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VARIATION IN STRUCTURE AND SELECTED PROPERTIES OF FINNISH BIRCH WOOD: I. INTERRELATIONSHIPS OF SOME STRUCTURAL FEATURES, BASIC DENSITY AND SHRINKAGE.

K. M. BHAT

SELOSTE:

SUOMALAISEN KOIVUPUUN RAKENTEEN JA ERÄIDEN OMINAISUUKSIEN VAIHTELU: I. ERÄIDEN RAKENNEOMINAISUUKSIEN, TIHEYDEN JA KUTISTUMISEN KESKINÄINEN RIIPPUVUUS

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Variation of wood characteristics was studied in two mature trees of *Betula pendula* and two of *B. pubescens* by stressing the interrelationships of some of the structural features, basic density and shrinkage. Correlation analysis revealed that basic density was related to some of the variables studied viz: number of rings (age) and distance from pith, height from the ground, ring width, fibre length and double wall thickness. Multiple regression equation showed that age from pith and height from the ground explained 80 % of variation of basic density in *Betula pendula*. Two structural variables viz: fibre wall thickness and ring width accounted for only 28 % of variation of basic density in *B. pubescens*. No significant relations could be found between shrinkage and any of the wood parameters measured in *B. pendula* while some of the relationships were significant in *B. pubescens*. However, only about 55 % of variation of volumetric shrinkage was explained by two related factors viz: basic density and moisture content while only 35 % of variation of tangential shrinkage was explained by ring width and fibre width. Increase in fibre length was highly associated with the increase in fibre width, double wall thickness and vessel length in either species.

INTRODUCTION

In recent years, tree breeders focussed their attention on Finnish birch for itse importance in plantation forestry apart from the end uses. Hence, it is desirable and necessary to know the relationships between wood structure and certain key index features like basic density and shrinkage in order to assess the quality of wood. If it can be shown that there are close and definable relationships between structural features or simple physical properties of wood and more complex properties or end use characteristics, then the investigation patterns of variation in wood, and of the factors that influence them will be greatly simplified. Hence, it may prove useful particularly in selecting desired phenotypes for tree breeding. Moreover, it would be advantageous if the wood structure and physical properties to be studied can be restricted to some of the key features that can be measured accurately and rapidly on small specimens and often with non-destructive sampling. This would make possible to plan for an adequate scale of sampling and to minimise laboratory work and analysis.

Literature reveals relatively little information regarding the definite relationships between wood structure and physical properties. As early as 1919, NEWLIN and WILSON attempted to correlate specific gravity to shrinkage and strength properties in different American tree species. CLARKE (1930), studying in *Ulmus campestris* showed that specific gravity is much more closely connected with radial than with tangential shrinkage and it is fairly closely related to volumetric shrinkage. On the other hand, KANDEEL and BENSEND (1969) entablished that tangential shrinkage increases with the increase of specific gravity and radial shrinkage has no significant correlation to specific gravity in silver maple. Various other studies also showed the relationship between basic density and shrinkage anisotropy (KELSEY 1963, CREWS 1966, YAO 1969, NICHOLSON and DITCHBURNE 1973, NICHOLSON et.als 1975), although recently TRENARD and GUENEAU (1977) reported that mean density has little influence on shrinkage when compared to cellular morphology in fir and beech wood.

Effect of structural variables on differential shrinkage was stressed in many of the earlier studies. CLARKE (1930) reported that medullary rays restrict the radial shrinkage of wood in *Ulmus campestris*. The significant relationship of rays and transverse anisotropy was also evident from other studies (LINDSAY and CHALK 1954, Mc INTOSH 1955, 1957, BOSSHARD 1956, SCHNIEWIND 1959, KELSEY 1963, CREWS 1966). On the contrary, studies on Japanese softwoods (NAKATO 1958) and Swedish pine (BOUTELJE 1962) revealed that rays have no significant effect on shrinkage property. However, growth rings and other cellular features were reported to affect shrinkage rate considerably (FREY-WYSSLING 1943, BOUTELJE 1962, ELLWOOD and WILCOX 1962, KELSEY 1963, BARBER 1968, BARRET et.al 1972, BOYD 1977, TRENARD and GUENEAU 1977).

It is evident from the results of previous studies that interrelationships between wood structure and physical properties are highly variable and sometimes controversial among different species. In view of the lack of relevant information for Finnish birch, the present study was carried out on *Betula pendula* Roth and *B. pubescens* Ehrh. The objectives of this study were to measure the proposed related factors like basic density, shrinkage, moisture content and some structural variables viz: ring width, fibre length, fibre width, lumen diameter, wall thickness and vessel length.

The author wishes to express his gratitude to Dr. Matti Kärkkäinen for the valuable suggestions to the outcome of this study and for computorising the results with the assistance of Tarja Björklund. The material has been supplied from the Finnish Forest Research Institute. Thanks are also due to Prof. Bror-Anton Granvik for having organized the study in the Department of Logging and Utilization of Forest Products. The financial aid from the Ministry of Education, Finland is gratefully acknowledged.

