Elevated CO2 enhances short-term recovery after extreme drought and heat in a temperate grassland

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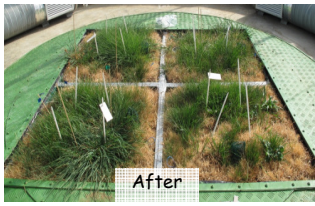
INTRODUCTION

Under warmer and drier climatic conditions, increase of atmospheric CO_2 concentration is expected to limit the negative effects of stress on grassland production. The capacity to recover after drought could also be favored by elevated CO_2, as it may improve plant growth through its primary effects on both leaf photosynthesis and stomatal conductance.

The aim of this study was to evaluate a possible mitigation effect of elevated CO_2 on canopy C and water fluxes, and its consequences on forage production and quality, during and after an extreme event (soil drought x heat).

METHODS

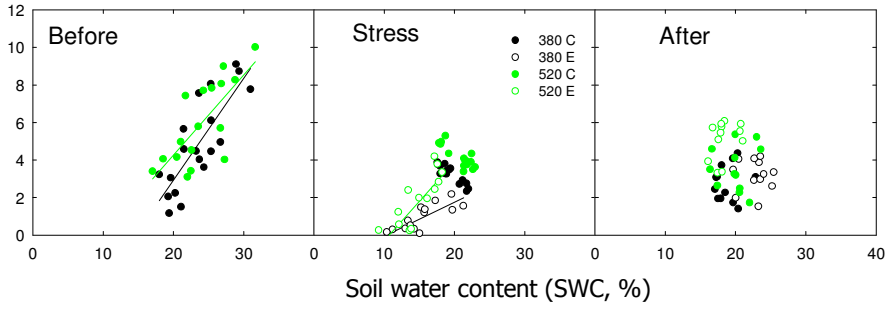
- ✓ 48 grassland monoliths (1m x 1m x 0.6 m depth, upland site: Auvergne, France) in 12 experimental units.
- ✓ Year 1: monoliths exposed to air temperature (T) and precipitation (P) expected for 2040-2060: **2.3 C warming combined with 10% reduction of P** by comparison to average climatic conditions
- ✓ Year 2: 6 of the 12 units exposed to elevated CO_2, i.e. 520 µmol mol^{-1}, compared with ambient CO_2, i.e. 380 µmol mol^{-1}.
  - In Summer, **P reduction from end of June** during **1 month**, then **no watering** combined with a **heat wave (+3 C)** during **17 days**, and finally progressive **rehydration until fall**.
  - Treatments: 380 C and 520 C: without heat wave and drought, 380 E and 520 E: with heat weave and drought
- ✓ C and water fluxes: gross primary production (GPP), evapotranspiration (ET) and soil water content (SWC, 0-60cm) were continuously measured. Water-use efficiency was calculated as WUE = GPP / ET.
- ✓ Above and below-ground (ingrowth-core method, picture) biomasses, forage quality (N, NDF: total cell wall) were measured before stress and after rehydration at cut date.



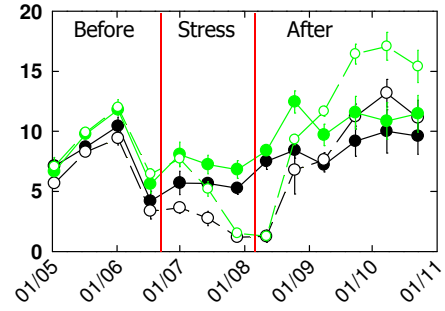
Root ingrowth-core

RESULTS

Gross primary production (GPP, gCO_2 m^{-2} d^{-1})



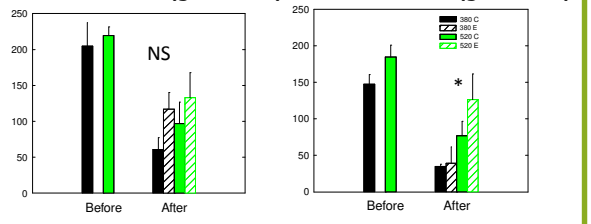
Water-use efficiency (WUE, $mgCO_2$ $g^{-1}H_2O$)



Higher GPP and WUE under elevated CO_2

- ✓ Before stress due to slightly higher SWC (+5%)
- ✓ During stress for similar SWC and evapotranspiration
- ✓ After rehydration at similar evapotranspiration but lower SWC

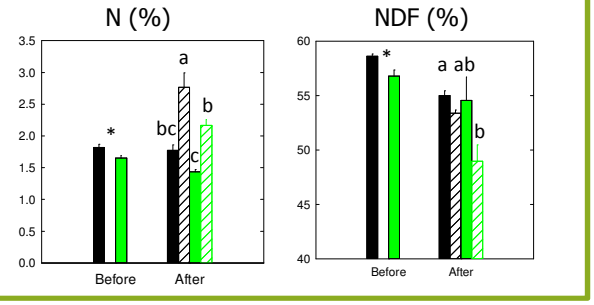
Green biomass (g DM m^{-2}) Root biomass (g DM m^{-2})



Under elevated CO_2

- ✓ Before stress: above and below-ground biomasses were unchanged, and lower N and NDF
- ✓ After stress: higher root biomass and lower N and NDF

N (%) NDF (%)



CONCLUSIONS

Under future climatic conditions (warmer and drier) forecasted for 2040-2060

- ➢ **Elevated CO_2 mitigated the negative effect of drought x heat** by increasing GPP and WUE, and **promoted recovery** of this permanent grassland
- ➢ These changes led to **higher root biomass** with **no effect on above-ground production**
- ➢ **Forage quality** was affected: **more digestible** forage but containing **less N**
- ➢ This study confirmed the **short-term recovery capacity of permanent grassland after severe drought and heat**

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