plants

MDPI

Article

Potential Use of Hyperspectral Reflectance as a High-Throughput Nondestructive Phenotyping Tool for Assessing Salt Tolerance in Advanced Spring Wheat Lines under Field Conditions

Salah El-Hendawy [1,2,*], Nasser Al-Suhaibani [1], Muhammad Mubushar [1], Muhammad Usman Tahir [1], Yahya Refay [1] and ElKamil Tola [3]

[1] Department of Plant Production, College of Food and Agriculture Sciences, King Saud University, Riyadh 11451, Saudi Arabia; nsuhaib@ksu.edu.sa (N.A.-S.); mmubushar@ksu.edu.sa (M.M.); mtahir@ksu.edu.sa (M.U.T.); refay@ksu.edu.sa (Y.R.)
[2] Department of Agronomy, Faculty of Agriculture, Suez Canal University, Ismailia 41522, Egypt
[3] Precision Agriculture Research Chair (PARC), College of Food and Agriculture Sciences, King Saud University, Riyadh 11451, Saudi Arabia; etola@ksu.edu.sa
* Correspondence: mosalah@ksu.edu.sa; Tel.: +966-535318364

Citation: El-Hendawy, S.; Al-Suhaibani, N.; Mubushar, M.; Tahir, M.U.; Refay, Y.; Tola, E. Potential Use of Hyperspectral Reflectance as a High-Throughput Nondestructive Phenotyping Tool for Assessing Salt Tolerance in Advanced Spring Wheat Lines under Field Conditions. *Plants* **2021**, *10*, 2512. https://doi.org/10.3390/plants10112512

Academic Editors: Pasqualina Woodrow and Loredana Filomena Ciarmiello

Received: 28 September 2021
Accepted: 16 November 2021
Published: 19 November 2021

Abstract: The incorporation of stress tolerance indices (STIs) with the early estimation of grain yield (GY) in an expeditious and nondestructive manner can enable breeders for ensuring the success of genotype development for a wide range of environmental conditions. In this study, the relative performance of GY for sixty-four spring wheat germplasm under the control and 15.0 dS m^{-1} NaCl were compared through different STIs, and the ability of a hyperspectral reflectance tool for the early estimation of GY and STIs was assessed using twenty spectral reflectance indices (SRIs; 10 vegetation SRIs and 10 water SRIs). The results showed that salinity treatments, genotypes, and their interactions had significant effects on the GY and nearly all SRIs. Significant genotypic variations were also observed for all STIs. Based on the GY under the control (GYc) and salinity (GYs) conditions and all STIs, the tested genotypes were classified into three salinity tolerance groups (salt-tolerant, salt-sensitive, and moderately salt-tolerant groups). Most vegetation and water SRIs showed strong relationships with the GYc, stress tolerance index (STI), and geometric mean productivity (GMP); moderate relationships with GYs and sometimes with the tolerance index (TOL); and weak relationships with the yield stability index (YSI) and stress susceptibility index (SSI). Obvious differences in the spectral reflectance curves were found among the three salinity tolerance groups under the control and salinity conditions. Stepwise multiple linear regressions identified three SRIs from each vegetation and water SRI as the most influential indices that contributed the most variation in the GY. These SRIs were much more effective in estimating the GYc (R^2 = 0.64 − 0.79) than GYs (R^2 = 0.38 − 0.47). They also provided a much accurate estimation of the GYc and GYs for the moderately salt-tolerant genotype group; YSI, SSI, and TOL for the salt-sensitive genotypes group; and STI and GMP for all the three salinity tolerance groups. Overall, the results of this study highlight the potential of using a hyperspectral reflectance tool in breeding programs for phenotyping a sufficient number of genotypes under a wide range of environmental conditions in a cost-effective, noninvasive, and expeditious manner. This will aid in accelerating the development of genotypes for salinity conditions in breeding programs.

Keywords: breeding; grain yield; multiple linear regression; spectral reflectance indices; stress tolerance indices; vegetation index; water index

1. Introduction

Insufficient freshwater supplies for the agriculture sector require a parallel increase in the use of nonconventional water resources for the sustainable production of food crops.