FOLIA FORESTALIA POLONICA
Seria B, Zeszyt 29, 1998

VARIATION IN CELL DIMENSIONS WITHIN SINGLE ANNUAL GROWTH RINGS OF BIRCH WOOD (*Betula pendula* Roth.)*

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The following growth rings counting from the pith, were taken for research. Each of the growth rings was divided into 10 even sections within a single growth ring. Particular sections were macerated in a mixture of glacial acetic acid 30% hydroxen peroxide. Measurements of the length of fibres and vessel members as well as diameter of the latter were performed. The measurements were made with the use of the "Imager 512" image proccesing system.

Key words: birch, fibre, vessel member, single growth ring, juvenile and mature wood

INTRODUCTION

There have been plans for increasing forestage in Poland by means of afforestation of fallow lands and lands which are not suitable for agricultural production. The goal of these plans is to improve the condition of the natural environment and enlarge the production basis of forestry in the future. According to estimates of experts, the species content of wood cultures located on formerly agricultural land is limited by the very low fertility and water capacity of soils assigned for afforestation. The main species to be grown on poor soils will be pine *(Pinus sylvestris* L.) and birch (*Betula pendula* Roth.). A particular role in the afore mentioned projects will be played by birch, which given the Polish conditions, is highly preferable for afforestation of formerly agricultural lands (Bernadzki and Kowalski 1983, Arbatowski 1991, Bernadzki 1990).

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* Short-version paper presented at the Intern. Sci. Conference "Forest-Wood-Environment '97, Zvolen (Slovak Republic), September 8-11,1997

This is due to the fact that birch exibits the ecologically pioneering characteristics of a first generation tree with a high degree of tolerance to atmospheric pollution (Berndt 1963, Białobok 1978, Sachsse 1989).

Therefore, greater interest in the problem of variation in birch wood's anatomical structure characteristics seems to be justified and relevant. It was in this context that research was conducted on the variability of chosen parameters of birch wood's anatomical elements (fibres and vessel members) within single annual growth rings taken from juvenile and mature parts of the stem cross-section. A variation in birch wood anatomical structure within single growth rings had not previously been sufficiently recognised (Ollinma 1958, Süß 1967).

EXPERIMENTS

Three 25-year-old experimental trees were chosen for research out of dominant trees in Forest Experimental Station - Murowana Goślina, Agricultural University of Poznań. The trees used in the experiment, grew on formerly agricultural lands as first generation trees. Characteristics of the studied trees are presented earlier (Helińska-Raczkowska and Fabisiak 1995).

Discs were taken from the experimental trees at a height of 1/6 of the whole tree. Sample strips 5 mm in width were cut out from the discs along their northern radius. The following growth rings, counting from the pith, were taken for research: the 3rd, 6th, 12th and 18th rings. Each of the growth rings was divided into 10 even sections within a single growth ring. Particular sections were macerated in a mixture of glacial acetic acid and 30 % hydrogen peroxide (in the ratio 1:1) at 60° C for 48 hours.

Measurements of the lengths of fibres and vessel members as well as diameter of the latter were performed. The measurements were made with the use of the "Imager 512" image proccesing system. 30 measurements of every measured parameter were made in each section of the studied growth rings. 10 800 measurements were made altogether.

RESULTS

The direct results of the experiments, given as mean values from all three experimental trees, are presented in a graphic form in Fig. 1. The diagrams shown in this drawing represent the fluctuations of the measured parameters of the birch wood's anatomical elements within the chosen annual growth rings (from the beginning to the end of each growth ring). Each point in these diagrams represents an average of 90 measurements. The average variation coefficients are relatively low, and are as follows: for fibre length - 11(8-14)%, for vessel member length - 14(10-18)%, for the

Table 1

Tabela 1

Average length of fibres and vessel members and diameter of vessel members in the birch annual growth rings studied
Średnia długość włókien i elementów naczyń oraz średnica elementów naczyń w badanych przyrostach rocznych brzozy

Age of annual growth rings / Wiek przyrostów rocznych	Length / Długość (μm)		Diameter of / Średnica (μm)		L_F/L_V / L_W/L_N	L_F/D_F / L_W/D_W	L_V/D_V / L_N/D_N
	fibres / włókien	vessel members / elementów naczyń	fibres*) / włókien*)	vessel members / elementów naczyń			
3	740±85	430±62	20±4	60±9	1,7	37	7,2
6	830±84	480±65	21±4	70±17	1,7	40	6,9
12	940±105	520±67	20±4	90±14	1,8	47	5,8
18	1130±113	580±74	21±4	90±14	1,9	54	6,4

L_F -length of fibres
L_W -długość włókien
L_V -length of vessel members
L_N -długość elementów naczyń
*) approximate data
*) dane orientacyjne

D_V - diameter of vessel memebers
D_N - średnica elementów naczyń
D_F - diameter of fibres
D_W - średnica wókien

diameter of vessel member -16(11-22) %. Similar variation coefficients of the length of birch wood's anatomical elements had been obtained earlier by Chovanec (1985).

