The influence of atmospheric carbon dioxide concentration on the carbon isotope composition of plant tissues

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Many environmental controls influence the ratio of ^{12}C:^{13}C fixed within plant tissue. However, how the concentration of atmospheric carbon dioxide, a raw material for photosynthesis that affects many aspects of plant biology, affects the net isotopic discrimination between plant tissue and atmospheric CO_2 has remained uncertain. Here we present a relationship quantifying how atmospheric CO_2 concentration (pCO_2) affects plant carbon isotope fractionation that is based on chamber and field studies conducted on a great diversity of C_3 plants. This relationship reconciles the wide range of fractionation factors previously reported and provides the framework for applying the pCO_2 effect to periods of changing pCO_2 level. Our analysis provides a minimum value for the fractionation due to catalysis by RuBisCO, which has implications for reconstructing plant water-use efficiency across any interval of pCO_2 change. Our work also helps to explain why terrestrial substrates commonly show a larger carbon isotope excursion than marine substrates during intervals of rapid changes in the global carbon cycle, and can be used to quantify the background and maximum pCO_2 levels for these events. We conclude that the effect of changing pCO_2 level on plant carbon isotope fractionation must be accounted for when analysing $\delta^{13}C$ records from terrestrial substrates across any interval of pCO_2 change.