Transfer and Accumulation of Tritium and Radiocarbon in Terrestrial Ecosystems

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Abstract

The operation of the spent nuclear fuel reprocessing plant in Rokkasho, Japan, is accompanied by the discharge of a small amount of tritium (T) and ^{14}C mainly in the form of HTO and $^{14}CO_2$. In terrestrial ecosystems around the reprocessing plant, both radionuclides are incorporated into organic compounds in plants mainly due to photosynthesis, followed by their supply to soil such as via dead leaves and roots. This raises the concern about accumulation of those radionuclides in soil, because soil organic matter is recognized as the largest carbon pool in terrestrial ecosystems. In order to predict the accumulation of those radionuclides in terrestrial ecosystems, simulation models to describe the dynamics of ^{3}H and ^{14}C in organic matter and HTO concentration in soil and plant are required. We selected a meadow and a forest of Japanese black pine (*Pinus thunbergii*), which are common around the reprocessing plant, as our target. To construct those models, we are measuring many parameters, which will be used in the models, through field observations and laboratory experiments.

In FY 2015, a 50 × 50 m quadrat in a black pine forest was established ~5 km east of the reprocessing plant. In FY 2016, root-ingrowth cores and dendrometers were installed in the forest to determine the growth rates of fine roots and trunk, respectively. Fallout rates of above-ground litter were also measured monthly from July 2015, for obtaining input rate of dead plant matter to the forest floor. Temporal changes in water equivalent of snow were observed, and soil properties affecting water percolation were determined in the forest and also in an experimental meadow described next.

We established an experimental meadow in FY 2015 on the grounds of our institute. For determining the parameters of the photosynthetic model, the growth data of leaves, stems, and roots of grasses germinated in autumn of 2015 were obtained from April to November 2016. In grass plants, carbohydrates accumulated in the stem base are redistributed to newly produced leaves and stems after harvesting. To determine the contribution of carbohydrate reserves to newly produced leaves and stems, part of which are supplied to soil as dead plant parts at the time of harvest, the concentration of ^{13}C in newly produced leaves and stems of the second- and third-harvested grasses were determined using potted grass plants exposed to $^{13}CO_2$-enriched air during the growth periods of the first- and second-harvested grasses, respectively. The experimental results showed that reserve carbon contributed less than 3% to total carbon in the newly produced leaves and stems at their harvest time.

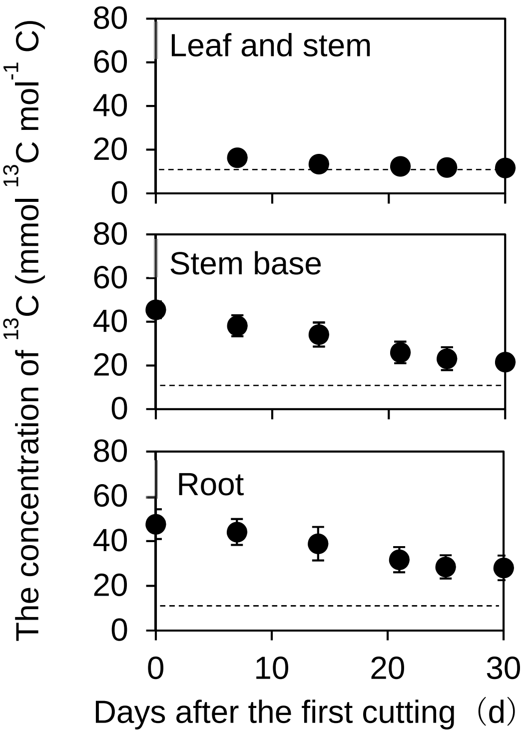

Fig. 1 The concentrations of ^{13}C in leaf and stem cut at 5 cm above ground level, stem base, and root after the first cutting of grass plants exposed to $^{13}CO_2$-enriched air during the growth of first grass.

Vertical bars indicate standard deviation of six samples. Dashed lines show the background concentration of ^{13}C (10.8 mmol ^{13}C mol^{-1} C).

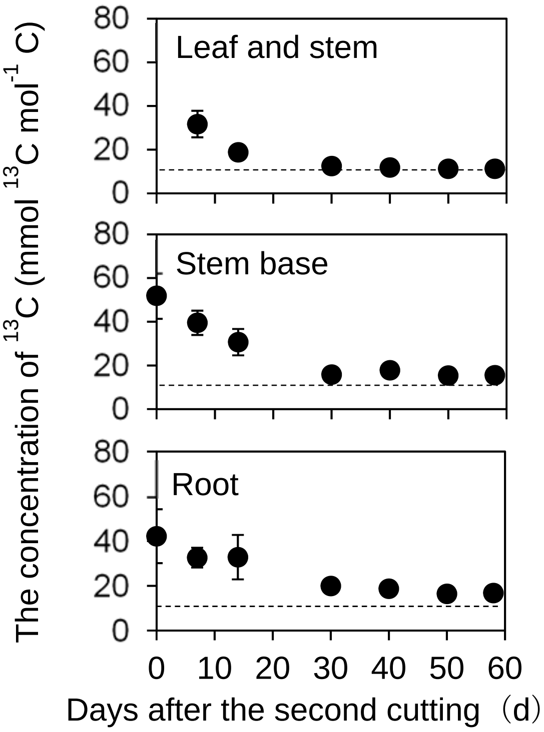

Fig. 2 The concentrations of ^{13}C in leaf and stem cut at 5 cm above ground level, stem base, and root after the first cutting of grass plants exposed to $^{13}CO_2$-enriched air during the growth of second grass.

Vertical bars indicate standard deviation of six samples. Dashed lines show the background concentration of ^{13}C (10.8 mmol ^{13}C mol^{-1} C).