Electronic Journal of Polish Agricultural Universities is the very first Polish scientific journal published exclusively on the Internet, founded on January 1, 1998 by the following agricultural universities and higher schools of agriculture: University of Technology and Agriculture of Bydgoszcz, Agricultural University of Cracow, Agricultural University of Lublin, Agricultural University of Poznan, Higher School of Agriculture and Teacher Training Siedlce, Agricultural University of Szczecin, and Agricultural University of Wroclaw.

ELECTRONIC JOURNAL OF POLISH AGRICULTURAL UNIVERSITIES

2003
Volume 6
Issue 2
Series FORESTRY

PAZDROWSKI W. SPŁAWA-NEYMAN S. 2003. STAGE GROWTH OF TREES AND ITS EFFECT ON SELECTED PROPERTIES OF NORWAY SPRUCE WOOD (*Picea abies* (L.) Karst.) **Electronic Journal of Polish Agricultural Universities**, Forestry, Volume 6, Issue 2.
Available Online http://www.ejpau.media.pl

STAGE GROWTH OF TREES AND ITS EFFECT ON SELECTED PROPERTIES OF NORWAY SPRUCE WOOD (*Picea abies* (L.) Karst.)

Witold Pazdrowski[1], Stanisław Spława-Neyman[2]
[1]*Department of Timber Utilization, Agricultural University of Poznań, Poland*
[2]*Department of Wood Science and Utilization, Wood Technology Institute, Poznań, Poland*

ABSTRACT

The study covers juvenile, transient and mature wood of Norway spruce. It was acknowledged that there is a close relation between stages of growth and wood properties. It appears that wood as of material, biological origin has diversified properties from the butt log to the crown. The weakest part of the log is the middle part composed of the juvenile wood. For the purpose of this study differentiation of growth stages was based on the wood density.

Key words: stage growth, juvenile wood, transient wood, mature wood, wood properties.

INTRODUCTION

Norway spruce is, after Scots pine, an essential tree species in Poland. It covers 6% of the forest area [1,10]. According to Jaworski [6] and Żybura [17] Norway spruce occurs in two ranges: Northern and South-western. This range covers also south lowland territories of Poland. The above-mentioned ranges are divided in Poland by a spruce-less belt of about 50 to 100 km.

In the course of tree onthogenesis many morphological and physiological changes take place. They are going through development phases, i.e. trough embryonic growth, juvenile, adolescent, mature and senile stages. This development has essential influence on the wood tissue, subsequent development stages of trees and determines overall wood properties[3].

The analysis of wood properties of Norway spruce in subsequent periods of the tree development process, that is juvenile transient and mature wood tissues, will contribute to more rational uses of spruce wood.

This study is an attempt to determine what kind of relation does exist among three stage zones of growth: juvenile, transient and mature, and selected properties of wooden tissue of Norway spruce (*Picea abies* (L.) Karst).

MATERIAL AND METHODS

The studies were carried out in the region of Silesia, in old pine – Norway spruce forest stands in conditions of forest type habitat- coniferous mixed fresh forest stand. In the chosen forest stands sample plot areas were prepared. Research plots were located in Silesian zone, Dept. 2e acc. to Trampler et al [16]. Material was taken from forest inspectorate- Góra Śląska, forest range Zawiszów, section 421. Then in each of them biometric features of all growing trees were measured, that is breast diameters (1.30 m above ground) and the height of trees proportionally to the number of trees in adopted (2 cm) thickness classes. The obtained characteristics of thickness-height of trees allowed, based on the dendrometric method of Urich II [2], for defining the dimensions of model trees and then to look for them on the sample plot area. After 6 trees were cut down, in each of them discs and 1 m long logs were cut out (starting from breast diameter). The discs allowed for the proper measurements, based on which the share of spring and summerwood in annual growth ring was defined. Logs of 1 m. long were used for cutting out small samples, based on which density, compression strength along the grains was examined and also for the examination of strength quality coefficient at compression.

Determination of growth zones for juvenile, transient and mature was made on the basis of their density according to the suggestions of Tassisa, and Burkhard [14]. Determination of selected properties of wood tissue was executed according to recommendations of proper Polish Standards.

Density was determined based on totally dry wood according to the Polish Standard –PN –77/D-04101 [8], while compression strength of wood along the grains , at moisture content level equal 12% according to the PN- 79/D-04102 [9].

The material was analyzed with the use of mathematical statistics. It has been presented in form of tables and diagrams. The paper presents quality features of wood tissues in form of absolute and relative figures.

