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Effects of climate change on plant carbon allocation to the soil microbial community

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Plant belowground carbon (C) allocation, and the consequent C transfer to soil microbes, links photosynthesis to heterotrophic respiration and is a key determinant of the ecosystem C cycle. Predicting climate change consequences on terrestrial C cycling thus requires a precise quantification of changes in plant C allocation. While information are available on the C transfer from plant to soil microbes in the presence of individual climate change factors, their interactive effects remain largely unknown. However, climate projections predict combined changes in multiple environmental factors, with higher precipitation variability following the increase in atmospheric CO_2 and in temperatures. While drought can reduce plant C transfer to soil microbes, elevated atmospheric CO_2 could enhance C available to plants and possibly ameliorate negative drought effects on belowground C allocation. Therefore, experiments analyzing the effects of combinations of different climate change factors on plant belowground C allocation are urgently needed.

The aim of this study was to quantify plant C allocation to different plant pools including belowground pools, and to soil microbes, in a managed montane C3 grassland under simulated climate change scenarios. At the experimental site, field plots were subjected to either ambient conditions or a simulated future climate, with a combination of increased temperature (+3°C) and elevated atmospheric CO_2 (+300ppm), for 3 years. A summer drought treatment was combined with the other treatment in a full factorial design in July 2017. We performed $13CO_2$ pulse-labeling experiments to trace the fate of plant C during peak drought. We measured 13C in plant biomass, and plant starch, fructans and soluble sugars, as well as in soil microbial biomass (PLFA).

Our results show that elevated CO_2 and warming altered plant biomass and C allocation patterns to different plant metabolites. Also transfer of plant C to the soil microbial community was quantitatively similar, but a higher amount of labelled carbon was found in bacterial PLFA biomarkers compared to ambient conditions. Drought treatment also altered plant labile carbohydrate composition and the allocation to different plant pools; however, the effects of drought were different under ambient vs future climatic conditions. Specifically, in future climate allocation to labile sugar increased and no major changes in the allocation towards reserve compounds were detected, while opposite results were found in ambient conditions. Finally, under ambient conditions drought caused minor changes in the relative C transfer to the microbial community, with an increase towards bacterial biomarkers. In the simulated future climate, drought reduced the relative C transfer to most of the microbial groups.

In conclusion we show that future climatic conditions altered plant C allocation and the transfer of plant C to the soil microbial community. Drought led to major changes in plant C allocation to different pools, as well as to the soil microbial community. The effects of drought were strongly modulated by the presence of elevated CO_2 and warming, highlighting the importance of assessing climate change effects in factorial experiments.