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SELECTED TREE CHARACTERISTICS AND WOOD PROPERTIES OF TWO POPLAR CLONES

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ABSTRACT

Poplar clones, genetically improved with fast growth had been planted. Usually the purpose of such plantations is production of biomass, pulp and paper.

For selecting and managing trees it is important to know the properties of wood that are often under genetic control. This article presents tree characteristics and some anatomical properties of two poplar clones grown on two sites in Croatia; the Italian 'I-214' (*P.* × *euroamericana*) and the Serbian 'S1-8' (*P. deltoides*).

Five trees from each clone were collected from both sites. Site and clone had statistically significant influence on tree characteristics of chosen poplars. Clone 'S1-8' had superior growth increment, survival and it had significantly larger cell wood and ray wood percentage and lower fiber lumen percentage on both sites, while fiber length of both clones was larger on less favourable site in Koprivnica. At the same time clone 'S1-8' had larger amount of undesired tension wood.

KEY WORDS: poplar clones, site, anatomical wood properties, growth increment

INTRODUCTION

The increasing demands for wood and fibers gave impulse for selecting, planting and investigating fast-growing poplar species as a potential raw material for different markets.

Usually they are genetically improved with good survival of trees.

Poplars are used in production of fibers for pulp and paper, solid wood and composite wood production. Nowadays, poplar clones are also used as a biomass for energy, for carbon sequestration and phytoremediation of environmental problems. Rotations are usually short up to 15 years (De Bell et al. 2002). Larger part of the wood produced in poplar clones is in the juvenile core. The juvenile wood properties differ from the mature wood.

Many authors studied the difference between the juvenile and mature wood (Zobel and Buijtenen 1989). In juvenile zone wood properties generally change from pit outward, while in mature wood zone nearly all properties of wood are relatively constant. The fiber length is often important factor for using wood and has been well studied. According to investigations of many authors, mature wood of *Populus* has fiber lengths from 1.3 to 1.4

mm (Panshin and deZeeuw 1980, Zobel and Sprague 1998). Fiber length in poplar species and clones increases with age or distance from pith (Holt and Murphey 1978, Cheng and Bensend 1979; Murphey et al. 1979, Yanchuk et al. 1984, Bendtsen and Senft 1986, Koubaa et al. 1998, DeBell et al. 1998 and 2002). Different authors reported interclonal, intraclonal, and within-tree variation of fiber length in poplars and their hybrids (Yanchuk et al. 1984, Koubaa et al. 1998).

Due to their rapid growth rate, poplar clones are often sensitive to formation of undesired tension wood. Tension wood generally appears on the tightened upper face of inclined stems and branches. Usually tension wood is considered as an abnormal wood tissue produced by cambium in reaction to gravitational stimulus by displacement of an axis from its vertical position (Wardrop 1964, Timell 1969, Côté et al. 1969).

Some authors reported that due to rapid growth tension wood could be formed regardless to other environmental effects in straight stems (Isebrands and Bensend 1972, Kroll et al. 1992). Jourez et al. (2001) report that in young stems of poplar clones only 2h 15 min of exposure to the stimulus is sufficient for the formation of reaction wood.

Wood structure of 'I-214', the Italian poplar clone is well investigated. It requires intensive silviculture treatment, and the wood is considered of lower density (Peszlen 1994). The Serbian, clone 'S1-8' showed superior growth increment and better survival compared to clone 'I-214' (Pfeifer 1994, 2001). By survival it is assumed number of stems that have survived some time after plantation. Yet, in spite of its good increment and survival the quality of wood of 'S1-8' clone (wood structure properties) is still insufficiently studied.

The aim of this article was to provide some information on the characteristics of stem wood produced in 'S1-8' and 'I-214' poplar clones grown on two sites in Croatia as well as information about some wood structure properties important for wood processing. For that purpose fiber length, cell wall percentage, vessel percentage, wood ray percentage and fiber lumen percentage were also measured. The amount of tension wood was visually estimated on transverse sections.

