Phyton (Austria) Special issue: "APGC 2004"	**Vol. 45**	Fasc. 4	(295)-(298)	1.10.2005

Soil Respiration in a Bamboo Forest as Affected by Soil Temperatures and Soil Moisture Contents

By

X. WEI[1)], Y. KITAYA[1)], T. SHIBUYA[1)] & M. KIYOTA[1)]

Key words: Bamboo, *Phyllostachys pubescens*, soil moisture content, soil respiration, soil temperature.

Summary

WEI X., KITAYA Y., SHIBUYA T. & KIYOTA M. 2005. Soil respiration in a bamboo forest as affected by soil temperatures and soil moisture contents. – Phyton (Horn, Austria) 45 (4): (295)-(298).

The growth rate of bamboo plants is considered to be greater than other tree species and thus it will be promising plants for afforestation. Bamboo plants have the role as a CO_2 absorber, if the bamboo forests can be well managed. In order to understand CO_2 absorption ability of the bamboo forests, it is important to know the characteristics of CO_2 exchange of the underground parts of bamboos as well as the aerial parts. In the present study, we examined soil respiration (CO_2 efflux from soil surface) in bamboo forests as affected by soil temperatures and soil moisture contents. The soil respiration rate was measured by a chamber method in the bamboo forest consisted of *Phyllostachys pubescens* throughout one year. The soil respiration rate was greater at the measurement sites nearer the bamboo stems. The mean soil respiration rates were 10, 23, 13 and 4 μmol CO_2 m^{-2} s^{-1} in April, August, October and December, respectively. The soil respiration rate increased with increase of the soil temperature. Because the rate in the bamboo forest was greater than that in other temperate forests, the respiration rate of the underground parts of bamboos seemed to be greater than that of other tree species. There was no significant effect of the soil moisture content on the soil respiration rate in a range of 25-40 % volume water contents in April, October and December, although the soil respiration rate tended to decrease with increase of the soil moisture contents in August.

Introduction

There are over 70 genera of bamboo with over 1200 species in the world and more than 80% of bamboo species distribute in Asia (DRANSFIELD & WIDJAJA

[1)] Graduate School of Agriculture and Biological Sciences, Osaka Prefecture University, Environment Control in biology, Gakuen-cho 1-1, Sakai, Osaka, Japan. Fax: 072-254-9433, e-mail: kitaya@envi.oskafu-u.ac.jp

1995). Bamboo have been utilized as an important resources and materials for the life and culture of Asian people. The growth rate of bamboo plant is relatively high comparing with other tree species (LIESE & WEINER 1995). It means that bamboo plants could be an effective absorber of CO_2 that has induced global warming. If the plantation forests of bamboo can be well managed, they will be promising plants for afforestation and for a carbon sink. The distribution of bamboo roots and rhizomes is limited near the soil surface. For example, the distribution of *Phyllostachys pubescens* roots was limited at the soil surface layer with the depth of 0.4 m (CHRISTANTY & al. 1997). More than 90% of underground biomass of *P. pubescens* was distributed at the soil surface layer with the depth of 0.6 m (QIU & al. 1992). Higher growth rate of bamboos would be associated with the greater underground biomass and the higher respiration rate of the underground parts. The high level of CO_2 in the soil would suppress photosynthesis in bamboo leaves (WEI & al. 2005).

The goal of this research is to evaluate ability of bamboo forests for accumulating carbon. Soil is a very important component in bamboo forest ecosystem. In this study, the soil respiration rate in a bamboo forest as affected by soil temperatures and soil moisture contents was assessed.

Material and Methods

The experiment was conducted in the bamboo forest consisted of *P. pubescence* in Shizuoka prefecture, Japan. The soil respiration was measured with a chamber method. The chamber (1.3 L in volume) was set on the soil surface in the bamboo forest. Before setting the chamber, a litter layer of 0.03-0.05 m in thickness on the soil surface was removed. The CO_2 concentration at the inlet and the outlet of the chamber were measured with a portable photosynthesis system (Li-6400, LI-COR Inc., USA). The soil respiration rate was determined from the CO_2 concentration difference between inlet and outlet of chamber and the airflow rate into the chamber. The airflow rate was adjusted to 200 μmol s^{-1}. The soil temperature and the soil moisture content were measured at a depth of 0.1 m in the soil surface layer with a thermometer (TR-72, T&D Inc., Japan) and a soil water content meter (HYDRO SENSE, Decagon Devices Inc., USA), respectively. The CO_2 production rate rates of the soil samples collected at depths of 0-0.1 m in the soil surface layer were measured with the same system as the soil respiration measurement system in the laboratory. Each soil sample was put in a glass dish (0.08 L in volume) after removing root and was covered with the chamber. The measurement was conducted at air temperature of 16-17 °C, in April.

Results and Discussion

The soil respiration rate was greater at the measurement points near the bamboo stems (Fig. 1a). The density of roots increased at the plants near to the bamboo stems (Fig. 2b). There is no difference in the CO_2 production rate of soil samples collected at different distance from the bamboo stems (Fig. 1c). As for the characteristic of bamboo, there are many roots and underground biomass in nearer the bamboo stems. Therefore, in this study, the soil respiration in a bamboo forest as affected by soil temperatures and soil moisture contents of measurement was made at 0.05m to the bamboo stems.

