Port-Harcourt until 1977 when its name was changed to University of Port-Harcourt after it gained university status. The University Park extends from 04° 52' 30" to 04° 55' 00" North latitude and from 06° 54' 40" to 06° 55' 40" East longitude (Fig. 3.1). The study site is characterized by tropical climate with mean annual temperature of 28°C and

annual rainfall of 2500mm. The relative humidity is very high with an annual mean of 85% while, the soil is usually sandy or sandy loam underlain by a layer of impervious pan and is always leached due to heavy rainfall. The relief is generally lowland which has an average elevation between 20m and 30m above sea level, geology of the area comprises basically of alluvial sedimentary basin and basement complex. It has a total land area of 121km² and it borders on Aluu Community in Ikwere Local Government Area and Choba Community in Obio/Akpo Park LGA also in Rivers State (Aiyelaja *et al.*, 2014).

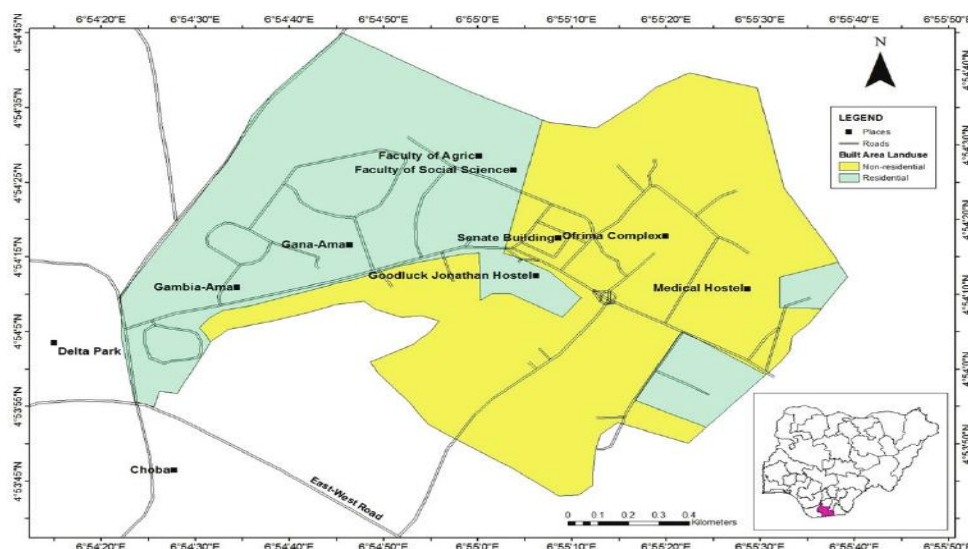


Fig. 1. Map of University of Port Harcourt Park

Source: Eludoyin *et al.*, 2015

Selection of tree species

Assessment of the tree species composition within the University of Port Harcourt Park was carried out in order to select four species for the study. The selection of tree species was done based on the abundance of trees in the study area.

Data Collection

Quantitative data were taken from the selected tree species (*Terminalia mantaly*, *Azadirachta indica*, *Mangifera indica* and *Terminalia catappa*) within the University Park based on abundance of the tree species. The tree growth and shade effect parameters were measured using the required

instruments. The following tree growth variables were measured for all selected trees:

- i. Total height
- ii. Clear Bole height
- iii. Merchantable height
- iv. Crown length
- v. Crown diameter
- vi. Diameter outside bark at breast height (DBH, 1.3m above the ground)

Clinometer and distance tape was used to measure tree height and crown diameter measurements respectively while diameter tape was used to measure diameter

outside bark at breast height. The following shading effects variables were estimated.

Crown Projection Area

In order to assess the impact of each tree on the local environment, the area of shade was calculated using the morphological measurements such as crown projection area (equation 1).

$$CPA = \frac{\pi CD^2}{4} \quad \text{Equation 1}$$

Where; CPA is the crown projection area,
CD is the crown diameter
 π is 3.142 or 22/7

Air Temperature

Two air temperature readings were taken between 11am to 4pm using thermometer under every sampled tree. The first reading was taken at the center of the shade casted by the tree canopy while the second reading was taken at the edge of the tree crown.

Humidity and Light intensity

The humidity and light intensity of the sampled trees were taken between 11am to 4pm under the tree and measured using digital hygrometer and digital Light Meter respectively.

