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 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 accumulation in them for an apple tree using stable carbon isotope (^{13}C). In FY 2015, we conducted two preliminary experiments (1) to reveal the effects of soil temperature on potted young apple trees and (2) to clarify short-term retention of photo-assimilated ^{13}C in fruit-bearing shoot in fruit development stages by exposure to $^{13}CO_2$. The former experiment was for checking the requirement of soil temperature control in cultivating young apple trees in growth chambers.

To change the soil temperature in cultivated pots, the potted young trees (varieties of Fuji and Tsugaru) were positioned on the ground surface or buried in the ground in three different climatic areas (Rokkasho, Kuroishi City and Morioka City). In addition, potted apple trees were preliminarily cultivated in the growth chambers with different temperature settings to check growth, leaf physiology and fruit maturity without controlling soil temperature. We also exposed a fruit-bearing shoot of mature Fuji trees in Morioka City to $^{13}CO_2$ on October 6 (before maturation stage), November 5 (maturation stage) and November 20 (harvest stage). Inventories of ^{13}C in leaves, branch and fruit 72 h after the exposures were measured in each fruit development stage.

Soil temperature in the pots buried in the ground was lower in the daytime and higher in the nighttime in comparison with the pots positioned on the ground surface, while the daily average temperature did not apparently differ between the two. The differences of the soil temperature had hardly any effect on the growth of young apple trees in the field experiment. In the growth chambers with different temperature settings, the soil temperature in the pots was similar to that of air temperature. The different temperature settings of the growth chambers did not largely affect the growth, leaf physiology and fruit maturity of the young apple trees. Our preliminary short-term exposure to $^{13}CO_2$ in the fruit-bearing shoots revealed that $^{13}CO_2$ was assimilated even in the maturation and harvest stages, and that the transfer of assimilated ^{13}C into the fruits decreased after the maturation stage.

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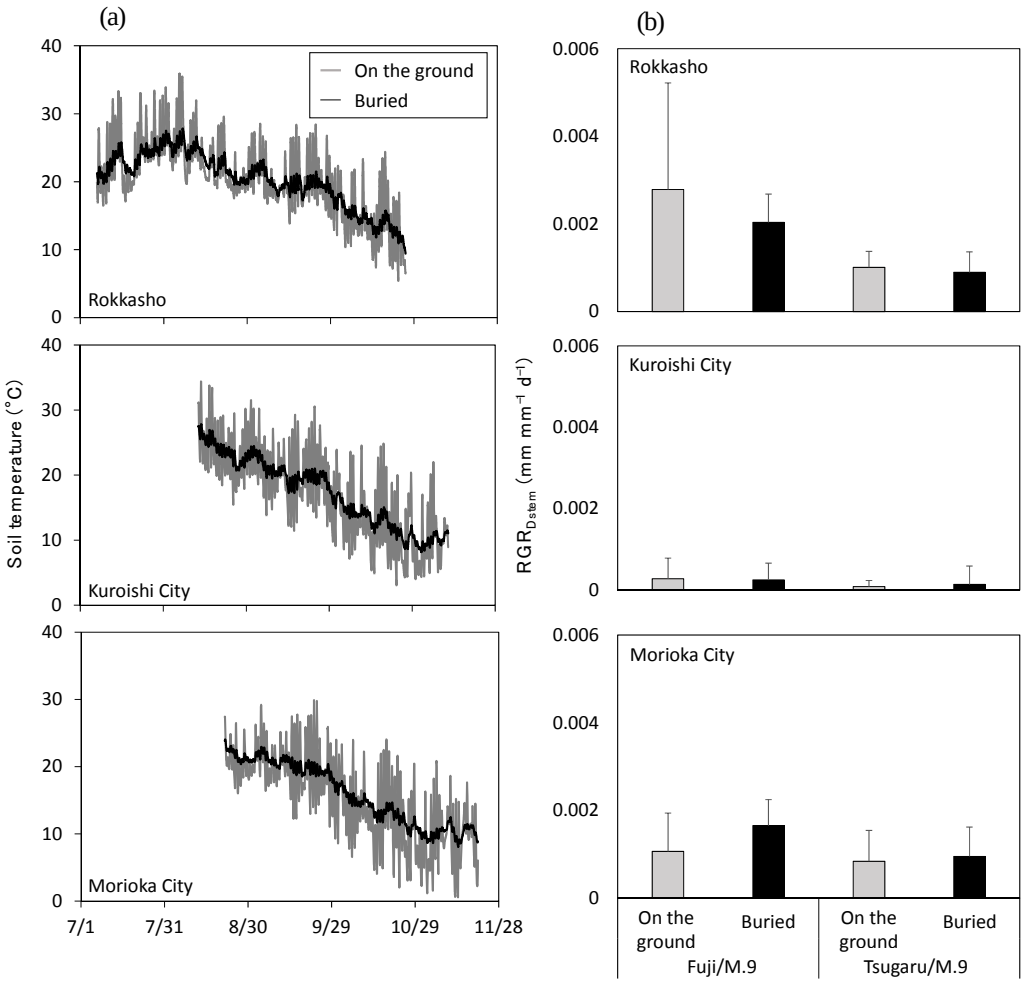

Fig. 1 Seasonal changes in soil temperature (a) and the relative growth rate of stem diameter (RGR_{Dstem}) of young apple trees (b) in pots positioned on the ground and the buried pots in three different climate areas. Error bars represent a standard deviation in six to seven replicates.

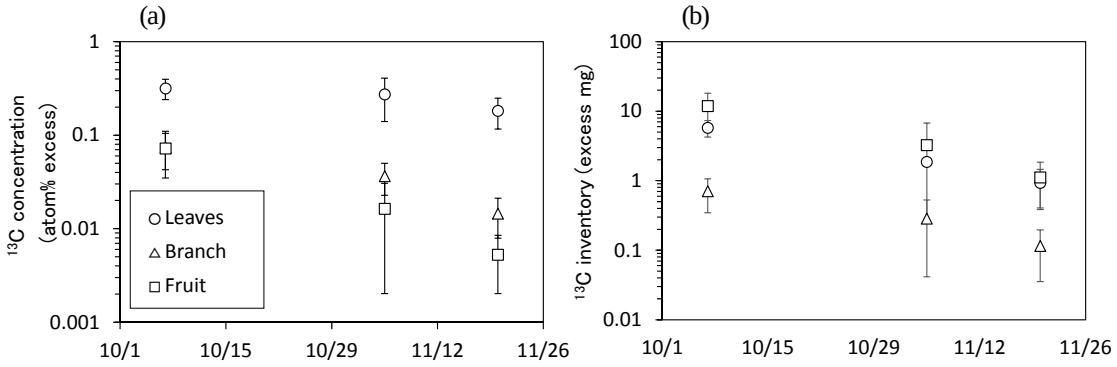

Fig. 2 The ^{13}C concentration (a) and inventories (b) in the leaves, branch and fruit of a fruit bearing shoot of mature Fuji trees before maturation (October 6), maturation (November 5) and harvest (November 20) stages. Error bars represent a standard deviation in three replicates.