

Mycorrhiza and primary succession

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ABSTRACT

The importance of mycorrhizal fungi for soil formation and carbon sequestration has been highlighted in recent research. Here we discuss these findings in relation to primary successions by use of data from Surtsey and from lava fields around Mount Fuji in Japan.

Assembly of host associated fungal communities in remote islands such as Surtsey depend on numerous factors. Fungal propagules must come to the island, most likely by wind or birds, and the presence of compatible hosts determines what associations can form. However, to what extent these associations will be stable depends on environmental and biotic filters (Fig. 1). Associations between ectomycorrhizal (ECM) and arbuscular mycorrhizal (AM) fungi have been confirmed on Surtsey (Magnusson et al. 2009, Greipsson & El-Mayas 2000 and Eyjolfsdottir 2009), but little is known about the amount and composition of spores that arrive on the island. Based on the species of sporocarps found on Surtsey, ECM genera such as *Hebeloma*, *Laccaria* and *Inocybe* have established, but more species are likely present on root tips, but they have not been investigated. The root tip community is probably more diverse, because many ECM species do not form sporocarps or only do so occasionally or belowground.

It is generally recognized that the first plants establishing in primary succession are non-mycorrhizal, and it has been suggested that these are replaced by more competitive plants colonized by arbuscular mycorrhizal (AM) fungi, whereas

ericoid and ECM associations establish later when soil organic matter has accumulated (Reeves 1979). In Surtsey, three out of four Icelandic *Salix* species established during 1995-1999 (Magnusson et al., 2009). A possible reason for their relatively late and synchronous establishment may be that compatible host-fungal associations had not been encountered earlier. *Salix* spp. form associations with both ECM or AM fungi and it is possible that AM associations need to precede ECM associations which are well established today (Magnusson et al. 2009, Greipsson & El-Mayas 2000 and Eyjolfsdottir 2009). A better understanding of the prerequisite for *Salix* establishment in primary succession is needed.

Recent research has emphasized an important role of ECM associations for soil formation and carbon sequestration (Clemmensen et al. 2013), but this has not been investigated to any extent in primary successions. Production and turnover of external ectomycorrhizal mycelium (EMM) can be substantial, and residues of mycorrhizal necromass have been suggested to contribute significantly to soil organic matter (Ekblad et al. 2013). Studies using ingrowth mesh bags (Wallander et al. 2010) or ingrowth cores (Hendricks et al. 2006, Sims et al. 2007),

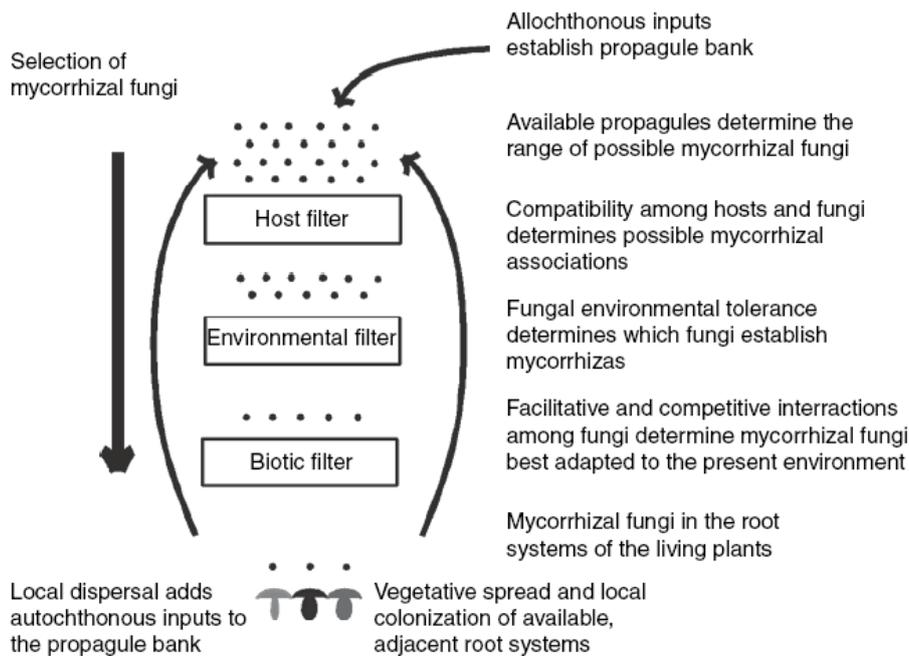


Figure 1. Conceptual community assembly model for mycorrhizal fungal communities during succession. Initially, out-of-site, allochthonous propagules establish available species pool (propagule bank). Successful component species are selected by filtering out those species that are incompatible with available hosts in their present physiological state (HOST filter), those species whose environmental tolerances do not include the prevailing conditions in the successional environment (ENVIRONMENTAL filter), and those species that are outcompeted by others in the prevailing environment (BIOTIC filter). Species with adequate fitness to reproduce contribute to the autochthonous propagule bank via production of vegetative mycelium or via production of sexual and asexual propagules (from Jumpponen and Egerton-Warburton 2005).

