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DIMENSIONAL VARIATION OF WOOD COMPONENTS OF *AILANTHUS EXCELSA* ROXB. ACROSS THE TREE TRUNK AND ITS ECOLOGICAL IMPORTANCE

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ABSTRACT

The growth and development of the vascular plants depend on the transpiration rate. The frequency and dimension of the vessels determine the transpiration efficiency of the xylem. However, this feature of tropical species, particularly Indian tropical trees, is still neglected, hence the current study was designed to study the ecological wood anatomy of *Ailanthus excelsa*. The results showed that the wood's vulnerability ratio decreased with the tree's age, with the magnitude of the difference (8.71 percent - 23.13 percent) usually decreasing with tree age, periphery to pith with minimal variability in a few blocks. The extent of the variation between the mesomorphic ratios from the pith to the periphery increases with the plant's growing age. The ratio of the length and vessel elements (f/v) consistently decrease with the plant increasing age (pith to periphery), the magnitude of the difference of 8.71%-23.13% was in general enhanced with tree age.

Keywords: Ailanthus**,** vessels, ecological effects, xylem.

Introduction

Almost all the woody angiospermous and gymnospermous plants exhibit periodic growth in height as well as in girth. Plants continue to grow in thickness as long as they remain alive, and therefore the girth of the trunk keeps increasing with age. The growth and development of the vascular plants depend on the transpiration rate and transpiration efficiency of the xylem which depends mainly on the dimension of the vessels and their frequency (Kitin *et al.,* 2010).Thus, it is clear that the overall growth and development of plant depends on the existing ecological condition. It happens mainly due to the activity of lateral meristem called vascular cambium that produces secondary xylem and secondary phloem. The cambium usually undergoes successive active and dormant phases during a growth year in most species, except for a few arid zone tropical evergreen species that exhibit cambial activity all around the year (Arx *et al.,* 2016). The performance of vascular cambium in woody plants is regulated by the genetic makeup, physiological phenomenon and environmental conditions of the habitat (Begum *et al.,* 2013).

The local environmental condition especially temperature and the daily fluctuation in the temperature may have a decisive role in modulating the periodicity of cambium, such as dormancy and production of their derivatives i.e., xylem and phloem (Begum *et al*., 2013). The importance of ecological anatomy has been realized as far back as 1889 by Vesque. He cautioned the taxonomists to give careful consideration to the wood anatomical diversity before they are utilized it as a taxonomic tool as a number of such diversities are being induced by environmental factors. In an experiment, Vesque (1881) proved that when a pea plant was cultivated in a humid atmosphere, fewer and smaller vessels were formed than plants grown in dry environment. However, the importance of ecological anatomy had come to light when Carlquist published his work “Ecological strategies of xylem evolution” (1975).

However, this characteristic of tropical species, particularly Indian tropical trees, has received little attention. Keeping in view the existing knowledge about the ecological wood anatomy in the tropical species, the present work has been undertaken to analyze the ecological wood anatomy of *Ailanthus excelsa* Roxb.

Materials and Methods

Site selection and sampling

To study the cell length variation across the tree trunk, a fully grown tree of *A. excelsa* was selected at Jamia Hamdard University, New Delhi, India. The wood was collected from the main trunk at breast height (about 1.35m from the ground) with the help of a chisel and hammer. Several woodblocks of 2 cm^2 size were obtained successively at 1.6

cm intervals along the radius of the trunk to cover up the distance up to the central pith region.

Preparation of stains

0.5% solution of haematoxylin was prepared in distilled water. This stain was little or no affinity for tissues unless iron or aluminum is present in the latter. Therefore, the sections are treated with a mordant (iron alum) before staining.

Iron alum (ammonium ferric sulphate) is used as a mordant or fixer. A 2% solution of the mordant was prepared in distilled water. It increases the degree of association between the tissues and the stain.

The Bismark Brown solution prepared by dissolving one gram of the dye in 100cc of 70% alcohol.

