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

Shogo IMADA, Yasuhiro TAKO, 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 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 2016, we conducted three preliminary experiments comparing two apple (*Malus domestica*) cultivars ('Fuji' and 'Tsugaru') (1) to determine the effects of temperature on potted young apple trees in experimental growth chambers, (2) to clarify short-term retention of photo-assimilated ^{13}C in fruit-bearing shoots in different fruit development stages by exposure to $^{13}CO_2$, and (3) to establish an estimation method for leaf, branch, and fruit biomass.

In the first experiment, we grew young 'Fuji' and 'Tsugaru' apple trees planted in pots in two experimental growth chambers with different temperature settings and their growth was compared particularly during a vigorous growth period. In both chambers, temperature was changed at 10 days intervals according to the averaged day- and night-time temperatures of natural conditions, but the diurnal patterns were simulated for only one chamber (Chamber A) and not for the other (Chamber B). Young 'Fuji' trees successfully bore fruit, while 'Tsugaru' trees did not. The fruit diameter and its growth rate for 'Fuji' apples did not change with different temperature settings. The shoot length and stem diameter and their growth rates did not vary between the different temperature settings or between the cultivars.

We conducted the second experiment using the fruit-bearing shoots of mature 'Fuji' and 'Tsugaru' trees in an orchard in Morioka, Iwate Prefecture. Three fruit-bearing shoots on trees were exposed to $^{13}CO_2$ in different fruit development stages by using a newly developed exposure chamber system. Net assimilated ^{13}C during exposure and inventories of ^{13}C in leaves, branch and fruit at 72 h after the exposures were measured in each development stage. The ^{13}C remaining ratio (^{13}C inventory in each plant organ)/(net assimilated ^{13}C during exposure) of fruit increased from the early development stage to the development stage in both cultivars, while the ratio in 'Fuji' apples decreased from the development stage to the late development stage, but not in 'Tsugaru'.

In the third experiment, we established an estimation method for the biomass of each plant organ by measuring the size of leaf, branch, and fruit of 'Fuji' and 'Tsugaru'. Biomass of leaf, branch and fruit was estimated by length, width, and the time function of specific leaf weight, by length and diameter, and by lateral and longitudinal diameters, respectively. High coefficients of determination were found between estimated and measured biomass in both cultivars ($R^2 > 0.93$).

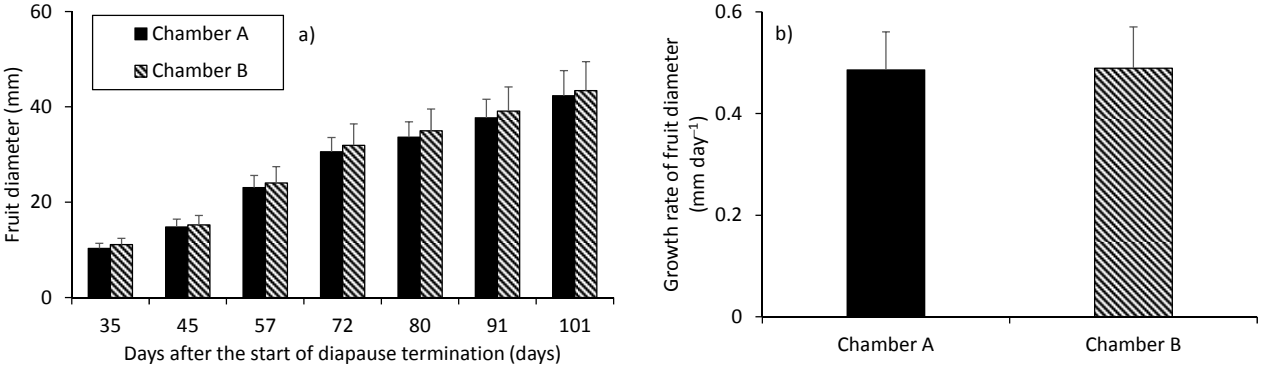

Fig. 1 Growth of fruit diameter (a) and its growth rate in three years old 'Fuji' trees (b) in two growth chambers (GCs) with different temperature settings（Chamber A, n = 8; Chamber B, n = 13; bars indicate standard deviation）