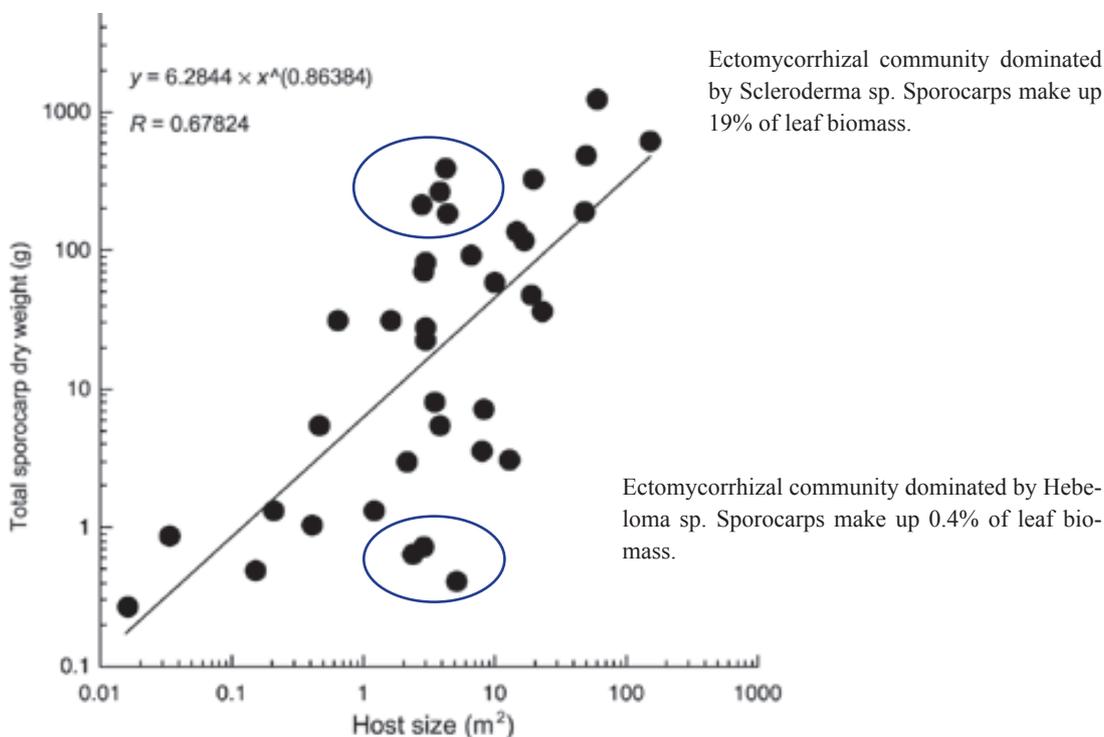


Figure 2. The biomass production of ectomycorrhizal sporocarps in relation to associated host size. The x-axis, shown logarithmically, indicates the area covered by *Salix renii* in each patch. The y-axis, shown logarithmically, represents the total ectomycorrhizal sporocarp biomass produced in each vegetation patch in 2000 and 2001. The correlation is statistically significant ($P < 0.01$). Modified from Nara (2006).

we demonstrated that EMM can constitute several hundred Kg of biomass per hectare in coniferous forests, whereas sporocarps usually produce only a few Kg of biomass per hectare per year. Still sporocarp formation constituted a major carbon sink (19% of leaf biomass) in *Salix renii* clones colonized by *Scleroderma* sp. on scoria substrate on the slopes of Mount Fuji, which had an eruption in 1707 (Nara 2006). In contrast, *S. renii* clones of similar age colonized by *Hebeloma* sp. produced only minute amounts of sporocarps (0.4% of leaf biomass), and the host plants performed much worse than those colonized by *Scleroderma* sp. (Nara 2006). However, it was not clear if this difference resulted from the ECM communities or if variable nutrient conditions in the volcanic substrate could explain the different growth rates of the hosts. However, the study firmly demonstrated that allocation of carbon to ECM fungi can be large in primary succession, and that this process can have large potential to enhance soil formation. Furthermore, the composition of the ECM community may have a major impact on soil formation: this is a subject that needs more research, especially in unique sites such as Surtsey, where plant succession has been followed in detail.

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