Root growth and root respiration of a perennial grassland subject to future climate

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Root growth and root respiration of a perennial grassland subjected to future climate change and extreme event

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INTRODUCTION

Future climate scenarios suggest not only an increase in atmospheric CO_2 concentration and air temperature, but also more frequent and severe extremes events, such as summer heat wave and severe drought. An increase of atmospheric CO_2 may improve plant growth through its primary effects on both leaf photosynthesis and stomatal conductance. The aim of this work was to test the hypothesis that elevated CO_2, combined with air warming and severe soil drought, improves root growth and root respiration through its direct effects on leaf photosynthesis and plant transpiration and indirect effects on soil water content.

METHODS

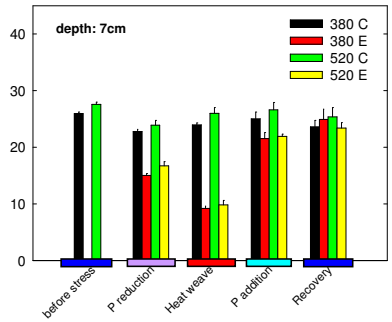
Forty-eight grassland monoliths coming from an upland site in France were divided in 12 replicate units and exposed, from May 2010 until December 2011, to a future scenario reproducing air temperature and precipitation (P) expected for the period 2040-2060 (Control: C, +3.5°C, -10% P, annual based). Since March 2011, 6 units were maintained at ambient CO_2 (380C) and 6 units at +180 ppm [CO_2] (520C). In addition, 3 units per [CO_2] (380E, 520E) were subjected during summer 2011 to a heat wave (15 days at +6.7°C) combined with a severe P reduction (-100%). Root growth rate was estimated with the in-growth core method (IGC, 15cm depth, 0.754 L). Root respiration (SRR, Licor6400-09 chamber system) and root dry matter content (RDMC) collected in the IGC were measured before, during and after the extreme event.

TREATMENTS	BEFORE STRESS	P REDUCTION	HEAT WEAVE	P ADDITION	RECOVERY	AVERAGE April-Nov
Warming *vs* actual climate (°C)	All: 3.2	All: 2.5	C: 3.3 E: 6.7	All: 3.1	All: 3.8	All: 3.7
P reduction *vs* actual climate (%)	≈ 0	C: -35 E: -54	C: +67 E: -100	C: -22 E: -54	C: -61 E: -59	C: -26 E: -39
Duration (days)	84	26	13	42	49	214

In-growth core

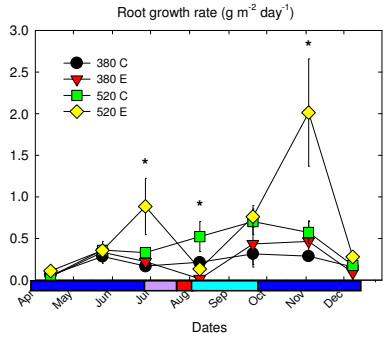
Root respiration

SOIL WATER CONTENT



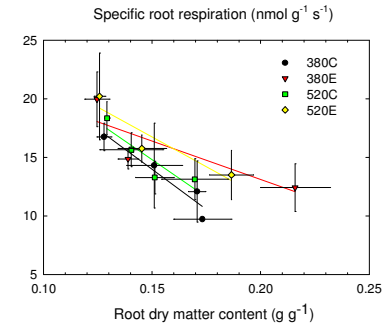
- Elevated CO_2 slightly increased (7%) soil water content (SWC) whatever the period.
- During P reduction but before the heat weave, the effect of elevated CO_2 on SWC was more pronounced (+12%)
- During heat weave, rehydration and recovery periods, this effect disappeared
- Drought stress combined with heat weave reduced SWC to values lower than 10%

ROOT GROWTH RATE



- Before stress period, there was no differences between treatments
- At the beginning of P reduction, and after heat weave, root growth rate was higher under elevated CO_2
- Heat weave sharply decreased root growth, but the recovery was 4 fold higher under elevated CO_2

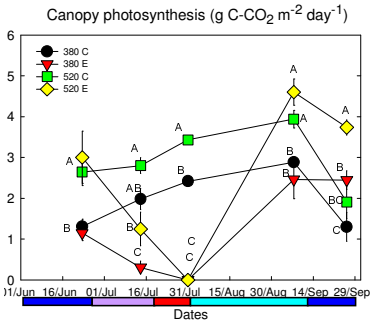
ROOT RESPIRATION AND MORPHOLOGY



- A trade-off was observed between specific root respiration (SRR) and root dry matter content (RDMC)
- RDMC slightly increased in extreme treatments, whereas SRR was unaffected by treatments

CANOPY PHOTOSYNTHESIS

- Elevated CO_2 increased canopy photosynthesis during the experiment in the control treatment
- The CO_2 effect was maintained during P reduction and sharply increased during the recovery period and was even higher than the control (520E > 520C) at the end of the recovery period



CONCLUSIONS

Upland grasslands are expected to better recover from a summer extreme event under elevated CO_2 combined with warmer and drier climate than actually. Higher canopy photosynthesis and soil water content contributed to higher root growth rate. Thus faster recovery of the below-ground compartment is expected to contribute to grassland survival in future climate.

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