

STRUCTURE AND PROPERTIES OF LOCUST TREE WOOD

(*Robinia pseudoacacia* L. var. *rectissima* Raber.)

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Abstract

White acacia (Locust tree, Robinia pseudoacacia L.) is a fast growing tree species, which can produce high quality wood within 15-20 years and is therefore economically very important. The structure and wood properties of 7 locust clones (Robinia pseudoacacia L.var.rectissima Raber) at ages between 7 and 35 years were investigated. They were cultivated in four schemes of plantation densities on carbonate chernozems (CH), alluvial (FL) and alluvial-meadow (Fle) soils in North Bulgaria. The obtained results show that there is good correlation between thickness of wood fibers, thickness of cell walls, wood density and mechanical properties. High quantities of extractive substances are found in the cell lumens, due to which the old locust tree wood has been classified as highly resistant against the wood-destroying basidiomycetes Serpula lacrimans (Wilf.ex Fr.) and Polyporus sulphureus (Bull.ex Fr.) according to EN 350/1-93. Our analysis showed insignificant differences between dry mass losses of the studied clones. We suggest that such differences are due to site influence, plantation densities and tree age.

Key words: *Robinia pseudoacacia L.v.rectissima; wood structure and properties; resistance against decay*

1. INTRODUCTION

The Locust tree belongs to the leguminous family (Leguminosae). Its natural area of distribution is the eastern part of North America (Pennsylvania, West Virginia and the Appalachian Mts. chain) and Mexico [2]. It was transferred to Europe in 1601 by the Parisian court gardener Jean Robin (1550-1629). It was him and his son Vespasian Robin (1579-1662), who cultivated it in Europe. In his honour Linney named the species *Robinia pseudoacacia*, because its leaves are similar to these of the real acacia, growing in North Africa. The Locust tree was transferred to Bulgaria more than 200 years ago (Donchev, J. - 1968) and now it is completely naturalized to the local conditions [8]. A number of foresters worked on the problems of growth and productivity of Locust tree stands in Bulgaria (Georgiev, Zh. - 1955; Kitin, B. - 1960; Iliev, A. and S. Petrov - 1967; Alexandrov, A. - 2001 and at present; Naidenov, J. - 1989; Iliev, I. - 1991 and at present; Kalmukov, K. - 1991 and at present). Serious scientific research activity related to implementing the Locust tree in Bulgaria was launched in 1980 in the Experimental Station for RGWT– Svishtov, where the work was focused on 65 clones of the “rectissima” form, described as a straight trunk fast growing tree species [5; 11; 25]. For this purpose, a method for vegetative Locust tree reproduction was developed with root cuttings from grown-up trees [3; 8; 18]. At the same time, selection of model trees was started in different regions of the country and clones were imported from Hungary, Serbia, Slovakia and Italy. A clone collection has been created in the nursery-garden in the Vardim village, which is constantly complemented with new clones. In addition, sort testing experiments have been started in different regions of the country on plain terrains with deep, fresh to moist soils of the chernozem, alluvial, gray and dark gray type with good moisture-physical parameters of the humus horizon with heavy sandy-clayey to clayey-sandy mechanical composition. It is supposed that the more intensive spacious growth will be

favorably reflected on the annual ring width and it has been established that in deciduous species the technical properties of wood are improved with increasing the annual ring width due to the higher density [1]. Some of the selected clones reach such a growth within 15-20 years, which is typical within 35-40 years for the conventional species [5; 11; 17].

2. MATERIALS AND METHODS OF INVESTIGATION

Wood from 10 (model trees) clones of the straight trunk locust tree (*Robinia pseudoacacia* forma *rectissima*) was selected for the purposes of the present investigation. The specimens were designated with archive numbers for the regions of the towns of Svishtov (Vardim village – carbonate chernozem: Chernozems-CH, calcic-CHk; the Novgrad village alluvial soil: Fluvisols-FL) and Gorna Oryahovitsa (Dzulyunitsa village – alluvial-meadow soil: Fluvisols-FL, Eutric-Fle).

The following indexation was introduced for more concise description of the clones:

„C” – habitat Svishtov (Vardim) with density of planting 2x1 m and age of 16 years;

„B” – habitat Vardim with density of planting 3x3 m and age of 7 years;

„H” – habitat Novgrad with density of planting 5x4 m and age of 15 years;

„D” – habitat Dzulyunitsa-GO with density of planting 4x4 m and age of 13 years;

Wood from 35-year aged trees is also tested for comparison (designated by an index P₁₀), grown in the region of the town of Byala, Ruse district, for which no specific data are available about habitat conditions, i.e. randomly taken from unknown stands. The data about the habitats, soils, schemes of cultivation and age of the trees are given in Table 1.

Table1 - Site conditions, age and diameter growth of the clones tested (after Kalmukov, 2005)

No	Clone	Age, years	Planting scheme, mxm	Soil	Mean diameter, cm			Mean width of annual rings, mm	
					With bark	Without bark	Hard wood	measured	calculated
1	C ₄	16	2x1	CH-CHk	19.7	17.50	15.95	5.47	9.31
2	C ₂₇	16	2x1		15.6	14.72	12.95	4.61	7.83
3	C ₃₃	16	2x1		19.3	17.40	16.00	5.43	8.32
4	C ₅₄	16	2x1		14.5	12.65	10.55	3.95	4.40
5	B ₄	7	3x3	CH-CHk	18.1	16.75	14.70	11.96	15.91
6	B ₃₃	7	3x3		14.5	13.20	10.50	9.43	12.80
7	B ₅₄	7	3x3		16.1	14.35	12.15	10.25	13.70
8	H ₁₂	15	5x4	FL	29.5	26.30	23.00	8.77	9.50
9	H ₂₇	15	5x4		20.5	18.40	16.70	6.13	9.42
10	D ₅₀	13	4x4	FL- Fle	21.0	18.80	16.25	7.23	8.40
11	P ₁₀	35	2x1	n. a.	23.5	21.40	19.35	3.06	2.70

The studied properties are provisionally distinguished in the following groups: chemical composition (content of: cellulose, lignin, pentosans, extractive substances, ash); anatomical structure (length and thickness of fibers; cell wall thickness; slenderness); resistance against wood-destructing fungi; physical and mechanical properties (width of the annual rings; density; porosity; water sorption; swelling during water sorption; hardness; static bending strength; elasticity in static bending – modulus of elasticity; compressive strength along fiber length; shear strength parallel to fiber length; resistance against splitting parallel to fiber length). The investigations were carried out in conformity with standardized or practically verified methods. The chemical composition is determined according to methods verified by practice [24]. The cellulose content is determined using the Kürschner-Hoffer method. The lignin content is estimated according to the modified method of Komarov. The extractive substance content is determined by means of a Soxhlet apparatus in hot water and ethanol extragents. The ash content is established by burning in a muffle furnace at a temperature of 600°C. The anatomical analysis is made using a light microscope of the Laboval type, an object-micrometer and an ocular micrometer. The measurements with the microscope of the Laboval type are made using microscopic preparations, as well as preparations of macerated wood, processed according to a practically verified methodology (Bluskova, 1994). The parameters of the physical and mechanical properties are determined using sections taken from the trunk zone in the range from 0.1 to 1.0 m for ensuring conditions for comparison. Two mutually perpendicular diameters of the block specimens are measured in the section of 1.0 m, with and without bark, as well as the heart wood diameters. One central board with a thickness of 6 cm is taken from each block (a yan-plank) and the rest wood of the model is sawed in boards with a thickness of 3 cm. The resistance against wood-destructing fungi (Basidiomyceten) is determined according to methods, regulated by EN 113 – 1997 using test specimens of heart wood with dimensions 15/25/50 mm, the latter being along the fiber length. Each test series consisted of 18 test specimens. Strains of *Serpula lacrimans* (Wilf.ex Fr.) and *Polyporus sulfureus* (Bull.ex Fr.), grown in malt-agar nutritious environment (4 % malt, 2 % agar) in Cole flasks, are used as test fungi. The test specimens are exposed in the flasks in the course of 90 days at a temperature of 22-24 °C, relative air humidity of 80-90 % and indirect light. The authentic domestic fungus *Serpula lacrimans* (Schum.) with a synonym *Merulius lacrimans* (Schum.) is chosen because it is mentioned in EN350/1:93 as the obligatorily used fungus in determining the natural durability of wood from both deciduous and coniferous tree species. This fungus is widespread all over Europe. The authentic domestic fungus is considered to be the most hazardous one since it produces its own moisture, necessary for its development, and under favorable conditions it is capable of destroying cellulose containing materials, including wood, in the course of several months. The other reference sample fungi are *Coniophora puteana* (cerebella), *Lentinus lepideus* (timber sleeper fungus), *Poria vaporaria* (placenta), *Schizophyllum commune*, *Trametes Versicolor*, which have been used in one of our previous investigations, with the exception of *Lentinus lepideus* (timber sleeper fungus), on acacia heart wood of unknown origin but with high density [21;22]. The timber sleeper fungus has not been used in Bulgaria so far as a reference fungus because a standard strain was not available. The sulphurous fungus *Polyporus sulfureus* (Schwefelporling) attacks both the sap- and the heart wood of the deciduous species as oak, acacia, elm- and ash-tree, etc. [4]. It causes also brown prismatic rot. According to Göre (1952) it attacks both the tree and the incorporated in structures acacia wood and when the moisture exceeds the limits of fiber saturation after a 3-month period of exposure, it may cause mass losses of more than 4 % [4]. The mass loss (dry substance loss) of the specimens exposed to the fungi mycelia in the course of 3 months is used as a criterion for evaluating the resistivity against fungi. The investigations were carried out in the Phytopathology Laboratory of the Forest Research Institute of the Bulgarian Academy of Sciences [25]. The results were processed by variation-statistical analysis. The physico-mechanical parameters were determined according to methods regulated by the Bulgarian State Standards (BDS), corresponding to DIN (Germany). The results were subjected to variation-statistical analysis using the least square method. On the basis of

