NON-INVASIVE EVALUATION OF ALFALFA ROOT TRAITS UNDER WATER STRESS USING GROUND PENETRATING RADAR

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ABSTRACT

Alfalfa (*Medicago sativa* L.) is a valuable forage crop with significant economic and ecological relevance in the arid western U.S. A complete understanding of alfalfa root system dynamics is necessary for elucidating the effects of water stress caused by deficit irrigation on plant development, yield, and nutritional value. Conventional root assessment methods are often invasive and time-consuming, limiting the collection of accurate and comprehensive data. This study examined the use of ground penetrating radar (GPR) as a non-invasive, efficient technique to quantify alfalfa root traits, such as dry root biomass and root diameter and correlate them to water stress. The experiment was conducted at the University of Nevada, Reno's Valley Road Field Laboratory in Reno, Nevada with two alfalfa varieties (Ladak II and Stratica) subjected to three irrigation treatments: 100, 80, and 60% of the irrigation amount required to fully satisfy the water requirements of alfalfa. Irrigation amounts required by each treatment were quantified on a weekly basis using a network of soil water sensors consisting of three Time Domain Reflectometry (TDR) sensors buried at depths of 20, 60, and 90 cm. Irrigation amounts applied to each treatment were precisely controlled using a drip irrigation system with operation times controlled by timers. GPR data acquisition was done during the third (2023) and fourth (2024) growing seasons of the experiment using a multichannel GPR system with horizontal transmit and horizontal receive polarization. Destructive sampling was performed using a subsoil probe, collecting two soil cores per plot. The soil cores were partitioned into six depth intervals (0-5, 5-15, 15-30, 30-50, 50-80, and 80-120 cm). Fresh and dry root biomass, root water mass, and root diameter were measured in each subsample. Root parameters were correlated with amplitude and a simple linear regression model was fitted to each parameter as a function of amplitude according to the irrigation treatment. A negative correlation was found between the amplitude and fresh root biomass (r = -0.47), dry root biomass (r = -0.53), root water mass (r = -0.4) and root diameter (-0.45). Water stress affected root development, causing a decline in root biomass and root diameter in the mild and moderate deficit irrigation treatments. The simple linear regression models of the root parameters as a function of amplitude had different residual standard errors and coefficients of determination. However, GPR was able to capture the differences in root biomass and root diameter among the three irrigation treatments. These findings highlight the potential of GPR to provide valuable insights into alfalfa root architecture and response to water stress.

Key Words: Alfalfa, ground penetrating radar, water stress, deficit irrigation, root parameters

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