Amino acid uptake in C4 plants: Compound-specific ^{13}C and ^{15}N probing in lipids and amino acids

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A huge number of studies have used stable carbon and hydrogen isotopic compositions of individual lipids (e.g., long-chain *n*-alkanes), particularly for inferring geographical delivery of C3/C4 organic matter [1] and for reconstructing hydrological cycles in palaeoenvironments [2]. However, 'unexplainable' isotopic compositions have often been observed in modern C4 plants, which allows a large uncertainty on the interpretation of the isotope data in geochemical cycles.

To understand these unexplainable isotopic compositions, we investigated (1) the mixotrophic ability of the C4 plant to take up amino acids and (2) the contribution of the amino acid uptake to the carbon isotopic composition of lipids in C4 plants, in the laboratory incubation of *Zea mays* (corn) with ^{13}C and ^{15}N dual-labeled amino acids.

During the incubation for 72 hrs, significant ^{13}C-(up to +896‰) and ^{15}N-enrichments (up to +778‰) are found for amino acids in *Zea* leaves. Moreover, the ^{13}C-enrichment propagates into a wide range of lipid molecules (e.g., up to +211‰ for n-C_{18} fatty acid and up to +50‰ for phytol). These results reveal (1) C4 plants can directly take up not only inorganic nitrogen (e.g., NH_4^+ and NO_3^-) but also organic nitrogen (i.e., amino acids) from roots, and (2) C4 plants can transfer the amio acids to leaves as a carbon source of lipid biosynthesis for plant growth.

C4 plants have generally higher growth rates than C3 plants, because the Hatch-Slack cycle efficiently delivers concentrated CO_2 to the photosynthesis [3]. C4 plants thus likely require a large amount of nitrogen to maintain C/N balance in their high production. Our results suggest that the uptake of organic nitrogen (e.g., amino acids) activates the large productivity of C4 plants, resulting in that the uptake subsidiary but significantly affects the carbon and hydrogen isotopic compositions of leaf lipids in C4 plants.

[1] Schefuß et al. (2003) Nature **442**, 418-421. [2] Sachse et al. (2012) Annu Rev Earth Planet Sci **40**, 221-249. [3] Hatch and Slack (1996) Biochem J **101**, 103-111.