THE ROLE OF ROOT RESPIRATION IN TEMPERATE DECIDUOUS FOREST IN CENTRAL JAPAN

M. Dannoura[1], Y. Kominami[2] , K. Tamai[3], M. Jomura[1], T. Miyama[2], Y. Goto[2], and Y. Kanazawa[1]

[1]*Graduate School of Science and Technology, Kobe University, Kobe 657-8501, Japan; dan@alpha.ocn.ne.jp*

[2]*Kansai Research Center, Forestry & Forest Products Research Institute, Kyoto 612-0855, Japan*

[3]*Kyushu Research Center, Forestry & Forest Products Research Institute, Kumamoto 862-0862, Japan*

ABSTRACT

To evaluate the role of root respiration (*Rr*), we measured spatial and temporal variation of *Rr*. We measured root biomass, *Rr* and soil respiration (*Rs*) in temperature deciduous forest in central Japan. The size dependence of *Rr* was shown and *Rr* in fine root (< 2 mm) accounted more than half of total *Rr* per unit area. Moreover, we had measured continuously *Rr* and *Rs* using automated system. *Rr* responded exponentially to soil temperature. High soil moisture during and just after rainfall caused limiting factor in *Rr*. And the contribution of *Rr* to *Rs* changed seasonally.

INTRODUCTION

CO_2 flux from root, considered a part of *Rs*, plays an important role in the carbon cycle. *Hanson et al*. [2000] concluded in their review that the contribution of *Rr* to *Rs* might converge at approximately 48.5% in the forest ecosystem. However, it is difficult to build the technique to separate accurately *Rr* from *Rs*. For estimating *Rr* in forest, adoption of multiple methods is necessary because each method has much uncertainty. In this study, to evaluate *Rr*, we researched spatial *Rr* calculated on the basis of root biomass distribution and temporal *Rr* measured continuously by new system.

SITE DESCRIPTION

Measurements were conducted at Yamashiro Experimental Forest (YEF) in Kyoto, which is a mixed forest of deciduous and evergreen broad-leaved trees including some conifers. The soil is immature and originated from granite. DBH (Diameter of breast high) of all trees (DBH > 1.0 cm) were measured in this research site in 1999 [*Goto et al*., 2003].

METHODS

The relationship between root diameter and *Rr*

To quantify root biomass in YEF, we dug out 16 root systems and measured root volume and diameter in detail, and made allometric relationship between DBH and root biomass by several root diameter classes. Using the data of tree's DBH in YEF [*Goto et al*., 2003], we estimated root biomass bigger than 2mm in diameter. About fine root (< 2 mm), we sampled soil blocks and calculated fine root biomass per unit area. As a result, we estimated root biomass defining 5 diameter classes; 0-2, 2-5, 5-20, 20-50, 50- (mm). Next, *Rr* of each diameter class was measured by sampling methods. Root samples of various diameters were collected from typical deciduous and evergreen tree species in YEF. We measured CO_2 flux from root samples of each diameter class by closed-chamber system using IRGA. We had conducted measurements at Apr.(T: 20.6℃), Jul.(T: 32.4-34.0℃), Sep.(T: 24.6-31.7℃), Nov.(T: 18.9-21.2℃), and Dec.(T: 6.8-7.9℃). By combining the data with root biomass of each size, the diameter distribution of *Rr* in YEF was estimated. Moreover, on 9th and 11th Sep, *Rs* was measured at the same time as *Rr* measurement in YEF [*Tamai et al*., 2005].

Temporal measurement of *Rr* using automatic chamber system

We developed an automatic chamber system for measuring CO_2 flux from fine root. It consisted of IRGA, a pump, and 5 chambers that were alternately operated. To measure only *Rr*, forest soil of A layer including organic matter was removed, and only living root was remained (Fig.1-2). Instead of removed soil, the space was stuffed with decomposed granite soil. Acrylic board was put between A and B layer to remove the influence of CO_2 flux from B layer (mineral soil). At the same time, *Rs* and CO_2 flux from B layer were measured (Fig.1-1,3).We set up 3 chambers for *Rr*, 1 chamber for *Rs*, and last one for CO_2 flux from B layer. At each chamber, CO_2 flux was measured at 35-min intervals, soil temperature and water content were measured continuously from April 2004 to May 2005.

