Acta Sci. Pol.
Silv. Colendar. Rat. Ind. Lignar. 7(1) 2008, 31-38

PERCENTAGE SHARE OF SAPWOOD AND HEARTWOOD IN STEMS OF EUROPEAN LARCH (*LARIX DECIDUA* MILL.) REPRESENTING II AND III CLASS OF AGE GROWN IN DIFFERENT FOREST SITE TYPES, REPRESENTING MAIN TREE STAND AT KRAFT BIOSOCIAL CLASSIFICATION

Marcin Nawrot, Witold Pazdrowski, Marek Szymański
Agricultural University of Poznań

Abstract. The study is an attempt to determine share of sapwood and heartwood in stems of European larch trees from II and III class of age, grown in conditions of fresh coniferous mixed forest site (BMśw), fresh forest mixed site (LMśw), fresh forest site (Lśw). The highest hare of heartwood was observed in stems of European larch in conditions of fresh forest site Lśw, and the smallest in conditions of fresh coniferous mixed forest site (BMśw). Differences were also observed within the investigated classes of age, and higher share of heartwood observed in III class of age. The smallest share of heartwood characterized codominant trees and the highest dominant trees (from main tree stand in Kraft classification).

Key words: sapwood, heartwood, European larch, forest site type, class of age

INTRODUCTION

Share of sapwood and heartwood is one of the most important criteria of raw wood material usefulness for different types of industry. Wide differentiation in physical, chemical and mechanical properties determines the purpose of wood material which is found in sapwood and heartwood. Ply-wood industry requires sapwood, but chemical and fermentation industry for tanks and vats made of wood prefer heartwood and ignore sapwood for its higher permeability and minor durability [Krzysik 1970].

Quantitative proportion of heartwood and sapwood in stems of pine tree depends mainly on tree age, climate and soil conditions and localization on tree of the examined disc, and magnitude of the tree crown [Duda and Pazdrowski 1975].

Corresponding author – Adres do korespondencji: Mgr inż. Marcin Nawrot, Department of Forest Utilization of Agricultural University of Poznań, Wojska Polskiego 71 A, 60-625 Poznań, Poland, e-mail: marcin.nawrot@au.poznan.pl

European larch is a specific species, because it early culminates volume growth and keeps it for a long time, in a tree stand with high wood reserve and good value of wood [Chylarecki 2000]. On examined forest site types in State Forest, European larch is proposed to be an admixture for refined quality of produced raw wood material.

The aim of this study is an attempt to determine the share of sapwood and heartwood in stems of European larch representing first three class of Kraft biosocial classification in two different class of age, grown in conditions of fresh coniferous mixed forest site (BMśw), fresh forest mixed site (LMśw) and fresh forest site (Lśw).

MATERIAL AND METHODS

Investigations were carried out in a tree stands from II and III class of age grown on the terrain of Miradz Forest District (Regional State Forest Directorate Toruń), where European larch was grown as admixture (minimum as a group) in conditions of fresh coniferous mixed forest site (BMśw), fresh forest mixed site (LMśw) and fresh forest site (Lśw). In the chosen part of the forest the diameter was measured at breast height and put in two cm diameter class. Then was made measurement of tree height adequate to the frequency in diameter class. On the basis of height and diameter characteristics of trees 18 model trees were chosen (three in each of the investigated plot) using Hartig's dendromertic method [Grochowski 1973] and Kraft biosocial classification (only three first class of biosocial Kraft classification – the main tree stand were taken into consideration). The model trees were cut down of and their trunks were cut into two meter sections and from middle of each section were taken discs necessary for the study of some macrostructural features of wood. Discs were useful for measurements of sapwood and heartwood width and diameter made in two upright directions (North and South and East and West). On the basis of the gained measurements volume of sapwood ring was calculated, as well as heartwood cylinder in each of two meter sections of the trees investigated. During the analysis of the results arithmetic mean was used from sapwood and heartwood zones measured in each tree for each examined tree stand.

