Vapor pressure deficit is not a limiting factor for gas exchange in a mature dryland forest

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Abstract

Climate change is often associated with increasing vapor pressure deficit (VPD) and decreasing soil moisture (SM). While atmospheric and soil drying often co-occurs, their differential effects on plant functioning and productivity remain uncertain. We aimed to elaborate on the divergent effects and underlying mechanisms of soil and atmospheric drought, based on continuous, in situ measurements of branch gas exchange, with automated chambers, in a mature semiarid Aleppo pine forest. We investigated the response of control trees exposed to combined soil-atmosphere drought (low SM, high VPD) during the rainless Mediterranean summer, and that of trees experimentally unconstrained by soil dryness (high SM; using supplementary dry season water supply) but subjected to atmospheric drought (high VPD). During the seasonal dry period, branch conductance (g_{br}), the rates of transpiration (E) and net photosynthesis (A_{net}) decreased in low-SM trees but greatly increased in high-SM trees. The response of E and g_{br} to the massive rise in VPD (to a maximum of 7 kPa) was negative in low-SM trees and positive in high-SM trees. These observations were consistent with predictions based on a simple plant hydraulic model showing that plant water potential is a good predictor of the g_{br} and E response to VPD. These results demonstrate that the release from drought on the supply-side, in combination with plant hydraulic regulation, eliminates the effect of atmospheric demand (VPD) as a stressor and on canopy gas exchange in mature, drought-adapted pine trees.

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