

Full Length Research Paper

# Stomatal features and humidification potentials of *Borassus aethiopum*, *Oreodoxa regia* and *Cocos nucifera*

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The atmosphere contains water vapors which humidifies it and later condenses in order to form cloud and subsequently rainfall. The falling of rain is an inevitably necessary thing for plants and animals, which in turn release water back to the atmosphere through evapotranspiration. Larger portion of water is obtained in the atmosphere through plant transpiration. Transpiration rate is relatively regulated by the opening and closing processes of stomata located on the leaf surfaces. Leaves of *Borassus aethiopum*, *Oreodoxa regia* and *Cocos nucifera* are hypoamphistomatic, epiamphistomatic and hypostomatic respectively. Tetracytic stomata were present in *B. aethiopum* and *O. regia* and paracytic stomata in *C. nucifera*. Stomatal size and density show differences from one species to another as feature, which influences rate of transpiration. *O. regia* has more stomata on its adaxial surface than abaxial (hypoamphistomatic), tetracytic stomata, large stomata and high stomatal density transpired at faster rate ( $7.63 \times 10^{-5}$  mol/m<sup>2</sup>/s) and humidifies the atmosphere faster than *C. nucifera* with paracytic stomata which were restricted to adaxial surface.

**Key words:** Stomatal complex types, atmosphere, humidification, palms, transpiration.

## INTRODUCTION

Plants provide useful and essential products which are being utilized to a great extent by animals and human and these have resulted in an increased interest in the continuous existence of such plant products from generation to generation. Studies about its sociable habitat, behaviour, mode of propagation, environmental conditions favourable to their growth and intense advanced studies in finding out other hidden products of such plants have been carried out. Palms are members of the family Arecaceae and economically and medicinally useful. For example *Borassus aethiopum* is used as vegetable, a beverage called arrack, crude sugar called jaggery; *Oreodoxa regia* is used for decoration, beautification and landscaping of royal places and hotels (Buddendorf and Woltering, 1994); and *Cocos nucifera* is used as staple food in tropics, to make beverages, fans, baskets, mats, cakes and thatch and used as fire wood.

Plants with higher transpiration rate have the potential to humidify the atmosphere and thereby have direct relevance to cloud formation and rainfall. Hence, the effect of

low transpiration rate may, in some extent, account for the reason of drought. This means transpiring plants having higher number of subsidiary cells per stoma have more potential of humidifying the atmosphere than plants with lower number of subsidiary cells. In previous studies, faster transpiration rate has been determined on plant having higher number of subsidiary cells per stoma than those with lower number in some *Citrus* species and afforestation tree species (Obiremi and Oladele, 2001; Oyeleke et al., 2004).

The study materials are commonly planted around residential houses, offices and recreation centres there is therefore need to study their potential to serve as coolers or humidifier of our immediate environments. Therefore, the present study determines the humidification potentials of *B. aethiopum*, *O. regia* and *C. nucifera*.

## MATERIALS AND METHODS

### Collection of specimens

The seedlings of *B. aethiopum*, *O. regia* and *C. nucifera* (Table 1) were collected from the Femi Horticulture Flower Garden, Manatan, Ibadan, Oyo State, Nigeria. 10 seedlings each of these species

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**Table 1.** Scientific, family and common names of the study materials.

Scientific name	Family name	Common name
<i>Borassus aethiopum</i>	Arecaceae (Palmae)	Palmyra palm
<i>Oreodoxa regia</i>	Arecaceae (Palmae)	Royal palm
<i>Cocos nucifera</i>	Arecaceae (Palmae)	Coconut, Apon (Yoruba)

were used for the study. They were identified at the Herbarium Unit of Department of Plant Biology, University of Ilorin, Ilorin, Nigeria.

#### Isolation of leaf epidermal layers

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

#### Staining, mounting and observation of leaf surfaces on microscope

A portion of each macerated cuticle was taken for microscopic studies. It was stained in 1% aqueous solution of safranin for about 3 - 5 min. Excess stain was rinsed off with clean water. The stained cuticle was mounted in glycerin. Observations were made on the microscope to determine: stomatal complex types and their frequencies, stomatal size, stomatal density. All observations were recorded with drawings or Figures and Tables.

