

Summer Education: Nano- and Biological Approaches to Protect Plants against Drought Stress

Summer Research Theme

An 8-week summer research experience for undergraduates was developed at Utah State University to train participants in nanotechnology and microbiome engineering approaches that the participants applied to improve plant resilience to stress and enhance food production.

Demographics and Aims

Nine participants from two-year colleges serving predominantly Native American and Hispanic populations were recruited with the aim of providing these students the confidence, skills, and passion for life-long learning to complete a four-year STEM degree and beyond.

Guided Labs → Open Projects

Five weeks of guided research modules were followed by student-designed projects conducted as small groups. Students synthesized and characterized nanoparticles, assessed NP toxicity, measured mechanical properties of plants, isolated endophytic bacteria from wheat seed, used 3D printing to construct soilless growth matrices, and assessed the plant-protective properties imparted by NPs and bacteria.

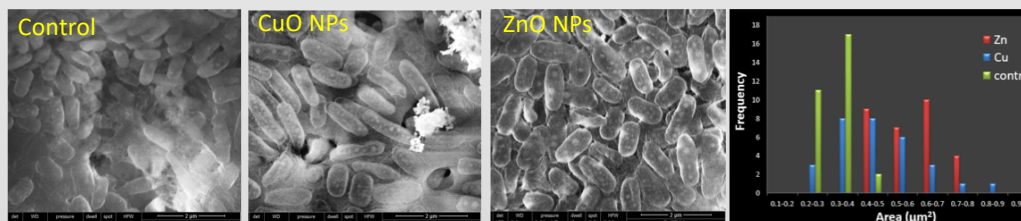
Retention and Tracking

One participant dropped out of the program at six weeks, as the program transitioned into student-designed projects. Of the eight participants who completed the summer program, 6 are currently enrolled in their two-year colleges, and two have enrolled in 4-year Engineering programs in Mechanical & Aerospace, and Biological Engineering.

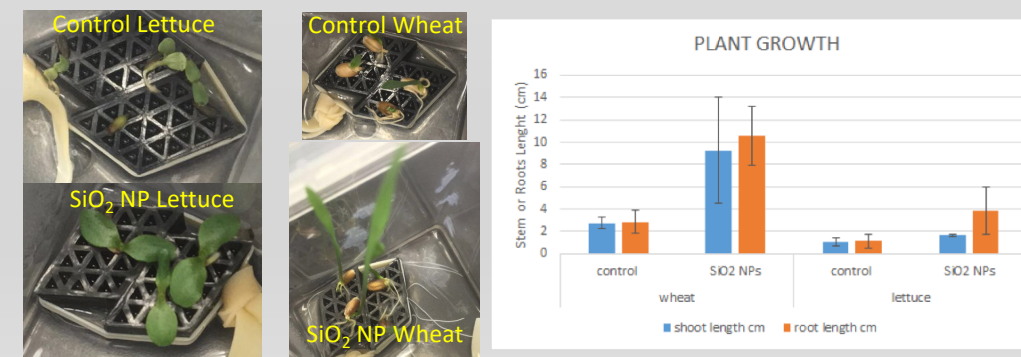
| Weeks 1 – 5: Peer Mentor and Facilitator Guided Laboratory Modules | M | T | W | Th | F |
|--|-------|-------|----|-------|----|
| "Meet&greet": (~45 min) proposed research for the day, discussion of data collection and analyses, and/or watch student-selected TED Talk | am | am | am | am | am |
| Lab time: (~2-3 h) | am/pm | am/pm | am | am | am |
| Student-led discussions: based on student-selected educational videos pertinent to plant growth, bacteria, nanotechnology, space, or other interests | | | pm | | |
| Data processing: collection, analysis, and result presentation workup | | | | am/pm | |
| "Wrap-up-day": one student group presents research of that week (background for the topic, relevance to previous findings, application) | | | | | am |
| USU Center / Industry visits: (to be discussed on Monday am) | | | | | pm |

Weeks 6 – 8: Student-Directed Research & Design – 3 Team Projects

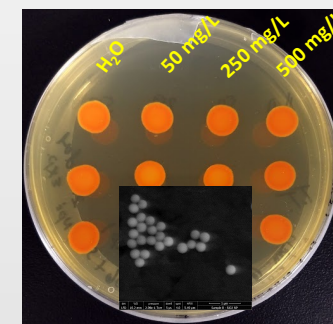
Team 1. Investigated the impact of commercial CuO and ZnO nanoparticles (300 mg/mL) on *Pseudomonas chlororaphis* O6 (PcO6), a plant symbiont



Team 2. Investigated influence of SiO₂ NPs on lettuce and wheat using 3D-printed scaffolds as soilless growth platforms



Team 3. Synthesized SiO₂ NPs and assessed toxicity on PcO6



Outcomes

Participants gained a broad overview of nanotechnology and microbiome engineering as sustainable approaches for advancing plant productivity and agriculture under abiotic stress. Three participants presented their research as posters at SACNAS 2017. The program broadened participant views on engineering to encompass biology and nanotechnology. Participants identifying with non-STEM fields did not indicate a desire to enter a STEM major following the program

| Participant Identified field of Study / Area of Interest | Week-1 | Week-8 |
|--|--------|--------|
| Social Work | 4 | 4 |
| Mechanical Engineering | 4 | 2 |
| Biological / Biomedical Eng. | 0 | 2 |
| Electrical Engineering | 1 | 1 |

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