the mean parameter values and the mean error, the Student coefficient values ($\bar{t}$) were calculated for the reliability of the differences by means of the following formula:

$$\bar{t} = \frac{|Aver_1 - Aver_2|}{\sqrt{Ser_1^2 + Ser_2^2}} \geq 3 \quad (1)$$

where: $Aver_1$ and $Aver_2$ are the mean arithmetic values of the parameters for the compared properties and m_1 and m_2 are their corresponding errors.

3. RESULTS AND ANALYSIS

3.1. Chemical composition

The obtained results concerning the chemical composition are presented in Table 2. It is seen that the ash content of the straight trunk acacia clones, cultivated in the country varies from 0.2 to 0.7 %. On the basis of these results it has been established that the habitat conditions do not exert significant effect on the chemical composition of the single clones, i.e. the cellulose and lignin contents do not differ substantially for clones from various habitats. The negligible differences are probably due to the differences in the spacious growth area. For example, when comparing C 27 and H 27, it is established that the cellulose content in C 27 is 45.3 % and it is lower than that of H 27 (46.5 %). This difference may be probably attributed to the bigger growth space of H 27. The situation with lignin is just the opposite: the lignin content is higher in C 27 (22.0 %), compared to that in H 27 (respectively 21.6 %). A similar pattern is revealed in the comparison of clones P 10 and D 50. Obviously, the difference between the extractive substances content is more significant for the conventional Locust tree and the cultivated acacia clones. For example, in P 10 the amount of the ethanol extracts is 4.2%, while it is almost twice higher for some of the clones (8.3 % for C 4).

Table 2 - Chemical composition of wood from various acacia clones

Index	Do kg/m ³	Cellulose %	Lignin %	Pentosans %	Soluble substances		Ash %
					in water %	in ethanol %	
P10	670	44.5	22.0	17.5	7.6	4.20	0.30
D 50	720	44.4	22.4	20.6	8.6	7.10	0.20
C 4	840	45.6	23.0	18.3	9.8	8.30	0.30
B 4	695	45.5	21.1	20.9	9.8	6.60	0.40
C 33	790	42.7	22.9	17.9	9.1	6.90	0.30
B 33	720	44.0	21.1	20.5	8.7	7.30	0.30
C 27	785	45.3	22.0	18.0	9.0	6.00	0.50
H 27	780	46.5	21.6	19.2	8.5	6.40	0.70
C 54	885	47.9	21.7	19.1	8.8	5.40	0.60
B 54	725	45.6	21.5	18.9	8.1	5.30	0.20
H 12	780	45.2	22.0	19.6	9.2	7.20	0.40
GÖHRE	720	46.3	28.8	22.3	-	1.23**	0.33
Eberswalde	725	40.6	29.1	21.3	-	4.93*	0.32

*alcohol-benzene extraction; ** ether extraction

The obtained results show that the acacia wood is very suitable for cellulose production. It is seen that the differences in the cellulose, lignin, pentosan and extractive substances in the respective acacia

wood clones are not high and are within 10% of the respective component amount. Hence the effect of chemical composition on the production of bleached cellulose will be relatively not very pronounced, the expected maximum deviation of the yield being within the range of 1–1.5%. The substances soluble in hot water include the easily hydrolized hemicelluloses in the wood, which will increase the consumption of alkalis in the very beginning of the boiling process, without exerting substantial impact on delignification. Except for enhancing the production of technical cellulose, the pentosans also contribute to improving the breaking length parameter and accelerate the milling of cellulose, which is highly appreciated in paper production. The established differences in the density of wood clones may exert significantly higher impact on the productivity and effectiveness in wood boiling and cellulose bleaching compared to the influence of the differences in chemical composition. The application of wood with density of 850kg/m^3 , compared with wood of density 690kg/m^3 , may lead to increasing the capacity of the cellulose producing plant with more than 20%. If applying wood density as a first factor for comparison, then the most prospective for cellulose production would be the clones C 54, C 4, C 27 and C 33, followed by H 12, H 27, B 33 and B 4. On the other hand, the more dense wood may hamper the penetration of alkalis and cause irregular progress of the boiling process in the interior of the wood matrix. This disadvantage is overcome by steam treatment and impregnation of the chops with the boiling solution and by correction of the temperature-moisture regime – measures that are broadly applied in practice. The final and exact conclusion about the advantages of a certain wood clone can be made after carrying out boiling and bleaching under laboratory conditions. In this case, difference in the consumption of chemical substances for boiling and bleaching, as well as physico-mechanical parameters of the obtained cellulose types may be also established.

3.2. Wood structure

The obtained results for the microstructure of the selected clones of the straight-trunk acacia are given in Tables 3, 4, 5 and 6. The cell wall thickness, the cell void size, the dimension of wood fiber cross-section (fiber thickness) and fiber lengths have been determined. The fiber length data for 25 measurements are shown in Table 3. The fiber length varies from $738\text{ }\mu\text{m}$ to $1265\text{ }\mu\text{m}$. It is the lowest for B 54 – $738\text{ }\mu\text{m}$, and the highest – for H 27 ($1265\text{ }\mu\text{m}$), i.e. the difference is $527\text{ }\mu\text{m}$. The fibers of B 33 are also relatively shorter – $884\text{ }\mu\text{m}$. The fibers in the wood of C 4 and H 12 are longer than these in the D 50 wood. The fiber length in mature acacia wood is from 0.76 to 1.25 mm (Wagenführ and Scheiber 1985). When comparing the fiber length of one clone, for example 27 (C 27: 0.967 mm and H 27: 1.265 mm), that was grown on different spacious growth area and in different habitats, it is established that the growth space exerts positive and significant impact. The value of the Student's criterion for the reliability of the differences between the fiber lengths of the compared two clones is 7.45, i.e. the difference is reliable. Hence it follows that the wood fiber length of the investigated acacia clones rises with increasing the growth space. The comparison of P 10 and C 27 (grown with the same growth space, but with two times age difference in favour of P 10) proves that fiber length rises with increasing the age of wood. In this case the value of the Student's criterion for the reliability of the differences in the fiber length of the compared clones is 7.36, i.e. the difference is reliable.

