ABSTRACTS (MASTER THESIS)

A comprehensive analysis of the changes in organic acid metabolism of ectomycorrhizal fungus *Laccaria bicolor* in response to aluminum salts

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Ectomycorrhizal (ECM) fungi are a symbiont forming ectomycorrhizae on the roots of woody plants. The ectomycorrhizae play an important role for the woody plants in taking up water and nutrients such as nitrogen, phosphorus and minerals from soil through extrametrical ECM hyphae distributed widely in soil. Of the world's land surface where the agriculture is possible, 41.7% is classified as acid soils [1]. Due to acid rains, soil acidification is accelerated. By the mineral acid precipitation, aluminum is mobilized as Al^{3+} from rock containing minerals. In these acid soil areas, the Al^{3+} causes forest deterioration through inhibition of growth of plant roots, which is recognized as an Al-toxicity. However, several experimental evidences *in vitro* have shown that ECM fungi protect their host plants from the Al-toxicity. In the protective effect of ECM fungi, formation of stable and lower toxic chelate complexes with Al^{3+} by organic acids such as malate, citrate, and oxalate released from ECM fungi is essential for detoxification of Al^{3+}.

On the other hand, aluminum phosphate ($AlPO_4$), a source of phosphorus nutrient for ECM fungi and woody plants, is difficult to be solubilized by mineral acid [2]. However, $AlPO_4$ is solubilized by organic acids with chelating activity [3], by which dihydrogen orthophosphate ion ($H_2PO_4^-$) or hydrogen orthophsphate ion (HPO_4^{2-}) depending on pH in soil are released. These forms of phosphate can be utilized by fungi and host plants.

Therefore, it is important to elucidate mechanisms for detoxification of Al^{3+} and solubilization of $AlPO_4$ by ECM fungi for sustainable forest management. To elucidate the mechanism, ECM fungus *Laccaria bicolor* 1283 was grown on MMN agar medium containing $AlPO_4$ or $AlCl_3$ and metabolites in glycolysis, pentose phosphate pathway and tricarboxylic acid cycle were analyzed by CE-MS. Organic acids with chelating ability pooled in mycelia or released to medium were also analyzed by GC-MS.

CE- and GC-MS analyses showed that the amounts of most metabolites pooled in mycelia were increased and those of oxalic acid and citric acid released to medium were also increased several times when the fungus cultured with $AlPO_4$. On the other hand, $AlCl_3$ did not affect significantly on the amounts of the organic acids pooled in mycelia and released in medium.

The results suggest that increments of the amounts of organic acid pooled in mycelia and released in medium are due to effects of $H_2PO_4^-$ and HPO_4^{2-}, but not Al^{3+}. The two phosphorus anions taken up by *L. bicolor* are suggested to accelerate the release of organic acids with chelating activity. The more released these organic acids would more detoxify Al^{3+} by formation of chelate complex, which accelerates detoxification of Al^{3+} required for healthy growth of woody plants in acid soils.

References

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