

## Cooling Effects and Humidification Potentials in Relation to Stomatal Features in Some Shade Plants

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### Abstract

Thirty shade trees namely *Lonchocarpus cyanescens*, *Albizia lebbek*, *Blidelia ferruginea*, *Prosopis africana*, *Burkea africana*, *Lophira lanceolata*, *Ficus elastica*, *Ficus trichopoda*, *Annona senegalensis*, *Citrus aurantifolia*, *Gliricidia sepium*, *Dioclea reflexa*, *Gmelina arborea*, *Acacia auriculiformis*, *Anacardium occidentale*, *Vitellaria paradoxa*, *Parkia biglobosa*, *Citrus paradisi*, *Citrus reticulata*, *Citrus limon*, *Citrus sinensis*, *Terminalia catappa*, *Tectonia grandis*, *Delonix regia*, *Mangifera indica*, *Thevetia nerifolia*, *Plumeria alba*, *Blighia sapida*, *Azadirachta indica*, and *Daniela oliveri* were studied to determine their canopy characteristics in relationship to stomatal features possessed and the rate at which they transpire. The canopy characteristics vary in all species with *D. oliveri*, *T. catappa* and *L. cyanescens*, etc has the widest canopy while *P. alba* and *C. limon* has the narrowest canopy. Density of leaves (LD) is highest in *T. nerifolia* and *D. regia*, and it is lowest in *P. alba*, *B. sapida*, *T. grandis*, *T. nerifolia*. The tree height is tallest in *L. cyanescens* followed by *A. auriculiformis*, *G. arborea* and *D. oliveri*. In each species, leaves were taken and observed anatomically to reveal stomatal features and rate of transpiration; for instance, *T. catappa*, *A. auriculiformis* and others that possessed amphistomatic leaves with heterogeneous stomatal complex types (SCT<sub>s</sub>) transpired faster than species such as *T. grandis*, *A. senegalensis*, *A. occidentale* etc with hypostomatic leaves and homogeneous SCT<sub>s</sub>. Stomata in the studied species were all more than 15µm with *A. auriculiformis*, having larger size (73.75µm) while *D. regia* possessed the smaller size (47µm). *T. catappa* has the highest stomatal density of 91.00mm<sup>2</sup> while *D. regia* has the lowest stomatal density of 8.25mm<sup>2</sup>. Coolness provided by the shade trees is evidence in the temperature under the trees and in the open space; temperature is higher in the open than under the trees in all the 30 species studied. Based on the canopy characteristics and stomatal features possessed by each of these shade plants as well as their rate of transpiration, species such as *T. catappa*, *A. indica*, *A. lebbek*, *F. trichopoda*, *L. cyanescens*, *D. regia*, *D. oliveri*, and *A. auriculiformis* are the most preferable shade plant.

**Keywords:** Shade trees, canopy characteristics, stomata, transpiration, humidification, cooling effect

### Introduction

The need for planting trees around houses, schools, environments, along major cities, recreation centre and other places is for many purposes among which include erosion controls where trees act as wind break, soil protection cleansing of atmosphere by accumulation of pollutant like CO<sub>2</sub>, and provision of shade against rain and sun.

Plants with dense canopy are usually used as shade plants. A plant that can effectively serve as shade plants must possess many branches arising from a trunk, particularly; there must be dense leave on such plant. This is to say that a plant with many branches but loosely arranged leaves will not be considered as shade plant because this gives room for much penetration of sun rays and rain drops.

Shade plants are primarily for people's relaxation either in front or back of the house but they can also be used to mitigate negative effect of climate change. Afforestation program and planting of ornamental plant species are some of the measure to actively control or reduce accumulation of greenhouse gases like CO<sub>2</sub> in the atmosphere (Abdulrahman and Oladele, 2008). As means of effectively mitigating climate changes especially in Africa, plants with high number of subsidiary cells on stomata complex types (SCTs) like tetracytic and anomocytic types open more often for transpiration as well as allow influx of CO<sub>2</sub> into the leaves for photosynthesis thus, cleansing the atmosphere (Obiremi and Oladele, 2001; Oladele, 2002; Oyeleke *et al.*, 2004; Abdulrahman and Oladele, 2008; Saadu *et al.*, 2009; AbdulRahaman *et al.*, 2010) consequently, these plants humidify the atmosphere with water vapour (Encarta, 2007; Adulrahman and Oladele, 2008).

A stoma (plural stomata) is pore, found in the leaf and stem epidermis that is used for gaseous exchange. The continuity of the epidermis is interrupted by minute openings that can be opened or closed to control gas exchange. In botany, stomata are tiny pores, mostly on the undersurface of leaves, used for gaseous exchange. Air containing CO<sub>2</sub> and oxygen enters the plant through these openings for photosynthesis in the collenchymas cells of the leave interior exits through these same openings. Also, excess closing of a stoma is controlled by guard cells that surround the openings (Trejo *et al.*, 1993). Stomata are usually found on the aerial portions of the plant and especially on leaves, ordinary stems and rhizomes. Stomata are absent from the root and the entire plant body of certain parasitic plants that lack chlorophyll such as *Monotropa* and *Neotta*. Stomata are present in some submerged water plants but not in most others (Barry, 1997). During warm weather when a plant is in danger of losing excessive water, the guard cell closes cutting down evaporation from the interior of the leave (Eduardo *et al.*, 2002). Each guard cell is kidney-shaped and its wall varies in rigidity. The wall bordering the pore is thickened and rigid, whereas the outside wall is thin and extensible. As the paired cell absorb water they swell, and the thin wall region bends outwards, pulling the non-extensible thicker wall with it and opening the pore. Loss of water has the reverse effect, resulting in shrinking of the guard cells and closure of the pore.

In this study, canopy characteristic such as canopy density (CD), height of tree, (TH), height of trunk (HT), trunk diameter (DT), number of main branch (NMB) and length of petiole (LOP), as well as stomata features like stomata complex types (SCTs), stomata density (SD), stomata index (SI), and stomata size (SS), temperature under the trees, temperature in open space and transpiration rates (TR) in thirty shade plant species were studied in order to elucidate cooling effects of these trees. Attempt was made to relate canopy characteristics to the stomata features, temperature and transpiration rate in thirty species studied.

## ***Materials and Methods***

### **Study species**

Canopy characteristics of thirty shade plants were studied. Leaves of these shade plants were collected from various parts of Ilorin, Kwara State, Nigeria for anatomical studies (Table 1). The plants were identified and kept for documentation at the Herbarium of Department of Plant Biology, University of Ilorin, Ilorin, Kwara state, Nigeria.

**Table 1: List of species studied, family names and their locations**

	Species	Family	Location
1.	<i>Citrus reticulata</i>	Rutaceae	Basin and Unilorin
2.	<i>Citrus paradisi</i>	Rutaceae	Basin and Unilorin
3.	<i>Citrus limon</i>	Rutaceae	Basin and Unilorin
4.	<i>Citrus aurantifolia</i>	Rutaceae	Basin and Unilorin
5.	<i>Citrus sinensis</i>	Rutaceae	Basin and Unilorin
6.	<i>Anacardium occidentale</i>	Anacardaceae	Tanke and Unilorin
7.	<i>Bridelia ferruginea</i>	Euphorbiaceae	Unilorin and Basin
8.	<i>Azadirachta indica</i>	Meliaceae	Tanke and Basin
9.	<i>Albizia lebbek</i>	Mimosaceae	Kwara Poly-
10.	<i>Blighia sapida</i>	Sapindaceae	G.R.A, Ilorin+
11.	<i>Vitellaria paradoxa</i>	Sapotaceae	Unilorin and Basin
12.	<i>Tectona grandis</i>	Verbanaceae	Unilorin and Basin
13.	<i>Gmelina arborea</i>	Vertaceae	Unilorin, Basin and Kwara Poly
14.	<i>Daniela olivieri</i>	Caesalpinaceae	Unilorin*
15.	<i>Thevetia neriifolia</i>	Apocynaceae	G.R.A, Ilorin
16.	<i>Parkia biglobosa</i>	Mimosaceae	Unilorin, Basin and Kwara Poly
17.	<i>Delonix regia</i>	Caesalpinaceae	Unilorin and Kwara Poly
18.	<i>Terminalia catappa</i>	Combretaceae	Unilorin
19.	<i>Plumeria alba</i>	Apocynaceae	Basin and Unilorin
20.	<i>Acacia auriculiformis</i>	Fabaceae	Unilorin and Basin
21.	<i>Mangifera indica</i>	Anacardaceae	Unilorin and Basin
22.	<i>Lonchocarpus cyanescens</i>	Fabaceae	Basin and Unilorin
23.	<i>Dioclea reflexa</i>	Fabaceae	Unilorin Clinic
24.	<i>Gliricidium sepium</i>	Fabaceae	Unilorin
25.	<i>Annona senegalensis</i>	Annonaceae	Unilorin
26.	<i>Ficus elastic</i>	Moraceae	Unilorin
27.	<i>Lophira lanceolata</i>	Ochnaceae	Basin and Okeoyi
28.	<i>Prosobis Africana</i>	Mimosaceae	Unilorin
29.	<i>Ficus trichopoda</i>	Moraceae	Okeodo and Basin
30.	<i>Burkea Africana</i>	Fabaceae	Unilorin Garden

+GRA = Government Reserve Area, -Kwara Poly = Kwara State Polytechnics, \*Unilorin = University of Ilorin

#### **Crown diameter (CD)**

To determine the crown diameter, two measurements per tree were taken at plane parameter to each other. The mean diameter per tree was calculated using the formula:

$$\frac{d_1+d_2}{2} = D$$

Where  $d_1$  and  $d_2$  = measurement along perpendicular planes.

