Cross-field Pitting Characteristics of Reaction Wood in the Stem Wood of *Pinus merkusii* and *Agathis loranthifolia*

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This research investigated and compared the pitting type, pit number (PN), and pit diameter (PD) in the cross-field of compression wood (CWD), lateral wood (LWD), and opposite wood (OWD) in stem wood of *Pinus merkusii* and *Agathis loranthifolia* growing in Indonesia. Identification and quality evaluation were done using optical and scanning electron microscopy. A piceoid pit type was observed in the CWD of both species. The LWD and OWD of *P. merkusii* showed window-like and pinoid pits, whereas those of *A. loranthifolia* showed taxodioid and cupressoid pits. The PN and PD were the smallest in CWD of both species. In *P. merkusii*, LWD and OWD showed similar PN values, and PN in all parts increased from the pith to the bark. In *A. loranthifolia*, LWD had higher PN than in OWD, and PN in CWD and LWD decreased from near the pith to the bark, whereas in OWD, it increased. All parts of *P. merkusii* and CWD and OWD of *A. loranthifolia* showed a positive correlation between PN and radial tracheid diameter, whereas LWD showed a negative correlation. In *P. merkusii*, the PD of LWD approximated that of OWD, whereas, in *A. loranthifolia*, LWD had a larger PD than that exhibited by OWD.

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INTRODUCTION

Compression wood (CWD) is formed in leaning stems because of the mechanical stress on trees and restores the vertical growth of the main stems (Barnett *et al.* 2014). On the transverse surface of a leaning stem, CWD can be readily recognized based on its dark brown color, similar to lateral wood (LWD) and opposite wood (OWD) in a leaning stem (Purusatama and Kim 2018; Purusatama *et al.* 2022).

Several studies have revealed differences in the qualitative and quantitative anatomical characteristics of CWD, LWD, and OWD in temperate conifers. In terms of qualitative characteristics, helical cavities on cell wall-shaped tracheids surrounded by intercellular spaces, highly lignified S_2 layers, and slit-like bordered and cross-field pits are distinctive characteristics of CWD (Timell 1986; Purusatama *et al.* 2021). Quantitatively, the tracheids of CWD showed thicker cell walls, shorter tracheid lengths, and smaller tracheid and lumen diameters than those of LWD and OWD. In addition, CWD has a higher number of fusiform rays and smaller ray numbers, ray height, and relative crystallinity index than LWD and OWD (Purusatama and Kim 2020; Purusatama *et al.* 2020). Moreover, there are noticeable differences between LWD and OWD in the tracheid diameter, cell wall thickness, and relative crystallinity index (Kienholz 1930; Park *et al.* 1979; Eom and Butterfield 1997; Eom and Butterfield 2001; Purusatama *et al.* 2019; Yong *et al.* 2022).

Studies on the anatomical characteristics of CWD, LWD, and OWD in tropical softwoods are limited. The helical cavity is absent in the CWD of a few tropical species, such as *Agathis* spp,. *Araucaria* spp., and *Agathis robusta* (Westing 1965; Timell 1986). In *Araucaria brasiliana*, the tracheid of mild CWD exhibits a round shape, rich lignin content in the S_2 layer, and a helical cavity in the cell wall (Yoshizawa and Idei 1987). In *Agathis loranthifolia*, a circular tracheid is observed on the transverse surface, and helical cavities are present in the radial section (Pandit and Rahayu 2007). In *Agathis borneensis*, intercellular spaces and high lignification in the outer part of the S_2 layer are consistently observed in mild CWD, whereas helical cavities and rounded tracheids are absent (Kim *et al.* 2015). Recently, Purusatama *et al.* (2021) reported that the CWD of *Pinus merkusii* and *A. loranthifolia* contained helical cavities, slit-like bordered pits, and an irregular arrangement of tracheids, whereas helical ribs only occurred in *P. merkusii*. Purusatama *et al.* (2024a,b) reported that in both species, the tracheids of CWD have the shortest length, smallest tracheid and lumen diameters, thickest cell walls, and greatest microfibril angles (MFAs). In addition, CWD shows the highest ray numbers and the smallest relative crystallinity index among the parts. In *A. loranthifolia*, CWD exhibits the highest average ray height, whereas, in *P. merkusii*, CWD exhibits the smallest uniseriate ray height. The LWD and OWD in both species have distinctive tracheid properties and comparable ray, MFA, and crystalline properties.

Agathis (*A. loranthifolia*) and Sumatran pine (*P. merkusii*) are commercial wood resources naturally found in the mountainous regions of Indonesia and are common fast-growing species in plantation forests (Martawijaya *et al.* 2005; Darmawan *et al.* 2018; Trisatya *et al.* 2021). Wood from both species is widely used in various industries, *e.g.*, for making musical instruments, panels, furniture, molding, packaging, pulp, and paper. A challenge associated with the industrial use of these species is the presence of frequently observed CWD, which may cause problems when mixed with normal wood because of its distinctive physical and mechanical properties (Purusatama *et al.* 2020, 2022).

