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Research Article

WOOD ANATOMY (STEM AND ROOT) OF *BERBERIS LYCIUM* ROYLE (BERBERIDACEAE) AND ITS ECOLOGICAL ADAPTATION

Manju Sahney[1] and *Shakti Nath Tripathi[1&2]
[1]Department of Botany, University of Allahabad, Prayagraj-211002, U.P. India
[2]Department of Botany, Nehru Gram Bharati Deemed to be University Prayagraj-221505
**Author for correspondence: tripathishaktinath@gmail.com*

ABSTRACT
Wood anatomy of *Berberis lycium* has been investigated to compare the anatomical features of stem and root wood and to correlate them with ecology of the plant. Quantitatively, vessels are narrow and are large groups in stem wood than those of root wood. Rays are taller in stem wood but broader in root wood; however, qualitatively septate fibres have been recorded only in root wood. Occurrence of vessels in large groups is indicative of xeromorphy while presence of helical thickening in vessels has been correlated with climates that are cool or dry or both. Furthermore, vulnerability (v) and mesomorphy (m) values also indicating its adaptation to xeric conditions. The observed anatomical characteristics may also be useful for identification and ecological studies of *B. lycium*.

Keywords: *Berberis lycium,* rays, vessels, vasicentric tracheids, *wood anatomy*

INTRODUCTION
It is well known that plants develop anatomical strategies and adaptations to survive in different environmental conditions. According to Baas (1973), environmental factors influence the structure of secondary xylem. Thus in various environmental conditions and under different ecological trends, anatomical characteristics can influence the functional performance of xylem (Carlquist, 2001). The present work is undertaken to study the anatomical characters of secondary xylem of *Berberis lycium* which grows in subtropical to temperate zone of Himalayan region. *B. lycium* was collected from Kausani, situated in Bageshwar district at an altitude of 1890 m where annual temperature ranges between -4°C to 27°C.

B. lycium is a woody evergreen shrub belonging to family Berberidaceae. According to International Union for Conservation of Nature (IUCN), categories *B. lycium* species are vulnerable (Waseem *et al.,* 2006, Hamayun *et al.,* 2006) while Gupta *et al.,* (2015) mentioned as endangered species. The stem and branches are bright yellow in colour and have spines and narrow fine pointed leathery leaves. *B. lycium* also known as Indian Barberry. Various parts of the plant were extensively used to cure different diseases like diarrhea, intestinal colic, diabetes, throat pain, scabies, bone fractures, sun blindness and fever (Ahmed *et al.,* 2004 and Kaur *et al.,* 2001). This plant has also gained wide acceptance for its nutritious and are rich source of vitamins, minerals, antioxidants, anthocyanin etc.

General anatomical features of the family Berberidaceae have been provided by Solereder (1908) and Metcalfe and Chalk (1950). Carlquist (1995) presented qualitative and quantitative data of wood anatomy of Berberidaceae including 21 species of *Berberis* with special reference to their ecological and phylogenic trends. However, information on wood anatomy of *B. lycium* is desirable. The present study provides detailed anatomical description of secondary xylem of root and stem of *B. lycium*. This is the first comprehensive report on the wood anatomy of *B. lycium*, exploring the correlation with the ecological adaptation of the plant.

Physiography of the collection site - Bageshwar
The Bageshwar district lies between 29.838°N latitudes and 79.771°E longitudes at an altitude of 1690m. It is located in the central part of Kumaun region of Uttarakhand. It has a long winter season, January being the coldest month when the minimum temperature goes down to 2ºC, it may go to freezing point or

even below. During summer season the temperature rises from 12ºC to 30ºC in May and June. July and August are main rainy months.

MATERIALS AND METHODS

Fresh materials of both stem and root were collected from Kausani, situated in Bageshwar district. The stem and root woods were cut into small pieces and fixed in FAA (Berlyn and Miksche, 1976). Transverse and longitudinal (both T.L.S and R.L.S) sections of 15-20 µm in thickness were cut, stained with safranin–fastgreen combination, and mounted in Canada balsam. Small pieces of stem and root woods were macerated using Jaffery's fluid (Johansen, 1940) and thirty random measurements of the macerated cells were taken, using an ocular micrometer scale, to obtain the mean measurements for each cell type. An Olympus binocular compound microscope (Model No.CH2i) and a Leica binocular compound microscope (Model: DM2500) were used for examining the anatomical sections and for photography, respectively. F/V ratio is calculated by dividing mean libriform fibre length with mean vessel element length. Vulnerability (v) of wood was calculated by dividing mean vessel diameter with vessel frequency, while mesomorphy (m) was obtained by multiplying the vulnerability with mean vessel-element length, following Carlquist (1977). The cell counts, measurements and anatomical description follow the rules of the IAWA Committee, 1989.