Fixation and preservation of wood blocks

The blocks are fixed in formaldehyde alcohol acetic acid (FAA). After a week, they were sliced and numbered serially from cambium inwards and then preserved in an alcoglycerol mixture (50% ethanol and 50% glycerol taken in equal volume). Subsequently, after few weeks, these slices were then macerated by giving hot treatment of nitric acid (40%) following the method of Ghouse and Yunus (1976). The macerated wood elements were washed in running water, stained with safranin and mounted in 5% glycerol for the microscopic study.

Measurement of elements and staining

In each slice, 50 elements (fibers and vessel elements each) were measured with the help of an ocular micrometer scale. The results obtained were statistically analyzed. The wood samples were also sectioned in the transverse plane to study the number of vessels per unit area. For this purpose, the sections of the preserved materials were obtained on a sliding microtome at a thickness of 12-15µm. The sections were stained with Heidenhain's haematoxylin and Bismark Brown solutions as described by Johansen (1940).

The Vulnerability ratio was determined at different positions along the wood core radius by dividing the mean vessel diameter by the mean vessel number mm^{-2} of wood. Mesomorphic ratio was obtained by multiplying the vulnerability ratio with the mean length of corresponding vessel element. F/V ratiowas calculated by dividing the mean length of fibre by mean length of vessel (Wali *et al.*, 2007). These ratios could help in assessing the significance of change in dimensions of tracheary elements with plant age.

Data analysis

Standard deviation has been calculated for each parameter with the help of the following formula:

$$\text{S.D.} = \frac{(X-1)^2 + (X-2)^2 + (X-3)^2 \dots \dots (X-n)^2}{n}$$

Where, X = Mean of observation, 1, 2, 3, 4…. = Different observations and n = Total number of observations.

Results and Discussion

The result showed that the *A. excels* vessels were diffuse porous, solitary and radial multiples of 2-3, each with an oblique sample perforation plate. Fibers are living, septate with oval to oblong nuclei. The sequential anatomical changes occurring in main trunk wood were analyzed from 1.7 cm wood block collected from pith to periphery of each (7 wood disk) (Figure 1). The anatomical features of vessel and fiber from the wood during the transition from juvenile to adult are given in Figure 2.

The vessel elements showed a gradual decrease in length while increasing in width (narrow lumen) from the periphery to the pith (Fig. 2 A&B). The frequency of vessels was comparatively higher in the wood closer to the cambium (up to the 3rd block). Though, the vessel frequency gradually decreases from the periphery to the central core of the wood. The width of vessels generally decreases as the distance from cambium increases. The length of fiber showed significant variation from the 1st (near cambium) to the 8th (central core) block. However, fiber width did not show significant variation (Fig. 2 C&D).

The vulnerability ratio of the wood consistently decreased with the tree's age. The magnitude of difference (8.71% - 23.13%) generally decreased with tree age, periphery to pith, with minor fluctuation in the 4th and 5th blocks (Fig. 2 E). Mesomorphic ratio increased from pith to periphery with the growing age of the plant on the whole; the magnitude of difference (3.40 % -49.82%) (Fig. 2 F). The ratio of the length and vessel elements (f/v) consistently decreases with the plant's increasing age (pith to periphery). The magnitude of the difference of 8.71%-23.13% was in general enhanced with tree age (Fig. 2 G).

Vessel frequency (number of vessel mm^{-2} of wood transverse surface) which was higher in the younger wood than in the older one (periphery to pith). However, percent vessel areas of wood surface declined from pith to periphery.