The International Association of Wood Anatomists (IAWA) Committee (2004) reported that cross-field pit characteristics, such as pit aperture shape and number of pits in the cross-field, are essential for identifying softwood species. Additionally, as reported in a few studies, cross-field pitting characteristics have been utilized to identify species as the structural members of historic timber structures (Noshiro 2011; Dong *et al.* 2017) and fossil wood (Falcon-lang 2005; Gerards *et al.* 2007).

In the authors' previous study (Purusatama and Kim 2020), it was suggested that cross-field pitting characteristics, such as pit type, pit diameter (PD), and pit number (PN), could be utilized to identify CWD, LWD, and OWD in the stem wood of temperate species, such as *Gingko biloba* and *Pinus densiflora*. The authors reported that the CWD of *G. biloba* contains piceoid pits, whereas its LWD and OWD contain cupressoid pits in the cross-field. The CWD of *P. densiflora* exhibits cupressoid and piceoid pits, whereas its LWD and OWD show pinoid and window-like pits. In both *G. biloba* and *P. densiflora*, the highest number of pits in the cross-field is present in OWD, whereas the smallest is present in CWD. The number of pits per cross-field in the CWD, LWD, and OWD of *G.*

biloba increases with the increasing number of growth rings, but there is no radial variation in *P. densiflora*.

Hitherto, there have been no studies on the cross-field pitting characteristics of reaction wood in the stem wood of tropical species, such as *P. merkusii* and *A. loranthifolia*. Therefore, in this study, the authors aimed to investigate and compare the cross-field pitting characteristics of CWD, LWD, and OWD in the stem wood of *P. merkusii* and *A. loranthifolia* to provide valuable information on the wood identification and quality of both species.

EXPERIMENTAL

Materials

The tree specimens used in this study mirror those examined in previous studies (Purusatama *et al.* 2021, 2022, 2024a, 2024b). Specifically, a 49-year-old *P. merkusii* and a 65-year-old *A. loranthifolia* were harvested from the Gunung Walat IPB University Research Forest, West Java, Indonesia (coordinates: 6.882937°N, 106.818511°E). The authors investigated the cross-field pitting features of CWD, LWD, and OWD across three distinct zones, *i.e.*, adjacent to the pith (NP), middle section, and proximate to the bark (NB). These zones were situated at distances of 5, 20, and 35 cm from the pith in the NP, middle section, and NB, respectively.

Methods

Microscopy

The cross-field pitting characteristics, such as cross-field pitting type, PN, and PD, were observed using optical and scanning electron microscopy, as described in the authors' previous study (Purusatama and Kim 2020). Small blocks of 1 cm^3 dimensions, softened in a heated mixture of glycerin and water (50:50), were used for optical microscopy. Radial sections with a 15 to 20 µm thickness were obtained using a sliding microtome (Nippon Optical Works Co. Ltd., Tokyo, Japan). The slices were first stained with 1% safranin solution before dehydration using a series of alcohol grades (50, 70, 90, 95, and 99%) and xylene. Subsequently, permanent slides were created using Canada balsam. The slides were examined under an optical microscope (Eclipse E600; Nikon, Tokyo, Japan) fitted with an image analysis system (IMT i-solution lite, version 9.1; Burnaby, British Columbia, Canada).

For scanning electron microscopy, wood blocks with dimensions of 1 cm^3 were air-dried and then coated with gold using a sputter coater (Cressington Sputter Coater 108; Cressington, Watford, UK). After coating, the samples were examined using a scanning electron microscope (JSM-5510; JEOL, Tokyo, Japan) operating at 5 kV.

The number of pits in the cross field was examined in 35 earlywood cross fields. The cross-field PD was measured for 50 pits in each zone.

Statistical analyses

Statistical analyses were conducted to examine the differences in PN and PD among CWD, LWD, and OWD, as well as between different zones. A one-way analysis of variance followed by *post-hoc* Duncan's multiple range test was used. Additionally, Pearson's correlation analysis was used to explore the relationship between radial tracheid diameter (TD) and PN. Data on TD from a previous study (Purusatama *et al.* 2024b) were incorporated into the analysis. All statistical analyses were performed using the SPSS ver. 26 (IBM Corp., Armonk, NY, USA) software.

RESULTS AND DISCUSSION

Cross-field Pitting Type

Optical and scanning electron micrographs of the cross-fields in *P. merkusii* and *A. loranthifolia* are shown in Figs. 1 and 2, respectively. The CWD of *P. merkusii* showed a piceoid pit in the cross-field, whereas LWD and OWD showed pinoid and window-like pits, respectively. In *A. loranthifolia*, CWD showed a piceoid pit, whereas LWD and OWD showed taxodioid and cuppresoid pits.