RESULTS

Stem wood

Vessels: vessels are arranged in semi-ring porous pattern; occur mostly in diagonal groups; number of vessels per group is 35-40. The frequency of vessels is 480/mm²; individual vessel element narrow, oval to angular in cross-section; 30-45-55µm in diameter; 30-164-324µm in length. Perforation plate simple on transverse to the slightly oblique end wall, frequently tailed at one or both the ends; intervascular pitting alternate; helical thickenings are frequently present in vessels (Pls. 1A, C, D, H; 3A, B)

Vulnerability (v) index- 0.093, and mesomorphy (m) index- 15.37

Vasicentric tracheids: vasicentric tracheids are found intermixed with vessels; 250-300µm in length (Pls. 1C; 3E, F).

Fibres and Fibre-tracheids: libriform fibres extremely short to very short in length (87-190-550µm), nucleated; starch grains are present in fibres; fibre-tracheids 150-195-500µm in length (Pls. 1F; 3G, H). F/V ratio is 1.47.

Parenchyma: axial parenchyma scarce paratracheal. Rays multiseriate, 5-8 cells wide, up to 1000µm in height; heterocellular with procumbent, upright and square cells. Starch grains present in ray cells. Calcium oxalate crystals are present in the pith region (Pls.1B, E-G; 3C, D).

Root wood

Vessels: vessels are arranged in semi-ring porous pattern; occur mostly in diagonal groups, number of vessels per group 12-15. The frequency of vessels 140/mm²; individual vessel element narrow, oval to angular in cross-section; 30-48-60.5µm in diameter; 100-180-210µm in length. Perforation plate simple on transverse to oblique end wall frequently tailed at one or both the ends; intervascular pitting alternate; helical thickenings are frequently present in vessels (Pls. 2A, D, E; 4A)

Vulnerability (v) index- 0.342, mesomorphy (m) index- 61.7

Vasicentric tracheids: vasicentric tracheids are found intermixed with vessels; 205-215µm in length (Pls. 2A; 4D).

Fibres and Fibre-tracheids: libriform fibres short in length (250-338-500µm), septate as well as non-septate, nucleated; starch grains are present in fibres, fibre - tracheids 50-120-225µm in length (Pls. 2G; 4B, C). F/V ratio - 1.87.

Parenchyma: axial parenchyma scarce paratracheal. Rays multiseriate 6-9 cells wide, up to 700µm in height; occasionally uniseriate or biseriate; heterocellular with upright, procumbent and square cells. Starch grains present in ray cells (Pls. 2B, C, F; 4 E, F).

