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THE PROPORTION AND SOME SELECTED PHYSICAL AND MECHANICAL PROPERTIES OF JUVENILE MATURING AND ADULT WOOD OF BLACK PINE AND SCOTS PINE

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ABSTRACT

In the performed investigations an attempt was made to determine the proportion and some selected physical and mechanical properties of juvenile and transitional (maturing) and adult wood in boles of black pine and Scots pine trees grown in conditions of the fresh broad-leaved forest.

The performed studies revealed that the black pine, at the age of 91, had distinctly less juvenile wood and more maturing and adult wood than the Scots pine. Juvenile wood in both of the examined pine tree species was characterised by lower values of the analysed physical and mechanical properties than adult and maturing wood.

Key words: juvenile wood, maturing (transitional wood), adult wood, physical properties, mechanical properties, fresh broad-leaved forest.

INTRODUCTION

The wood tissue developing in leaved twigs or in other parts situated close to leaved shoots exhibits a different structure than the wood developing in parts which are situated some distance from the above-mentioned areas [4, 5, 10, 13]. An example of wood developed in conditions of a strong influence of the crown (assimilation apparatus), at considerable availability of hormones, is the area of the core wood (juvenile) which develops during the early stages of tree life or building up in the apex portions of the stem within the region of the tree crown [9, 12].

The wood of this area is characterised by a number of features which are considered unfavourable from the point of view of the quality of the produced wood raw material, i.e. a low share of thick-walled elements (late wood), low wood density, smaller cellulose content, large angle of cellulose fibrillar systems in relation to the cell axis, smaller length of fibre elements, greater contraction coefficient and a considerably worse durability [6, 9].

Juvenile wood occurs in all trees and its structure and properties differ from the tissues of adult wood found in the same tree. The above-mentioned variations affect the undesirable heterogeneity of wood functional properties found to occur within the tree trunk or bole [1, 2, 7, 8, 11].

Zobel and Talbert [14] argue that the main cause of wood variability of coniferous species should be attributed to the presence of juvenile wood and its proportion to adult wood in the tree, especially in its functional part. The above-mentioned characters exert a significant influence on wood physical and mechanical properties and, consequently, affect its utilisation. The recognition of its properties and determination of the proportion of juvenile wood in boles or trunks of trees growing in our forests will allow optimising the processing and utilisation of the manufactured wood raw material.

The objective of this research project was an attempt to determine the proportion and selected physical and mechanical properties of juvenile wood as well as transitional and adult wood in boles of black pine and Scots pine trees developed on the fresh broad-leaved forest site.

RESEARCH MATERIAL AND METHODS

Trees for investigations were cut out from a 91-year old stand of the following tree composition: 7Db (oak), 2So (Scots pine) and 1So cz (black pine). The experimental surface was selected in the 24f compartment of the Uniejów Forest Range, in the Turek Forest Division of the Poznań RDLP. Breast height diameters as well as heights of all growing trees in the designated experimental area (1 ha) were measured proportionally to the size in the adopted (2 cm) degrees of thickness. After obtaining thickness-height characteristics of the trees, dimensions of test trees were calculated using, for this purpose, the Urich I dendrometric method [3] and appropriate trees were selected in the stand. The total of six trees were chosen of which 3 were black pine and 3 Scots pine trees.

After cutting the trees, disks were cut out from each bole starting at the tree base and then at the distance of 1 m and later at 2 m intervals up to the top of each tree. In addition, wood blocks were cut out from each of the trees from the segments extending from the height of 1.30 to 2.0 m, which were later used to carry out wood physical and mechanical investigations. The obtained disks were used to perform breadth measurements of early and late wood areas in consecutive wood increments (annual rings). The measurements were carried out using a LINTAB 3 increment metre coupled with a computer. On the basis of the performed measurements, it was possible to determine the breadth proportion of the late wood area to that of early wood in annual rings. This, in turn, allowed the identification of juvenile wood and transitory and adult wood in the boles of test trees.

The method of determining wood physical and mechanical properties was based on the assumptions of appropriate standards. The performed investigations included: wood pure density, along-fibre compression strength, static bending strength as well as the modulus of elasticity during static bending. All the examined mechanical properties were determined at 12% absolute wood moisture content.

The obtained results were presented in tables expressing them in absolute and relative values.

RESEARCH RESULTS

The black pine, which developed in the conditions of the fresh broad-leaved site of a 91-year old forest, was characterised by a significantly lower content of juvenile wood in its bole and a higher content of transitional and adult wood in comparison with the Scots pine growing in the same stand. This regularity is confirmed by values of the ratio of juvenile wood volume to transitory and adult wood volume presented in Table 1. Assuming the mean value of the analysed ratio in the black pine as 100%, this value was found to be by 31% higher in the case of the Scots pine (Table 1). Numerical values characterising the discussed volume ratio of juvenile wood to transitory and adult woods in relation to the biosocial position of trees in the stand exhibit certain variability. In both of the examined pine species, dominant trees showed a higher value of this ratio than representatives of predominant and co-dominant groups of trees.