Data Analysis

Descriptive and inferential statistic was used. Descriptive statistic in the form of table and charts was used. Analysis of Variance (ANOVA) was used to compare means of studied tree species growth characteristics and their shading characteristics to diameter classes. Duncan Multiple Range Test was used for the mean separation. Correlation Analysis was used to know the Relationship between the tree

growth and shade effect parameters of each tree species.

RESULTS

Tree Composition

A total of 651 trees were identified during study belonging to thirteen (13) species and twelve (12) family (Table 1). *Terminalia mantaly* has the highest frequency (214) while *Milicia excelsa* has the lowest frequency (4). It was also observed that the combretaceae family has the highest frequency 293 (*Terminalia mantaly* 214 and *Terminalia catappa* 79).

Growth and Shade Parameters

Growth Parameters

The result on growth parameter revealed that mean DBH of all the trees measured was 0.55 m. *Mangifera indica* and *Terminalia mantaly* had the highest (0.69m) and lowest (0.43m) respectively (Table 2). It was also observed that *Mangifera indica* has the highest mean for DBH (0.69 m), Crown Length (14.09 m), Total Height (16.81 m), Merchantable height (7.17 m), Volume (7.25 m³), and Basal Area (0.42 m²) and *Terminalia catappa* and *Terminalia mantaly* has the highest mean Crown diameter (16.33m) and Clear Bole Height (3.11m) respectively (Table 2).

Shade Parameters

The following shade parameters (Crown Projection Area, Temperature, Light and Humidify) were measured. The result shows the variations of the crown projection area of the studied species with *T. catappa* having the highest mean crown projection area and *A. indica* having the lowest (Fig. 2).

Table 1: Inventory of Amenity Trees within the University of Port Harcourt Park

S/No	Species	Family	Frequency	Percentage composition
1.	<i>Terminalia mantaly</i>	Combretaceae	214	32.87
2.	<i>Azadirachta indica</i>	Meliaceae	123	18.89
3.	<i>Mangifera indica</i>	Anacardiaceae	82	12.60
4.	<i>Terminalia catappa</i>	Combretaceae	79	12.14
5.	<i>Delonix regia</i>	Fabaceae	33	5.07
6.	<i>Psidium guajava</i>	Myrtaceae	22	3.38
7.	<i>Persea Americana</i>	Lauraceae	20	3.07
8.	<i>Anacardium occidentale</i>	Anacardiaceae	19	2.92
9.	<i>Lagastroemia speciose</i>	Lythraceae	19	2.92
10.	<i>Hura crepitans</i>	Euphorbiaceae	19	2.92
11.	<i>Gmelina arborea</i>	Lamiaceae	9	1.38
12.	<i>Prunus subg. Prunus (plum)</i>	Rosaceae	8	1.23
13.	<i>Milicia excelsa</i>	Moraceae	4	0.61
TOTAL			651	100

Table 2: Descriptive Analysis of Tree Growth Parameters in University of Port Harcourt Park