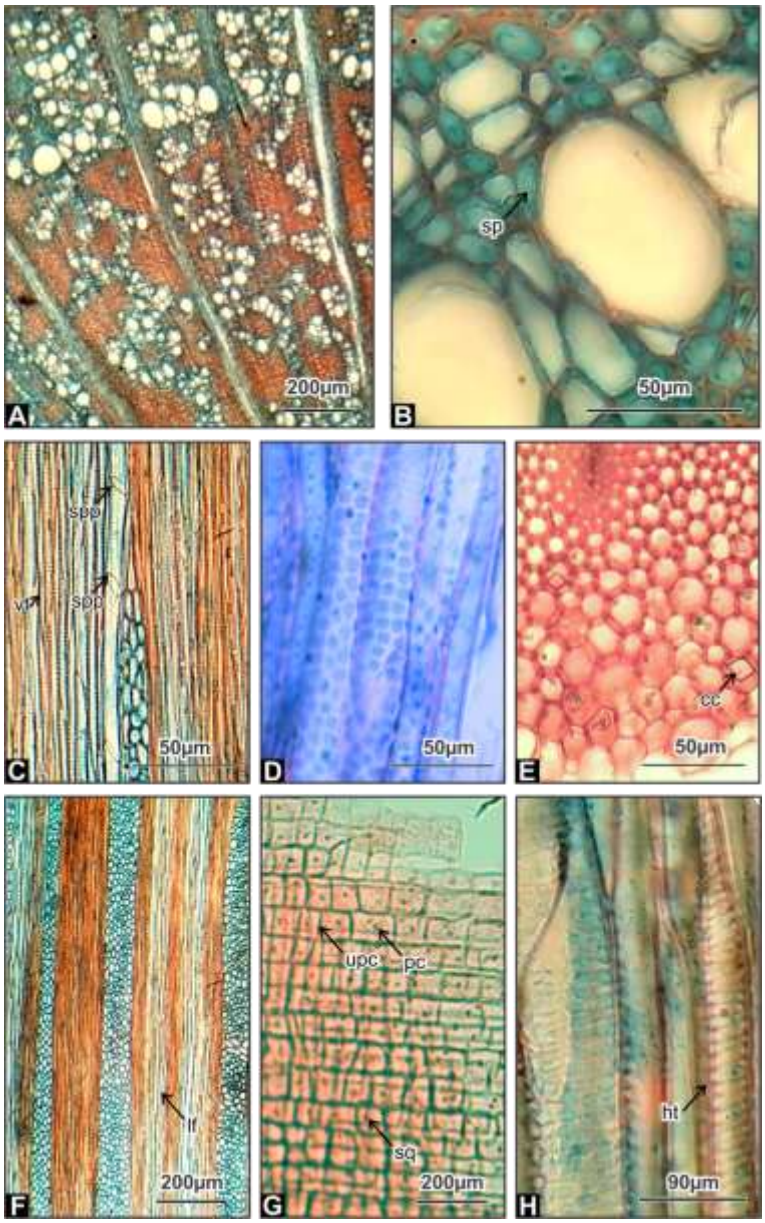

PLATE 1: Stem wood anatomy of *B. lycium* Royle

A. *T.S showing diagonal pattern of vessels*
B. *Magnified image showing scarce paratracheal parenchyma*
C. *T.L.S showing simple perforation plate and vasicentric tracheids*
D. *T.L.S showing alternate intervascular pits*
E. *Magnified portion showing crystal in the pith region*
F. *T.L.S showing multiseriate rays and non-septate libriform fibres*
G. *R.L.S showing procumbent, upright and square cells*
H. *T.L.S showing helical thickening in vessels*

Abbreviations in Plate: *sp- scarce paratracheal parenchyma, vt- vasicentric tracheid, spp- simple perforation plate, cc- calcium oxalate crystal, lf- libriform fibre, upc- upright cell, pc- procumbent cell, sq- square cell, ht- helical thickening. Scale bars: A, F, G = 200 µm; B, C, D, E, = 50 µm; H = 90 µm*