Table 1. Statistical characteristics of the volume ratio of juvenile wood to transitory and adult wood in boles of black pine (*Pinus nigra* Arnold) and Scots pine (*Pinus sylvestris* L.) in relation to their biosocial position in the stand

Tree biosocial position	Juvenile wood/transitory and adult wood	
	Black pine	Scots pine
Predominant	0.4286	0.4776
Dominant	0.4783	0.6410
Codominant	0.4242	0.6207
Arithmetic mean	0.4437	0.5798
[%]	100	131
Standard deviation	0.2453175	0.07271654
Variability coefficient [%]	5.5	12.5

The analysis of the obtained results concerning the selected wood physical and mechanical properties of both pine species (Tables from 2 to 5) showed that the examined wood properties were higher, generally speaking, in the black pine trees in comparison with the Scots pine, with the exception of the co-dominant group of trees in the first of the two pine tree species. In the case of this group, lower values were recorded for: the along-fibre compression strength in juvenile and transitory wood, static bending strength in juvenile, transitory and adult wood as well as the elasticity modulus in juvenile and transitory wood in comparison with the Scots pine. The biosocial position of trees in the stand of both pine tree species affected the variability of the analysed wood properties. Juvenile wood was characterised by lower values of the examined wood physical and mechanical properties in comparison with adult and transitory wood. The highest parameters of the physical and mechanical wood properties were observed in the adult wood of both pine tree species. Differences in the recorded relative values, depending on the biosocial position of trees, ranged from some to several percentage points (Tables from 2 to 5).

Table 2. Statistical characteristics of the wood density of black pine (*Pinus nigra* Arnold) and Scots pine (*Pinus sylvestris* L.) in relation to their biosocial position in the stand and wood area

Tree species	Biosocial position	Position and dispersion measures	Wood area		
			juvenile	transitory	Adult
Black Pine	Predominant	Arithmetic mean [MPa]	664	693	703
		[%]	94	98	100
		Variability coefficient [%]	5.4	2.8	6.8
	Dominant	Arithmetic mean [MPa]	683	768	782
		[%]	87	98	100
		Variability coefficient [%]	10.6	5.4	1.4
	Codominant	Arithmetic mean [MPa]	756	792	829
		[%]	91	96	100
		Variability coefficient [%]	15.0	7.9	8.5
Scots Pine	Predominant	Arithmetic mean [MPa]	482	502	502
		[%]	96	100	100
		Variability coefficient [%]	5.0	6.6	5.3
	Dominant	Arithmetic mean [MPa]	561	614	620
		[%]	90	99	100
		Variability coefficient [%]	11.0	9.7	8.2
	Codominant	Arithmetic mean [MPa]	614	625	651
		[%]	94	96	100
		Variability coefficient [%]	4.9	6.1	4.6

Table 3. Statistical characteristics of the along-fiber wood compression strength of black pine (*Pinus nigra* Arnold) and Scots pine (*Pinus sylvestris* L.) in relation to their biosocial position in the stand and wood area

Tree species	Biosocial position	Position and dispersion measures	Wood area		
			juvenile	transitory	Adult
Black pine	Predominant	Arithmetic mean [MPa]	53.0	54.0	56.6
		[%]	94	95	100
		Variability coefficient [%]	13.3	13.6	10.8
	Dominant	Arithmetic mean [MPa]	49.7	63.0	66.6
		[%]	75	94	100
		Variability coefficient [%]	19.7	9.8	9.0
	Codominant	Arithmetic mean [MPa]	32.1	48.6	55.8
		[%]	58	87	100
		Variability coefficient [%]	19.6	18.4	12.3
Scots Pine	Predominant	Arithmetic mean [MPa]	39.6	41.2	42.8
		[%]	92	96	100
		Variability coefficient [%]	12.4	10.9	9.9
	Dominant	Arithmetic mean [MPa]	43.4	49.3	50.1
		[%]	87	98	100
		Variability coefficient [%]	15.8	10.4	8.0
	Codominant	Arithmetic mean [MPa]	47.7	51.9	54.2
		[%]	88	96	100
		Variability coefficient [%]	13.6	10.5	9.2

Table 4. Statistical characteristics of the wood static bending strength of black pine (*Pinus nigra* Arnold) and Scots pine (*Pinus sylvestris* L.) in relation to their biosocial position in the stand and wood area

