Nutrient relations in calcareous grassland under elevated CO2

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Plant nutrient responses to 4 years of CO2 enrichment were investigated in situ in calcareous grassland. Beginning in year 2, plant aboveground C:N ratios were increased by 9% to 22% at elevated CO2 (P > 0.01), depending on year. Total amounts of N removed in biomass harvests during the first 4 years were not affected by elevated CO2 (19.9 +/- 1.3 and 21.1 +/- 1.3 g N m(-2) at ambient and elevated CO2), indicating that the observed plant biomass increases were solely attained by dilution of nutrients. Total aboveground P and tissue N:P ratios also were not altered by CO2 enrichment (12.5 +/- 2 g N g(-1) P in both treatments). In contrast to non-legumes (<98% of community aboveground biomass), legume C/N was not reduced at elevated CO2 and legume N:P was slightly increased. We attribute the less reduced N concentration in legumes at elevated CO2 to the fact that virtually all legume N originated from symbiotic N-2 fixation (%N-dfa approximate to 90%), and thus legume growth was not limited by soil N. While total plant N was not affected by elevated CO2, microbial N pools increased by +18% under CO2 enrichment (P = 0.04) and plant available soil N decreased. Hence, there was a net increase in the overall biotic N pool, largely due increases in the microbial N pool. In order to assess the effects of legumes for ecosystem CO2 responses and to estimate the degree to which plant growth was P-limited, two greenhouse experiments were conducted, using firstly undisturbed grassland monoliths from the field site, and secondly designed 'microcosm' communities on natural soil. Half the microcosms were planted with legumes and half were planted without. Both monoliths and microcosms were exposed to elevated CO2 and P fertilization in a factored design. After two seasons, plant N pools in both unfertilized monoliths and microcosm communities were unaffected by CO2 enrichment, similar to what was found in the field. However, when P was added total plant N pools increased at elevated CO2. This community-level effect originated almost solely from legume stimulation. The results suggest a complex interaction between atmospheric CO2 concentrations, N and P supply. Overall ecosystem productivity is N-limited, whereas CO2 effects on legume growth and their N2 fixation are limited by P.
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