Multi-Temporal Estimation of Maize Yield and Flowering Time Using UAV-Based Hyperspectral Data

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Abstract

Maize (Zea mays L.) is one of the most consumed grains in the world and improving maize yield is of great importance for food security, especially under global climate change and more frequent severe droughts. However, traditional phenotyping methods relying on manual assessment are time-consuming and prone to human errors. Recently, the application of unmanned aerial vehicles (UAVs) has gained increasing attention in plant phenotyping due to their efficiency in data collection. Moreover, hyperspectral sensors integrated with UAVs can offer data streams with high spectral and spatial resolutions, which are essential for estimating plants' physiological and biochemical traits. In this study, we developed machine learning models to estimate grain yield and flowering time of maize breeding lines using multi-temporal UAV-based hyperspectral imagery. The performance of multiple machine learning models and the efficacy of different hyperspectral features were evaluated on Genomes to Fields (G2F) experimental sites in Wisconsin. Results showed that ridge regression is the most robust model in estimating grain yield and flowering time, compared to random forest and support vector regression models. Furthermore, the ridge regression model achieved a correlation coefficient (r) of 0.551 for yield, 0.906 for days to silking, and 0.914 for days to anthesis when using the full-bands spectra features for estimation. In addition, we assessed the modeling performance using data acquired from different growing stages. The best time of applying the UAV survey was also identified in order to reduce the data collection efforts.

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Keywords: maize; high-throughput phenotyping; hyperspectral imagery; unmanned aerial vehicle (UAV); machine learning; flowering time; grain yield

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