Consequently, the augmentation of the wood fiber length of the straight trunk acacia clones depends both on the higher growth space and on wood age.

The investigated wood is a juvenile one, it has many tensile fibers, but despite of this in most of the studied clones the fiber length exhibits values close to the average ones, established for mature wood [27; 28]. The obtained results for the wood fiber thickness (size of fiber cross-section) are presented in Table 4. The results for the cell wall thickness are given in Table 5 and for the cell voids – in Table 6. These results provide the grounds to conclude that the fiber thickness is approximately equal to the sum of the cell wall thickness and the cell void dimension. It is seen in Table 5 that the cell wall thickness varies from 6.75 to $12.10\text{ }\mu\text{m}$. The cell wall thickness is measured by the distance between

two neighboring voids (between two adjacent lumens). The comparison of the difference between the fiber cell wall thickness of the wood of clones C 27 and H 27 shows that the value of the Student's criterion is 8.9 and hence this difference is reliable and it may be accepted that the cell wall thickness increases with rising the spacious growth area. The Student's criterion for the comparison between C 27 and P 10 is 7.03 and hence the difference is reliable. Consequently, for an equal growth space the cell wall thickness increases with increasing the age, i.e. both factors exert favorable effect on the cell wall thickness. The comparison of the obtained results for the fiber length (Table 3) and fiber thickness (Table 4), proves that the wood of the clones with longer fibers (P 10; H 27; C 4 and C 54) exhibits greater cell wall thickness. This is probably due to the cambium age, when they were formed (P 10 is 35 years old and the clones H and C are 15-16 years old).

Table 3 - Fiber length, μm

Variation	C l o n e										
	B ₄	B ₃₃	B ₅₄	C ₄	C ₂₇	C ₃₃	C ₅₄	H ₁₂	H ₂₇	D ₅₀	P ₁₀
Aver.	983	884	738	1097	967	1009	1017	1025	1265	897	1190
StD	112.5	109.0	76.5	86.2	101.5	77.5	104.5	88.97	171.6	100.3	112.7
Ser	22.5	21.8	15.3	17.2	20.3	15.5	20.9	17.8	34.3	20.1	22.5

Table 4 - Dimension of the cross-section, μm

Variation	C l o n e										
	B ₄	B ₃₃	B ₅₄	C ₄	C ₂₇	C ₃₃	C ₅₄	H ₁₂	H ₂₇	D ₅₀	P ₁₀
Aver.	12.43	13.07	13.00	16.24	13.06	15.24	16.06	15.30	15.43	13.62	19.46
StD	2.097	0.973	2.989	2.989	2.175	2.516	4.203	4.729	4.029	0.973	4.203
Ser	0.52	0.24	0.75	0.75	0.54	0.63	1.05	1.18	1.01	0.24	1.05

Table 5 - Cell wall thickness, μm

Variation	C l o n e										
	B ₄	B ₃₃	B ₅₄	C ₄	C ₂₇	C ₃₃	C ₅₄	H ₁₂	H ₂₇	D ₅₀	P ₁₀
Aver.	7.80	7.94	7.50	8.00	6.75	7.44	7.50	7.80	12.10	7.25	10.90
StD	1.71	0.93	1.41	1.59	1.00	1.36	1.51	2.14	2.53	2.49	3.27
Ser	0.43	0.23	0.35	0.40	0.50	0.34	0.38	0.53	0.63	0.62	0.82

Table 6 - Dimensions of the cell void of the fibers, μm

Variation	C l o n e										
	B ₄	B ₃₃	B ₅₄	C ₄	C ₂₇	C ₃₃	C ₅₄	H ₁₂	H ₂₇	D ₅₀	P ₁₀
Aver.	4.625	5.134	5.500	8.500	6.313	8.500	8.563	7.500	3.250	6.375	8.563
StD	1.746	0.691	1.862	1.966	2.120	1.966	3.098	3.098	2.783	0.691	3.098
Ser	0.463	0.173	0.465	0.491	0.530	0.491	0.774	0.774	0.696	0.173	0.774

Most generally, the obtained results for acacia wood structure provide the grounds to consider that the increasing of the trunk thickness of straight trunk acacia clones with the higher growth space and with age is due to the increasing of the cell wall thickness.

Fiber slimness is of major importance when using the wood as raw material for the production of cellulose products as paper, cardboards and wood fiber boards [24; 28]. This parameter is expressed

by the ratio between fiber length and fiber thickness. The analysis of this parameter shows that the highest slimness is attributed to the fibers of the clones: H 27 (82.0); B 4 (79.1); C 27 (74.1); B 33 (67.6); C 4 (67.5); C 33 (66.2); D 50 (65.8); C 54 (63.3), and hence their wood could be recommended as raw material for the production of fiber wood materials.

3.3. Resistance against decay

Table 7 presents the values for the mass loss of wood from different clones of acacia, exposed in the course of 3 months in mycelia of the authentic domestic fungus *Merulius lacrymans* (*Serpula lacrymans*). The average wood mass (dry wood substance) loss caused by the lachrymose fungus is within the range from 1.08 % to 2.44 %. The comparative analysis reveals that the denser wood loses less mass. For example, the loss mass of C 33 is 1.20 % ($D_w = 824 \text{ kg/m}^3$) and of B 33 – 2.52 % ($D_w = 735 \text{ kg/m}^3$); the mass loss of C 27 is 1.08 % ($D_w = 861 \text{ kg/m}^3$), and of H 27 – 2.12 % ($D_w = 806 \text{ kg/m}^3$). These differences are reliable, because in the first example the value of the Student's criterion is 9.13, and in the IInd – 10.1.

Table 7 - Wood mass loss for different clones of *Robinia pseudoacacia rectissima* after 3 months of exposure in *Merulius lacrymans*

Clone	Density kg/m ³		W %	Variation parameters					MeB,%	
	D _w	D ₀		Aver. m.%	StD. ± %	Ser ±%	V %	p %	H ₂ O	EtOH
P 10	724	674	18.01	1.23	0.21	0.056	17.07	3.73	6.3	4.9
D 50	827	785	14.18	1.76	0.30	0.066	17.04	3.72	8.6	7.1
C 4	903	848	15.86	1.45	0.19	0.039	13.05	2.69	9.8	8.3
B 4	836	802	13.57	1.33	0.19	0.040	14.14	3.01	9.8	6.6
C 27	861	817	13.48	1.08	0.23	0.047	21.08	4.35	9.1	6.9
H 27	806	765	13.54	2.12	0.37	0.081	17.45	3.82	8.7	7.3
C 33	824	768	14.51	1.20	0.17	0.037	13.93	3.09	9.0	6.0
B 33	735	703	13.33	2.44	0.52	0.114	20.03	4.66	8.5	6.4
C 54	835	801	13.40	2.11	0.41	0.089	19.59	4.25	8.8	5.4
B 54	757	726	13.38	2.00	0.45	0.098	22.74	4.92	8.1	5.3
H 12	862	823	13.19	1.83	0.22	0.048	11.99	2.63	9.2	7.2

Table 8 shows the wood mass loss values for different acacia clones, exposed in the course of 3 months in mycelia of the sulphurous fungus *Polyporus sulphureus*.