RESULTS

Percentage share of volume of sapwood and heartwood in the investigated class of age is shown in Table 1 and Figure 1. Higher share of heartwood and smaller share of sapwood were investigated at trees from III class of age (41-60 years old). Difference in share of the examined zones of wood between trees from II (21-40 years old) and III (41-60 years old) class of age (24 years old tree stand representing II class of age and 45 years old tree stand representing III class of age) was more than 13% more favourable for trees representing III class of age.

Share of sapwood and heartwood zones in stems of the analysed trees depends on tree age. Share of sapwood and heartwood (in volume) in II and III class of age was different at statistical important level (Table 2).

Share of sapwood and heartwood in tree stems investigated trees depend on their age.

Table 1. Statistical comparison of sapwood and heartwood share in investigated classes of age
Tabela 1. Porównanie statystyczne udziałów bielu i twardzieli w badanych klasach wieku

	Mean value, m^3 – Wartość średnia, m^3		t-Student's t-Studenta	Level of statistical importance Poziom istotności
	II class of age II klasa wieku	III class of age III klasa wieku		
Sapwood Biel	0.13	0.29	–3.39	$p < 0.05$
Heartwood Twardziel	0.09	0.37	–5.54	$p < 0.05$

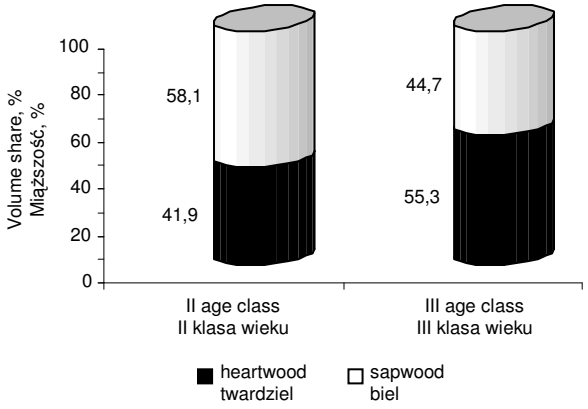

Fig. 1. Mean percentage share of volume of sapwood and heartwood in stems of European larch on ground of class of age
Rys. 1. Średni procentowy udział miąższości bielu i twardzieli w strzałach modrzewia europejskiego na tle klas wieku

Percentage share of volume of sapwood and heartwood in examined forest site types shows Table 1 and Figure 2 a and b. The highest share of sapwood fined in conditions of Lśw, and the smallest in conditions of BMśw. These dependences were observed in both investigated class of age. From the data presented, it is evidente that habitats conditions influenced the dynamics of heartwood production process. Richer site type of forest probably provided quicker maturation of parenchyma cells and in this way influenced dynamic process of heartwood production in stems of trees.

The share of sapwood and heartwood in each biosocial Kraft class is shown in Table 1 and Figure 3. In II class of age the biggest share of heartwood characterized I Kraft class (42.7%), and the smallest III Kraft class (40.3%). In III class of age the biggest share of heartwood was observed in II Kraft class (59.6%), and the smallest (51.4%) at tree from III Kraft class. The share of sapwood was presented inversely to the share of heartwood (Fig. 3). Differences in share of investigated zones of wood was higher in III Kraft class (8.2%) then in II class of age (2.4%).

Table 2. Percentage share of volume of sapwood and heartwood for experimental trees in investigated classes of age on the basis of Kraft classes and forest site types
Tabela 2. Procentowy udział miąższości bielu i twardzieli u drzew próbnych w badanych klasach wieku na tle klas Krafta i siedliskowych typów lasu

Kraft biosocial class Klasy Krafta	II class of age – II klasa wieku						III class of age – III klasa wieku					
	BMśw		LMśw		Lśw		BMśw		LMśw		Lśw	
	S	H	S	H	S	H	S	H	S	H	S	H
I	59.6	40.4	57.9	42.1	54.2	45.8	35.5	64.5	55.9	44.1	43.9	56.1
II	59.4	40.6	56.5	43.5	56.5	43.5	49.9	50.1	33.4	66.6	37.9	62.1
III	60.4	39.6	61.7	38.3	57	43	52.7	47.3	43.9	56.1	49.3	50.7
Standard deviation Odchylenie standardowe	0.52		2.69		1.49		9.22		11.25		5.7	
Mean value Wartość średnia	59.8	40.2	58.7	41.3	55.9	44.1	46.1	53.9	44.4	55.6	43.7	56.3

S – sapwood, H – heartwood, BMśw – fresh coniferous mixed forest site, LMśw – fresh forest mixed site, Lśw – fresh forest site.
S – biel, H – twardziel, BMśw – bór mieszany świeży, LMśw – las mieszany świeży, Lśw – las świeży.

