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Descriptive Anatomy of Invasive Weed, *Ruellia tuberosa* Linn.

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Short Research Article

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ABSTRACT

Ruellia tuberosa is an invasive weed found growing in wide range of habitat particularly those habitats not preferred by other weeds mostly where there is little availability of water. This work studied the anatomical structures that aid its survival and colonization in these habitats. Samples of the plant were collected from open habitats of different catena profiles in the fields around South Western Region of Nigeria. Anatomical studies carried out on it by preparation of microscopic slides from specimens of the leaf epidermis, stem and roots showed the features that aid its adaptation to these habitats such as even distribution of stomata on leaves, possession of numerous parenchyma cells in its tuberous roots for storage, and possession of long unicellular trichomes on leaves, stem and roots.

Keywords: Ruellia tuberose; plant anatomy; invasive weed; adaptation and survival.

1. INTRODUCTION

Ruellia tuberosa L. is little known but very widely distributed herb in a predominantly herbaceous family, Acanthaceae. Its native range is in Central America but presently it has become naturalized in many countries of tropical South and Southeast Asia [1] and becoming invasive in certain parts of West Africa, for instance, Nigeria. It is adapted to a wide range of habitats,

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particularly those habitats not preferred by other weeds.

Several adaptation mechanisms have been found to be possessed by many plant species in relation to their adaptation in varying habitats. Genetic factors, environmental conditions have been found to have effect on leaf expansion rates and duration [2] and bring about changes in the morphology of leaf tissues which directly relates to functioning of the leaf in transpiration and photosynthesis [3]. It has also been reported that reduction in water use in some plant species usually occurs via stomatal closure or a decline in leaf area, and both of which reduces whole-plant photosynthetic capacity [4]. Exposure to sunlight, as well as water availability, are well known to have strong effects on leaf structure, and both can be important factors influencing the development of leaves adapted for sun-shade [5]. Conducting tissues such as the xylem and phloem have also been found out to adapt to environmental changes [6].

Studies on anatomical features of plants in relation to their functions have been done by several other authors including; mesophyll cells [7], root cells, epidermal cells [8], stomata, trichomes, vascular tissues [9]. However, previous anatomical studies on *R. tuberosa* is scanty as most literature discussed only the morphological description and ecological distribution. Some ethnobotanical studies were also also reported with ethanol extracts of *Ruellia tuberosa* showing antinociceptive and anti-inflammatory activities [10]. Due to the paucity of information on its anatomy, this work was done with the aim of knowing the anatomical structures that aid its survival in varying habitats especially in dry habitats and comparing the anatomy of the different tissues in survival strategy.

2. MATERIALS AND METHODS

Time frame: This research was carried out in the University of Ibadan, 2020

Sample collections and Plant materials*:* Fresh samples of *Ruellia tuberosa* were collected from open habitats of different catena profiles including rocky, sandy, loamy, and clayey soils, in the University of Ibadan, and they were collected over two seasons (dry and wet seasons).

Preparation of samples for light microscopy: After collections, they were fixed in 50% ethanol. There was a complete histological preparation of the leaf epidermis, stem and root using a modification of the [11] method of slide preparation; sectioning was done using a microtome, dehydrated in a series of ethyl alcohol 70%, 80%, 90% and 95% while staining was done using Safranin O as primary stains while Alcian blue and Lactophenol was used as secondary stain. Buechler's method of clearing the leaves [12] was followed before the epidermal surfaces were peeled and subsequently stained using Safranin O. The sections and peels were then attached firmly on separate slides and analysed under various resolutions of the microscope. Photomicrographs were recorded using a high sensitivity colour camera system which allows generation of an in-focus composite image from up to ten images recorded by merging their sharply focused regions together.

3. RESULTS

3.1 Anatomy of the Leaf

The detailed structure of the epidermis of the leaf is shown in Figs. A-C. The epidermis is the outer layer of cells covering the leaf. It forms the boundary separating the plant's inner cells from the external world.

