https://dx.doi.org/10.4314/dujopas.v10i2b.20
ISSN (Print): 2476-8316
ISSN (Online): 2635-3490
Dutse Journal of Pure and Applied Sciences (DUJOPAS), *Vol. 10 No. 2b June 2024*

Physio-Anatomical Potentials of Some Vegetable Species for Atmospheric Humidification and Purification in Ojo Area, Lagos, Nigeria

[1]Kehinde Theophilus Omolokun*, [1]Omoteso Karfeel Oluwa, [1]Olubunmi Josephine Sharaibi, [1]Anthony Wale Ojewumi, [1]Olajide Muritala Keshinro, [1]Opeyemi Shakirat Oyetunji, [1]Rasheed Abayomi Anofiu, [1]Gbemisola Ifeoluwa Fernandez, [1]Mustapha Muhammed Mamudu

[1]Department of Botany,
Lagos State University,
Ojo,
Lagos

Email: kehinde.omolokun@lasu.edu.ng

Abstract
The stomatal features of plant species have capacity to release water vapour into the atmosphere. Therefore, the correlation between the stomatal features and transpiration rate in six vegetable species: Amaranthus cruentus, Capsicum annuum, Celosia argentia, Corchorus olitorius, Solanum lycopersicum and Talinum fruticosum were examined for their atmospheric humidification and purification. The leaf epidermal layers were isolated using nail polish; and were observed under the light microscope to examine their stomatal features. The transpiration rate was carried out using the cobalt chloride method. Results obtained reveal that all the six species are amphistomatic. The stomatal complex types observed are anisocytic, paratetracytic, staurocytic, brachyparatetracytic, anomotetracytic and anomocytic. The stomatal density ranged from 52.63 to 153.22 mm^{-2} on both leaf surfaces. The stomatal index ranged from 31.34 to 71.42% on both leaf surfaces. This investigation showed that stomatal features such as amphistomatic leaf nature, stomatal complex types (i.e. anomocytic, anomotetracytic, brachyparatetracytic, staurocytic, paratetracytic and anisocytic) with many subsidiary cells, high stomatal density and high stomatal index were responsible for the high transpiration rate of the studied species. Hence, Capsicum annuum humidifies the atmosphere most (8.85 × 10^{-6}), followed by Solanum lycopersicum (8.83 × 10^{-6}), Celosia argentia (7.29 × 10^{-6}), Amaranthus cruentus (6.85 × 10^{-6}), Talinum fruticosum (5.42 × 10^{-6}), and the least was Corchorus olitorius (5.11 × 10^{-6} mol. M^{-2}s^{-1}). Conclusively, the stomatal traits showed positive correlations with transpiration rates, thereby enhancing atmospheric humidification and climate change mitigation (i.e. atmospheric purification).

Keywords: Stomatal features, Transpiration, Purification, Humidification, Correlation

INTRODUCTION
Vegetable is a herbaceous plant or portion of a plant that is eaten whole or in part, raw or cooked (Welbaum, 2015). Vegetables have many nutritional, health and industrial benefits (Wargovich, 2000; Sienera, 2006; Dias and Ryder, 2011). In Nigeria, vegetable crops are produced in different agro-ecological zones through commercial as well as small scale farmers both as a source of income and food (Welbaum, 2015).

The atmosphere contains water vapour, which humidifies it and later condenses in order to form rainfall (AbdulRahaman *et al*., 2013). The falling of rain is unavoidably necessary things

Author for Correspondence

for plants and animals which in turn release water back to the atmosphere through evapo-transpiration (Oyeleke *et. al.,* 2004). Larger portion of water is obtained in the atmosphere through plant transpiration (Saadu *et al*., 2009). Transpiration rate is relatively regulated by the opening and closing processes of stomata located on the leaf surfaces (Taylor *et al*., 1997; AbdulRahaman and Oladele, 2009).