Parameters	Species	Min.	Max.	Mean	Std. Error	Std. Deviation
DBH	<i>A. indica</i>	0.38	0.89	0.59	0.01	0.10
	<i>T. mantaly</i>	0.24	0.70	0.43	0.01	0.09
	<i>T. catappa</i>	0.14	0.97	0.50	0.03	0.21
	<i>M. indica</i>	0.29	1.24	0.69	0.03	0.22
	Total	0.14	1.24	0.55	0.01	0.19
Crown Length	<i>A. indica</i>	5.98	19.00	12.18	0.34	2.79
	<i>T. mantaly</i>	5.18	20.04	13.25	0.35	2.88
	<i>T. catappa</i>	1.19	27.14	13.65	0.64	5.19
	<i>M. indica</i>	5.98	29.80	14.09	0.54	4.42
	Total	1.19	29.80	13.29	0.25	4.00
Crown Diameter	<i>A. indica</i>	8.90	18.05	12.85	0.23	1.87
	<i>T. mantaly</i>	6.26	22.10	14.48	0.36	2.93
	<i>T. catappa</i>	5.55	29.90	16.33	0.62	5.02
	<i>M. indica</i>	5.55	21.65	13.79	0.46	3.76
	Total	5.55	29.90	14.36	0.23	3.79
Clear Bole Height	<i>A. indica</i>	1.52	5.40	2.90	0.08	0.62
	<i>T. mantaly</i>	1.68	6.65	3.11	0.13	1.08
	<i>T. catappa</i>	1.52	6.77	2.88	0.12	0.94
	<i>M. indica</i>	1.46	4.36	2.72	0.09	0.69
	Total	1.46	6.77	2.90	0.05	0.86
Total Height	<i>A. indica</i>	9.55	22.02	15.08	0.32	2.60
	<i>T. mantaly</i>	7.08	23.73	16.35	0.38	3.10
	<i>T. catappa</i>	3.81	28.97	16.52	0.65	5.28
	<i>M. indica</i>	9.15	32.64	16.81	0.55	4.43
	Total	3.81	32.64	16.19	0.25	4.03
Merchantable Height	<i>A. indica</i>	3.72	12.05	6.42	0.21	1.74
	<i>T. mantaly</i>	2.50	12.20	6.25	0.24	1.99
	<i>T. catappa</i>	1.52	14.52	6.98	0.38	3.12
	<i>M. indica</i>	2.44	19.52	7.17	0.33	2.67
	Total	1.52	19.52	6.71	0.15	2.46
Volume	<i>A. indica</i>	1.28	12.48	4.41	0.24	1.95
	<i>T. mantaly</i>	0.48	8.49	2.54	0.17	1.40
	<i>T. catappa</i>	0.06	17.65	4.45	0.53	4.30
	<i>M. indica</i>	0.72	25.32	7.75	0.75	6.11
	Total	0.06	25.32	4.79	0.27	4.33
Basal Area	<i>A. indica</i>	0.11	0.62	0.28	0.01	0.09
	<i>T. mantaly</i>	0.05	0.39	0.15	0.01	0.07
	<i>T. catappa</i>	0.01	0.74	0.23	0.02	0.17
	<i>M. indica</i>	0.06	1.21	0.42	0.03	0.26
	Total	0.01	1.21	0.27	0.01	0.19

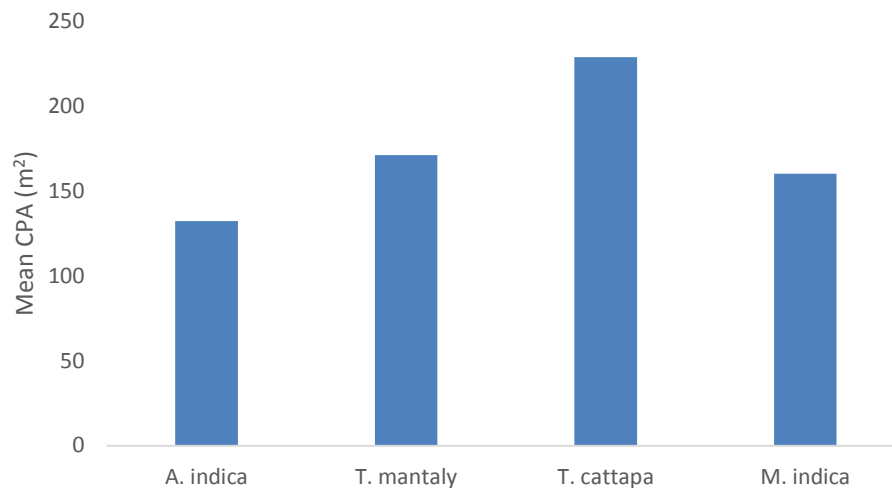


Fig. 2. Mean Distribution of Crown Projection Area of species

Minimum and maximum temperature were taken both underneath the tree and outside the tree shade. The result from Fig 3 shows that *M. indica* consistently had the highest mean maximum temperature (30.32°C and

30.23) both underneath the tree and outside the tree while *A. indica* had the lowest temperature readings ranging from 27.49°C – 28.92°C.

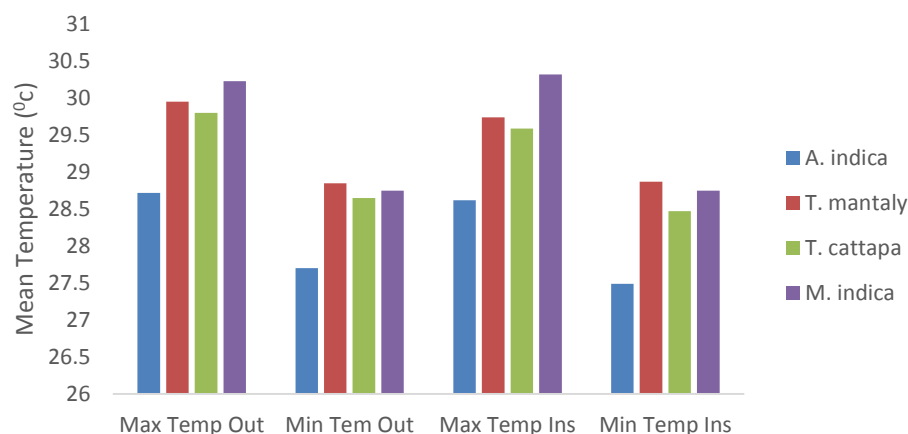


Fig. 3. Mean Distribution of Temperatures inside and outside of species

Result on minimum and maximum light intensity revealed that the tree with the highest maximum and minimum light intensity was *T. mantaly* (4677.6 lux and