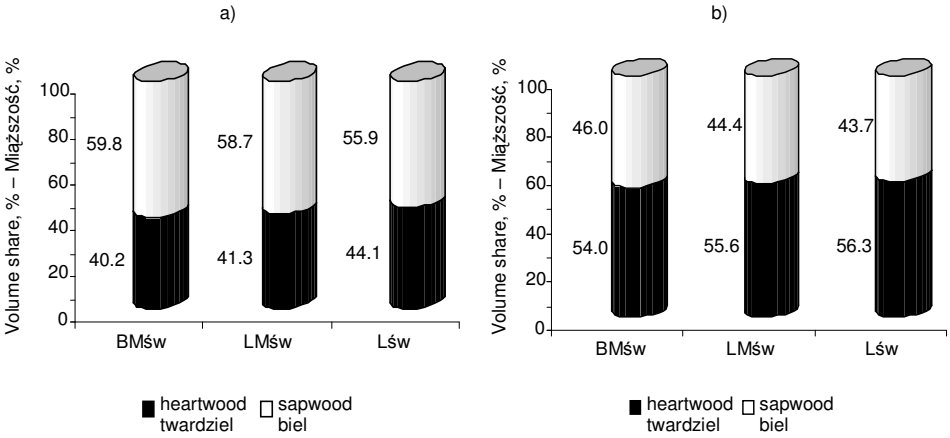

Fig. 2. Mean percentage share of volume of sapwood and heartwood in stems of European larch in investigated classes of age on the basis of forest site types: a – II class of age, b – III class of age
Rys. 2. Średni procentowy udział miąższości drewna bielastego i twardzielowego w strzałach modrzewi w badanych klasach wieku na tle typów siedliskowych lasu: a – II klasa wieku, b – III klasa wieku

Figures 4 a and b present radial location of zones of sapwood and heartwood along stems of European larch in two investigated classes of age. Crossing point of curves represented share of zones of sapwood and heartwood (50% in radial cut) are located lower in stems of II class of age (Fig. 4 a) then in trees from III class of age (Fig. 4 b).

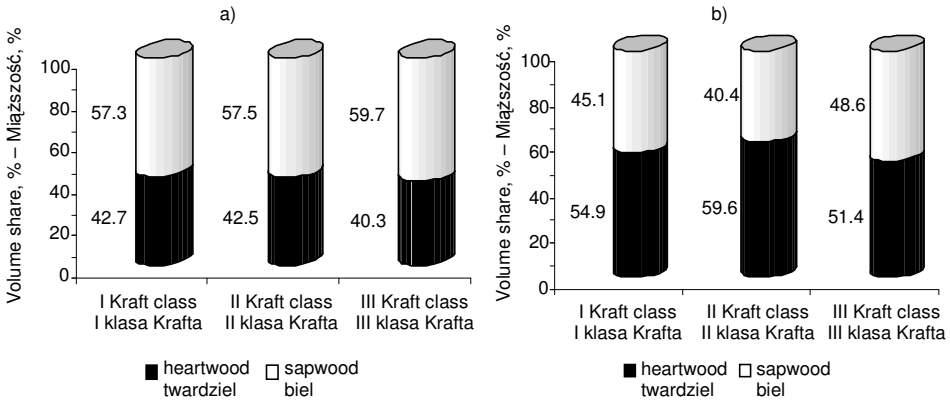

Fig. 3. Mean percentage share of volume of sapwood and heartwood in stems of European larch in Kraft classes on the basis of age class: a – II class of age, b – III class of age

Rys. 3. Średni procentowy udział miąższości drewna bielastego i twardzielowego w strzałach modrzewi w klasach Krafta na tle klas wieku: a – II klasa wieku, b – III klasa wieku

