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Combining Hyperspectral Reflectance and Multivariate Regression Models to Estimate Plant Biomass of Advanced Spring Wheat Lines in Diverse Phenological Stages under Salinity Conditions

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Abstract: An area of growing interest in wheat-breeding programs for abiotic stresses is the accurate and expeditious phenotyping of large genotype collections using nondestructive hyperspectral sensing tools. The main goal of this study was to use data from canopy spectral signatures (CSS) in the full-spectrum range (400–2500 nm) to estimate and predict the plant biomass dry weight at booting (BDW-BT) and anthesis (BDW-AN) growth stages, and biological yield (BY) of 64 spring wheat germplasms exposed to 150 mM NaCl using 13 spectral reflectance indices (SRIs, consisting of seven vegetation-related SRIs and six water-related SRIs) and partial least squares regression (PLSR). SRI and PLSR performance in estimating plant traits was evaluated during two years at BT, AN, and early milk grain (EMG) growth stages. Results showed significant genotypic differences between the three traits and SRIs, with highly significant two-way and three-way interactions between genotypes, years, and growth stages for all SRIs. Genotypic differences in CSS and the relationships between the three traits and a single wavelength over the full-spectrum range depended on the growth stage. Water-related SRIs were more strongly correlated with the three traits compared with vegetation-related SRIs at the BT stage; the opposite was found at the EMG stage. Both types of SRIs exhibited comparable associations with the three traits at the AN stage. Principal component analysis indicated that it is possible to assess plant biomass variations at an early stage (BT) through published and modified SRIs. SRIs coupled with PLSR models at the BT stage exhibited good prediction capacity of BDW-BT (57%), BDW-AN (82%), and BY (55%). Overall, results demonstrated that the integration of SRIs and multivariate models may present a feasible tool for plant breeders to increase the efficiency of the evaluation process and to improve the genetics for salt tolerance in wheat-breeding programs.

Keywords: biological yield; booting stage; partial least squares regression; plant dry weight; principal component analysis; vegetation-related SRIs; water-related SRIs

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1. Introduction

Wheat (*Triticum aestivum* L.) is one of the most important cultivated cereal crops around the world and plays a crucial role in global food security. It ranks first and second