D = the average crown diameter (Bennett and Humphries, 1974).

#### **Area of canopy (CA)**

This was determined by calculating from the density of leaves with the formula:

$$D^2 \times \frac{3}{4}$$

Where D= density of leaves

#### **Number of main branches (NMB)**

The number of main branches on thirty (30) trees was counted and the mean number determined (Bennett and Humphries, 1974).

#### **Density of leaves (LD)**

Density of leaves was determined by placing the 25cm x 25cm quadrant over a certain area of the tree, the leave within the quadrat was counted.

**Length of petiole (LP)**

The length of petiole was measured from every tree by using measuring tape.

**Area of leaf (AOL)**

The area of leaf was determined by using the formula:  $L \times B \times K$  Franco (1939)

Where L= length

B= breadth

K= Franco constant (0.79)

**Height of tree (TH)**

This was determined by using improvised altimeter (Bennett and Humphries, 1974). This was measured by putting the altimeter at eye level and ensuring that the vertical point is perpendicular to the ground surface, then look through the straw to the tree top, the point at which the feet is to the tree is measured. Then, the height of the measurer was measured and added to the distance between the feet and the base of the tree. This was sum up to give the tree height.

**Height of trunk (HT)**

This was determined by measuring from the ground to the point where the tree split into branches.

**Diameter of trunk (DT)**

The diameter of the girth at the breast height was measured using measuring tape.

**Determination of transpiration (TR)**

A cobalt chloride paper method was used to determine the transpiration rate of each specimen (Obiremi and Oladele, 2001; Dutta, 2003). Stripes of filter paper of 2cm x 6cm dimension was cut and immersed in 20% cobalt chloride solution. The stripes were thoroughly dried in an oven. The property of cobalt paper is that they are deep blue when dried, but in contact with moisture, they turn pink. The blue dried stripes were placed in a sealed, air tight polythene bag and weighed ( $w_1$ ) using mettler balance. It was transferred quickly to the plastic containers and affixed with a string to the marked small branch (of the plant) with leaves. Two dried cobalt paper was placed on the leaf, one on the upper and the other on the lower surface of a thick healthy leaf and would be covered completely with glass slides this is to determine transpiration rate from the two surface of a dorsiventral leaf (Dutta, 2003). The time (in seconds) taken for the stripes to turn pink was noted. Once turned pink, the bag was quickly untied and sealed again, and transferred to the laboratory and weighed ( $w_2$ ). Weight of water transpired was determined as  $w_2$  minus  $w_1$ . The surface area of leaves used was measured (i.e. as described for the mean leaf area above). Transpiration rate was expressed as  $\text{mol/m}^2/\text{sec}^{-1}$ .

**Determination of temperature**

Using thermometer, temperature under the tree and some distance from the tree e.g. about 10 meters away was taken to determine variation in temperature of the two areas. Time taken for temperature was 7:30am -8:00am, 12:00pm -12:30pm and 6:30pm-7:00pm. A sample of thirty (30) trees was used for each species.

**Anatomical studies of the leaf epidermis**Isolation of leaf epidermal layer

Leaf segment of an area of 1cm square from each specimen was cut and immersed in concentrated solution of nitric acid (some in trioxonitrate (v) acid) for maceration. The upper (adaxial) and the lower (abaxial) surfaces were separated with dissecting needle and forceps, and were rinsed with clean water.

Determination of frequency of stomatal complex types (SCT<sub>s</sub>)

Using the field of view at x40 objective as quadrats, the number of subsidiary cells per stoma was noted to determine the frequency of the different complex types present in each specimen. Frequency of each complex type was expressed as percentage occurrences (Obiremi and Oladele, 2001). Terminologies for naming SCT<sub>s</sub> followed those of Dilcher (1974).

Frequency of each stomata complex type was therefore determined as:

$$\text{Frequency (\%)} = \frac{\text{Number of occurrence of a type}}{\text{Total number of occurrences}} \times 100$$

Determination of stomatal density (SD) and index (SI)

The SD was determined as the number of stomata per square millimeter (Stace, 1965).

Stomatal index was determined using this formula

$$S.I = S/E + S \times 100$$

Where SI = stomatal index

S = number of stomata per square millimeter

E = number of ordinary epidermal cells per square millimeter

#### Determination of stomatal size (SS)

The mean stomatal size of a species was determined by measuring length and breadth of guard cells using eye piece micrometer. A sample of 30 stomata was used. The methods follow those of Franco (1939) and Wilkinson (1979).

$$SS = L \times B \times K$$

L= length

B= breadth

K= Franco's constant = 0.79

#### **Statistical analysis**

All data were reported and analyzed using analysis of variance (ANOVA) and Duncan's multiple range test (DMRT). Computer software was used. A probability value 0.05 was used as bench mark for significant difference between parameters.

#### **Results**

Canopy characteristics of thirty (30) shade plants studied are shown in Table 2. Table 3 shows the stomatal features, transpiration rate and temperature parameters of the thirty (30) species studied. Peculiar features of each of the plants are itemized below:

##### ***Danielia olivieri***

Stomata are present on the abaxial surface and absent on the adaxial surface making the species hypostomatic. The stomata complex type present is paracytic. The epidermal cells on both the abaxial and adaxial surfaces were found to be pentagonal (Figs. A17 and A18). The transpiration rate is high in this species.

##### ***Azadirachta indica***

Stomata are present on the abaxial surface and absent on the adaxial surface making the species hypostomatic. The stomata complex type present is paracytic. The epidermal cells on both abaxial and adaxial surfaces were found to be hexagonal (Figs. A29 and A30). Transpiration rate is very high in this species.

##### ***Albizia lebbek***

Stomata are present on the abaxial surface and absent on the adaxial surface making the species hypostomatic. The stomata complex type is paracytic and tetracytic. The epidermal cells on the abaxial are isodiametric while wavy is present on the adaxial surface (Figs. A11 and A12). The transpiration rate is high in this species.

##### ***Blighia sapida***

Stomata are present on the abaxial surface and absent on the adaxial surface making the species hypostomatic. The stomata complex types present are anomocytic and staurocytic. The epidermal cells on the abaxial surface are pentagonal while wavy is present on the adaxial surface (Figs. A57 - A58). The transpiration rate is very high in this species.

##### ***Plumeria alba***

Stomata are present on the abaxial surface and absent on the adaxial surface. The stomata complex type present is paracytic. The epidermal cells on both the abaxial and adaxial surfaces were found to be pentagonal (Figs. A31 and A32). The transpiration rate is high in this species.

##### ***Thevetia nerifolia***

Stomata are present on the abaxial surface and absent on the adaxial surface making the species hypostomatic. The stomata complex type is paracytic. The epidermal cells on the abaxial surfaces are wavy while pentagonal on the adaxial surface (Figs. A13 and 14). Transpiration rate is high in this species.

##### ***Mangifera indica***

Stomata are present on the abaxial surface and absent on the adaxial surface making the species hypostomatic. The stomata complex type is paracytic. The epidermal cells on the abaxial surface are hexagonal while wavy is present on the adaxial surface (Figs. A27 and A28). The transpiration rate is high in this species.

***Delonix regia***

Stomata are present on the abaxial surface and absent on the adaxial surface making the species hypostomatic. The stomata complex types present are anomocytic and paracytic. The epidermal cells on both the abaxial and adaxial surfaces were found to be wavy (Figs. A43 and A44). Transpiration rate is low in this species.

***Tectonia grandis***

Stomata are present on the abaxial surface and absent on the adaxial surface making the species hypostomatic. Stomata complex type present is paracytic. The epidermal cells on both the abaxial and adaxial surfaces were found to be isodiametric (Figs. A59 and A60). The transpiration rate is low in this species.

