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Biologically-Crusted Soil Respiration in Response to Simulated Precipitation Pulses in the Tengger Desert, Northern China

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ABSTRACT

Soil respiration (SR) is a major process of carbon loss from dryland soils, it is closely linked to precipitation which often arrived as discrete episodic event. However, knowledge about the dynamic patterns of SR of biologically crusted soils in response to precipitation pulses is still quite limited. In this study, we investigated CO_2 emission from moss (MCS) and cyanobacteria-lichen (CLCS) crusted soils after 2, 4, 8, 16, and 32 mm of precipitation treatments during the dry season in the Tengger Desert, northern China. Results showed that two hours after precipitation, SR rates of both MCS and CLCS were often increased up to 18 times greater than those before rewetting, and then gradually declined and returned to background levels, the decrease was faster at lower precipitation intensity and slower at the higher. The peak and average SR rates over the first 2 h in MCS increased with increasing precipitation magnitude, but did not vary in CLCS. Total CO_2 emission over the whole 72-h experiment ranged from 1.35 to 5.67 g C m^{-2} in MCS, and 1.11 to 3.19 g C m^{-2} in CLCS. Peak and average SR rates as well as total carbon loss were all greater in MCS than in CLCS. SR rates of both MCS and CLCS were logarithmically correlated with soil water content. Comparisons of SR among different amount of precipitation events together with the analysis of long-term precipitation data suggest that small rainfall events have the potential for large short-term carbon losses and biological soil crusts might be the major contributor to soil CO_2 emission of the water-limited desert ecosystem.

Key Words: soil respiration, precipitation pulse, biological soil crusts, Tengger Desert

INTRODUCTION

Arid and semiarid ecosystems cover about 40% of Earth's land surface (Reynolds *et al*., 2007), and store 15.5% (equivalent to 232.5 Pg C) of the world's total soil organic carbon (SOC) (Lal, 2004). They have long been considered as carbon sources in the terrestrial carbon cycle due to the low vegetation coverage (Schlesinger, 1990; Wang *et al*., 1999; Conant *et al*., 2000; Liu *et al*., 2002). Soil respiration (SR) is a major process of C loss from dryland soils (Conant *et al*., 2000), any changes in SR could slow or accelerate the increase of atmospheric CO_2 concentration (Raich and Schlesinger, 1992; Trumbore *et al*., 1996; Cox *et al*., 2000; Raich *et al*., 2002), and have a large impact on the soil C storage and fertility since these soils have relatively low levels of organic C content (West *et al*., 1994; Castillo-Monroy *et al*., 2011). Thus, quantifying likely responses of soil CO_2 emission to controlling factors is critical to our understanding of C budgets in dry ecosystems and their significance to global C cycling and balance.

In arid and semiarid ecosystems, soil water availability which is directly linked to precipitation, is the principle driving variable of ecosystem processes (Noy-Meir, 1973), including C dynamics (Bowling *et al*., 2011). Precipitation in these regions often arrives as discrete episodic event. Dry soils are irregularly interrupted by precipitation pulses that elevate water availability for short periods, and drive carbon effluxes

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