Table - 8 Wood mass loss for different clones of *Robinia pseudoacacia f. rectissima* after 3 months of exposure in *Polyporus sulphureus*

Clone	Density kg/m ³		W %	Variation parameters					MeB,%	
	D _w	D ₀		Aver. m.%	StD. ± %	Ser ±%	V %	p %	H ₂ O	EtOH
P 10	724	674	18.01	0.89	0.121	0.026	13.59	2.92	6.3	4.9
D 50	827	785	14.18	0.77	0.333	0.074	43.25	9.61	8.6	7.1
C 4	903	848	15.86	1.09	0.368	0.077	33.79	7.06	9.8	8.3

B 4	836	802	13.57	1.40	0.344	0.075	24.58	5.36	9.8	6.6
C 27	861	817	13.48	0.80	0.355	0.081	44.41	10.13	9.1	6.9
H 27	806	765	13.54	1.04	0.443	0.110	42.61	10.58	8.7	7.3
C 33	824	768	14.51	0.55	0.293	0.065	53.18	11.82	9.0	6.0
B 33	735	703	13.33	0.59	0.569	0.158	35.79	9.94	8.5	6.4
C 54	835	801	13.40	1.65	0.735	0.190	44.53	11.52	8.8	5.4
B 54	757	726	13.38	1.85	1.533	0.334	82.86	18.05	8.1	5.3
H 12	862	823	13.19	0.49	0.445	0.063	44.53	13.01	9.2	7.2

The average wood mass loss caused by the sulphureous fungus is within the range from 0.49 % to 1.85 %. The analysis of these results also proves that with increasing the density the mass loss slightly decreases. For example, the mass loss for C 4 is 1.09 % ($D_w = 903 \text{ kg/m}^3$), and for B 4 it is 1.44 % ($D_w = 836 \text{ kg/m}^3$). The mass loss for C 33 is 0.55% ($D_w = 824 \text{ kg/m}^3$), and for B 33 it is 1.59 % ($D_w = 735 \text{ kg/m}^3$). The obtained results provide the ground to consider that the acacia wood of all studied clones is resistant against the destructive effect of the two used fungi, because the average mass loss is within the range from 0.49 ± 0.06 % to 1.85 ± 0.33 % for the sulphurous fungus (*Polyporus sulphureus*) and within the range from 1.33 ± 0.04 % to 2.12 ± 0.09 % for the lachrymose fungus (*Merulius lacrymans*) and is lower than 3 %, as regulated by EN113. The acacia heart wood is resistant against the destructive impact of the mycelia of the fungi *Poria placenta* (2.25 ± 0.03 %) and *Schizophyllum commune* (2.38 ± 0.02 %), [Panayotov et al., 2000]. With respect to the durability index parameter (ND), the arbitrary selected from practice acacia heart wood is referred to class 1 (CND-1, i.e. very durable), as regulated by EN350/1-93.

This high durability of acacia wood results from the considerable amount of extractive substances, which are accumulated in the wood regardless of the habitat, growth space and age of the tree, and from the high tilly content, plugging its conductive elements [21; 22].

3.4. Physical and mechanical properties

3.4.1 Physical properties

Density is the most important physical and qualitative parameter of wood. Table 9 shows the density parameters of some of the investigated acacia clones in four moist states, as well as the parameters of the provisional density and porosity, obtained as mean arithmetic values from test specimens used for the determination of all examined properties. In addition, the parameters of the calculated width of the growth rings and the measured share of late wood are also shown. For specific areas, the density is also determined for the raw state, the absolute dry state and the so-called provisional (basic) density. The provisional density indicates the amount of the absolute dry substance contained in 1 m^3 of raw wood. In order to determine the shrinkage coefficient, it has been accepted (according to the definitions of Enchev, 1975), that it is numerically equal to the relative provisional density. The moisture content in the point of wood fiber saturation is determined as a ratio between the volumetric shrinkage and the provisional density according to equation (2), also mentioned by Enchev, 1975 [6].

$$W_{sp} = \frac{S_{hv}}{D_b} 1000, \% \quad (2)$$

In order to compare the reliability of the differences between the density values for the different Locust tree clones, grown at various growth space the t-criterion of Student has been calculated. The analysis of this criterion reveals that the reliable differences are between the clones “C” and “B”, since the values of the t-criterion of Student are higher than 3.19, representing the critical value for reliability of the result for confidence level of 0.001. This is due to the 4.5 times difference in the

growth space. The clones "C" were grown in space of 2x1 m, while the clones "B" were grown in space of 3x3 m, and moreover, the clones "C" were two times older. The differences in wood density for the tree selected from practice in the region of the town of Byala, designated by an index "P10" and the wood density of all the rest clones are also reliable, since the Student's criterion values are higher than the critical one of 3.19.

Table - 9 Density in different moist states

Clone	Bgr mm	Share of bark wood %	Moisture %	Density, kg/m ³				Porosity, V _p		M _w %	$\frac{S_{wt}}{S_{ht}}$ %	$\frac{S_{wr}}{S_{hr}}$ %	C _{sh}	W _{sp} %
				In-dex	Aver.	StD	Ser	%	cm ³ /g					
P10	2.2	49.02	58.85	D _m	979	30	4.4	-	-	78	$\frac{9.8}{7.7}$	$\frac{3.9}{4.6}$	0.58	21.3
			17.12	D _w	687	31	4.5	-	-					
			12.00	D ₁₂	669	30	4.5	-	-					
			0.00	D _o	670	32	4.7	56.49	0.810					
			-	D _b	580	6	2.1	-	-					
C4	9.3	81.72	50.68	D _m	1146	32	4.7	-	-	49	$\frac{10.9}{7.4}$	$\frac{6.0}{5.2}$	0.74	16.9
			15.86	D _w	903	24	3.6	-	-					
			12.00	D ₁₂	885	24	3.5	-	-					
			0.00	D _o	848	20	3.0	44.96	0.393					
			-	D _b	738	7	2.0	-	-					
B4	16	74.92	71.79	D _m	992	27	4.0	-	-	59	$\frac{8.4}{7.1}$	$\frac{6.3}{5.8}$	0.69	18.6
			13.57	D _w	836	12	1.7	-	-					
			12.00	D ₁₂	829	12	1.7	-	-					
			0.00	D _o	802	13	2.0	47.93	0.598					
			-	D _b	693	8	2.2	-	-					
D50	8.4	72.34	58.71	D _m	1303	30	4.4	-	-	63	$\frac{7.2}{7.4}$	$\frac{5.1}{4.5}$	0.62	19.2
			14.18	D _w	827	16	2.3	-	-					
			12.00	D ₁₂	818	16	2.3	-	-					
			0.00	D _o	785	16	2.3	49.00	0.760					
			-	D _b	625	7	2.1	-	-					
C27	7.8	78.31	55.91	D _m	1167	31	4.6	-	-	56	$\frac{9.8}{8.2}$	$\frac{5.2}{5.2}$	0.71	19.0
			13.48	D _w	861	28	4.2	-	-					
			12.00	D ₁₂	855	28	4.1	-	-					
			0.00	D _o	817	31	4.6	46.94	0.537					
			-	D _b	715	17	4.9	-	-					
H27	9.5	82.54	51.09	D _m	1065	32	4.7	-	-	52	$\frac{10.2}{8.8}$	$\frac{6.1}{6.0}$	0.68	21.8
			13.93	D _w	864	22	3.3	-	-					
			12.00	D ₁₂	855	22	3.3	-	-					
			0.00	D _o	818	21	3.2	46.88	0.573					
			-	D _b	684	6	2.0	-	-					
C33	8.3	73.66	52.95	D _m	1103	31	4.6	-	-	57	$\frac{10.3}{8.1}$	$\frac{6.3}{5.9}$	0.66	20.4
			14.51	D _w	820	30	4.4	-	-					
			12.00	D ₁₂	810	29	4.3	-	-					
			0.00	D _o	771	43	6.4	49.33	0.671					
			-	D _b	655	3	0.8	-	-					
B33	13	84.84	66.51	D _m	1106	32	4.8	-	-	66	$\frac{10.9}{9.9}$	$\frac{7.2}{7.2}$	0.66	26.0
			13.33	D _w	735	48	7.0	-	-					
			12.00	D ₁₂	730	47	6.9	-	-					

			0.00	D _o	703	41	6.1	54.31	0.774					
			-	D _b	659	19	5.6	-	-					
C54	4.4	74.68	54.33	D _m	1105	31	4.6	-	-	59	<u>7.5</u>	<u>4.1</u>		14.3
			13.40	D _w	835	22	3.3	-	-		6.0	4.0		
			12.00	D ₁₂	829	22	3.2	-	-					
			0.00	D _o	801	25	3.7	47.96	0.598					
			-	D _b	700	10	2.8	-	-					
B54	14	70.73	74.50	D _m	1088	31	4.6	-	-	58	<u>11.1</u>	<u>6.4</u>	0.62	25.7
			13.38	D _w	757	25	3.6	-	-		9.6	6.3		
			12.00	D ₁₂	752	24	3.6	-	-					
			0.00	D _o	727	24	3.5	52.81	0.725					
			-	D _b	616	12	3.4							