#### Determination of frequency of stomatal complex types

Using 35 fields of view at  $\times 40$  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 occurrence of such complex type based on all occurrences. Terminologies used followed those of Dilcher (1974) and Metcalfe and Chalk (1988).

#### Determination of stomatal density and stomatal size

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

#### Determination of stomatal size

The mean stomata size of a species was determined by measuring length and breadth using a micrometer of a sample of 35 stomata using eye-piece micrometer.

#### Determination of transpiration rate

A cobalt chloride paper method was used to determine the transpiration rate of each specimen (Obiremi and Oladele, 2001; Dutta, 2003). Strips of filter paper of 2 x 6 cm dimension were cut and immersed in 20% cobalt chloride solution. The strips 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 dried strips were placed in a sealed, airtight polythene bag and weighed (W1) using mettler balance. It was transferred quickly to the plastic containers and fixed with a string to the

marked small branch (of the plant) with leaves. The time (in seconds) taken for the strips to turn pink was noted. Once turned pink, the bag was quickly untied and sealed again, and transferred to the laboratory and weighed (W2). Weight of water transpired (WT) was determined as W2 minus W1. The surface area of leaves used was measured taking note if the leaf is amphistomatic, when the upper and lower surfaces of the leaf were measured. Transpiration rate was expressed as mol/m<sup>2</sup>/s.

## RESULTS

### Types and frequency of stomatal complex

Each of the three species studied (Table 1) in this work possessed a distinct leaf type based on the occurrence and distribution of stomata on the leaf surfaces. Therefore, three types of leaves were identified namely amphistomatic and epiamphistomatic (stomata occurred on both leaf surfaces with more on the adaxial than on the abaxial) which occurred in *B. aethiopum*, amphistomatic and hypoamphistomatic (stomata occurred on both leaf surfaces with more on the abaxial than on the adaxial) occurred in *O. regia*, and hypostomatic type (stomata on the abaxial surface only) occurred in *C. nucifera*.

### Stomatal density and size

Distribution, number and size of the stomatal complex types varied from one species to another (Table 2). Stomatal density was high (267.66 mm<sup>-2</sup>) on the abaxial leaf surface of *O. regia* and low (37.16 mm<sup>-2</sup>). Stomatal sizes are large in the three species with larger ones (393.75  $\mu$ m) on abaxial surface of leaves of *O. regia* and smaller ones (175.00 and 187.50  $\mu$ m) on both leaf surfaces of *B. aethiopum*.

### Transpiration rate

The rate which these plants transpire varied. Rate of transpiration was high (7.63 x 10<sup>-5</sup> mol/m<sup>2</sup>/s) in *O. regia* while it was low (2.04 x 10<sup>-5</sup> mol/m<sup>2</sup>/s) in *C. nucifera*.

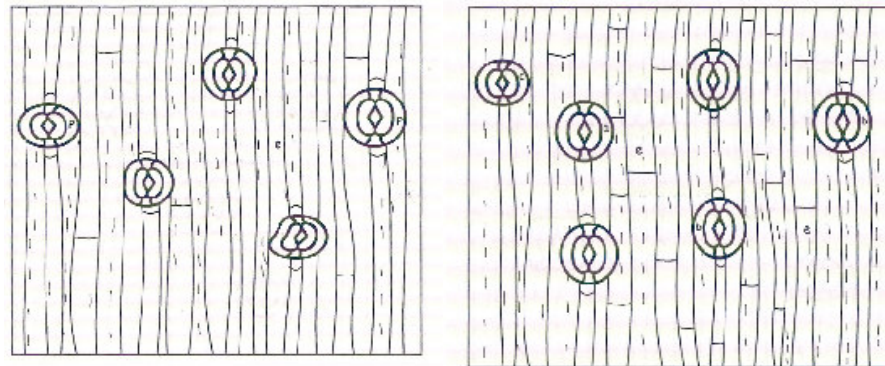
## DISCUSSION

Two types of stomatal complex were identified namely paracytic (stomata with two subsidiary cells surrounding guard cells) and tetracytic (stomata with four subsidiary cells surrounding guard cells). The former occurred in *C. nucifera* (Figure 2) while the latter occurred in *B. aethiopum* (Figure 1) and *O. regia* (Figure 3). These stomata

