THE IMPACT OF ELEVATED CO_2 ON SOIL CARBON DYNAMICS IN A TROPICAL SAVANNA REGION

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Atmospheric carbon dioxide (CO_2) levels are rising and are expected to double present levels (~370 ppm) by the end of this century. This may significantly impact the environment, potentially altering plant growth, nutrient cycles and soil carbon dynamics. Much research has investigated the impact of elevated CO_2 on plant vegetation and above ground ecologies, but consequences for below ground biomass has received less attention.

The Australian free-air CO_2 enrichment (OzFACE) facility established near Townsville (N. Qld, Australia) in the year 2000 and decommissioned in late 2006 provided a unique opportunity to study the effects of elevated CO_2 on the root growth, microbial community and organic carbon pool dynamics of a savannah soil, with tropical wet summers and dry winters (rainfall = 1143 mm/annum). The open woodland vegetation has an under storey of perennial grasses consisting primarily of the C4 grasses *Themeda triandra*, *Chyrsopogon fallax* and *Eriachne obtusa* (Stokes *et al*., 2005). Separate plots were maintained at CO_2 concentrations of 370 ppm (i.e., ambient levels), 460 ppm and 550 ppm throughout the experiment. The common land practices of fertilisation via annual nutrient supplementation and grazing via regular clipping were also separately investigated at all CO_2 concentrations. Soil cores were taken to a depth of 10 cm and separated into the three depth intervals of 0-2 cm; 2-5 cm and 5-10 cm. These were then each separated into the following particle size fractions: a >53 μm particulate organic carbon (POC) fraction, representing the active pool and a <53μm passive pool. The POC fraction was further subdivided into a larger >200 μm fraction and a comparably finer 200-53 μm fraction, with the former representing the most labile pool of the active fraction. Surface soil and larger sized fractions, respectively, are expected to be most susceptible to changes in carbon input (Krull and Bray, 2005).

The $\delta^{13}C$ of the larger >200 μm POC fractions had $\delta^{13}C$ values in the range -16 to -23 ‰. The 0-2 cm depth data versus CO_2 concentration are shown in Figure 1. Corresponding values at 460 ppm were less than at ambient CO_2 concentrations for each treatment regime (i.e, control, fertilized and clipped) reflecting uptake of the industrially sourced carbon ($\delta^{13}C$ of -25 ‰ compared to -8 ‰ of ambient air). The $\delta^{13}C$ values at 550 ppm were typically also less than ambient values but significantly higher than 460 ppm values.

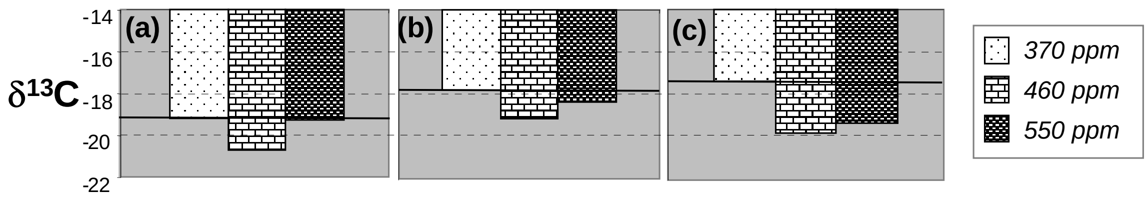

Figure 1. $\delta^{13}C$ data for mobile >200 μm, 0-2 cm depth fractions versus CO_2 concentration for (a) control; (b) fertilised and (c) clipped soils.

The root biomasses, which generally increased with CO_2 concentration, showed a similar trend with the mass of some fractions less at 550 ppm than at 460 ppm. The $\delta^{13}C$ and root biomass data suggest the effective removal of the new (predominantly ^{13}C depleted) carbon at 550 ppm via increased microbial mineralization. A previous study of tallgrass prarie soils exposed to elevated CO_2 showed at least 55% of new carbon was mineralized (Williams et al., 2004). Previous research has also shown that an increased input of root exudates and dead root matter, possibly stimulated by increased CO_2 levels, can increase microbially activated CO_2 respiration and carbon mineralization. The $\delta^{13}C$ values might also be influenced by an increased contribution of ^{13}C enriched carbon inputs such as additional C4 grasses stimulated by enhanced CO_2 concentrations, clipping or fertilization, although this is not supported by the lack of appreciable TOC variation with CO_2 concentration or treatment.

Previous predictions have suggested at least 7-10 years of enhanced CO_2 concentrations would be needed to have any significant change on carbon pools (Smith., 2004). Co-incident increases of carbon inputs and mineralisation in the >200 μm labile POC pool fraction may contribute to no net change. The $\delta^{13}C$ analysis of the slow 53-200 μm and passive <53 μm fractions of the soils is presently underway. The sequestration of carbon in the more recalcitrant organic pools of the soil would have significant implications for global carbon cycles. Much further research is needed to fully understand the effects of CO_2 concentration on below (as well as above) ground carbon dynamics with important variables such as soil type, vegetation, climate and nutrient levels requiring particular attention.

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