Stomatal features influence the rate of transpiration through stomatal conductance (Oyeleke *et al.,* 2004). That is, the rate of gas exchange, which is carbon dioxide uptake and water loss through the stomata. However, greater stomatal conductance indicates potentially higher entry of carbon dioxide into the leaves for photosynthesis and higher rate of water loss from the leaves through transpiration (Omolokun, 2019).

Stomatal features such as nature of stomata on the leaf surfaces (i.e. hypostomatic and amphistomatic), composition of stomatal complex types (i.e. heterogenous or homogenous), stomatal density, stomatal index and stomatal size influence transpiration rate (Obiremi and Oladele, 2001; Omolokun, 2019).

The number of subsidiary cells surrounding the stomata of each species may be a factor to its transpiration rates (Olofinobinu and Oladele, 1997; Saadu *et al*., 2009). However, the relationship between stomatal complex types and transpiration rates had been affirmed to be useful in atmospheric humidification and purification (Oladele and AbdulRahaman, 2008; Saadu *et al*., 2009).

The global community is experiencing serious environmental challenges such as climate change, ozone layer depletion and desertification. One of the tactics being employed in reducing the effects of climate change is through the use of plants with high humidifying potentials based on stomatal apparatus. Therefore, the aim of this study was to assess the anatomical capacity of some leafy vegetables for atmospheric humidification and purification.

MATERIALS AND METHODS

Study Area

The study was carried out in the botanical garden of Department of Botany, Lagos State University, Ojo Campus; which lies at latitude 6.467708′N and longitude 3.199527 E.

Collection and Identification of Plant Species

The seedlings of the plant species were collected randomly from a farm land in Post Service Housing Estate, Ojo and Lagos State University, Ojo campus, Lagos in February, 2022 (Table 1). The identification of the plant species was authenticated at the Lagos State University Herbarium.

Raising of the Seedlings

Each seedling was transplanted into perforated planting bucket; and watered for one week in order to allow them to acclimatize with the environment for anatomical and transpiration purposes.

Table 1: Information on Studied Plant Species

S/N	Plant Species	Family	Common Name	Location
1.	*Amaranthus cruentus* L.	Amaranthaceae	Red amaranth	Ojo, Lagos
2.	*Corchorus olitorius* L.	Malvaceae	Jute mallow	Ojo, Lagos
3.	*Colosia argentia* L.	Amaranthaceae	Plumed cockscomb	Ojo, Lagos
4.	*Capsicum annuum* L.	Solanaceae	Sweet pepper	LASU, Ojo campus
5.	*Solanum lycopersicum* L.	Solanaceae	Tomato	LASU, Ojo campus
6.	*Talinum fruticosum* (L) Juss.	Talinaceae	Water leaf	LASU, Ojo campus

LASU - Lagos State University

Sampling and Isolation of Leaf Epidermal Layers

Three (3) leaves of each of the six plant species were taken randomly from the potted plants raised in the botanical garden for anatomical study. The leaf sections of an area of 1 cm square from each species was incised from identical regions of the leaf samples, typically from the mid-way between the apex and base of the leaf lamina including the margin. The isolation of the leaf epidermal layers was carried out using the nail polish method. It was done by rubbing transparent nail polish on the abaxial and adaxial surfaces of each leaf. The nail polish was allowed to dry. After drying, a short clear cellophane tape was tightly affixed over the dried nail polish on the leaf surfaces. The tape was carefully peeled from the leaf and attached to a clean slide for microscopic study (Mbagwu *et al*., 2007).

Microscopic Observation

The observation was carried out on a binocular light microscope at a magnification of (x40 objective) to examine the stomatal complex types, stomatal density and stomatal index. Sample size of 30 was used for each of the parameters. Photomicrographs of good preparations were taken using binocular light microscope fitted with Amscope Camera (Model MU 1000) at a magnification of ×2000(Omolokun *et al*., 2023).

Identification and Determination of Frequency of Stomatal Complex Type

Stomatal complex types were identified based on the number of subsidiary cells per stoma (Omolokun, 2019). The frequency of each stomatal complex type was determined as percentage occurrence of each stomatal complex type relative to all occurrences using thirty fields of view at ×40 objective as a quadrat (AbdulRahaman *et al*., 2013).

