Soil Respiration Dynamics and Its Relationship with Hydrothermal Factors in a Planted Haloxylon ammodendron Forest in the Lower Reaches of the Shiyang River (Postprint)

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Abstract

Soil respiration is not only an important indicator of soil biological activity, but also a critical research focus in global carbon cycle studies. In the lower reaches of the Shiyang River, a typical arid region, using shifting sand dunes and artificial Haloxylon ammodendron forest with removed soil crust as controls, the diurnal variation of soil respiration in artificial Haloxylon ammodendron forests planted for approximately 40 a, 30 a, 10 a, and 5 a was examined during both growing and non-growing seasons using the LI-8100 soil carbon flux monitoring system, and the effects of soil moisture and temperature on soil respiration were analyzed. The results revealed that: (1) The diurnal variation of soil respiration rates in Haloxylon ammodendron forests of different stand ages exhibited distinct unimodal curves during both growing and non-growing seasons, with certain fluctuations; the maximum daily emission rate occurred at 12:00–14:00, while the minimum appeared at approximately 8:00. (2) The establishment of Haloxylon ammodendron forests and soil crust removal treatment significantly increased desert soil respiration rates, and soil respiration rates generally increased with planting years across different stand ages, showing the pattern MC >40 a>30 a>10 a>MS >5 a, while in the non-growing season the pattern was MC >40 a>10 a>5 a>30 a>MS. (3) Soil respiration rates in Haloxylon ammodendron forests of different stand ages all showed pronounced seasonal variations, with soil respiration in the growing season (August) being significantly stronger than in the non-growing season (January). (4) Correlation analysis indicated that soil respiration in both growing and non-growing seasons was significantly correlated with 0–5 cm soil moisture, and both exhibited quadratic relationships: Y =-0.205 8X 2+0.946 5X-0.316 6 (R 2 =0.506 2, P= 0.041 7) and Y= 0.118 7 X 2+0.156 3X+0.118 8 (R 2=0.675 7, P =0.001 1),

respectively; however, the correlation with 10 cm soil temperature was not significant, indicating that soil moisture is the key factor regulating soil respiration in artificial Haloxylon ammodendron forests. This study further demonstrated that the establishment of artificial Haloxylon ammodendron forests significantly improved the biological activity of desert soil and increased soil carbon flux levels, and that the degradation of artificial Haloxylon ammodendron forests and desertification, characterized fundamentally by soil crust destruction, would inevitably intensify carbon emissions in the short term. Therefore, it is necessary to promote rational afforestation practices in desert areas and pay attention to protecting soil crusts during afforestation and forest management processes to reduce CO2 emissions.

Full Text

Soil Respiration Variation Characteristics and Its Relationship with Hydrothermal Factors of Artificial Haloxylon ammodendron Forest in the Lower Reaches of Shiyang River

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Abstract

Soil respiration is not only an important indicator of soil biological activity, but also a key topic in global carbon cycle research. To characterize soil respiration patterns in artificial Haloxylon ammodendron forests at different life stages (40-year, 30-year, 10-year, and 5-year stands) in the lower reaches of the Shiyang River, Gansu Province—a typical arid region—we used an LI-8100 automated soil CO flux system to measure diurnal soil respiration variations during both growing and non-growing seasons. Mobile sand dunes and artificial H. ammodendron forest plots with soil crust removal served as control samples. The influence of soil moisture and temperature on respiration rates was also evaluated.

The main findings were as follows: (1) Diurnal soil respiration rates in artificial H. ammodendron forests at different life stages exhibited obvious single-peak curves with certain volatility during both growing and non-growing seasons, with maximum rates occurring between 12:00 PM and 2:00 PM and minimum rates around 8:00 AM. (2) Planting H. ammodendron forests and breaking soil

crusts significantly enhanced desert soil respiration. Respiration rates generally increased progressively with stand age, following the descending order MC > 40a > 30a > 10a > MS > 5a in the growing season and MC > 40a > 10a > 5a > 30a > MS in the non-growing season. (3) Seasonal variations in soil respiration rates were pronounced across all life stages, with values in the growing season (August) substantially higher than in the non-growing season (January). (4) Correlation analysis revealed that soil respiration rate (Y) was significantly correlated with soil water content at 0–5 cm depth (X) in both seasons, described by the quadratic regression equations:

Growing season: $Y = -0.2058X^2 + 0.9465X - 0.3166$ ($R^2 = 0.5062$, $P = 0.0417$)

Non-growing season: $Y = 0.1187X^2 + 0.1563X + 0.1188$ ($R^2 = 0.6757$, $P = 0.0011$)

However, no significant correlations were found between soil respiration rate and soil temperature at 10 cm depth. These results demonstrate that soil water content is the critical factor controlling soil respiration in artificial H. ammodendron forests, and affirm the importance of establishing these forests for promoting biological activity and carbon flux in desert soils. Nevertheless, degradation of artificial H. ammodendron forests and land desertification, as reflected by destroyed soil crusts, will inevitably increase carbon emissions in the short term. Therefore, artificial afforestation in desert areas should be accompanied by soil crust protection and effective forest management to reduce CO emissions.

Keywords: artificial Haloxylon ammodendron forest; soil respiration; lower reaches of Shiyang River; diurnal variation

Note: Figure translations are in progress. See original paper for figures.