4179.6 lux) while *T. cattapa* (3349.4 lux and 2743.8 lux) had the lowest maximum and minimum light intensity (Fig. 4).

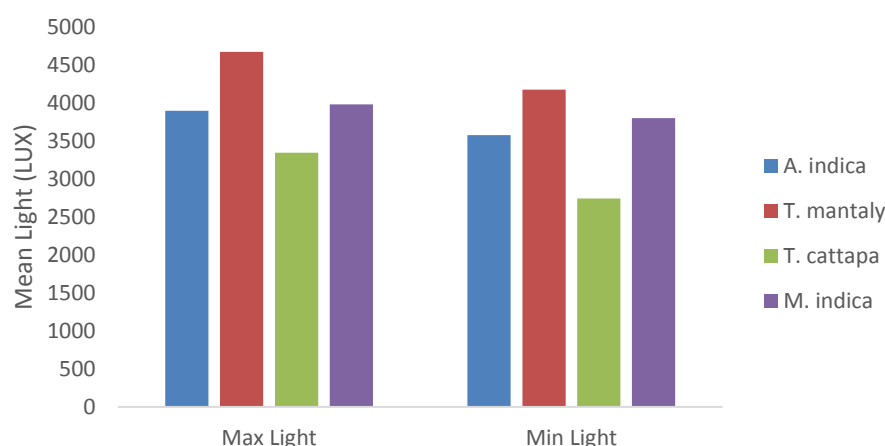


Fig. 4: Mean Distribution of Light intensity of species in University of Port Harcourt Park

Maximum and minimum humidity was taken under the tree. *A. indica* recorded the highest for both mean maximum (69.85%) and mean minimum humidity (66.20%). *T. mantaly* recorded the least mean maximum

humidity while *M. indica* recorded the least mean minimum humidity. The Total Mean for Maximum and Minimum Humidity are 66.55% and 62.58% respectively (Fig. 5)

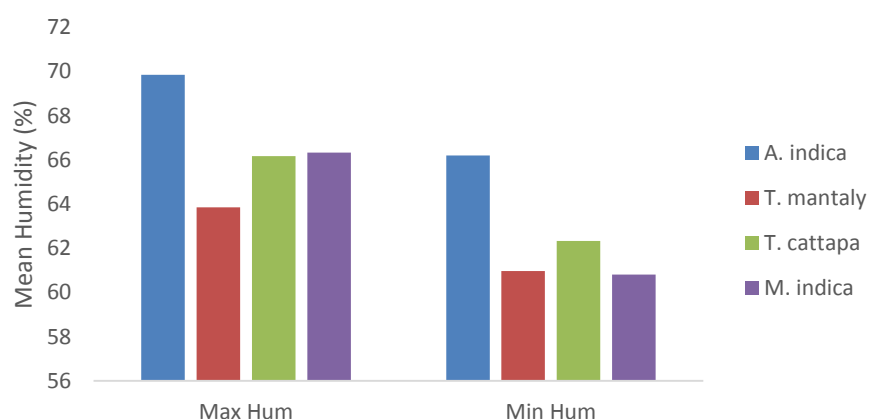


Fig. 5: Mean Distribution of Humidity of species in University of Port Harcourt Park

Relationship between Tree Growth and Shading Effect

Crown projection area (CPA) has a significant relationship with the growth parameters measured with exception of clear bole height, at a significant level of $p < 0.01$ (table 3). The Pearson correlation coefficient for the relationship of CPA with various growth variables were diameter at breast height (0.450), crown length (0.641), crown diameter (0.981), total height (0.648), merchantable (0.532), volume (0.516) and basal area (0.430). This indicates a moderate (0.4-0.6) to strong

(0.7-0.9) positive relationship. No significant relationship resulted from Max and Min temperature outside, Max and Min light, and Max and Min Temperature inside with the growth parameter. Weak but significant relationships was also observed between DBH~Max Humidity (0.150), DBH~Min Humidity (0.197), crown diameter ~ Min Humidity (0.167), merchantable height ~ Min Humidity (0.187), and basal area ~ Min Humidity (0.148) (Table 3).

