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RESEARCH ARTICLE

Genetic Nature of Elemental Contents in Wheat Grains and Its Genomic Prediction: Toward the Effective Use of Wheat Landraces from Afghanistan

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Abstract

Profiling elemental contents in wheat grains and clarifying the underlying genetic systems are important for the breeding of biofortified crops. Our objective was to evaluate the genetic potential of 269 Afghan wheat landraces for increasing elemental contents in wheat cultivars. The contents of three major (Mg, K, and P) and three minor (Mn, Fe, and Zn) elements in wheat grains were measured by energy dispersive X-ray fluorescence spectrometry. Large variations in elemental contents were observed among landraces. Marker-based heritability estimates were low to moderate, suggesting that the elemental contents are complex quantitative traits. Genetic correlations between two locations (Japan and Afghanistan) and among the six elements were estimated using a multi-response Bayesian linear mixed model. Low-to-moderate genetic correlations were observed among major elements and among minor elements respectively, but not between major and minor elements. A single-response genome-wide association study detected only one significant marker, which was associated with Zn, suggesting it will be difficult to increase the elemental contents of wheat by conventional marker-assisted selection. Genomic predictions for major elemental contents were moderately or highly accurate, whereas those for minor elements were mostly low or moderate. Our results indicate genomic selection may be useful for the genetic improvement of elemental contents in wheat.

Introduction

Elements, along with nucleic acids, proteins, and metabolites, are essential building blocks of cells, and are involved in almost every process in living organisms [1]. Ionome is defined as