MATERIAL AND METHODS

Transverse discs available for this study were obtained from four mature trees belonging to the age group of 45 . . . 56 years. The trees have been selected from the forest of the Ruotsinkylä Experimentation near Helsinki. Sampling has been done with the equal proportion of *Betula pendula* and *B. pubescens*. The discs were collected at three heights of 4 m intervals, starting from 2 m above the ground level. A diametrical segment was cut from each disc in such a way that any portion of tension wood and knots were eliminated from the samples. 2 x 2 x 3 cm blocks were prepared from pith outwards on either side for measuring basic density and shrinkage. Number of growth rings and distance from pith to outer margin of the blocks were noted. Basic density was determined on oven dry weight to green volume basis.

Radial and tangential green dimensions of the blocks were measured to 0.1 mm. After oven drying, the blocks were allowed to cool to room temperature in a desiccator and remeasured the dimensions to determine the percentage of radial and tangential shrinkages. Volumetric shrinkage was calculated from the linear shrinkage values assuming that longitudinal shrinkage value was zero as the error is very small and is often neglected (KELSEY and KINGSTON 1953). On the average, each block contained 10 growth rings and the average width of the ring was calculated in each sample. A total of 42 samples have been used in each species for measuring basic density and shrinkage.

21 samples of 1 mm wide strips were collected pith outwards from the adjacent portion of the sample blocks, in both the species for macerating the wood elements, using the mixture of potassium fluoride and nitric acid. By projecting the images 100 measurements were taken in each sample for the average value of fibre length. 50 measurements have been considered for the average values of fibre width, lumen diameter, wall thickness and vessel length. The total number of measurements made for these were 4 200 on fibre length and 2 100 on fibre width, lumen diameter, wall thickness and vessel length with the equal proportion of *Betula pendula* and *B. pubescens*.

RESULTS AND DISCUSSION

Average values and standard deviations of the wood parameters measured are presented in Table 1. It may be seen that basic density and shrinkage rates in both radial and tangential directions are higher in *Betula pendula* than in *B. pubescens*. The results showing the

Table 1. Average values and standard deviations of some physical properties and anatomical features of *Betula pendula* and *B. pubescens*.

Taulukko 1. Hies- ja rauduskoivun eräiden physikaalisten ja anatomisten ominaisuuksien keskiarvot ja standardipoikkeamat.

Variable *Muuttuja*	*B. pendula* *Rauduskoivu* $\bar{x}$	 s	B. pubescens *Hieskoivu* $\bar{x}$	 s	t-value *t-arvo*
Basic density, kg/m³ *Kuiva-tuoretiheys, kg/m³*	483.3	40.7	444.8	32.8	4.916***
Radial shrinkage, % *Säteen suuntainen kutistuminen, %*	6.7	1.3	5.7	1.4	2.668***
Tangential shrinkage, % *kutistuminen, %*	8.2	1.5	7.4	1.5	2.003*
Volumetric shrinkage, % *Tilavuuden kutistuminen, %*	15.0	1.8	13.2	2.3	5.653***
Fibre length, mm *Kuidun pituus, mm*	1.170	.188	1.114	.160	1.023NS
Fibre width, µm *Kuidun paksuus, µm*	21.5	1.8	23.4	2.5	2.184*
Fibre lumen diameter, µm *Kuidun ontelon läpimitta, µm*	13.1	1.1	15.6	1.7	5.172***
2× fibre wall thickness, µm *Kaksinkertseinämän paksuus, µm*	8.4	1.2	7.8	1.4	1.190NS
Vessel length, mm *Putkisolun pituus, mm*	.755	.01	.783	.01	.736NS

Table 2. Correlation coefficients of some of the physical properties and anatomical features of *Betula pendula* (A) and *B. pubescens* (B).

Taulukko 2. Hies- (B) ja rauduskoivun (A) puuaineen ja anatomisten ominaisuuksien välinen korrelaatiomatriisi.

Characteristic and tree species *Tunnus ja puulaji*		Characteristic – *Tunnus* 1	2	3	4	5	6	7	8	9	10	11	12	13
1. Basic density *Tiheys*	A	–.457**	.102	.087	.121	–.436**	.634**	.441**	.160	.519**	.564**	.864**	.849**	–.431**
	B	–.121	.245	.256	.321*	.280	.400**	.095	–.222	.421**	.303	.134	.311*	–.327*
2. Moisture content *Kosteus suhde*	A		.090	–.070	.036	.276	–.248	–.293	–.170	–.281	–.333*	–.578**	–.546**	.011
	B		.559**	.423**	.626**	.422**	–.320*	–.484**	–.237	–.564**	–.399**	–.585**	–.477**	.674**
3. Radial shrinkage *Säteen suunt. kutist.*	A			.101	.786**	–.091	–.030	–.246	–.219	–.176	–.161	.198	.227	.163
	B				.767**	.352*	.193	–.129	–.160	–.039	.085	–.161	–.023	.345*
4. Tangential shrinkage *Tangentin suunt. kutist.*	A				.673**	–.113	.236	.027	–.003	.028	.132	.106	.150	.036
	B				.795**	.457**	.215	–.410**	–.400**	.242	.020	–.013	.133	.217
5. Volumetric shrinkage *Tilavuuden kutist.*	A					–.147	.124	–.091	–.077	–.081	–.039	.214	.255	.155
	B					.520**	.261	–.350*	–.362*	–.183	.066	–.109	.073	.357*
6. Ring width *Vuosiluston paksuus*	A						–.303*	–.254	–.082	–.289	–.261	–.523**	–.419**	.274
	B						.173	–.091	–.060	–.087	.100	–.182	.018	.165
7. Fibre length *Kuidun pituus*	A							.717**	.283	.825**	.808**	.670**	.624**	–.296
	B							.428**	.029	.711**	.858**	.532**	.597**	–.265
8. Fibre width *Kuidun paksuus*	A								.784**	.811**	.567**	.465**	.378*	–.380*
	B								.831**	.764**	.610**	.596**	.531**	–.351*
9. Lumen diameter *Kuidun ontelon läpim.*	A									.278	.133	.144	.064	–.168
	B									.276	.323*	.439**	.337*	–.149
10. 2× wall thickness *Kaksinkert. seinämän paksuus*	A										.734**	.563**	.505**	–.445**
	B										.684**	.524**	.528**	–.432**
11. Vessel length *Putkisolun pituus*	A											.567**	.548**	–.288
	B											.542**	.561**	–.425**
12. Age from pith *Ikä ytimestä*	A												.969**	–.234
	B												.955**	–.273
13. Distance from pith *Etäisyys ytimestä*	A													–.188
	B													–.256

