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WOOD QUALITY CHANGE IN FOREST PINE AND SPRUCE PLANTATIONS

The results of research of the quality of wood from pine and spruce forest plantations are submitted. The density of wood from pine and spruce forest plantations in the whole planting is reduced compared with the control stands. However, the observed reduction in the density of wood from plantations is not credible.

Introduction. When trees are grown in forest plantations, quality characteristics of the wood obtained are of special importance. For this reason I. V. Shutov and other authors [1] underline that "quantity characteristics of wood harvest from forest plantations should be considered only together with its quality values'. Besides, quality of the obtained wood raw materials is of more vital importance that its amount. This is especially true for those plantations where they wood for decorative and furniture-manufacturing purposes.

Main part. Some experimental plantations were established in the Republic of Belarus as early as in the 70s and 80s of XX century. Being 30-47 years old now, wood of common pine and common spruce harvested from these plantations can be compared to that from control plantations as to its quality characteristics.

Interested data on wood quality were obtained by us in the summer of 2012 during study of forest plantations of a stationary experimental site in quarter 32 of Podsvilskoye forest station of Dvinskaya Experimental Forest Base (Forest Research Institute of Belarus NAS). The plantations under study were established in the spring of 1977 by thinning 11-year-old common pine stands. The plantations are characterized by varying density of standing trees, intensive chemical reclamation (four-time fertilization by nitric and all-nutrient fertilizers in a dose of 100-150 kg/ha application rate) and two-stage branch cutting up to 6.0-7.0 m of the tree trunk.

Another study of wood quality involved an experimental common spruce plantation in quarter 40 of Podsvilskoye forest station of Dvinskaya Experimental Forest Base planted in the spring of 1982, that plantation's present age being 30 years. The experimental study included four options to be repeated three times:

− control option: forest trees planted as seedlings (five-row lanes);

− forest trees planted as seedlings (five-row lanes), chemical reclamation involved;

− forest trees planted as seedlings (two-row lanes) combined with perennial lupine;

− forest plantations (single rows) combined with perennial lupine, no thinning.

Experimental forest sites with perennial lupine have trees planted in both five-row and two-row lanes, the inter-row space being 1.7 m, the inter-lane space being 3.5 m. The forest type is wood sorrel spruce forest, the forest growth conditions type is D_2. The area of the experimental site makes up 6 ha.

Perennial lupine was planted in wide inter-row spaces in the second year of spruce growth. Forests with perennial lupine and two-row lane trees location were thinned in their twelfth year of growth thus the forest density making up 720 trees per 1 ha and the branches being cut up to 6.0–6.5 m of the tree trunk. This scenario is of the greatest practical and scientific value as it takes into the plantation forest growing rules and techniques. So, spruce wood quality was studied in thinned forest stands with perennial lupine, the trees planted in two-row lanes, as well as in those lupine-containing stands where thinning had not been carried out.

Basic wood density was studied by analyzing specimens of cylinder shape (core specimens) taken from growing trees by an increment borer at the height of 1.3 m at five main diameter classes (central and four adjacent). Almost all 30-year-old trees of the forest plantation under study had these diameter classes. The results of the study are given in the Table.

It has been determined that basic wood density has some peculiarities as to its distribution by diameter classes, wood species and plantation type. In particular, common pine plantations reveal only inconsiderable basic density differences by diameter classes in both forest and control plantations. The differences can vary from 426 kg/m^3 (minimum) to 451 kg/m^3 (maximum) or 5.9% for all diameter classes in forest plantations. Basic wood density varies very inconsiderably by different diameter classes (20, 24 and 28 cm) being 444, 442 and 448 kg/m^3 respectively, i.e. changes very little. The same situation applies to trees from the control plantation.

Common spruce plantations have a little different distribution of density by diameter classes, i.e. the tree diameter increasing, wood density becomes considerably lower. So, the wood density decreased from 371 kg/m^3 (diameter class 16 cm) to 329 kg/m^3 (diameter class 32 cm) in forest spruce plantations.