***Terminalia catappa***

Stomata are present on both the abaxial and adaxial surfaces making the species amphistomatic. Anisocytic, tetracytic and laterocytic stomata complex types were found to be present on the abaxial surface while tetracytic were present on the adaxial surface were found to be wavy (Figs. A25 and A26). The transpiration rate is very high in this species.

***Citrus sinensis***

Stomata are present on the abaxial surface and absent on the adaxial surface making the species to be hypostomatic. The stomata complex types present is paracytic and anomocytic. The epidermal cells on both the abaxial and adaxial surfaces were found to be pentagonal (Figs. A39 and A40). The transpiration rate is very high in this species.

***Citrus limon***

Stomata are present on the abaxial surface and absent on the adaxial surface making the species to be hypostomatic. The stomata complex type is paracytic. The epidermal cells on the abaxial surface are pentagonal while cells on the adaxial surface are hexagonal (Figs. A35 and A36). The transpiration rate is very high in this species.

***Citrus reticulata***

Stomata are present on the abaxial surface and absent on the adaxial surface making the specie hypostomatic. The stomata complex types are paracytic, brachyparacytic and anomocytic. The epidermal cells on the abaxial and adaxial surfaces were found to pentagonal (Figs. A1 and A2). The transpiration rate is high in this species.

***Citrus paradisi***

Stomata are present on the abaxial surface and absent on the adaxial surface making the species hypostomatic. The stomata complex types are paracytic and hemiparacytic. The epidermal cells on the abaxial surface and the adaxial surface were found to be pentagonal (Figs. A37 and A38). The transpiration rate is high in this species.

***Parkia biglobosa***

Stomata are present on both the abaxial and adaxial surfaces making the species amphistomatic. The stomata complex types present on both surface are paracytic. The epidermal cells on the abaxial surface is pentagonal while the on the adaxial surface is hexagonal (Figs. A21 and A22). The transpiration rate is high in this species.

***Vitellaria paradoxa***

Stomata are present on the abaxial surface and absent on the adaxial surface making the species hypostomatic. The stomata complex type present is paracytic. The epidermal cells on both the abaxial and the adaxial surfaces were found to be pentagonal (Figs. A23 and A24). The transpiration rate is high in this species.

***Anacardium occidentale***

Stomata are present on the abaxial surface and absent on the adaxial surface making the species hypostomatic. The stomata complex type present is paracytic. The epidermal cells on the abaxial surface surface are isodiametric while pentagonal is present on the adaxial surface (Figs. A41 and A42). The transpiration rate is high in this species.

***Gmelina arborea***

Stomata are present on both abaxial and adaxial surfaces making the specie amphistomatic. The stomata complex type present is paracytic (Figs. A47 and A48). The transpiration rate of this species is low.

***Acacia auriculiformis***

Stomata are present on both abaxial surface and adaxial surface making the specie amphistomatic. Anomotetracytic, paracytic, tetracytic and anomocytic stomata were found to be present on the abaxial surface while tetracytic and paracytic were found on the adaxial surface. The epidermal cells on both the abaxial and adaxial surface were found to be pentagonal (Figs. A19 and 20). The transpiration rate is very high in this species.

***Bridelia ferruginea***

Stomata are present on both the abaxial and adaxial surfaces making the specie amphistomatic. Tetracytic and paracytic stomata complex types were found to be present on the abaxial surface while paracytic type was found on the adaxial surface. The epidermal cells found to be present on both the abaxial and adaxial surfaces is pentagonal (Figs. A15 and A16). The transpiration rate is very high in this species.

***Prosobis africana***

Stomata are present both on the abaxial surface and adaxial surface making the specie amphistomatic. The stomata complex types on both surfaces are paracytic. The epidermal cell on the abaxial surface is pentagonal while hexagonal is present on the adaxial surface (Figs. A49 and A50). The transpiration rate is low in this species.

***Burkea africana***

Stomata are present on both the abaxial and adaxial surfaces and this make the specie amphistomatic, but stomata are relatively more frequently on the abaxial surface than the adaxial surface. Stomatal are evenly disturbed on both abaxial and adaxial surfaces. Stomata complex type on both the abaxial and adaxial surfaces is paracytic types. Stomata size varies and bigger on the abaxial than the adaxial. Trichome is present on both the abaxial and adaxial surfaces (Figs. A7 and A8). Transpiration rate is high in this species.

***Lophira lanceolata***

Stomata are present on both the abaxial and adaxial surfaces and this make the specie amphistomatic. Stomata are more frequent on the abaxial than the adaxial surface. Stomata density varies with the abaxial surface having a higher density than the adaxial surface. Stomata complex types present on both surfaces are paracytic (Figs. A3 and A4). Transpiration rate is high in this species.

***Ficus elastica***

Stomata are present on the abaxial and adaxial surface making the specie amphistomatic. Paracytic and tetracytic stomata complex types were found to be present on the abaxial while paracytic on the adaxial surface. The epidermal cells on both the abaxial and adaxial surface were found to be pentagonal (Figs. A55 and A56). Transpiration rate is high in this species.

***Ficus trichopoda***

Stomata are present on the abaxial surface and absent on the adaxial surface making the specie hypostomatic. Paracytic stomata complex types were found to be present on the abaxial surface. The epidermal cells present on both surfaces were found to be pentagonal (Figs. A53 and A54). Transpiration rate is low in this species.

***Annona senegalensis***

Stomata are present on the abaxial surface only making the specie hypostomatic. Staurocytic stomata complex types were found to be present on the abaxial surface. The epidermal cell present is pentagonal on both surfaces (Figs. A45 and A46). Transpiration rate is low in this species.

***Citrus aurantifolia***

Stomata are present on the abaxial surface and absent on the adaxial surface making the species hypostomatic. The stomata complex types are paracytic. The epidermal cells on both the abaxial and adaxial surfaces were found to be pentagonal (Figs. A33 and A34). Transpiration ration rate is high in this species.

***Gliricidium sepium***

Stomata are present of the abaxial surface only making the specie hypostomatic. The stomata complex types are anomocytic and paracytic. The epidermal cell found to be present is hexagonal (Figs. A51 and A52). Transpiration rate is high in this species.