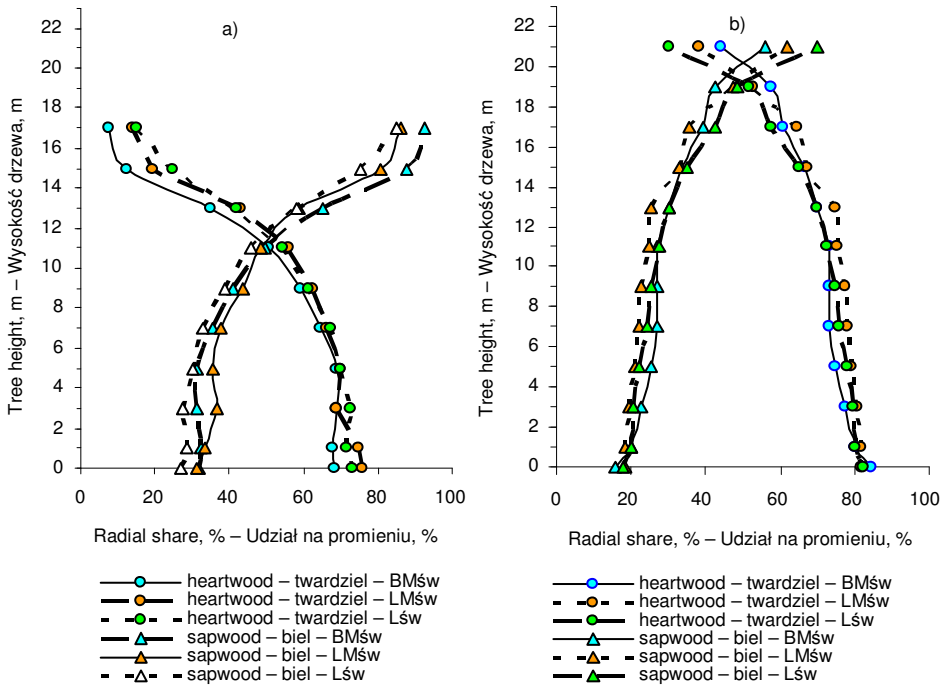

Fig. 4. Mean percentage share of sapwood and heartwood on radial cross-section in stems of European larch grown in conditions of fresh coniferous mixed forest site (BMśw), fresh forest mixed site (LMśw) and fresh forest site (Lśw) in ground of class of age: a – II class of age, b – III class of age

Rys. 4. Średni procentowy udział na promieniu bielu i twardzieli w strzałach modrzewia europejskiego wyrosłego w warunkach BMśw, LMśw i Lśw na tle klas wieku: a – II klasa wieku, b – III klasa wieku

In II class of age crossing point of the curves was located on the level of 65% of tree height and in III class of age on 90% of tree height (Fig. 4 a and b). In II class of age the lowest located crossing point of the curves was observed in III class of age grown in condition of Lśw. In both classes of age the share of heartwood was the biggest near the ground level and decreased into top direction (Fig. 4 a and b).

DISCUSSION

Share of heartwood in stems of European larch significantly increases with the age of trees. A similar statement was made by Jakubowski [2004], while investigating pine trees. On the other hand Duda and Pazdrowski [1975] observed connection between fertility of site type and the share of heartwood in pine trees. Pine trees grown in richer plant association (richer, fertile soils) produced more heartwood than trees from poor soil conditions. In 100 year old pine trees differences in percentage share of heartwood between *Leucobryo--Pinetum* (poor association) and *Galio-Carpinetum* (rich association) was about 16%, so more than in European larch stems in II and III classes of age (Fig. 2 a and b). That differences probably originated from differences in age class of the investigated species, because alongside with the progress of tree age the difference in the share of sapwood and heartwood in different conditions of forest site types can be increasing.

In the process of heartwood production the important element is time factor, especially maturation of parenchyma cells, which termination of life is initiating the moment for changing the sapwood into heartwood. In the opinion of Hejnowicz [2002] until the age of a tree stem is under the border of living parenchyma cells – wood contains only sapwood. The process of increasing of the volume of heartwood is a function of time – that is why we are talking about the process of heartwood production, determining its dynamics.