Determination of Stomatal Density

The mean stomatal density was determined as the number of stomata per square millimetre based on the entire leaf surface. That is the number of stomata in a 0.152 mm^2 field of view (Omolokun and Oladele, 2010).

Determination of Stomatal Index

The mean stomatal index was determined as the number of stomata per square millimetre divided by the number of stomata plus the number of ordinary epidermal cells per square millimetre multiplied by 100. It was expressed mathematically according to Omolokun and Oladele (2010) using the formula below:

$SI = S/E + S \times 100$

Where: SI = stomatal index; S = number of stomata per square millimetre.

E = number of ordinary epidermal cells per square millimetres.

Determination of Transpiration Rate

The cobalt chloride method paper was used to determine the transpiration rate of each species (Obiremi and Oladele, 2001; Dutta, 2003).The strips of filter paper of 2 by 6cm dimension was cut and immersed in 20% cobalt chloride solution. The strips were thoroughly dried in an oven. The property of cobalt paper is that it is deep blue when dried, but in contact with moisture, it turns pink. The blue dried strips were placed in a sealed, air tight polythene bag and weighed (W_1) using meter balance. It was transferred quickly to the field and affixed 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, sealed again and weighed (W_2). The weight of water transpired was determined as W_2 minus W_1. The leaf area of the leaves used was determined using the leaf area meter. The transpiration rate was expressed as mole per square meter per second (i.e. $mol/m^{-2}/sec^{-1}$).

Statistical Analysis

The data collected were subjected to Analysis of Variance (ANOVA) for comparison of means using Statistical Packages for Social Sciences (SPSS) version 20.0 software. The means with significant difference were separated using Duncan's Multiple Range Test (DMRT). A probability value of 0.05 was used as bench mark for significant difference among parameters.

RESULTS

Stomatal Features and Transpiration Rate

The leaf epidermal structures are presented in Plate 1; while the stomatal features (i.e. stomatal density, stomatal index) and transpiration rates are presented in Table 2. The studied plant species were amphistomatic in nature. The stomata types present in the studied species are paracytic, brachyparacytic, brachyparatetracytic, anisocytic, anomotetracytic and anomocytic.

The stomatal density ranged from 52.63 to 153.22 mm^{-2}. The highest stomatal density (153.22 mm^{-2}) was found in the abaxial surface of *Celosia argentea*; while the lowest stomatal density (52.63 mm^{-2}) was found in the adaxial surfaces of *Corchorus olitorius, Solanum lycopersicum* and *Talinum fruticosum*.

The stomatal index ranged from 31.34 to 71.42%. The highest stomatal index (71.42%) was found in the adaxial surface of *Solanum lycopersicum*; while the lowest stomatal index (31.34%) was found in the adaxial surface of *Corchorus olitorius*.

The transpiration rate ranged from 2.19×10^{-6} to 4.89×10^{-6} $mol.m^{-2}s^{-1}$. The highest transpiration rate was found in the adaxial surface of *Capsicum annuum* (4.89×10^{-6} $mol.m^{-2}s^{-1}$); while the lowest transpiration rate was found in the adaxial surface of *Corchorus olitorius* (2.19×10^{-6} $mol.m^{-2}s^{-1}$).