Looking at the diagrams in Fig. 1, one can see that the lengths of the fibres and vessel members increase with the growing cambial age of the growth rings from 3 to 18 years. This is a reflection of a well-known regularity concerning the relation between the length of anatomical elements and the cambial age of annual growth rings (eg. Panshin and de Zeeuw 1980, Zobel and Buijtenen 1989).

The relationships between the length of fibres and vessel members, and the cambial age of growth rings were established earlier on the same experimental material by Helińska-Raczkowska and Fabisiak (1995). The results of these observations indicate that the 3rd and 6th growth rings (immature wood) and the 12th one (maturate wood) belong to the juvenile wood zone, whereas the 18th increment belongs to the mature wood zone.

The measured lengths of wood fibres as well as lengths and diameters of vessel members in the birch mature wood zone are close to the data obtained earlier (Berndt 1963, Bhat 1980, Chovanec 1985, Helińska-Raczkowska and Fabisiak 1995, Nepveu and Velling 1983, Sachsse 1988, 1989,Wagenführ 1989). The diameter of the vessel

Table 2

Tabela 2

Parameters of the equation $y = a + bx + cx^2$ describing the relationship between the length of anatomical elements of birch wood (y, μm) and their location on the width of single growth rings (x, parts of growth ring width)
Parametry równania typu $y = a + bx + cx^2$ opisującego zależność między długością elementów anatomicznych drewna brzozy (y,μm) i ich położeniem w szerokości pojedynczych przyrostów (x, części szerokości przyrostu)

Type of anatomical elements Rodzaj elementów anatomicznych	Age of growth rings (years) Wiek przyrostów (lat)	Equation parameters Parametry równania			R^2
		a	b	c	
Fibres Włókna	3 6 12 18	705,33 725,65 920,45 1069,10	133,52 395,36 115,33 217,11	-93,94 -295,83 -97,35 -167,53	0,41 0,84 0,26 0,28
Vessel members Elementy naczyń	3 6 12 18	398,45 439,57 504,53 600,05	143,02 222,59 85,88 -42,10	-130,68 -218,9 -93,94 13,26	0,20 0,73 0,44 0,45
Vessel members diameter Średnica elementów naczyń	3 6 12 18	61,13 69,08 86,17 91,98	-12,12 26,13 25,83 7,42	15,15 -26,89 -29,55 -26,14	0,44 0,27 0,37 0,76

members also increases with the growing cambial age of the increments. As follows from Table 1 data, both the average length of fibres and vessel members and the diameter of vessel members increase in the range between the 3rd to the 18th growth ring by ca 40-50%. The length of fibres is 70 to 90 % longer than the length of vessel members; whereas the fibre slenderness coefficient (L_F/D_F) was 40 to 50, and the vessel members slenderness coefficient 6-7.

The parameters of the regresion equation (Fig. 1) given by the formula $y = a + bx + cx^2$ are listed in Table 2. Due to relatively low determination coefficient (R^2) in the range of the variation on the length of fibres and vessel members within single increments, in most cases one should speak rather of trends than regularities.

As follows from Fig. 1, the curves representing the relationship between the length of fibres and vessel members within single annual increments have a slightly convex shape. Their shape is similar in juvenile and mature wood. Only the curve obtained for the vessel member lengths in the18th growth ring does not follow the general tendency. The Fig. 1 data reflect a weak trend towards increasing lengths of fibres and vessel members from the very beginning of an increment up to ca 1/2 -3/4 of its width, and then towards decreasing lengths as the edge of the growth ring is approached. However, the variation in fibre and vessel member lengths within single increments is

