

RESEARCH ARTICLE

Phenotypic plasticity versus ecotypic differentiation under recurrent summer drought in two drought-tolerant pine species

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Abstract

1. Despite worldwide reports of high tree mortality, growing evidence indicates that many tree species are well adapted to survive repeated dry spells. The drought resilience of trees is related to their phenotypic plasticity and ecotypic differentiation. Whether these two mechanisms act at the same organisational level of a tree and involve similar plant traits is still unknown.
2. We assessed phenotypic plasticity and ecotypic differentiation across four populations of *Pinus sylvestris* and *Pinus nigra* seedlings grown for 3 years under a recurrent summer drought treatment or well-watered control conditions in a common garden. We measured the response to the summer drought treatment of a total of 26 traits including shoot and needle morphology, needle anatomy and foliar macronutrients, and related the traits to the growing season water deficit (GSWD) at the location of the seed origin.
3. Foliar phenotypic plasticity in response to recurrent summer drought was surprisingly low, with the needle length and the fraction of mesophyll and phloem tissue adjusting to some extent. In comparison, shoot morphological traits were much more plastic in both species with predominant responses to the summer drought stress including shorter and less numerous apical and lateral shoots. These three traits were also correlated with GSWD at the seed origin, indicating local adaptation. In contrast, between-population variation of foliar morphological and anatomical traits, and macronutrients were mostly unrelated to the GSWD at the seed origin.
4. Consequently, phenotypic plasticity and ecotypic differentiation occurred at the same level of organisation and in the same plant traits, that is, shoot morphology. This combination of plasticity and ecotypic differentiation allowed *P. sylvestris* and *P. nigra* seedlings to rapidly acclimate to recurrent and long-lasting dry spells.
5. **Synthesis.** *Pinus sylvestris* and *P. nigra* seedlings showed considerable ecotypic differentiation and phenotypic plasticity of shoot morphological traits, and not foliar traits. Acclimation to recurrent severe summer drought was achieved by reducing shoot growth.

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