Drought adaptation of Italian silver fir genotypes in a climate change perspective

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Abstract

Resilience of Mediterranean forest ecosystems is closely linked to their ability to adapt to drought and increasingly hot temperatures. Such ability can be influenced by genetic differences between and within species, or provenances. Therefore, it is essential to define management guidelines that consider the role of local provenances in forest adaptation to climate change, and to promote the conservation and sustainable management of resilient forest genetic resources.

In this study, we analyse growth responses to drought of silver fir (*Abies alba*) in the Tuscan-Emilian Apennines National Park, while comparing the physiological performance of three provenances of this species in Italy: (a) Piedmont - (b) Northern Apennines (local) - (c) Southern Apennines. Drought severity was defined through the Standardised Precipitation-Evapotranspiration Index (SPEI). We carried out dendrochronological analyses by assessing climate-growth relationships, applying drought 'resilience indices' (RRR) based on tree ring width, and estimating water use efficiency (iWUE) through carbon isotope analyses ($\delta^{13}C$) on wood samples. Finally, we used FORMIND, an individual-tree process-based model, to simulate growth under two climate scenarios (R.C.P. 4.5 and 8.5). We used field data to parametrize allometric and growth equations used by FORMIND to describe provenance-specific behaviour.

Artificial forests had a faster growth than natural forests (BAI_{art}= 16.4 cm^2, BAI_{nat}= 13.2 cm^2), also showing higher resilience during severe droughts and higher recovery during severe and extreme droughts. Fir provenances differed slightly in growth rate (BAI_a= 17.5 cm^2, BAI_b= 19.0 cm^2, BAI_c=22.8 cm^2), with higher performance by the southern provenance. The southern Italian provenance also had better recovery and resilience during moderate and extreme dry years. Preliminary modelling results confirmed these trends, even if the differences between climate scenarios were not significant. Isotope analysis on tree rings will be performed soon.

The workflow proposed in this paper couples morphological with eco-physiological analyses, allowing a comprehensive overview of tree response to drought. These results provide important information on the adaptive response of silver fir under climate change, underlying the importance of local genetic diversity for adaptation. Southern provenances have shown better growth and resilience against drought, proving to be a very important resource in a climate change perspective. Thanks to the strong collaboration with the National Park and local forest managers, these results may find concrete application e.g. by planning assisted migration activities in the Park forests, and providing better protection of local fir provenances in natural forests.

Keywords: genetic diversity, SPEI, dendrochronology, forest modelling, C isotopes