Promotive Effects of *Paraburkholderia aspalathi* Rhizobacteria on Drought Stress Tolerance and Post-Drought Recovery

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Improving drought stress tolerance and post-drought recovery in cool season turfgrass is an important objective for reducing water use, while maintaining turf quality

Drought Stress

- Reduced turf quality
- Chlorosis, yellowing
- Reduced growth and tillering
- Decline in canopy density
- Ethylene increases

https://www.usga.org/content/usga/home-page/course-care/water-resource-center/bmp-case-studies/2017/transitioning-from-poa-annua-to-creeping-bentgrass-putting-green.html

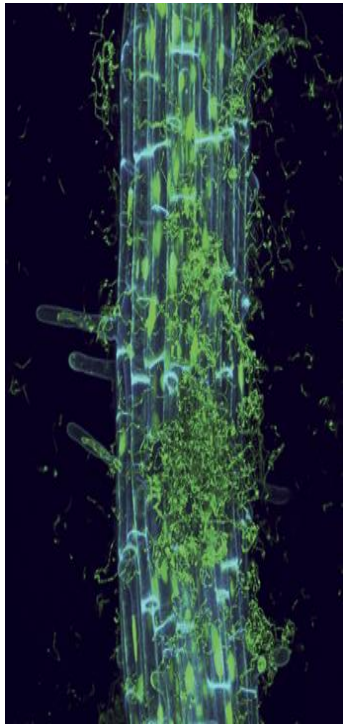
Recovery

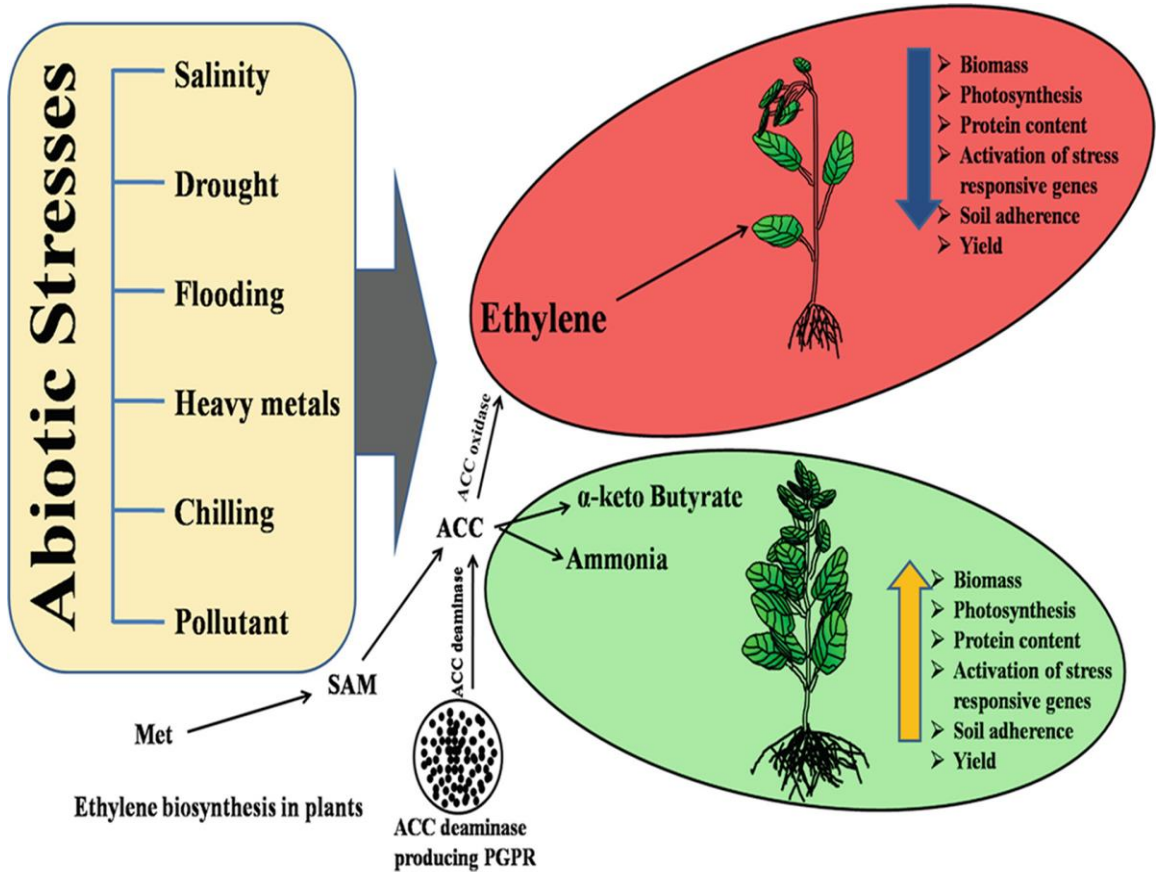
- Turf quality increases
- Ethylene levels are reduced
- Root viability for water and nutrient uptake
- Formation of new tillers
- Increased canopy density

https://www.usga.org/content/usga/home-page/course-care/regional-updates/central-region/2017/how-much-water-is-needed-to-flush-a-usga-putting-green-.html