In this study, it was found that the CWD of both species showed distinctive cross-field pitting types with those of LWD and OWD, whereas LWD and OWD showed comparable characteristics, consistent with the results of several studies. As reported by Lee and Eom (1988), in the branch wood of *Pinus koraiensis*, CWD shows narrower and steeper pit apertures in the cross field than those of OWD. In the cross-field of *Pinus radiata*, piceoid pits in CWD and pinoid pits in OWD and LWD have been observed (Eom and Butterfield 1997). The cross-field of CWD in the stem and branch wood of *Dacrydium cupressinum* exhibits piceoid pits, whereas LWD and OWD exhibit cupressoid and taxodioid pits, respectively (Eom *et al*. 2001). Furthermore, Tarmian *et al*. (2011) reported that the CW in *Picea abies* showed a small taxodioid pit in the cross-field, whereas the OWD exhibited a cupressoid pit. Purusatama and Kim (2020) reported that CWD in the stem wood of *G. biloba* exhibited piceoid pits in the cross field, whereas LWD and OWD exhibited cupressoid pits. They also mentioned that the CWD of Korean red pine showed elliptical pit apertures (cupressoid pits) and piceoid pits, whereas LWD and OWD showed oval pit apertures similar to pinoid and window-like pits.

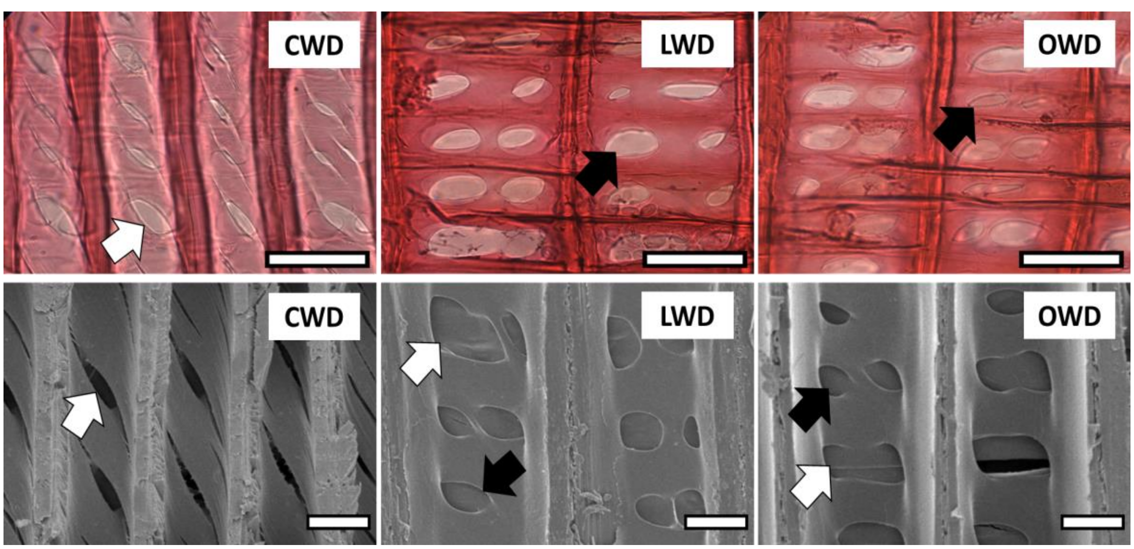

Fig. 1. Optical and scanning electron micrographs of the cross-field in the radial section of *Pinus merkusii*. Piceoid pit (white arrow) in CW; Pinoid pit (black arrow) and window-like (white arrow) in lateral wood (LWD) and opposite wood (OWD). Scale bars = 25 µm