MATERIAL AND METHODS

Five trees of two poplar clones, 'I-214' (*P. × euroamericana*) and 'S1-8' (*P. deltoides*) had been collected from 20 years old plantations managed on two contrast sites in the lowland of the river Drava in Croatia. General description of sites is given in Tab. 1. The outward appearance of all trees was that they were straight, sound and round.

Tab. 1: General description of sites

Site parameters	Site 1	Site 2
City	Osijek	Koprivnica
Climate	Continental	
Soil type	Alluvial soil with clayey to loamy interactions within 150 cm or with paleosoil at 150 cm*	Alluvial soil more gravely and sandy - cause of weak or impossible capillary ascent of ground water
* indicates qualities more favourable for hybrid poplar		

After individual trees have been selected and felled, the height, crown width, bark thickness, and diameter at breast height were determined.

From each tree, wood disks about 100 mm thick were cut at breast height. For fiber lumen, vessel lumen and cell wall percentage measurements, transverse sections (20 µm) from each 2nd, 4th, 7th, 10th, 14th and 18th growth ring were cut. Sections were stained with safranin and fast green to distinguish normal fibers from gelatinous fibers (Johansen 1940). Wood ray percentage was measured on tangential sections of the corresponding growth rings. Cell wall percentage was calculated by subtracting vessel lumen area, ray area and fiber lumen area percentages from unit area.

All measurements were preformed on a digitalized photographs using SCION image program. From each measured growth ring, five images as random replicates were analysed: one from the early wood region, one from the latewood region, and three from the middle part of each measured growth ring (Peszlen 1994).

FIBER LENGTH MEASUREMENTS

The wood from each 2nd, 4th, 7th, 10th, 14th and 18th growth ring was separated with a razor blade. Each ring for measurements was placed into an individual test tube and submerged by addition of a hiydrogen peroxide solution (20 % by volume). The test tubes were placed in a drying oven at 63°C for 24 hours to fasten the chemical maceration process. After 24 hours, the samples were rinsed three times with de-ionized water and stained with an aqueous solution of safranin to improve contrast for microscoping. The stained macerated material from each growth ring was placed on two microscopic slides and mounted in glycerine gelatine. Fiber length was measured on Reichert fiberscope. For each growth ring 50 unbroken fibers were measured. The data was transferred to computer and fiber length was calculated. The amount of tension wood percentage was visually estimated on the transverse sections.

RESULTS AND DISCUSSION

The average values of tree characteristics and anatomical properties of wood are presented in Tabs. 2 and 3. Analysis of variance procedure was used to test the effect of site, clone and site x clone on selected properties (Tab. 4).

Tab. 2: Mean tree characteristics and anatomical wood properties for both clones grown on two sites

Site	Trees	Source	Tree height (m)	Crown width (m)	Bark thickness (cm)	Tree diameter (cm)	Fiber lumen area (%)	Vessel lumen area (%)	Wood ray area (%)	Cell wall area (%)	Fiber length (mm)
Osijek	10	Mean	33	19.83	3.06	40.78	25.06	30.1	9.03	35.81	1.11
		St. Dev	2	2.78	1.03	6.65	6.29	6.38	1.59	3.72	0.27
Koprivnica	10	Mean	27.92	15.84	2.93	30.45	22.72	31.32	8.72	37.24	1.18
		St. Dev	3.84	4.01	0.93	4.99	4.34	5.01	1.07	3.41	0.24

Tab. 3: Mean tree characteristics and anatomical wood properties for two clones

Clone	Trees	Source	Tree height (m)	Crown width (m)	Bark thickness (cm)	Tree diameter (cm)	Fiber lumen area (%)	Vessel lumen area (%)	Wood ray area (%)	Cell wall area (%)	Fiber length (mm)
'S1-8'	10	Mean	30.66	18.58	3.78	39.16	20.65	31.02	9.84	38.49	1.16
		St. Dev	5.15	4.57	0.64	8.67	1.88	7.35	0.99	2.71	0.25
'I-214'	10	Mean	30.43	17.1	2.21	32.06	27.13	30.19	8.12	34.56	1.14
		St. Dev	2.88	3.21	0.45	4.86	5.75	5.35	0,88	3.18	0.26