Table 3: Correlation Matrix of Tree Growth and Shade Parameters in University of Port Harcourt Park

Parameter	CPA	Max. Temp. Outside	Min. Temp. Outside	Max. Humidity	Min. Humidity	Max. Light	Min. Light	Max. Temp. Inside	Min. Temp. Inside
DBH	.450**	-.011	-.065	.150*	.197**	-.030	.015	-.026	-.079
CL	.641**	.052	.095	.070	.091	.021	.038	-.021	.058
CD	.981**	-.025	-.007	.015	.167**	-.063	-.038	-.118	-.011
CBH	.053	-.030	-.003	.035	.089	.020	-.025	-.049	.027
THT	.648**	.045	.093	.077	.109	.025	.032	-.032	.064
MH	.532**	-.058	-.015	.100	.187**	-.017	-.039	-.113	.007
Vol.	.516**	.057	.041	.086	.120	-.020	.006	.044	.025
BA	.430**	.028	-.026	.109	.148*	-.026	.011	.028	-.029

Shade Effects of Studied Tree Species

From the mean comparison carried out, the result shows that there is significant difference in the mean Crown Projection Area between the class diameters, while there is significant difference in the Mean

Crown Projection Area based on species between *A. indica*, *T. mantaly* and *T. catappa* but there is no significant difference in the mean Crown Projection Area between *T. mantaly* and *M. indica* (Table 4.).

Table 4: Mean Comparison of Crown Projection Area Based on Species and Diameter Class

Dbh class	<i>A. indica</i>	<i>T. mantaly</i>	<i>T. catappa</i>	<i>M. indica</i>	Total
<= 0.30	-	97.20 ± 43.91	86.32 ± 40.89	75.44 ± 0.00.	88.74 ± 39.63 ^a
0.31 - 0.60	120.18 ± 33.03	177.94 ± 64.75	192.52 ± 74.41	97.68 ± 47.77	156.04 ± 68.33 ^b
0.61 - 0.90	146.02 ± 40.48	161.47 ± 90.24	339.43 ± 121.54	172.49 ± 76.21	204.29 ± 112.02 ^c
0.91+	-	-	638.02 ± 0.00	244.50 ± 59.17	277.30 ± 126.83 ^d
Total	132.32 ± 38.67 ^a	171.32 ± 66.71 ^b	228.93 ± 136.77 ^c	160.35 ± 82.16 ^b	

Means with similar alphabets are not significantly different

There is no significant difference in the Mean Maximum Temperature Outside between the class diameters; while there is significant difference in the Mean Maximum Temperature Outside based on species between *A. indica*, *T. mantaly*, *T. catappa* and *M. indica* but there is no significant difference in the Mean Maximum Temperature Outside between *T. mantaly*, *T. catappa* and *M. indica*. Also, there is no significant difference in the Mean of Minimum Temperature Outside between the class diameters; while there is significant difference in the Mean of Minimum Temperature Outside based on species between *A. indica*, *T. mantaly*, *T. catappa* and *M. indica* but there is no significant difference in the Mean

Minimum Temperature Outside between *T. mantaly*, *T. catappa* and *M. indica*. (Table 5).

Table 5 also shows that there is significant difference in the Mean of Maximum Temperature inside between the class diameters, there is significant difference in the Mean of Maximum Temperature inside between class <= 0.30, 0.31 - 0.60 and 0.61 - 0.90 and <= 0.30 and 0.91+; while there is significant difference in the Mean of Maximum Temperature inside based on species between *A. indica*, *T. mantaly*, *T. catappa* and *M. indica* but there is no significant difference in the Mean of Maximum Temperature inside between *T. mantaly* and *T. catappa*. There is significant

difference in the Mean of Minimum Temperature inside between the class diameters, but there is no significant difference in the Mean of Minimum Temperature inside between class ≤ 0.30 , $0.31 - 0.60$ and $0.91+$ and $0.31 - 0.60$ and 0.91 ; whereas there is significant difference

in the Mean of Minimum Temperature inside based on species between *A. indica*, *T. mantaly*, *T. catappa* and *M. indica* but there is no significant difference in the Mean of Minimum Temperature inside between *T. mantaly* and *T. catappa* and between *T. mantaly* and *M. indica*