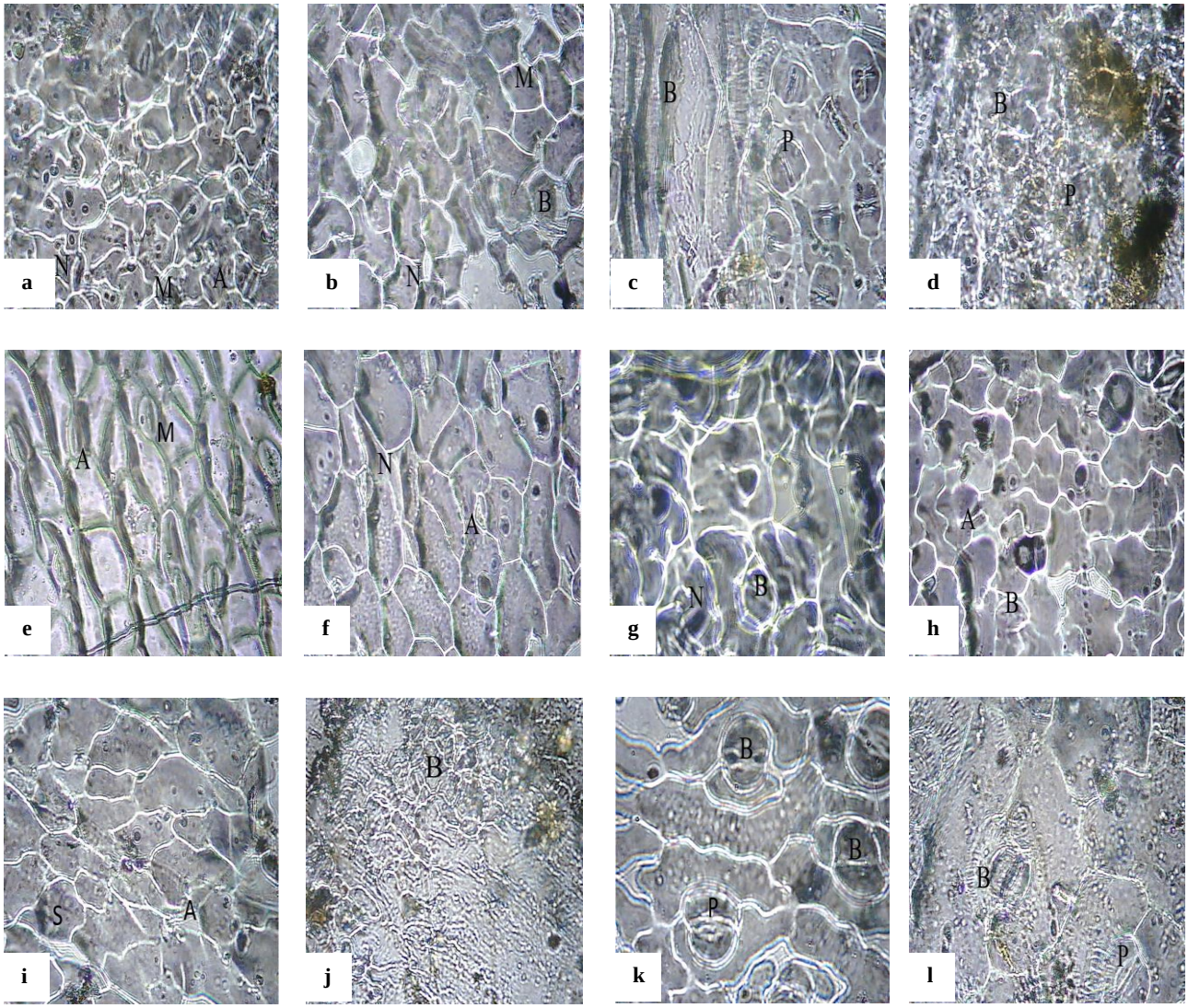

Plate 1: Photomicrographs of abaxial and adaxial surfaces showing leaf epidermal features *Amaranthus cruentus* (a and b), *Corchorus olitrius* (c and d), *Celosia argentea* (e and f), *Capsicum annuun* (g and h), *Solanum lycopersicum* (i and j) and *Talinum fruticosum* (k and l). (A - anisocytic stomata; M - anomotetracytic stomata; N – anomocytic stomata; B - brachyparacytic stomata; P - paracytic stomata and S - staurocytic stomata). Abaxial surface (a, c, e, g, I, k); Adaxial surface (b, d, f, h, j, l). (All magnifications at ×2000.