Tab. 4: Analysis of variance results for tree characteristics and anatomical wood properties of two clones grown on two sites

Source of variation	Df	Tree height (m)	Crown width (m)	Bark thickness (cm)	Tree diameter (cm)	Fiber lumen area (%)	Vessel lumen area (%)	Wood ray area (%)	Cell wall area (%)	Fiber length (mm)
Site	1	**	**	NS	**	NS	NS	NS	NS	*
Clone	1	NS	NS	**	**	**	NS	*	*	NS
Site x clone	1	NS	NS	NS	NS	NS	NS	NS	NS	NS

*** Statistically significant at the 1 % level, * Statistically significant at the 5 % level, NS Not significant at the 5 % level*

Measured macroscopic features of trees differed between sites (Tab. 2) and between clones (Tab. 3).

Among them only tree diameter was under strong influence of both clones and sites.

Tree height and crown width were strongly influenced only by site being always larger in Osijek, and bark thickness was strongly influenced only by clone being thicker always in clone 'S1-8' (Tab. 4). On more favourable site (Osijek) both clones had greater growth increment (Tab. 2).

At the same time on both sites clone 'S1-8' had superior diameter increment, thicker bark and greater percentage of wood rays compared to clone 'I-214' (Tab. 3). Good survival (adaptation to climate conditions as well as disease resistance) of clone 'S1-8' that was observed earlier (Pfeifer 1994, 2001) can partly be explained with its thicker bark and greater wood ray percentage. Superior diameter increment of clone 'S1-8' additionally made it popular in breeding programs.

Fiber lumen area, cell wall area and wood ray area were strongly influenced only by clone (Tab. 4). On both sites clone 'S1-8' had greater cell wall area and lower fiber lumen area (Tab. 3) as well as larger amount of tension wood estimated compared to clone 'I-214' (Tab. 5). The tension wood was visually observed in most of the growth rings of clone 'S1-8' on both sites.

Tab. 5: Average visually estimated tension wood percentage (%) for both clones grown on two sites

Site	S1-8	I-214
Osijek	50%	10%
Koprivnica	60%	25%

Badia et al. (2006) reported highest percentage of tension wood in trees of cultivars with best morphology. Larger average amount of tension wood estimated in clone „S1-8" (Tab. 5) could also be explained by its better tree morphology (Tab. 3 and 4) and its survival. There is no data in the literature on tension wood percentage of clone „S1-8".

On both sites, clone „I-214" had lower amount of tension wood compared to „S1-8" (Tab. 5). Although the amounts of tension wood were estimated on microscopic level, the estimated values were similar to other reports (Badia et al. 2006, Sacre 1974). From these rough estimations one can say that percentage of tension wood is greater on less favourable site even in clone „I-214".

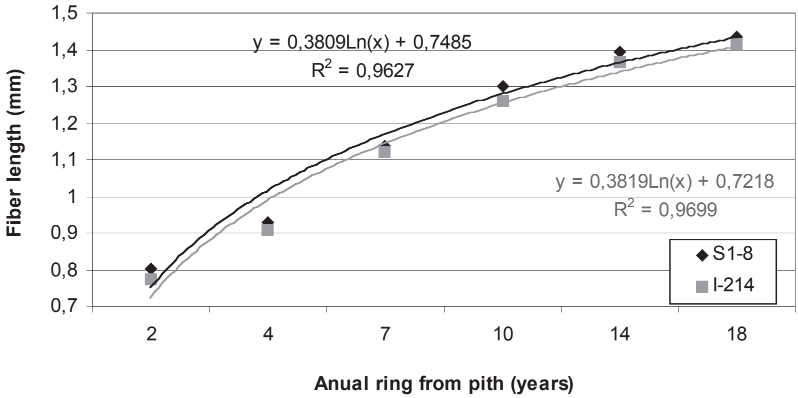

Fig. 1: Mean fiber length as a function of ring number from pith for 'S1-8' and 'I-214' poplar clones

There was no statistically significant difference between clones in average fiber length (Tab. 2), as well as in radial variation in fiber lengths from pith outwards (Fig. 1).