The differences between the wood density of clone “D50” and all the other studied clones are reliable with the exception of the difference between “D50” and “C33”, for which the Student’s criterion value is 2.22, i.e. it is lower than the critical value of 3.19. The density of “D50” is a bit higher (786 kg/m³) than that of “C33” (771 kg/m³). This may be due to the fact that “D50” was grown at greater spaciousness (4x4 m) although it is younger: 13 years old, while “C33” is older (about 16 years old). However this difference is not reliable and it should not be taken into account. The differences between “C4” and all the rest of the clones are reliable because their Student’s criterion values are considerably higher than the critical value (3.19). This is the clone with the highest density (847.64±3.03 kg/m³) in absolute dry state. This is probably due to the fact that this tree is older than both clones “B” and “D50”, although it was grown at relatively low spaciousness (2x1m). The difference between this clone and the clones “H” is also reliable (the criterion between this clone and clone “H12” is 6.15, and between clone “H27” – 6.85). The difference between the wood density of clone “C27” and clone “H27” is of extreme interest. In fact, this is one and the same clone, grown under different growth space (2x1 against 5x4), on different soils (Table 1: “C” – on carbonate chernozem; “B” – on alluvial soil), and with one and the same age (about 16-15 years). This difference is not reliable because the value of the Student’s criterion is 0.18, i.e. it is far below the critical value (3.19). The clone H 27 has a little higher density and wider annual rings (8.5 mm), but the minimal and maximal values of “C 27” are a bit higher and the width of the annual rings is smaller (7.8 mm), i.e. for and the same clone and one and the same age with ten times increasing the growth space there is no substantial difference in wood density, or if there is some small difference, it is not proved and is in favor of the bigger spacious growth area. Hence, there is a trend for a certain effect of the growth space. The differences for clone 4 grown in different growth space (C4: 2 m²) and (B4: 9 m²) are proved and in addition, the trees grown on 5.5 times greater spaciousness are twice younger. Hence, the age factor is more important than the growth spaciousness. However, this is rather provisional. If the trees with index “P” (practice) are compared with these of the clones “C”, it will be established that the prevalence belongs to the clones “C”, although they are twice younger than “P” and were grown under approximately at the same spaciousness (2x1). The provisional density (basic density) data (Table 9) may be also analyzed in order to determine the influence of the habitat conditions, the age and the growth space. When comparing the provisional wood density of clone “C27”, grown at spaciousness of 2 m² in the region of Svishtov and of clone “H27”, grown at spaciousness of 20 m² in the region of the Novgrad village, it is established that the Student’s criterion is equal to 5.75 and the difference of 30 kg/m³ in favor of “C27” is reliable, i.e. the impact of soil type is also important. The comparison of the provisional density of clone “C22”, grown at spaciousness of 2 m² in the region of Svishtov and clone “H22”, grown at spaciousness of 20 m² in the region of the Novgrad village, shows that the Student’s criterion is equal to 1.82 and the difference of 2 kg/m³ in favor of “H22” is not reliable. When comparing the provisional wood density of clone “C4”, grown in the course of 16 years

at spaciousness of 2 m² in the region of Svishtov, and clone “B4”, grown in the course of 7 years at spaciousness of 9 m² also in the region of Svishtov, it is established that the criterion of Student is equal to 15,2 and the difference of 45 kg/m³ in favor of “C4” is reliable, i.e. the age factor has a stronger more significant effect on the density growth. The same trend is observed when comparing the provisional wood density of clones “C34” and “B34”. The Student’s criterion is equal to 15 and the difference of 38 kg/m³ in favor of C34 is reliable. The comparison between the provisional density of the tree selected from practice “P10”, grown 35 years at spaciousness of 2 m², and the clones from habitat “C”, grown for 16 years also at spaciousness of 2 m², proves a significant difference in favour of clones “C”. For example, the criterion of Student between “P10” and “C4” is 19.15 and the difference in density amounting to 158 kg/m³ in favor of “C4” is reliable. Hence the habitat, chemical composition and type of soil also exert considerable positive impact on the density of the formed acacia wood. The obtained results provide the grounds to confirm the attitude of a number of authors as Göhre–1952, Poliboyarinov – 1976, Molnar – 1984, and Niklas – 1997, that the density of wood depends on the variation of the structural elements of wood (dimensions and structure of cell wall, ratio between the volume of cell walls and voids, share of late wood, heart wood rays and wood parenchyma, share of tensile and juvenile wood), position in the trunk, degree of heart wood formation. According to Bluskova – 1994, the basic density of 5-year old acacia trees depends on the spacious growth and on the annual ring width [2]. With increasing the growth space from 0.5 m² to 4 m² the basic density of the Locust tree wood rises from 595 to 633 kg/m³, and the annual ring width increases from 3 to 5 mm. The share of early wood decreases with the increase of the annual ring width and this dependence is described with the regression equation: $EP = 9.26 - 0.61.D_w$, [2].

K. Niklas (1997) considers that the wood density in the peripheral layers in the fresh state of trees of up to 8-year age is significantly higher than that of the older internal layers, situated close to the heart core [19]. With the progress of age the average density of the acacia wood, representing mainly heart wood, increases and it may reach from 800 kg/m³ for an 8-year old tree to 1080 kg/m³ for a 32-year tree.

These facts prove that the wood density of a given acacia clone is its basic inherent biological feature (property). Hence the factors of age and heredity exert more substantial impact than the growth spaciousness. It has been unambiguously proved that density depends also on the anatomical features of wood but since they are more difficult to be practically determined, density measurement is recommended. For this reason density has been adopted as the basic identifier of wood quality. All properties of wood are functionally dependent on density and regression equations are derived for the particular cases. For example, in order to determine the specific weight of raw acacia wood on its density in the raw state, Karl Niklas derived the equation: $SG = 0.13 + 0.0006.D_{max}$, [19].

The porosity is an indirect parameter, indicating the pore volume expressed in percents with respect to the total volume of the wood body. The sum of the cell wall volume and the pore volume is equal to the volume of the wood body. Hence the greater the density of the wood body, the lower will be its porosity. For this reason the porosity is determined by using the density of the wood body and the density of the wood substance, which is equal to 1540 kg/m³ [Kollmann, 1951; Enchev, 1975]. The porosity may be determined by a porosimeter or may be calculated according to equation (3):

$$V_p = 100 - \frac{D_o}{1540} \cdot 100, [\%] \quad (3)$$

where: V_p is wood porosity and D_o is wood density in the absolute dry state. The results for the porosity of some of the investigated Locust tree clones calculated according to equation (3) and the measured ones with the Porosimeter 1500 of the Carlo Erba Italian company are shown in Table 9.

