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Can plant-soil traits predict grassland CO_2 flux responses to drought? Evidence from controlled factorial mesocosm experiments

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It is vital to understand greenhouse gas fluxes from terrestrial ecosystems, and importantly these fluxes are dependent on ecosystem type, climate, nutrient availability and plant species composition. Previous research suggests that increased nitrogen (N) availability can reduce the resistance of plant communities to drought although this has not been found in all studies. Several potential mechanisms have been suggested for how N addition may increase vulnerability to drought, however they have not been tested in combination to assess relative importance. Mechanisms include: (i) greater plant biomass increasing water demand, thus reducing soil moisture and increasing drought stress; (ii) decreased root:shoot allocation reducing resistance to drought due to competition aboveground for light rather than belowground for nutrients, and (iii) species specific life-history and growth strategies e.g. altered rates of nutrient turnover and physiological resistance to drought. All three mechanisms can either be considered as plant traits (e.g. biomass) and/or with the potential to alter a range of other plant traits (e.g. root:shoot allocation, specific leaf area, leaf N content). This means we expect to be able to use plant traits to predict the effects of drought on biogeochemical cycling, specifically Net Ecosystem Exchange and Ecosystem Respiration.

To test this we conducted a glasshouse mesocosm experiment investigating the effects of drought on grassland plant species with and without N addition and shade conditioning. Shade conditioning during the early stages of growth was used to limit light availability and therefore reduce biomass. It was key to alter biomass through an alternate mechanism to N addition so that the independent effects of N addition and biomass could be investigated. We used abiotic factors (soil moisture content and N addition) and biotic factors, including biomass and plant traits (specific leaf area, specific root length, root diameter, leaf and root dry matter content, leaf and root C and N content and root:shoot biomass allocation) to explain responses of C cycling processes to drought (e.g. Net Ecosystem Exchange, Ecosystem Respiration and C and N losses through leaching).

We found that only abiotic factors and plant biomass were needed to predict CO_2 fluxes with no additional plant traits significantly improving prediction. This indicates that biomass is the key plant trait and that other plant traits do not have the same predictive power. We therefore conclude that increased plant biomass in response to N addition is the key mechanism determining the resistance of grassland plant communities to drought.