Environmental factors (temperature, humidity, rainfall, wind speed, water and soil) affect every aspect of plant growth and development (Butto *et al*., 2021). Plants adopt different strategies for survival and growth under the fluctuated environmental conditions (Yao *et al.*, 2021). The wood (secondary xylem), an outcome of the activity of vascular cambium (radial growth) and leaf production pattern is greatly influenced by the environmental factors of the habitat (Qaderi *et al.*, 2019). Alternation in wood composition and variation in wood cell size and frequency across the tree trunk and within the growth ring was first worked out by Sanio (1872) in *Pinus Sylavestris*, which were later endorsed by subsequent works. The size variation of wood component across the tree trunk was worked out by Baily and his associate Bailey and Sheprd (1915), Bailey and Tupper (1918) in several conifers where they found that the average length of tracheids increases from the pith to cambium side, but fluctuates widely in the outer ring instead of remaining constant as suggested by Sanio (1872). A similar investigation was carried out by Gerry (1914) in *Pinus strobus* and Bailey (1916) in *Carya ovate.*

The length of fiber and vessel segment at any level in the axis of *Ulmus procera* have been noted by Wheeler *et al.* (2007) to increase outward from the pith through a number of growth rings until it reached a specific maximal value beyond which the cell elongation ceased. Similar observation obtained by Mahmooduzzafar and Iqbal (1986) for their wood elements of *Terminalia tomentosa* revealed that the fiber length attains the maximum near the cambium and then showed alternate fall and rise while proceeding towards the pith. Vessel elements were longer near the pith, shorter in the middle region and again slightly longer towards the cambium; their width showed approximately constancy with slight fluctuation all along the radius but in the vicinity of cambium gains noticeably. The present study on *A. excelsa* confirms several early reports with regard to the length variation of fibers and vessel elements. The vessel element length is considered as a sensitive indicator of ecological conditions. Narrow vessels are positively correlated with xeromorphiosm in dicotyledons (Stevenson *et al.,* 2004). Further, the small-diameter, latewood vessels and the vasicentric arrow tracheids near the large vessels help in water during the air embolism (Cochard *et al.,* 2001).

Vulnerability index of wood is calculated to determine the impact of an ecological domain on water carrying ability of wood, demonstrated a great tendency of *A. excelsa* studied toward xeromorphism under fluctuated (unfavorable) environmental condition *A. excelsa* of water transport system in angiosperm is linearly related to pore diameter (Choat *et al.,* 2003). It may also have a positive correlation with stress level and or plant age (Hegazy *et al*., 2010) narrow and numerous vessels having inter vascular pit resistance, ensure a successful plant performance in xeric condition are under several unfavorable conditions of environment (Tyree and Zimmermann 2002). In the present, study vulnerability factors per mesomorphic ratio of *A. excels*a endorse all these views. In this plant vulnerability ratio of the wood consistently decrease with the age of the tree while the mesomorphic ratio increased from pith to periphery with the growing age of the plant.

Conclusion

Environmental factors such as temperature, humidity and pollution affects the anatomical features of the plants. In this study, we investigated the ecological wood anatomy of *Ailanthus excelsa*. The results showed that the wood's vulnerability ratio usually decreasing with tree age. Whereas, the mesomorphic ratios increases with the plant's growing age. The length of xylems elements decrease with increasing age.

