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Annual rings characteristic of Scots pine (*Pinus sylvestris* L.) wood from seedling seed orchard

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Abstract: *Annual rings characteristic of Scots pine (Pinus sylvestris L.) wood from seedling seed orchard.* Trees in a seedling seed orchard are grown in big spacing with larger access to the sunlight. Due to these conditions competition between trees is small which is a cause of larger annual rings with limited height increments in comparison with trees grown in stand conditions. The objective of the paper was to find out characteristic of annual rings of pine trees grown in seedling seed orchard. Special attention was paid to early and late wood as well as juvenile and mature wood. For that LE (ratio of late wood width to early wood width) coefficient was calculated as well as coefficient of optimal structure (COS, understood as ratio of LE to annual ring width). The study was carried out in seedling seed orchard established in 1983 in Forest District Zdrojowa Góra (Regional Directorate of the State Forest in Piła). In compartment 95a all dbhs and heights were measured. Furthermore, 5 trees (with diameters from the smallest to the biggest) were selected with Urich II method. Next, form all selected trees wood discs were cut from dbh area for further annual rings measurements with accuracy of 0.02 mm. The study showed that pine timber from seedling seed orchard has very wide annual rings with mean value of 5.83 mm. LE coefficients were of low values with some exceptions observed in the ring number 15. At the same time LE coefficient was the highest for a tree with average dbh. Both, LE coefficient and COS suggest that at the age of 25 analysed trees formed only juvenile wood or/and intermediate wood. Growing conditions of trees at the seedling seed orchard were main cause of late development of mature wood in pine trees.

Keywords: Scots pine (Pinus sylvestris L.),seedling seed orchard, early wood. late wood, juvenile wood, nature wood

INTRODUCTION

The central part of the trunk is formed by juvenile wood, which is surrounded by mature wood. Juvenile wood consists of several annual rings, depending on species and the test methods applied (Csoka et al. 2005; Alteyrac et al. 2006). Scots pine juvenile wood consists of approximately 20 annual growth rings (Mutz et al. 2004; Fries and Ericsson 2006). The formation of juvenile wood depends on proximity to leaves while the proportion of juvenile wood is related to length of a tree crown (Kučera 1997; Tomczak et al. 2007).

In comparison to mature wood, juvenile wood is characterised by lower density (regardless of annual ring width), shorter tracheids on average, a lower proportion of late wood and a higher proportion of lignin (Zobel and Sprague 1998).

The analysis of the mechanical properties of juvenile and mature wood from trees grown in post-agricultural soil and forest soil conditions indicated juvenile wood was less resistant to shrinkage and static bending than mature wood in all the trees analysed. Additionally, properties in pine trees grown on former farmland can be of significantly lower values than of trees from forest sites (Jelonek et al. 2010; Tomczak and Jelonek 2013).

Wróblewska and Spława-Neyman (1995) revealed that tree spacing significantly affects the chemical content of the wood. The wood of pine trees initially grown at closer spacing showed higher levels of cellulose and lignin. In general, many factors affect tree growth and development, and for this reason geographical location, habitat, biosocial position and silvicultural treatment are reflected in the wood cell structure and tissue properties

(Arnold and Mauseth 1999; Wiemann and Williamson 2002; Tomczak and Pazdrowski 2004; Jelonek et al. 2008; Riesco Muñoz et al. 2008).

Considering the differences between the described physical properties of juvenile and mature wood from post-agricultural land and forest soil and the influence of the aforementioned factors on the chemical constitution of wood, the hypothesis was that wood structure (in terms of yearly increments, juvenile and mature wood) of seedling seed orchard trees will be different in comparison with pine grown in the forest. Therefore the aim of this study was to determine annual rings width of Scots pine trees from seedling seed orchards with special attention to early-late wood (LE) and coefficient of optimal structure (COS, understood as ratio of LE to annual ring width).

MATERIAL AND METHODS

The research material was collected from Scots pine trees grown in seedling seed orchard established in 1983 in Forest District Zdrojowa Góra (Regional Directorate of the State Forest in Piła). In compartment 95a all dbhs and heights were measured. Furthermore, 5 trees were selected with Urich II method (trees with numbers: 244, 246, 247, 251 and 256). North and West were marked on selected trees. On felled trees total length of each tree was measured as well as living crown length. From each tree at dbh disc was cut for laboratory measurements. After polishing of disc's surfaces width of early and late wood of annual increments were measured along with main directions (E-W and N-S) from the centre to outer ring. For that special ruler with magnifying glass was used with accuracy of 0.02 mm. Data of early and late wood width were used for calculation of LE co-efficient (linear proportion of late wood to early wood).