The results were in agreement with the results of Peszlen (1994) and Cheng and Bensend (1979) who reported no clonal effect on fiber length of poplar clones. They explained that the variation in fiber length is mainly result of physiological and environmental factors rather than genetic control. Average fiber length was statistically significantly larger in both clones in Koprivnica (Tab. 3).

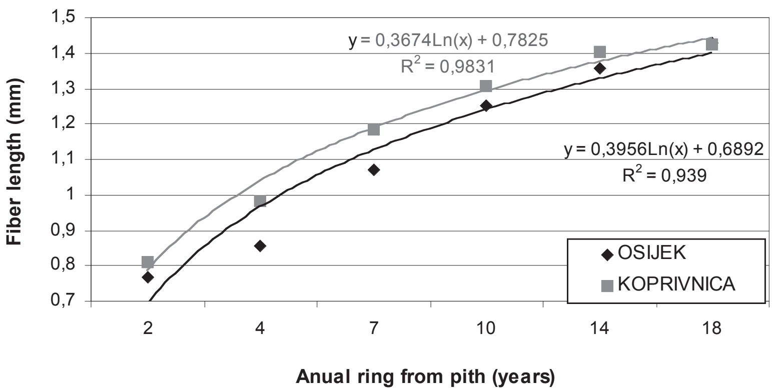

Fig. 2: Mean fiber length as a function of ring number from pith for poplar clones grown on two sites

Mean fiber length as a function of ring number from pith was also larger in Koprivnica (Fig. 2). The relative effect of growth rate on cell length was described by Bailey (1920) and Priestley (1930) in which the cambial initials are shorter because of earlier transverse divisions in the initials that occur with rapid diameter growth. As it is shown in Tab. 2 growth rate was slower in trees grown in less favourable site (Koprivnica). As a consequence fibre lengths were consistently longer in Koprivnica than in Osijek.

Fiber length on both sites was initially quite short near the pith, then steadily increased until tenth growth ring after it showed tendency to level off (Fig. 2.). A rather similar pattern has been reported for poplars and their hybrids (Cheng and Bensend 1979, Yanchuk et al. 1984, De Bell et al. 1998).

CONCLUSIONS

The growth increment of both poplar clones was strongly under site and genetic control. On more favourable site in Osijek both clones had better growth increment.

At the same time clone 'S1-8' had larger diameter at breast height and thicker bark compared to clone 'I-214'. More favourable site additionally provided larger growth increment in both clones as well as larger tree height and crown width.

Faster growth together with thicker bark and good survival of 'S1-8' poplar clone are certainly important factors in selection and breeding programs.

However the anatomical properties of wood measured in two clones differed.

The cell wall percentage, fiber lumen percentage and wood ray percentage were strongly under genetic control.

Clone 'S1-8' had larger cell wall percentage and wood ray percentage, but lower fiber lumen percentage with larger amount of undesired tension wood fibers compared to clone 'I-214'.

A statistically significant difference in average fiber length existed only between two sites. On less favourable site in Koprivnica average fiber length was larger. There was no significant difference in average fiber lengths between clones.

At breast height, fiber length increased from pith outward, with a tendency to level of from tenth annual ring.

Although average fiber lengths between clones did not differ significantly, larger cell wall percentage, lower fiber lumen percentage with large amount of tension wood in clone 'S1-8' will certainly define its potential as a raw material.

In future the selection of poplar clones should be focused for production of trees that will satisfy different demands of market.

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