Correction for Silva Fennica Vol. 14, 1981, N:o 4, p. 387. The Table 2 should be as follows.

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	B													−.256
14. Height level *Korkeus*	A													1.00
	B													1.00

differences in properties of the two species are in agreement with those of the earlier studies (RUNQVIST and THUNELL 1945, KUJALA 1946, BRUUN and SLUNGAARD 1959, HAKKILA 1966) except for a small statistically nonsignificant difference in fibre length. The average fibre length was little more in *B. pendula* than in *B. pubescens*. This nonsignificant contradictory result might be due to the effect of site and rate of growth, as for instance, there is significant negative correlation between fibre length and ring width in *B. pendula* (Table 2). However, further investigation is necessary to know the effect of growth rate on fibre length in *Betula* species as this relationship might be also due to the fact that the pattern of increasing in fibre length from pith to surface is accompanied by decrease in ring width.

Basic density increases with the increase of age and distance from pith as it has been established in a previous study (HAKKILA 1966). However, it is of particular interest to note the pattern of variation in basic density of crown formed wood. The rate declines from pith outwards after certain growth rings (Fig. 1) or distance from pith in *Betula pendula*. Furthermore, it may be seen in fig. 1 that there is even decrease in basic density towards bark region after the initial increase up to certain growth rings at 10 m height level in *B. pubescens*. The results of the present study support some of the findings of HAKKILA (1966) at 60 % and 70 % of the heights. However, it remains to be confirmed by further studies.

Correlation analysis revealed that basic density is positively related to fibre length, double wall thickness, number of rings (age) and distance from pith and it is negatively related to ring width and height from the ground in *Betula pendula* while the relationships with ring width and number of rings from pith were not found to be significant in *B. pubescens*.

The relative effect of age and ring width on basic density was further analysed in *Betula pendula* by comparing the partial correlation coefficients (Table 3). The effect of age from

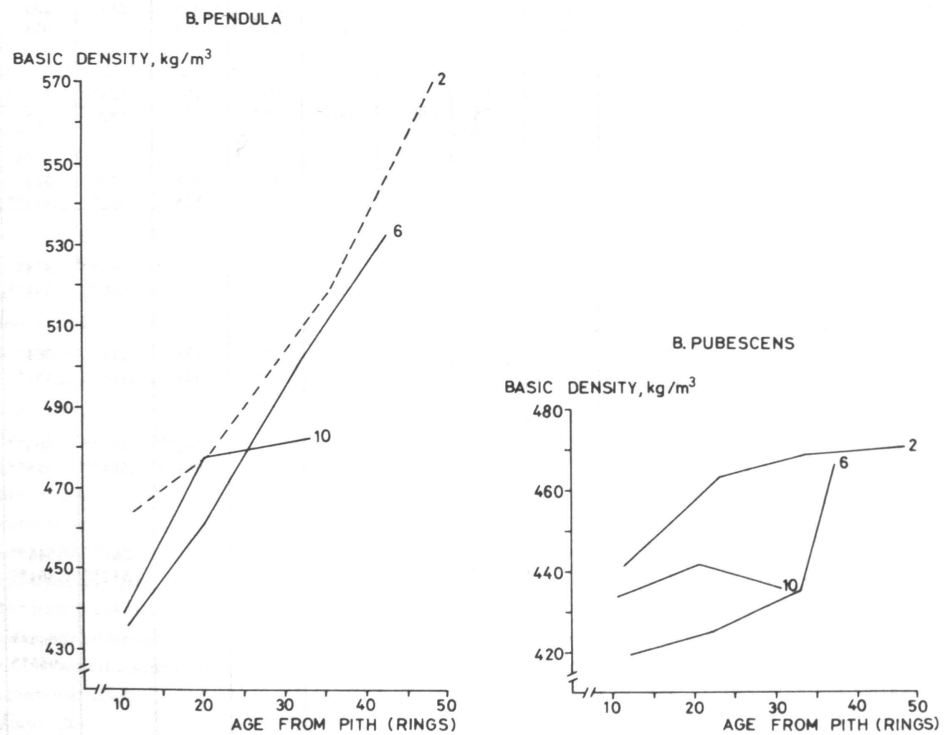

Figure 1. Relationship between basic density and age from pith at three height levels.
Kuva 1. Kuivatuoretiheys eri iässä ytimestä lasketun puun eri korkeuksilla.