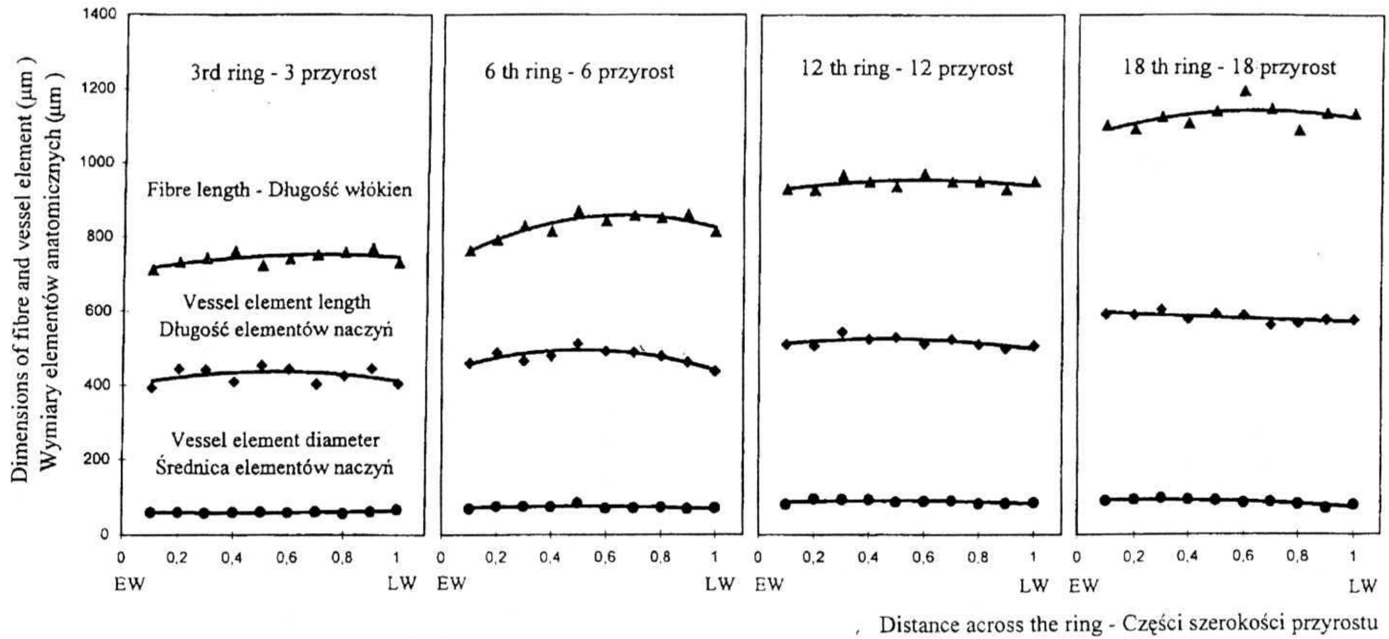

Fig.1. Cell dimension changes within growth rings from early (EW) to late (LW) part in birch wood increment
Rys. 1. Zmiany wymiaru komórek w przyrostach rocznych drewna wczesnego (E_W) do późnego (L_W) w drewnie brzozy

very small. The variation coefficient (CV) of the average length of the anatomical elements measured in individual growth rings does not exceed 5 %(2,1 to 4,7%). The vessel member diameter does not depend on the vessel location in the annual increment.

The experiment conducted shows that birch wood is characterized by a very high homogeneity of anatomical structure. The research carried out so far on the variation in birch anatomical elements within single annual increments is scant, and therefore sometimes controversial. Ollinma (1958) found, for example, that there is no clear difference between the length of birch fibres from early and late growth ring parts. While Süß (1967) observed that fibre length increases from the initial to the end parts of the increment, but decreases at the very end, though the length of vessel elements is more or less similar in the beginning and the end of the increment (Süß 1967).

The research performed on the fluctuation of the size of anatomical elements shows that deciduous species of wood with unclear annual increments exhibit very small changes in the fibre length, which are ca 5 % or even less (Wilson and White 1986). This opinion is supported by the results obtained for birch wood.

RECAPITULATION

With the increase of the growth rings' cambial age, the fibre and vessel member lengths increase according to a commonly known relation. The diagram curves representing the variation of fibre and vessel member lengths within a single annual increment show a slightly convex shape. This reflects a weak trend towards increasing lengths of the fibre and vessel members from the very beginning of an annual increment up to 1/2 - 3/4 of its width and, then towards decreasing lengths as the edge of the growth ring is approached. The variation in fibre and vessel member lengths within single growth rings, is rather small. The variation coefficient (CV) of the measured anatomical elements' average length in single annual growth rings does not exceed 5 %. The vessel member diameter does not depend on the vessel location in the annual increment.

Received in October 1997

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ZMIENNOŚĆ WYMIARÓW KOMÓREK W OBRĘBIE POJEDYNCZYCH PRZYROSTÓW DREWNA BRZOZY (*Betula pendula Roth.*)

Streszczenie

Oznaczano zmienność długości włókien oraz długości i średnicy elementów naczyń w granicach pojedynczych przyrostów brzozy. Mierzono zmienność wymienionych parametrów w 3, 6, 12 i 18 przyroście licząc od rdzenia na 1/6 wysokości trzech drzew doświadczalnych w wieku 25 lat.

Ze wzrostem wieku kambialnego przyrostów długość włókien i elementów naczyń zwiększa się według znanej prawidłowości. Zmienność natomiast długości włókien i elementów naczyń w obrębie pojedynczych przyrostów jest bardzo mała. Współczynnik zmienności ($V_{\%}$) średniej długości mierzonych elementów anatomicznych w pojedynczym przyroście rocznym nie przekracza 5%. Średnica elementów naczyń praktycznie nie zależy od miejsca występowania naczynia w przyroście.

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