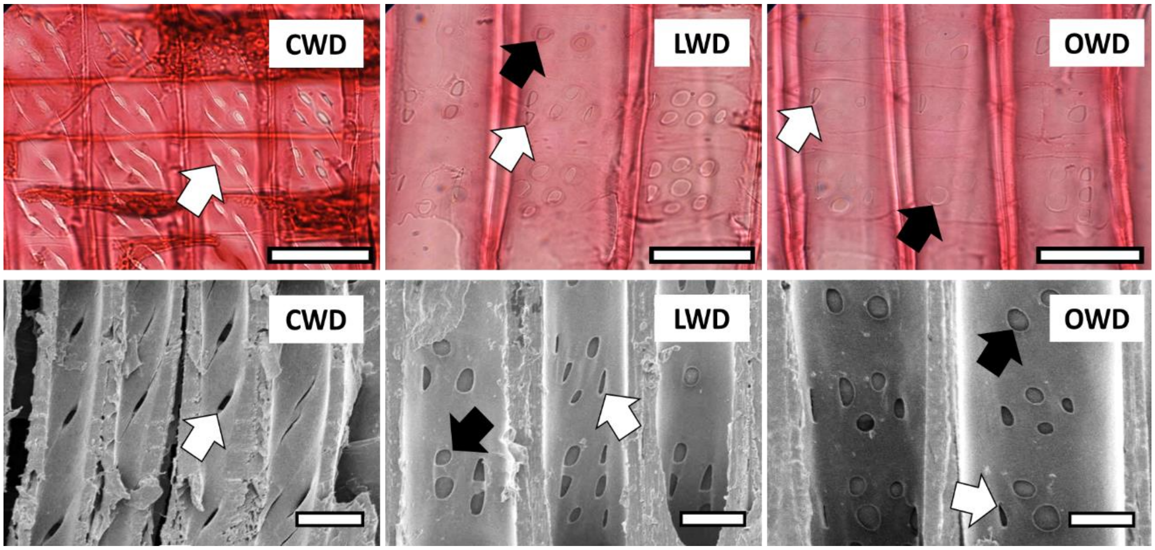

Fig. 2. Optical and scanning electron micrographs of the cross-field in the radial section of *Agathis loranthifolia*. Piceoid pit (white arrow) in compression wood (CWD). Taxodioid (black arrow) and cupressoid pits (white arrow) in lateral wood (LWD) and opposite wood (OWD). Scale bars = 25 μm

Pit number in the Cross-Field

The PN values in the CWD, LWD, and OWD of *P. merkusii* and *A. loranthifolia* are presented in Table 1. Near the pith of *P. merkusii*, CWD and LWD had similar PN values, which were lower than those of OWD. In the middle zone, the CWD of *P. merkusii* had the lowest PN value. The LWD displayed the highest PN, whereas OWD was intermediate. Near the bark of *P. merkusii*, CWD had the smallest PN, whereas LWD and OWD had comparable PN.

Table 1. Number of Pits in the CWD, LWD, and OWD of *Pinus merkusii* and *Agathis loranthifolia*

		NP	Middle	NB	Average
P. merkusii	CWD	1.0 ± 0.2^{aA} 1 to 2*	1.1 ± 0.2^{aA} 1 to 2*	1.2 ± 0.4^{aB} 1 to 2*	1.1 ± 0.1^{a0} 1 to 2*
	LWD	1.1 ± 0.3^{aA} 1 to 2*	1.7 ± 0.6^{cB} 1 to 3*	2.0 ± 0.5^{bC} 1 to 3*	1.6 ± 0.4^{b0} 1 to 3*
	OWD	1.3 ± 0.5^{bA} 1 to 2*	1.5 ± 0.5^{bA} 1 to 3*	2.0 ± 0.3^{bB} 1 to 3*	1.6 ± 0.3^{b0} 1 to 3*
A. loranthifolia	CWD	3.9 ± 0.9^{aC} 3 to 6*	3.6 ± 0.5^{aB} 3 to 4*	2.9 ± 0.6^{aA} 2 to 4*	3.5 ± 0.5^{a1} 2 to 6*
	LWD	5.1 ± 0.8^{bB} 4 to 6*	4.4 ± 1.1^{bA} 3 to 6*	4.7 ± 1.0^{bB} 3 to 6*	4.7 ± 0.4^{c1} 3 to 6*
	OWD	3.9 ± 1.0^{aA} 2 to 6*	4.2 ± 1.1^{bA} 2 to 7*	4.4 ± 0.9^{bB} 2 to 7*	4.2 ± 0.2^{b1} 2 to 7*

Note: Identical lowercase superscript letters beside the mean values in the same columns indicate insignificant outcomes at the 5% significance level for comparison among CWD, LWD, and OWD. Identical uppercase letters beside the mean values in the same row denote insignificant outcomes at the 5% significance level for comparison between the near the bark (NB), middle zone, and near the pith (NP) groups. Identical superscript numbers "0" and "1" in the average column indicate the insignificant difference between species. The asterisk symbol "*" indicates the range value.

Near the pith of *A. loranthifolia*, CWD had a PN comparable to that in OWD, whereas LWD had the greatest value among the parts. In the middle zone and near the bark, CWD had the smallest PN, whereas there was no significant difference between LWD and OWD. The CWD had the lowest average PN among all parts. The LWD had the highest average PN, whereas OWD had an intermediate average. The average PN content of *A. loranthifolia* was significantly higher than that of *P. merkusii*. The PN of CWD and LWD decreased from near the pith to near the bark, whereas that of OWD increased from NP to NB.

Purusatama and Kim (2020) reported that PN in the CWD, LWD, and OWD of *P. densiflora* was 1.0 ± 0.03, 1.2 ± 0.03, and 1.2 ± 0.13, respectively. Further, PN in the CWD, LWD, and OWD of *G. biloba*, another temperate species, was 2.4 ± 0.03, 2.8 ± 0.26, and 3.4 ± 0.33, respectively. Therefore, PN in the CWD, LWD, and OWD of *P. merkusii*, a tropical species, was greater than that in the CWD, LWD, and OWD of *P. densiflora*, a temperate species. Similarly, PN in the CWD, LWD, and OWD of *A. loranthifolia*, which grows in tropical regions, was greater than that in the CWD, LWD, and OWD of *G. biloba*, a temperate species.

