Submitted Abstract

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Abstract

Plants can modulate the source and magnitude of water uptake under environmental stresses, ultimately constraining water and energy fluxes across Earth's surface. These alterations are scarcely quantified for future climatic scenarios such as warming, elevated atmospheric CO2 (eCO2) and droughts, and their interactions. Here we used diurnal soil moisture dynamics throughout the 2019 growing season to quantify the impacts of these three global change factors on root water uptake across a multilayer 3-–36 cm soil profile in a managed C3 mountain grassland in Austria; a key agricultural landscape within central Europe. We expected that 1) annual summer drought and eCO2 (+300 ppm) would reduce root water uptake relative to ambient conditions due to supply limitation and a lower stomatal conductance, whereas 2) greater vapour pressure gradients in warmed systems (+3 #) would elevate transpiration rates, increasing root water uptake. Furthermore, we determined the effects of these global change factors on root mass, length and further morphological traits using fine roots obtained from ingrowth root cores extracted three times during the season. We expected that 3) these root parameters would explain water uptake capacity across the global change treatments.

Plants reduced water uptake in droughted plots by ~35% by decreasing water extraction from the upper soil profile during the peak drought, also when additionally exposed to warming and eCO2. Contrary to our expectation, warmed plots had lower water uptake by 17-25% relative to control plots. Finally, vegetation in eCO2 plots displayed similar water uptake to plots under ambient conditions; however, eCO2 effects did buffer warming effects, such that plots with eCO2 and warming extracted less water than those subjected to warming alone. Treatments that affected root water uptake (drought, warming and multifactor treatments) generally increased root weight, length and some traits whilst decreasing others, whereas fine roots exposed to eCO2 remained similar to those under ambient conditions. Root water uptake capacity was related to fine root biomass and some root traits in ambient, drought, and eCO2 plots, yet no significant relationships were found for plots under warming or multifactor treatments. From our study, we conclude that eCO2, warming and drought have non-additive effects on grassland root water uptake, which are partially mediated by global change responses of root biomass and traits.