Transfer of Radionuclides from the Atmosphere to Agricultural Products

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Abstract

While radionuclides (^{3}H, ^{14}C, ^{129}I etc.) are released into the atmosphere from the first commercial nuclear fuel reprocessing plant in Aomori Prefecture, the transfer of such radionuclides to commercially important agricultural products grown in the prefecture, such as fruit trees (especially, apple) and Chinese yam plants has not been adequately understood. In addition, under some abnormal situations, it is probable that the reprocessing plant will discharge radiocesium. The first purpose of this research project is to obtain empirical parameters for the transfer of ^{14}C to apples and Chinese yams and for the transfer of radioiodine and radiocesium to apples by conducting tracer experiments using stable isotopes. The second purpose is to contribute to realistic dose assessment in the future through the accuracy improvement of the advanced environmental transfer and dose assessment model (AdvETDAM).

In FY 2020, the data for the transfer of stable carbon isotope (^{13}C) to each plant organ after $^{13}CO_2$ exposure experiments and for the growth of the plant organs were obtained in mature apple trees. These data are needed for extending the model developed for young apple trees to mature apple trees. Furthermore, the method for carrying out cultivation experiments of Chinese yam in growth chambers was developed and the data related to growth in each plant organ were obtained. In addition, the parameters for the transfer and accumulation of iodine (I) and cesium (Cs) applied on the surface of each plant organ of apple and for the weathering of the elements from the surface were obtained.

For the research on ^{14}C transfer to crop plants, an *in-situ* exposure chamber system was developed for 16-year old 'Fuji' apple (*Malus domestica*) trees grafted on JM. 1 rootstock. $^{13}CO_2$ exposure experiments to mature apple trees were conducted three times from September to October and the data for the concentrations of photo-assimilated ^{13}C in each plant organ were obtained over time. For two mature apple trees, the size of each plant organ on 12 branches in each of the trees was nondestructively measured over time and the biomass of each plant organ at a whole-tree level and corresponding C content were determined in mid-November, so that temporal variations in the C mass of each plant organ at a whole-tree level were estimated. Temporal variations in plant organ biomass of Chinese yam (*Dioscorea opposita* 'nagaimo') were also determined under field conditions. In addition, Chinese yam plants were cultivated from propagules in growth chambers to check the effect of pot size on plant growth, and growth patterns of leaf and rhizophore in the field were reproduced using pots of 30 to 40 cm in depth and 15 to 25 cm in inner diameter.

For the research on weathering and transfer of I and Cs, three subjects were investigated with two types of apples: 1) the effect of rainfall on the weathering of I applied onto fruit surfaces of 'Fuji' apple trees (*M. domestica*) as dry aerosol; 2) the effect of rainfall on the weathering of Cs applied onto bark surfaces of 'Fuji' apple trees as dry aerosol; and 3) the absorption and translocation of stable I^{-} applied onto leaf surfaces of 'Alps Otome' apple (*M. domestica*) trees as liquid droplets. More I was removed from the fruit surfaces as the rainfall intensity increased and as the rainfall duration increased. Cs applied onto the bark surface was removed

slightly, but rainfall intensity and duration had little effect. I applied on the leaf surface was absorbed through the surface and accumulated inside the leaf, but the transfer of absorbed I to the fruit was negligible.

Fig. 1 A photo during the $^{13}CO_2$ exposure experiment using a mature apple tree in an orchard.

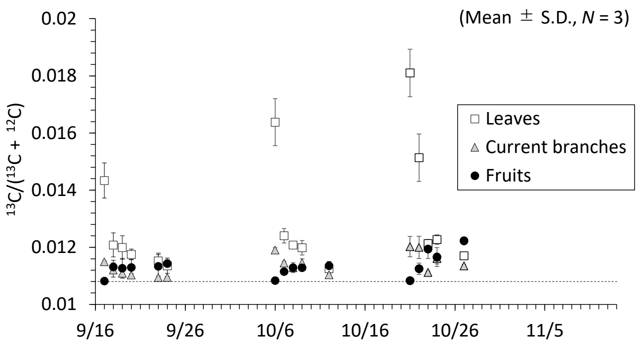

Fig. 2 Temporal variations in $^{13}C/(^{13}C + ^{12}C)$ in the leaves, current branches, and fruits of mature apple trees exposed on September 17, October 6, and October 21. Data were collected at 0, 24, 48, 72, and 144 h after the exposure finished.

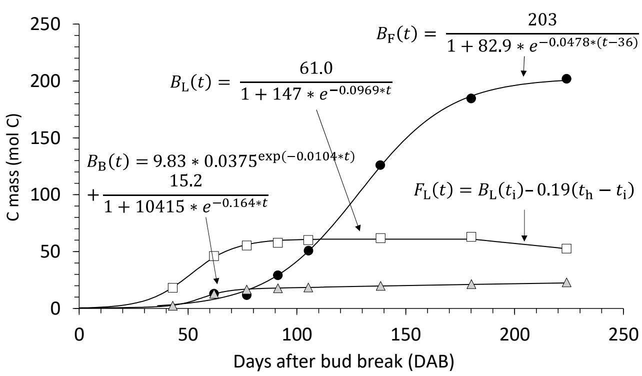

Fig. 3 Temporal variations in the C mass of the leaves ($B_L(t)$, $F_L(t)$), current branches ($B_B(t)$), and fruits of a mature apple tree ($B_F(t)$).