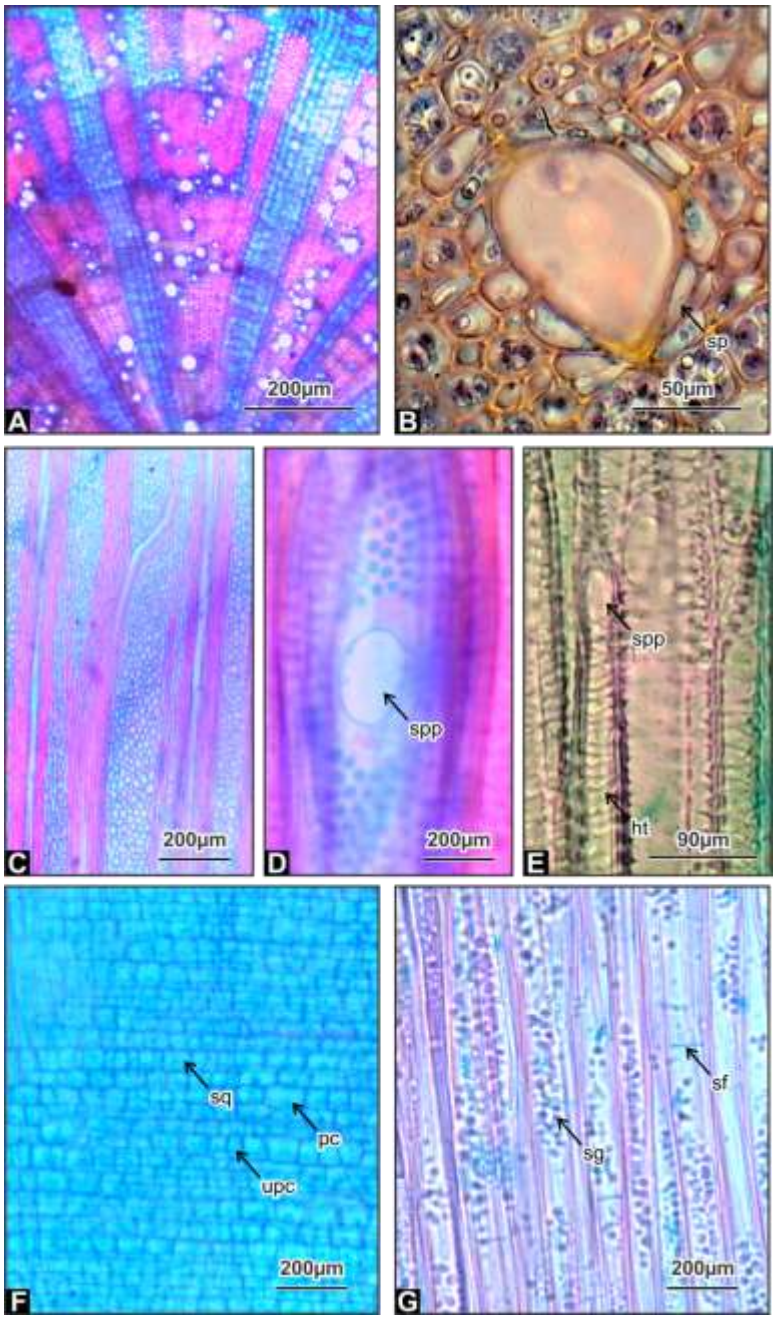

PLATE 2: Root wood anatomy of *B. lycium* Royle

A. T.S showing diagonal pattern of vessels
B. Magnified image showing scarce paratracheal parenchyma
C. T.L.S showing multiseriate rays
D. T.L.S showing alternate intervascular pits and simple perforation plate
E. T.L.S showing helical thickenings in vessels
F. R.L.S showing upright, square and procumbent cells
G. T.L.S showing septate fibres with starch grains

Abbreviations in Plate: *sp- scarce paratracheal parenchyma, spp- simple perforation plate, sf- septate fibre, upc- upright cell, pc- procumbent cell, sq- square cell, ht- helical thickening. Scale bars: A, C, D, F, G = 200 µm; B = 50 µm; E = 90 µm*

