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Selected Physiological and Functional Properties of Paulownia (*Paulownia* sp.) Breeding Strains in the Context of Their Application for Energy Purposes

Royal paulownia (*Paulownia tomentosa* Steud.) is applied in western and southern European countries for industrial and energy purposes due to the high growth intensity and high biomass yield that can be obtained in a short-time period. However, it is a species with high thermal and light requirements. Paulownia has not been cultivated on a larger scale in our country thus far. Therefore, the aim of the present study was to evaluate the possibilities of utilizing this species for biomass production in south-eastern Poland. In the present work, the strength of growth, yielding and winter hardiness of thirteen breeding strains of royal paulownia were compared. The overall physiological status of these plants was also evaluated. Based on the results of a 4-year experiment, fast-growing and winter-hardy paulownia strains and specimens were selected. An attempt was also made to identify morphological and physiological markers useful for initial estimation of biomass yield and selection of valuable paulownia genotypes.

A one-factor experiment was established in a randomized complete block design on organic soil formed of low peat, good wheat complex, class IIIa in June 2014 in the Świlcza Commune. Weather conditions in the years 2014-2018 significantly varied. Thirteen breeding strains of royal paulownia of different origin were assessed in extensive and stressful conditions, resulting from high plant density, lack of irrigation and supplementary mineral fertilization, as well as weed control limited to the beginning of vegetation.

Information on intensive growth and high yielding of royal paulownia plants has been confirmed. The tested breeding strains differed significantly in terms of growth intensity, biomass yield and winter hardiness. Therefore, fast-growing and highly productive paulownia strains with reduced thermal requirements and higher low-temperature resistance, i.e. most promising for cultivation in south-eastern Poland, were selected. These were ‘LuP’, ‘LuD’ and ‘We’ strains. They were characterized by a significantly higher SPAD index and usually higher chlorophyll a, b, carotenoids and free proline contents in relation to other strains. They also exhibited higher efficiency of the light photosynthesis phase and better overall physiological status determined by chlorophyll fluorescence measurements. It could

therefore be argued that the selected strains were more tolerant to abiotic stress than others. Cultivation of these strains could provide approximately a total of up to 17.6 tons of fresh and 8.8 tons of dry stem mass per hectare after the first three years of vegetation. The 'LuD' strain was characterized by clearly higher productivity and winter hardiness than the sister strain – 'LuB', which indicated a significant proportion of cytoplasmic genes in the expression of these traits. The heat of combustion of paulownia stems was generally similar to the value reported in the literature for willow and poplar. Nevertheless, a relatively higher nitrogen and sulfur content reduces the value of paulownia biomass as an energy resource. Moreover, paulownia specimens that better adapted to Polish climatic conditions were selected in the present experiment. Based on the allometric equation, cultivation of clones of fast-growing paulownia specimens could provide up to 12.8 $t \cdot ha^{-1}$ of fresh stem mass after the second, 8.3 $t \cdot ha^{-1}$ after the third and even up to 18.0 $t \cdot ha^{-1}$ after the fourth year of vegetation.

Many significant relationships have been demonstrated between biometric, yielding and physiological traits, as well as winter hardiness of royal paulownia plants. Based on the results of a four-year field experiment, two markers were found, i.e. length of the strongest shoot and the SPAD index, which may prove useful for the selection and breeding purposes of valuable strains and specimens of royal paulownia. These indicators were strongly and positively correlated with plant growth, yielding and winter hardiness in each of the four years of research.