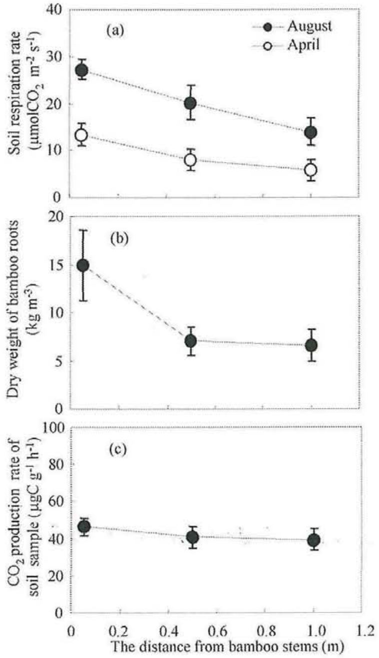

Fig. 1. Changes of (a) soil respiration rate in *P. pubescens* forest floor, (b) Dry weight of bamboo root in the soil sample, (c) CO_2 production rate of soil samples in the laboratory with distance from the bamboo stems.

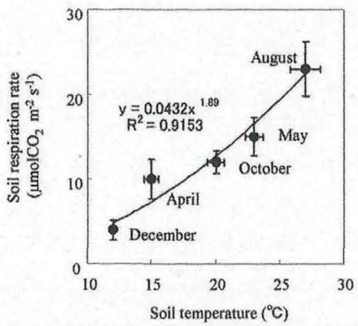

Fig. 2. Soil respiration rate as a function of soil temperature based on *P. pubescens* forest floor observations over one year.

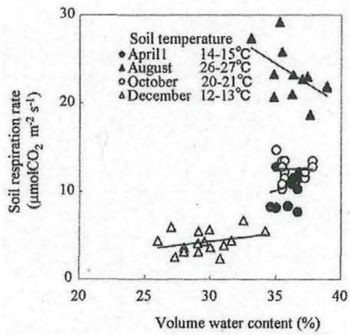

Fig. 3. Soil respiration rate as a function of volume water contend based on *P. pubescens* forest floor observations over one year.

The soil respiration rate was seasonally different (Fig. 2). The soil respiration rate increased with the rise in the soil temperature. It is considered that the respiration activity of the bamboo roots and microbe in soil increase with the rise in the soil temperature. The volume water content varied in a range of 25-40% at the depth of 0.1 m in soil surface layer of the bamboo forest floor in a year. There was no significant effect of the soil moisture content on the soil respiration rate in April, October and December, although the soil respiration rate tended to decrease with increase of the soil moisture contents in August (Fig. 3).

In this study, there is evidence that the soil respiration in the bamboo forest floor can be strongly affected by increase in soil temperature and no significant effect of the soil moisture content on the soil respiration rate in the bamboo forest floor. The soil respiration rate were 23 μmol CO_2 m^{-2} s^{-1} in August, the result was imitate with the measurement result of ISAGI 1994. In contrast to the results of EVANH & al. 2003 and BARR & al. 2002, we found the soil respiration rate in the bamboo forest floor was greater than those other temperate forests, and the main resource for CO_2 production rate in the bamboo forest floor was roots and rhizomes of bamboo. It is considered that the higher growth rate of bamboos would be associated with the greater underground biomass and the higher respiration rate of the underground parts. In conclusion, the soil respiration rate significantly increased with the rise in the soil temperature in the bamboo forest. However, there was no significant effect of the soil water content on the soil respiration rate.

Acknowlegements

This study was carried out with the financial support provided by The New Technology Development Foundation.

References

BARR A. G., GRIFFIS T. J., BLACK T. A., LEE X., STAEBLER R. M., FUENTES J. D., CHEN Z. & MORGENSTERN K. 2002. Comparing the carbon budgets of boreal and temperate deciduous forest stands. - Can. J. For. Res. 32: 813-822.

CHRISTANTY L., KIMMINS J. P. & MAILLY D. 1997. Without bamboo, the land dies: a conceptual model of the biogeochemical role of bamboo in an Indonesian agroforestry system. - For. Ecol. Manage 91: 83-91.

DRANSFILED S. & WIDJAJA E. A. 1995. Plant resources of South-East Asia. No. 7: Bamboos. - Backhuys publishers, Leiden, Netherlands.

EVANH D., MATTHEW T., ADRIANS.W., KEVINL G., DAVID T. T ., DAVID G., TONYM M. & DAVID W. 2003. The contribution of bryophytes to the carbon exchange for a temperate rainforest. - Global Change Biol. 9: 1158-1170.

ISAGI Y. 1994. Carbon stock and cycling in a bamboo phyllostacbys bambusoides stand. - Ecological Research 9: 47-55.

LIESE W. & WEINER G. 1995. Aging of bamboo culms. A review. - Wood sci. Technol. 30: 77-89.

QIU G. X., SHEN Y. K., LI D. Y., WANG Z. W., HUANG Q. M., YANG D. D. & GAO A. X. 1992. Bamboo in sub-tropical eastern China. - In: LONG S. P., JONES M. B. & ROBERTS M. J. (Eds.), Primary productivity of grass ecosystems of the tropics and sub- tropics, pp. 159-188. - Chapman & Hall, London, U.K.

WEI X., KITAYA Y., SHIBUYA T. & KIYOTA M. 2005. Effects of soil gas composition on transpiration and leaf conductance of bamboos. - J. Agric. Meteorol. 60: 845-848.