BS-00239

Growth variation and heat resistance in spruce trees (*Picea* spp.)

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Keywords: Genetic variation, heat resistance, maximal photochemical efficiency, *Picea*, transcriptome

The genus *Picea*, or spruce, has a wide geographical range and includes species with significant economic and ecological values in the northern hemisphere. As the growth variation and heat resistance of *Picea* species have not been studied, we conducted a garden experiment to study these parameters by examining 13 native and four exotic *Picea* species. Growth traits and gas exchange parameters were significantly different among the species studied as they were under relatively strong genetic control. The four exotic species (*P. abies*, *P. laxa, P. mariana* and *P. pungens*) exhibited good growth performance. In general, growth traits showed a significantly positive correlation with branching characteristics. Moreover, species with good growth performances also had a relatively high photosynthetic rate. The tremendous growth differences among *Picea* species were substantially related to the interspecies variation in maximum photosynthesis and photosynthetic nitrogen use efficiency. Subsequently, three *Picea* species with good growth performance, namely *P. abies*, *P. pungens* and *P. omorika*, were subjected to heat resistance tests at 35°C, 40°C and 45°C for 6 hours. Overall, all three species were negatively affected by exposure to 45°C, but *P. pungens* exhibited full recovery, with the highest relative water content. On the contrary, *P. omorika* exhibited partial recovery, and *P. abies* showed minimal recovery. The photosystem II of all three species were damaged after 45°C heat treatment, but *P. pungens* exhibited the most dramatic recovery with maximal photochemical efficiency recovering from 0 to 0.26. Transcriptome analysis showed that differential genes were mainly enriched in flavonoid biosynthesis and phenylpropanoid biosynthesis, which may affect differences in heat tolerance. Thus, thermal tolerance should be considered a tool for species selection and conservation in the face of climate change that is expected to bring high summer temperature events year on year.