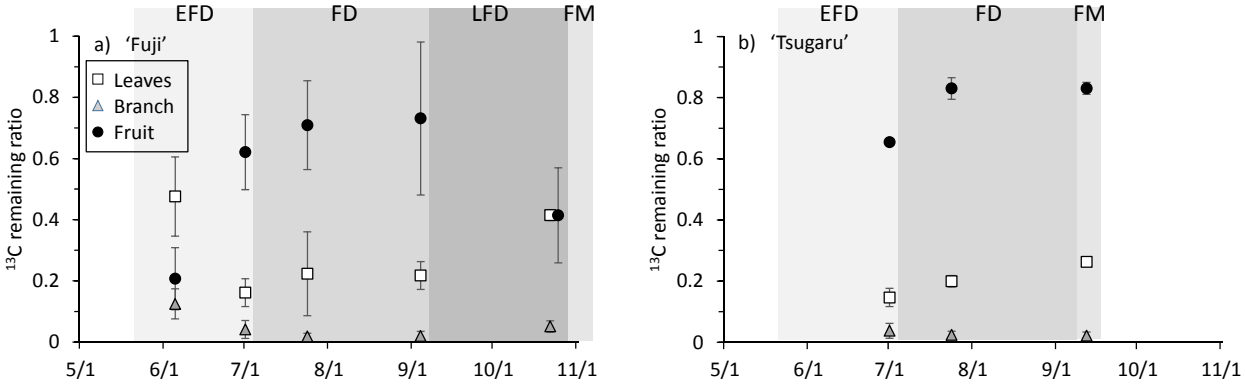

Fig. 2 The seasonal changes in the ^{13}C remaining ratios (^{13}C inventory in each plant organ)/(net assimilated ^{13}C during exposure) in the leaves, branch, and fruit of the 'Fuji'(a) and 'Tsugaru' (b) apple shoots at 72 h after $^{13}CO_2$ exposure in different fruit development stages. EFD, early fruit development stage. FD, fruit development stage. LFD, late fruit development stage. FM, fruit maturation stage. Number of samples for each point was three. Bars indicate standard deviation.

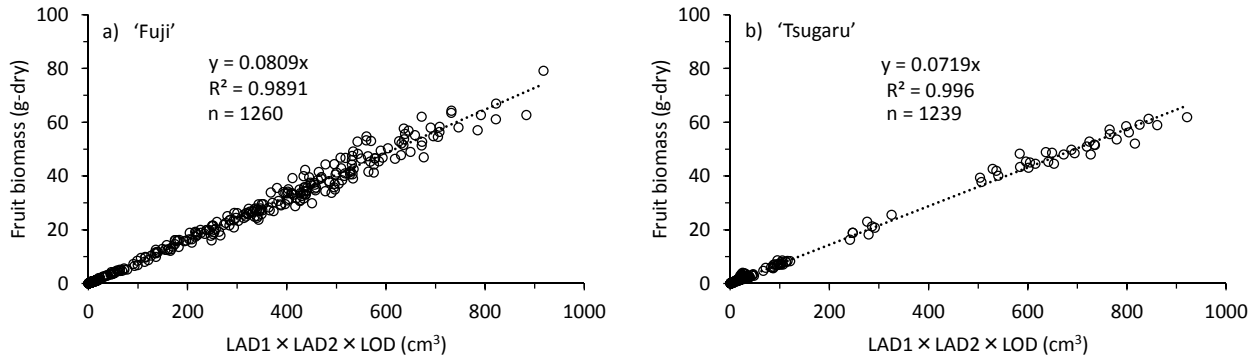

Fig. 3 The relationships between the product of lateral (bidirectional measurements; LAD1 and LAD2) and longitudinal diameters (LOD) and their corresponding biomass in the fruit of 'Fuji' (a) and 'Tsugaru' (b) apple trees