Poster # 1004

Transfer Factor of Radiocesium from Soil to Vegetables Grown in Decontaminated Soil in Fukushima

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ABSTRACT

In Fukushima, Japan, where soils were contaminated by radiocesium (Cs134+Cs137) due to the accident of the Fukushima Daiichi Nuclear Power Plant in 2011, farmlands were decontaminated by scraping a top 5 cm fertile soil layer containing most of fallout Cs as well. Decontaminated farmlands received a 5–10 cm thick Cs-free yet less-fertile sandy soil. We applied a cloud-based fertigation system to grow vegetables in the less-fertile sandy soil mixed with the original soil in a greenhouse. The Cs concentration in the sandy soil that we planted vegetables was 1,448 Bq/kg whereas that in a contaminated soil as a control was 30,351 Bq/kg. The Cs concentration of tomato grown in the decontaminated soil ranged between 0.3 and 0.8 Bq/kg, meaning the transfer factor (*f*=Cs concentration in vegetables/Cs concentration in soil) ranged between 0.0002 and 0.0006, whereas that of bell pepper ranged between 5.4 and 7.2 Bq/kg (*f*=0.004-0.005). The Cs concentration of spinach ranged between 6.2 and 9.0 Bq/kg (*f*=0.0042-0.0063), for a normal K application, but Cs concentration decreased to 2.2 Bq/kg (*f*=0.0015) for a doubled K application. Spinach grown in the high Cs concentration soil contained 139.3 Bq/kg for the normal K application (*f*=0.0046) whereas the doubled K application reduced Cs concentration to 77.0 Bq/kg (*f*=0.0025). The transfer factors of spinach grown in high or low Cs concentration soil were similar although the K addition might be less effective to reduce a transfer rate in the high Cs concentration soil.

MATERIALS AND METHODS

Transfer factor *f* was defined as:

$$f = \frac{Cs_{vg}}{Cs_{soil}}$$

where Cs_{vg} is the Cs concentration in vegetables (Bq/kg), and Cs_{soil} is the Cs concentration in soil (Bq/kg).

Soil treatment (sand=60% and clay=15%)

soil	Cs134+Cs137 (Bq/kg dry soil)
Low Cs soil	1,448
High Cs soil	30,351

K fertilizer treatment

soil	K_2O (g/m^2)
Normal rate	7.5
High rate	15

RESULTS

soil treatment	vegetable	Cs134+Cs137 concentration (Bq/kg fresh weight)	Transfer factor *f*
Fritted clay for reference	tomato	ND (Aug)	–
Low Cs soil	tomato	0.3 (Aug)	0.0002
	cherry tomato	0.8 (Aug)	0.0006
	bell pepper	5.4 (Oct)	0.004
	bell pepper	ND–0.4 (Aug) 7.2 (Nov)	0.0003 0.005
	spinach	6.2 (Feb) 9.0 (Feb)	0.0042 0.0063
	spinach w/ high K	2.2 (Feb)	0.0015
High Cs soil	spinach	139.3 (Feb)	0.0046
	spinach w/ high K	77.0 (Feb)	0.0025

Transfer factor for tomato was the lowest followed by spinach with high K added. Transfer factors for bell pepper and spinach with no K addition were higher than those for other vegetables. The high rate K decreased transfer factor in both low and high Cs soils.

Figure 1. A Cs-contaminated surface soil remover (A), Cs-contaminated soils piled up in rice paddy fields (B), low Cs but less-fertile soil in a greenhouse (C), bell pepper grown in low Cs soil in the greenhouse (D), and spinach grown in low Cs soil in the greenhouse (E).

ACKNOWLEDGEMENTS This research was partly supported by the 2016 Research Grant of the Meiji University Promoting Education and Research Foundation.