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Article

Assessing Heat Stress Tolerance of Wheat Genotypes through Integrated Molecular and Physio-Biochemical Analyses

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Abstract: Heat as an abiotic stress significantly impairs the sustainable productivity of wheat (*Triticum aestivum* L.). To determine the tolerance of genotypes to heat stress, a comprehensive approach should be used that integrates simultaneous phenotyping and genotyping analyses. The aim of this study is to identify local heat-tolerant genotypes using simple sequence repeat (SSR) markers and evaluate the selected genotypes under field conditions for their tolerance to heat stress. Of the 12 SSR markers that showed polymorphism, eight were associated with six important traits. The use of hierarchical cluster analysis (HC) based on SSR markers led to the identification of 13 genotypes that showed varying results and were grouped into three distinct heat tolerance classes: tolerant (T), moderately tolerant (MT), and sensitive (S). The results showed that heat stress had a significant effect on 19 traits under this study, with significant variation in tolerance to heat stress between genotypes. The tolerant genotypes exhibited a range of average thousand-kernel weight (TKW) values between 40.56 and 44.85, while the sensitive genotype (Yecora Rojo) had an average TKW of 35.45. Furthermore, the tolerant genotypes showed two to three times higher levels of antioxidants compared to the sensitive genotypes when exposed to heat stress. Among the traits analyzed, six showed a favorable combination of high heritability (>60%) and genetic gain (>20%). Through the integration of principal component analysis and stepwise multiple linear regression, it was determined that six traits (grain yield, 1000-kernel weight, plant height, intercellular carbon dioxide, flag leaf area, and grain filling duration) revealed differences between the 13 genotypes. HC analysis of the six traits resulted in the same division of genotypes into three main categories as observed in an HC analysis based on SSR markers. It is worth noting that Saudi wheat, including KSU106, KSU105, and KSU115 as local genotypes, in addition to the 16HTWYT-22 genotype, showed higher heat tolerance compared to the other genotypes tested, indicating its potential suitability for agriculture in Saudi Arabia. These results contribute to breeding programs focused on developing heat-tolerant wheat varieties and accelerate progress in wheat productivity improvement programs.

Keywords: wheat genotypes; heat stress tolerance; molecular markers; antioxidant system

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1. Introduction

Wheat (*Triticum aestivum* L.) is a cereal crop of great importance to world agriculture, but its agriculture often suffers from the harmful effects of heat stress. In Saudi Arabia, for instance, a rise in temperature by one degree Celsius can reduce crop productivity by 7–25% [1]. According to the 2014 Intergovernmental Panel on Climate Change (IPCC) report, there has been a consistent rise in atmospheric temperatures since the beginning of the 21st century, with projections of a further increase of approximately 1.0–1.7 °C [2]. Consequently, wheat growth and development have been increasingly challenged by more