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

Under warmer and drier climatic conditions, increase of atmospheric CO₂ 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 CO₂, 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 CO₂ 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 CO₂, i.e. 520 µmol mol⁻¹, compared with ambient CO₂, 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 wave 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.

RESULTS

Under elevated CO₂
- Before stress: above and below-ground biomasses were unchanged, and lower N and NDF.
- After stress: higher root biomass and lower N and NDF.

CONCLUSIONS

Under future climatic conditions (warmer and drier) forecasted for 2040-2060
- Elevated CO₂ 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.