Belowground carbon allocation: recovery of 13C in root growth and respiration after in situ 13CO2 pulse labelling

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ABSTRACT

Allocation of assimilated carbon among organs is controlled by the environment and the phenology, and it affects the growth of tree, the contribution of each organ to autotrophic respiration, the transfer of carbon to the rhizosphere and in fine, carbon sequestration in ecosystems. Our aim is to quantify the amount of carbon which is allocated to root growth and root respiration in *Pinus pinaster*. Short term pulse labelling with almost pure $^{13}CO_2$ (99%) was applied on 2 trees. ^{13}C recovery in root respiration is measured by incubating roots sorted from soil cores collected at different dates after labelling, and by continuously monitoring soil respiration and root respiration of intact roots enclosed in a soil free chamber connected to a tuneable diode laser spectrometer. The use of recently fixed carbon for new root growth is evaluated from the isotope composition of roots that are growing in ingrowth cores installed after the labelling of the tree. Preliminary results showed that root respiration was enriched in $^{13}CO_2$ about two days after labelling, showing a pattern similar to that of soil respiration.

Keywords: carbon isotope, labelling, root respiration, soil respiration

1. INTRODUCTIONS

Understanding soil carbon cycle in forest requires a better description of the partitioning of soil CO_2 efflux between heterotrophic organisms and roots. In a previous study using a system developed for measuring root continuously respiration, we found that root respiration at a given soil temperature was higher during the growth period than during other periods, which may be due to the influence of phenology on fine root dynamics (Dannoura et al. 2006). In this study, we used pulse labelling of ^{13}C at different phenological stages to describe the fate of assimilated carbon into the root.

2. METHODS

2.1. Site preparation and labeling

This study is conducted in a 11 year old *Pinus pinaster* plantation sited in south west of France. Twelve trees were selected for 4 labelling dates (early summer, late summer, autumn and winter). At each date, 2 trees are labelled and 1 tree is kept as control. A 0.5-0.6m deep trench is dug

around each tree, lined with a polyethylene film and filled back. This delineates a 2m ×3 m area where all roots and only roots of the labelled trees are present. A first pulse labelling with almost pure $^{13}CO_2$ (99%) was conducted in 12th June 2009 using a 40 m^3 polyamine chamber which covered whole tree crown. Air temperature and moisture were monitored and controlled with a cooling device during labelling.

2.2. Soil and root respiration chamber

Soil and root CO_2 effluxes (F_S and F_R) and their isotope composition ($\delta^{13}C_{FS}$ and $\delta^{13}C_{FR}$) were measured by tuneable diode laser absorption spectroscopy (TDLAS, Marron et al. 2009) with a trace gas analyzer (TGA 100A; Campbell Scientific) coupled to flow-through chambers (380 cm^2 area). Two soil chambers and 2 root chambers were installed in the vicinity of each tree. The top soil of the root chamber was carefully removed, leaving only the living roots. A polycarbonate board was inserted under root to exclude soil contribution to respiration. The removed soil was replaced with an equal depth of sand that was similar to the original sandy soil at the study site. Soil temperature (thermocouples) and soil water contents (TDR probes) are measured continuously at three depths (2.5, 7.5, 15 cm).

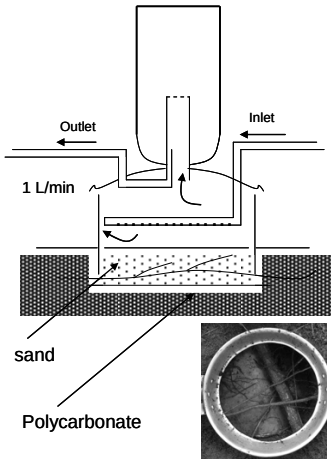

Figure 1. Root chamber

2.3. Root biomass and root growth

Fine roots were sorted from soil cores collected at different dates after labelling and incubated for collecting respired CO_2. Four ingrowth cores per trees were installed three days after labelling and will be collected after one month and three months of root ingrowth. Isotope composition of root and respired CO_2 will be measured with an Isotope Ratio Mass Spectrometer.

3. RESULTS AND DISCUSSION

At the control tree, the isotope composition of $\delta^{13}C_{FS}$ and $\delta^{13}C_{FR}$ were -22--31‰ and -25--33‰, respectively. The first signal of $\delta^{13}C$ (10‰-enrichment of $\delta^{13}C$ compared to the control) arrived the bottom of trees hours after the beginning of the pulse labelling. It appeared in both soil and root chamber 46 and 52 hours later (Figure 2).

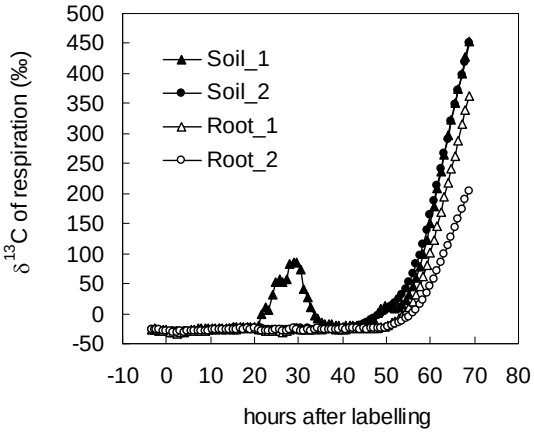

Figure 2. Time courses of respired δC^{13} from soil and root in *Pinus pinaster*

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