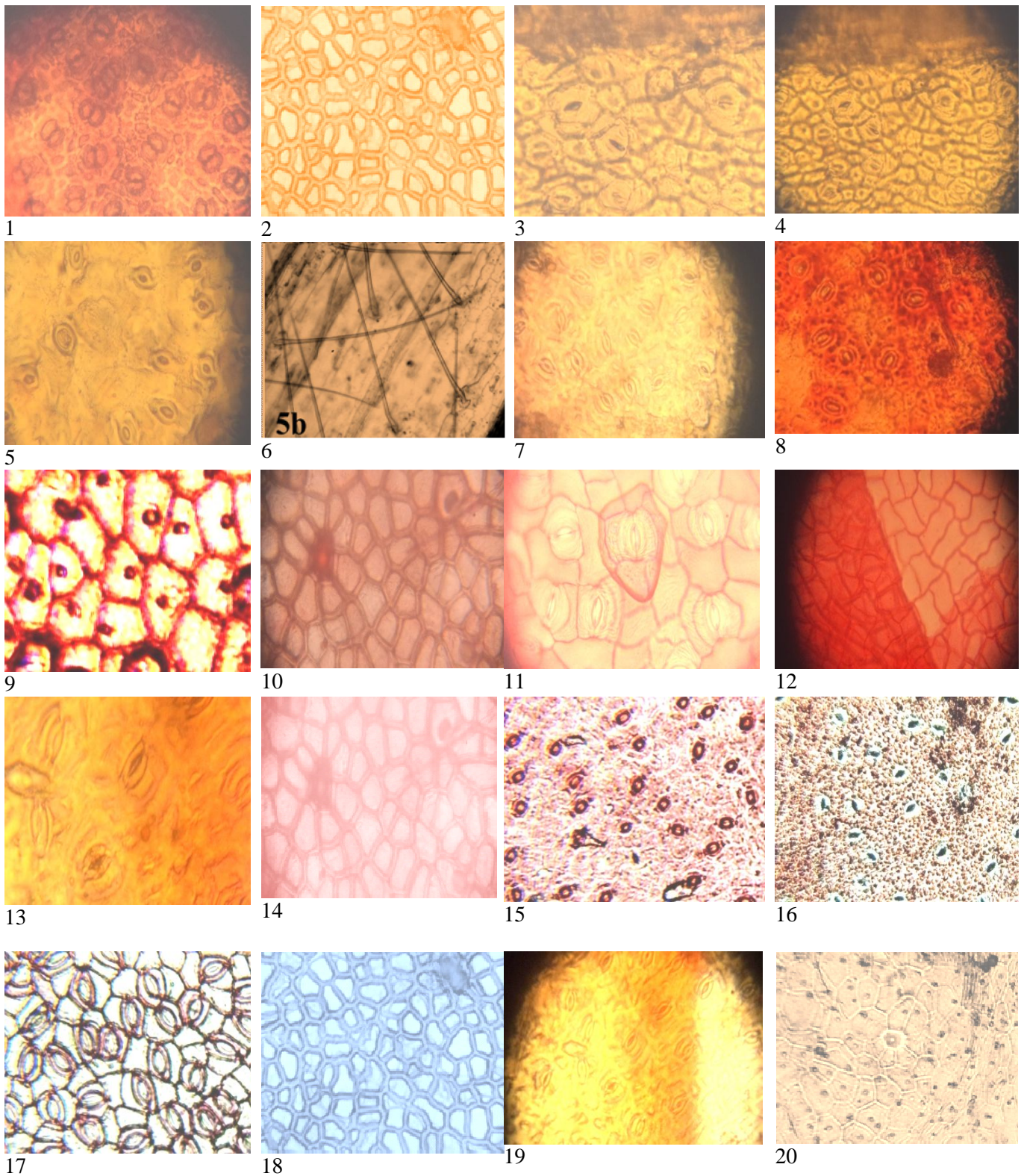
***Dioclea reflexa***

Stomata are present on the abaxial surface and absent on the adaxial surface making the species hypostomatic. The stomata complex types are anomocytic and staurocytic. The epidermal cell found to be present is pentagonal (Figs. A9 and A10). The transpiration rate is high in this species.

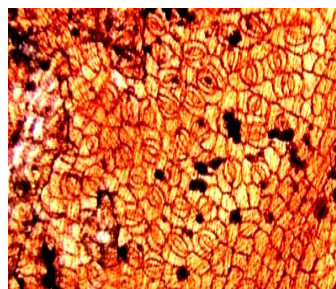


***Lonchocarpus cyanescens***

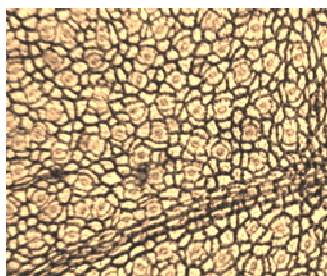
Stomata are present on the abaxial surface and absent on the adaxial surface thus making the species hypostomatic. The stomatal complex types present is paracytic and the epidermal cell found is hexagonal (Figs. A5 and A6). Transpiration rate is low in this species.



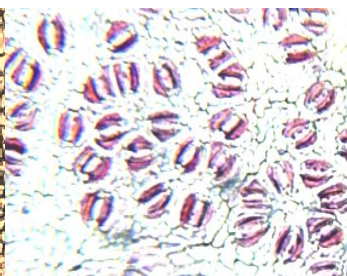




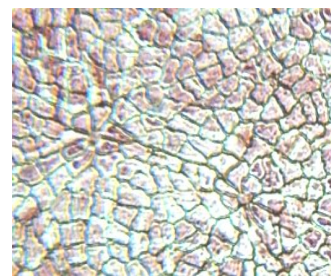
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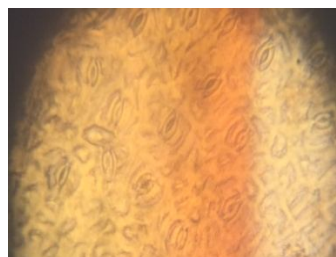
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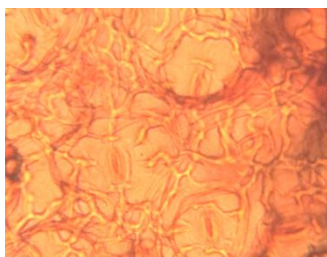
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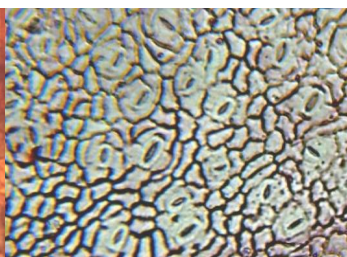
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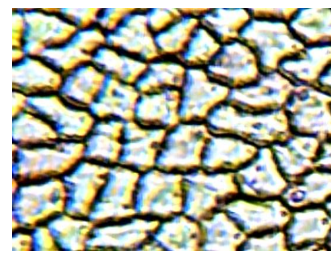
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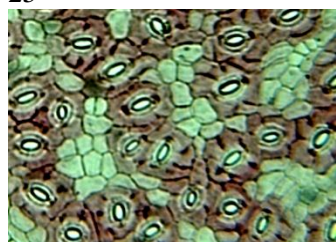
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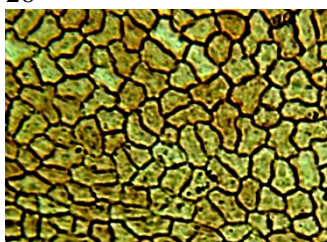
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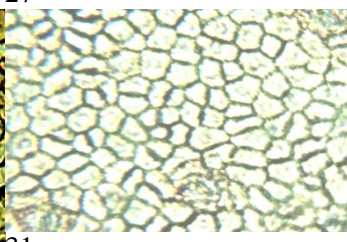
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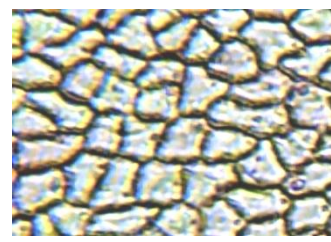
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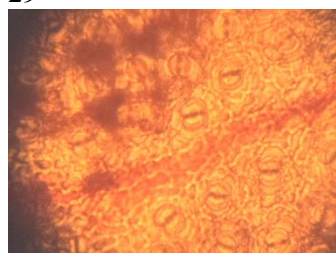
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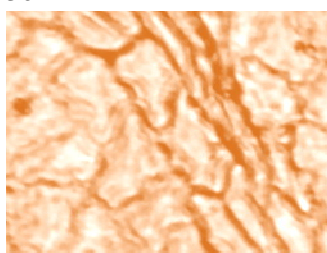
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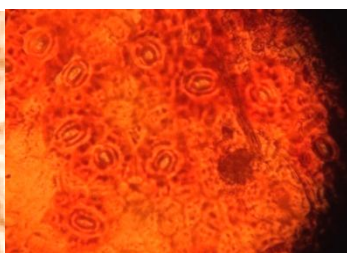
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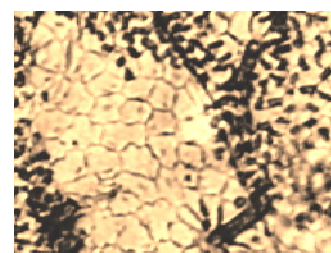
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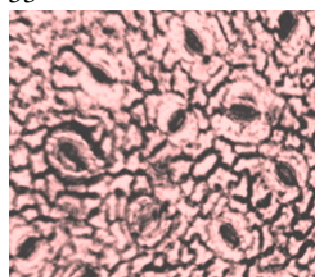
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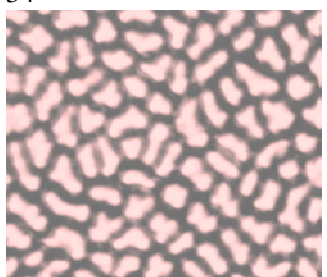
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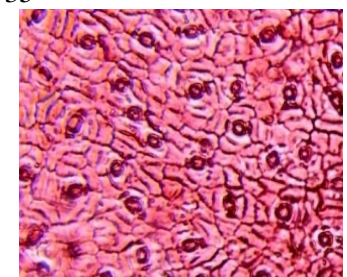
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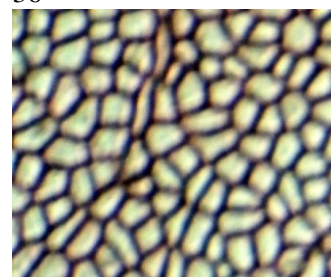
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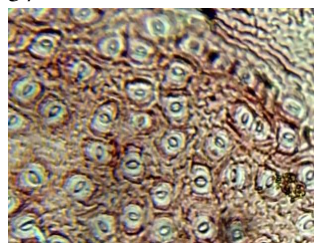
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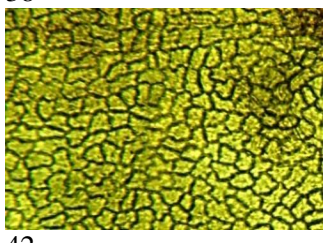
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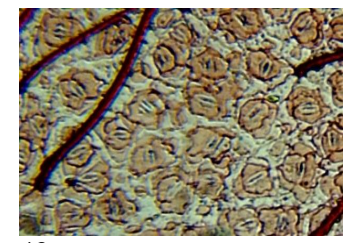
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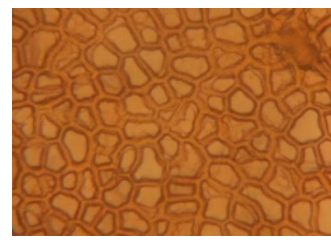
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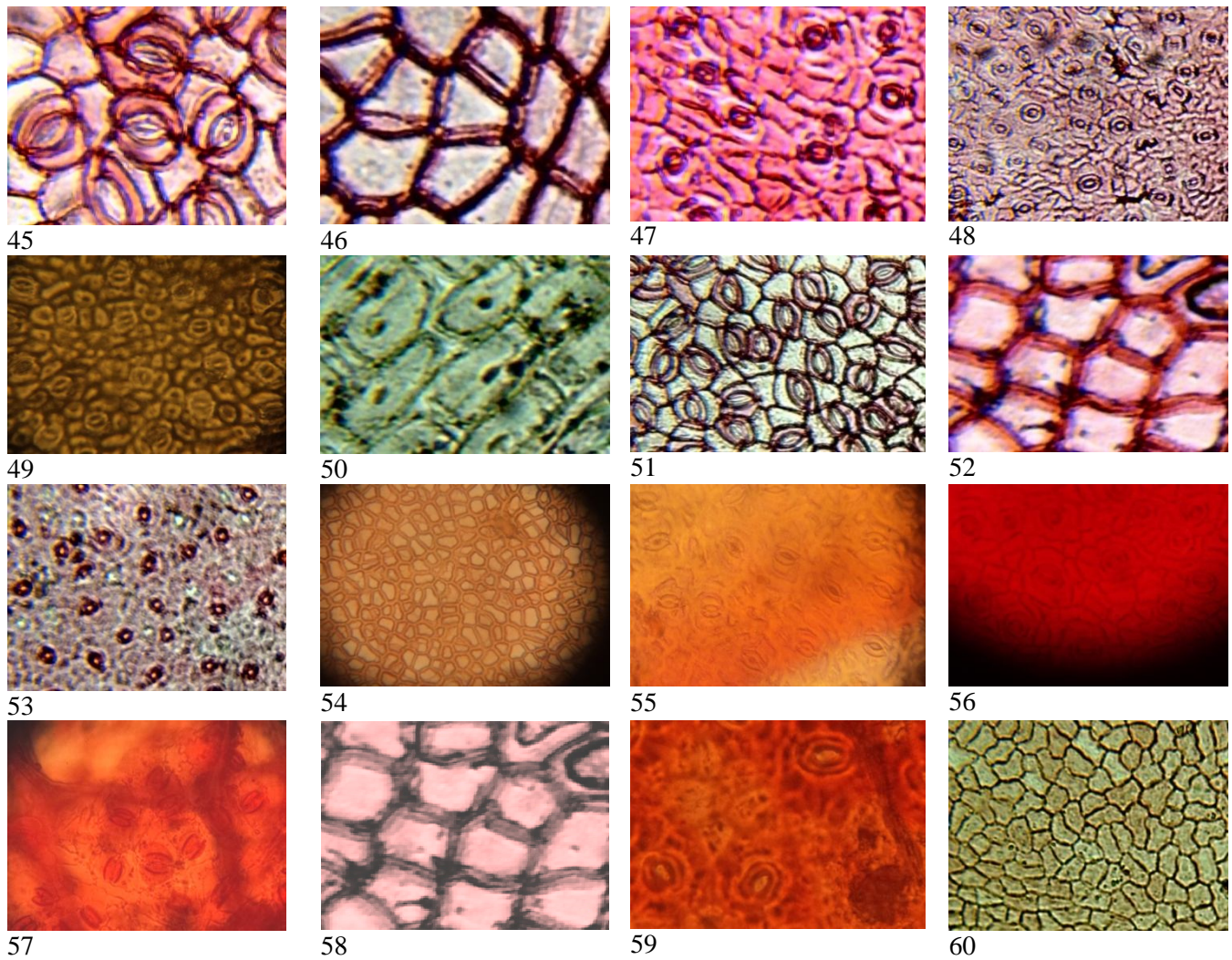


