Optimizing hydroponic growth system for metal stress studies of bioenergy crops

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Project Goals: The Quantitative Plant Science Initiative (QPSI) is a capability that aims to bridge the knowledge gap between genes and their functions. A central aspect of our strategy is combining genome-wide experimentation and comparative genomics with molecular-level experimentation. In this way, we leverage the scalability of 'omics data and bioinformatic approaches to capture system-level information, while generating sequence-specific understanding of gene and protein function. By incorporating molecular-level experimentation in our workflow, we are addressing the question of how a protein functions and establishing mechanistic insight into how sequence variation impacts phenotype. This knowledge serves as a touchstone for accurate genome-based computational propagation across sequenced genomes and forms the foundation for robust predictive modeling of plant productivity in diverse environments.

Populus is one of the primary bioenergy crops that DOE has been focusing on for decades. With the state-of-the-art genomics resources, *Populus* has emerged as an ideal model system to study woody perennial plants. There is general agreement that the study of *Populus* is required to understand the specialized physiology of woody perennials, especially adaptation to environmental stresses. The transition metals iron (Fe) and zinc (Zn) are indispensable cofactors for numerous critical aspects of plant growth, including metabolism, signaling, gene expression, genome stability, and the assimilation of other nutrients. However, in excess, these metals can be cytotoxic for plants. Imbalanced Fe and Zn concentrations in soils can cause physiological stress es that negatively impact crop health and yield. How woody perennials deal with Fe or Zn stress (deficiency and excess) is poorly understood. We are combining transcriptomics, ionomics, and non-destructive physiological measurements in a time-series study of *Populus* treated by various Zn and Fe stresses to characterize the genome-wide response of *Populus* towards transition metal stresses. Our studies will enhance the understanding of the specialized physiology of long-lived perennial plants and the genetic improvement of *Populus* as a cost-effective sustainable biomass feedstock.

To perform the time-series study, we have optimized a hydroponic system for *Populus* growth that allows us to precisely manipulate Fe and Zn bioavailability. Using this versatile platform, we observed stress phenotypes within two weeks. Additionally, the hydroponic system is inexpensive to build and can easily be adapted for other bioenergy crops like sorghum.

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