Table 2: Stomatal features and Transpiration Rate of Some Vegetable Species in Lagos Metropolis

S/N	Plant Species	Leaf Surface	Stomatal Complex Type	Frequency (% age)	Stomatal Density (mm^{-2})	Stomatal Index (% age)	Transpiration Rate ($mol.\ m^{-2}s^{-1}$)
1.	*Amaranthus cruentus*	Abaxial	Anisocytic Anomotetracytic Anomocytic	55.00 10.00 35.00	131.58^{ab}	60.28^{a}	4.22×10^{-6a}
		Adaxial	Anisocytic Anomotetracytic Brachyparatetracytic	67.67 13.33 20.00	98.68^{a}	42.62^{bc}	2.63×10^{-6b}
2.	*Corchorus olitorius*	Abaxial	Brachyparacytic Paracytic	66.67 33.33	98.68^{bc}	51.02^{a}	2.92×10^{-6a}
		Adaxial	Brachyparacytic Paracytic	50.00 50.00	52.63^{b}	31.34^{c}	2.19×10^{-6b}
3.	*Celosia argentea*	Abaxial	Anisocytic Anomotetracytic Anomocytic	40.92 45.45 13.64	153.22^{a}	61.11^{a}	4.36×10^{-6a}
		Adaxial	Anisocytic Anomoetracytic Anomocytic	55.55 38.89 5.56	118.42^{a}	52.49^{abc}	2.93×10^{-6b}
4.	*Capsicum annuum*	Abaxial	Anisocytic Paratetracytic Brachyparacytic Anomocytic	50.00 12.50 25.00 12.50	72.63^{cd}	56.28^{a}	3.96×10^{-6a}
		Adaxial	Anisocytic Anomocytic Brachyparatetracytic	75.00 8.33 16.67	98.68^{a}	66.66^{ab}	4.89×10^{-6a}
5.	*Solanum lycopersicum*	Abaxial	Anisocytic Staurocytic	66.67 33.33	52.63^{d}	35.00^{a}	3.96×10^{-6a}
		Adaxial	Anisocytic Brachyparatetracytic	50.00 50.00	98.68^{a}	$71..42^{a}$	4.87×10^{-6a}
6.	*Talinum fruticosum*	Abaxial	Anisocytic Brachyparacytic Paracytic	7.69 30.77 61.54	65.79^{cd}	56.92^{a}	2.97×10^{-6a}
		Adaxial	Paracytic Brachyparacytic	50.00 50.00	52.63^{b}	34.43^{c}	2.45×10^{-6b}

Means with same letters along the column are not significantly different at $p \leq 0.05$

Correlation between Stomatal Features and Transpiration Rate of the Studied Species

Correlation between abaxial and adaxial stomatal features (i.e stpmatal density and stomatal index) and transpiration rates are shown in Tables 3 and 4 respectively. The abaxial surface revealed that there was positive correlation between stomatal features and transpiration rates. The adaxial surface revealed that there was positively strong significant correlation between the stomatal features and transpiration rates.

Table 3: Correlation Coefficient between Abaxial Stomatal Features and Transpiration Rates of Studied Plant Species

CHARACTERS	Stomatal Density	Stomatal Index	Transpiration Rate
Stomatal Density	1		
Stomatal Index	.541*	1	
Transpiration Rate	.325	.005	1

***. Correlation is significant at the 0.05 level**

Table 4: Correlation Coefficient between Adaxial Stomatal Features and Transpiration Rates of Studied Plant Species

CHARACTERS	Stomatal Density	Stomatal Index	Transpiration Rate
Stomatal Density	1		
Stomatal Index	.390	1	
Transpiration Rate	.480*	.767**	1

***Correlation is significant at the 0.05 level**
****Correlation is significant at the 0.01 level**

DISCUSSION

The correlation between the stomatal features and transpiration rates of some vegetable species was conducted to assess their potentials for atmospheric humidification. The studied species had amphistomatic leaf nature. The presence of stomata on both the abaxial and adaxial leaf surfaces of the studied species might be responsible for their higher rate of transpiration. This is in line with the observations of Oyeleke *et al*. (2004):Omolokun (2019) on some afforestation and wasteland species respectively, where those species that are amphistomatic in nature released higher amount of water vapour to the atmosphere.
The investigation portrayed that the heterogenous nature of the stomatal types of the studied species might influence their transpiration rates. That is, the different types of stomatal complex types in all the species might be accounted for their higher rate of transpiration. This corroborates with the submissions of Saadu *et al*. (2009):AbdulRahaman *et al.* (2013) on some tuber and tree species respectively.

