ANATOMICAL FEATURES OF *ARUNDINARIA FALCONERI* AND *SINOBAMBUSA TOOTSIK* WITH REFERENCE TO THEIR EFFECTS ON PENETRATION OF PRESERVATIVES

M. Younus-uzzaman

ABSTRACT

The anatomy of two bamboo species, *Arundinaria falconeri* and *Sinobambusa tootsik* was investigated to know the effect of anatomical features on the pattern of preservative penetration inside the culm cells of these species. The study indicates that in bamboos the most advantageous pathway for the longitudinal flow of preservative liquid is through the vessels. The parenchyma aids in only to lateral flow. Vascular bundles of both the species fall under type-1 of the four types categorised by Grosser and Liese.

সারসংক্ষেপ

বাঁশের আভ্যন্তরীণ গঠনতন্ত্র কি ভাবে রাসায়নিক সংরক্ষণী প্রবেশের ধরনকে প্রভাবিত করে তা দেখার জন্য *এরান্ডিনারিয়া ফালকোনারি* এবং *সাইনো ব্যামবুসা টুটসিক* নামের দুইটি প্রজাতির বাঁশের গঠনতন্ত্র পরীক্ষা করা হইয়াছে। পরীক্ষায় দেখা গিয়াছে যে বাঁশের ভিতরে তরল পদার্থ সহজভাবে প্রবেশ করার পথ হইতেছে ভেসেল এবং প্যারেনক্যাইমা। ভেসেল দিয়া তরল পদার্থ লম্বালম্বিভাবে এবং প্যারেনক্যাইমা দিয়া আড়াআড়িভাবে প্রবেশ করে। উল্লেখিত দুই প্রজাতির ভাসকুলার বাণ্ডলের ধরন গ্রোসার এবং লিজের ভাসকুলার বাণ্ডলের চার প্রকার শ্রেণীর মধ্যে প্রথম প্রকারের অন্তর্ভুক্ত।

INTRODUCTION

Bamboo is a perennial grass with a woody stem or culm which occurs mostly in natural vegetation of tropical, subtropical and temperate regions, and is abundant in tropical Asia. In these areas bamboo is used for house construction, scaffolding, ladders, fencing, containers, furniture and many kinds of handicraft articles, and also for pulp and paper making (Higuchi 1986). It grows rapidly and becomes available for exploitation in about 3 to 4 years (Purushotham 1963).

A major disadvantage in the utilization of bamboo, generally is its low natural durability. The durability of bamboo depends upon the species, climatic conditions and environment. It is susceptible to attack by termites, insects

M. Younus-uzzaman, Research Assistant, Wood Preservation Division, Bangladesh Forest Research Institute, Chittagong, Bangladesh.

and fungi. Preservative treatment of the bamboo culm depends on the species, moisture content and its anatomical structure. The anatomy of bamboo differs significantly from that of wood.

As a part of investigation of various methods for applying preservative chemicals to two bamboo species *Arundinaria falconeri* and *Sinobambusa tootsik* (Younus-uzzaman 1987), the anatomical study of these species was undertaken. It was primarily made to ascertain how anatomical features might influence preservative penetration patterns. The present study was based on the descriptions of bamboo culm anatomy by Grosser and Liese (1971) and Liese (1980). They have recognised four major categories for the types of vascular bundles in bamboo species. A fifth type has been added by Wen and Chou (1984).

MATERIALS AND METHOD

Bamboo samples : Green culms of *Arundinaria falconeri* and *Sinobambusa tootsik* were collected from the Royal Botanical Gardens, Kew, England and fixed in Formyl acetic alcohol (FAA) solution.

Slide preparation and staining : The preserved (FAA) samples were thoroughly washed in running water before cutting microtome section. Microtome sections were cut at a thickness of 25/μm with a sliding microtome. Transverse section(TS), radial longitudinal sections (RLS) and tangential longitudinal sections (TLS) were cut from the bottom and top portions of culms for both the species. The sections were then stored in 50% alcohol to avoid drying. A drop of saffranin was added, followed by four drops of alcian blue and the preparation was left for about five minutes. After staining the sections were passed through different alcohol grades (75%, 95%) and finally through absolute alcohol. The sections were made permanent in euparal.

Samples for scanning electron microscophy (SEM) : Small blocks of about 5 mm square, were prepared from both the bamboo species. The blocks were trimmed with a sharp razor blade for fine surface. Then all the blocks were stored in a petridish for air-drying and to protect from fungus. About one week later these were stuck into SEM stubs and sputter coated with gold.