Table 5: Mean Comparison of Temperature Based on Species and Diameter class

Temperature	Diameter Class	<i>A. indica</i>	<i>T. mantaly</i>	<i>T. catappa</i>	<i>M. indica</i>	Total
Max. Temp. Outside	≤ 0.30	-	31.04 ± 1.89	29.62 ± 0.99	30.20 ± 0.00	30.04 ± 1.38^a
	$0.31 - 0.60$	28.44 ± 1.04	29.83 ± 1.38	29.99 ± 1.33	30.19 ± 0.93	29.58 ± 1.39^a
	$0.61 - 0.90$	29.03 ± 1.43	30.90 ± 1.70	29.66 ± 1.22	30.26 ± 0.91	29.70 ± 1.31^a
	$0.91+$	-	-	29.40 ± 0.00	30.22 ± 1.06	30.15 ± 1.03^a
	Total	28.72 ± 1.26^a	29.95 ± 1.45^b	29.80 ± 1.22^b	30.23 ± 0.92^b	
Min. Temp. Outside	≤ 0.30	-	29.56 ± 1.85	28.81 ± 1.10	28.30 ± 0.00	28.99 ± 1.32^a
	$0.31 - 0.60$	27.64 ± 0.85	28.74 ± 1.37	28.48 ± 0.75	28.85 ± 1.01	28.43 ± 1.18^a
	$0.61 - 0.90$	27.77 ± 1.28	30.25 ± 1.48	28.77 ± 1.29	28.72 ± 0.53	28.44 ± 1.17^a
	$0.91+$	-	-	29.20 ± 0.00	28.68 ± 0.75	28.73 ± 0.73^a
	Total	27.70 ± 1.07^a	28.85 ± 1.43^b	28.65 ± 1.02^b	28.75 ± 0.73^b	
Max. Temp. Inside	≤ 0.30	-	30.66 ± 1.36	29.90 ± 1.20	30.20 ± 0.00	30.13 ± 1.22^{ab}
	$0.31 - 0.60$	28.30 ± 1.00	29.63 ± 1.14	29.72 ± 1.34	30.77 ± 1.40	29.48 ± 1.41^a
	$0.61 - 0.90$	28.99 ± 1.46	30.80 ± 2.26	29.29 ± 0.94	30.03 ± 0.89	29.50 ± 1.24^a
	$0.91+$	-	-	28.50 ± 0.00	30.40 ± 1.37	30.24 ± 1.42^b
	Total	28.62 ± 1.28^a	29.74 ± 1.21^b	29.59 ± 1.20^b	30.32 ± 1.17^c	
Min. Temp. Inside	≤ 0.30	-	29.72 ± 2.09	28.49 ± 0.82	29.70 ± 0.00	28.90 ± 1.35^a
	$0.31 - 0.60$	27.49 ± 0.82	28.77 ± 1.31	28.44 ± 0.70	28.84 ± 1.00	28.40 ± 1.17^{ab}
	$0.61 - 0.90$	27.49 ± 1.07	29.50 ± 0.42	28.52 ± 1.01	28.63 ± 0.41	28.22 ± 1.00^b
	$0.91+$	-	-	28.10 ± 0.00	28.92 ± 0.79	28.85 ± 0.79^a
	Total	27.49 ± 0.94^a	28.87 ± 1.37^b	28.47 ± 0.82^c	28.75 ± 0.71^{bc}	

Means with similar alphabets are not significantly different

From the mean comparison between humidity based on species and Diameter class, it was observed that there is no significant difference in the Mean of Maximum Humidity between the class diameters; while there is significant difference in the Mean of Maximum Humidity based on species between *A. indica*, *T. mantaly*, *T. catappa* and *M. indica* but there is no significant difference in the Mean of Maximum Humidity between *T. catappa* and *M. indica*. There is significant

difference in the Mean of Minimum Humidity between the class diameters but there is no significant difference in the Mean of Minimum Humidity between class diameters $0.31 - 0.60$, $0.61 - 0.90$, $0.91+$; while there is significant difference in the Mean of Minimum Humidity based on species between *A. indica*, *T. mantaly*, *T. catappa* and *M. indica* but there is no significant difference in the Mean of Minimum Humidity between *T. mantaly*, *T. catappa* and *M. indica* (Table 6).