Fig. A: Leaf epidermis (abaxial and adaxial surfaces) of *Citrus reticulata* (1 and 2), *Lophira lanceolata* (3 and 4), *Lonchocarpus cyanescens* (5 and 6), *Burkea africana* (7 and 8), *Dioclea reflexa* (9 and 10), *Albizia lebbeck* (11 and 12), *Thevetia nerifolia* (13 and 14), *Bridelia ferruginea* (15 and 16), *Daniela oliveri* (17 and 18), *Acacia auriculiformis* (19 and 20), *Parkia biglobosa* (21 and 22), *Vitellaria paradoxa* (23 and 24), *Terminalia catappa* (25 and 26), *Mangifera indica* (27 and 28), *Azadirachta indica* (29 and 30), *Plumeria alba* (31 and 32), *Citrus aurantifolia* (33 and 34), *Citrus limon* (35 and 36), *Citrus paradisi* (37 and 38), *Citrus sinensis* (39 and 40), *Anacardium occidentale* (41 and 42), *Delonix regia* (43 and 44), *Annona senegalensis* (45 and 46), *Gmelina arborea* (47 and 48), *Prosopis Africana* (49 and 50), *Gliciridium sepium* (51 and 52), *Ficus trichopoda* (53 and 54), *Ficus elastic* (55 and 56), *Blighia sapida* (57 and 58) and *Tectonia grandis* (59 and 60) showing stomata, trichomes and epidermal cell wall x600

