Warty Layer Structure of Bordered Pits in Main Wood Species of Pinaceae Grown in Korea

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Introduction

The ultrastructure of bordered pits in coniferous tracheids, as a modified region of the cell wall organization or as a main route in the movement of liquids within the wood, has attracted considerable attention from many investigators (Imamura and Harada 1973). In terms of wood ultrastructure, the cell wall is built up by several layers, namely the middle lamella (M); the primary wall (P); and the secondary wall (S), which is composed of three layers, designated as the outer (S1), the middle (S2) and the inner (S3) secondary layers; and the warty layer. Warty layer an isotropic layer of material deposited on the inner surface of the secondary wall of many kinds of wood; this layer frequently contains encysted globules of a dissimilar material; these inclusions produce the warts which lend the name to the layer. The warty structure gradually developed external to the plasma membrane after secondary wall deposition and the greater part of lignification were complete and warts were synthesized first in the cell corners and pit cavities and then on the remainder of the cell walls (Baird et al. 1974). In Korean pine trees, the warty layer distribution in longitudinal bordered pit or longitudinal tracheid was observed from pith to bark.

Materials and Methods

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. Climatic condition of sample collection area is shown in Table 1 and Table 2 representing the characteristics of sample disc.

〈**Table 1**〉 Environmental factors in Chunchon (the average value of during 30 years)

Month	Temperature (℃)	Precipitation (㎜)	The amount of sunlight (MJ/m^2)	Hours of sunlight (hr)	The speed of wind (m/s)	Relative humidity (%)	The amount of evaporation (㎜)
April	11.3	78.5	409.2	222.2	2.1	61	118.5
May	16.9	93.3	472.4	240.4	1.8	65	149.5
June	21.4	139.6	464.6	214.9	1.5	72	145.3
July	24.2	331	401.5	153.9	1.3	79	124.4
August	24.3	267.4	412.9	180.8	1.3	79	127.8
September	18.8	153.6	354.8	180.9	1.3	78	98.3
October	12.3	40.1	292.9	180.8	1.2	75	73.1
Average	18.46	157.64	401.19	196.27	1.50	72.71	119.56

〈**Table 2**〉 General habit of sample disc observed by naked eye.

Features	*P. densiflora*	*P. rigida*	*P. koraiensis*	*L. kaempferi*
Number of annual rings (Number)	27	26	35	18
Range of juvenile wood (years from pith)	1~17	1~14	1~19	1~14
Range of matured wood (years from pith)	18~27	15~26	20~35	15~18
Range of heartwood (years from pith)	1~6	1~6	1~22	1~13
Range of sapwood (years from pith)	7~27	7~26	23~35	14~18

Radial sections (1cm width) of four wood species were dried under vacuum condition and coated with Pt+Pd. 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).

Results and Discussion

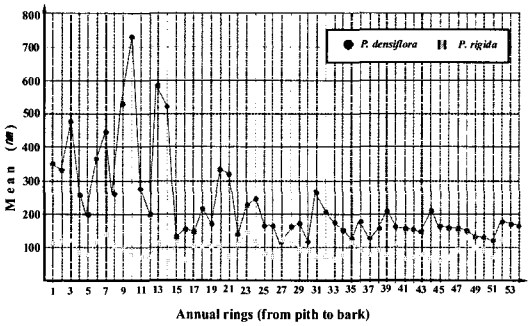
Field Emission Scanning Electron Microscope was used to find out the warty layer structure in bordered pits of pine trees which are shown in Table 3.

〈**Table 3**〉 Different features of four wood species observed under FE-SEM.

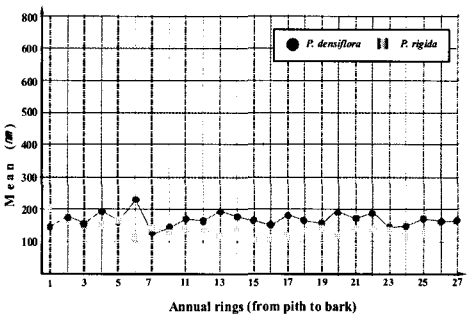
Features	Species			
	P. densiflora	*P. rigida*	*P. koraiensis*	*L. kaempferi*
Height of warty layer (㎚)	237.67	95.46	-	-
Horizontal diameter of warty layer (㎚)	172.79	139.84	-	-

The warty layer is a thin amorphous membrane located in the inner surface of the cell wall in all conifers, containing warty deposits of a still unknown composition (Sjöström 1993). Warty layer structures of different wood species were observed in bordered pits from pith to bark. Among four species, only in *P. densiflora* and *P. rigida* have the wart in their

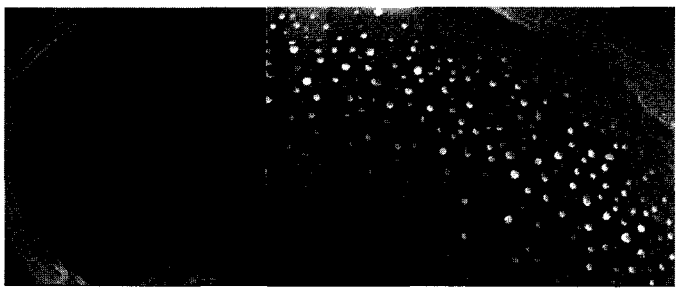
bordered pits. The height of warty layer was found higher in *P. densiflora*. In this species the variation of warty layer height fluctuated higher from pith to bark especially annual rings from 1 to 15. Mean horizontal diameter also found highest in *P. densiflora* species. It means that the size of warty layer was found higher in *P. densiflora* than that of *P. rigida*.



〈**Fig. 1**〉 Mean height of warty layer in tangential section



〈**Fig. 2**〉 Mean horizontal diameter of warty layer in radial section



〈**Fig. 3**〉 Warty layer in bordered pit of *P. densiflora* (left) and *P. rigida* (right)

Warty layer height and diameter was compared among *P. densiflora* and *P. rigida*. Highest diameter and height was found in *P. densiflora*. This type of structure was not observed in *P. koraiensis* and *L. kaempferi*. The height of warty layer was found highest in the early stage of *P. densiflora* then it decreased with the increase of aging.

Conclusion

In bordered pit of longitudinal tracheid, the mean height of warty layer and horizontal diameter was found the highest in *P. densiflora*. This type of structure was not observed in *P. koraiensis* and *L. kaempferi*. The height of warty layer was found highest in the early stage of *P. densiflora* then it decreased with the increase of its age.

References

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