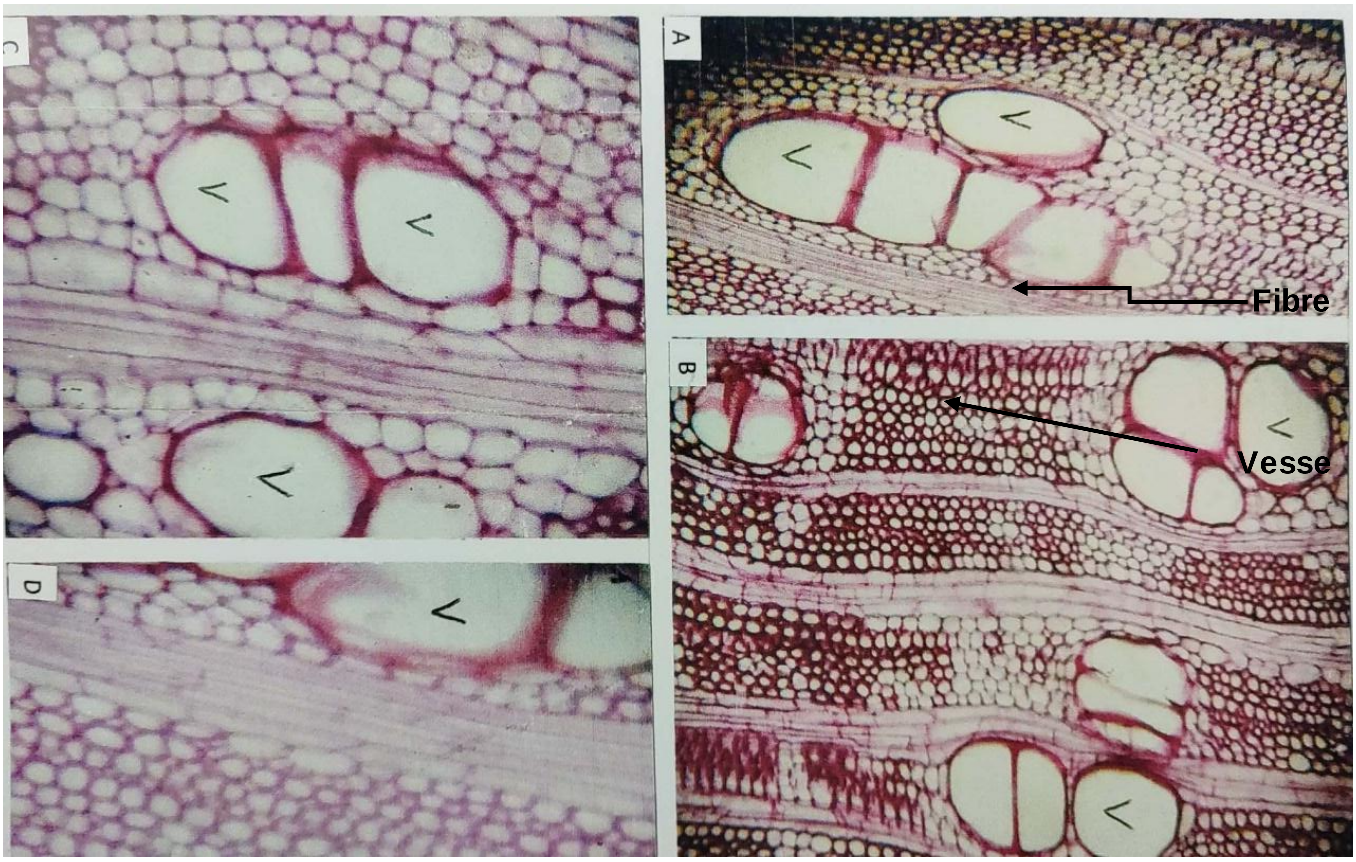

Fig. 1: photo plates of *A. excelsa* from **A&B)** Polluted environment, **C&D)** Control environment