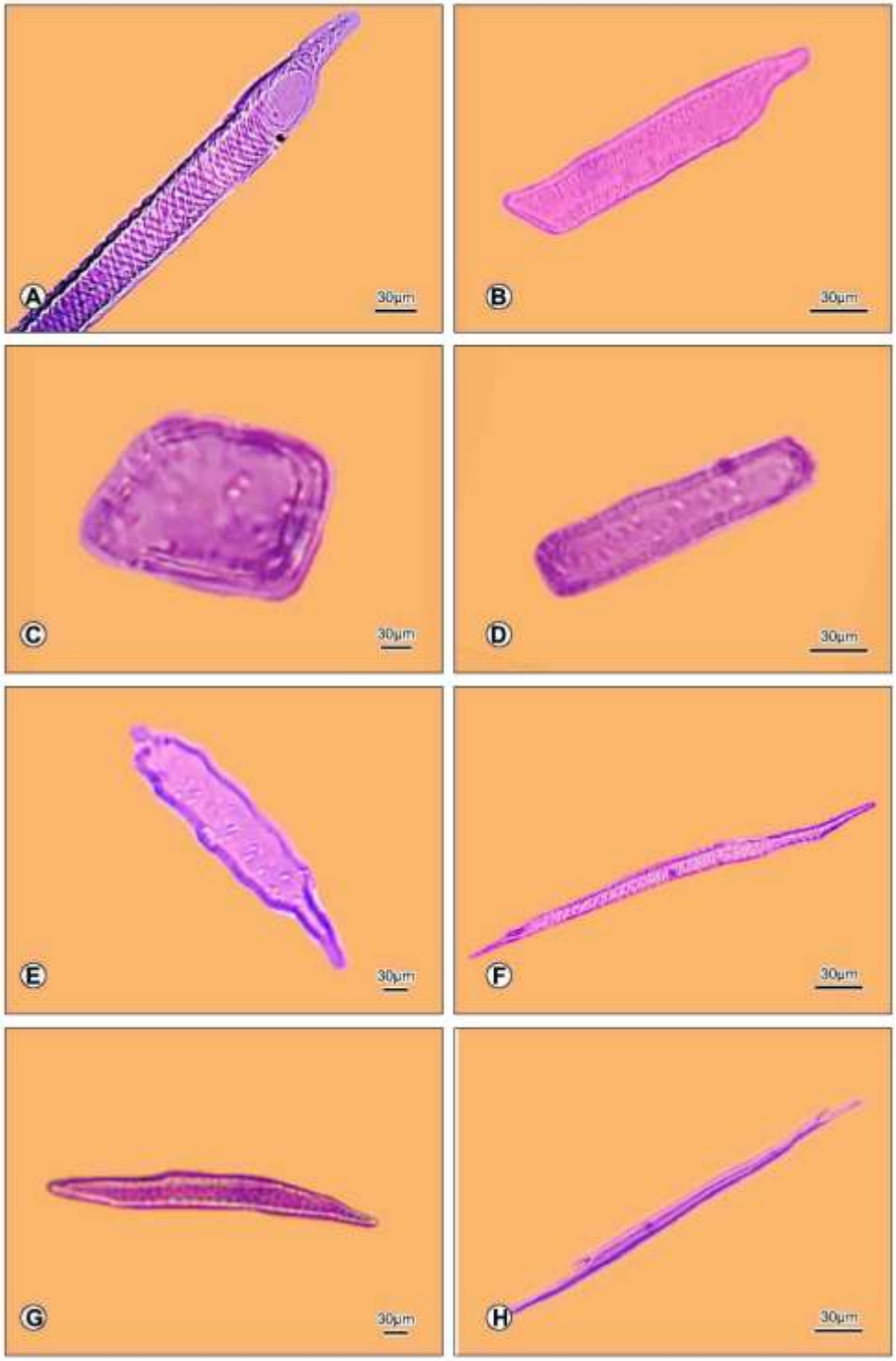

PLATE 3: Stem wood elements of *B. lycium* Royle
A.-B. Vessel elements showing helical thickening
C.-D. Parenchyma cells
E.-F. Vasicentric tracheids
G.-H. Libriform fibres
Scale bars: A - H = 30 µm

