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Biomass of fine roots and mycrorhizal fungi in forest ecosystems

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In the case of mycorrhizal plants, not only roots of the smallest diameter class (called "fine roots"; usually less than 2.0 mm in diameter) but also their symbiotic fungi (mycorrhizal fungi) are needed to obtain water and nutrients. At the same time, fine roots and their symbiotic fungi act as a sink for photosynthate. Although these roles of fine roots and mycorrhizal fungi are well known, many aspects of them, such as fine roots amount and the amount of associated mycorrhizal fungi, are poorly understood. In the present study, therefore, I used two quantitative approaches (clarifying the biomass of fine roots and mycorrhizal fungi, and clarifying the turnover of fine roots) to discuss the role of fine roots, mycorrhiza and mycorrhizal fungi in forest ecosystems. The major goals of this study were: to determine whether the above quantitative data can be used A) as indices of forest decline and B) to reveal new insights in carbon dynamics of the forest ecosystems.

1) I compared the pine fine root biomass at Japanese red pine (*Pinus densiflora*) decline and healthy stands around Mt. Gokurakuji. The ground area-basis fine root biomass of the pines were in the range 16.1-43.5 g m^{-2}, despite the differences of tree density and tree size among the stands.

I studied the fine root biomass of Japanese red pine and the fine root biomass of other plants in three sets of adjacent managed and un-managed stands. Pine fine root biomass was in the range 16.1-55.5 g m^{-2} in all stands. On the other hand, the fine root biomass of the other plants was higher in the un-managed stand than in the managed stand in all cases, which suggests that there is severe competition for water and nutrients among the pine and other plants.

I studied the biomass and fungal content of fir (*Abies firma*) trees around Mt. Oyama. In the case of fungal content, which is evaluated by a fungal biochemical indicator (ergosterol), the ergosterol content of fir fine roots were in the range 81.4-322.4 μg g^{-1} root dw irrespective of the tree location. On the contrary, fir fine root biomass tended to be small in the trees growing at the higher parts of the urban-facing side of Mt. Oyama.

2) I found that the biomass and fungal content of fine roots were not always useful as indices of forest decline.

Biomass of fine roots and mycorrhizal fungi in roots at a Japanese red pine stand

In a Japanese red pine stand, I studied pine fine root biomass and fungal content of fine roots. Fine roots (less than 2.0 mm in diameter) were divided into three types: class I fine roots (0.5 < diameter < 2.0 mm), class II_S fine roots (short roots with less than 0.5 mm in diameter) and class II_L roots (long roots with less than 0.5 mm in diameter). The ergosterol content of pine fine roots (I, II_S and II_L) were in the range 43.1-231.0 μg g^{-1} root dw. Pine fine root biomass was 91.0 g m^{-2}, which included 2.0 g m^{-2} fungi. Fine root biomass and fungal biomass in the study stand were individually 2% and <1%, respectively, of the below-ground total biomass of pine (3932.0 g m^{-2})

that was estimated by an allometric equation.

Ergosterol contents, used as a fungal biomass indicator, were 781.6 μg g^{-1} root dw in tree ectomycorrhizal fine roots, 214.3 μg g^{-1} root dw in tree non-ectomycorrhizal fine roots and 72.2 μg g^{-1} root dw in bamboo fine roots. Coarse root biomass of trees and bamboo were 2045.1 and 548.7 g m^{-2}, respectively. At the soil surface (0-10 cm in soil depth), fine root biomasses of trees were in the range 101.5-120.5 g m^{-2} and fine root biomasses of bamboo were in the range 60.1-72.6 g m^{-2}. Considering that 63.5% of fine roots were at the soil surface (Hashimto and Hyakumachi, 1998), fine root biomass of trees and bamboo were estimated to be 278.0 and 63.3 g m^{-2}, respectively. Fine roots of trees and bamboo were estimated to contain 18.4 and 2.8 g m^{-2} fungi, respectively, accounting for 6.6% and 11.5% of fine root biomass, respectively. Consequently, each value of fine root biomass was estimated to be 12% of tree total below-ground biomass (2323.1 g m^{-2}) and 10% of bamboo total below-ground biomass (612.3 g m^{-2}). In addition, fungal biomass in fine roots was estimated to be 1% of tree total below-ground biomass and <1% of bamboo total below-ground biomass.

I estimated the production and mortality turnover of fine roots in a cool-temperate deciduous forest using the minirhizotron method. Production turnover was estimated to be about 1.11 $year^{-1}$ irrespective of soil depths. On the contrary, estimated values of mortality turnover were different in connection with soil depth; 1.14 $year^{-1}$ in 0-5 cm soil depth, 0.73 $year^{-1}$ in 5-10 cm soil depth, 0.48 $year^{-1}$ in 10-15 cm soil depth and 0.36 $year^{-1}$ in 15-20 cm soil depth, respectively. Fine root production was estimated to be 378.3 g m^{-2} $year^{-1}$, which accounts for 42% of net primary production of trees (882.0 g m^{-2} $year^{-1}$; Akiyama *et al.*, 1996) at the same site. Fine root mortality was estimated to be 261.3 g m^{-2} $year^{-1}$, which accounts for 77% of year total leaf litters (340.0 g m^{-2} $year^{-1}$; Jia *et al.*, 2002).

Key words: carbon cycle, ergosterol, forest decline, minirhizotron, turnover