Epigenetic Control of Heat Stress Resilience in *Populus*

Background

- Epigenetic regulation, particularly DNA methylation, plays a crucial role in the development of stress memory in perennial plants, enhancing their resilience to recurring environmental stresses. Unlike annuals, perennials benefit from these heritable epigenetic modifications, which can persist across seasons and potentially be transmitted to subsequent generations. This stress memory facilitates improved adaptation and biomass productivity. However, the specific mechanisms and their long-term stability remain areas of active investigation.

Approach

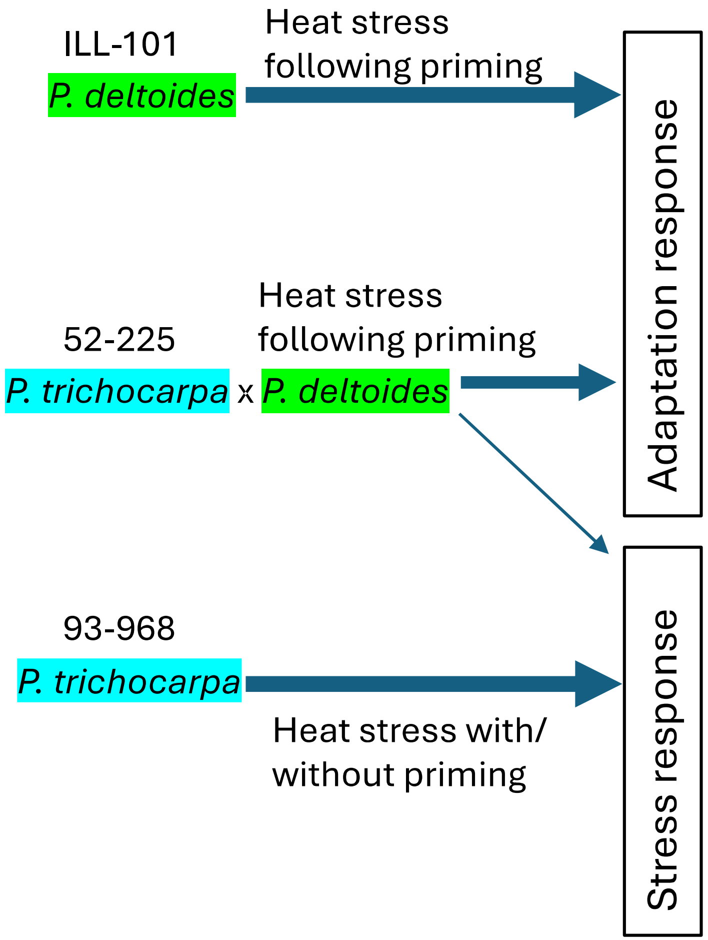
- Physiological responses of two *Populus* species and their F1 hybrid to heat priming and stress were assessed by linking photosynthetic traits to epigenetic and gene expression changes to uncover mechanisms of heat tolerance.

Results

- Heat priming drives distinct epigenetic changes, especially in DNA methylation, that influence gene expression and are mirrored in proteomic and metabolomic profiles.
- *P. deltoides* enhances photosynthetic efficiency via targeted epigenetic responses, while *P. trichocarpa* activates stress defenses without sustaining carbon assimilation.
- In hybrids, primed heat stress increases expression of key thermotolerance transcription factors.

Significance/Impacts

- These findings reveal that priming does not uniformly enhance stress tolerance in perennial trees but confers significant heat resilience in *P. deltoides*. Importantly, the species-specific benefits of priming can be inherited through hybridization, underscoring its potential as a breeding strategy for developing heat-tolerant trees.



A schematic model showing species-specific stress pathways. *P. deltoides* and the hybrid trigger an adaptation mechanism during heat stress following priming whereas *P. trichocarpa* employs a stress defense strategy.

Feyissa et al., *GCB Bioenergy* (2025) 17:e70033, https://doi.org/10.1111/gcbb.70033