Table 6: Mean Comparison of Humidity Based on Species and Diameter Class

	Diameter Class	<i>A. indica</i>	<i>T. mantaly</i>	<i>T. catappa</i>	<i>M. indica</i>	Total
Max.	<= 0.30	-	63.20 ± 2.95	65.08 ± 6.16	65.00 ± 0.00	64.56 ± 5.23 ^a
Humidity	0.31 - 0.60	70.06 ± 4.38	64.07 ± 5.33	65.90 ± 6.91	67.10 ± 7.06	66.32 ± 6.17 ^a
	0.61 - 0.90	69.61 ± 5.01	59.00 ± 5.66	67.00 ± 6.83	65.76 ± 7.02	67.26 ± 6.55 ^a
	0.91+	-	-	69.00 ± 0.00	66.82 ± 8.86	67.00 ± 8.47 ^a
	Total	69.85 ± 4.65 ^a	63.85 ± 5.22 ^b	66.17 ± 6.64 ^c	66.33 ± 7.22 ^c	
Min.	<= 0.30	-	57.60 ± 2.51	59.67 ± 2.46	62.00 ± 0.00	59.22 ± 2.60 ^a
Humidity	0.31 - 0.60	66.20 ± 4.10	61.42 ± 5.05	61.65 ± 5.23	60.25 ± 4.44	62.46 ± 5.21 ^b
	0.61 - 0.90	66.19 ± 4.98	56.00 ± 1.41	64.55 ± 5.60	60.62 ± 3.92	63.43 ± 5.39 ^b
	0.91+	-	-	67.00 ± 0.00	62.36 ± 4.15	62.75 ± 4.18 ^b
	Total	66.20 ± 4.50 ^a	60.97 ± 5.00 ^b	62.33 ± 5.22 ^b	60.82 ± 4.09 ^b	

Means with similar alphabets are not significantly different

The mean of light intensity based on species and diameter classes were compared for both maximum and minimum light intensity. It was observed that there is no significant difference in the Mean of Maximum Light between the class diameters; whereas there is significant difference in the Mean of Maximum Light based on species, there is no significant difference in the Mean of Maximum Light between *A. indica*, *M. indica* and *T. catappa*, *T. mantaly*, *A. indica* and *M. indica*, *A.*

indica and *M. indica* but there is no significant difference in the Mean of Minimum Humidity between *T. mantaly*, *T. catappa* and *M. indica*. and also, there is no significant difference in the Mean of Minimum Light between the class diameters; whereas there is significant difference in the Mean Minimum Light based on species, but there is no significant difference in the Mean Minimum Light between *A. indica*, *T. mantaly* and *M. indica* (Table 7).

Table 7: Mean Comparison of Light Based on Species and Class Diameter

		<i>A. indica</i>	<i>T. mantaly</i>	<i>T. catappa</i>	<i>M. indica</i>	Total
Max.	<= 0.30	-	3418.40 ± 1624.55	3373.83 ± 3075.94	4183.00 ± 0.00	3431.17 ± 2603.59 ^a
Light	0.31 - 0.60	3637.89 ± 3084.24	4692.86 ± 2170.98	3688.32 ± 2948.24	3435.05 ± 1865.29	4049.96 ± 2589.52 ^a
	0.61 - 0.90	4194.77 ± 3196.25	7374.00 ± 1469.37	2807.50 ± 1954.77	4424.82 ± 2710.82	4011.18 ± 2805.72 ^a
	0.91+	-	-	4474.00 ± 0.00	3617.09 ± 2534.95	3688.50 ± 2429.61 ^a
	Total	3899.45 ± 3125.59 ^{ab}	4677.56 ± 2178.78 ^b	3349.44 ± 2649.75 ^a	3986.61 ± 2440.12 ^{ab}	
Min.	<= 0.30	-	3030.00 ± 1569.46	2951.92 ± 2783.80	4163.00 ± 0.00	3040.89 ± 2381.95 ^a
Light	0.31 - 0.60	3351.37 ± 2803.31	4171.34 ± 1958.40	2934.77 ± 2305.50	3057.10 ± 1788.96	3555.36 ± 2283.17 ^a
	0.61 - 0.90	3839.13 ± 2990.49	7296.00 ± 1480.68	2317.73 ± 1532.06	4295.03 ± 2507.43	3714.90 ± 2628.02 ^a
	0.91+	-	-	3699.00 ± 0.00	3604.64 ± 2487.26	3612.50 ± 2371.67 ^a
	Total	3580.47 ± 2880.69 ^a	4179.56 ± 2002.04 ^a	2743.79 ± 2150.32 ^b	3802.83 ± 2320.71 ^a	

