Foliar Uptake of Elemental Iodine by Radish Plants – a Chamber Experiment

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1. Introduction

Radioiodine can be released into the air in the form of elemental iodine (I_2), which can be absorbed by crop plants through their stomata [1,2]. Accordingly, foliar uptake of elemental radioiodine can be a significant pathway for man's exposure to internal radiations due to food consumption. Radish is highly consumed by Korean people but little is known about its foliar uptake of elemental radioiodine. In this study, an experiment was carried out using an exposure chamber in which radish plants were exposed to I_2 vapor at different growth stages. Stable iodine was used for a surrogate of radioiodine.

2. Materials and Methods

Radish plants were grown in pots outdoors at a density of one plant per pot. Plant exposure to I_2 vapor was performed in a transparent plastic chamber (118 cm long, 92 cm wide and 150 cm high) for 80 minutes at four different times between sowing and harvest. I_2 vapor was generated through a sublimation of stable iodine crystals [2].

Two pots of the plants were used for each-time exposure and one of the two plants was removed from the pot immediately after the end of an exposure. Detailed methods of the plants' exposure to I_2 vapor and the measurement of the air concentration in the chamber are described elsewhere [3]. Radish was sown on August 24 and grown until 81 d (Nov. 13) after sowing. Iodine concentrations in air and plant samples were measured by means of neutron activation analyses.

Using the concentration data, uptake coefficients (U_c, l/g) and deposition velocities (V_d, m/s) were calculated as shown in equations (1) and (2), respectively.

$$U_c = \frac{I_p}{I_a} \qquad (1)$$

where I_p (g/g-fresh) was the plant iodine concentration at the end of an exposure and I_a (g/l) was the average iodine concentration in the chamber air.

$$V_d = \frac{I_d}{I_b \times T_e} \qquad (2)$$

where I_d (g/m^2) was the total amount of the iodine deposited to the aerial parts of the plants standing in 1 m^2, I_b (g/m^3) was the average air concentration and T_e was the exposure time, 4800 s.

3. Results and Discussions

3.1 Meteorological Conditions in the Chamber

Table 1 summarizes the meteorological conditions and the I_2 concentrations in the air in the exposure chamber for each exposure. The values are averages of 10 measurements, successively made for the exposure time, 80 minutes. A significant rise in the temperature due to an increased solar radiation was observed during the exposure on Oct. 7. Relative humidity was particularly high during the exposure on Oct. 16 because of a comparatively low temperature. The I_2 concentrations in the chamber air were not much different among the four exposures.

Table 1. Conditions in the chamber during exposure

Date	Temp. (°C)	R. hum. (%)	Radiation (klux)	I_2 conc. air (g/l)
Sep. 22	21.8	67.8	28.8	1.1×10^{-4}
Sep. 24	22.0	67.3	37.9	7.4×10^{-5}
Oct. 7	24.3	60.5	45.1	7.6×10^{-5}
Oct. 16	17.0	81.1	20.0	9.0×10^{-5}

3.2 Growth Curves of Radish

Fig. 1 shows the growth curves of the radish. The root weight increased very slowly for the first about 30 d and then increased almost linearly until harvest. The leaf weight also increased slowly for the first 30 d, followed by a linear increase for 20 d and then a gradual decrease until harvest.

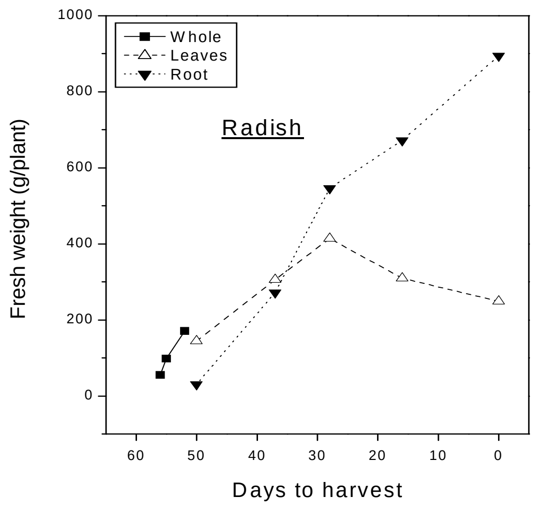

Fig. 1. Growth curves of radish.

3.3 Foliar Uptake of I_2 Vapor

Table 2 presents the uptake coefficient (U_c) of I_2 vapor and its plant deposition velocity (V_d) for each exposure.

It is likely that the especially high U_c value for the exposure on Sep. 22 resulted from a biological disorder due to an overdose of I_2. For the following three exposures, therefore, lower doses were applied. Of these exposures, the exposure on Sep. 24 produced the highest U_c value likely because of a better contact of the leaf surface with air flows and a higher area-to-weight ratio of the leaf. For the other two exposures, almost the same U_c values were observed. The values for the upper roots, which had been directly exposed to I_2 vapor as the leaves had, were much lower than those for the leaves.

In spite of the highest solar radiation, the exposure on Oct. 7 produced the lowest U_c value. It is well known that solar radiations increase the opening of plant stomata. In the case of the exposure on Oct. 7, it seems that the opening of stomata was lessened due to the increased temperature and the resultant decrease in relative humidity [1]. On the other hand, some portion of the foliar uptake of I_2 vapor might be related to its adsorption onto the outmost layer of the epidermis [2,3].

Except for the exposure on Sep. 22, the exposure on Oct. 16 produced the highest V_d values. This was because the plant biomass was much increased at this exposure compared with the previous two exposures. The V_d values for the upper roots were almost negligible. Some reported V_d values for outdoor plants [4,5] are 1–2 orders of a magnitude higher than the present values. This can be ascribed mainly to a much lower wind speed in this experiment and partly to different plant types [1,6]. The present leaf and total values are rather comparable to the total values reported for rice plants by Choi et al. [3].

Table 2. Uptake coefficients of I_2 vapor and its plant deposition velocities

Expos. Date	Upt. coeffi. (l/g)		Deposition velocity (V_d, m/s)		
	Leaves	Roots [a]	Leaves	Roots [a]	Total
Sep. 22	6.6	–	3.9×10^{-4}	–	3.9×10^{-4}
Sep. 24	1.6	–	9.6×10^{-5}	–	9.6×10^{-5}
Oct. 7	0.8	0.03	1.0×10^{-4}	1.3×10^{-6}	1.0×10^{-4}
Oct. 16	1.1	0.04	1.9×10^{-4}	2.7×10^{-6}	1.9×10^{-4}

[a] Upper parts of the radish roots.

4. Conclusions

Foliar uptake of elemental iodine by radish plants was made to occur in an exposure chamber at their different growth stages to measure its plant deposition velocities. The results showed that the plant deposition velocity tended to increase with increasing plant biomasses. The present values for the deposition velocity were much lower than some reported values from outdoor measurements. This may reflect a dependence of the deposition velocity on the wind speed. Therefore, certain caution needs to be used in applying the present data to an outdoor condition. On the other hand, it indicates that the use of unnecessarily high values should be avoided for a calm or low-wind-speed condition.

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