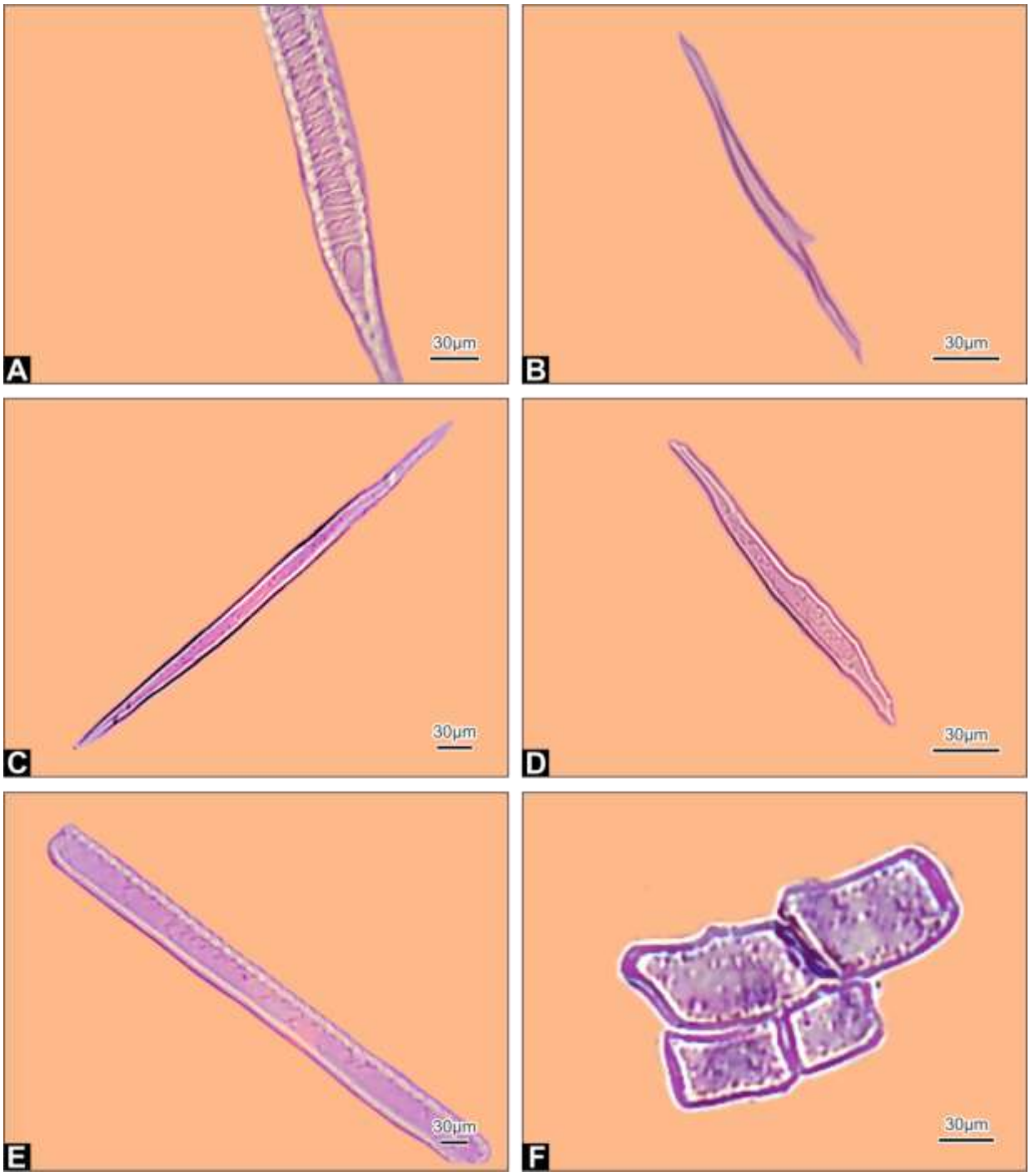

PLATE 4: Root wood elements of *B. lycium* Royle
A. A vessel element showing helical thickening
B.-C. Libriform fibres
D. A vasicentric tracheid
E.-F. Parenchyma cells
Scale bars: A- F = 30 µm

DISCUSSION

The present work provides first report on wood anatomy (stem and root) of *Berberis lycium* Royle. Findings of the present work are largely similar in line with previously reported features of stem wood of Berberidaceae (Solereder, 1908; Metcalfe and Chalk, 1950, Carlquist, 1995). However, Solereder (1908) and Metcalfe & Chalk (1950) reported absence of axial parenchyma in the wood of Berberidaceae, while some workers reported its presence in some species of the family (Shen, 1954, Rancusi *et al.*, 1987, Schweingruber 1990). Carlquist (1995) reported the presence of scarce axial parenchyma with strands of 2-4 cells in one species of Berberidaceae i.e. *Berberis paniculata*. He also mentioned that axial parenchyma is scarce or absent in the woods that have living fibers. In the present work scarce axial parenchyma is observed in the wood of *B. lycium* that has living fibres.

Qualitatively, wood anatomy of stem and root is largely similar except for the septate fibres which are present in root wood only. Quantitatively in stem wood vessels are narrow and are in larger groups than those of root wood. Rays are taller in stem wood but broader in root wood.

B. lycium is an evergreen shrub showing the normal woody type of secondary growth. In the stem wood narrow vessels occur in large groups. Vessel elements have simple perforation plates and helical thickening bands. Grouping of narrow vessels with simple perforation plate in the stem wood help in vessel safety enabling water transport through neighboring vessels in the case of cavitations which may be due to the extreme low temperature during the winter months in the Himalayan region (Davis, *et al.*, 1999, Hacke and Sperry, 2001, Psaras and Sofroniou, 2004). Vasicentric tracheids which are found present intermixed with vessels also safeguard the hydrosystem in case of vessel embolism (Carlquist, 1985). Presence of helical thickening in vessels has also been correlated with the climates that are cool or dry or both (Carlquist, 1975, 1983). Further, the occurrence of vessels in large groups is indicative of xeromorphy in species in which vessels are accompanied by fibre-tracheids or libriform fibres (Carlquist, 1966, 1984b).

In *B. lycium* stem wood vulnerability index for stem wood is less than 1 (0.093) and mesomorphy index is 15.37 indicating its adaptation to xeric conditions. F/V ratio in the stem wood of *B. lycium* is 1.13 indicating optimal mechanical strength of the plant axis.

Findings of the present study contribute to the knowledge of wood anatomy of Berberidaceae. Quantitative and qualitative anatomical data of the wood like the grouping of the vessel, narrow vessel diameter, simple perforation plate, vasicentric tracheids, helical thickening in vessels, living fibres, v and m indices and F/V ratio indicate the ecological adaptation of *B. lycium* towards xeromorphism under dry and cold climate.