Table 3. Partial correlation coefficients of some of the wood characteristics of *Betula pendula*.
Taulukko 3. Rauduskoivun osittaiskorrelaatiokertoimia.

Correlating properties *Korreloivat ominaisuudet*	Eliminated property *Eliminoitu tekijä*	Partial correlation coefficient *Osittaiskorrelaatio-kerroin*
Basic density, ring width *Kuiva-tuoretiheys, vuosiluston paksuus*	Age from pith *Ikä ytimestä*	.243^{NS}
Basic density, age from pith *Kuiva-tuoretiheys, ikä ytimestä*	Ring width *Vuosiluston paksuus*	.827**
Fibre length, ring width *Kuidun pituus, vuosiluston paksuus*	Age from pith *Ikä ytimestä*	.085^{NS}
Fibre length, age from pith *Kuidun pituus, ikä ytimestä*	Ring width *Vuosiluston paksuus*	.631**

Table 4. Basic density (kg/m³) as dependent variable on age from pith and height level in *Betula pendula*.
Taulukko 4. Ytimestä lasketun iän ja maasta mitatun etäisyyden vaikutus rauduskoivun puuaineen kuiva-tuoretiheyteen (kg/m³).

Variable *Muuttuja*	Rgeression coefficient *Regressio-kerroin*	t-value *t-arvo*	Loss in R^2 value if variable is deleted. *R^2 -arvon häviö, jos muuttuja on poistettu*
Age from pith *Ytimestä laskettu ikä*	2.5964	11.0304***	61.6 %
Height level *Korkeus*	−2.9989	−3.3024**	5.5 %

Constant: 437.2, $100 \times R^2 = 80.2$ %, F (2,39) = 79.177***
Vakio

Table 5. Basic density as dependent variable on fibre wall thickness and ring width in *Betula pubescens*
Taulukko 5. Kaksinkertaisen kuidun seinämän paksuuden ja vuosiluston paksuuden vaikutus hieskoivun puuaineen kuiva-tuoretiheyteen (kg/m³).

Variable *Muuttuja*	Regression coefficient *Regressio-kerroin*	t value *t-arvo*	Loss in R^2 value if variable is deleted. *R^2 -arvon häviö, jos muuttuja on poistettu*
2 x fibre wall thickness. *Kaksinkert. kuidun seinämän paksuus*	1.4395	3.2842**	19.9 %
Ring width. *Vuosiluston paksuus*	2.2837	2.3319*	10.0 %

Constant: 428.7, $100 \times R^2 = 27.8$ %, F (2.39) = 7.504**
Vakio

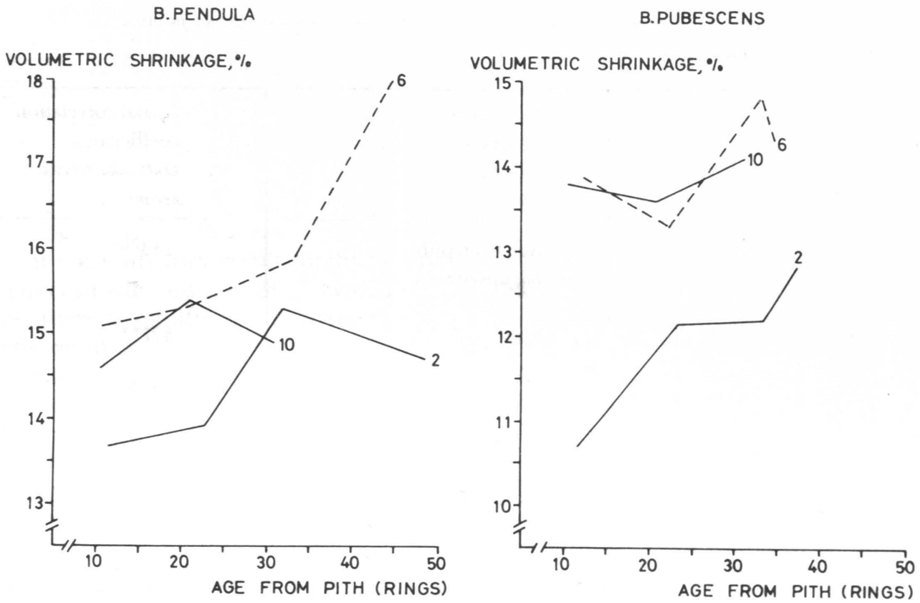

Figure 2. Volumetric shrinkage in relation to age from pith at different height levels.
Kuva 2. Tilavuuden kutistuminen eri iässä ytimestä lasketun puun eri korkeuksilla.

pith was significant when ring width value was kept constant and effect of ring width was not significant when age value was held constant.

