RESPONSES OF SOIL WATER POTENTIAL AND PLANT PHYSIOLOGICAL STATUS TO PULSED RAINFALL EVENTS IN NORTHWESTERN CHINA: IMPLICATIONS TO DISCLOSE THE WATER-USE STRATEGIES OF DESERT PLANTS

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Abstract - Drylands represent vulnerable areas of the terrestrial environment and are extremely sensitive to climate change. Rainfalls in drylands are characterized by brief pulses of varying amounts, short durations (minutes or hours), and uncertain intervals of drought. This infrequent, discrete and largely unpredictable water input is the main source of soil water for drylands, which changes the soil water state and provides the necessary resources for the survival of plants. Soil water status is characterized by both the amount of water present (soil water content, SWC) and the energy with which the water is held (soil water potential, SWP). SWP is a more robust descriptor of the soil water regime than SWC. SWP describes the energy state and movement characteristics of water in the soil, providing information on the availability of water for plant absorption or microbial activity, and how the soil retains or releases water in the soil-plant-atmosphere continuum (SPAC). Fluctuations in SWP caused by pulsed rainfall determine the availability of soil water to plants. Haloxylonammodendron (HA) is one of the main constructive perennial species widely distributed in northwestern China. HA responds considerably to rainfall pulses larger than 5 mm and primarily utilizes shallow soil water to support life activities. Rainfall less than 5 mm is typically regarded as ineffective. While others suggest that a 1 mm minor rainfall can change HA's stomatal behavior. The water-use strategies of HA remain inadequately investigated, especially in the role of utilizing small rainfall pulses (i.e., < 5 mm). This study, therefore, takes HA as the research object based on the measured data of SWP during the growing season (May to October) from 2016 to 2018 in the arid desert area of northwest China. Seven precipitation gradients (+10%, +20%, +30%, CK, −10%, −20%, and −30%) were set through precipitation control experiment to determine the characteristics of SWP and plant physiological status affected by various rainfall pulses. Multivariate Adaptive Regression Splines (MARS) were used to rank the factors influencing the response patterns of these variables. We discuss the main mechanisms affecting plant water use and highlight the critical function of small precipitation events in alleviating water stress. The response rate of SWP increased with the rainfall magnitudes, showing an “S-shaped” curve across vertical profiles, and affected by three most vital factors (antecedent SWP, rainfall amplitude, and rainfall intensity). Very small rainfall (< 2 mm) can increase the SWP in 20 cm by nearly 30%, and thus likely contribute to the drought relief of HA under low antecedent SWP (< -3.5 MPa), while large rainfall events (> 15 mm) influenced deep SWP (60 cm) and enhanced the negative correlation between SWP and soil temperature. Very small rainfall plays a vital role in maintaining SWP and promoting desert plants’ use of water. We predict that with longer intervals between future rainfall events, HA will tend to improve water utilization efficiency. Re-examine ecologically valid SWP thresholds of HA is critical.

Keywords - Rainfall Pulses, Soil Water Potential, Soil Temperature, Desert Environments, Haloxylonam Modendron.

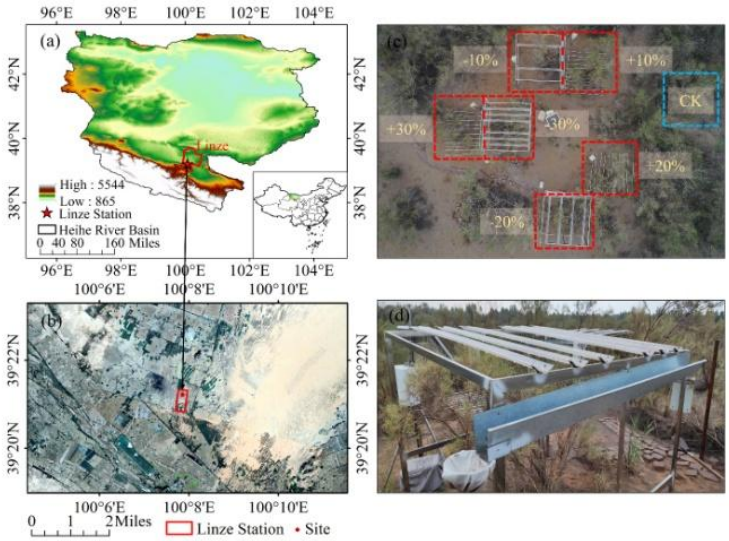


Fig. 1 (a) Location of the of experimental station in the Heihe River Basin and in China; (b) location of the experimental site in the Linze Inland River Basin; (c) photograph of the rainfall intercept-guide devices (-10%, +10%, -20%, +20%, -30%, and +30%) and control group (CK); (d) photograph of the rainfall intercept-guide device (-30%)

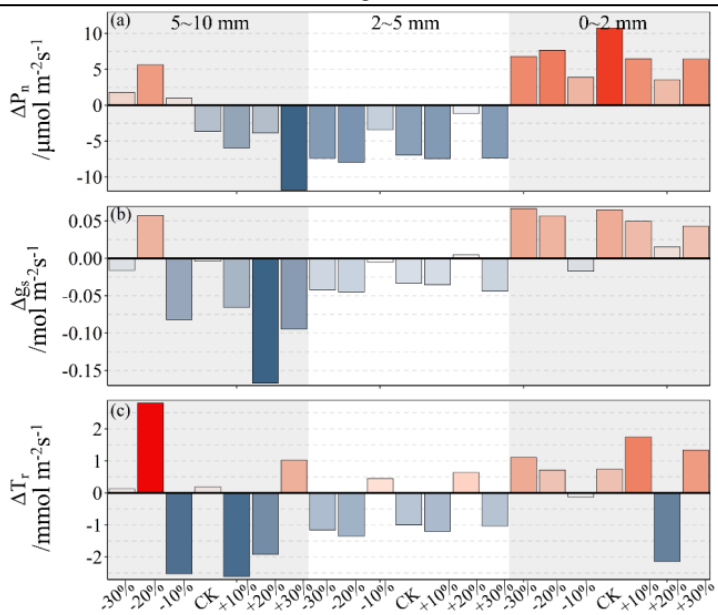


Fig. 2 Changes of photosynthetic rate (P_r) (a), stomatal conductance (g_s) (b) and transpiration rate (T_r) (c) of Haloxylonammodendron(HA)response to different rainfall events (0-2 mm, 2-5 mm, and 5-10 mm) under seven treatments (-30%, -20%, -10%, CK, +10%, +20%, and +30%)

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