The slides were studied under a compound microscope but certain features were examined under a scanning electron microscope.

RESULTS

General arrangement of the bamboo culms : Bamboo culms are characterised by a cylindrical cross section, usually hollow although occasionally solid, and divided at intervals by raised nodes from which branches arise. At the nodal region there is a solid transverse wall inside the diaphragm, which separates the cavity of one internode from the next. The culm wall is composed of scattered vascular bundles in a parenchymatous ground tissue. The bundles run longitudinally both in the internodes and the nodes. The outside of the culm is composed of a single epidermis layer with waxy cuticle and the inside is covered by a layer of sclerenchyma cells.

Internode region : The structure of both the bamboos in transverse section was characterised by numerous vascular bundles embedded in the parenchymatous ground tissue. They were larger in the inner parts, but appeared smaller and denser towards the periphery (Fig. 1).

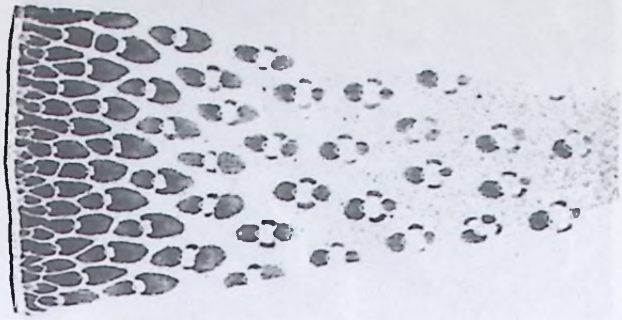

Fig. 1 : TS bottom section of *S. tootsik* (12 x).

As can be seen from Fig. 1, the vascular bundles, parenchyma cells and ground tissues of *S. tootsik* were different from those of *A. falconeri*. In *S. tootsik* the size of the vascular bundles from the periphery to inner wall increased and were less dense than that in the *A. falconeri*. Parenchyma and conducting cells were more frequent in the inner third culm wall, whereas in the outer third the percentage of fibres was higher.

The size, form, number and concentration of the vascular bundle changed continuously from the periphery of the culm towards the centre. The bundles were smaller and more numerous near the periphery. In the periphery the conducting tissues (i.e. xylem vessels and phloem) of the bundles were much reduced and generally consisting of only two small vessels and a few sieve tubes with their companion cells. The intercellular space was rarely visible and might have been absent altogether. The vascular bundles were larger and more widely distributed towards the centre of the culm.

Distinct differences in the structure of vascular bundles were noted between the lower and upper regions of the culms. In both the species, the vascular bundles of the upper regions were more circular in cross-section with reduced sclerenchyma sheaths than those of the lower parts. These differences of structure with the height in the culm agree well with the findings of Grosser and Liese (1971).

Typical vascular bundles of *A. falconeri* and *S. tootsik* were shown in Fig. 2. The vascular bundles of both the species consisted of one central vascular strand, two large metaxylems and one or two protoxylems, and of phloem with thin walled, unlignified sieve tubes connected to companion cells. The vessels were large at the inner part of the wall and became smaller towards the outer part. Both the vessels and the phloem were surrounded by sclerenchyma sheaths. They differed considerably in size and shape and according to their position in the culm and to the bamboo species. The characteristics of the vascular bundles indicated that they fell into type I in the four categories of Grosser and Liese (1971). Though both the species possess type I vascular bundles, there were some differences in the bundles. In *S. tootsik* the sclerenchyma sheaths, particularly

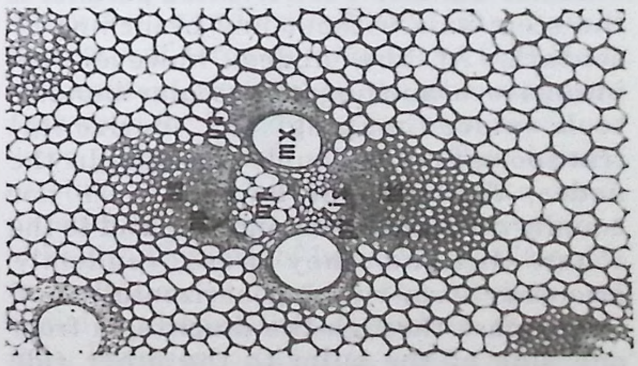

Fig. 2 : Vascular bundle of *A. falconeri* (130 x).
mx = metaxylem, px= protoxylem,
mp = metaphloem, pp = protophloem
pa = parenchyma cell, is = inter cellular
space, bs = bundle sheath.

around the metaxylem vessels, are considerably thicker than those in *A. falconeri*. The bundles in *A. falconeri* also tend to be smaller and more numerous than those in *S. tootsik*.