Basic wood density at 1.3 m of the tree trunk by diameter classes

Type of plantation	Basic density, kg/m3, and proportion of trees by diameter classes, cm							Weighted-average wood density parameters, kg/m^3
	8	12	16	20	24	28	32	
Pine								
Forest plantation	–	–	426 15.9%	444 21.7%	442 30.5%	448 20.3%	451 11.6%	442 ± 3.75
Control plantation	–	418 58%	453 21.8%	453 32.2%	460 39.6%	463 4.6%	–	454 ± 4.02
Spruce								
Forest plantation	–	–	371 3.4%	376 13.8%	362 48.2%	359 22.4%	329 12.2%	354 ± 3.54
Control plantation	378 4.9%	375 296%	380 42.0%	365 17.3%	359 6.2%	–	–	373 ± 3.62

A similar but less conspicuous trend was registered in the control plantation where the wood density decreased from 378 kg/m^3 to 359 kg/m^3 (5.0%). The most essential established matter was the fact that basic wood density in both spruce and pine forest plantations was slightly lower than that registered in the control plantations which was proven by the weighted-average wood density parameters. This can primarily be attributed to wider annual rings in forest plantations and larger tree diameters in those plantations. However the results of statistical analysis show that the registered wood density decrease are not very reliable (for pine: $t_f = 1.5$ at $t_{st} = 3.2$; for spruce: $t_f = 2.2$ at $t_{st} = 3.2$). Therefore, wood density of forest trees is almost the same as that of artificially created stands. Wood science describes wood density as a universal parameter of its quality as there is a close dependence between wood density and its quality characteristics. The calculated mechanical properties of pine and spruce in forest and control plantations prove that the most important mechanical properties of wood are essentially the same for both forest and control plantations. The revealed differences in compression parallel to the grain, statistical bending, impact bending, butt hardness, modulus of elasticity are typical of the plantations species composition. As can be seen in the above table, wood density of common pine is by 22% higher than that of common spruce.

It should be noted that similar data were obtained in the course of earlier research carried out by S. S. Shtukin, E. E. Paul, D. A. Podoshvelev and A. P. Mayseenok [2] when sample trees were cut to study the properties of wood of common pine. Wood samples were made from one-meter trunk sections cut at 1.3-meter height and close to the crown.

Branchiness is known to be a major factor for determining a grade of wood and the crown density is highly determined by inter-branch distances. The study has shown that mineral fertilization of common pine plantations fosters the diameter increment of branches. Thus, the plantation density being 2 000 trees per 1 ha, the average diameter of the largest branch is 4 cm that is 5 mm thicker than registered in the plantations without mineral fertilization and perennial lupine [3]. At the same time, 8-year-old plantations having 4 000 and 8 000 trees per 1 ha do not reveal any considerable differences of the branch average diameters in both fertilized and control plantations. However, the number of branches remains constant.

Comparing branch diameter data to the STB 1711−2007 standards ("Coniferous round timber. Specifications") [4], it can be noted that larger pine and spruce trees show a branch diameter which is considerably smaller than second-grade timber limit (5 cm) for plantations without mineral fertilization and without perennial lupine.

Branchiness standards became a lot stricter after STB 1711-2007 had been introduced (as compared to the earlier standard GOST 9463-88 "Coniferous round timber"). According to the earlier GOST standard first-grade large round timber was allowed have 5-cm diameter branches. Therefore now first-grade timber (where branches and side shoots are not allowed) can be obtained only in forest plantations with earlier branch cutting.

As our research shows branch growth in the butt-log portion ceases by the time pine trees of forest plantations have reached the age of 30 years [3]. Therefore, on condition that chemical or biological melioration is applied, experimental forest plantations with 2 000 trees per 1 ha will be dominated by pine trees yielding second-grade large timber by the time the plantations have reached their 'cutting' age.

Conclusion. Basic wood density in forest plantations of common pine and common spruce is revealed to be lower as compared to the control plantations. This can be explained by thicker trees and wider annual rings of trees grown in the forest plantations. However the registered lower wood density cannot be considered reliable statistical data.

Wood density by diameter classes varies only inconsiderably in both forest and control plantations. These differences do not exceed 5.9% for common pine. Moreover, the busiest diameter classes (20, 24 and 28 cm) do not reveal any considerable variations. The same principle applies to the trees from experimental control plantations. Spruce plantations reveal a different basic wood density distribution by diameter classes. i.e.: the diameter increasing the wood density decreases notably. This reduction can make up 11%. This principle, however less clearly marked, is revealed in the control plantation as well with wood density decreasing by 5%.

The 2–4-times reducing density of pine and spruce trees results in 1.3-1.6-times increasing average diameter of the largest branches of standard-bearing trees at the trunk height of up to 6 m.

Due to the newly introduced STB 1711–2011 standard "Coniferous round timber. Specifications" the requirements to branchiness of coniferous timber have become stricter. First-grade timber where branches and side shoots are not allowed can be obtained only from forest plantations with branch cutting. In spruce plantations the average diameter of the largest branch is considerably (twofold) lower than the required standard for large second-grade timber.

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