Variation for Grain Mineral Concentration of Current and Historical Great Plains Hard Winter Wheat Germplasm

A shift toward whole-grain wheat products in U.S. consumer diets increases the influence of wheat mineral concentration because minerals are most concentrated in bran fractions removed in milling to white flour but are retained in whole-grain products. Identifying variation within adapted germplasm is a necessary prerequisite for biofortification breeding in Great Plains winter wheat. Grain yield is the primary target of Great Plains wheat breeders, and previous studies have shown that as grain yields increased, grain mineral concentrations generally decreased. The efforts of breeders to improve yields in Great Plains winter wheat, therefore, may have had the unintended consequence of reducing grain mineral concentrations. Recent analyses also indicate that increases in global CO$_2$ concentration may further decrease grain mineral concentrations (Myers et al., 2014).

To assess the variation in grain mineral concentration in Great Plains winter wheat germplasm and evaluate the trends in the germplasm over time, grain mineral concentrations were measured in a collection of 299 winter wheats developed by public and private programs in eight states and spanning the history of cultivated winter wheat production in the Great Plains. Concentrations of As, Ca, Cd, Co, Cu, Fe, K, Li, Mg, Mn, Ni, P, S, and Zn were measured in grain produced in Nebraska and Oklahoma, and results are reported in the May–June issue of Crop Science.

Significant genetic variation for mineral concentrations is present in the germplasm pool, but significant interactions of genotype with environment will challenge breeding efforts for some of the most nutritionally valuable minerals, including Fe, Mg, and Zn. Grain mineral concentrations generally were positively correlated among genotypes, and some grain mineral concentrations were negatively correlated with grain yield. Zinc concentration was negatively correlated with yield in all environments.

Grain yields have increased more rapidly than zinc concentrations have decreased. Among the wheat cultivars released from 1960 to 2014, grain yield increased with year of release by 0.58 to 1.25% per year while zinc concentration decreased 0.15 to 0.25% per year, relative to the long-term check cultivar, ‘Scout 66’. Iron concentrations also trended lower over this time period but at slower rates. Great Plains breeders continue to have access to significant genetic variation for zinc concentration in their germplasm: among the 93 cultivars released after 2000, zinc concentration varied as much as 2.3-fold.

Zinc concentration was strongly correlated with grain protein concentration, even when controlling for their common negative association with grain yield. Underlying physiology links zinc and protein concentrations, and so breeding for increased grain protein concentration may be an efficient strategy to select for increased zinc concentration in grain. Grain protein can be rapidly, cost-effectively, and non-destructively measured while measurement of zinc is time-consuming, costly, and destructive. Selection for grain protein deviation, positive deviations from the consistently negative protein–yield relationship, has been proposed by others as an approach for improving both grain protein and yield in breeding. Data from this study indicate that selection for positive grain protein deviation also will identify breeding lines with higher zinc concentration, a win–win for nutritional quality.

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Reference


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