Development of a Transfer Model of Carbon from the Atmosphere to Crops

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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 by a mathematical model consisting of two compartments of an edible part (ears) and a vegetative shoot part (leaves and culms) which supplies carbon storage compounds for the growth of ears. Transfer coefficients of carbon getting into and leaving these compartments were estimated using growth curves of the edible and vegetative shoot parts. The ratio of carbon fixed at each growth stage to the total carbon in the edible part at harvest ($R(t)$) was predicted by the model. The predicted $R(t)$ and experimentally measured $R(t)$ were compared to the growth rate ($G(t)$) of the edible part normalized by its total carbon at harvest . Both $R(t)$s were higher than $G(t)$ from the early vegetative growth to milk stages, which implied the existence of translocation of carbon stored in the vegetative shoot part to the edible part. The results indicated that the effect of translocation of carbon stored in the vegetative shoot part to the edible part could be properly taken into account for predicting activity concentration of ^{14}C in the edible part of rice plant using the two-compartment model.

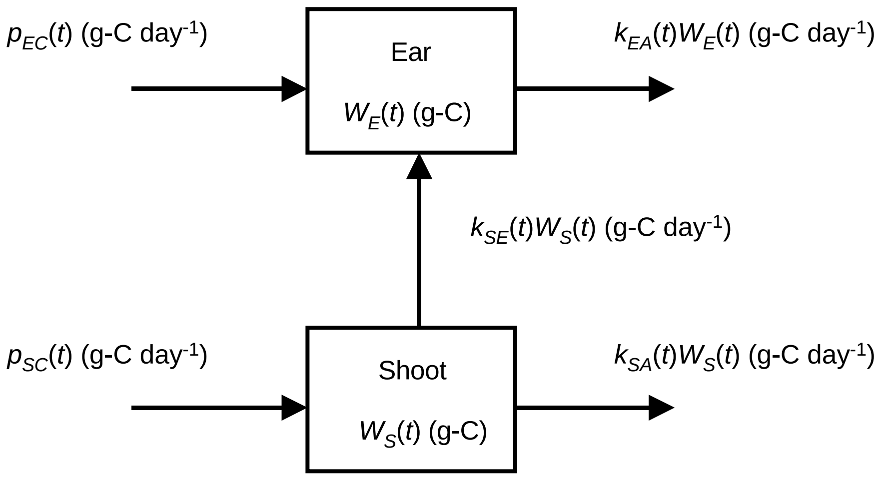

Fig. 1 Block diagram of the compartment model. The symbols are as follows: $p_{EC}(t)$, carbon transfer rate from air to ear compartment (g-C day^{-1}), i.e. translocation rate of carbon fixed by shoot (leaves and culms) at t into ears; $p_{SC}(t)$, carbon transfer rate from air to shoot compartment (g-C day^{-1}); $W_E(t)$, amount of carbon in ear compartment (g-C); $W_S(t)$, amount of carbon in ear compartment (g-C); $k_{EA}(t)$, transfer coefficient from ear compartment to air (day^{-1}); $k_{SA}(t)$, transfer coefficient from shoot compartment to air (day^{-1}); $k_{SE}(t)$, transfer coefficient from shoot compartment to ear compartment (day^{-1}).

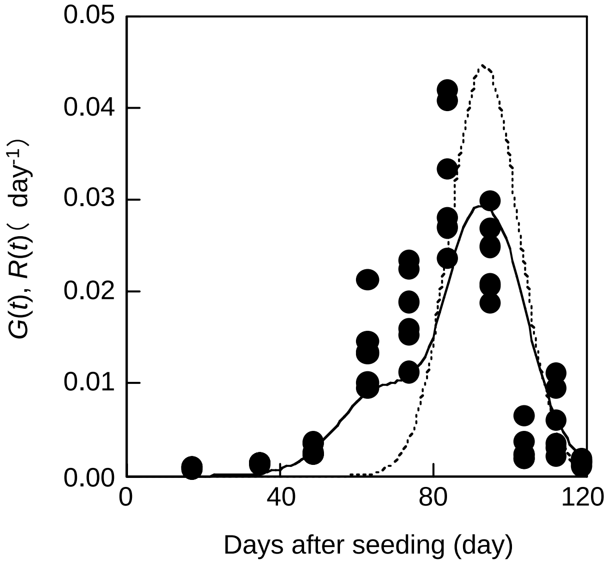

Fig. 2 Measured (black circles) and predicted (solid line) values of the ratio of carbon fixed at different days after seeding to the total carbon in ears of a rice plant at harvest ($R(t)$). The dotted line shows the ratio of growth rate of ears (g-C day^{-1}) to the total carbon in ears at harvest ($G(t)$).