Examining the pore volume values (cm^3/g), obtained by a mercury porosimeter with a pressure of 250 atmospheres, it is established that the denser the wood, the lower is the porosity. Hence the equation derived by world known researchers in wood material science is also valid for acacia wood regardless of the clone type. If porosity is transformed in percents, a small difference appears which is not statistically proved and is probably related to tilly formation. The analysis of the integral pore size distribution shows that in the more dense clones “C” and “H” pores with size of up to 1500 nm predominate (85 %), and the share of the rest of the pores with diameters exceeding this limit up to 0.4 mm is about 15 %. In the clones with the lowest density, for example “P10”, the percentage share of the nano pores is about 65 %, and the rest 35 % belong to the micro pores. These results are directly related with the processes of water sorption and swelling of acacia wood, the corresponding values being shown in Table 9. Inverse relationships exist between density, water sorption and swelling, which may be approximately described by linear functions. It has been established that the denser the wood, the lower is its water sorption. Water sorption and swelling during water sorption have been followed in the course of 30 days. The obtained mean arithmetic values are presented in Table 9. It is established that the lower the wood density in the absolute dry state, the higher is the water sorption. The wood of clone “P10” exhibits the highest water sorption (77.95 %), and the wood of clone “C4” – the lowest (48.75 %). The dependence of water sorption on density is presented in Fig. 1. This dependence may be described by the linear equation:

$$W = 78 - 0.025 \cdot D_0.$$

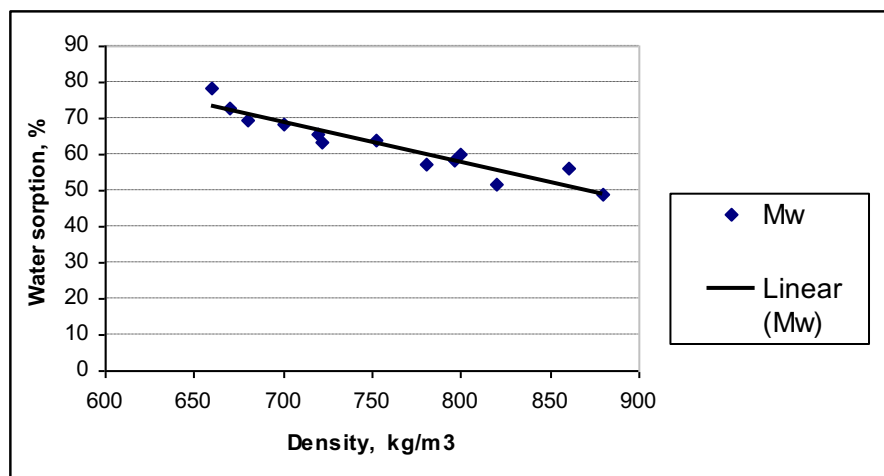


Fig. 1 - Dependence of acacia water sorption on density

The dependence of swelling during water sorption on the density in the absolute dry state is shown in Fig. 2. It has been established that the values of tangential swelling are almost twice higher than these of the radial one and are higher than the values cited in reference literature [6].

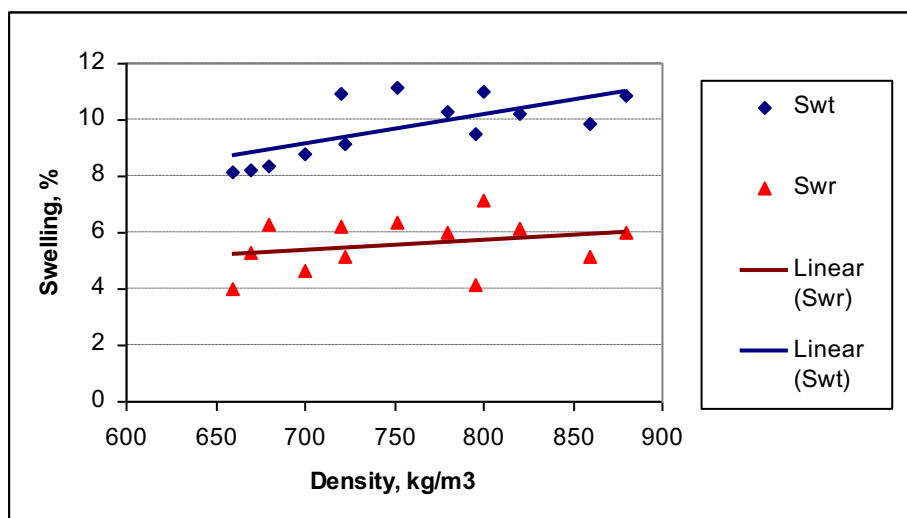


Fig. 2 - Dependence of swelling on the density of acacia wood in the absolute dry state

The dimensions of the wood body decrease with the moisture release beyond the limit of cell wall saturation. This property is called shrinkage and it is an important physical parameter of wood, which is always related to the shrinkage coefficient parameter. The obtained results for the shrinkage in tangential and radial direction and the shrinkage coefficient of the investigated acacia clones are given in Table 9. The data show that the shrinkage in radial direction (S_{hr}) is one and a half times lower than the shrinkage in tangential direction (S_{ht}). The higher values of tangential shrinkage are the reason for the occurrence of cracks along the heart wood rays below the fiber saturation limit, especially at sharp temperature rise. The shrinkage coefficient (C_{sh}) varies from 0.57 to 0.74. For practical needs its value may be assumed to be 0.655. Shrinkage is always related with moisture at the limit of cell wall saturation, called also the moisture at the saturation point of wood fibers. The obtained parameters of moisture at the point of fiber saturation are also presented in Table 9. The moisture values at the wood fiber saturation (W_{sp}) vary from 16.9 to 25.7 %. It is always dependent on the basic density (D_b). The higher the basic density, the lower is the saturation limit of wood fibers. The shrinkage is characterized by the shrinkage coefficient, which shows the magnitude of shrinkage when the water content is reduced with 1 % below the fiber saturation limit till the absolute dry state.

The mean arithmetic values of the investigated mechanical properties, recalculated for 12 % of moisture content, are shown in Table 11. The static hardness is one of the most important properties of wood, which predetermines the further mechanical processing and utilization of the material in floor coverings. The hardness has a direct impact on the wear resistance of wood. The analysis of the hardness values indicates that it depends on density. This relationship is shown in Fig. 3. The hardness increases with the growth of density. This relation is linear and is described with the equations:

$$H_l = 0.163.D_{12} - 47.022, [MPa] \quad \text{and} \quad H_q = 0.151.D_{12} - 50.555, [MPa]$$

It is seen from the data in the table that the values of transverse hardness are lower than these of the front one. The values of radial hardness vary from 53.77 MPa (clone B4) to 94.69 MPa (clone C27). When the radial hardness values of wood C27 (94.69 MPa) are compared with these of wood H27 (76.69 MPa), it is established that the criterion of Student amounts to 5.96, i.e. the difference of 18 N/mm² in favor of C27 is reliable and it may be concluded that the plant growth spaciousness does not exert substantial effect, while the soil composition is significant. The comparison between the radial

hardness of C4 (86.62 MPa) and B4 (53.77 MPa) shows a value of the Student's criterion of 11.45 and hence the difference of 32.85 N/mm² in favor of C4 is reliable. Since the samples are characterized by different growth spaciousness and by a two-fold age difference, it may be concluded that the age is the more decisive factor. The comparison of the differences between C4 (86.62 MPa) and D5 (64.21 MPa) yields a value of the Student's criterion of 9.79 and hence the difference of 22.41 N/mm² in favor of clone C4 is reliable. This cannot be attributed to the almost 8 times different plant growth spaciousness but rather to different soil composition. When comparing the radial wood hardness values of C4 (86.62 MPa) and P10 (55.26MPa), which have grown under conditions of the same plant growth spaciousness but have a two-fold age difference, a value of 10.21 is obtained for the Student's criterion and hence this difference is reliable too and could be attributed to differences in soil composition. When comparing the radial wood hardness values of H27, which was grown under conditions of plant spaciousness of 20 m² in the course of 15 years with these of P10, grown under free space conditions of 2 m² in the course of 32 years, it is established that the value of the Student's criterion is 8.18 and hence this difference of 21.43 N/mm² in favor of H27 is reliable. This provides the ground to conclude that the plant growth spaciousness also exerts positive effect on wood hardness. This influence is not direct but indirect by the age-ring width and the higher share of later wood.