This study showed that number of subsidiary cells surrounding the stomata of the species may influence their transpiration rates. The investigated species (i.e. *Capsicum annuum, Celosia argentia, Solanum lycopersicum* and *Amaranthus cruentus*) having stomatal complex types with higher number of subsidiary cells like anisocytic, anomocytic, anomotetracytic and brachyparatetracytic tend to release higher amount of water vapour to the atmosphere than those species (i.e. *Corchorus olitorius* and *Talinum fruticosum*) with mostly smaller number of subsidiary cells such as paracytic and brachyparacytic. This suggests that the high number of subsidiary cells surrounding the stomata encourage rapid opening of the stomata to allow more water vapour to escape to the atmosphere (i.e. encouraging higher rate of transpiration). However, the other aspect of stomata opening that allow carbon dioxide to enter the leaves (i.e. favouring the removal of carbon dioxide from the atmosphere) aids atmospheric purification to reduce the effects of climate change. This observation conforms to the report of Oladele and AbdulRahaman (2008): Saadu *et al*. (2009):Omolokun (2019).

The stomatal density had been reported to show positive correlation with transpiration rate; where high stomatal density resulted to high rate of transpiration and vice versa (Oyeleke *et al*. 2004). This present study does not conform to their assertions because there was no significant correlation between stomatal density and transpiration rates on the abaxial surface. Hence, *Celosia argentea* with the highest value of stomatal density (271.64mm^{-2}) on both leaf

surfaces did not give rise to the highest transpiration rate (Table 2), This might probably be as a result of the overwhelming influence of the stomatal complex types over other stomatal density.

The stomatal index had positive correlation with transpiration rate on the abaxial surface; but significant positive correlation on the adaxial surface. In this study, *Capsicum annuum* with the highest stomatal index (i.e. 56.28 and 66.66%) on abaxial and adaxial surfaces respectively had the maximum transpiration rate (8.85×10^{-6} mol. $m^{-2}s^{-1}$); while *Corchorus olitorius* with the lowest stomatal index (i.e. 51.02% and 31.34%) on abaxial and adaxial surfaces respectively had the least transpiration rate (5.11×10^{-6} mol. $m^{-2}s^{-1}$). This result agrees with the findings of Obiremi and Oladele (2001) and Oyeleke *et al*. (2004) on some afforestation tree species.

CONCLUSION

This investigation showed that anatomical attributes such as amphistomatic leaf nature, stomatal complex types with higher number of subsidiary cells, high stomatal density and high stomatal index in the studied species showed positive correlation with transpiration rates; thereby enhancing their high humidifying potentials to favour the survival of the species in wet environment. Hence, *Capsicum annuum* humidifies the atmosphere most, followed by *Solanum lycopersicum*, *Celosia argentia*, *Amaranthus cruentus, Talinum fruticosum*, and the least was *Corchorus olitorius.*

This study recommends that further research work using other vegetable species should be embarked on for wider comparison of their potentials for atmospheric cleansing.

Acknowledgement

The authors appreciate the technical assistance from Mr. Fadiora Adewumi; the Chief Technologist, Department of Botany, Lagos State University, Ojo, Lagos State, Nigeria.

REFERENCES

AbdulRahaman, A. A. and Oladele, F. A. (2009). Stomatal features and humidification potentials of *Borassus aethiopum*, *Oreodoxa regia* and *Cocos nucifera*. *Journal of Plant Sciences*. 3(4), pp. 59-63.

AbdulRahaman, A. A., Olayinka, B. U., Haruna, M., Yussuf, B. T., Aderemi, M. O., Kolawole, O. S., Omolokun, K. T., Aluko, T, A. and Oladele, F. A. (2013). Cooling Effects and Humidification Potentials in Relation to Stomatal Features in some shade Plants. *International Journal of Applied Science and Technology*, 3(8), pp. 138-152.

