Crop Science Futurology: A Data-Driven Approach Through Phenomic, Genomic and Enviromic Insights

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Abstract

In recent years, the use of field-based high-throughput phenotyping (FHTP) has surged across diverse disciplines. Particularly, it has gained significant traction in agricultural research, enabling scientists to efficiently gather extensive data for a deeper understanding of plant biology in the context of plant growth dynamics. This abstract aims to demonstrate potential applications of data obtained through high-throughput phenotyping in the fields of plant biology and predictive plant breeding.

The study utilized temporal phenotype data derived from repetitive drone flights equipped with various sensors. These data were incorporated into a novel mixed model, providing insights into the temporal genetic effects on different genotypes/plants. Gaussian or Lorentzian peak models, as well as Functional Principal Component analysis, were employed to characterize the growth patterns of various genotypes in diverse environments. The research revealed that Temporal Effect Sizes of Quantitative Trait Loci (QTLs) influence growth differently across time points, highlighting the dynamic nature of plant development. Furthermore, the study uncovered time-dependent associations between genotypes and their environments based on temporal phenotype values.

The predictive capability of temporal phenomic data was found to surpass that of genomic data in predicting complex traits in maize. However, the combination of phenomic and genomic data consistently yielded the most accurate predictions for complex traits. By analyzing drone flights at specific growth stages, the study quantified physiological traits such as senescence progression across multiple time points. This analysis led to the calculation of new traits, including days to senescence and grain filing period, providing valuable insights into plant development and growth dynamics.

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