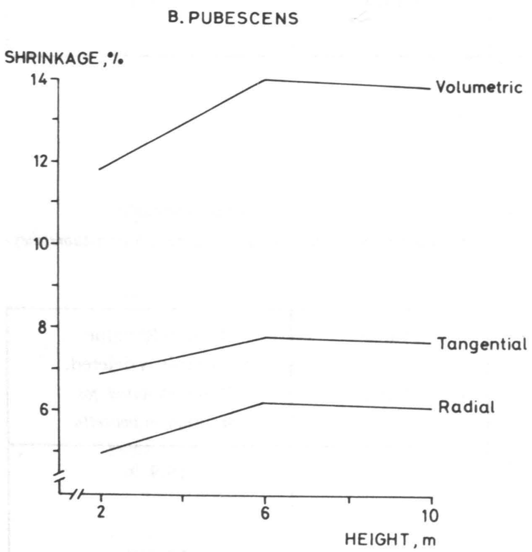

Figure 3. Relationship between differential shrinkage and height levels.
Kuva 3. Kutistumisen riippuvuus näytteen etäisyydestä maan pintaan.

Therefore, it is evident that effect of age would appear to be stronger although ring width has significant negative relationship with basic density.

Two selected factors viz:age from pith and height from the ground in stepwise regression aquation explained 80 % of total variation of basic density in *Betula pendula* and two structural variables viz: fibre wall thickness and ring width accounted for only 28 % of variation of basic density in *B. pubescens*.

Shrinkage property did not show a clear trend of variation either with the number of rings (age) or with the distance from pith (See fig. 2) in either species. In *Betula pubescens,* volumetric and radial shrinkages had significant positive correlations with the height from the ground while the relationship of tangential shrinkage was not significant. Therefore, it is obvious that at least in this species radial shrinkage is more related to height than tangential shrinkage as in silver maple (KANDEEL and BENSEND 1969). However, percentage of volumetric, radial and tangential shrinkages increased initially with the increase of height from the ground up to 6 meters and then gradually decreased towards the crown region (Fig. 3).

Table 6. Volumetric shrinkage as dependent variable on moisture content and basic density in *Betula pubescens*
Taulukko 6. Kosteussuhteen ja kui-va-tuoretiheyden vaikutus hieskoivun puuaineen tilavuuskutistumiseen (%).

Variable *Muuttuja*	Regression coefficient *Regressio-kerroin*	t value *t-arvo*	Loss in R^2value if variable is deleted *R^2 -arvon häviö, jos muuttuja on poistettu*
Moisture content *Kosteussuhde*	.0331	6.2352***	44.7 %
Basic density *Kuiva-tuoretiheys*	.0028	3.7176***	15.9 %

Constant: 10.4, 100 x R^2 = 55.1 %, F (2,39) = 23.897***
Vakio

Table 7. Tangential shrinkage as dependent variable on ring width and fibre width in Betula pubescens
Taulukko 7. Vuosiluston ja kuidun paksuuden vaikutus hieskoivun puuaineen tangetiaaliseen kutistumiseen (%).

Variable *Muuttuja*	Regression coefficient *Regressio-kerroin*	t value *t-arvo*	Loss in R^2value if variable is deleted *R^2 -arvon häviö, jos muuttuja on poistettu*
Ring width *Vuosiluston paksuus*	.1405	3.2540**	17.7 %
Fibre width *Kuidun paksuus*	–.0316	–2.8548**	13.6 %

Constant: 7.4, 100 x R^2 = 34.6 %, F (2,39) = 10.301**
Vakio

No significant correlations could be found between shrinkage property and other variables studied in *Betula pendula.* Therefore, it appears possible that in this species it is more related to microscopic cellular morphology than mean basic density and other structural features considered in this study. Similar conclusion has also been drawn by TRENARD and GUENEAU (1977) in fir and beech wood.

Volumetric shrinkage, in *Betula pubescens,* was found to be associated with basic density, moisture content, ring width, fibre width and lumen diameter. Radial and tangential shrinkages also had significant correlations to moisture content and ring width. Tangential shrinkage had negative correlation with fibre width and lumen diameter. The relationship of radial shrinkage with fibre width and lumen diameter were not significant. The strong correlation of transverse shrinkage with the initial moisture content of the samples indicates that transverse shrinkage commences in *Betula pubescens* even at the moisture content of above 45 %, as these samples were dried from the average moisture content of 47. . . 49 %.

Volumetric shrinkage, as dependent variable, related variables like basic density and moisture content explained 55 % of variation in *Betula pubescens.* It was only about 35 % of variation of tangential shrinkage was explained by two wood parameters viz: ring width and fibre width.

It is apparent from the results of this study that shrinkage property is affected by different factors in different species of even within the same genus *Betula.*

The average width of growth rings decreases with the increase of distance and number of rings (age) from pith although there is an

