

**The Advanced Plant Phenotyping Laboratory: A phenomics platform for dissecting genomics of plant performance and health**

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The Advanced Plant Phenotyping Laboratory (APPL, pronounced ‘apple’) houses a conveyor system to automatically move plants through imaging stations for sophisticated measurements of physiological, compositional, and architectural plant properties. The imaging modalities currently include chlorophyll fluorescence, hyperspectral, 3D laser scanning, multispectral, thermal, and RGB color imaging. These modalities allow inference of photosynthetic efficiency, plant leaf area and biomass, and compositional attributes like nitrogen content or specific metabolic profiles. These multimodal data capabilities will allow us to use machine learning approaches and explainable AI to generate unique ‘health fingerprints’ for every plant. APPL also allows automatic watering and weighing of plants to impose specific water stress regimes. This research highlights recent advancements in the use of this phenomics platform for genome wide association studies (GWAS) in poplar (*Populus trichocarpa*), monitoring of heat-stress tolerance in pennycress (*Thlaspi arvense*), and drought tolerance in switchgrass (*Panicum virgatum*). Central to the success of these projects is the APPL Public Interface (APPL PI, pronounced ‘pie’) that combines state-of-the-art data management tools and computational infrastructure to facilitate the research. We demonstrate how multiple modalities increase statistical power to uncover gene candidates using GWAS in poplar. Chlorophyll fluorescence uncovers heat tolerance in pennycress. Water use efficiency and leaf temperature from thermal cameras uncover mechanisms of drought tolerance in switchgrass. We will discuss in the context of plant disease epidemics. APPL is a state-of-the-art phenotyping platform allowing researchers to push the boundaries of phenomics and genomics to address challenges of the 21st century.