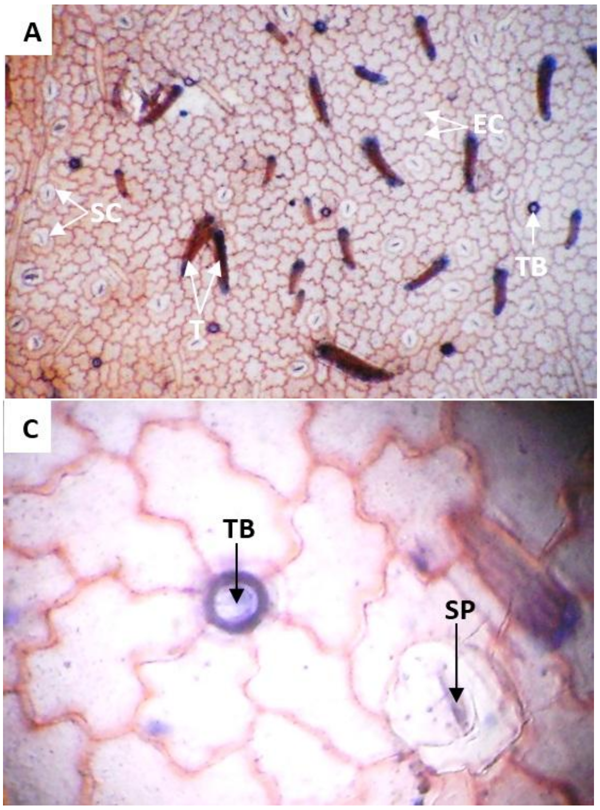
The leaf shows a dorsiventral organization; the upper (adaxial) and lower (abaxial) surfaces have similar morphology (Figs. A and B). The epidermal tissue reveals several differentiated cell types: epidermal cells, trichomes and the stomata complex which include the guard cells and subsidiary cells.

The epidermal layers have numerous trichomes which are multicellular uniseriate. The epidermal cells are the most numerous, largest, and least specialized and form the majority of the epidermis (Figs. A and B). The epidermis is covered with anomocytic type of stomata surrounded on each side by guard cells, and four to six subsidiary cells which are not easily distinguishable from the epidermal cells (Fig. B). The stomata are evenly distributed on both abaxial (Fig. A) and adaxial surfaces (Fig. B) of the leaf, having cells in rosette around the base cell of the trichomes.

3.2 Anatomy of the Stem

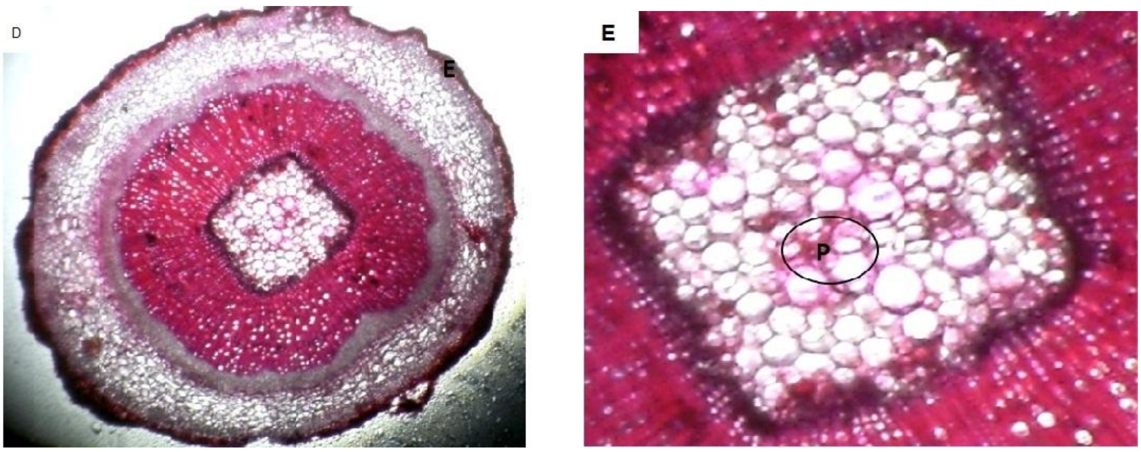
Fig. F shows the outline of the matured stem as observed under the low power objective, while

