Response of soil respiration to precipitation variation in alfalfa grassland on the western Loess Plateau: Hysteresis and Diel Q_{10}

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Introduction

Soil respiration (Rs) plays an important role in the terrestrial carbon cycle, but how precipitation variation affects Rs in alfalfa grassland is poorly understood, especially in the overwintering preparation period. Therefore, this study explores the relationship between Rs and soil temperature (Ts) under different precipitation variation conditions on alfalfa grassland to provide a theoretical basis for accurate estimation of carbon cycle in alfalfa grasslands of the Loess Plateau.

Methods and study sites

- The experiment was conducted at Qingyang, the Loess Plateau Experimental Research Station of Lanzhou University (35.67° N, 107.85° E, 1297 m a.s.l.).
- The alfalfa was established in late September, 2018, to varying precipitation of 30% precipitation reduction (P-30), normal precipitation (CK) and 30% precipitation increase (P+30) were achieved using rain fall shelter.
- Continuous measurements of Rs were made in situ using an automated soil respiration system (LI-8150, LI-COR).
- Hourly Rs was continuously measured from September 20th to November 8th, 2019, which was the preparation period for the over-wintering of alfalfa. Simultaneous determination of Ts and VWC in 10 cm soil layer with Rs.

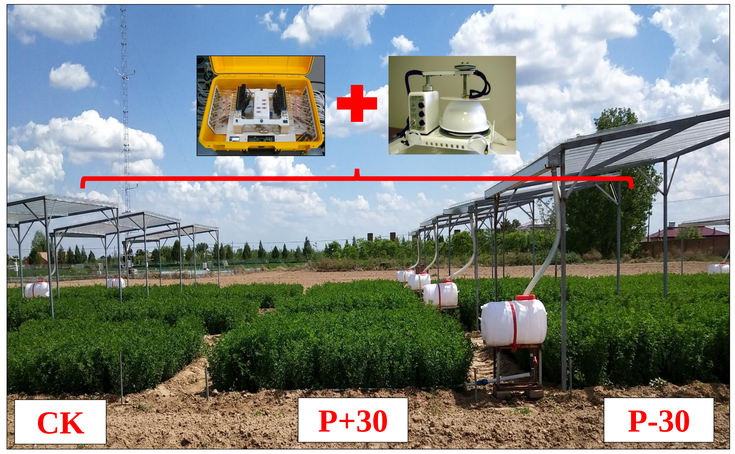

Fig 1. Rain fall shelter design and measuring instruments

Results

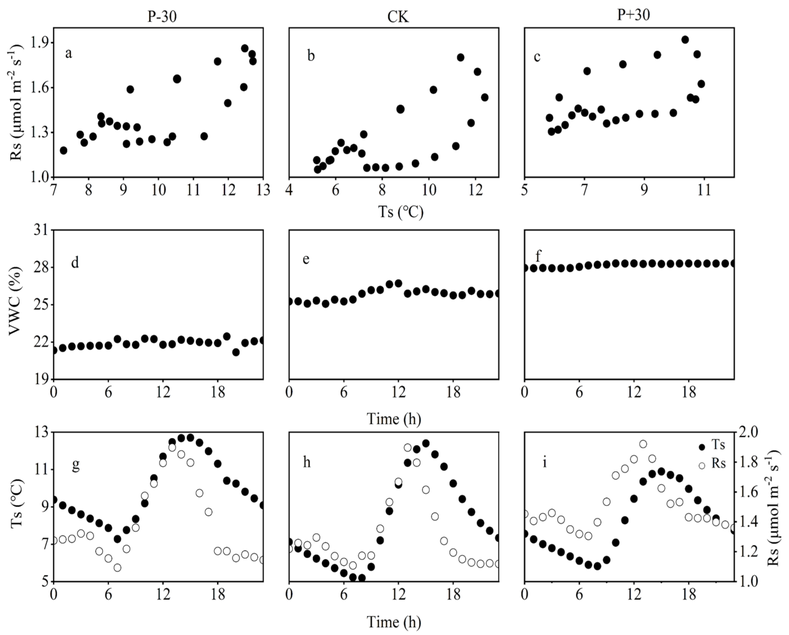

Fig 2. Daily averages of soil respiration (Rs), volumetric water content (VWC) and soil temperature (Ts) during the preparation period for overwintering

Table 1. The average value of soil respiration (Rs), soil temperature (Ts), volumetric water content (VWC), Q_{10} (temperature sensitivity of soil respiration) and lag times during the preparation period for overwintering

Treatments	Rs	Ts	VWC	Q_{10}	Lag time
P-30	1.43 a	9.90 a	21.89 c	1.87 a	2h
CK	1.24 b	8.19 b	25.80 b	1.58 ab	2h
P+30	1.51 a	8.16 b	28.19 a	1.44 b	2h

All regressions were significant at the 0.05.

- Rs under P-30 and P+30 treatment were 1.43 and 1.51 umol m^{-2} s^{-1}, respectively, which is significantly higher than CK treatment by 12.3% and 21.8% ($P < 0.05$, Table 1). The sensitivity of Rs to Ts (Q_{10}) in CK, P-30 and P+30 were 1.58, 1.87 and 1.44, respectively.
- Our results showed a significant phase hysteresis from Rs to Ts under precipitation variation at 10 cm depth (Fig. 2g-i). The mean time lag between Rs and Ts was 2 hrs for three treatments (Table 1), with Rs peaking earlier than Ts.

Conclusions

- The Q_{10} decreases with increasing soil water content.
- The Rs increases with increase in temperature during the overwintering preparation period of alfalfa.
- The mean time lag between Rs and Ts was 2 hrs.

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