RESULTS AND DISCUSSION

Analysed wood from pine trees of seedling seed orchard was characterised by large annual rings of mean value amounting to 5.83 mm (tab. 1). These big increments were created due to large habitat of each tree. Trees in the seedling seed orchard were planted with spacing of 4 x 4 m, which was much bigger to spacing of planted pine trees on forest land (artificial stand regeneration with spacing 1.5 m x 0.5-0.8 m). Additionally, trees were selected and felled due to thinning, which made the habitat of a single tree and spacing even bigger.

Tab. 1 Annual ring characteristics of selected trees

dbh/clone number	**mean (all trees)**			**19/247**			**21/246**			**24/256**			**26/251**			**28/244**		
feature	AR	LE	COS	AR	LE	COS	AR	LE	COS	AR	LE	COS	AR	LE	COS	AR	LE	COS
mean	5.83	0.61	0.12	4.73	0.57	0.15	5.41	0.61	0.12	5.73	0.93	0.17	6.31	0.46	0.08	7.21	0.46	0.07
minimum	3.78	0.28	0.04	2.64	0.24	0.03	3.24	0.17	0.03	3.58	0.39	0.06	3.13	0.19	0.02	4.07	0.17	0.01
maximum	7.67	1.33	0.24	7.42	1.26	0.38	7.89	1.23	0.26	7.65	1.62	0.33	9.42	1.47	0.27	11.6	1.47	0.25
standard deviation	1.19	0.21	0.05	1.55	0.28	0.11	1.35	0.27	0.07	1.24	0.34	0.07	1.65	0.27	0.06	1.97	0.29	0.06
n AR	21	21	21	21	21	21	20	20	20	21	21	21	21	21	21	20	20	20

[a] AR: annual ring (mm); [b] LE: late-early wood ratio; [c] COS: coefficient of optimal structure

Narrow annual rigs are considered when do not exceed 3 mm. This can be observed in pine wood from trees grown in small spacing where trees compete for sunlight and build long and slender stems. Increments of mean width up to 2 mm are considered as optimal and perform the best durability (Krzysik 1978).

There were 20 or 21 annual rings at the dbh in all analysed trees (tab. 1). Separate measurement of early and late wood in all trees allow calculate mean LE co-efficient, which changes every year (fig. 1).

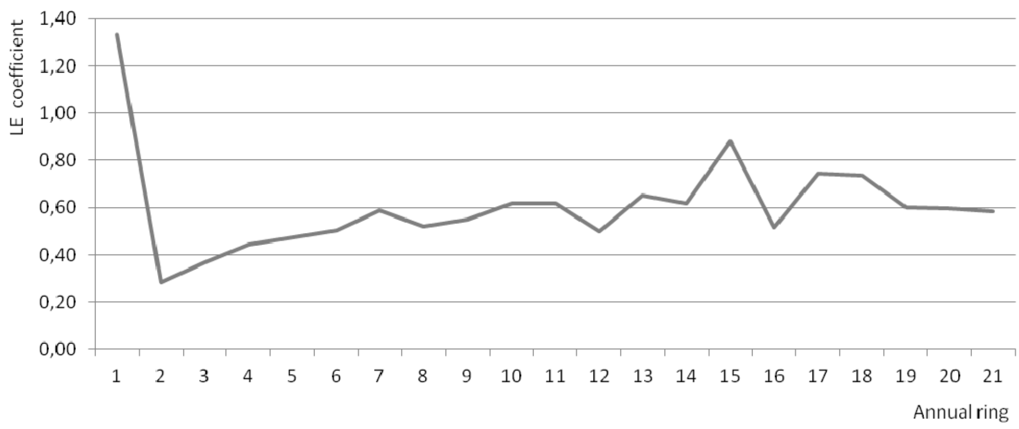

Figure 1. LE coefficient along annual rings – mean from all trees

In the annual ring 15 the ratio of LE shows growth of late wood against early wood. It suggests that 25-year-old trees at the age of 17-19 years (including age of seedlings and growth up to 1 m height) show signs of mature wood on one annual ring (tab. 1).

However, length of tree crown reflects on mature and juvenile wood proportions. Trees from seedling seed orchard grown in large spacing had large and long crowns (slow natural pruning). In such trees mature wood is created later then in trees grown in small spacing (stand conditions). Kučera (1994) in his findings presents that immediate wood in spruce grown in large spacing appears at the age of 28-30 years. According to Jakubowski (2004) juvenile wood in pine wood can be expected up to 16^{th}-20^{th} annual ring. Therefore it can be concluded that in the analysed wood from seedling seed orchard after 17-19 years is still juvenile wood or intermediate wood also because after 15^{th} increment LE ratio was lower in comparison with LE in AR 15.

