Transfer of ^{14}C from the Atmosphere to Fruit Trees

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Abstract

Part of the ^{14}C released from the nuclear fuel reprocessing plant in Rokkasho, Aomori, Japan in the form of CO_2 is incorporated into the organic compounds of crop plants by photosynthesis and causes a radiation dose to people who consume the crops. The purpose of this study is to establish a dynamic compartment model describing transfer of photo-assimilated ^{14}C into fruits and its accumulation in them for an apple tree using a stable carbon isotope (^{13}C).

In FY 2017, we conducted a $^{13}CO_2$ exposure experiment using three-year old potted 'Fuji' apple (*Malus domestica*) trees (JM. 1) (hereafter, young apple trees) to obtain data for the model construction. The young apple trees were exposed to $^{13}CO_2$ (approximately 15 atom%) for 8 hours in an experimental chamber at different fruit development stages, particularly during the first half of the fruit growing period. The sample trees were then cultivated in artificial climate chambers, followed by sampling fruits, leaves and current-year branches at the time of harvesting the fruits. The collected samples were analyzed for ^{13}C concentration to get ^{13}C retention in the plant parts. Since the C inventory of plant parts during the growing season is necessary for model construction, we measured the size of fruits, leaves, and current-year branches of unexposed control sample trees. The C inventory in the samples was nondestructively estimated by using allometric equations between the size and C concentration, which were established by destructively measured C concentration data for the trees and other unexposed control sample trees.

The retained ^{13}C concentrations in the fruits at the harvest date increased with later exposure during the first half of the fruit growing period, while those in the leaves and current-year branches had a peak with the exposure at around 45 days after buds broke and then decreased with later exposure. The allometric equations to estimate C inventory in the plant parts were well established, and the C inventory data during the fruits developing period were obtained. All those data will be used for model construction together with $^{13}CO_2$ retention data during the latter half of the fruit growing period, which we plan to get in FY 2018.

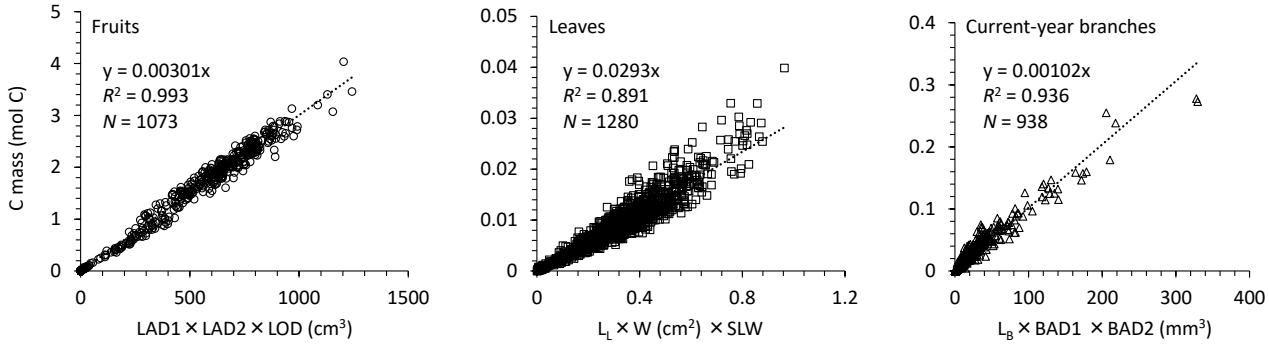

Fig. 1 The allometric equations between the size and C mass of each of the fruits, leaves, and current-year branches of potted apple trees. LAD1 and LAD2 are lateral diameters of fruits from perpendicular directions, and LOD is the longitudinal diameter. L_L, W and SLW are the length, width and the time-dependent function of specific leaf area of leaves, respectively. L_B is the length of current-year branches, and BAD1 and BAD2 are the basal diameters from perpendicular directions.

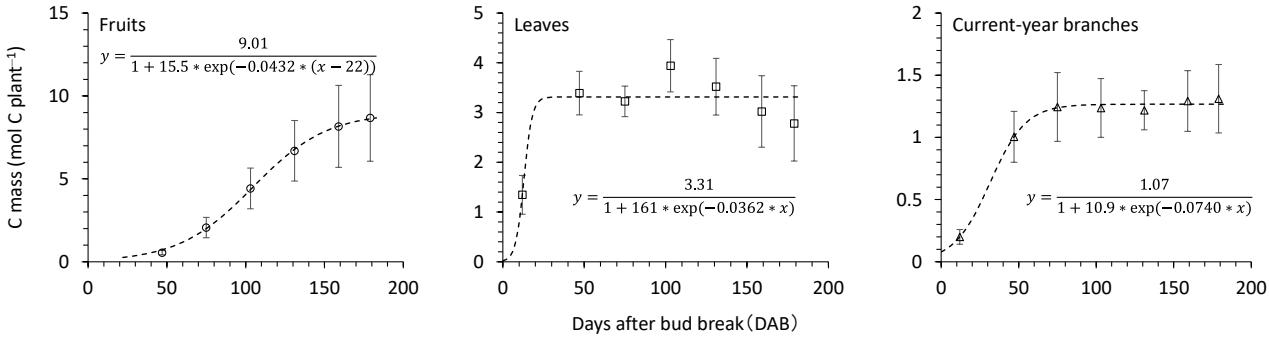

Fig. 2 The growth curves of C mass for the fruits, leaves, and current-year branches of apple trees (n = 5, bars indicate standard deviation) obtained from allometric equations between size and C

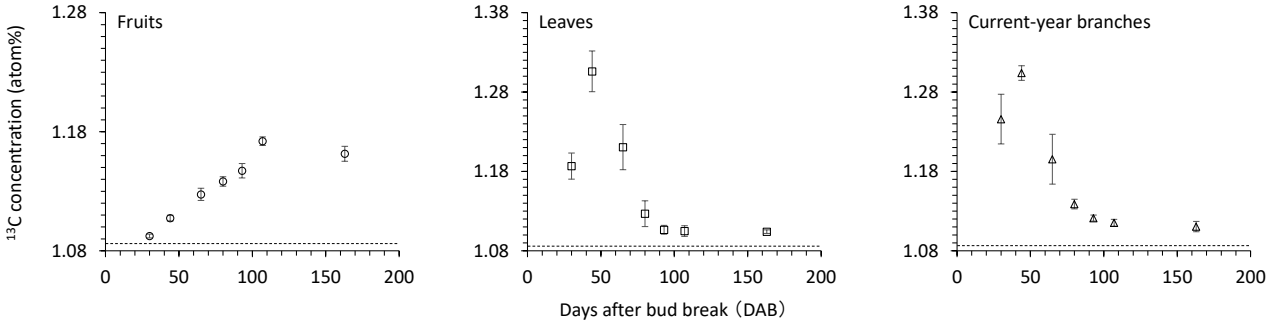

Fig. 3 The ^{13}C concentration in the fruits, leaves, and current-year branches at the harvest date (n = 5, bars indicate standard deviation).
*Broken lines indicate the ^{13}C concentration of control apple trees without $^{13}CO_2$ exposure.