Vapor pressure deficit was not a primary limiting factor for gas exchange in an irrigated, mature dryland Aleppo pine forest

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Abstract

Climate change is often associated with increasing vapor pressure deficit (VPD) and changes in soil moisture (SM). While atmospheric and soil drying often co-occur, their differential effects on plant functioning and productivity remain uncertain. We investigated 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-atmospheric 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}), transpiration rate (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 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 the importance of plant water potential in the g_{br} and E response to VPD. These results demonstrate that avoiding drought on the supply side (soil moisture) and relying on plant hydraulic regulation constrains the effects of atmospheric drought (VPD) as a stressor on canopy gas exchange in mature pine trees under field conditions.

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