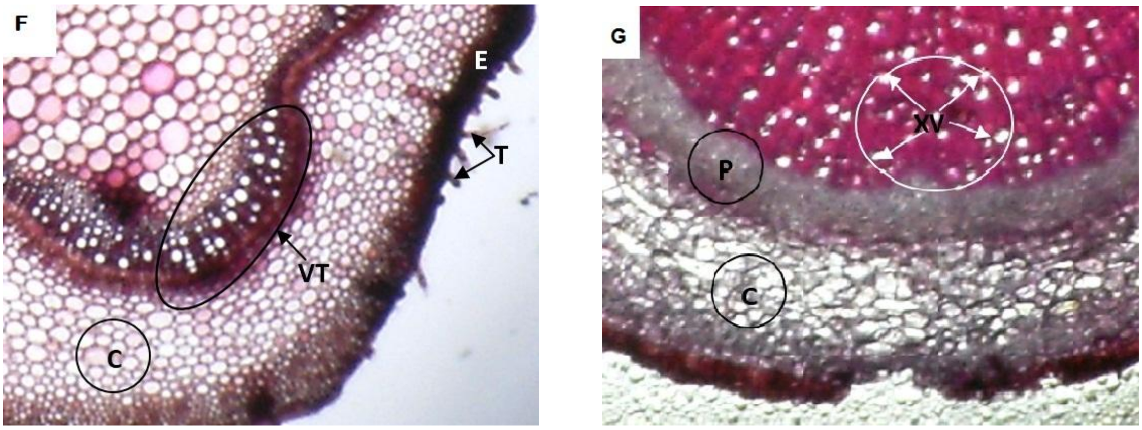
Figs. E-G represents a more detailed arrangement as observed under high power objective. The epidermis which is the outermost layer consists of a single layer of cells (Figs. D and F). It secretes a waxy substance which forms a superficial layer called cuticle which is not easily distinguishable from the epidermis (Fig. G). The epidermis possesses hairs otherwise known as trichomes which are non-glandular and multicellular (Fig. F). The next internal zone to epidermis is the cortex (Fig. D); it is multi-layered and composed of different types of tissues. A few collenchyma cells were seen at the periphery of the cortex forming a continuous ring while parenchyma cells were found immediately after the collenchyma cells (Fig G). In between the vascular system and the cortex, there is a layer of non-conducting parenchyma cells forming the pericycle.



Figs. A-C. *Ruellia tuberosa* Leaf; A:Abaxial surface; B:Adaxial surface; C:Detailed structure of the epidermal peel

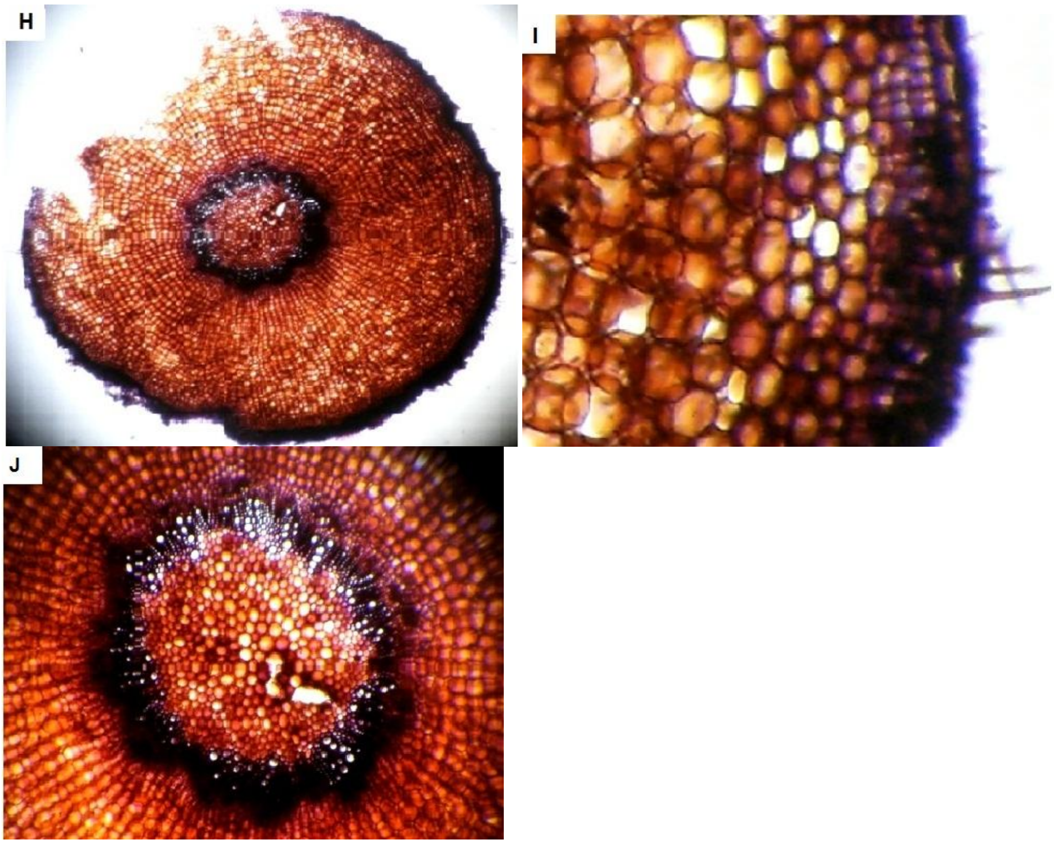
Keys; *T-Trichome, TB- Base Cell of Trichome, EC-Epidermal Cell, SC-Stomata Complex, GC-Guard Cells, SP-Stomatal Pore*