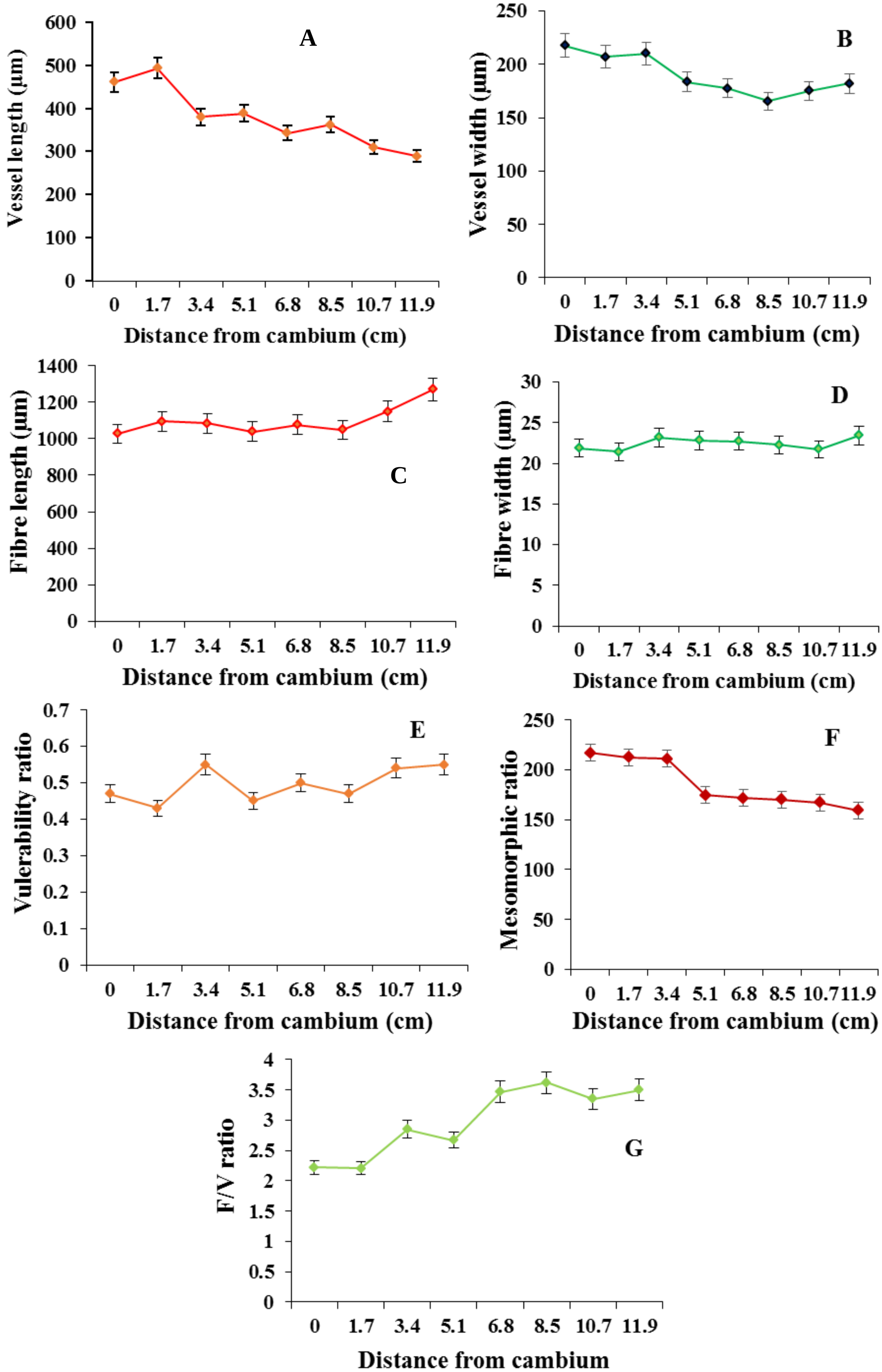

Fig. 2: Dimensional variation in the wood of *A. excelsa* **A)** Vessel length variation **B)** Vessel width variation **C)** Fibre length variation **D)** Fibre width variation **E)** Vulnerability ratio **F)** Mesomorphic ratio **G)** F/V ratio.

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References

Arx, G.V.; Crivellaro, A.; Prendin, A.L.; Cufar, K. and Carrer, M. (2016). Quantitative wood anatomy-practical guidelines. *Front. Plant Sci*., 7: 781.

Bailey, I.W. and Sinnott, E.W. (1916). The climatic distribution of certain types of angiosperms leaves. *Am. J. Bot*., 3(1): 24-39.

Bailey, I.W. and Tupper, W.W. (1918). Size variation in tracheary cells. I. A comparison between the secondary xylems of vascular cryptograms, gymnosperms and angiosperms. *Proc. Amer. Arts amp Sci*., 54: 149–204.

Baily, I.W. and Shepard, H.B. (1915). Sanio laws for the variation in size of coniferous tracheids. *Bot Gaz*., 60(1): 66-71.

Begum, S.; Nakaba, S.; Yamagishi, Y.; Oribe, Y. and Funada, R. (2013). Regulation of cambial activity in relation to environmental conditions: understanding the role of temperature in wood formation of trees. *Physiol. Plant*., 147(1): 46-54.