**Table 2: Canopy characteristics of the selected thirty (30) shade plants**

Species	Number of main branch	Density of leaves	Length						
			of petiole (m)	Height of trunk	Diameter of trunk	Height of tree	Crown diameter	Area of Leaf	Area of Canopy
1 <i>Citrus reticulata</i>	2.63 <sup>bcd</sup>	127.94 <sup>q</sup>	2.14 <sup>cde</sup>	100.56 <sup>d</sup>	52.94 <sup>a</sup>	331.69 <sup>a</sup>	293.56 <sup>a</sup>	14.26 <sup>cd</sup>	367.81 <sup>l</sup>
2 <i>Citrus paradisi</i>	4.63 <sup>i</sup>	58.31 <sup>k</sup>	2.22 <sup>def</sup>	73.31 <sup>b</sup>	115.75 <sup>c</sup>	709.94 <sup>d</sup>	759.69 <sup>f</sup>	65.94 <sup>g</sup>	455.38 <sup>m</sup>
3 <i>Citrus limon</i>	2.00 <sup>a</sup>	13.13 <sup>a</sup>	2.04 <sup>cde</sup>	123.38 <sup>e</sup>	134.19 <sup>gh</sup>	743.75 <sup>d</sup>	872.81 <sup>h</sup>	14.47 <sup>cd</sup>	132.38 <sup>b</sup>
4 <i>Citrus aurantifolia</i>	2.63 <sup>bcd</sup>	121.44 <sup>p</sup>	2.19 <sup>de</sup>	93.06 <sup>cd</sup>	54.25 <sup>a</sup>	327.31 <sup>a</sup>	308.25 <sup>b</sup>	166.58 <sup>o</sup>	239.13 <sup>g</sup>
5 <i>Citrus sinensis</i>	4.19 <sup>ghi</sup>	82.56 <sup>m</sup>	2.29 <sup>def</sup>	91.44 <sup>c</sup>	56.44 <sup>a</sup>	511.75 <sup>abc</sup>	421.31 <sup>c</sup>	29.13 <sup>g</sup>	517.31 <sup>o</sup>
6 <i>Anacardium occidentale</i>	2.69 <sup>bcd</sup>	39.31 <sup>g</sup>	2.89 <sup>efg</sup>	142.50 <sup>f</sup>	163.06 <sup>j</sup>	660.25 <sup>bcd</sup>	956.56 <sup>jk</sup>	100.63 <sup>k</sup>	1233.61 <sup>t</sup>
7 <i>Bridelia ferruginea</i>	2.81 <sup>cd</sup>	54.06 <sup>j</sup>	1.08 <sup>abc</sup>	235.00 <sup>l</sup>	252.69 <sup>n</sup>	508.75 <sup>abc</sup>	1042.44 <sup>l</sup>	35.08 <sup>h</sup>	150.81 <sup>c</sup>
8 <i>Azadirachta indica</i>	2.19 <sup>ab</sup>	45.81 <sup>hi</sup>	7.41 <sup>i</sup>	194.13 <sup>i</sup>	120.00 <sup>cd</sup>	941.25 <sup>ef</sup>	990.94 <sup>k</sup>	10.66 <sup>c</sup>	1622.44 <sup>x</sup>
9 <i>Albizia lebbek</i>	4.25 <sup>ghi</sup>	43.88 <sup>h</sup>	0.60 <sup>ab</sup>	272.56 <sup>m</sup>	184.13 <sup>k</sup>	1654.38 <sup>l</sup>	2025.19 <sup>x</sup>	0.81 <sup>a</sup>	1480.38 <sup>v</sup>
10 <i>Blighia sapida</i>	2.81 <sup>cd</sup>	14.75 <sup>ab</sup>	0.54 <sup>ab</sup>	124.38 <sup>e</sup>	131.56 <sup>fg</sup>	481.88 <sup>ab</sup>	1219.06 <sup>q</sup>	21.78 <sup>e</sup>	172.13 <sup>e</sup>
11 <i>Vitellaria paradoxa</i>	3.88 <sup>fg</sup>	29.81 <sup>f</sup>	8.72 <sup>j</sup>	289.00 <sup>o</sup>	196.75 <sup>l</sup>	1006.31 <sup>fg</sup>	1499.00 <sup>u</sup>	107.85 <sup>l</sup>	683.13 <sup>p</sup>
12 <i>Tectona grandis</i>	2.31 <sup>abc</sup>	14.69 <sup>ab</sup>	3.31 <sup>fg</sup>	142.56 <sup>f</sup>	125.44 <sup>de</sup>	692.50 <sup>cd</sup>	1238.19 <sup>r</sup>	126.17 <sup>m</sup>	167.25 <sup>de</sup>
13 <i>Gmelina arborea</i>	2.94 <sup>de</sup>	25.31 <sup>e</sup>	3.55 <sup>gh</sup>	150.19 <sup>f</sup>	179.38 <sup>k</sup>	1136.63 <sup>fgh</sup>	919.94 <sup>i</sup>	47.42 <sup>i</sup>	504.06 <sup>n</sup>
14 <i>Daniela olivieri</i>	2.81 <sup>cd</sup>	63.38 <sup>l</sup>	1.33 <sup>abcd</sup>	197.81 <sup>i</sup>	222.00 <sup>m</sup>	1350.00 <sup>jk</sup>	1388.81 <sup>t</sup>	27.31 <sup>fg</sup>	3149.88 <sup>β</sup>
15 <i>Thevetia neriifolia</i>	2.25 <sup>ab</sup>	107.38 <sup>o</sup>	0.57 <sup>ab</sup>	119.88 <sup>e</sup>	53.75 <sup>a</sup>	443.13 <sup>a</sup>	555.94 <sup>d</sup>	5.75 <sup>b</sup>	899.06 <sup>r</sup>
16 <i>Parkia biglobosa</i>	4.19 <sup>ghi</sup>	19.44 <sup>cd</sup>	0.50 <sup>ab</sup>	218.75 <sup>k</sup>	270.31 <sup>o</sup>	1219.38 <sup>hij</sup>	1725.00 <sup>v</sup>	0.71 <sup>a</sup>	287.50 <sup>i</sup>
17 <i>Delonix regia</i>	2.69 <sup>bcd</sup>	98.56 <sup>n</sup>	12.43 <sup>l</sup>	125.00 <sup>e</sup>	130.56 <sup>efg</sup>	488.56 <sup>ab</sup>	1142.44 <sup>o</sup>	0.92 <sup>a</sup>	256.75 <sup>h</sup>
18 <i>Terminalia catappa</i>	4.44 <sup>hi</sup>	18.44 <sup>bcd</sup>	1.89 <sup>cde</sup>	208.31 <sup>j</sup>	98.06 <sup>b</sup>	628.88 <sup>bcd</sup>	1036.00 <sup>l</sup>	294.13 <sup>p</sup>	2811.19 <sup>α</sup>
19 <i>Plumeria alba</i>	2.94 <sup>de</sup>	12.63 <sup>a</sup>	1.28 <sup>abcd</sup>	143.75 <sup>f</sup>	131.56 <sup>fg</sup>	491.25 <sup>ab</sup>	1215.63 <sup>q</sup>	16.46 <sup>d</sup>	121.69 <sup>a</sup>
20 <i>Acacia auriculiformis</i>	2.38 <sup>abc</sup>	37.25 <sup>g</sup>	0.49 <sup>a</sup>	278.81 <sup>mm</sup>	148.88 <sup>i</sup>	1837.88 <sup>m</sup>	1190.56 <sup>p</sup>	23.81 <sup>ef</sup>	1072.31 <sup>s</sup>
21 <i>Mangifera indica</i>	6.06 <sup>j</sup>	20.63 <sup>d</sup>	4.61 <sup>h</sup>	287.56 <sup>no</sup>	125.75 <sup>de</sup>	802.50 <sup>de</sup>	740.13 <sup>e</sup>	70.41 <sup>j</sup>	1336.13 <sup>u</sup>
22 <i>Lonchocarpus cyanescens</i>	2.25 <sup>ab</sup>	44.06 <sup>hi</sup>	0.67 <sup>ab</sup>	166.75 <sup>g</sup>	121.25 <sup>cd</sup>	2167.19 <sup>n</sup>	960.94 <sup>j</sup>	25.68 <sup>efg</sup>	1490.06 <sup>w</sup>
23 <i>Dioclea reflexa</i>	3.00 <sup>de</sup>	14.50 <sup>ab</sup>	1.89 <sup>cde</sup>	468.56 <sup>q</sup>	127.75 <sup>ef</sup>	1455.94 <sup>k</sup>	1060.13 <sup>m</sup>	28.90 <sup>g</sup>	161.19 <sup>d</sup>
24 <i>Gliricidium sepium</i>	4.19 <sup>ghi</sup>	31.88 <sup>ab</sup>	8.99 <sup>cde</sup>	306.25 <sup>q</sup>	117.94 <sup>c</sup>	1371.88 <sup>jk</sup>	1234.94 <sup>r</sup>	25.86 <sup>efg</sup>	793.44 <sup>q</sup>
25 <i>Annona senegalensis</i>	2.63 <sup>bcd</sup>	48.25 <sup>i</sup>	1.59 <sup>bcd</sup>	56.31 <sup>a</sup>	139.94 <sup>h</sup>	929.94 <sup>ef</sup>	848.56 <sup>g</sup>	50.75 <sup>i</sup>	1786.63 <sup>y</sup>
26 <i>Ficus elastica</i>	2.56 <sup>bcd</sup>	21.06 <sup>d</sup>	10.79 <sup>k</sup>	118.38 <sup>e</sup>	131.63 <sup>fg</sup>	786.25 <sup>de</sup>	1295.63 <sup>s</sup>	148.60 <sup>n</sup>	344.44 <sup>k</sup>
27 <i>Lophira lanceolata</i>	2.94 <sup>de</sup>	25.31 <sup>e</sup>	3.55 <sup>gh</sup>	150.19 <sup>f</sup>	179.38 <sup>k</sup>	1136.63 <sup>fgh</sup>	919.94 <sup>i</sup>	47.42 <sup>i</sup>	504.06 <sup>n</sup>
28 <i>Prosobis africana</i>	3.94 <sup>fg</sup>	19.75 <sup>cd</sup>	0.51 <sup>ab</sup>	219.38 <sup>k</sup>	268.25 <sup>o</sup>	1261.25 <sup>ij</sup>	1736.25 <sup>w</sup>	0.71 <sup>a</sup>	297.75 <sup>j</sup>
29 <i>Ficus trichopoda</i>	4.06 <sup>gh</sup>	59.19 <sup>k</sup>	16.19 <sup>m</sup>	183.31 <sup>h</sup>	182.38 <sup>k</sup>	1075.00 <sup>fgh</sup>	1106.63 <sup>n</sup>	69.60 <sup>j</sup>	2739.81 <sup>z</sup>
30 <i>Burkea africana</i>	3.44 <sup>ef</sup>	15.81 <sup>abc</sup>	1.20 <sup>abcd</sup>	124.63 <sup>e</sup>	130.88 <sup>efg</sup>	479.38 <sup>ab</sup>	1221.56 <sup>q</sup>	9.99 <sup>bc</sup>	192.94 <sup>f</sup>

Table 3: Stomatal features, transpiration rate and temperature parameters in the thirty (30) species studied