Means with similar alphabets are not significantly different

DISCUSSION

Trees have been used overtime to provide shades in both rural and urban environment. The University of Port Harcourt being an academic area is a typical urban setting with several tree species have been used in this regard to provide shades. Species such as *Gmelina arborea*, *Persia americana*, *Hura crepitans* amongst other species were present in the University of Port Harcourt

park serving the purpose of shade as ornamental trees with *Terminalia mantaly*, *Azadirachta indica*, *Mangifera indica* having the highest percentage composition in the park. Research carried out in Kano State University of Science and Technology showed that *Azadirachta indica* and *Eucalyptus camadulensis* accounted for about 80% of the floristic composition in the area while *Mangifera indica* (1.44%)

and *Terminalia cattapa* (0.04%) with a very low percentage composition within the same study area (Wakawa *et al.*, 2016). Also, in a study in the University of Benin it was observed that *Elaeis guineensis* (22.90%), *Terminalia cattapa* (15.42%) and *Cocos nucifera* (15.9%) gave the highest percentage composition with *Mangifera indica* (4.67%) according to Ogwu *et al.*, 2016. These results indicated that *Terminalia cattapa*, *Mangifera indica*, *Azadirachta indica* were good species of trees used for tree shades in urban setting. Similar to the study of Eguakun and Okebalama (2015) in the University of Port Harcourt park, *Mangifera indica* had the greatest mean for majority of the growth indices such as DBH, Crown length, Total height, and Merchantable height. *Mangifera indica* produced the best tree development factors, both measured and estimated (Volume and Basal Area) because of its propensity to grow quickly and amass biomass, *Mangifera indica* is commonly used in urban environments.

All growth parameters measured had positive relationship with crown projection area as a measure of shade with the exception of Clear Bole height, implying that the tree growth characteristics measured affected the level of shade produced at $p < 0.01$. The shade effects of the tree species studied compared were significantly different among them. The sampled tree species showed significant difference with their morphological characteristics which is in confirmation with the study of Armson *et al.*, (2013) that the sampled tree species showed significant differences in their canopy size and shape.

Trees provide a good number of benefits to the urban environment in controlling its temperature. The presence of ornamental trees lowered the air temperature in the study area agrees with the research of Pauleit and Duhme (2000) and Leuzinger *et al.* (2010) who stated that leaf temperatures have been found to be 11°C–30°C cooler

than adjacent constructed surface. Although street trees should be particularly effective at providing cooling benefits, the effectiveness of different species is likely to differ. In general, Shashua-Bar and Hoffman (2000) stated that more drought-tolerant and slow-growing trees have less dense canopies, and so reduce radiation less than faster-growing species, as well as providing less evapotranspiration cooling. Research has proven that the effect of trees on temperature reduction is larger than that of green roofs or grass. Hence, due to the morphological characteristics of trees, different species respond differently to air temperature reduction. The cooling effect of trees on air temperature is linked to shade, transpiration, and moisture dispersion into the atmosphere (Eguakun and Okebalama, 2015). Crown projection area, temperature, humidity, and light were used in the study to evaluate the effectiveness of trees in producing shade, and *T. cattapa* had the maximum crown projection area, which can be attributed to the spreading nature of the branches. It was also observed that *A. indica* produced the lowest temperature measurements in the study, implying that it has the best long-term cooling impact which is contrary to the study of Gupta *et al.*, (2018) who found out in his study that some evergreen species such as *M. indica* were preferred for plantation especially on sites where people want coolness under shades of trees during summers because these species provide shade in abundance with higher cooling experience during summers.

CONCLUSION

The study shading effect analysis of selected avenue trees in University of Port Harcourt Park shows that the cooling effect of trees varies by species, therefore temperature reductions could be further boosted by selecting and planting trees with denser canopies such as *A. indica*, *T. catappa* amongst others. As a result, the planting of such trees in urban areas should be encouraged.

RECOMMENDATION

In urban environment like in the Universities, it is important to engage in planting of more and suitable trees that will produce good amount of shade to improve temperature reduction in the area and hence provide good and conducive micro climate for the environment. Urban construction materials often have a high specific heat capacity, causing heat on calm nights. Hence, while building plan is important, urban tree planning must also be considered within the landscape by altering the amount of engineered surface and adopting cooling strategies of trees, the urban climate can be effectively modified.

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