Table 11 - Mean arithmetic values of mechanical properties of Locust tree wood

Index	Hardness MPa			Compr. MPa		Shear MPa		Splitting kN/m		Bending- B _s , MPa Modulus- E _s , MPa			Impact KJ/m ²	
	D ₁₂	H _{yq}	H _{yl}	D ₁₂	R _c	D ₁₂	R _{st}	D ₁₂	R _{cl}	D ₁₂	B _s	E _s	D ₁₂	R _r
P10	710	51.5	68.4	708	61.7	645	11.3	710	32.3	649	102.5	13690	666	47.3
C4	918	83.4	113.3	924	80.2	924	13.6	925	52.1	925	170.0	14020	884	121.4
B4	724	50.1	65.8	762	58.8	762	12.4	762	47.5	762	112.2	11980	729	49.8
C27	885	88.7	107.9	863	75.8	863	12.9	864	44.0	863	168.6	17070	825	79.7
H27	826	75.2	83.1	847	71.9	855	14.1	845	49.3	855	127.4	10780	822	70.2
C33	795	78.4	81.2	778	70.5	776	12.6	780	39.1	780	141.1	13910	798	72.2
B33	760	67.9	72.9	844	58.5	844	13.1	845	41.3	845	142.3	12880	761	52.7
C54	920	87.4	93.8	880	77.9	880	15.9	883	68.2	885	174.6	15580	933	147.2
B54	764	72.7	79.8	762	50.1	761	13.0	765	49.8	763	117.7	13090	765	58.5
D5	718	60.4	82.7	732	86.5	744	12.0	734	47.1	745	149.9	15840	760	50.4
H12	724	64.5	80.1	736	54.1	735	12.7	735	53.2	736	109.9	10490	820	91.6

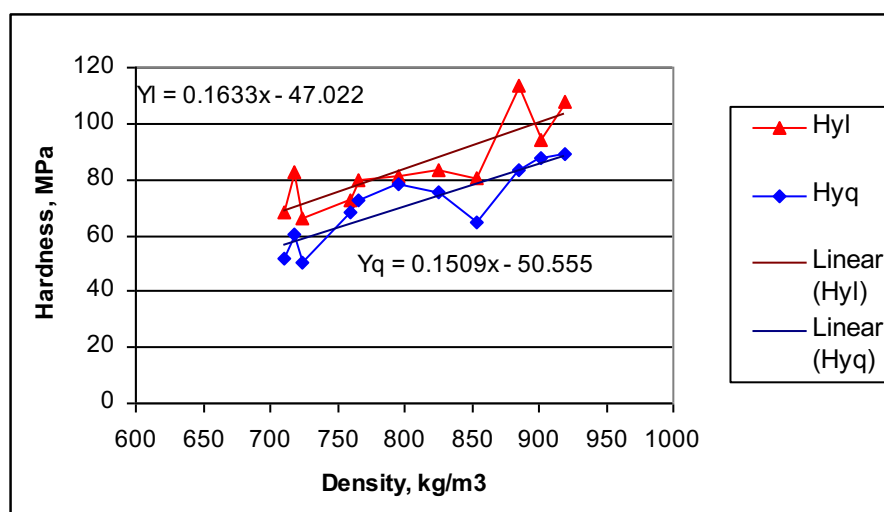


Fig. 3 - Dependence of static hardness determined according to the method of Janka on density Hyq – hardness in transverse direction; Hyl – front hardness

Consequently, the factors of soil composition, age and heredity, and under comparable conditions also the plant growth spaciousness, exert more substantial influence on hardness values. The greater plant growth spaciousness contributes to the formation of wider age-rings, in which the share of later wood with thicker cell walls is 3-4 times higher. This leads to the formation of wood with higher density and hence – with higher hardness.

The results for the compressive strength in direction parallel to the fiber length are presented in Table 11. This property depends also on density. The compressive strength increases with the growth of density as seen in Fig. 4. The relationship is linear and is described by the equation: $\sigma_c = 0.1143 \cdot D_{12} - 21.606, [MPa]$. The comparison of this strength parameter values for the wood of clones C4 (80.23 MPa) and P20 (61.74 MPa) shows that the criterion of Student is 16.96, i.e. the difference of 18.49 MPa in favor of C4 is reliable. Hence the soil composition and biological specificity exert significant effect on the compressive strength. The comparison of the differences between C27 (75.81 MPa) and H27 (71.89 MPa) shows that the criterion of Student amounts to 1.96, i.e. the differences are not reliable but the wood was formed under very different conditions of plant spaciousness and is almost of equal age and of the same clone. This indicates that the soil conditions are especially important for this property. Hence the more substantial influence of composition and type of soil on the compressive strength is confirmed once again. The comparison of the values of this strength for the wood of clone D5 (86.55 MPa), grown under spaciousness conditions of 16 m² in the course of 13 years, and B4 (58.84 MPa), grown under spaciousness conditions of 9 m² in the course of 7 years, yields a value of the Student's criterion of 14.51 and hence the difference of 27.71 MPa in favor of D5 is reliable. This indicates that together with the factors of age, composition and type of soil and biological specificity, the plant growth spaciousness also affects, although indirectly, the compressive strength.

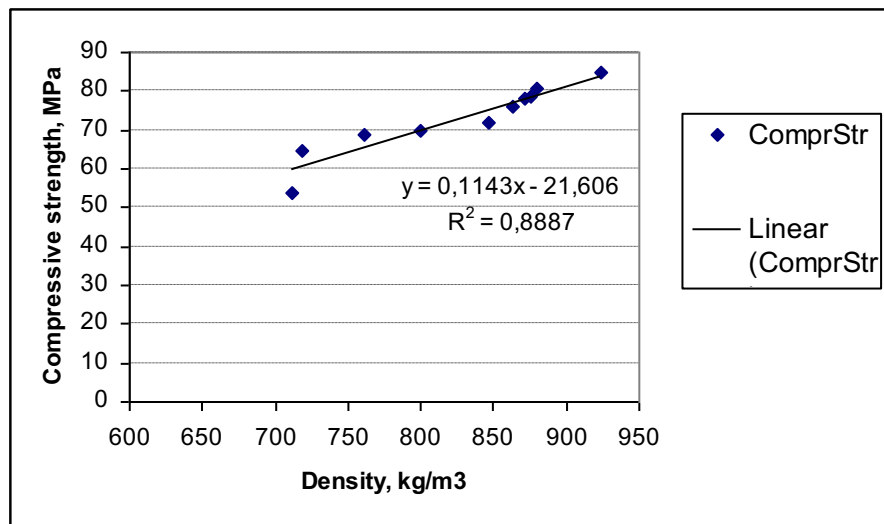


Fig. 4 - Dependence of the compressive strength parallel to fiber length on density

The obtained mean arithmetic values for the modulus of elasticity and the bending strength are presented in Table 11 and Fig. 5 and Fig. 6. It is seen that these dependencies are similar to those, established by Göre [1952], i.e. the dependencies are best described by the following equations:

$$E_{12} = 0.0043.D_{12} + 10.334, [GPa] \text{ and } B_{12} = 0.261.D_{12} - 69.247, [MPa].$$

Both the modulus of elasticity and the bending strength are increased when the density rises. The comparison of the bending strength values for clones C27 (168.61MPa) and H27 (127.38 MPa) shows that the difference is reliable ($t = 6.69$), i.e. in this case the greater growth spaciousness also does not guarantee better wood quality. The comparison of the bending strength values for clones C4 (170.04 MPa) and P20 (140.11 MPa) exhibits reliability of the differences ($t = 6.69$). Thus it has been proved once again that bigger plant growth spaciousness is not the decisive factor for better wood quality.