Tree species	Biosocial position	Position and dispersion measures	Wood area		
			juvenile	transitory	Adult
Black pine	Predominant	Arithmetic mean [MPa]	91.7	97.2	107.6
		[%]	85	90	100
		Variability coefficient [%]	20.5	14.9	13.3
	Dominant	Arithmetic mean [MPa]	89.4	114.6	117.0
		[%]	76	98	100
		Variability coefficient [%]	35.0	19.2	8.1
	Codominant	Arithmetic mean [MPa]	55.3	81.7	104.8
		[%]	53	78	100
		Variability coefficient [%]	31.5	27.4	7.7
Scots Pine	Predominant	Arithmetic mean [MPa]	59.2	75.4	78.2
		[%]	76	96	100
		Variability coefficient [%]	11.5	7.7	5.5
	Dominant	Arithmetic mean [MPa]	70.7	90.2	94.1
		[%]	75	96	100
		Variability coefficient [%]	19.9	12.9	5.9
	Codominant	Arithmetic mean [MPa]	87.6	99.5	106.5
		[%]	82	93	100
		Variability coefficient [%]	10.2	9.7	8.1

Table 5. Statistical characteristics of the elasticity modulus at wood static bending of black pine (*Pinus nigra* Arnold) and Scots pine (*Pinus sylvestris* L.) in relation to their biosocial position in the stand and wood area

Tree species	Biosocial position	Position and dispersion measures	Wood area		
			juvenile	transitory	Adult
Black pine	Predominant	Arithmetic mean [MPa]	9582.4	10137.9	11064.5
		[%]	87	92	100
		Variability coefficient [%]	21.9	20.5	19.4
	Dominant	Arithmetic mean [MPa]	8829.0	10801.4	11716.0
		[%]	75	92	100
		Variability coefficient [%]	37.5	17.1	13.4
	Codominant	Arithmetic mean [MPa]	4286.3	8360.9	11714.6
		[%]	36	71	100
		Variability coefficient [%]	34.2	33.9	12.6
Scots Pine	Predominant	Arithmetic mean [MPa]	5590.8	7626.1	8001.6
		[%]	70	95	100
		Variability coefficient [%]	13.8	12.7	5.0
	Dominant	Arithmetic mean [MPa]	6748.8	9285.8	9616.9
		[%]	70	96	100
		Variability coefficient [%]	25.4	17.3	12.8
	Codominant	Arithmetic mean [MPa]	8444.5	10390.9	10781.1
		[%]	78	96	100
		Variability coefficient [%]	15.9	12.4	8.6

The variability of the examined properties was, generally speaking, greater in the case of juvenile wood and distinctly smaller in adult wood. Some deviations from the above-stated regularity were found in the case of wood density, i.e. in the case of a predominant tree of black pine and predominant and co-dominant trees of Scots pine. In the first two cases, the variability of this physical property was slightly higher in adult wood than in the juvenile one, whereas in the third case – slightly lower (Table 2).

SUMMING UP OF RESEARCH RESULTS

Juvenile wood develops in the tree bole during the initial phase of wood tissue production. Most commonly, it develops during a few to several years of the tree life and is strongly influenced by its assimilation apparatus (tree crown) [5, 6, 9]. Wood developing later on is usually referred to as adult wood. Both wood areas, i.e. juvenile and adult, exhibit different proportions in the tree bole. The above proportion depends on a number of factors of which the most important ones are: tree age, site conditions and tree species [13]. Pine tree species analysed in this study revealed distinct variations in their proportions of juvenile and adult wood. A more favourable composition of the above-mentioned wood areas (as a raw material) was observed in the black pine than in the Scots pine, even though the trees developed in similar site-climatic conditions and applying similar silvicultural procedures during individual developmental stages of the stand.

The observed differences in the proportion of juvenile and transitory and adult wood in tree boles as well as in the analysed physical and mechanical properties can be attributed, primarily, to pine species and to the biosocial position of trees in the stand.

A thorough knowledge of quantitative proportions of juvenile wood to those of transitory and adult ones in the boles of both pine tree species as well as of their physical and mechanical properties will have a significant importance for the rational processing and utilisation of wood raw material harvested from stands in which black pine will be one of constituent elements.

CONCLUSIONS

1. Both pine species, which grew in similar site conditions, at the age of 91 exhibited differences in the proportions of juvenile and transitory (maturing) and adult wood in the bole. The black pine showed considerably less juvenile wood and more transitory and adult wood than the Scots pine.
2. Juvenile wood in both pine species was characterised by lower values of the analysed physical and mechanical properties than adult and maturing (transitory) wood.
3. The biosocial position of trees in the stand affected, to a certain degree, the proportion of juvenile wood and transitory and adult wood in boles. It also exerted some influence on variations in the analysed wood physical and mechanical properties.

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