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"Solidarity in a competing world — fair use of resources"

High-Throughput and Homogeneous ^{13}C-Labelling of Plant Material for Fair Carbon Accounting in Maize Cropping Systems

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Abstract

With growing political acknowledgement of the anthropogenic drivers and consequences of climate change, development of carbon accounting mechanisms is essential to distribute the burdens of greenhouse gas emission mitigation. Therefore, carbon storage and emission must be accurately quantified. Plant material labelled with ^{13}C can be used to measure carbon storage and carbon dioxide emission of various cropping practices under local conditions, both via *in situ* and incubation experiments. Such an approach, however, is only useful to stakeholders when plant material can be labelled homogeneously, cost-effectively and in sufficient quantity. Current pulse labelling methods often result in heterogeneous signatures and produce only limited amounts of material. We developed a high-throughput method in a walk-in growth chamber of 12 m^3, where ambient CO_2 concentration and isotopic composition are continuously monitored by an off-axis integrated cavity output spectroscope (Los Gatos Research), and are held at a δ^{13}C value between 350 and 400‰. Maize was chosen as a first test crop because of its global importance as cash crop and animal fodder, as well as the possibility to produce considerable amounts of biomass, yielding one kilogram dry matter of plant material per run. The resulting material showed a homogeneous isotopic labelling and variability in isotopic signature decreased with leaf age. Bottom leaves had an average δ^{13}C value of 277‰, with a 95 % confidence interval of [247, 307] whereas top leaves showed an average δ^{13}C value of 366‰, the 95 % confidence interval equalling [362, 370]. As C uptake by the plants in the initial growing phase is low, the effects of chamber leaking, although limited, were larger during this stage, which could be compensated for by having higher ^{13}C concentrations during early growth stages. Future steps of high-throughput ^{13}C labelling will focus on legumes and other cereal crops, opening research avenues for better understanding carbon dynamics in existing crop rotation systems. Furthermore, dual labelling with ^{13}C and ^{15}N would enable simultaneous accounting of not only CO_2 but also CO_2-equivalent emissions, such as N_2O. High-throughput isotopic labelling of plant material can thus provide accurate and cost-effective methods to establish fair plans for greenhouse gas emission reduction.

Keywords: ^{13}C, carbon accounting, CO_2, greenhouse gas emissions, stable isotopes

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