Akobundu, I. O. and Agyakwa, C. W. (1998). *A hand book of West African Weeds*. Second Edition. Produced by International Institute of Tropical Agriculture, Ibadan. Intec Printers. 564pp.

Dias, J. S. and Ryder, E. (2011). "World Vegetable Industry: Production, Breeding, Trend". *Hort. Review*, 38, pp. 299-356.

Dilcher, D. L. (1974). Approaches to the identification of angiosperm leaf remains. *Botanical Review*, 40(1), pp. 1-157.

Dutta, A. C. (2003). Conduction of water and mineral salts. In: *Botany for Degree Students*. Revised 6thEdition. Oxford University Press, New Delhi. pp. 227-248.

Metcalfe, C. R. and Chalk, L. (1988). *Anatomy of the Dicotyledons*. Second edition, volume 1. Clarendon press, Oxford. pp. 97-117.

Mbagwu, F. N., Nwachukwu, C. U. and Ubochi, B. C. (2007). Leaf Epidermal Characteristics of four Species of the Genus *Citrus* (Rutaceae). *Agricultural Journal,* 2(6), pp. 713-716.

Obiremi and Oladele, F.A. (2001). Water Conserving Stomatal Systems in Selected *Citrus* Species. *South Africa Journal of Botany*. 67, pp. 258-260.

Oladele, F. A. and Abdulrahaman, A. A. (2008). Climate Change and the role of Africans in Its Mitigation. *Journal of the Department of History and International Studies, Adekunle Ajasin University: African Studies Review*, 7, pp. 221-229.

Olofinobinu, E.O. and Oladele, F.A. (1997). Stomatal complex types and transpiration rate in some afforestation tree species. *Bioscience Research Communication*, 9, pp. 121-126.

Omolokun, K.T. and Oladele, F.A. (2010). Comparative study of leaf epidermis of *Milicia excelsa* (welw.). C.C.Berg and *Triplochiton scleroxylon* K. Schum. *Nigerian Journal of Pure and Applied Sciences*, 23, pp. 2149-2153.

Omolokun, K.T. (2019). *Eco-Taxonomic and Anatomical Evaluation of Landscape Potentials of Plant Species on some Wastelands in Nigeria.* Ph.D. Thesis, University of Ilorin, Ilorin, Nigeria. 598pp.

Omolokun, K. T., Oluwa, O. K., Sharaibi, O. J., Durosinmi, O. J. and Jayeola, A. A. (2023). Taxonomic Importance of Leaf Epidermal and Morphological Characteristics of Five Species of *Ficus* (Moraceae) From Ojo and Ipaja Areas, Lagos, Nigeria. *FUOYE Journal of Pure and Applied Sciences*, 8(1), pp.83-93.

Oyeleke, M. O., Abdulrahaman, A.A. and Oladele, F.A. (2004). Stomatal anatomy and transpiration rate in some afforestation tree species. *NISSEB Journal,* 4(2), pp. 83-90.

Saadu, R. O., Abdulrahaman, A. A. and Oladele, F. A. (2009). Stomatal complex types and transpiration rate in some tropical tuber species. *African Journal of Plant Science*, 3(5), pp. 107-112.

Sienera, R. (2006). "Oxalate Contents of Species of the Polygonaceae, Amaranthaceae and Chenopodiaceae Families". *Food Chemistry*, 98(2), pp. 220-224.

Wargovich, M. J. (2000). "Anticancer Properties of Fruits and Vegetables". *Hort. Science*, 35, pp. 573-575.

Welbaum, G. E. (2015). Vegetable History, Nomenclature and Classification. In: *Vegetable Production and Practices*. pp. 1-15.

Taylor, D..J., Green, N.P.O. and Stout, G.W. (1997). Transpiration and movement of water through the leaf. In: *Biological Science*. Third Edition. Edited by Scoper, R. Cambridge University Press, Cambridge, New York. pp. 445-458.