A Model for Carbon Transfer from the Atmosphere to Crops

Takashi TANI, Ryuji ARAI, Yasuhiro TAKO and Yuji NAKAMURA
Department of Environmental Simulation

Abstract

Estimation of activity concentration of ^{14}C in edible parts of crops is necessary to assess the local radiological impact of ^{14}C released from the spent nuclear fuel reprocessing plant in Rokkasho, Japan. In this study, carbon transfer in rice plant was described in a three-compartment model consisting of ear, and the mobile and immobile carbon pools of shoot. Photosynthetically fixed carbon moves into the ear and mobile carbon pool, and these two compartments release a part of the carbon into the atmosphere by respiration. Carbon accumulated in the mobile carbon pool is redistributed to the ear. Carbon transferred into the immobile carbon pool from the mobile one is accumulated there until harvest. Transfer coefficients of carbon going into and coming from these compartments were estimated by fitting the model to observed ratios of carbon fixed at each growth stage to the total carbon in the edible part at harvest ($R_P(t)$). The model was validated by measurement of $\delta^{13}C$ in the ear of rice plant exposed to atmospheric CO_2 with temporally changing ^{13}C concentration. The estimate of $\delta^{13}C$ value in the ear by the model was closer to the observed one, compared to that calculated by the specific activity method. This result implies that the newly developed model is applicable to estimate properly radiation dose to the neighboring population of nuclear facilities due to dynamic release of ^{14}C from the facilities.

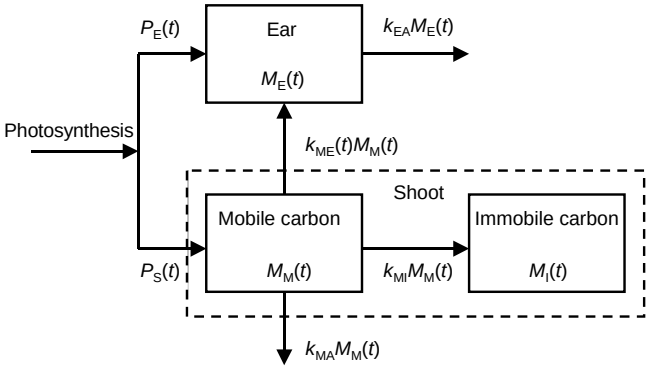

Fig. 1 Conceptual diagram of the dynamic compartment model. The dotted lines enclose the shoot part of rice plant.

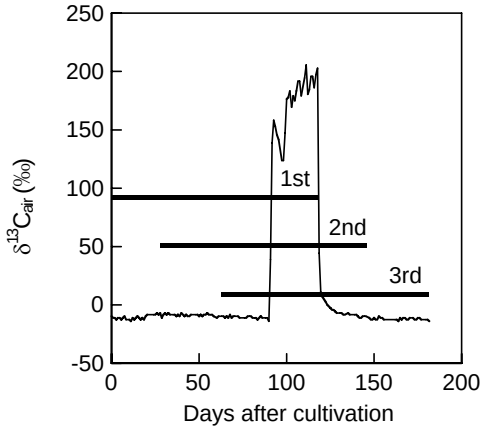

Fig. 2 Temporal changes in $\delta^{13}C$ in the air during cultivation of rice plant. Plants in this study were cultivated during three different periods (1st, 2nd, 3rd). The horizontal lines indicate the cultivation period from seeding to harvest for each of the three groups.

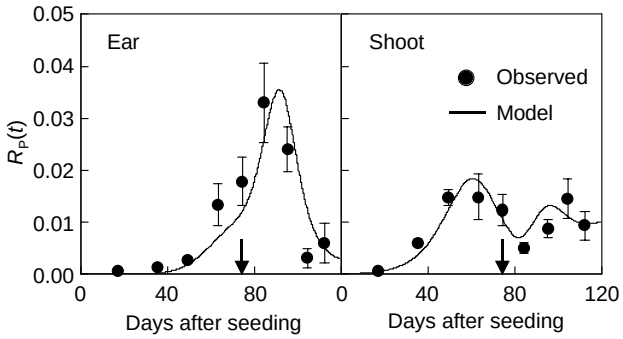

Fig. 3 The observed ratio and model estimate of carbon fixed at different times after seeding to the total carbon at the time of harvest ($R_P(t)$) in ear or shoot. Each point indicates the observed value (mean ± SD, n = 4). The solid lines indicate the model estimate calculated by the dynamic compartment model (Fig. 1). The arrows in the graph indicate the time of heading (74 days after seeding).

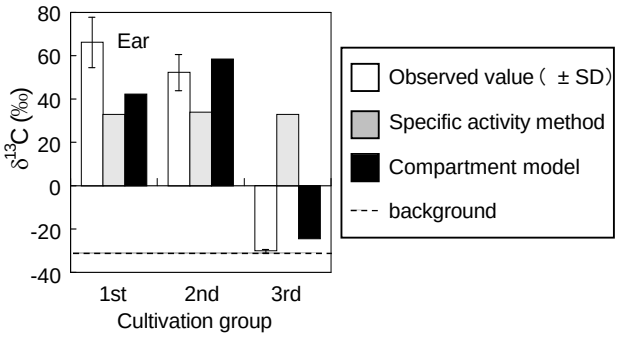

Fig. 4 The observed $\delta^{13}C$ and model estimates in ear of rice plant exposed to atmospheric CO_2 with changing ^{13}C concentration. The three groups correspond to those in Fig. 2. Each open column indicates the observed value (mean ± SD, n = 10). In every stage (1st, 2nd, 3rd), the estimates by the compartment model (black column) are closer to the observed values than the predictions by the specific activity method (gray column).