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Unveiling Drought-Resilient Pathways: Integrating High Throughput Phenotyping and Multivariate Modeling to Enhance Barley Adaptation to Climate Change

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Abstract

The increasing threat of climate change makes developing drought-resilient crops ever more important. Barley *(Hordeum vulgare)*, is a highly drought-tolerant cereal and a key player in the future of farming. Moreover, the pivotal role of plant architecture, development patterns and roots in conferring drought tolerance to plants has been understudied, despite their potential importance for drought tolerance. In this context, we delve into the intricate interplay between barley plants and the environment – specially drought - with a distinct focus on leveraging multi-data integration and machine learning techniques to analyse high-throughput phenotyping data from the field. By employing automated ground-based platforms, such as the Phenomobile equipped with multi-spectral, RGB cameras, LiDAR and the Physiotron – a lysimeter with a multi-sensor bridge – that provides controlled environmental conditions for in-depth study of roots, for monitoring responses to stress with unmatched precision, we can capture large data encompassing many critical phenotypic indicators at plot and field level. This large dataset is subjected to multivariate modeling to discover complex relationships between multiple traits and environmental factors. We concentrate on predicting complex traits such as root traits, biomass accumulation, yield, stress responses that are fundamental to barley's resilience under stress. Leveraging the power of machine learning with phenomics and genotypic data holds the promise of unraveling the complex relationships between genetic makeup and observable traits enabling us to understand the fundamental genetic drivers of various phenotypic characteristics By identifying hidden correlations and interdependencies, our models will enable the prediction of phenotypic traits of interest under different stress conditions, offering invaluable insights into barley's drought resistance potential and performance. Our work will highlight the importance of data integration and machine learning to unlock the potential of agricultural research.

Keywords: High throughput phenotyping, Multivariate modeling, Remote-sensing, Machine Learning, Phenotypic traits, Barley.