Butto, V.; Rozenberg, P.; Deslauriers, A.; Rossi, S. and Morin, H. (2021). Environmental and developmental factors driving xylem anatomy and micro ‐ density in black spruce. New *Phytol.* 230(3).

Carlquist, S.J. (1975). Ecological strategies of xylem evolution. *Univ. Calif. Press*. 1-31.

Choat, B.; Ball, M.; Luly, J. and Holtum, J. (2003). Pit membrane porosity and water stress-induced cavitation in four co-existing dry rainforest tree species. *Plant Physiol*., 131(1): 41 48.

Cochard, H.; Lemoine, D.; Ameglio, T. and Granier, A. (2001). Mechanisms of xylem recovery from winter embolism in *Fagus sylvatica*. *Tree Physiol*, 21(1): 27-33.

Gerry, E. (1914). Tyloses: their occurrence and practical significance in some American woods. Department of Agriculture. 6(1): 445-470

Ghouse, A.M. and Yunus, M. (1976). Ratio of ray and fusiform initials in the vascular cambium of certain leguminous trees. *Flora.* 165(1): 23-28.

Johansen, D.A. (1940). Plant microtechnique. McGraw-Hill Book Company, Inc: London; 530 pp.

Kitin, P.; Voelker, S.L.; Meinzer, F.C.; Beeckman, H.; Strauss, S.H. and Lachenbruch, B. (2010). Tyloses and phenolic deposits in xylem vessels impede water transport in low- lignin transgenic poplars: a study by cryo-fluorescence microscopy. *Plant Physiol*., 154(2): 887-898.

Mahmooduzzafar, K.; Iqbal, M. and Ahmad, Z. (1986). A plant grows under the stress of environmental pollution. *J. Plant Resour. Environ*., (3): 5-7.

Hegazy, S.S., Aref, I.M. and Muhammad, I. (2010). Anatomical changes in the wood of *Syzygium cumini* exposed to coal-smoke pollution. *J Food Agric Environ*. 8(3/4 part 2): 959- 964.

Qaderi, M.M.; Martel, A.B. and Dixon, S.L. (2019). Environmental factors influence plant vascular system and water regulation. *Plant J*., 8(3): 65.

Sanio, K. (1872). Ueber die Grosse der Holzzellen bei gemeinen Kiefer (*Pinus sylyestris*). *Jahr Wissenschaft Bot*. 8: 401-420.

Stevenson, J.F. and Mauseth, J.D. (2004). Effects of environment on vessel characters in cactus system and water regulation. *Plant J.* 8(3): 65.

Tyree, M.T. and Zimmermann, M.H. (2002). Hydraulic architecture of whole plants and plant performance. In Xylem structure and the ascent of sap Springer, Berlin, Heidelberg. Pp. 175- 214.

Vesque, J. (1881). De l'anatomie des tissus appliquée à la classification des plantes. *Nouv. Arch. Muséum* (Paris) 2e sér. 4: 1–56.

Vesque, M.J. (1889). The use of anatomical characteristics in the classification of plants. *Bull. Soc. Bot*. 36(10): XLI-LXXXIX.

Wali, B. and Iqbal, M. (2007). Anatomical and functional responses of *Calendula officinalis* L. to SO_2 stress as observed at different stages of plant development. *Flora*., 202(4): 268-280.

Wheeler, E.A. and Manchester, S.R. (2007). Review of the wood anatomy of extant Ulmaceae as context for new reports of late Eocene Ulmus woods. *Bull. Geosci*. 82(4): 329- 342.

Yao, X.; Cao, Y.; Zheng, G.; Devlin, A.T.; Li, X.; Li, M. and Xu, L. (2021). Ecological adaptability and population growth tolerance characteristics of *Carex cinerascens* in response to water level changes in Poyang Lake, China. *Sci. Rep*., 11(1): 1-15.Arx GV, Crivellaro A, Prendin.