In the inner regions most of the cells including parenchyma were elongated vertically (Fig. 3). This is especially true for the heavily pitted vessel elements and the sclerenchyma sheaths.

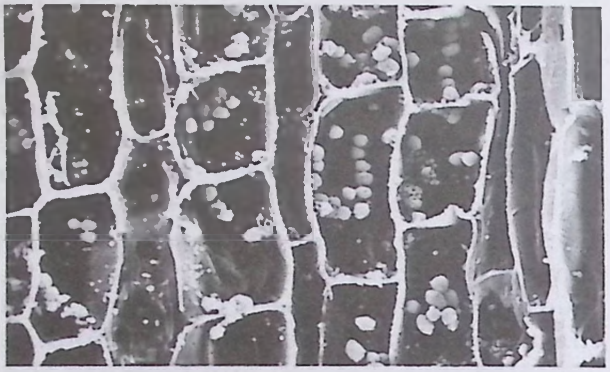

Fig. 3 : Elongated parenchyma tissue of *S. tootsik* with granules (200 X SEM).

Nodal region : In the internode all vascular bundles were oriented parallel to the stem axis without any branching or contact. At the nodes, however, an intensive branching of vascular bundles took place making the horizontal transportation of liquids possible. In the nodes, the vascular bundles were not equally distributed through one end to the other. Instead they were randomly oriented, often running horizontally and might pass through the diaphragm from one side of the culm to the other side (Fig.4).

The vascular bundles inside the diaphragm originated from the inner part of the culm, but some bundles from the periphery also bent radially and passed into the diaphragm. This consisted of a ground tissue of shorter and longer parenchyma cells and was

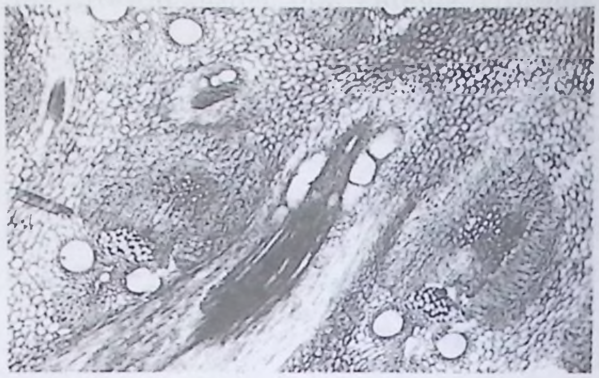

Fig. 4 : Variable orientation of vessels in the nodal area of *S. tootsik* (45 X).

lined with rows of heavily sclerified cells. The small and mostly round vascular bundles in the diaphragm consisted mainly of conductive cells surrounded by supporting tissues (Fig. 4). The structure of the vascular bundles in the node was also considerably altered (Fig.5) and

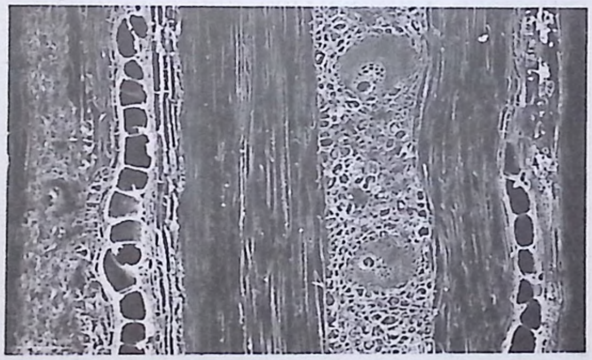

Fig. 5 : Shortened vessel elements at the node of *S. tootsik* and horizontal bundles (50 X SEM).

might consist only of one metaxylem vessel with metaphloem, companion cells and sclerenchyma sheath when horizontally oriented. Vertically oriented vascular bundles in the node also differed from internode bundles with considerably shortened vessel elements (Figs. 5 & 6). The vessels were heavily pitted with simple perforation plates although the latter appeared to have smaller apertures than in the internode zones (Fig. 6).