Differentiation of sapwood and heartwood share in stems of trees from different forest site conditions is marked in both analysed class of age, and more significantly in II class of age. In the opinion of Jakubowski [2004], who examined pine trees – differentiation of share of sapwood and heartwood in different site conditions, was observed only in trees from V class of age, so much later than in European larch trees. Worth stressing is the fact, that the share of heartwood is increasing in case of European larch trees observing from the poorest site conditions to the best ones. These relationship was identified in both classes of age, showing a significant trend of probably more efficient ongoing process of heartwood production in trees growing in better fertility conditions. So raw wood material from higher class of age and better site conditions will be better for construction purposes and for chemical industry opposite to wood originated from younger trees and poorer site conditions, which should be used for plywood and cellulose industry [Jelonek at al. 2006]. In opinion of Pazdrowski [1994] for optimum in wood utilization it is necessary to have its correct evaluation. In this valuation the type of wood, its size, and common defects, a wide range of macrostructural features of produced raw wood material should be considered. Definitely the smallest share of heartwood characterized III Kraft class, that is codominant trees. This fact can be interpreted probably by slower ongoing process of heartwood production inside tree stem originated from worse biosocial position in tree stand. As it was stated by Pazdrowski and Spława-Neyman [1993] biosocial class of tree in a tree stand, and the problem of the tree crown closely connected with it can be defined as symptoms of maturation of pine tree tracheas. So worse biosocial position in a tree stand can retard maturation and cause

dying of parenchyma cells which is expressed by slower ongoing process of heartwood formation in tree stems. Differences between I and II Kraft class are not large and can originate from natural process of changing position in the tree stand structure and connected with it process of natural pruning.

Codominant trees are characterized by higher share of shadow part of the crown if compared with trees from higher biosocial class, that can influence later dying of parenchyma cells and lower dynamics in the process of heartwood formation. From the available bibliography it is known, that light-rich part of the tree crown is in higher degree responsible for assimilation and transpiration processes than the shadow-part of the tree crown [Assmann 1968]. Between the transpirating crown and the area of sap and water transport there is a balance, so it is not easy to explain such a high share of sapwood in codominant trees. In II class of age the highest share of heartwood characterized predominant trees (42.7%) and in III class of age dominant trees (59.6). Dominant trees (II Kraft class) are the most numerous in a tree stand, so II Kraft class is the most changeable in biometric features. It is also important, that these trees are changing their biosocial position most often – and are the most labile layer of tree stand [Jaworski 2004], that can influence for share of investigated zones of wood in such photophilous species as European larch.

The focus subject of the study is important not only for general scientific interests, but also for forestry and wood industry practice. Good knowledge of factors determining the share of the analysed types of wood in tree stems can help in the production of good quality wood and optimalization of its utilization, but owing to its complicated character it is still necessary to carry out further investigations.

CONCLUSIONS

1. Better quality of forest site types gives raw wood material production with higher share of heartwood. In both investigated classes of age the highest share of heartwood was stated in European larch trees growth in conditions of Lśw and the smallest in the conditions of BMśw. In the conditions of Lśw the share of heartwood was on the average about 50.2%, at LMśw – 48.4% and at BMśw – 47%.

2. The share of heartwood increases proportionally to the age of trees. In III class of the age the share (volume) of heartwood was bigger than in II class of age by about 13%.

3. The smallest mean share of heartwood (45.8% in investigated class of age was stated in trees from third Kraft class (codominant), and the highest (51.5%) in trees from second Kraft class (dominant).

4. Differences were stated in radial share of sapwood and heartwood zones in stems of European larch grown in conditions of BMśw, LMśw, Lśw.

REFERENCES

Assmann E., 1968. Nauka o produkcyjności lasu [Theory about the productivity of forest]. PWRiL Warszawa [in Polish].

Chylarecki H., 2000. Modrzewie w Polsce. Dynamika wzrostu, rozwój i ekologia wybranych gatunków i ras [European larch in Poland. Dynamic of height growth, development and ecology of some species and kind of European larch]. Bogucki Wyd. Nauk. Poznań [in Polish].

