Effects of Rain Events on Carbon Fluxes from Biological Soil Crusts

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Introduction

In dry ecosystems, biological soil crusts (BSCs) have been suggested as one of the factors responsible for the large rate of annual CO_2 net uptake (Xie *et al*. 2009). However, most studies carried out on carbon (C) fluxes in arid and semi-arid ecosystems, such as soil respiration, have neglected the carbon fluxes from BSCs. Although BSCs are a vital component of the dry-land soil C cycle, few studies have parameterized the conditions required for photosynthesis in BSCs or determined BSCs respiration (Elbert *et al*. 2009, Castillo-Monroy *et al*. 2011). Precipitation in dry land is dominated by small events (Lauenroth and Bradford 2009). Even the smallest events will influence the carbon fluxes of BSCs, while intermediate pulses might wet the subsurface biotic community, and typically only larger events are used by plants for carbon gain or growth of roots or shoots (Belnap *et al*. 2005). As BSCs dry quickly and are hence very responsive to moisture pulses, the pulsed nature of precipitation can lead to highly variable carbon fluxes from BSCs (Bowling *et al*. 2011). Therefore, it is very important to study the effect of rain events upon carbon fluxes through BSCs in the dry ecosystem.

Methods

Study site

The study was conducted in an enclosed grassland at the Semi-Arid Climate and Environment Observatory of Lanzhou University (*SACOL*), located at 35°57′ ; 104°09′E (Gansu, China) with a continental semi-arid climate in *Loess Plateau*, western China.

Measurements of carbon fluxes through BSCs

Carbon fluxes were measured by a LICOR-8150 soil respiration systems equipped with a 104 and 104c chamber (LICOR, Inc., Lincoln NE, USA). Polyvinyl chloride collars (20 cm in diameter and 10 cm in height) were used for measurements. The difference between system carbon output (soil respiration plus BSCs respiration) and soil respiration (without BSCs) was considered as BSCs respiration. The net CO_2 budget of BSCs was determined by the difference between respiration values with and without BSCs when equipped with a 104c chamber, and the photosynthesis of BSCs was obtained by the difference between BSCs respiration and the net CO_2 budget. We grouped rain events from July to September into two types (small events: <5 mm; large events: >5 mm) to analyse the increased ratios of carbon fluxes from BSCs and soil respiration, based on the records of precipitation.

Results

The changes of soil respiration, BSCs respiration and photosynthesis after rain events were different (Fig. 1). After small events (<5 mm), BSCs respiration and

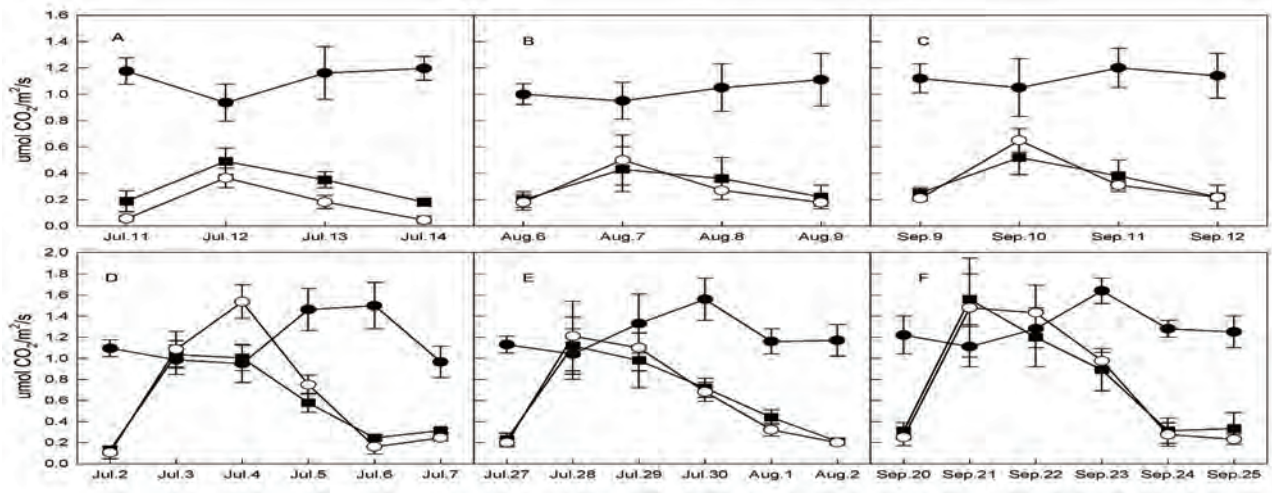

Figure 1. Change in soil respiration (●), BSCs respiration (■) and photosynthesis (○) after rain events. The values are daily means, the vertical bars are standard errors. The panel A, B and C are the influence of small events (<5 mm) and D, E and F represent large events (>5 mm). All rain events occurred after the first days of all panels.

photosynthesis increased significantly (P<0.05), and returned to initial levels by the third day after the rain, while soil respiration showed a slight decrease after rain, which might be due to the decrease of soil temperature. The influence of small events lasted for only a short time. Nevertheless, when there was a larger rain event (>5 mm), there was a different consequence. BSCs respiration and photosynthesis increased immediately and to a greater extent after the rain event, and then decreased gradually. However, soil respiration barely changed in the following two days, but in the third day, a significant increase was found that lasted for the next two days. In summary, small events did not affect the soil respiration significantly, but increased BSCs respiration and photosynthesis significantly compared to before the rain events (P<0.05), while large events influenced all of the three greatly.

Conclusion

The small rain events did not influence soil respiration, but affected both respiration and photosynthesis of BSCs. The big rain events changed soil respiration and carbon fluxes of BSCs significantly, and the increased respiration and photosynthesis of BSCs lasted for a couple of days. BSCs respiration and photosynthesis increased several times after small events, while soil respiration showed no change. However, large events can influence soil respiration, BSCs respiration and photosynthesis. BSCs were more sensitive to rain events compared to the soil.

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References

Belnap J, Welter JR, Grimm NB, Barger N, Ludwig JA (2005) Linkages between microbial and hydrologic processes in arid and semi-arid watersheds. *Ecology* **86**, 298-307.

Bowling DR, Grote EE, Belnap J (2011) Rain pulse response of soil CO_2 exchange by biological soil crusts and grasslands of the semiarid Colorado Plateau, United States. *Journal of Geophysical Research* **116**, 2156-2202.

Castillo-Monroy AP, Maestre FT, Rey A, Soliveres S, Garcıa-Palacious P (2011) Biological soil crust microsites are the main contributor to soil respiration in a semiarid ecosystem. *Ecosystems* **14**, 835-847.

Elbert W, Weber B, Budel B, Andreae MO, Poschl U (2009) Microbiotic crusts on soil, rock and plants: neglected major players in the global cycles of carbon and nitrogen? *Biogeoscienc, Discussions* **6**, 6983-7015.

Lauenroth WK, Bradford JB (2009) Ecohydrology of dry regions of the United States: Precipitation pulses and intra-seasonal drought. *Ecohydrology* **2**, 173-181.

Xie JX, Li Y, Zhai CX, Lan Z(2009) CO_2 absorption by alkaline soil and its implication to the global carbon cycle. *Environmental Geology* **56**, 953-61.