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論文の内容の要約

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学位論文名	Analysis of factors affecting ^{137}Cs uptake by *Brassica* species in the contaminated farmland soils of Nihonmatsu, Fukushima Prefecture: With focus on different soil types, organic manure amendment, microbial inoculation and different plant root systems

【論文の内容の要約】

Soil pollution with radioactive ^{137}Cs through atmospheric deposition has been one of the major environmental concerns for agricultural farmlands after the Fukushima nuclear power plant accident on 11 March, 2011. In agricultural farmlands, the entry of ^{137}Cs into food chain occurs mainly through plant root uptake after fallout. Soil-to-plant transfer via roots is one of the key steps concerning the entry of ^{137}Cs into plants. The transferability of ^{137}Cs to plants is generally controlled by many factors associated with the chemical and physical characteristics of soil, including pH, exchangeable potassium, cation exchange capacity, microbial activities of soil, amount of organic matter, clay minerals and clay content of the soil, climatic conditions, and plant genotype. Understanding the fate of deposited ^{137}Cs in soil and its uptake by plants is particularly important for establishing proper strategies to manage the ^{137}Cs contaminated farmlands. Therefore, a series of experiments were conducted in this study to understand the dynamics of deposited ^{137}Cs in soil-plant systems with primary focus on transfer of ^{137}Cs from contaminated soils to plants as influenced by soil types, organic manure amendment, microbial inoculation and different plant root systems. Field experiments at three study sites, namely, Miyanoiri, Takanishi and Ota, in Nihonmatsu City, Fukushima Prefecture, as well as pot experiments at the Tokyo University of Agriculture and Technology, Japan were carried out from 2012 to 2015. Commonly consumed leafy and root vegetables from the Brassicaceae family were selected as test crops because they are important vegetable crops that show high phenotypic variability and a high accumulation ability for heavy metals and caesium. Cattle manure-based compost was used as an organic amendment and *Bacillus pumilus* TUAT1 strain as a microbial inoculant.

Results of soil analysis showed that ^{137}Cs activity concentration increased with higher clay contents and CEC in soils. In the first experiment, it was found that organic compost amendment stimulated plant biomass production and tended to induce higher ^{137}Cs uptake by *Brassica* vegetables in terms of activity concentration and transfer factor (TF) in most cases. Among the studied sites, Takanishi soil which exhibited low exchangeable potassium (0.10 $cmol_c\ kg^{-1}$) was associated with an increased concentration of ^{137}Cs in plants. TF values of ^{137}Cs for all tested vegetables ranged from 0.025 to 0.119. The increase in ^{137}Cs TFs was dependent on higher plant biomass production, high organic matter content, and high sand content in the studied soils. Average ^{137}Cs TF values for all study sites and compost treatments were higher in komatsuna (0.072) and radish (0.059) compared to mustard and turnip. The transferability of ^{137}Cs to vegetables from soils was in the order komatsuna > radish > mustard > turnip. The highest ^{137}Cs TF value (0.071) of all tested vegetables was recorded for Ota soil with high organic matter content and a high clay proportion of 470 g kg^{-1} consisting of Al-vermiculite clay mineral.

Results of second experiment indicated that microbial inoculation resulted in a significant increase of ^{137}Cs concentration and higher ^{137}Cs transfer from the soil to plants although it did not enhance growth in any of the tested vegetables. The *Brassica* vegetables exhibited different ^{137}Cs uptake abilities in the order komatsuna> turnip> mustard> radish. TF values of ^{137}Cs ranged from 0.018 to 0.069 for all tested vegetables. Komatsuna possessed the largest root surface area and root volume, and showed a higher ^{137}Cs concentration in plant tissue as well as a higher ^{137}Cs TF value (0.060) than the other vegetables. Similar to the first experiment, higher ^{137}Cs transfer to plants was prominent in Ota soil with a high amount of organic matter and an Al-vermiculite clay mineral type.

Similar to the second experiment, results of third experiment showed that microbial inoculation did not enhance plant biomass but increased ^{137}Cs uptake by plants in terms of activity concentration and TF. In this experiment, root analysis revealed that microbial inoculation resulted in larger root surface area and root volume of all vegetables, except in turnip. The pH changes due to rhizosphere acidification by microbial inoculation and root exudation did not affect the bioavailability of ^{137}Cs. However, concentrations of ^{137}Cs in plant tissues and TF values increased as a result of the larger root volume and root surface area of vegetables due to inoculation. Moreover, this study clarified that leafy vegetables, which possessed larger root volume and root surface area, had higher ^{137}Cs TF values than root vegetables.

Comparing differences in ^{137}Cs uptake by fourteen *Brassica* species, results confirmed that leafy vegetables possessed larger fine root morphological characters than root vegetables. Consequently, leafy vegetables led to higher ^{137}Cs transfer from soil to plants. However, differences in ^{137}Cs uptake among the examined *Brassica* species were not only due to variations in root morphological characters but also partially attributed to differences in root distribution patterns and genetic background of individual plant species.

In conclusion, findings from this study suggest that the use of organic amendment, microbial inoculation and choice of crops should be taken into consideration in managing contaminated farmlands in order to reduce the ^{137}Cs transfer from soils to plants in the long term.