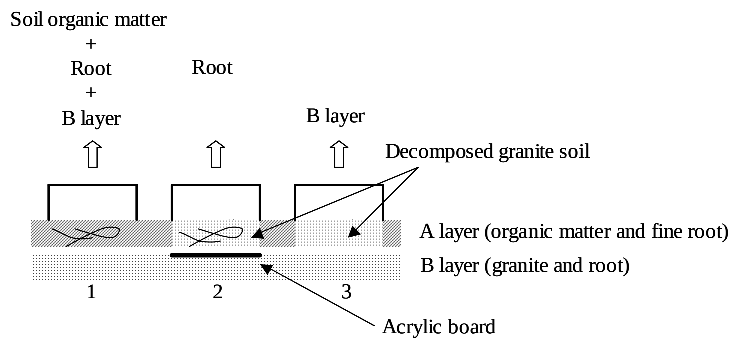

Fig.1 The image of treatment for this measurement

RESULT AND DISCUSSION

Estimation of *Rr* per unit area in YEF

Independently of tree species and tree size, the smaller the diameter of root, the higher *Rr* per unit weight. *Rr* in Fine root (< 2 mm) per unit weight was remarkably higher. And this tendency was remained throughout the year. *Rr* per unit area was calculated using CO_2 flux per unit weight and root biomass of each diameter classes. As a result, fine root of only about 16% in total root biomass occupied more than the half in the respiration. The result showed that it is necessary to consider root size, especially fine root in estimating *Rr* of forest. We compared estimated *Rr* to *Rs*, too. *Rs* was measured at 256 points on 9^{th} and 11^{th} Sep. (Tamai et al., 2005). So, the effect of unevenly spatial distribution was removed because of multi point simultaneous measurements. The mean *Rs* rate on 9^{th} and 11^{th} Sep in YEF was 0.91 $mgCO_2m^{-2}s^{-1}$. And the contribution rate of *Rr* to *Rs* was 37.2%.

Estimation of contribution of *Rr* to *Rs* by temporal measurement

From annual measurement of CO_2 flux using automatic chamber system, *Rr* in fine root responded exponentially to soil temperature. High soil moisture during and just after rainfall caused limiting factor in *Rr*. *Rs* responded exponentially to soil temperature, too. There was positive relationship between soil moisture and *Rs*. CO_2 flux from B layer did not make response to soil temperature and soil moisture. From annual measurement, relation between *Rr* and soil temperature did not change seasonally and *Rr* reached its peak at summer same as soil temperature. On the other hand, *Rs* showed clearly hysteresis to soil temperature. Therefor, yearly peak of *Rs* reached earlier than that of soil temperature. The ratio of *Rr* to *Rs* changed from about 20% to 70% through a year. The decomposition rate might be accelerated by high temperature in YEF, so most litter was decomposed by summer. We suspected that the variation of *Rr*/*Rs* ratio was caused by seasonal change of the amount of decomposed litter. These results suggested the importance of analysis of long-term measurement for discussion about the role of *Rr* in forest ecosystem.

REFERENCES

Tamai, K., Y. Kominami, T. Miyama and Y. Goto (2005), The estimation of time series data of *Rs* based on soil temperature and soil moisture content ratio and its spatial variation in a small mountainous catchment –In the case of weathered granite region in southern Kyoto Pref.- (in Japanese with English summary), *J. Japanese Forest Society*, 87, in press.

Hanson P.J., N. T. Edwards, C. T. Garten and J. A. Andrews (2000), Separating root and soil microbial contribution to *Rs*: A review of methods and observations, *Biogeochemistry*, 48, 115-146.

Goto, Y., Y. Kominami, T. Miyama, K. Tamai, and Y. Kanazawa (2003), Above ground biomass and net primary production of broad-leaved secondary forest in the southern part of Kyoto prefecture, central Japan. *Bull. FFPRI*, 387, 115-147. (in Japanese, with English summary).