学 位 論 文 内 容 の 要 旨

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学 位 論 文 題 名

Role of acid-tolerant arbuscular mycorrhizal fungi in plant acid tolerance and their distribution along soil pH gradients
（耐酸性アーバスキュラー菌根菌の植物耐酸性に果たす役割と土壌 pH 勾配に沿った分布）

Plant productivity is largely restricted by soil acidity due to high-levels of aluminum that inhibits root elongation and thus nutrient uptake. *Miscanthus sinensis* is an important pioneer grass in early primary succession in acidic soil. The adaptability of *M. sinensis* to strongly acidic soil, however, is largely conferred by the symbiotic associations with arbuscular mycorrhizal (AM) fungi. AM fungi associate with most land plants and supply immobile nutrients, especially phosphorus, to their host plants. In the present study, the mechanism underlying the improved plant acid-tolerance by mycorrhizal formation was investigated with respect to acid-tolerance/sensitivity of AM fungi. Furthermore, a global distribution pattern of acid-tolerant/sensitive AM fungi along soil pH gradients was for the first time demonstrated by a large-scale field survey in conjunction with a model experiment.

1. Role of acid-tolerant arbuscular mycorrhizal fungi in plant acid tolerance

The physiological mechanism of the enhanced plant acid-tolerance by mycorrhizal formation was investigated based on the hypothesis that AM fungi would provide an alternative pathway for nutrient uptake instead of the roots damaged by aluminum. *M. sinensis* seedlings were grown at pH 3.2 and 5.2 in the presence of either P-fertilizer, an acid-sensitive fungus *Claroideoglomus etunicatum*, or an acid-tolerant fungus *Rhizophagus* sp. RF1. At pH 5.2, the growth and shoot P concentration of the plants were significantly increased both by P-fertilizer and the mycorrhizal fungi irrespective of their sensitivity to soil acidity. Whereas, at pH 3.2, only the plants associated with the acid-tolerant fungus could grow sustainably. The plants grown at pH

3.2 showed more aluminum-deposition on the root tips, more damaged root tips, and shorter root length than those grown at pH 5.2, and no difference in the root damages among the treatments was observed. These observations suggested that the acid-tolerant AM fungus improved plant adaptability to acidic soil indirectly via improving plant nutrient status and not via alleviating the root damages caused by aluminum.

2. Community structure of arbuscular mycorrhizal fungi along soil pH gradients

To clarify distribution of acid-tolerant/sensitive AM fungi in the field, a hypothesis that acid-tolerant fungi are specialists in acidic soil was addressed. Six field sites that covered a soil pH range of 3.0–7.4 were chosen across Japan, and rhizosphere soils of the pioneer grass *M. sinensis* grown in the sites were collected. *M. sinensis* seedlings were grown on the soils in a greenhouse, and the community compositions of AM fungi in the roots were determined based on the sequences of fungal large subunit ribosomal RNA gene. Overall, about 2,700 clones were sequenced, and 52 AM fungal phylotypes (sequence types) were defined. AM fungal richness decreased significantly with increases in soil acidity. Ordination analysis showed that soil pH is a major driver of the communities, but geographic isolation and climatic factors were not. Nestedness analysis indicated that the communities in lower-pH soils were nested within those in higher-pH soils, implying that the fungi that occurred in acidic soil were not specific to acidic soil, but were commonly distributed from acidic to neutral soils. This idea was further tested in the subsequent model experiment in which the fungal communities originated from neutral and acidic soils were grown at different pH in association with *M. sinensis* seedlings. In the neutral soil-community fungal richness decreased with increases in soil acidity, and the communities grown at lower pH were nested within the community grown at higher pH. In contrast, the acidic soil-community was unresponsive to the changes in pH. These results confirmed that soil acidity is a major constraint on AM fungal richness and acid-tolerant fungi are the generalists that occur over wide ranges of pH.

The present study provides new insight of the function and ecology of arbuscular mycorrhizal fungi in an extremely harsh environment and is expected to contribute to restoration of acidic soil.