Regarding the radial variation in *P. densiflora*, CWD showed constant PN with increasing growth rings, whereas the PN of OWD and LWD tended to increase. The PN values in the CWD, LWD, and OWD of *G. biloba* increased from the pith toward the bark (Purusatama and Kim 2020), which suggests differences in the radial variation of PN in CWD, LWD, and OWD among *P. merkusii*, *A. loranthifolia*, *P. densiflora*, and *G. biloba*.

The distribution of the number of pits per cross-field in *P. merkusii* is shown in Fig. 3. The CWD universally showed a one-pit-cross-field in each zone, whereas a two-pit-cross-field in the CWD of each zone was a rare occurrence. Near the pith, LWD and OWD dominantly showed a one-pit-cross-field. In addition, OWD showed a higher number of two-pit-cross-fields than the LWD. One- and two-pit-cross-fields were distributed evenly in LWD and OWD in the middle zone. Moreover, LWD and OWD frequently showed two-pit-cross-fields with a few one- and three-pit-cross-fields near the bark.

Further, the distribution of the number of pits per cross-field in *A. loranthifolia* is shown in Fig. 4. Near the pith, the cross-field of CWD showed three to six pits and predominantly showed three- and four-pit-cross-fields. The PN value in LWD ranged from four to six pits, and the cross-field predominantly consisted of five to six pits. The cross field of OWD consisted of two to six pits, and three- and four-pit-cross-fields were the most dominant. In the middle zone, the CWD exclusively showed three- and four-pit-cross-fields. The LWD predominantly exhibited a four-pit-cross-field, and the cross-field with three, five, and six pits showed a slightly even distribution. The cross-field with three to four pits was dominant in OWD, with a few cross-fields having five to seven pits. Near the bark, the cross-field of CWD showed two to four pits, and cross-fields with three pits were dominant. The LWD showed dominant cross fields with four to six pits and a few cross fields with three pits. The OWD cross-field had two to seven pits, and the four-pit-cross-field was dominant.

In the present study, the LWD and OWD of *P. merkusii* showed a wider range of PN than that in CWD, whereas, in *A. loranthifolia*, CWD and OWD showed a wider range of PN than that in LWD. Purusatama and Kim (2020) reported that PN in the CWD and OWD of *G. biloba*, a temperate softwood, ranged between one and six pits, whereas PN in LWD ranged between one and five. In *P. densiflora*, PN in CWD and LWD ranged from one to two pits, whereas it ranged from one to three in OWD. Therefore, it could be suggested that the distribution of PN in the CWD, LWD, and OWD varies between species.

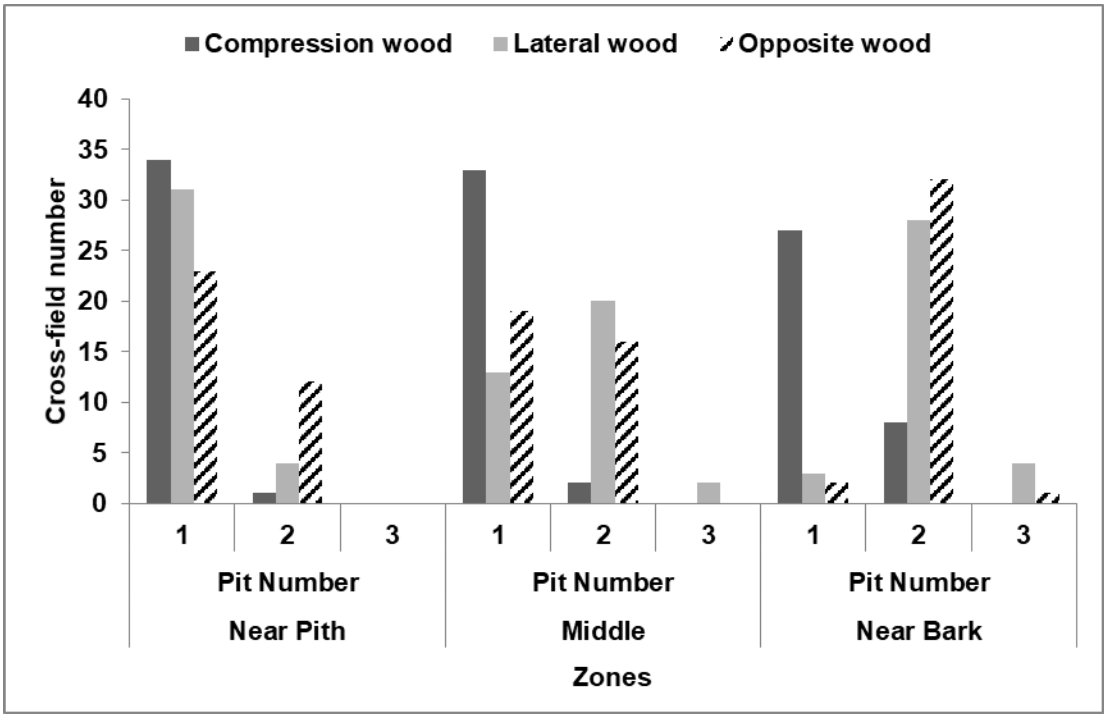

Fig. 3. Distribution of pit numbers in the cross-fields of compression wood, lateral wood, and opposite wood in *Pinus merkusii*