Species	Leaf surface	Stomatal complex types	Frequency (%)	Stomatal density (mm <sup>2</sup> )	Stomatal size (µm <sup>2</sup> )	Stomatal index (%)	Transpiration rate (mol <sup>-2</sup> sec <sup>-1</sup> )	Temperature under tree (°C)	Temperature in the sun (°C)
<i>Citrus reticulata</i>	Abaxial	Paracytic, Brachyparacytic, Anomocytic	82 7 11	294.34a	21.30c	22.90	1.18x10 <sup>-5</sup> <sub>b</sub>	31°C	39°C
<i>Citrus paradisi</i>	Abaxial	Paracytic, Hemiparacytic	92 8	267.22c	21.40c	21.40	2.44x10 <sup>-5</sup> <sub>a</sub>	31°C	40°C
<i>Citrus limon</i>	Abaxial	Paracytic	100	188.16c	23.60b	16.80	1.21 x 10 <sup>-5</sup> <sub>c</sub>	30°C	39°C
<i>Citrus aurantifolia</i>	Abaxial	Paracytic	100	187.5c	24.90a	17.30	1.30 x 10 <sup>-5</sup> <sub>c</sub>	30°C	39°C
<i>Citrus sinensis</i>	Abaxial	Paracytic Anomocytic	81 19	1185.97c	24.90a	16.80	3.22 x 10 <sup>-5</sup> <sub>a</sub>	31°C	41°C
<i>Anacardium occidentale</i>	Abaxial	Paracytic	100	24.37d	73.60c	6.95	2.68 x 10 <sup>-6</sup> <sub>a</sub>	25°C	41°C
<i>Bridelia ferruginea</i>	Abaxial	Tetracytic Paracytic	40 60	12.30f	52.33ef	7.95 <sub>d</sub>	3.52 x 10 <sup>-6</sup> <sub>a</sub>	27°C	43°C
	Adaxial	Paracytic	100	15.72e	48.52f	6.35 <sub>g</sub>	2.16 x 10 <sup>-6</sup> <sub>a</sub>		
<i>Azadirachta indica</i>	Abaxial	Paracytic	100	30.30c	52.15ef	29.60	3.30 x 10 <sup>-6</sup> <sub>a</sub>	31°C	42°C
<i>Albizia lebeck</i>	Abaxial	Paracytic Tetracytic	59 32	17.50e	32.68g	4.20	3.68 x 10 <sup>-6</sup> <sub>a</sub>	26°C	42°C
<i>Blighia sapida</i>	Abaxial	Anomocytic Staurocytic	68 33	22.68d	42.63	8.64	3.22 x 10 <sup>-6</sup> <sub>a</sub>	26°C	41°C
<i>Vitellaria paradoxa</i>	Abaxial	Paracytic	100	26.98c	61.53cd	19.82	2.85 x 10 <sup>-6</sup> <sub>a</sub>	29°C	41°C
<i>Tectona grandis</i>	Abaxial	Paracytic	100	16.65e	50.46f	3.30	6.42 x 10 <sup>-6</sup> <sub>a</sub>	31°C	43°C
<i>Gmelina arborea</i>	Abaxial	Paracytic	100	9.76g	43.37f	8.45	8.54 x 10 <sup>-6</sup> <sub>a</sub>	31°C	44°C
	Adaxial	Paracytic	100	2.23h	22.19	3.10	7.60 x 10 <sup>-6</sup> <sub>a</sub>		
<i>Daniela olivieri</i>	Abaxial	Paracytic	100	40.36a	137.20b	36.50 <sub>a</sub>	1.85 x 10 <sup>-6</sup> <sub>a</sub>	31°C	38°C
<i>Thevetia nerifolia</i>	Abaxial	Paracytic	100	15.77e	47.58f	6.30	2.18 x 10 <sup>-6</sup> <sub>a</sub>	31°C	41°C
<i>Parkia biglobosa</i>	Abaxial	Paracytic	100	17.80e	68.65cd	7.05 <sub>f</sub>	8.95 x 10 <sup>-6</sup> <sub>a</sub>	33°C	47°C
	Adaxial	Paracytic	100	9.30	53.62ef	4.02 <sub>h</sub>	6.40 x 10 <sup>-6</sup> <sub>a</sub>		
<i>Delonix regia</i>	Abaxial	Anomocytic Paracytic	40 60	8.25g	46.98f	9.30 <sub>d</sub>	3.30 x 10 <sup>-6</sup> <sub>a</sub>	34°C	40°C
<i>Terminalia catappa</i>	Abaxial	Anisocytic Paracytic Tetracytic	17 33 50	9.00g	66.18c	6.25 <sub>g</sub>	4.66 x 10 <sup>-6</sup> <sub>a</sub>	31°C	43°C
	Adaxial	Tetracytic	100	12.05f	47.52f	5.55 <sub>g</sub>	2.15 x 10 <sup>-6</sup> <sub>a</sub>		
<i>Plumeria alba</i>	Abaxial	Paracytic	100	15.05e	152.23a	4.54 <sub>h</sub>	2.64 x 10 <sup>-6</sup> <sub>a</sub>	31°C	40°C
<i>Acacia auriculiformis</i>	Abaxial	Anomocytic Paracytic Tetracytic Anomotetracytic	30 10 50 9	20.34d	71.73c	8.42 <sub>d</sub>	6.60 x 10 <sup>-6</sup> <sub>a</sub>	33°C	46°C
	Adaxial	Tetracytic	28 72	8.65g	58.30e	6.90 <sub>fg</sub>	2.60 x 10 <sup>-6</sup> <sub>a</sub>		
<i>Mangifera indica</i>	Abaxial	Paracytic	100	27.98c	62.60de	17.75 <sub>c</sub>	2.87 x 10 <sup>-6</sup> <sub>a</sub>	30°C	40°C
<i>Lonchocarpus cyanescens</i>	Abaxial	Paracytic	100	185.16c	23.58b	16.70	1.30 x 10 <sup>-6</sup> <sub>a</sub>	26°C	39°C
<i>Dioclea reflexa</i>	Abaxial	Anomocytic Paracytic	19 80	1185.82c	23.70a	16.20	3.20 x 10 <sup>-6</sup> <sub>a</sub>	30°C	41°C
<i>Gliricidium sepium</i>	Abaxial	Anomocytic Paracytic	81 16	118.13 c	24.90a	17.10	3.11 X 10 <sup>-6</sup> <sub>a</sub>	29°C	41°C
<i>Annona senegalensis</i>	Abaxial	Staurocytic	85	41.30a	132.20b	33.40 <sub>a</sub>	1.83 x 10 <sup>-6</sup> <sub>a</sub>	32°C	38°C
<i>Ficus elastica</i>	Abaxial	Paracytic	60	12.20f	52.20ef	6.90 <sub>d</sub>	3.45 x 10 <sup>-6</sup> <sub>a</sub>	29°C	42°C
	Adaxial	Tetracytic Paracytic	40 100	48.49f	14.70e	6.30 <sub>g</sub>	2.13 x 10 <sup>-6</sup> <sub>a</sub>		
<i>Lophira lanceolata</i>	Abaxial	Tetracytic Paracytic	30 70	13.13d	59.30ef	8.20 <sub>d</sub>	3.20 x 10 <sup>-6</sup> <sub>a</sub>	29°C	43°C
	Adaxial	Tetracytic	100	8.60g	45.40f	6.50 <sub>fg</sub>	2.10 x 10 <sup>-6</sup> <sub>a</sub>		
<i>Prosobis africana</i>	Abaxial	Paracytic	100	18.90e	65.60cd	7.07 <sub>f</sub>	7.80 x 10 <sup>-6</sup> <sub>a</sub>	29°C	45°C
	Adaxial	Paracytic	85	8.20g	50.62ef	4.03 <sub>h</sub>	5.20 x 10 <sup>-6</sup> <sub>a</sub>		
<i>Ficus trichopoda</i>	Abaxial	Paracytic	100	15.20e	50.49f	6.50 <sub>g</sub>	2.13 x 10 <sup>-6</sup> <sub>a</sub>	27°C	41°C
<i>Burkea africana</i>	Abaxial	Paracytic	100	188.15c	23.60b	16.60	4.30 x 10 <sup>-6</sup> <sub>c</sub>	28°C	44°C
	Adaxial	Paracytic	88	8.50g	55.20e	3.30	2.50 x 10 <sup>-6</sup>		

Means with same letters along columns are not significantly different at P ≤ 0.05