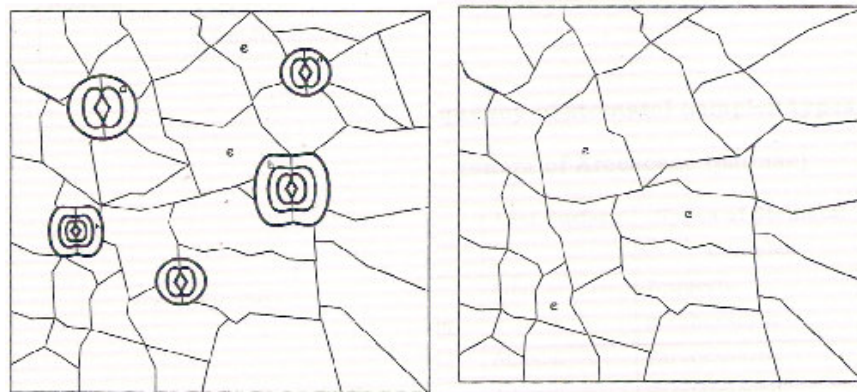
**Table 2.** Stomatal anatomy of *B. aethiopum*, *O. regia* and *C. nucifera*.

Species	Leaf surface	Stomatal complex types	Frequency (%)	Stomatal density (mm <sup>-2</sup> )	Stomatal size (µm)	Transpiration rate (mol/m <sup>2</sup> /s)
<i>Borassus aethiopum</i>	Abaxial	Tetracytic	100.00	37.16a	187.50a	5.05x10 <sup>-5</sup> a
	Adaxial	Tetracytic	100.00	223.50b	175.00a	
<i>Oreodoxa regia</i>	Abaxial	Tetracytic	100.00	267.66b	393.75b	7.63x10 <sup>-5</sup> b
	Adaxial	Tetracytic	100.00	176.16c	300.75b	
<i>Cocos nucifera</i>	Abaxial	--	--	--	--	2.04x10 <sup>-5</sup> c
	Adaxial	Paracytic	100.00	229.00d	312.50b	

Means with same letters along the columns are not significantly different at p = 0.05.



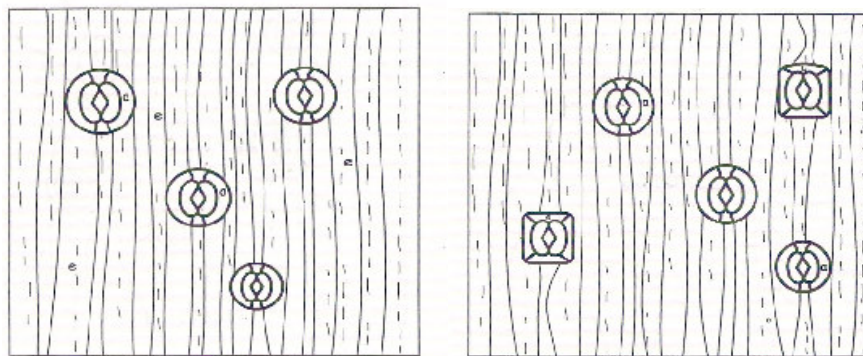
**Figure 1.** Surface view of leaf, abaxial (left) and adaxial (right) of *B. aethiopum* showing tetracytic (a, p) stomata and epidermal cells (e) x400.



**Figure 2.** Surface view of leaf, abaxial (left) and adaxial (right) of *C. nucifera* showing Paracytic (a, b) stomata and epidermal cells (e) x 400.

types occurred on both leaf surfaces in *B. aethiopum* and *O. regia* except in *C. nucifera* where stomata were restricted to adaxial surface only. Occurrence of the stomata in each of the species was 100.00% where they occurred. Stomata were large in all the three species studied with larger ones (393.75 µm) on abaxial leaf surface of *O. regia* while smaller ones in *B. aethiopum* (175.00 and 187.50 µm) on adaxial and abaxial surfaces respectively.

