Behavior of Trace Elements on Leaf Surface of Crop Plants

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Abstract

Radionuclides released into the atmosphere are deposited on the leaf surfaces of crop plants, taken up by the plants, and translocated to other parts from the leaves. Some amount of the radionuclides deposited onto the leaves is removed from the surface by the environmental process called weathering, i.e. removal by rain, wind, etc. Although weathering and translocation are important processes involved in the radiation dose assessment of radionuclides from plants, site-specific parameters to describe those processes have not yet been elucidated. This work aims to establish site-specific parameters for those processes for Cs, Sr, and I using stable elements in a climate chamber in which meteorological conditions are controlled. The effect of relative humidity on the behaviors of I^- and IO_3^- on leaf surfaces and in plants was studied in FY 2008.

After applying solid aerosols of NaCl containing NaI or $NaIO_3$ onto the leaf surfaces of radish plants, *Raphanus sativus*, the plants were grown for 14 d in the chamber at different relative humidity levels. The foliar uptake and translocation to root tubers of I were periodically obtained by analyzing plant samples and the solutions obtained by washing the leaf surface. Fraction of volatilized I was estimated by subtracting the sum of the I fraction in the plant and the washed amount from the amount of I initially deposited on the leaf surfaces. The deposited amount of I was estimated by using sample plants collected just after the applying the aerosols.

Absorption of I^- into the plant on 14 d after the applying the aerosol was several times higher than that of IO_3^-. Translocations of both of I^- and IO_3^- to root tuber were lower than 10% of the deposited I. Volatilized fraction of I^- was 23 - 31% of the deposited I, while IO_3^- was hard to volatilize. To analyze the behavior of I applied on leaf surfaces and in the plant, a dynamic model with four compartments was constructed. Two compartments were adopted as compartments of I on leaf surface for describing two phases of foliar absorption with rapid and slow rates. The fraction of I^- partitioned into the first leaf surface compartment was approximately seven times larger than that of IO_3^-. The first leaf surface compartment had a large rate constant of 2.2 - 7.2 d^{-1} to transfer I into the leaf, while the rate constant of the second one was a few order of magnitude smaller than that of the first one. The ratio of the rate constant of I^- translocated from root tuber to the leaf to that of the reverse route was approximately seven times larger than that of IO_3^-. This indicated that I was absorbed from the leaf surface with different chemical forms depending on the applied forms. Rate constants and partition constants to the first leaf surface component were not affected by the relative humidity levels examined.

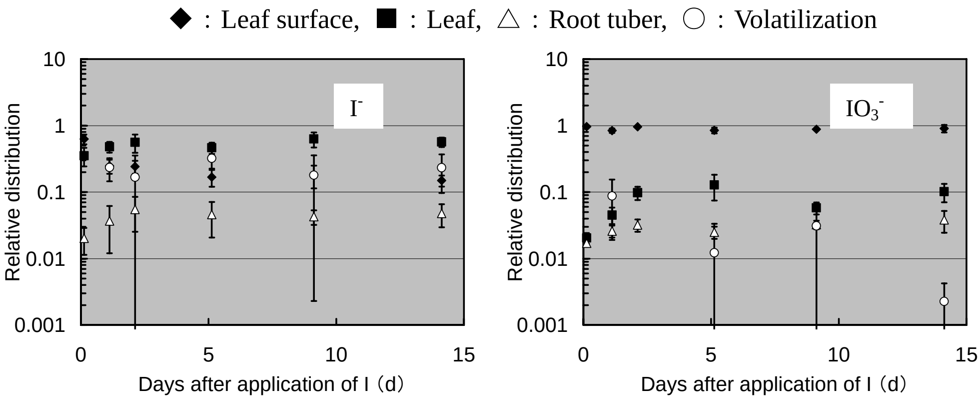

Fig. 1 Relative distribution of I applied on leaf surface of radish plant.
Vertical bar indicates a standard deviation of three samples.

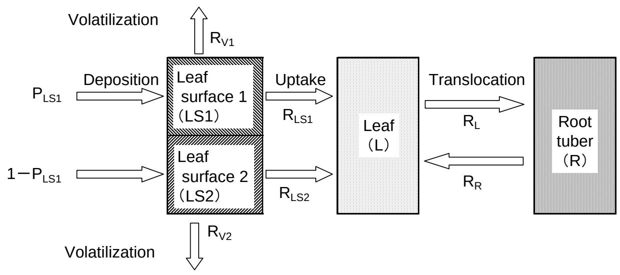

Fig. 2 Compartment model describing foliar uptake, translocation and volatilization of I in plant.

Table 1 Absorption, translocation and volatilization of I applied on leaf surface of radish plants up to 14 d after the application.

Humidity	Absorption into plants (%)		Translocation to root tuber (%)		Volatilization (%)	
(% RH)	I^-	IO_3^-	I^-	IO_3^-	I^-	IO_3^-
50	73 ±6	14 ±5	7.6 ±1.6	6.0 ±3.9	25 ±6	10 ±10
70	62 ±11	14 ±4	4.8 ±1.8	3.8 ±1.4	23 ±14	0.2 ±0.2
90	56 ±3	19 ±3	5.9 ±2.7	3.3 ±1.0	31 ±1	0

Table 2 Partition constant to the first leaf surface component, and rate constants of foliar uptake, translocation between leaf and root tuber and volatilization to atmosphere of I in compartment model.

Chemical form	Humidity (% RH)	Partition P_{LS1}	Rate constant (d^{-1}) R_{V1}	R_{V2}	R_{LS1}	R_{LS2}	R_L	R_R	R_R/R_L
I^-	50	0.78	0	0.12	5.2	0	1.1	15	13.7
	70	0.74	1.5	1.8×10^{-2}	4.5	2.9×10^{-2}	0.26	2.9	11.4
	90	0.69	1.0	7.6×10^{-2}	7.2	0	1.4	14	9.8
IO_3^-	50	6.5×10^{-2}	0.77	0	3.0	2.6×10^{-3}	10	12	1.2
	70	0.12	0.77	0	4.2	7.0×10^{-4}	9.7	20	2.1
	90	0.12	0	0	2.2	0	0	1.1	–