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Density of wood of 2-year *Paulownia* plantation damaged by wind in Poland

Marcin Jakubowski Marek Dobroczyński

Poznań University of Life Sciences, Faculty of Forestry, Department of Forest Utilisation,
corresponding author: Marcin Jakubowski, email: marcin.jakubowski@up.poznan.pl

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Abstract: The main purpose of his work was to examine a two type of wood density: basic density and green density. All the studies were carried out on a plantation grown in central Poland and damaged by tornado in summer 2017. For density tests a 36 broken plants were used. Results show a high value of green wood density (766 kg×m^{-3}) and very low value of basic wood density (208 kg×m^{-3}). The coefficient of variability was a bit higher for green density (11 %) than for basic density (7.6 %). Low value of basic density is probably caused by juvenile character of wood.

Key words: Green wood density, basic wood density, plantation, biomass production

INTRODUCTION

Paulownia is a type of genus origin from Asia, this tree is known for its very fast growth and high adaptability to various environment conditions (Icka et al. 2016). Because of these features paulownia dynamicly spread all over the world. Natural species, did not meet the expectations of farmers and scientists, so they began to create various hybrids. Currently in Europe several species hybrids are cultivated: Clon in vitro 112 (Icka et al. 2016, Berdón Berdón et al. 2017), Cotevisia, Sundsu (Zuazo et al. 2013), Shan Tong (Luca et al. 2014). Hybrids of Paulownia found a good conditions mainly in southern Europe in last 20 years, but selected hybrids has been cultivated in the countries of Central Europe too. In Poland they are best known Clone in vitro 112 under the trade name "Oxytree" and Shan Tong (Jakubowski et al. 2018). *Paulownia* crops are still too young to verify the usefulness of hybrids for cultivation in Poland (Jakubowski et al. 2018, Smarul et al. 2018). The main purpose of crops in southern Europe is to obtain high-quality wood in short 6-10 year cycles. The second goal is biomass production, which can be used for cellulose production and for energy purposes. In these cases the cycles may be even shorter (Berdón Berdón et al. 2017).

In this work fragments of 36 damaged trees were used for density testing. The main purpose of research was to examine a two type of wood density: basic density (BD) and green density (GD).

METHODS

This study was carried out on seedlings of the Shan Tong hybrid (*P. fortunei x P. tomentosa*). The plantation was established in the central part of Poland in 2016 (51°59'13.9"N 16°51'52.1"E), 90 trees were planted. Ultimately, cultivation was planned in an 8-year cycle. A year after establishing the plantation a small local tornado damaged most of the plants. The wind speed was unknown, but based on damage to nearby trees, it was estimated at about 90-100 km/h. Almost all leaves were torn off and most of trees were broken. The last measurements were taken there in June, a month before the damage. The trunks of 36 damaged trees were used to study of wood density. A two-year trunk fragment was subjected to density tests. Last year, the shoot was cut at a height of about 30 cm. In the spring of 2017, a new shoot was released from the cut tree. A new shoot which was intended to be the target tree trunk, was damaged by a gale at the end of July (Fig. 1). The diameter of the tree was measured at a height of 50 cm on new shoot. Strength tests were impossible due to too much damage of wood. The research material was collected a few days after the occurrence of the tornado from 36 trees, that were still alive. These trees could not grow further due to a broken stem in the upper part. The lower part of stem were useful for wood density research. Green wood density (GD) and basic density (BD) were tested according to following formula:

$$GD = \frac{M_F}{V_{max}} \text{ (kg×m}^{-3}\text{)}$$

where:

GD – green wood density

MF – mass of fresh sample wood

Vmax – volume of sample wood at maximum swelling,

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$$BD = \frac{M_{0\%}}{V_{max}} \text{ (kg×m}^{-3}\text{)}$$

where:
BD – basic wood density
$M_{0\%}$ – mass of sample 0% of moisture content

Vmax – volume of sample wood at maximum swelling

Due to the small size of trunk, tests were carried out on whole fragments of the debarked disks without zoning

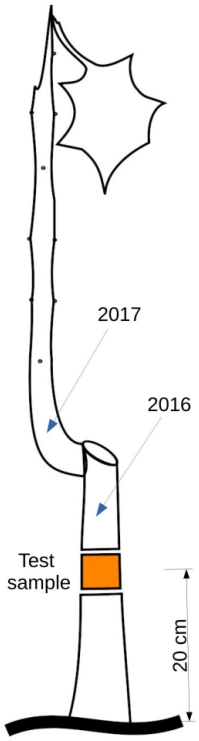

Fig. 1. Schematic drawing of a damaged paulownia tree and the place from which the samples were taken (orange).

(Fig. 1).

The material was collected from a height of about 15-20 cm from the ground surface. Mass of samples for green density was measured immediately by laboratory scales to an accuracy of 0.01g. For the basic density calculation samples before measuring were dried in electric drier at 105°C until they reached constant weight. Volume in both cases were measured by the water-displacement method which allows measurement for irregularly shaped green samples (Olesen 1971).

RESULTS

Plant height and diameter were measured on June 27, one month before the storm (Term I, Fig. 3). The average height of trees was then 74.8 cm. As a result of the gale, 39 trees survived out of 90. During this period, the trees were still in a phase of intensive growth. Due to the large damage, mainly consisting of breaking the leaves, further growth was already very slow, so the final average height amount 199 cm (Term II, Fig. 3). The graph (Fig. 3) shows the rate of plantation growth until a tornado occurs and from the moment of damage to the end of the growing season.

Table 1. Wood density of young Paulownia tree trunk.