Duda J., Pazdrowski W., 1975. Procentowy udział twardzieli i bielu w 100-letnich sosnach zwyczajnych (*Pinus sylvestris* L.) rosnących w różnych warunkach siedliskowych [Percentage proportion of heartwood and sapwood in 100-year old Scots pine trees]. Sylwan 11, 57-64 [in Polish].
Grochowski J., 1973. Dendrometria [Dendrometry]. PWRiL Warszawa [in Polish].
Hejnowicz Z., 2002. Anatomia i histogeneza roślin naczyniowych [Anatomy and histogenesis of vascular plants]. PWN Warszawa [in Polish].
Jakubowski M., 2004. Udział bielu, twardzieli, drewna młodocianego i dojrzałego w strzałach sosen zwyczajnych (*Pinus sylvestris* L.) wyrosłych w różnych warunkach siedliskowych [Proportion of sapwood, heartwood, juvenile and mature wood in trunks of Scots pine (*Pinus sylvestris* L.) developed in different site conditions]. Sylwan 8, 16-24 [in Polish].
Jaworski A., 2004. Podstawy przyrostowe i ekologiczne odnawiania oraz pielęgnacji drzewostanów [Ecological and growth bases of stands regenerate and tending]. PWRiL Warszawa [in Polish].
Jelonek T., Pazdrowski W., Tomczak A., Stypuła I., 2006. Radial and axial variability of the proportion of sapwood and heartwood in stems of Scott pine trees (*Pinus sylvestris* L.) developed in conditions of former farmlands and typical forest sites. EJPAU, Forestry 9, 3.
Krzysik F., 1970. Nauka o drewnie [Wood science]. PWN Warszawa [in Polish].
Pazdrowski W., 1994. Współzależność między niektórymi cechami ilościowymi koron drzew a makrostrukturą drewna sosen zwyczajnych (*Pinus sylvestris* L.) wyrosłych w warunkach BMśw [Interdependence between some quantitative features of crowns of trees and the macrostructure of the wood of Scots pines (*Pinus sylvestris* L.) growth in conditions of fresh coniferous mixed forest site]. Sylwan 11, 79-88 [in Polish].
Pazdrowski W., Spława-Neyman S., 1993. Badania wybranych właściwości drewna sosny zwyczajnej (*Pinus sylvestris* L.) na tle klas biologicznych w drzewostanie [Examining of chosen properties of the wood of the Scots pine (*Pinus sylvestris* L.), relating to biological classes in the tree stand]. Folia For. Pol. Ser. B, 24 [in Polish].

PROCENTOWY UDZIAŁ BIELU I TWARDZIELI W STRZAŁACH MODRZEWI EUROPEJSKICH (*LARIX DECIDUA* MILL.) II I III KLASY WIEKU WYROSŁYCH W ZRÓŻNICOWANYCH WARUNKACH SIEDLISKOWYCH, REPREZENTUJĄCYCH DRZEWOSTAN GŁÓWNY WEDŁUG KRAFTA

Streszczenie. W pracy podjęto próbę określenia udziału bielu i twardzieli w strzałach modrzewi europejskich reprezentujących II i III klasę wieku wyrosłych w warunkach BMśw, LMśw i Lśw. Największy udział twardzieli w strzałach modrzewi stwierdzono w warunkach Lśw, a najmniejszy na BMśw. Widoczne różnice zaobserwowano także pomiędzy badanymi klasami wieku, przy czym większy udział twardzieli stwierdzono w III klasie wieku. Najmniejszym udziałem drewna twardzielowego spośród drzew drzewostanu głównego według Krafta charakteryzowały się drzewa współpanujące, a największym drzewa panujące.

Słowa kluczowe: biel, twardziel, modrzew europejski, typ siedliskowy lasu, klasa wieku

Accepted for print – Zaakceptowano do druku: 19.12.2007

For citation – Do cytowania: Nawrot M., Pazdrowski W., Szymański M., 2008. Percentage share of sapwood and heartwood in stems of European larch (Larix decidua Mill.) representing II and III class of age grown in different forest site types, representing main tree stand at Kraft biosocial classification. Acta Sci. Pol., Silv. Colendar. Rat. Ind. Lignar. 7(1), 31-38.