学位論文内容の要旨

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学位論文題名

Study on dynamics of ionome and nitrogen in plant and soil

（植物と土壌におけるイオノームおよび窒素の動態に関する研究）

Ionome is a profile of elements in an organism at the organ, tissue or even cell level. The plant ionome represents all the mineral nutrients and trace elements of the plant, which is a dynamic network of elements that are controlled by the physiology and biochemistry of the plant, and ultimately controlled by the genome, in response to the various environmental factors. But in past studies, the ionmics study in plant under field conditions was rare. Moreover, among the nutrients required by plants, nitrogen (N) is the most essential nutrient in terms of quantity. Study on interaction between N and ionome in plant and soil is important to develop strategies for better nutrient management, but this interaction has not been understood very well. In addition, nobody has ever studied the ionomic interaction between plant and soil with emphasis on rhizosphere. As a result, three independent experiments were carried out. Firstly, a field study was conducted to investigate the ionomic information, particularly Cs and Sr, under thirty-three varieties of *Amaranthus*. Secondly, a pot experiment was designed to comprehend the regulation of various N sources on the interaction between N and ionome in soybean at different growth stages. Finally, a rhizobox experiment was conducted to profile the micro-distribution of N, ionome in the soil growing different plant species, which is helpful for expounding the N utilization by various plant species.

Firstly, the field study adopted 33 different varieties of *Amaranthus* and investigated the concentrations of 23 mineral elements in shoots grown in the fields of Iino in Fukushima prefecture. Among 23 elements, *Amaranthus* were less sensitive to the accumulation of Cs and Sr than most other mineral elements to the species level. There are six elements showing significant correlation with Cs, positive correlations between As, Rb, Al, Fe, Ni, and Cs, and negative correlation between Ba and Cs. Significant correlations between Ca, Mg, Mn, Zn, B, Ba, Cd, and Sr were detected, and all of the coefficients were positive. Cs and Sr did not present significant correlation,

but they were both significantly correlated with Ba. By principal component analysis (PCA), the first and second principal components (PC1 and PC2) accounted for 23.2 and 20.3% of the total variance and associated with Cs and Sr, respectively.

Secondly, we assessed the relative distribution of 22 mineral elements in the root, nodule and shoot of the soybean (*Glycine max* L. Merr.cv. Tsurumusume) at R1 (beginning of flowering stage) and R7 (beginning of ripening stage) in response to ammonium and manure N treatment. Although the addition of ammonium sulfate to the soil significantly reduced the biomass production of nodule and root, the accumulation of Ca, Mg, Fe, Mn, Cu and Zn significantly improved in the shoot, and that of Mo and Co improved in the nodule. The addition of manure to the soil significantly enhanced the levels of Sr, Ba, Cr and Cd in the shoot, whereas the shoot Cs concentration was inhibited at R7. Moreover, although the nodule cells are part of the root, the variation of concentrations of many elements was not consistent between nodule and root when soybean developed from juvenile to maturation. The variation of Mn, Zn, B and Al concentrations was independent on N treatments but Ca, Fe, Cu, Mo and Se strongly regulated by N treatments.

Lastly, seedlings of soybean and sorghum were grown in a rhizobox across three N input treatments (without N, ammonium sulfate or cattle farmyard manure). The preferable C sources varied between the soils growing various plant species and were significantly affected by various N treatments. The manure treatment on soybean altered belowground processes by stimulating the microbial utilization on some saccharide and amine, and increasing the uptake of NO_3^-, P, and some metal elements, although these processes did not cause significant variation on shoot biomass. On the other hand, addition of manure to the soil altered the sorghum growth by stimulating the microbial utilization on several types of amino acids, increasing the uptake of total amino acid, P, B and many metal elements, leading to a higher accumulation of shoot N and biomass. Our results indicate that the correlation between microbial activity and N, ionome differed between species grown with various N sources.

In conclusion, this study clarifies the ionome information in plant in response to variety effect, the dynamic variation of N and ionome in the plant as plant develops from juvenile to ripening, as well as the interactions between N, ionome in the plant and soil in response to various N sources. These achievements contribute greatly to interpret the connection among the ionome study, N fertilization, and plant nutrition.