## Discussion

A morphological survey of thirty (30) shade plant species was conducted in order to identify the characteristics of their canopies which could make them suitable for use as shade plants. In selecting a plant as shade plant or as a cover plant for the soil against erosion among other features, it must possess wide crown diameter, wide canopy area, high leaf density which reduces the penetration of direct sunlight and raindrops and low tree height and short petioles for firm grip of leaves (Finnigan and Raupach, 1987). Based on the parameter observed in this study, *D. oliveri* has the widest canopy followed by *T. catappa*, *F. trichopoda*, *A. indica*, *L. cyanenscens*, *Albizia lebeck*, *M. indica* etc while *P. alba*, *C. limon* has the narrowest canopy. Density of leaves (LD) is highest in *T. neriifolia* followed by *D. regia* etc and it is lowest in *P. alba*, *B. sapida*, *T. grandis*, *T. neriifolia* and *D. regia* will provide more shade by blocking penetration of sun rays and rain drops than other species while *P. alba* will be more susceptible to sun rays and raindrops than other species. Number of main branch (NMB) is larger in *M. indica* followed by *G. sepium*, *C. paradisi*, *T. catappa*, *D. regia* etc. The tree height is tallest in *L. cyanenscens* followed by *A. auriculiformis*, *G. arborea* and *D. oliveri* etc. Diameter of trunk is widest in *G. arborea*, and narrowest in *C. reticulata*, and *T. neriifolia*. Height of trunk is longest in *A. auriculiformis*, *D. oliveri*, *G. arborea* and shortest in *A. senegalensis*, *C. paradisi* etc. The longer trunk of *A. auriculiformis*, *D. oliveri*, *G. arborea* will make them prone to wind damage than *A. senegalensis* and *C. paradisi*. The shorter height of tree of *L. cyanenscens*, *A. auriculiformis*, *G. arborea*, and *D. oliveri* is an ability to withstand the pressure of stress of heavy wind blowing and other forces than *A. senegalensis* and *C. paradisi* (Table 2).

Having shade plants in our residential houses, offices along major streets in the cities and recreation centre will not only provide shade for relaxation, it will also help in combating environmental hazards like accumulation of greenhouse gases. They could also humidify the atmosphere. These two events i.e. Cleansing and humidification of the atmosphere are through the stomata present on the leaf surface of these plant (Edwards *et al.*, 1998; Oladele, 2002; Hetherington and Woodward, 2003; Caird *et al.*, 2007; Nilson and Assmann, 2007; AbdulRahaman and Oladele, 2008). These plants could also aid cloud formation and rainfall, through the transpiration process and humidification of the atmosphere. The SCTs SD, SS SI and rate of transpiration were studied to confirm their cooling effects as humidifiers and cleansers of the atmosphere. Some of the stomatal features studied in this work were discovered to have some correlations with transpiration rates. This includes:

### Homogeneity and heterogeneity of stomatal complex types (SCTs)

Different types of SCTs present in a species are factor in its rate of transpiration. For instance species like *A. auriculiformis*, *T. catappa*, *B. ferruginea*, *B. sapida*, *D. reflexa*, *L. lanceolata* etc with at least two types of SCTs transpired faster than species with homogenous SCT especially paracytic type as found in *B. africana*, *G. arborea*, *T. grandis*, *P. alba* and *P. africana*. Though there are some species in latter group which transpired faster than those in the former group. Reason for this may be possession of some other stomatal features such as stomatal density, stomatal size and stomatal index. Meanwhile, Carr and Carr (1990) had reported that stomata with many subsidiary cells open more rapidly than those with little subsidiary cells. This claim was confirmed by Obiremi and Oladele (2001), AbdulRahaman and Oladele (2003), Oyeleke *et al.* (2004), Saadu *et al.* (2009) in stomatal complex types of some *Citrus*, vegetation, afforestation tree and tuber sp respectively where those stomata with large number of subsidiary cells transpired faster than those with small subsidiary cells.

### Amphistomatic and hypostomatic leaves

Occurrence of stomata on one or both surfaces of the leaf is visible evidence that influence rate of transpiration in studied species. In the hypostomatic leaves (e.g. *V. paradoxa*, *L. cyanenscens*, *M. indica*, and *T. grandis* etc.), transpiration rarely takes place on the adaxial or upper surface of the leaves but in the amphistomatic leaves (e.g. *B. africana*, *L. lanceolata*, *A. auriculiformis*, and *T. catappa* etc.), transpiration rate takes place on both leaf surfaces. Thus, amphistomatic leaves (plants) transpired more and therefore releases more water to the atmosphere than the hypostomatic leaves (plants). Similar works on some other plant species also revealed that much of transpiration occurrence on leaf surface with occurrence of stomata and rarely occurred on surface without stomata (Oyeleke *et al.*, 2004; AbdulRahaman, 2009; Saadu *et al.*, 2009; AbdulRahaman *et al.*, 2010).

### Stomatal size (SS), stomatal density (SD) and stomatal index (SI)

Stomata in the 30 species studied can be described as large because according to Pataky (1969), stomata whose guard cells are less than 15 $\mu$ m are called "small" while those in which guard cells are more than 38 $\mu$ m are known as "large"; guard cells of 15 $\mu$ m-37 $\mu$ m are designated as "moderate" (AbdulRahaman, 2009).



Stomata in the studied species were all more than  $15\mu\text{m}$  with *A. auriculiformis*, having larger size ( $73.75\mu\text{m}$ ) while *D. regia* possessing the smaller size ( $47\mu\text{m}$ ). The SS of all the various species studied showed that *T. catappa* has the highest SD of  $91.00\text{mm}^2$  while *D. regia* has the lowest SD of  $8.25\text{mm}^2$  (Table 3). Studies by Metcalfe and Chalk (1988) and Beerling and Woodward (1997) showed that large stomata resulted in low SS while small stomata gave high SS. The work of AbdulRahaman and Oladele (2003) also showed this pattern where large stomata actually gave low stomata density and small stomata gave high stomata density in some vegetable species. It has been shown in this study that there were and were no correlation between SS and SD (Table 3). Stomata occupied large area on leaf surface in *D. oliveri* and least area in *G. arborea*. Unlike situation in some ornamental plants studied by AbdulRahaman (2009), the SI has no direct influence on the rate of transpiration in the species studied in this work.

Observation of different rates of transpiration among the 30 species may be due to variation in their  $\text{SCT}_s$ , SD, SI, and SS as well as occurrence of stomata either on one surface or both surfaces of leaves and on homogeneity or heterogeneity of  $\text{SCT}_s$  (AbdulRahaman, 2009). Transpiration rate was highest ( $6.62 \times 10^{-6} \text{ mol/m}^2/\text{s}^2$ ) in *A. auriculiformis*, followed by *T. catappa*, *B. ferruginea*, *A. indica*, *A. lebbeck*, *A. occidentale*, *C. sinensis*, *B. africana* etc. while lowest in *C. reticulata* ( $1.18 \times 10^{-6} \text{ mol/m}^2/\text{s}^2$ ) followed by *C. aurantifolia*, *L. cyanenscens*, *A. senegalensis*, etc. as shown in Table 3. This means that *A. auriculiformis* releases more water in form of vapour to the atmosphere than every other species while *C. reticulata* releases less water. The reason for this behavior can be traced to the stomata features possessed by each of the 30 species studied. Stomata size and density also influences the rate of transpiration. From the work carried out in the course of this work, it has been shown that there are correlations between the SS,  $\text{SCT}_s$ , and occurrence of stomata on leaf surfaces and transpiration rate than SD, SI and canopy characteristics in all the species studied.

Based on the canopy characteristics and stomatal features possessed by each of these shade plants as well as their rate of transpiration, species such as *T. catappa*, *A. indica*, *A. lebbeck*, *F. trichopoda*, *L. cyanenscens*, *D. oliveri*, and *A. auriculiformis* are the most preferable shade plant.

In conclusion, humidification potential of the studied species is relatively high as shade plants. Therefore with this quality, these plants apart from serving as a shade plant will also provide a fresh, conducive atmosphere by cleansing and humidifying the atmosphere where we live in. Also, one of the measures of preventing further deterioration effects of climate change, global warming and desertification is planting of afforestation plant species. The plants studied are capable of absorbing carbon (IV) oxide through their stomata for production of sugar and starch and thus cleanse the atmosphere of impurities (AbdulRahaman and Oladele, 2008; Oladele and AbdulRahaman, 2008; AbdulRahaman *et al.*, 2010). Also, by humidifying the atmosphere, these plants play a major role in global water cycle. Water vapour released from plants as a result of transpiration, helps in cloud formation and rainfall which in turn checks drought and the process of desertification (Keay, 1989; Oladele, 2002) especially in the arid and semi-arid environments where ornamental plants are planted for beautification of the environment.

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