



Title	Fine-root dynamics and soil respiration in forest ecosystems [an abstract of dissertation and a summary of dissertation review]
Author(s)	孫, 力飛
Degree Grantor	北海道大学
Degree Name	博士(農学)
Dissertation Number	甲第12716号
Issue Date	2017-03-23
Doc URL	https://hdl.handle.net/2115/66010
Rights(URL)	https://creativecommons.org/licenses/by-nc-sa/2.1/jp/
Type	doctoral thesis
File Information	Sun_Lifei_abstract.pdf, 論文内容の要旨



学位論文内容の要旨

博士の専攻分野名称：博士（農学）

氏名：孫 力飛

学位論文題名

Fine-root dynamics and soil respiration in forest ecosystems

（森林生態系における細根動態と土壌呼吸に関する研究）

Soil respiration (RS) is the carbon dioxide (CO₂) efflux from the soil surface to the atmosphere through root respiration (RR) and microbial decomposition of organic matter (RH). The RH is frequently partitioned into aboveground (leaf-litter decomposition: RL) and belowground microbial respiration (RB), because the qualities of organic matter are different. The processes play a key role in the global carbon (C) cycle. Several environmental factors, such as soil temperature (T_s) and water content (SWC), affect RS, whereas the environmental responses of RR, RL and RB are different. Therefore, to assess CO₂ balance of terrestrial ecosystems, especially of forests, are important to separately clarify the response of each soil CO₂ efflux component to environmental factors. In addition, fine root (< 2 mm in diameter) probably controls belowground carbon dynamics, because the fine-root net primary production (NPP) accounts for substantial part of the total NPP in cool-temperate forests. Fine root dynamics (production, mortality and decomposition) would be closely related to RR variation, though the information about the relationship between fine-root dynamics and RS is still limited. In this study, to understand the belowground carbon cycle of forest ecosystems, a field experiment was firstly conducted in an evergreen forest in central Japan to determine the method to measure RL, and then RR, RL and RB were separately quantified through the second experiment in deciduous and evergreen forests in northern Japan. In addition, fine-root dynamics were evaluated and related to RR through the second experiment.

To measure RL in the second field experiment, we firstly examined the reliability of the litter bag method and closed chamber method with leaf-litter addition / removal treatments (C-LART) in a temperate evergreen forest in central Japan. Annual RL by litter addition and removal were estimated to be 190 and 376% of added and removed litter carbon, respectively, whereas annual carbon loss estimated by the litter bag method was 49%. The overestimated RL was most probably due to the enhancement of soil microbial activities caused by the supply of available substrates and nutrients from the litter layer into underlying soil through leaching and fragmentation, which is known as the priming effect. Therefore, to apply the chamber method for directly measuring soil CO₂ efflux, a new approach that compensates the priming effect is necessary.

In the second field experiment in Hokkaido, northern Japan, soil CO₂ efflux and fine-root dynamics were measured from October 2014 to November 2015 in a deciduous forest and to July 2016

in a nearby evergreen conifer forest. RL was assessed using a modified chamber method based on the result of the first experiment. RR and RH were separated with the trenching method. Simultaneously, the decomposition of dead roots (RD) left in the trenching collar was determined using the root-litter bag method. Among treatments ($n = 5$), SWC in trenching collars was significantly higher than that in control collars because of no water uptake by living roots. The decomposition constant (k) of the decay function was highest for fine roots, followed by medium roots (2-10 mm) and coarse roots (> 10 mm), and higher in the deciduous site than in the evergreen site, partly because fine roots have a higher ratio of surface area / volume and the deciduous site was higher in T_s , which both would have enhanced microbial decomposition. Using the k and initial amount of dead roots, the annual RD from November 2014 to November 2015 in the trenching collars was calculated to be 136 and $95 \text{ gC m}^{-2} \text{ yr}^{-1}$, respectively, in the deciduous and evergreen sites. In all collars, CO_2 efflux showed seasonal variation with a peak in late July 2015. CO_2 efflux increased exponentially with T_s ($p < 0.05$). The temperature sensitivity of CO_2 efflux (Q_{10}) was significant higher ($p < 0.05$) in the deciduous site, whereas no significant difference was found among treatments. In contrast, CO_2 efflux showed no correlation with SWC, even after it was normalized by T_s using Q_{10} . Thus, the annual CO_2 effluxes of RS, RR, RB and RL were estimated from hourly T_s using simple exponential equations between November 2014 and November 2015. Annual RS, RR, RB and RL were 1255 ± 401 , 592 ± 447 , 452 ± 273 and $211 \pm 239 \text{ gC m}^{-2} \text{ yr}^{-1}$ (mean ± 1 standard deviation, $n = 5$), respectively, in the deciduous site, and 1139 ± 386 , 642 ± 248 , 386 ± 356 and $111 \pm 118 \text{ gC m}^{-2} \text{ yr}^{-1}$, respectively, in the evergreen site. The annual values of two sites were not significantly different in each component ($p > 0.05$). The contribution of RR to RS was 47 and 34%, respectively, in the deciduous and evergreen sites.

The ingrowth core and sequential core sampling methods were applied for the top 14-cm-thick soil layer, including the root mat, to determine fine root dynamics (biomass (B), production (P) and mortality (M)). B increased significantly in June 2015 ($p < 0.05$) in the deciduous site, whereas no significant difference was found among sampling dates in the evergreen site. Annual mean B was 219 ± 57 and $264 \pm 18 \text{ gC m}^{-2}$, respectively, in the deciduous and evergreen sites. Both in the two sites, fine-root production (P) showed a seasonal variation with a peak occurring between June and August and the minimum during the snowy season. Annual P from November 2014 was calculated to be 184 ± 21 and $176 \pm 31 \text{ gC m}^{-2} \text{ yr}^{-1}$, respectively, in the deciduous and evergreen sites. RR and P were positively correlated each other both in the two sites.

Root respiration and fine-root dynamics were measured simultaneously in the same plots in nearby deciduous and evergreen forests. The result of the field experiment showed a corresponding seasonal variation of root respiration and fine-root production with a peak in summer, whereas the variation was slightly different between the deciduous and evergreen forests, because these have different phenology. Through this study, the belowground carbon cycle via fine-root dynamics was shown.