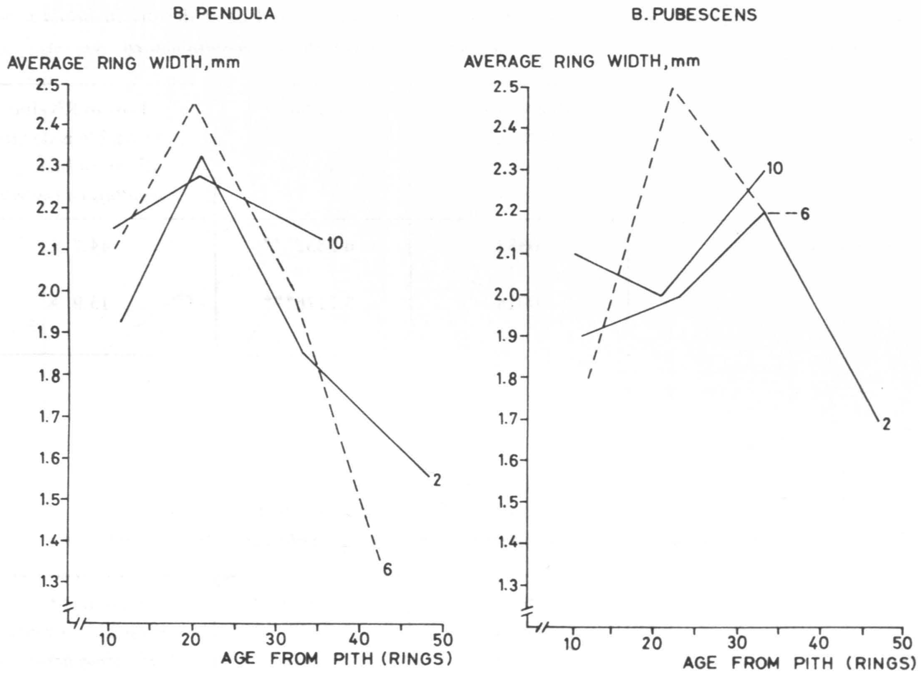

Figure 4. Relationship between average ring width (growth rate) and age from pith.
Kuva 4. Vuosiluston vahvuus eri iässä ytimestä laskettuna puun eri korkeuksilla.

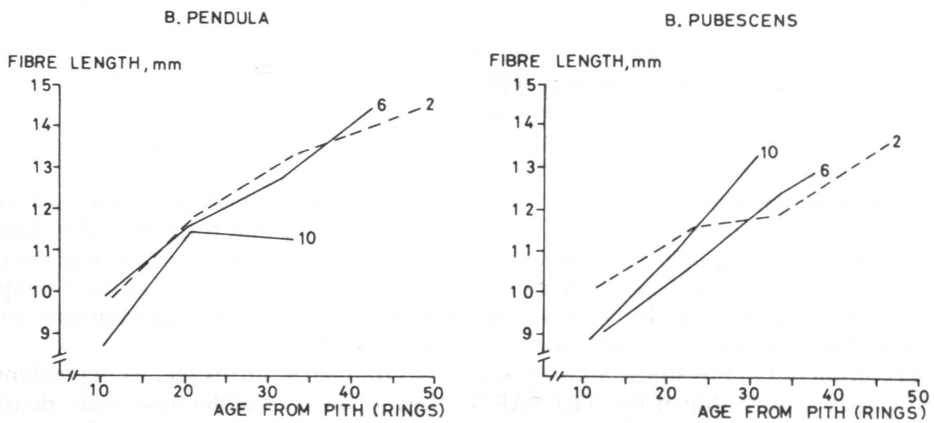

Figure 5. Relationship of fibre length and age from pith at different height levels.
Kuva 5. Kuidun pituus eri iässä ytimestä laskettuna puun eri korkeuksilla.

initial increase up to certain rings (Fig. 4). Therefore, it is obvious that diameter growth is slower in mature wood than in the early (juvenile) stage. As can be dedduced by the tree form, there is an increase in the average ring width from the butt portion to the top.

Fibre characteristics such as length, width and double wall thickness are strongly correlated to age and distance from pith. These features increase significantly with the increase of age while their average values in the discs were negatively related to the height from the ground. As fibre length, width and double wall thickness are strongly associated with

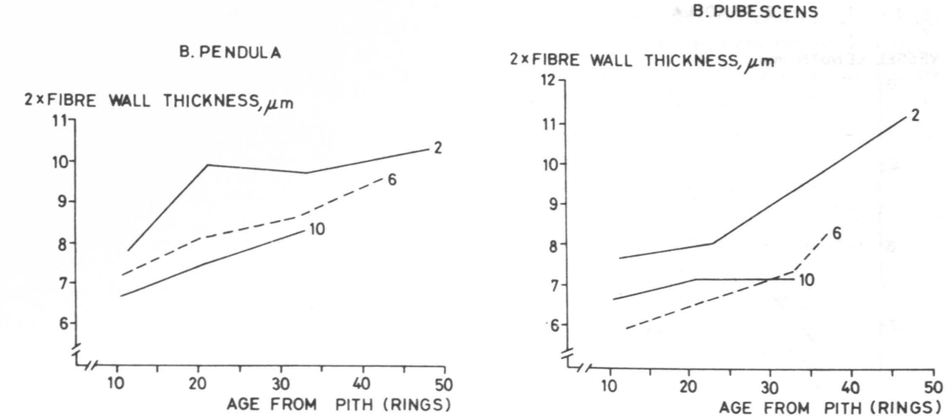

Figure 6. Relationship between fibre wall thickness and age from pith at different height levels.
Kuva 6. Kaksinkertaisen kuidun seinämän paksuus eri iässä ytimestä laskettuna puun eri korkeuksilla.

