Integrative approach for managing soil-borne diseases

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Soybean is a critical crop for global food systems, industrial applications, and biofuel production. However, its productivity is increasingly threatened by soil-borne pathogens such as *Phytophthora sojae* and *Fusarium virguliforme*. Traditional disease management strategies, including fungicide treatments, cultural practices, and host resistance genes (e.g., *Rps1k*), offer limited and often short-lived protection. My research explores integrative molecular and microbial approaches to develop more durable solutions for plant health.

In Project 1, we combined infection-responsive transcriptomics with transcription factor (TF) binding to build a gene regulatory network. This analysis uncovered extensive expression reprogramming and defense–growth tradeoffs governed by ERF and WRKY TFs. As the next steps, we are refining candidate nodes using multi-omic integration and machine learning prioritization, followed by functional validation.

As the second project, we interrogated root-associated microbial communities under pathogen pressure and observed a shift from nitrogen-fixing *Bradyrhizobium* toward pathogen-suppressive *Bacillus* and *Pseudomonas*. We have isolated and characterized these strains as biocontrol agents and are assembling synthetic consortia that have the potential to suppress disease.

By combining host-directed immune rewiring with microbiome engineering, we aim to deliver resilient soybean systems and reduce chemical inputs. This collaborative, multi-institutional effort advances both engineered germplasm and deployable microbial consortia to counter soil-borne disease and safeguard soybean productivity.