This is in corroboration with earlier study of Pataky (1969) that stomata with guard cells less than 15 µm are "small" while those with guard cells more than 38 µm in size are "large". Stomatal density was higher (267.66 mm<sup>-2</sup>) in *O. regia* and lower (37.16 mm<sup>-2</sup>) in *B. aethiopum* (Table 2). There were no numerical relationships between the stomatal size and density. Metcalfe and Chalk (1988) reported that large stomata give low stomatal density and



**Figure 3.** Surface view of leaf, abaxial (left) and adaxial (right) of *O. regia* showing tetracytic (a, b) stomata and epidermal cells (e) x 400.

small stomata give large stomatal density, but in this study there were no such correlations. For instance, small stomata (187.50  $\mu\text{m}$ ) gave small stomatal density (37.16  $\text{mm}^{-2}$ ) on abaxial surface of *B. aethiopum* while large stomata (393.75  $\mu\text{m}$ ) gave large stomatal density (267.66  $\text{mm}^{-2}$ ) on abaxial surface of *O. regia*.

Transpiration rate was high ( $7.63 \times 10^{-5} \text{ mol/m}^2/\text{s}$ ) in *O. regia*, followed by *B. aethiopum* ( $5.05 \times 10^{-5} \text{ mol/m}^2/\text{s}$ ) and lower transpiration ( $2.04 \times 10^{-5} \text{ mol/m}^2/\text{s}$ ) in *C. nucifera*. This translates to mean that *O. regia* releases more water in the form of vapour to the atmosphere than the other two species. The reason(s) for this behaviour can be traced to the stomata features possessed by each of the three species. In other words, there were some correlations between the stomatal features and transpiration rate. Amphihypostomatic leaves of *B. aethiopum* and *O. regia* favoured high rate of transpiration while low transpiration rate in *C. nucifera* could be traced to its hypostomatic leaves. Stomatal complex type is a factor in rate of transpiration. *B. aethiopum* and *O. regia* possessed tetracytic stomatal type while *C. nucifera* had paracytic stomata. Meanwhile, Carr and Carr (1990) had earlier reported that stomata with many subsidiary cells open more rapidly than those with little subsidiary cells. Stomatal size and density also influence rate of transpiration, large stomata of *O. regia* could be responsible for its high rate of transpiration than the other two species. Earlier study by Metcalfe and Chalk (1988) and Beerling and Woodward (1997) showed that large stomata resulted in low stomatal density while small stomata gave high stomatal density. The work of AbdulRahaman and Oladele (2003) also showed this pattern where large stomata actually gave low stomatal density and small stomata gave high density in some vegetable species. Even though, there were more stomata on the adaxial leaf surface of *C. nucifera* than in adaxial surface of *B. aethiopum*, presence of stomata on the abaxial surface of the latter may be responsible for its high rate of transpiration than in the former. This finding corroborates the study of Evenari (1938) and Oyeleke et al. (2004) that

high rate of transpiration occurs with high stomatal density and vice versa. There were significant differences at  $p < 0.05$  in stomatal density, stomatal size and rate of transpiration among the three species (Table 2). It therefore means that effects of stomatal features on the transpiration rate were significant.

In conclusion, humidification potential of the three species is relatively high as ornamental plants; therefore, *O. regia* has the higher potential, followed by *B. aethiopum* and *C. nucifera*. With this quality, the plants apart from adding beauty to environment also provide a fresh, conducive atmosphere by cleansing (AbdulRahaman and Oladele, 2008) and humidifying the atmosphere where we live in. Climate change, global warming and desertification are some of the topical issues in the world today. One of the measures for preventing further deterioration effects of these problems is planting of afforestation plant species. These plants, such as those studied in this work, are capable of absorbing carbon IV oxide via their stomata for production of sugars and starch and thus cleanse the atmosphere of impurities (AbdulRahaman and Oladele, 2008). 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 aid cloud formation and rainfall which in turn checks drought and the process of desertification (Oladele, 2002; Keay, 1989) especially in the arid and semi-arid environments where ornamental plants are planted for beautification of the environment.

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