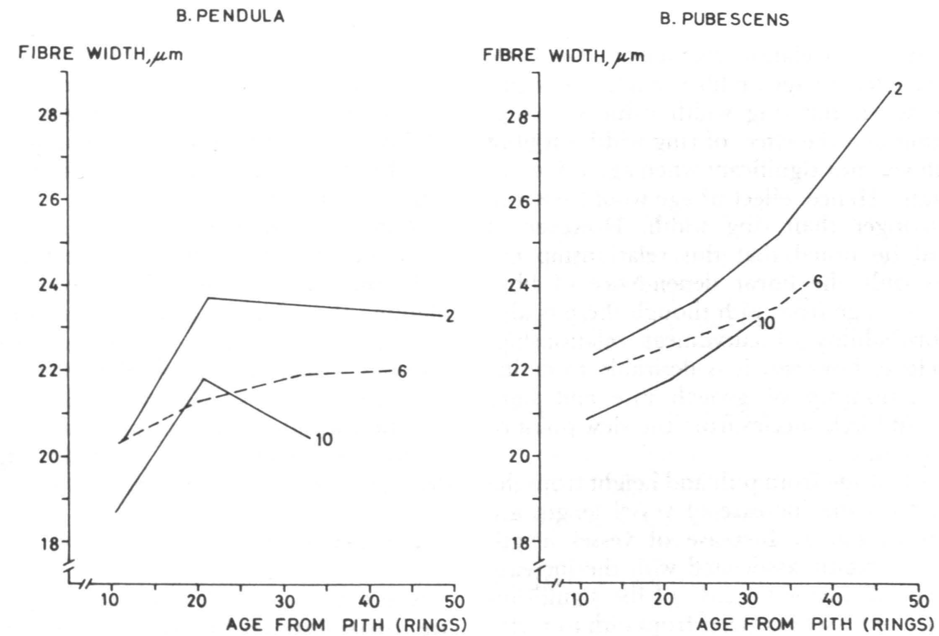

Figure 7. Fibre width in relation to age from pith at different height levels.
Kuva 7. Kuidun leveys eri iässä ytimestä laskettuna puun eri korkeuksilla.

each other, it is possible that fibres are shorter, narrower and more thin walled in pith and crown regions than in mature wood and base of the trees respectively. These results support the conclusions drawn by KASESALU (1969) that more thin walled fibres are found in youth than later.

In table 2, the negative relationship of fibre length with ring width was significant in *Betula pendula*. The influence of age on fibre length was found to be of higher order of significance than that of ring width. Therefore, the relative importance of age and ring width on fibre length was analysed by comparing

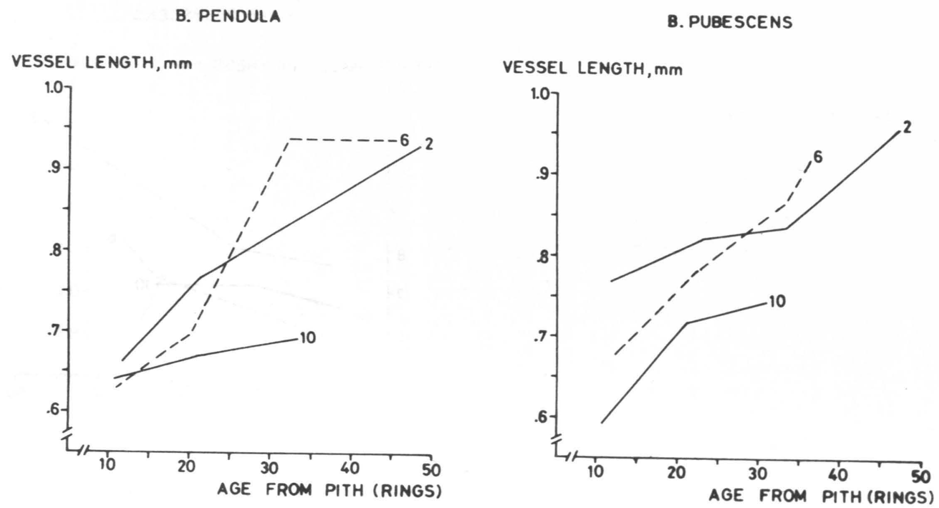

Figure 8. Vessel length in relation to age from pith at different height levels.
Kuva 8. Putkisolun pituus eri iässä ytimestä laskettuna puun eri korkeuksilla.

the partial correlation coefficients (See table 3). The effect of age on fibre length was significant when the ring width value was kept constant and the effect of ring width on fibre length was not significant when age value was constant. Hence. effect of age would seem to be stronger than ring width. However, it should be noted that this relationship explains only the linear dependence of fibre length on age from pith though there is also the probability of curvilinear relationship. Therefore, however, it is desirable to define the relationship of growth rate and fibre length in birch species from the view point of fibre yield.

Effect of age from pith and height from the ground on the increase of vessel length are shown in fig. 8. Increase of vessel length might be highly associated with the increase of vessel diameter because of the significant increase in vessel diameter from pith to surface (BHAT and KÄRKKÄINEN 1980). Increase of vessel length is also highly associated with that of fibre length (Table 2) as both the wood elements are derived from the same cambial initial and this might suggest the possibility of predicting the the length of one wood element if that of the other is known in a particular position of the tree.

Regression analysis:

In the present study, multiple regression technique was used with the objective of explaining the variation of dependent variables viz. basic density and different shrinkages. The best equation was obtained by stepwise regression analysis. The proportion of total variation was determined by the value of degree of determination (R^2). The following model was used to analyse the results:

$$Y = a+b_1X_1+b_2X_2$$

where Y is dependent variable, b_1 and b_2 are regression coefficients of the variables X_1 and X_2 are independent variables and a is constant.