RESULTS

Statistical characteristics of density of Norway spruce wood presented in table 1 shows, that there is a clear relation between growth stages of tree, its wood, and density.

The juvenile wood zone is showing the lowest density (435 $kg \cdot m^{-3}$). Similar value was found in transient wood; while in the zone of mature wood the average value was 468 $kg \cdot m^{-3}$. Assuming the value obtained for mature wood as 100% and comparison to values obtained for juvenile and transient wood indicates clearly that those tissues have lower density from 6% to 7%. The variability of this feature was 8.1% to 15.7%. The lowest variability coefficient was determined in respect of mature wood, and higher in transient and juvenile zone (table 1).

Table 1. Statistical characteristics of wood density of the Norway spruce (*Picea abies* (L.) Karst.)

Measures of position and distribution	Zone of wood growth		
	Juvenile	Transient	Mature
Arithmetic mean ($kg \cdot m^{-3}$) (%)	435 93	439 94	468 100
Standard deviation ($kg \cdot m^{-3}$)	53.82	68.94	37.96
Variability coefficient (%)	12.4	15.7	8.1

The formation of compression strength along the grains of Norway spruce wood in dependence upon the growth zone is presented in table 2.

Table 2. Statistical characteristics of wood of the Norway spruce (*Picea abies* (L.) Karst.)

Measures of position and distribution	Zone of wood growth		
	Juvenile	Transient	Mature
Arithmetic mean (MPa) (%)	 29.7 67	 38.2 86	 44.2 100
Standard deviation (MPa)	 4.71	 11.59	 5.8 9
Variability coefficient (%)	 15.8	 30.3	 13.3

Juvenile wood has in average lower (29.7 MPa) strength than the transient wood (38.2 MPa) and mature wood (44.2 MPa). When expressing this strength in relative values (%) and with assumption that the strength of mature wood will be 100%, it is to be stressed that the difference between mature wood and juvenile reached 33%, and between mature and transient wood 14%. The lowest variability of this qualitative feature was in mature wood (13.3%) a little higher in juvenile wood 15.8%. In the transient wood it was high and reached 30.3%.

The technical value of wood raw material is the higher, the higher its strength is, and the lower its density is. This condition is essential in selection and use of wood as structural material. Such evaluation could be made when strength quality coefficient is calculated. It depends on the ratio of strength of wood to its density. The statistical characteristics of strength quality coefficient of European spruce wood are presented in table 3. The values of this coefficient were expressed both in absolute linear figures (km) and in relative ones (%).

Mature wood served as comparison and it was compared to juvenile and transient wood. The coefficient defined for European spruce juvenile wood was 27% lower than mature. The difference between transient wood and mature wood was lower 9% (table 3).

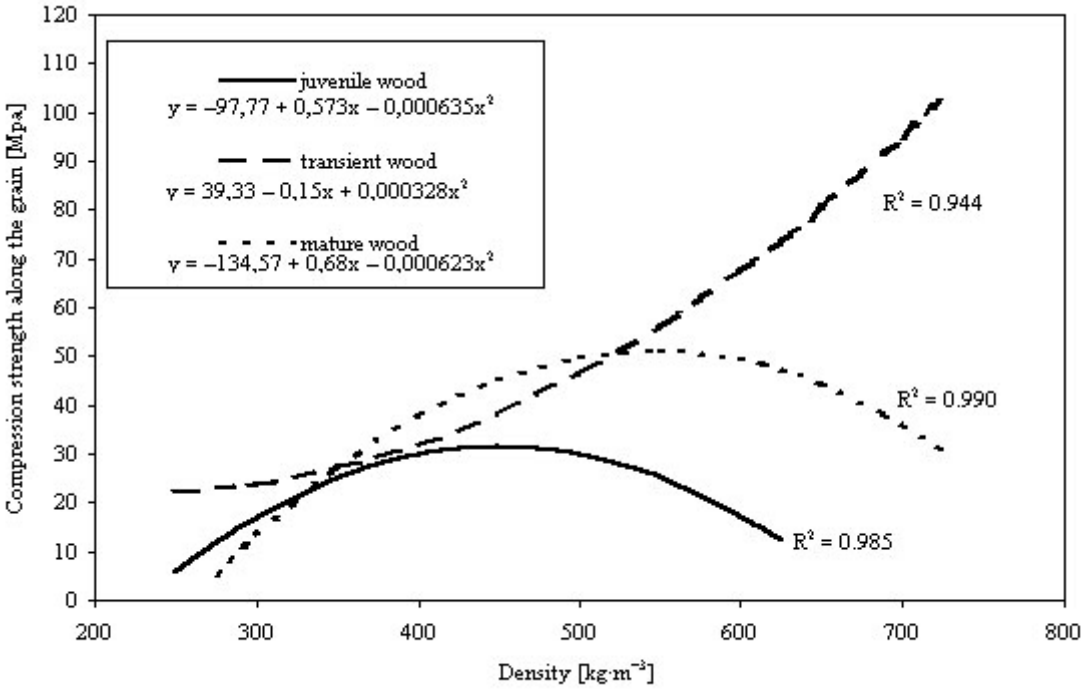
Table 3. Statistical characteristics of strength quality coefficient of wood of the Norway spruce (*Picea abies* (L.) Karst.)