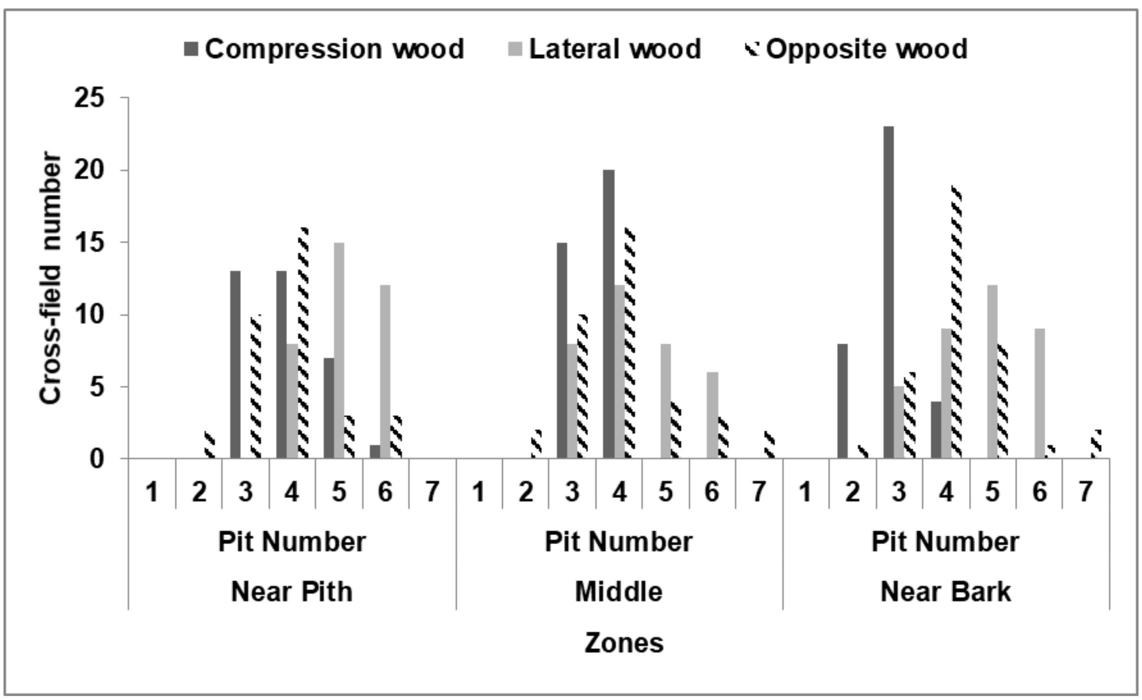

Fig. 4. Distribution of pit numbers in the cross-fields for compression wood, lateral wood, and opposite wood in *Agathis loranthifolia*

Cross-field PD

The PD values in the CWD, LWD, and OWD of *P. merkusii* and *A. loranthifolia* are presented in Table 2. In *P. merkusii*, the PD of CWD was the lowest in each zone. Both LWD and OWD had similar PD near the pith and middle zone, whereas OWD had the greatest PD near the bark. Based on the average value, CWD showed the smallest PD, OWD and LWD showed a comparable value. The PD values in CWD and OWD showed no variation in the radial direction, whereas those in LWD were constant from NP to the middle zone but significantly decreased toward the bark. In *A. loranthifolia*, CWD had the smallest PD in each zone, LWD had the greatest, and OW was intermediate among the parts. The PD of CWD and OWD increased with increasing distance from the pith, whereas that of LWD showed no variation in the radial direction. The average PD value in *A. loranthifolia* was significantly lower than that in *P. merkusii*.

A few studies revealed that the CWD in a few temperate conifers tends to show significantly smaller PD and tracheid PD than in LWD and OWD, which is consistent with the results of the present study. Purusatama and Kim (2020) reported that in *G. biloba*, the PD of CWD and OWD is 7.9 ± 0.43 µm and 7.7 ± 0.32 µm, respectively, showing no significant difference. However, the LWD of *G. biloba* exhibits the largest PD of 9.4 ± 1.02 µm. Furthermore, the authors noted that in *P. densiflora*, CWD displays the smallest PD value at 11.6 ± 1.12 µm, whereas the PD values of LWD and OWD are similar, approximately 27.0 µm. Additionally, Tarmian *et al*. (2011) reported that in a young tree of *Picea abies*, CWD demonstrates a pit aperture diameter of 2.3 ± 0.52 µm, and the pit aperture of OWD is 3.1 ± 0.52 µm.

