Bordered Pit Structure Observed by FE-SEM in Main Wood Species of Pinaceae Grown in Korea

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Bordered Pit Structure Observed by FE-SEM in Main Wood Species of Pinaceae Grown in Korea[*1]

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ABSTRACT

An experiment was conducted to investigate the pit structure of four kind of pine wood species grown in Korea. Torus diameter, margo width, margo lattice size, diameter of pit aperture and pit border width were taken under consideration for explaining the pit structure difference among *Pinus densiflora*, *Pinus rigida*, *Pinus koraiensis* and *Larix kaempferi*. Torus diameter was found highest in *Pinus rigida* and the lowest in *Pinus densiflora*. Margo lattice size varied with torus diameter. Wider torus lowered the margo lattice size. Highest margo width was found in *Pinus rigida* while the lowest one was found in *Pinus koraiensis*. Pit aperture diameter was found highest in *Pinus densiflora* and lowest in *Pinus koraiensis*. In *Pinus rigida*, pit border was found the highest and the lowest was found in *Larix kaempferi*. Pit aperture diameter and pit border were increased gradually from pith to bark while there was a decreasing trend in the margo lattice size measuring from the pith to bark.

Keywords : Bordered pit, pit aperture, pit border, torus, margo, margo lattice, margo width.

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1. Introduction

In coniferous trees, water in sapwood is known to move longitudinally through the tracheid lumina, passing from one tracheid lumen to the next through the bordered pits and the same pathway is also used by preservative liquids when penetrating wood from a transverse surface (Usta 2005). Gymnosperm wood is superficially simple and composed of mostly the single celled tracheid that functions both as a conduit for water flow and for providing mechanical strength to the axis. The pit openings, tiny pores in the cell wall also play a role in the treatability especially when a polar solvent is used for the preservatives (Nicholas and Siau 1973). The size of pits opening has been measured with electron microscope (Cote and Krahmer 1962). The pits present in longitudinal tracheids are called bordered pit with specialized characteristics. The differentiation of torus-margo structure varies from species to species thus allowing the variation of liquid permeability. The thin and porous margo provide the passage for liquid flow. In longitudinal direction the greatest bulk fluid conduction occurs through the bordered pits of the longitudinal tracheids. Because tracheid lumina provide an unobstructed pathway for flow and its flow largely control by bordered pits of conifer wood (Petty, 1970). Hacke et al. (2004) found that the smaller the torus diameter ceased the membrane conductivity to decrease even the presence of relatively large margo area because of its greater number of margo strands required to hold the narrower torus in sealing position. More margo strands reduce the pore size and membrane conductivity. In this report, the pit structures of four Pine woods grown in Korea are described to investigate the structural difference among the species for better understanding of permeability difference.

2. Materials and Methods

2-1 Wood species used

Four kinds of wood block were taken under consideration from ① *Pinus koraiensis* Sieb. et Zucc. ② *Pinus densiflora* Sieb. et Zucc. ③ *Pinus rigida* Mill. and ④ *Larix kaempferi* Carr. Wood samples were collected from Kangwon National University reserve forest at breast height. Immediately after collection, discs were made and kept in air tight cellophane bag to protect the moisture loss. Number of annual rings 27, 26, 35 and 18; range of juvenile wood 1-17, 1-14, 1-19 and 1-14; range of matured wood 18-17, 15-16, 20-35 and 15-18; range of heartwood 1-6, 1-6, 1-22 and 1-13; range of sapwood 7-27, 7-26, 23-35 and 14-18 were found in *P. densiflora*, *P. rigida*, *P. koraiensis* and *L. kaempferi* respectively. Radial sections (1cm width) of four wood species were dried under vacuum condition and coated with platinum and palladium. At different resolution and magnification, samples were observed under FE-SEM (Field Emission Scanning Electron Microscope).

Finally data were analyzed by statistical analysis software, SPSS (George and Mallery 2001).

3. Result and Discussion

Table 1 shows the different anatomical features of bordered pits in 4 wood species. *P. densiflora* (8.19㎛) had the lowest size of torus diameter.

3–2 Margo width

Highest margo width was found in *P. rigida* (4.94㎛) and lowest in *P. koraiensis* (4.22㎛). Liquid penetrate through margo. So, margo diameter and lattice size determine the liquid penetration in longitudinal direction. Overlapping area in torus and pit border was found highest in *P. rigida* (38.12㎛2) and lowest in *P. densiflora* (24.86㎛2). Overlapping area in torus and pit border means that the area of torus is covered by pit border.

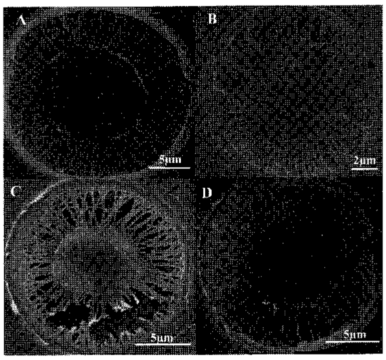
〈Table 1〉 Different features of bordered pit in longitudinal tracheid of four wood species

Features	Species			
	P. densiflora	*P. rigida*	*P. koraiensis*	*L. kaempferi*
Torus diameter (㎛)	8.19 bc	9.06 a	8.42 c	8.76 b
Margo width (㎛)	4.65 b	4.94 a	4.22 c	4.56 b
Margo lattice size (㎚)	342.89 c	521.79 a	351.81 c	379.99 b
Diameter of pit aperture (㎛)	5.95 a	5.79 c	4.88 b	5.85 bc
Pit border width (㎛)	6.84 a	7.03 a	6.24 b	6.14 b