CONCLUSIONS

On the basis of investigation of two trees of each species the following conclusions may be drawn.

Basic density: 1. Basic density is positively related to fibre length, double wall thickness, number of rings (age) and distance from pith.

2. It is negatively associated with height and ring width.

3. Effect of age appears to be stronger than that of ring width.

4. About 80 % of variation of basic density in *Betula pendula* is explained by age and height and two structural variables viz: fibre wall thickness and ring width account for only 28 % of variation in *B. pubescens.*

Shrinkage: No significant relations could be found between shrinkage property and any of the wood parameters measured in *B. pendula.* In *B. pubescens* the following relations could be established.

1. Volumetric, radial and tangential shrinkages increase initially with the increase of height from the ground and then gradually decrease towards the top of the tree.

2. Radial shrinkage is more related to the height from the ground than tangential shrinkage.

3. Volumetric and tangential shrinkages are more closely related to ring width than radial shrinkage.

4. Volumetric and tangential shrinkages are more negatively associated with fibre width and lumen diameter than radial shrinkage.

5. Volumetric shrinkage is more closely related to basic density than transverse shrinkages.

6. Basic density and moisture content explain about 55 % of variation of volumetric shrinkage while two related factors viz: ring width and fibre width account for only 35 % of variation of tangential shrinkage.

Structural variables: 1. Fibre characteristics such as length, width and double wall thickness are strongly correlated to each other and they increase with the increase of age and distance from pith in either species.

2. Age and distance from pith have stronger effect on fibre legth than ring width.

3. Increase in fibre length is strongly associated with the increase in vessel length in either species.

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SELOSTE:

SUOMALAISEN KOIVUPUUN RAKENTEEN JA ERÄIDEN OMINAISUUKSIEN VAIHTELU:I. ERÄIDEN RAKENNEOMINAISUUKSIEN, TIHEYDEN JA KUTISTUMISEN KESKINÄINEN RIIPPUVUUS

Tutkimuksessa tarkastellaan, kuinka raudus- ja hieskoivun puuaineen kuiva-tuoretiheys ja kutistumien riippuvat eräistä anatomisista ominaisuuksista. Aineistona käytettiin kahta kummankin puulajin runkoa, jotka kaadettiin Ruotsinkylästä. Niiden ikä oli 45 . . . 56 vuotta. Näytepalat kerättiin kolmelta korkeudelta neljän metrin välein lähtien kahden metrin korkeudelta maanpinnan tasosta. Kultakin korkeudelta näytepaloja leikattiin siten, että kuhunkin palaan tuli noin 10 vuosilustoa. Kaikkiaan kummastakin puulajista otettiin 42 näytepalaa, joista mitattiin kuiva-tuoretiheys ja kutistuminen tilavuusmääräisesti sekä säteen ja tangentin suunnissa. Lisäksi mitattiin maseroiduista näytteistä kuitujen ja putkilosolujen pituus sekä kuidun paksuus, soluontelon läpimitta ja kaksinkertainen seinämän paksuus.

Osoittautui, että tiheys korreloitui positiivisesti kuidun pituuden, seinämän paksuuden sekä ytimestä joko vuosina tai millimetreinä mitatun etäisyyden kanssa. Sitä vastoin tiheys korreloitui negatiivisesti näytteenottokorkeuden ja vuosiluston paksuuden kanssa. Jälkimmäisen vaikutus oli vähäinen ytimestä mitattuun ikään tai etäisyyteen verrattuna. Valikoivaa regressioanalyysiä käytettäessä muodollisesti merkitseviksi selittäjiksi saatiin rauduskoivulla ytimestä mitattu ikä sekä näytteenottokorkeus, jotka selittivät noin 80 % kuiva-tuoretiheyden vaihtelusta. Hieskoivulla tilastollisesti merkitseviksi selittäjiksi saatiin kaksinkertainen seinämän paksuus sekä vuosiluston paksuus, jotka yhdessä selittivät tiheyden vaihtelusta 28 %.

Rauduskoivulla kutistuminen ei korreloinut merkittävästi minkään tutkitun anatomisen ominaisuuden kanssa. Hieskoivulla tilavuusmääräinen sekä säteen ja tangentin suuntainen kutistuminen aluksi lisääntyivät tyvestä latvaan päin ja sitten uudelleen alenivat. Näytteenottokorkeuden vaikutus oli suurempi säteen suuntaiseen kutistumiseen kuin tangentiaaliseen kutistumiseen. Tilavuusmääräisestä kutistumisesta selittivät hieskoivulla 55 % kuiva-tuoretiheys sekä kosteussuhde.

Tutkimuksessa havaittiin edelleen, että kuidun tunnuksista pituus, paksuus ja kaksinkertainen seinämän paksuus korreloivat voimakkaasti keskenään. Pituus, paksuus ja seinämän paksuus lisääntyvät selvästi ytimestä pintaan päin. Tähän etäisyyden vaikutukseen verrattuna vuosiluston vahvuudella oli vähäinen merkitys. Kuitujen pituuden lisääntyessä kasvoi myös putkilosolujen pituus selvästi.