Fig. 6 : Elongated vessel elements in internode of *S. tootsik* (100X SEM).

Parenchyma tissue : A special attention was given to examine the dense accumulation of granular material observed in the parenchyma of both the species (Fig. 7). Scanning electron microscopy revealed that the granules are broadly spherical in shape and crystalline in nature.

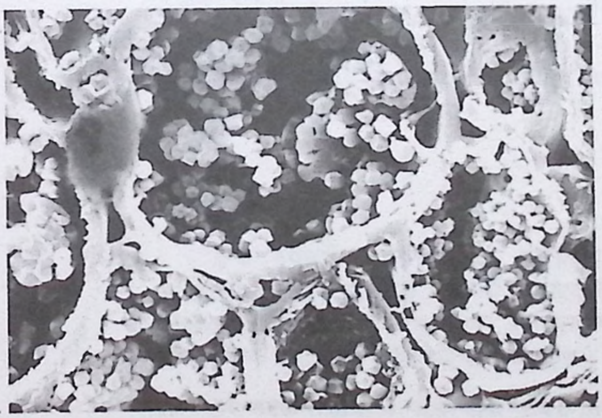

Fig. 7 : Granules in parenchyma cell of *S. tootsik* (1600 X SEM).

It was observed that starch grains were abundant in ordinary ground tissue cells in specimen of more than one year old culm. The average wall thickness in both fibres and ground tissue parenchyma increased considerably with age.

It was further observed that on drying most of the thin-walled parenchyma cells within vascular bundles collapsed frequently. This was shown in transverse view of a sample prepared for the SEM observation (Fig. 8).

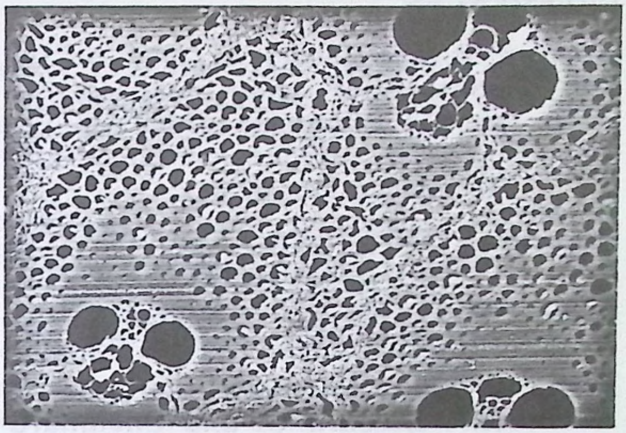

Fig. 8 : Collapsed parenchyma tissue of *A. falconeri* caused during drying (200 X SEM).

DISCUSSION

Both *A. falconeri* and *S. tootsik* were found to have nearly similar anatomy and vascular bundles fall into the type I category of Grosser and Liese (1971). It was evident that the most advantageous pathways for liquid flow in these bamboos were longitudinal vessels. The heavy pitting of the vessel elements and parenchyma might aid lateral movement of liquid. The lack of lateral flow of liquids in bamboos is due to the absence of radially oriented tissues such as the rays. It is, however, clear that wood-treatment processes, dependent upon liquid flow. e.g. vacuum-pressure or sap-displacement techniques can be expected to give acceptable penetration of the cross section when adequate access to exposed end grain is achieved. It would be of particular interest to determine through how many nodes, the longitudinal flow can be sustained with these treatments and the extent to which preservative solution moves out from vessels into the surrounding sclerenchyma and parenchyma tissues.

REFERENCES

Grosser, D. and Liese, W. 1971. on the anatomy of Asian bamboos with special reference to their vascular bundles. Wood science and Technolocy, 5 : 290-312

Higuchi, T. 1986. Bamboo : In : Bever, M. B. (ed.). Encyclopedia of materials Science and Engineering. Pergamon Press, Oxford, 266-275.

Liese, W. 1980. Preservation of Bamboos. In : Lessard G. and Chouinard (ed.). Bamboo Research in Asia, 165-172

Purushotham, A. 1963. Utilization of Bamboos. Journal of the Timber Development Association of India, 9 (13) : 1-19

Wen, T. and Chou, W.1984. A report on the anatomy of the vascular bundle of bamboos from China(I). J. Bamboo Res. 3 : 1-21

Younus-uzzaman, M.1987. Preservative treatments and anatomy of two bamboo species. M. Sc. thesis. Imperial College of Science and Technology, University of London.126 pp