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REFERENCES

Ahmed E *et al.*, (2004). Ethno pharmacological survey of some medicinal important plants of Galliyat areas of NWFP, Pakistan. *Asian Journal of Plant Science* **3** 410-415.

Baas P (1973). The wood anatomical range in *Ilex* and its ecological and phylogenetic significance. *Blumea* **21** 193-258.

Berlyn GP and Miksche JP (1976). Botanical Microtechnique and Cytochemistry. The Iowa State University Press. Amsterdam, Iowa. pp. 326.

Carlquist S (1966). Wood anatomy of Compositae: a summary, with comments on factors controlling wood evolution. *Aliso*: *A Journal of Systematic and Evolutionary Botany* **6** 25- 44.

Carlquist S (1975). Ecological Strategies of Xylem Evolution. University of California Press, Berkeley, pp. 259.

Carlquist S (1977). Ecological factors in wood evolution: a floristic approach. *American Journal of Botany* **64** 887-896.
Carlquist S (1983). Wood anatomy of Onagraceae: further species; root anatomy; significance of vestured pits and allied structures in dicotyledons. *Annals of Missouri Botanic Garden* **69** 755–769.
Carlquist S (1984b). Vessel grouping in dicotyledon woods: significance and relationship to imperforate tracheary elements. – *Aliso: A Journal of Systematic and Evolutionary Botany* **10** 505- 525.
Carlquist S (1985). Vasicentric tracheids as a drought survival mechanism in the woody flora of southern California and similar regions: review of vasicentric tracheids. *Aliso: A Journal of Systematic and Evolutionary Botany* **11** 37-68.
Carlquist S (1995). Wood anatomy of Berberidaceae: Ecological and phylogenetic consideration. *Aliso: A Journal of Systematic and Evolutionary Botany* **14** 85-103.
Carlquist S (2001). Comparative Wood Anatomy. Systematic, Ecological, and Evolutionary Aspects of Dicotyledons wood. – Springer Series in Wood Science.
Davis SD *et al.*, (1999). The relationship between xylem conduits diameter and cavitation caused by freezing. *American Journal of Botany* **86** 1367- 1372.
Gupta M *et al.*, (2015). *Berberis Lycium* multipotential medicinal application: An overview. *International Journal of Chemical Studies* **3** 10-13.
Hacke UG and Sperry JS (2001). Functional and ecological xylem anatomy. *Perspect plant ecology*. **4** 97-115.
Hamayun M *et al.*, (2006). Folk medicinal knowledge and conservation status of some economically valued medicinal plants of District Swat Pakistan. *Lyonia* **11** 101-113.
IAWA Committee. (1989). List of microscopic features of hard wood identification. *IAWA Bulletin* **10** 219–332.
Johansen DA (1940). Plant Microtechnique. MacGraw-Hill, New York, USA. pp. 523.
Kaur C and Miani SB (2001). Fruits and vegetables healthy foods for new millennium, *Indian Horticulture*, **45** 29-32.
Metcalfe CR and Chalk L (1950). The Anatomy of Dicotyledons: Vols 1 and 2. - Clarendon Press, Oxford, pp. 1500.
Psaras GK and Sofroniou I (2004). Stem and root wood anatomy of the shrub *Phlomis fruticosa* (Labiatae). – *IAWA Journal* **25**: 71-77.
Rancusi M *et al.*, (1987). Xylotomy of the important Chilean woods, 68-153. In M. Nishida [ed.], Contributions to the botany in the Andes II. – Academia Scientific Book Co., Tokyo.
Schweingruber FH (1990). Anatomie europaischer Holzer Anatomy of European woods. Verlag Paul Haupt, Bern and Stuttgart, pp. 800.
Shen YF 1954. Phylogeny and wood anatomy of *Nandina*. *Taiwania* **5** 85-92.
Solereder H (1908). Systematic Anatomy of the Dicotyledons, Vols 1 and 2. – Clarendon Press, Oxford, pp. 1175.
Waseem M *et al.*, (2006). Ethnopharmacological Survey of Plants Used for the Treatment of Stomach, Diabetes, and Ophthalmic Diseases in Sudhan Gali, Kashmir, Pakistan. *Acta Botanica Yunnanica*. **28** 535.