The characters of soil microbial biomass and metabolic quotient associated with shrub development in the arid region

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Keywords: Soil microbial biomass, qCO_2, soil microorganism, dry ecosystem.

Introduction

Soil microbial biomass (MBC), as the most active of soil organic constituents, controls many important ecological processes in the ecosystem including nutrient cycling and litter decomposition (Jia *et al*. 2010), and is considered to be the most sensitive biological indicator of soil quality (Sinha *et al*. 2009). Moreover, soil microbial metabolic quotient (qCO_2) reflects the quantity and quality of soil organic matter, soil nutrient availability, microbial substrate utilization efficiency and ecosystem stability (Mao *et al*. 2010). Shrub is the dominant vegetation of desert ecosystems, contributing to soil nutrient conservation and carbon sequestration. Considerable research related to shrubs in desert ecosystems has been reported, however changes of soil microbial properties throughout the process of shrub development remains poorly documented. The main objective of this study was to explore how soil microbial biomass and qCO_2 change with shrub development.

Methods

The study was carried out at a steppe desert in the eastern reaches of Alxa Plateau (E 105°38'19.18, N 38°59' 38.40), in an arid continental climate characterized by cold winters and hot summers. The annual precipitation varies from 60 mm to 150 mm, and mean annual temperature is approximately 9℃ (Pei *et al*. 2006). The plant community, with *Reaumuria soongarica* as the most common species, is a typical vegetation system in this region that has a vast distribution area. Hence, the shrub *R. soongarica* was selected for investigation in this research. Five distinct stages of shrub development were established, based on plant crown breadth (Table 1). Topsoil (0-10 cm) samples were collected from the centre, edge, and periphery of individual shrubs on August 10, 2012. Microbial biomass carbon was measured by the fumigation extraction method (Vance *et al*. 1987), Basal soil respiration (BSR) was measured as the CO_2 emerged from moist soil, adjusted to 60% WHC, over an incubation period of 10 days at 25±1℃, in the dark (Islam and Weil 2000), metabolic quotients (qCO_2) were calculated as BSR per unit of total MBC.

Table 1. The establishment of different development stages of *R. soongarica*

Different development stage	Crown breadth (cm)	Height (cm)
I	19.0±3.48e	15.2±1.46d
II	32.9±2.30d	17.8±1.77cd
III	49.3±3.23c	25.2±1.77bc
IV	65.1±3.25b	29.0±2.28ab
V	83.4±3.38a	34.8±1.85a

Results

Generally, individual plants can significantly influence the soil in which they grow, especially for some desert shrubs, as windborne soil deposits that collect under their canopies change physical and chemical soil properties and provide favorable habitats for soil microorganisms (Carrillo-Garcia *et al*. 2000). Our results showed that soil MBCs at shrub canopies centres were significantly greater than that of the other positions with shrub development (P<0.05), particularly during later development, however, soil MBC at the edge significantly decreased with the development of shrub (P<0.05) (Fig. 1a). The qCO_2 reflects the physiological status of soil microorganisms, and is often considered as a stress index for microorganisms and for evaluation of the substrate utilization efficiency of the soil microbial community (Sinha *et al*. 2009). An increase in qCO_2 has been interpreted as a microbial response to adverse environmental stress or disturbance (Wardle and Ghani 1995). In this study, the variation of qCO_2 at the centre was slight and the values of qCO_2 at the centre were lower than that of the other positions during five development stages, especially in the later development stage (Fig. 1b). Moreover, during the process of shrub development, qCO_2 at the edge showed a significantly increasing trend that was the inverse of MBC, indicating that the microenvironment at the edge became increasingly harsh with the development of shrubs.

Conclusion

Throughout the process of shrub development, soil MBC values at the centre slowly increased and were significantly higher than that of the other two positions in the later development period, while soil MBC at the edge decreased considerably. Additionally, qCO_2 at the edge showed a significantly increasing trend that was the inverse of MBC, and the qCO_2 values at the centres were significantly lower than that of the other two positions in the later develop

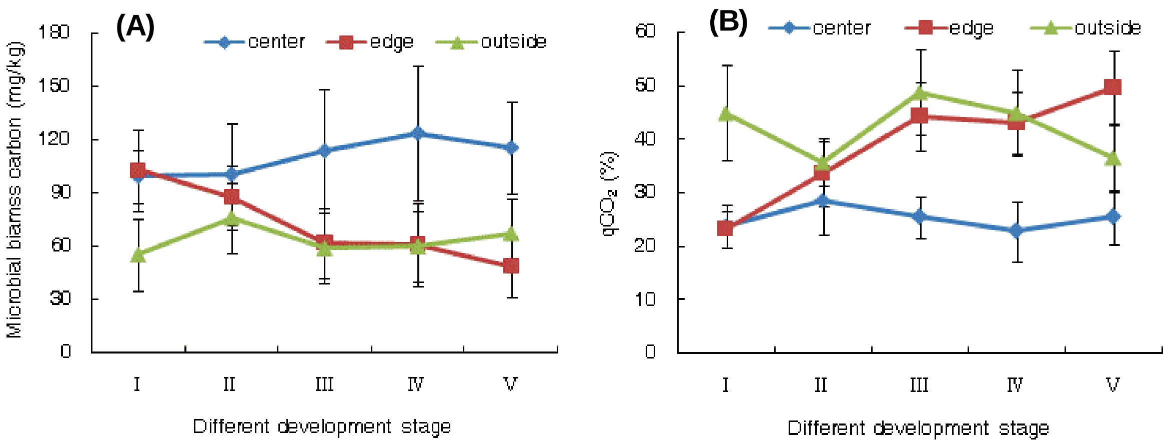

Figure 1. The characteristics of soil MBC (a) and qCO_2 (b) with different development stages of shrub, with standard error.

ment. Therefore, the microenvironment at the centre of mature shrub is relatively stable, and beneficial to soil microorganisms.

Acknowledgments

This research was supported by the "Strategic Priority Research Program — Climate Change: Carbon Budget and Related Issues" of the Chinese Academy of Sciences (XDA05050406-8), the Natural Science Foundation of China (31070412), China National Science and Technology Basic Research Programme (2012FY111900) and the Fundamental Research Funds for the Central Universities (lzujbky-2012-98).

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