The thicker the tree the bigger mean annual ring was (fig. 2), which is a natural consequence in trees of the same age.

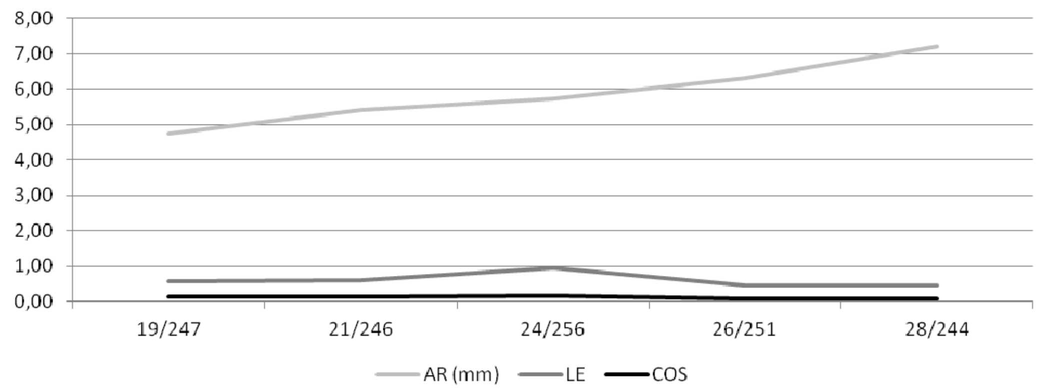

Figure 2. Relation of analysed wood features to mean annual rings

It was also found out that LE coefficient was the highest on tree with average dbh and then it was smaller in the thickest trees (fig. 2). According to Krzysik (1978) the bigger annual ring, the bigger proportion of early wood (and smaller LE). In the presented case this conclusion worked when trees of average and the biggest dbh were considered. At the same time COS did not depend on dbh (fig. 2). In general COS was very low. According to Jakubowski (2010), both, low COS and large annual rings are typical for juvenile wood.

CONCLUSIONS

1. Pine wood from a seedling seed orchard from trees aged 25 had features of juvenile wood. This was due to large increments and big proportion of early wood (low LE and COS coefficients). Large annual rings were due to growing conditions with large spacing and open access to the sunlight.
2. Pine wood from seedling seed orchard was of larger annual rings (mean: 5.83 mm) when compared with trees grown in stand conditions.
3. LE co-efficient suggests that in analysed pine seedling seed orchard trees at the age of 25 there is still intermediate or juvenile wood. However in some cases signs of mature wood appeared.
4. Low COS together with large annual rings suggest that analysed wood was a juvenile wood.

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Streszczenie: *Charakterystyka słojów rocznych sosny pospolitej (Pinus sylvestris* L.*) z plantacyjnej uprawy nasiennej.* Drzewa na plantacyjnej uprawie nasiennej wzrastają w dużej więźbie z szerokim dostępem do światła słonecznego. Warunki te są przyczyną małej konkurencji (o światło), co jest przyczyną znacznych przyrostów na grubość oraz zmniejszonych przyrostów na wysokość w porównaniu z drzewami rosnącymi w warunkach drzewostanowych. Celem niniejszych badań było określenie wielkości przyrostów rocznych sosny wyrosłej w warunkach plantacyjnej uprawy nasiennej. Dodatkowo określono współczynniki PW (stosunek szerokości drewna późnego do szerokości drewna wczesnego) oraz COS (współczynnik optymalności struktury = stosunek PW do szerokości słoja rocznego). Badania przeprowadzono na plantacyjnej uprawie nasiennej sosny pospolitej (*Pinus sylvestris* L.) założonej w roku 1983 w Nadleśnictwie Zdrojowa Góra (Regionalna Dyrekcja Lasów Państwowych w Pile). W pododdziale 95a pomierzono pierśnice i wysokości wszystkich drzew, z których metodą Uricha II wybrano drzewa reprezentatywne, z których z poziomu pierśnicy wycięto krążki. Na przygotowanym drewnie pomierzono szerokości drewna wczesnego oraz późnego za pomocą urządzenia optycznego z podziałką o dokładności 0,02 mm. Uzyskane dane wskazały na bardzo szerokie przyrosty roczne (średnio 5,83 mm). Współczynniki PW oraz COS charakteryzowały się niskimi wartościami co sugerowało, iż 25-letnie drzewa były na etapie wytwarzania drewna młodocianego i/lub drewna przejściowego. Warunki wzrostu i rozwoju drzew na plantacyjnej uprawie nasiennej były główną przyczyną opóźnionego wytwarzania drewna dojrzałego.

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