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

Shogo IMADA, Yasuhiro TAKO, Yuichi TAKAKU, Shun'ichi HISAMATSU
Department of Radioecology

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 an internal 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, as a representative for fruit tree crops, using a stable carbon isotope (^{13}C).

In FY 2018, 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 latter half of the fruit growing period. The sample trees were then cultivated in artificial climate chambers. At the time of harvesting the fruits, sampling was done for fruits, leaves and current-year branches. 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, which were used in the experiment, is necessary for model construction, we measured the size of fruits, leaves, and current-year branches of unexposed control sample trees at predetermined intervals. The C inventory in the samples was nondestructively estimated by using allometric equations between the sample size and C inventory, which was established by using destructively measured C biomass data for the trees.

The allometric equations to estimate C inventory in each plant part from the nondestructive measurements were well established with $R^2 > 0.91$ between estimated and observed values. The C inventory data of the plant parts during the fruit development period were estimated by using the equation and the measured size, followed by obtaining the growth curves of C inventory as logistic regression curves. The ^{13}C concentrations retained in the fruits at the harvest date increased with later exposure until 120 days after flowering (DAF), followed by similar values after 120 DAF. In the leaves and current-year branches, the retained ^{13}C concentrations consistently showed low values after 77 DAF. The retained ^{13}C concentration data in FY 2018 could be smoothly connected with those obtained in FY 2017 during the first half of the fruit growing period except for a few data. All those data and the logistic regression curves of C inventory will be used for model construction in FY 2019.

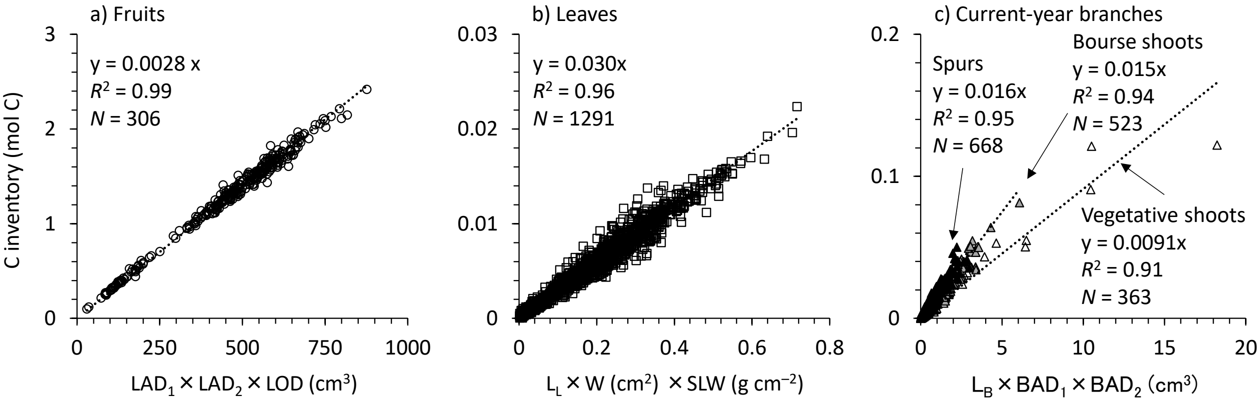

Fig. 1 The allometric equations between the size and C inventory of each sample of the fruits, leaves, and current-year branches of potted apple trees. LAD_1 and LAD_2 are lateral diameters of fruits from perpendicular directions, and LOD is the longitudinal diameter. L_L, W and SLW are the length, width and specific leaf weight, respectively. L_B is the length of current-year branches, and BAD_1 and BAD_2 are the basal diameters from the perpendicular directions.

*the broken lines indicate regression lines

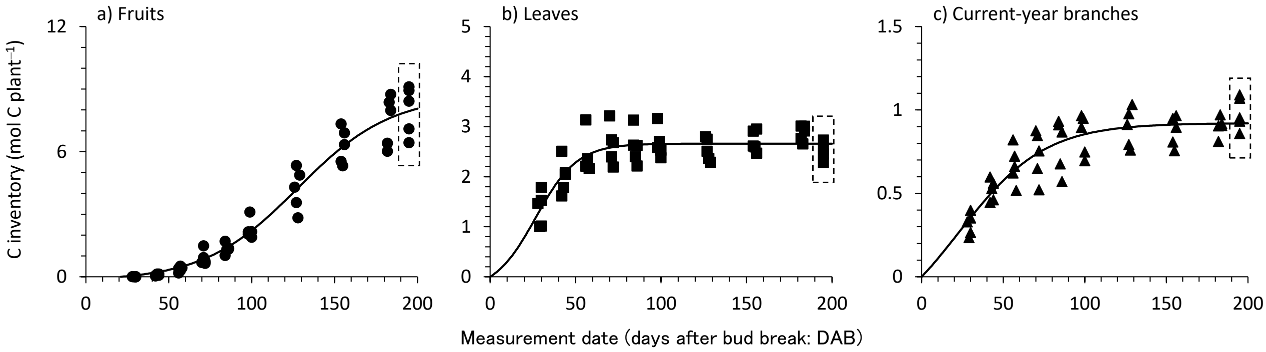

Fig. 2 The growth curves of C inventory for the fruits, leaves, and current-year branches of apple trees obtained from allometric equations between sample size and C inventory.

*The data enclosed by the broken lines indicate C biomass obtained by the destructive measurement at the harvest date. Solid lines indicate the growth curves obtained by the logistic regression models.

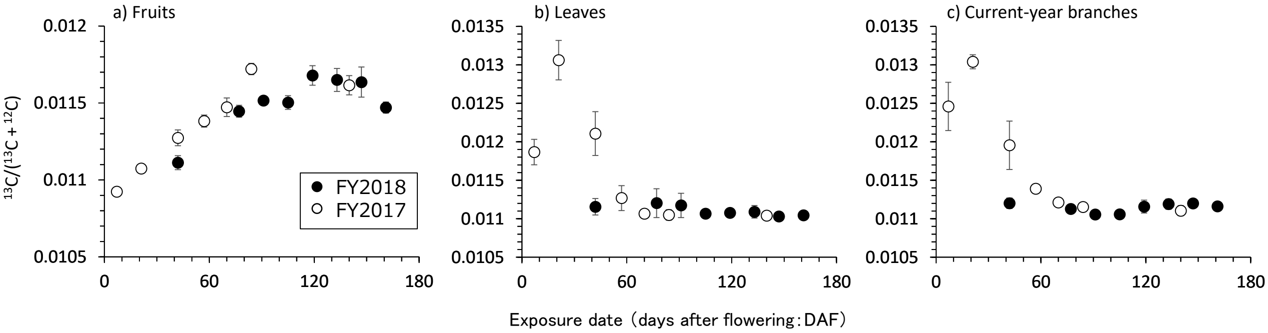

Fig. 3 The ^{13}C concentration in the fruits, leaves, and current-year branches at the harvest date (n = 5, mean ± S.D.). The data obtained in FY 2017 were shown together with those in FY 2018.