Measures of position and distribution	Zone of wood growth		
	Juvenile	Transient	Mature
Arithmetic mean (km) (%)	 6.9 73	 8.6 91	 9.4 100
Standard deviation (km)	 1.25	 1.28	 0.93
Variability coefficient (%)	 18.0	 14.9	 9.9

When testing the variation of strength quality coefficient at compression along the grains characterised by calculated coefficient, district relation with stage growth of trees and wood was shown. In case of juvenile wooden tissue coefficient of variability was highest (18%), lower in transient wood tissue (14.9%) and lowest for mature wood tissue – at the level of (9.9%), table 3.

In the presented paper the dependence of strength of wood at compression along the grains of juvenile, transient and mature woods against density was characterised by determination coefficients (R^2) and regression equations (Fig. 1).

Fig. 1. The determination coefficients on the effect of the density of Norway spruce wood on the compression strength along the grains



High determination coefficients occurred in zones of mature and transient wood with values: R^2=0.944, R^2=0.990 and R^2=0.985 respectively.

The regression curves show clearly, that the strength of wood tissue of transient zone at Norway spruce increases along the increase of wood density. To 400 kg·m^{-3} dynamics of compression strength increase is low, while after reaching this value of density dynamics of strength changes is exceptionally high. In mature wood the highest strength was found at densities of 500-600 kg·m^{-3}, while at juvenile wood 400-500 kg·m^{-3}, but in both cases after reaching the above values of densities a clear drop of wood strength takes place. It is to be stressed also, that the course of regression curves is showing clearly, that transient zone and mature zone are characterised with better properties in range of densities and wood strength, while juvenile wood in this respect differs from them significantly in minus (Fig. 1). The physical and mechanical properties of wood are in a considerable degree characterised by the share of thick-walled elements, characteristic for summerwood.

The results obtained allow to state, that juvenile wood is of worse technical quality in comparison with transient and mature wood. According to Spława-Neyman and Szczepaniak [12] the above zones are differing not only with properties but also by anatomical structure. As results from Swedish investigations 16% share of juvenile wood deteriorates technical quality of wood and its suitability as structural material [15]. Juvenile wood is characterised by lower percentage of summerwood than mature wood [11].

Juvenile wood is created under strong influence of liven crown [4,5]. Such conclusions were also stated by experts studying Norway spruce and *Cryptomeria japonica* [7,13].

The above-mentioned Norwegian studies of current growth of Norway spruce – *Picea abies* (L.] Karst. and of juvenile wood have shown close relations between the height of crown base, and formation of wood tissue [7].

CONCLUSIONS

1. Stage growth of trees and wood tissues of Norway spruce – *Picea abies* (L.) Karst. have significant effect on the technical value of timber, characterised by wood density, compression strength along the grains, and strength quality coefficient at compression.
2. Wood density, compression strength along the grains, and strength quality coefficient of juvenile wood tissue was lower than in mature and transient tissue. The differences was: 7%, 33% and 27% respectively.

3. Variability of the analysed quality features, that is density, compression strength along the grains and strength quality coefficient at compression was smallest in mature wood zone, while in juvenile and transient zone variability of properties was significantly higher as confirmed by the coefficients of variability.
4. The obtained results prove that juvenile wood tissue of Norway spruce – *Picea abies* (L.) Karst. is to be considered as material of worse technical value than mature or transient wood tissues. This fact is significant for the use and processing of spruce wood, especially in the production process of sawn timber for structural purposes.