Figs D-G; *Ruellia tuberosa* Stem; D:Transverse section of the matured stem; E:Detailed structure showing pith; F:Detailed structure of the juvenile stem showing trichomes and vascular tissues; G:Epidermis

Keys; *E-Epidermis, VT-Vascular Tissues, P-Pericycle, E-Epidermis C-Cortex, X-Xylem, PP-Parenchymatous Pith, T-Trichome, XV-Xylem Vessels*



Figs. H-J; *Ruellia tuberosa* Root; H:Transverse section; I:Detailed structure showing Trichomes; J:Detailed structure showing the Vascular System;

3.3 Anatomy of the Root

The structural arrangement of the root (Figs. H-J) is different from that of the stem. Fig. H shows the transverse section of the root as observed under the low power objective. Figs. I-J represents a more detailed arrangement as observed under high power objective. The epidermis possesses hairs otherwise known as trichomes which are unicellular multiseriate (Fig. I), similar to that of the leaves. Two to four layers of differently-shaped parenchymatous cells was found just below the epidermis. The next internal zone is the cortex; it composed of solely parenchyma cells (Fig. H). The vascular tissue consisting of xylem and phloem can be seen in Fig. M. A central, soft parenchymatous pith or medulla is found continuous in-between the vascular bundles. This pith consists of parenchymatous cells (Figs. H and J).

4. DISCUSSION AND CONCLUSION

Functionally, the equal distribution of stomata on both abaxial and adaxial surfaces can result in a substantial increase in the supply rate of CO2 to the mesophyll cells as supported by [7]. Studies showed that stomata did close in response to drying soil even when shoot water status was maintained at high turgor, either by experimental manipulation [13] or by growing the plants with part of root system in drying soil [14]. Thus the cuticle and epidermis of *R. tuberosa* which are the main contact between the outside air and the whole plant organ coupled with the opening and closing of the stoma complex in the epidermis play an important role in regulating the exchange of gases and water vapour between the outside air and the interior of the leaf and allowing photosynthesis without letting the leaf dry out, protection against water loss by way of transpiration, secretion of metabolic compounds and absorption of water. Epidermal cells have been taken into account in leaf size control when plants are subjected to varying environmental conditions [15]. The cuticle enhances the epidermal resistance of water vapour to reduce water loss.

The abundance of trichomes throughout the plant system offers diverse support in its adaptation to varying habitats. Such functions range from increasing the surface area for transpiration and helping in absorption of CO_2 to assisting in photosynthesis. The leaf trichomes may also increase resistance to abiotic stress as agreed in literature [16] that they may increase tolerance to drought by reducing absorbance of solar radiation and increasing the leaf surface boundary layer. By facilitating condensation of air moisture onto the plant surface, the trichomes of the root increase the surface area over which water and mineral absorption takes place.

The vascular system was observed to have dense xylem tissues in the stem is a function of environmental adaptation to enhance conducting efficiency and flow capacity, a fact supported by [6] in their studies of evolution of conducting tissues in addition to their efficiency in conduction.

It was also reported that this could be an adaptation feature in form of safer xylem with less flow capacity leading to a reduction in water use by the leaf canopy because the capacity of the stem to re-supply water lost in transpiration is reduced [17].

The outer wall of the root of *R tuberosa* has multiseriate ring internally reinforced by rows of parenchymatous cells in the outer cortex, which are aligned perpendicularly in the direction of the mechanical forces. These particular properties enable the formation of physically stable structures that add strength to the roots [18]. The surface area of the parenchyma cells was however observed under the microscope to be smaller in *R. tuberosa* samples found in stressed environment, this difference in cell sizes may culminate to their ability to survive.

The pith of the root of *Ruellia tuberosa* also consists of large parenchymatous cells capable of storing water and nutrients. The roots of *R. tuberosa* possess two to four layers of differently shaped parenchymatous cells in the outer layers of the cortex, with thicker cell walls. Presence of thicker cell walls in epidermal and sub-epidermal layers appeared to be a determinant in the high mechanical strength of these root structural types enabling it to survive in any environment [1].

The observations made from the anatomical study of *Ruellia tuberosa* revealed a number of functional traits responsible for its survival and colonization of a wide range of habitats particularly dry habitats including; the stomata distribution, abundance of trichomes, the presence of numerous parenchyma cells with thicker cell walls in its tuberous roots, and the vascular system of the stem and root. These features aid its adaptation and survival where unfavourable environmental conditions exist especially that of insufficient availability of water.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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