Table 2. Pit Diameters in the CWD, LWD, and OWD of *Pinus merkusii* and *Agathis loranthifolia* (Unit: µm)

		NP	Middle	NB	Average
P. merkusii	CWD	10.2 (3.8)^{aA}	10.1 (2.7)^{aA}	10.9 (3.5)^{aA}	10.4 (0.5)^{a1}
	LWD	14.8 (2.0)^{bB}	14.1 (2.0)^{bB}	12.5 (1.7)^{bA}	13.8 (1.2)^{b1}
	OWD	14.9 (3.1)^{bA}	14.4 (3.3)^{bA}	14.2 (1.4)^{cA}	14.5 (0.4)^{b1}
A. loranthifolia	CWD	7.9 (0.5)^{aA}	8.6 (0.9)^{aB}	9.0 (1.1)^{aC}	8.5 (0.6)^{a0}
	LWD	11.2 (1.2)^{cA}	11.3 (2.1)^{cA}	11.3 (2.1)^{bA}	11.3 (0.1)^{c0}
	OWD	9.8 (1.2)^{bA}	9.8 (1.5)^{bA}	10.8 (1.1)^{bB}	10.1 (0.6)^{b0}

Note: Identical lowercase superscript letters beside the mean values in the same columns indicate insignificant outcomes at the 5% significance level for comparison among CWD, LWD, and OWD. Identical uppercase letters beside the mean values in the same row denote insignificant outcomes at the 5% significance level for comparison between the near the bark (NB), middle zone, and near the pith (NP) groups. Identical superscript numbers “0” and “1” in the average column indicate the significant difference between species.

Relationship between PN and Tracheid Properties

The relationships and Pearson’s correlation coefficients between PN and TD values in each part of both species are presented in Fig. 5 and Table 3, respectively. In the CWD of both species, PN showed significant positive correlations with TD, whereas Pearson’s correlation coefficient in *A. loranthifolia* was higher than that in *P. merkusii*. The LWD of *P. merkusii* also showed positive correlations between PN and TD; however, these correlations were not statistically significant. In contrast, the LWD of *A. loranthifolia* showed a significant negative correlation between PN and TD. The OWD of both species exhibited significant positive correlations between PN and TD, whereas Pearson’s correlation coefficient in *P. merkusii* was higher than that in *A. loranthifolia*.

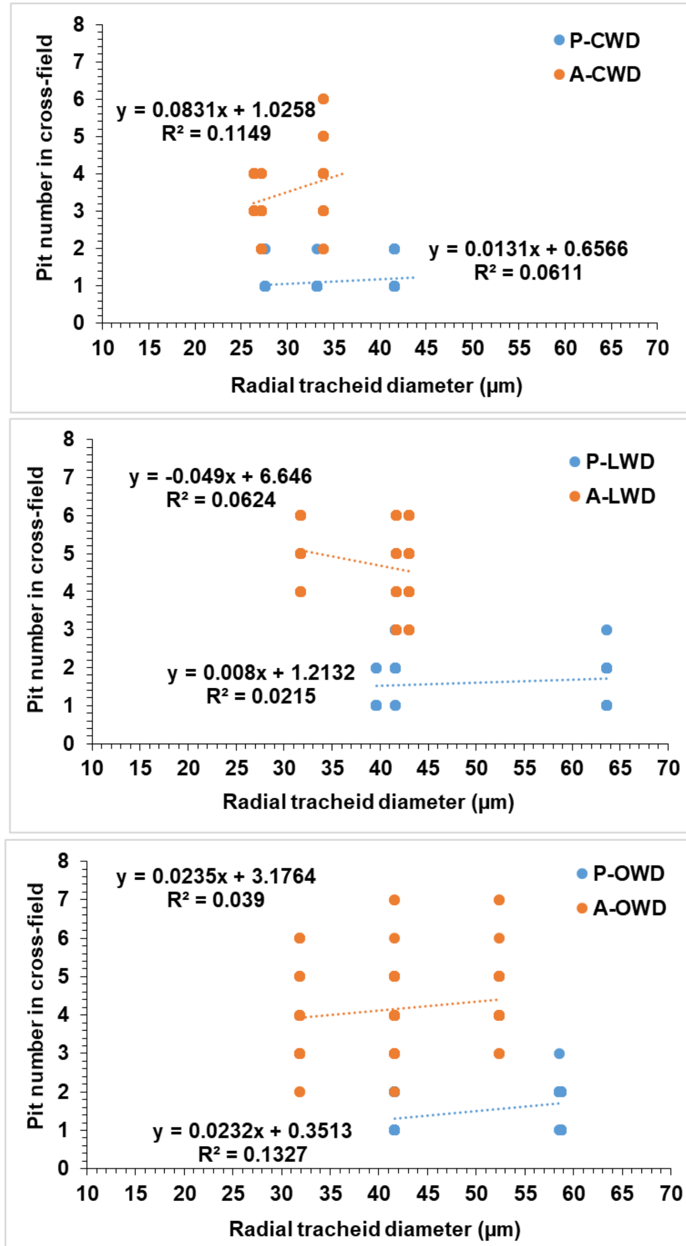

Fig. 5. Relationship between pit number and tracheid diameter in the compression wood (CWD), lateral wood (LWD), and opposite wood (OWD) of *Pinus merkusii* (P) and *Agathis loranthifolia* (A)