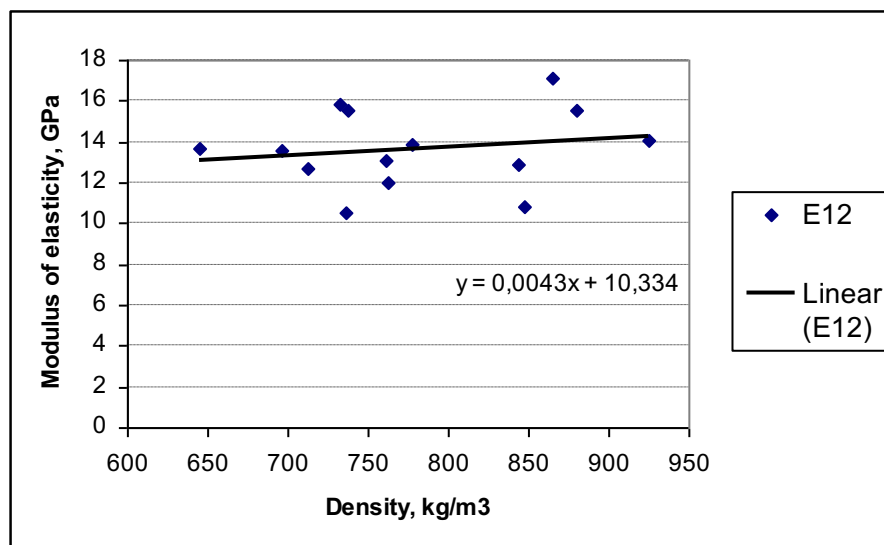


Fig. 5 - Dependence of the bending modulus of elasticity on density

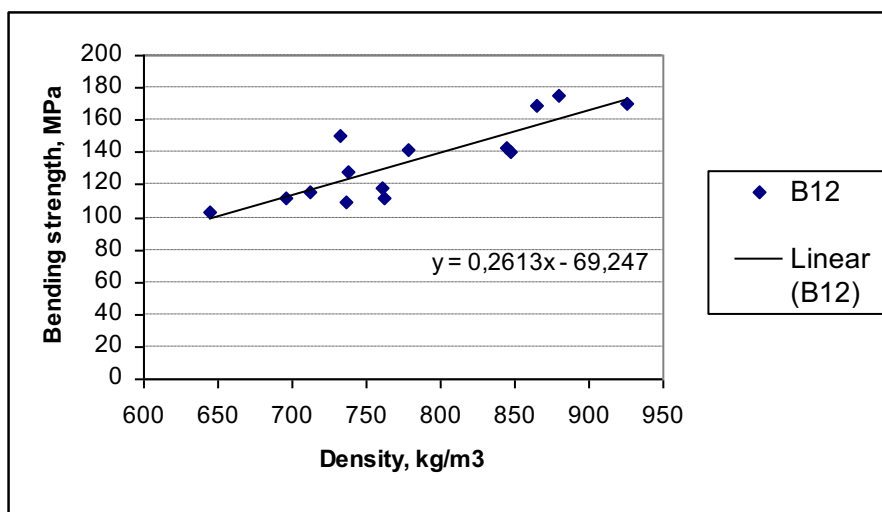


Fig. 6 - Dependence of the static bending strength on density

The impact strength is one of the most sensitive properties of wood. The obtained results are presented in Table 11 and Fig. 7. The dependence of the impact strength on density may be best expressed by an exponential function. The impact strength increases more significantly with the growth of density. The differences between C27 and H27 are not reliable, i.e. the big plant spaciousness does not exert any effect ($t = 2.62$). The differences between C4 and 320 are reliable ($t = 17.81$). Since both species have grown under equal free space conditions and C4 is a twice younger tree, while its strength is higher, in this case the decisive factor turns out to be heredity again.

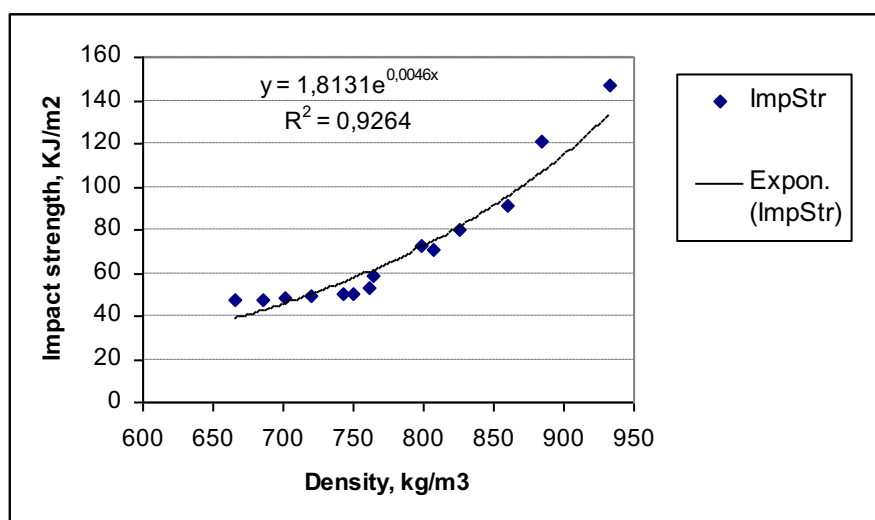


Fig. 7 - Dependence of the impact bending strength on density

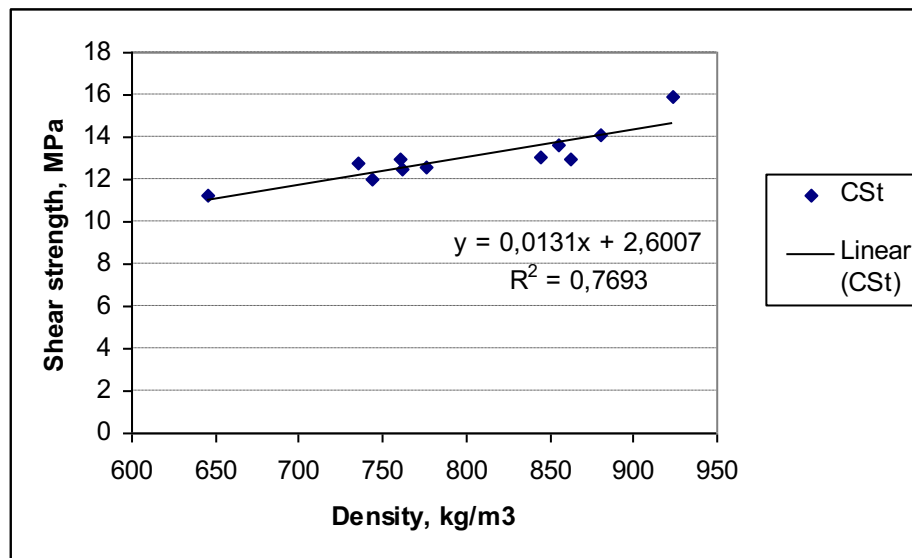


Fig. 8 Dependence of the shear strength in fiber length direction on density

The comparison between the impact bending strength values for wood clone H27, grown at a free space of 16 m² and for clone P10, grown at spaciousness of 2 m² reveals that the differences are reliable ($t = 5.89$). This difference is reliable and it may be concluded again that heredity is the more important factor for wood quality.

Consequently, the plant growth spaciousness exerts effect on the impact strength. The bigger is the growth spaciousness, the higher is the impact strength.

The shear strength along the fiber length is the most important property for furniture production and construction. The obtained results are shown in Table 11 and Fig. 8. It has been established that the shear strength increases with the growth of density, the dependence being expressed by a linear equation. The highest shear strength has been exhibited by C54 (15.92 MPa). Compared to B4 (12.96 MPa), it is a bit higher and the difference is reliable ($t = 6.88$), the age being the basic reason for this. The differences between C27 and H27 are not reliable, i.e. the plant growth spaciousness does not exert any effect on this property and the heredity factor is the decisive one. The comparison between the shear strength values of clones C4 (13.61 MPa) and P10 (11.28 MPa) shows a slight preponderance of the cultivated Locust tree. The values of the splitting resistance are calculated according to the Bulgarian standard in KN/m. The obtained mean arithmetic values are shown in Table 11. The differences between C27 and H27 are not reliable ($t = 1.58$ %). The differences between C4 and P20 are reliable ($t = 5.49$) and the decisive role of heredity is confirmed. It has been established that the resistance against splitting increases with the increase of density.

4. CONCLUSIONS

The wood of the straight trunk acacia is characterized by high density and high extractive substance content. These circumstances predetermine its high resistance against wood-destructing fungi. With respect to the durability index parameter (ND) the acacia heart wood is referred to class 1 (CND-1, i.e. very durable) as regulated by EN350/1-93. The acacia wood is very hard and this predetermines its high wear resistance. These properties are the reason for using this material in the production of floor

covers, park furniture and structures operated in the open. Floor covers may be also produced from Locust tree wood because it is very hard and possesses high wear resistance. The performed comparative studies on the mechanical properties of the Locust tree wood have shown that these parameters are very high and depend substantially on density. With respect to its mechanical properties the Locust tree wood is competitive to the oak wood and may successfully replace it in the construction of structures and elements intended for exterior applications.

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