Basic statistics	Basic density (BD)	Green density (GD)
Average (kg×m^{-3})	208.2	765.9
N	36	36
Min (kg×m^{-3})	184.3	546.9
Max (kg×m^{-3})	247.8	1011
Std dev (kg×m^{-3})	15.79	88.42
Variability Coeff (%)	7.6	11.54

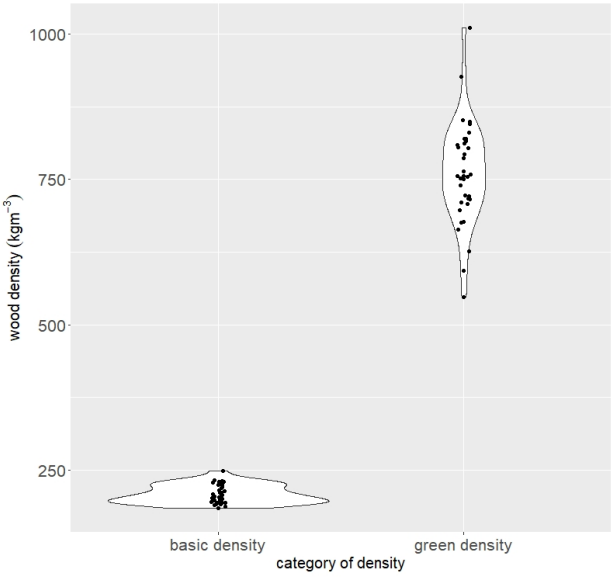

Fig. 2. Distribution of wood density in the population of tested wood samples.

Green wood density and basic density differ significantly (Fig 2.). The average density of green wood (GD) was 766 kg×m^{-3}, while the basic density (BD) of only 208 kg×m^{-3} and it seems to be extremely low value. Wood density reported by the others range from 220 kg×m^{-3} to 350 kg×m^{-3} (Kaymakci et al. 2013, Kozakiewicz 2013, Joshi et al. 2015). It should be noted that variability of green wood density (GD) range from 547 kg×m^{-3} to 1011 kg×m^{-3}, but in basic density (BD) we noticed less variations, so coefficient of variability was also less for basic density (7.6 %) than for green density (11%) (Tab. 1).

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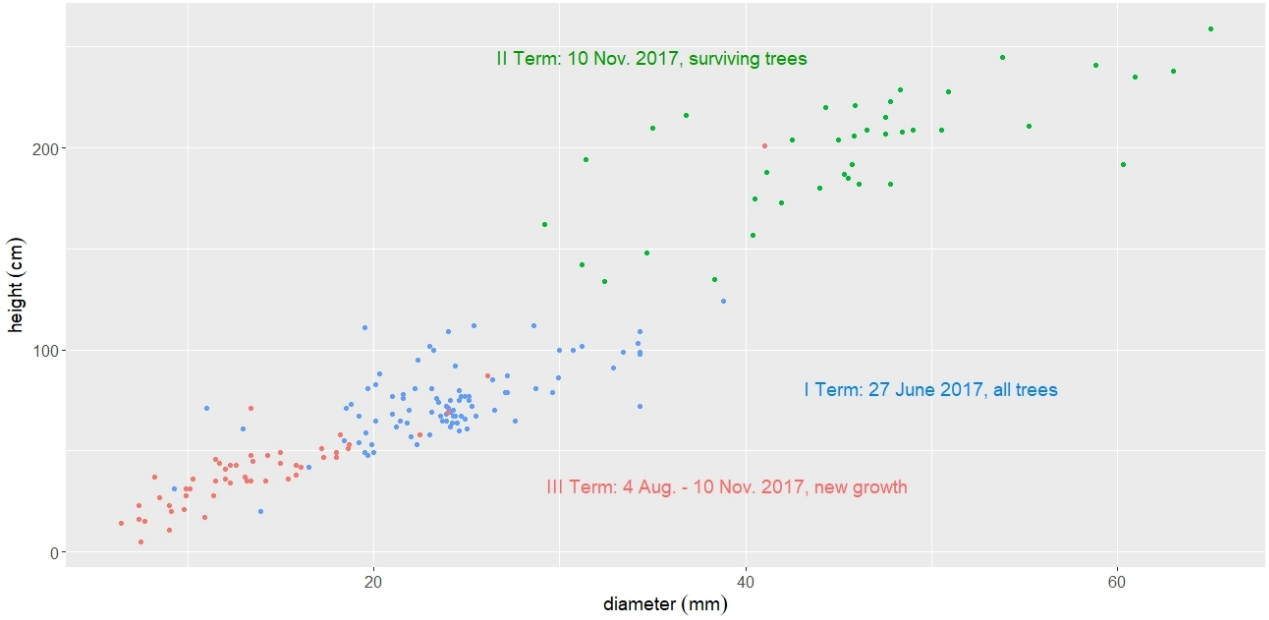

Fig. 3. Correlation between height and diameter in different growth periods during the growing season in 2017. I term – plantation complete (before the storm), II – trees damaged but promising, III – regrowth from cut stumps.

We conclude that the most of green wood mass was the water. This is indicated by the high difference between green wood density (GD) and basic wood density (BD). Some studies indicate a high demand for water in the early years of plantation (García-Morote et al. 2014, Icka et al. 2016). Examined plantation was established in the vicinity of the water reservoir, and the plants were well supplied with water. Probably the low value also results from the juvenile character of wood, we assume that the next annual rings will show a higher density. We also noticed, that trees grew well despite serious damage and show successful regrowth from all of the stumps.

CONCLUSION

There was a high difference between green wood density (765.9 kg×m^{-3}) and basic density (208.2 kg×m^{-3}) which amount of 558 kg×m^{-3}. This result shows that in the first 16 months production of dry mass of the trunk is at a very low level.

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