REFERENCES

1. Głaz J. 1996. Strategia użytkowania lasu. [Strategy of forest utilization] Przemysł Drzewny 47 (12), 12-15 [in Polish].
2. Grochowski J. 1973. Dendrometria. [Dendrometry] PWRiL Warszawa [in Polish].
3. Grzeczyński T., Spława-Neyman S. 1980. Właściwości przyobwodowej tkanki drewna sosny zwyczajnej (*Pinus silvestris* L.) w zależności od wieku drzew i bonitacji siedliska.[Properties of peripheral wood tissue of Scots pine(Pinus sylvestris L) in dependence upon age of trees and site index] Prace Inst. Technol. Drew., 3/4, 3-17 [in Polish].
4. Hejnowicz Z. 1973: Anatomia rozwojowa drzew. [Development anatomy of trees] PWN Warszawa [in Polish].
5. Hejnowicz Z. 2002. Anatomia i histogeneza roślin drzewiastych [Anatomy and histogenesis of woody plants] Wydawnictwo naukowe PWN [in Polish].
6. Jaworski A. 1995. Charakterystyka hodowlana drzew leśnych.[Breeding characteristics of forest trees] Wyd. II Przeds. Gutenberg. Kraków, 26-28 [in Polish].
7. Kucera B. 1994. A hypothesis relating current annual height increment to juvenile wood formation in Norway spruce. Wood and Fiber Science 26/1, 152-167.
8. Polska Norma [Polish Sandard] -PN –77/D-04101 Drewno. Oznaczanie gęstości. [Wood . Determination of density] [in Polish].
9. Polska Norma [Polish Standard] -PN –79/D –04102. Drewno. Oznaczanie wytrzymałości na ściskanie wzdłuż włókien [Wood. Determination of compression strength along the grains] [in Polish].
10. Praca zbiorowa 1999. Rocznik statystyczny – Leśnictwo [Statistical yearbook-Forestry] GUS. Warszawa [in Polish].
11. Spława-Neyman S., Pazdrowski W., Owczarzak Z. 1995. Biometryczne parametry budowy drewna sosny zwyczajnej (*Pinus sylvestris* L.) w aspekcie więźby sadzenia upraw. [Biometrical parameters of wood of the Scots pine (Pinus sylvestris L) in the aspect of planting distances] Folia Forestalia Polonica Ser. B – Drzewnictwo 26, 73-84 [in Polish].
12. Spława-Neyman S., Szczepaniak J. 1999. Niejednorodność cykliczna budowy drewna iglastego. [Cyclical heterogenity of structure of the coniferous wood] XIII Konferencja Naukowa Wydziału Technologii Drewna SGGW Drewno – Materiał o wszechstronnym przeznaczeniu i zastosowaniu. Warszawa 16-18 listopad, 21-24 [in Polish].
13. Sung-Young Wong and Kan Nan Chen 1992. Effect of plantation spacings on tracheids length, annual ring and percentage of Taiwan –grown Japanese cedar Makuzi Gakaishi 38 (7), 615-656.
14. Tassisa G., Burkhart H. E. 1997. Juvenile – mature wood demarcation in loblolly pine trees. Wood and Fiber Science, 30 (2), 119-127.
15. Thörnquist T. 1993. Juvenile wood in coniferous trees. Document D. 13. Uppsala.
16. Trampler i inn. 1990. Siedliskowe podstawy hodowli lasu. [Site type background of forest breeding] PWiRL Warszawa [in Polish].
17. Żybura H. 1990. Lasotwórcza rola świerka pospolitego *Picea abies* (L.) Karst. w Polsce ze szczególnym uwzględnieniem obszaru nizinnego.[Forest creation rrole of tthe Norway spruce Picea abies (L.) Karst in Poland with special attention to the lowlands] Rozprawy Naukowe i Monografie. Warszawa, Wyd. SGGW-AR [in Polish].

This study has been sponsored by KBN
Number of project 3 P06 L 006 23

Witold Pazdrowski
Department of Timber Utilization
The August Cieszkowski Agricultural University of Poznań
ul. Wojska Polskiego 71A, 60-625 Poznań, Poland
tel. +48 (061) 848-77-57
e-mail: pazdroww@au.poznan.pl

Stanisław Spława-Neyman
Department of Wood Science and Utilization
Wood Technology Institute in Poznań
ul. Winiarska 1, 60-654 Poznań, Poland

Responses to this article, comments are invited and should be submitted within three months of the publication of the article. If accepted for publication, they will be published in the chapter headed 'Discussions' in each series and hyperlinked to the article.