Table 3. Pearson's Correlation Coefficients Between Pit Number and Tracheid Diameter

	Pinus merkusii	*Agathis loranthifolia*
CWD	0.247*	0.335**
LWD	0.147	−0.250*
OWD	0.364**	0.197*

Note: **Correlation is significant at the 0.01 level (two-tailed); *Correlation is significant at the 0.05 level (two-tailed). Abbreviations: CWD, compression wood; LWD, lateral wood; OWD, opposite wood.

As reported in the authors' previous study (Purusatama *et al*. 2024), in *P. merkusii*, the TD values in CWD, LWD, and OWD tended to increase from NP to NB. Near the pith, the diameters were recorded as follows: 33.2 ± 4.6 µm for CWD, 39.6 ± 4.6 µm for LWD, and 40.6 ± 6.5 µm for OWD. In the middle zone, measurements were 27.6 ± 3.8 µm for CWD, 63.6 ± 8.3 µm for LWD, and 41.6 ± 6.3µm for OWD. Near the bark, the diameters were 40.7 ± 6.5 µm for CWD, 61.9 ± 8.8 µm for LWD, and 60.2 ± 8.5 µm for OWD.

In *A. loranthifolia*, the TD values in CWD were 33.9 ± 4.3 µm near the pith, 26.3 ± 4.7 µm in the middle zone, and 27.6 ± 3.8 µm near the bark, showing a decreasing pattern from the pith to the bark. The TD values in LWD were 31.8 ± 5.0 µm near the pith, 41.6 ± 5.6 µm in the middle zone, and 43.6 ± 7.3 µm near the bark, whereas the TD values in OWD were 31.9 ± 4.4 µm, 45.2 ± 6.4 µm, and 52.4 ± 10.4 µm near the pith, in the middle zone, and near the bark, respectively. The TD values in LWD and OWD increased from NP to NB.

Hitherto, there have been no studies on the correlation between PN and TD in CWD, LWD, and OWD. In a previous study, Purusatama and Kim (2020) revealed differences in the radial variation in PN and TD between CWD, LWD, and OWD in temperate conifers. The authors mentioned that PN and TD in the CWD, LWD, and OWD of *G. biloba* increased from the pith to the bark. Furthermore, in *P. densiflora*, CWD showed a constant PN with an increasing number of growth rings, whereas TD tended to decrease from the pith toward the bark. The PN and TD of OWD and LWD tended to increase with the increasing number of growth rings.

CONCLUSIONS

Herein, the research examined the cross-field pitting characteristics of compression wood (CWD), lateral wood (LWD), and opposite wood (OWD) in *P. merkusii* and *A. loranthifolia*.

1. The CWD of both species showed a piceoid pit in the cross-field. The LWD and OWD of *P. merkusii* showed pinoid and window-like pits in the cross-field, respectively, whereas the LWD and OWD of *A. loranthifolia* showed taxodioid and cupressoid pits, respectively.
2. The CWD of both species showed the smallest pit number (PN) and pit diameter (PD). The LWD and OWD mostly showed comparable PN and PD values. Moreover, CWD, LWD, and OWD showed a distinct distribution of PN in each zone of both species.
3. The number of pits in the CWD, LWD, and OWD of *P. merkusii* increased slightly from near the pith to near the bark, whereas the number of pits in the CWD and LWD of *A. loranthifolia* decreased from near the pith to near the bark and that in OWD increased from near the pith to near the bark.
4. The PD values in the CWD and OWD of *P. merkusii* were constant from near the pith toward the bark, whereas those in LWD gradually decreased from near the pith to the bark. In *A. loranthifolia*, the PD values in CWD and OWD increased from near the pith toward the bark, whereas those in LWD showed no variation in the radial direction.
5. The number of pits in the CWD, LWD, and OWD of *P. merkusii* was correlated positively with TD. In *A. loranthifolia*, PN in CWD and OWD was correlated positively with TD, whereas in LWD, PN was negatively correlated with TD.

6. In broad terms, there were distinct differences in the cross-field pitting characteristics of CWD, LWD, and OWD, and between species. Furthermore, cross-field pitting characteristics can be used to identify the reaction wood and evaluate the wood quality of *P. merkusii* and *A. loranthifolia*.

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