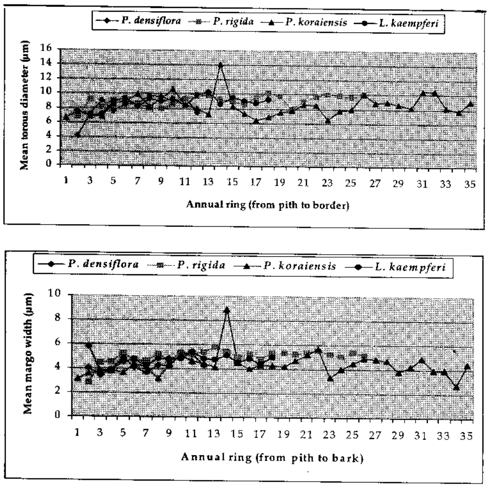
Mean with the same letter are not significantly different at $p=0.05$

3–1 Torus diameter

Heartwood has higher frequency of aspirated pit compared with sapwood. A common modification of bordered pit -pairs is the lateral displacement of the membrane and the phenomenon is called aspiration usually occurs when sapwood is transformed in to the heartwood or when wood dries (Tsoumis 1991). Also chemical constituents in heartwood differ from sapwood. Longitudinal tracheids form a capillary tube through which liquid is conducted and diffused to other cell through pits. So, more aspirated pit results in lower permeability. Diameter of torus was not found same for 4 wood species in longitudinal tracheid (Fig. 2). *P. rigida* (9.06㎛) had the highest and



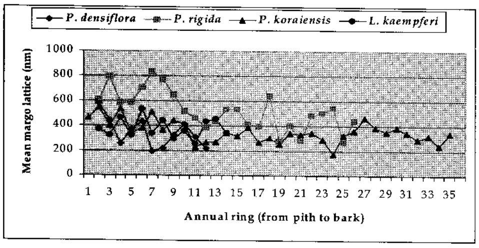
〈Fig.1〉 Bordered pits of longitudinal tracheid in A: *L. kaempferi*, B: *P. densiflora*, C: *P. rigida* and D: *P. koraiensis*.



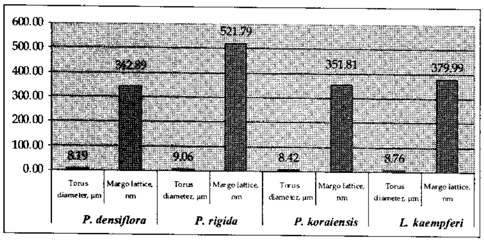
⟨Fig.2⟩ Mean torus diameter (up) and margo width (down) of bordered pit in longitudinal tracheid of different wood species.

3-3 Margo lattice size

In this experiment, the highest margo lattice size was found in *P. rigida* (521.79nm) and lowest in *P. densiflora* (342.89nm). Margo lattice size was directly related with torus diameter.



⟨Fig.3⟩ Mean margo lattice size of bordered pit in longitudinal tracheid of different wood species.

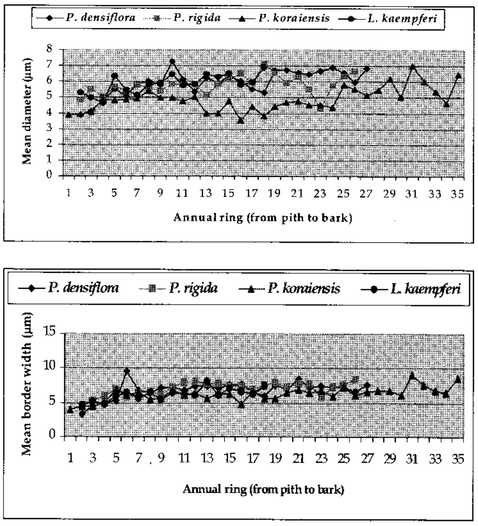


⟨Fig.4⟩ Comparison of torus diameter and margo lattice size in different wood species.

For small torus, greater number of margo strands are required for holding the torus compared with bigger one. As result, *P. rigida* has the largest margo lattice size compared with the other species (Fig. 4). More margo strands reduced the size of margo lattice (Fig.1). Margo lattice size decreased from pith to bark.

3-4 Pit aperture and pit border (excluding pit aperture)

Highest diameter of pit aperture was found in *P. densiflora* (5.95μm) and lowest in *P. koraiensis* (4.88μm). *L. kaempferi* was higher than *P. rigida*. Another part of bordered pit is pit border. Under FE-SEM observation, highest mean width of pit border was found in *P. rigida* (7.03μm) and lowest in *L. kaempferi* (6.14μm).



⟨Fig.5⟩ Mean pit aperture diameter (up) and border width (down) of longitudinal tracheid in different wood species

Bolton and Petty (1975) showed that the part of the bordered pit system other than the pit margo pores contribute the total resistance to flow and that structural component was the pit aperture. Pit aperture diameter and pit border increased from pith to bark (Fig.5). Pit aperture diameter and border were increased with the increasing number of annual rings.

4. Conclusion

For explaining the anatomical features of four pine wood species, pit structures were taken under consideration. Highest diameter of torus was found in *P. rigida* and the lowest in *P. densiflora*. Torus diameter was found responsible for the size of margo lattice. Wider torus lowered the margo lattice size and it was found the lowest in *P. densiflora*. Margo lattice size decreased from pith to bark. Highest margo width was found in *P. rigida* and the lowest in *P. koraiensis*. Pit aperture diameter was found highest in *P. densiflora* and lowest in *P. koraiensis*. Highest pit border was observed in *P. rigida* and lowest in *L. kaempferi*. Pit aperture diameter and pit border increased gradually from pith to bark. These anatomical features of pit will help us for the better understanding the pits role in liquid conductivity in wood. In this regard, research work is suggested by the authors.

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