**3D imaging and physics-based modeling for optimized root characteristics**

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**Abstract**

The proposed project assembles scientists with complementary research programs that aim to generate valuable preliminary data for pursuing large scale federal grants. The overarching science goal is to develop a cyber-enabled framework that will allow the accelerated design of crops with optimized response. Our hypothesis is that an integrated approach combining genetic experiments (genomics, high throughput phenotyping), in-situ measurements (high resolution x-ray visualization, root-on-a-chip systems), physics based modeling (nutrient and water transport and uptake, root growth dynamics), and numerical optimization will enable rigorously linking the genotype and the phenotype and tune the genotype to access tailored responses. A specific vision of this project is to leverage the cyber-methodology and tailor the root system to optimize tolerance to drought of a crop (maize). We plan to address this vision by incorporating computational thinking in two stages (1) relate root phenotypes to agronomically relevant traits such as grain yield, drought tolerance, nutrient uptake, etc., and (2) relate phenotypic information for root (and other) traits to genomic information.

This proposal will allow us to lay the groundwork for this ambitious science goal via the following synergistic activities:

1. Generate data to link genotype with phenotype and phenotype with response: perform root phenotyping experiments under controlled conditions (TL, TH), complete 3D x-ray visualization of root systems (TH, BG), and implement root-on-chip measurements of nutrient uptake rates and growth rates.

2. Model root growth and uptake dynamics: model water and nutrient diffusion in soil, model root system as a pipe network to calculate uptake rates, integrate and validate with experiments (BG, TH)

3. Optimize root system to maximize nutrient uptake: Utilize numerical optimization principles on the validated physics-based model to tailor root systems that perform well under draught conditions (BG, TL).