Suppressing Ethylene Production by ACC Deaminase Producing Bacteria may Improve Drought Tolerance

- 1-Aminocyclopropane-1-carboxylic acid **(ACC) – precursor of ethylene**.
- Plant Growth Promoting Rhizobacteria (PGPR) **with ACC Deaminase (ACCd)** enzyme break down ACC into ammonia and a-keto butyrate before ACC becomes ethylene.
- ACCd rhizobacteria utilize the nitrogen from ACC while plant roots benefit from the reduction in ethylene production.
- Reduced ACC → Reduced Ethylene → Reduced Stress Damage

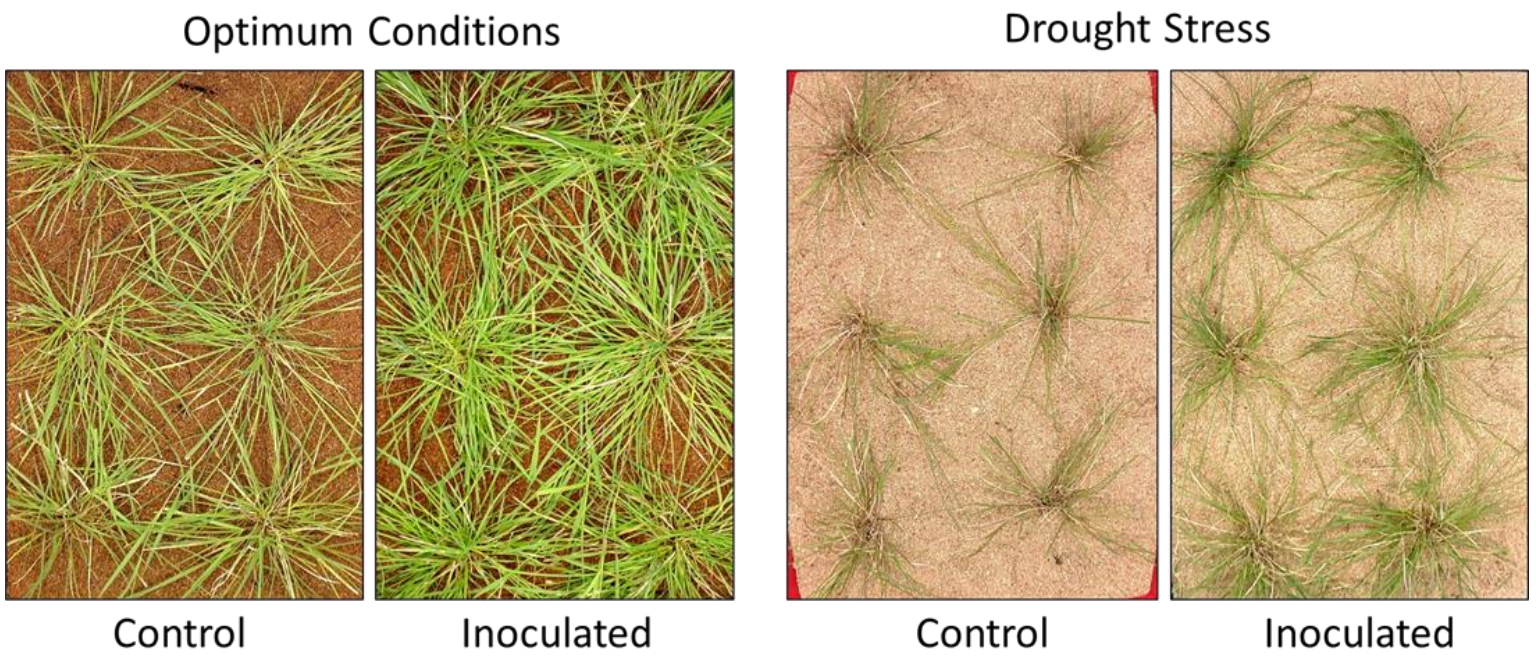


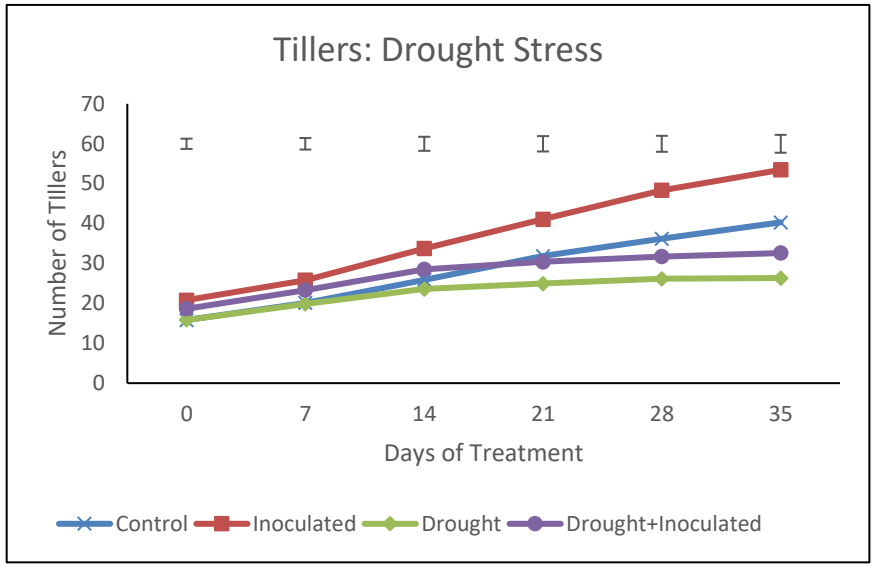


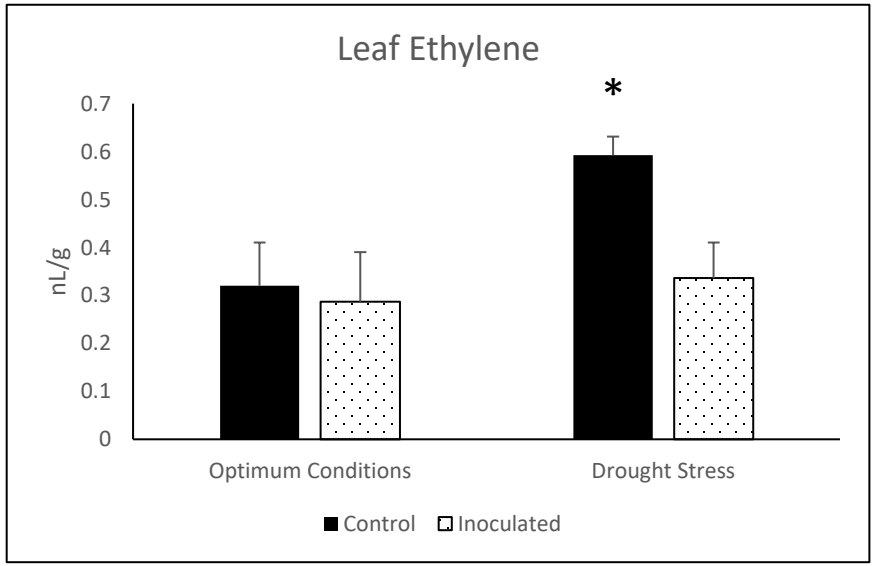
https://link.springer.com/chapter/10.1007/978-981-13-7553-8_14

ACCd bacteria *Paraburkholderia aspalathi* enhanced tiller production by reducing ethylene concentrations during drought stress in creeping bentgrass

(Errickson and Huang, 2021 unpublished)







Success in controlled environment growth chambers can be challenging to replicate in field trials because variable environmental conditions and native soil organisms may influence the successful inoculation and effects of PGPR.

Research Questions

Can these novel strains of *P. aspalathi* improve drought tolerance and post-drought recovery of cool season turfgrass in field conditions?

What is the most effective method and concentration for field inoculations of cool season turfgrass?

Research Objectives

To evaluate physiological improvements in drought tolerance and post-drought recovery of cool season turfgrass inoculated with *P. aspalathi* in field conditions

To determine effective field inoculation methods and dosages for *P. aspalathi* in field conditions for cool season turfgrass

Project 1
Field Inoculation Methods
(2020, 2021)

Project 2
Field Dosage Optimization
(2022)

Project 1: Field Inoculation Methods (2020, 2021)

- Fairway creeping bentgrass cv. Penncross field plots (1m x 1.3m, 4 replicates) maintained at fairway height.
- *P. aspalathi* strains 'WSF23' and 'WSF14' were applied at a concentration of 1.0 x 10^7 CFUs in a 0.01% humic acid solution with a carrier volume of 2.0 gallons per 1,000 square feet.

Inoculation Treatments

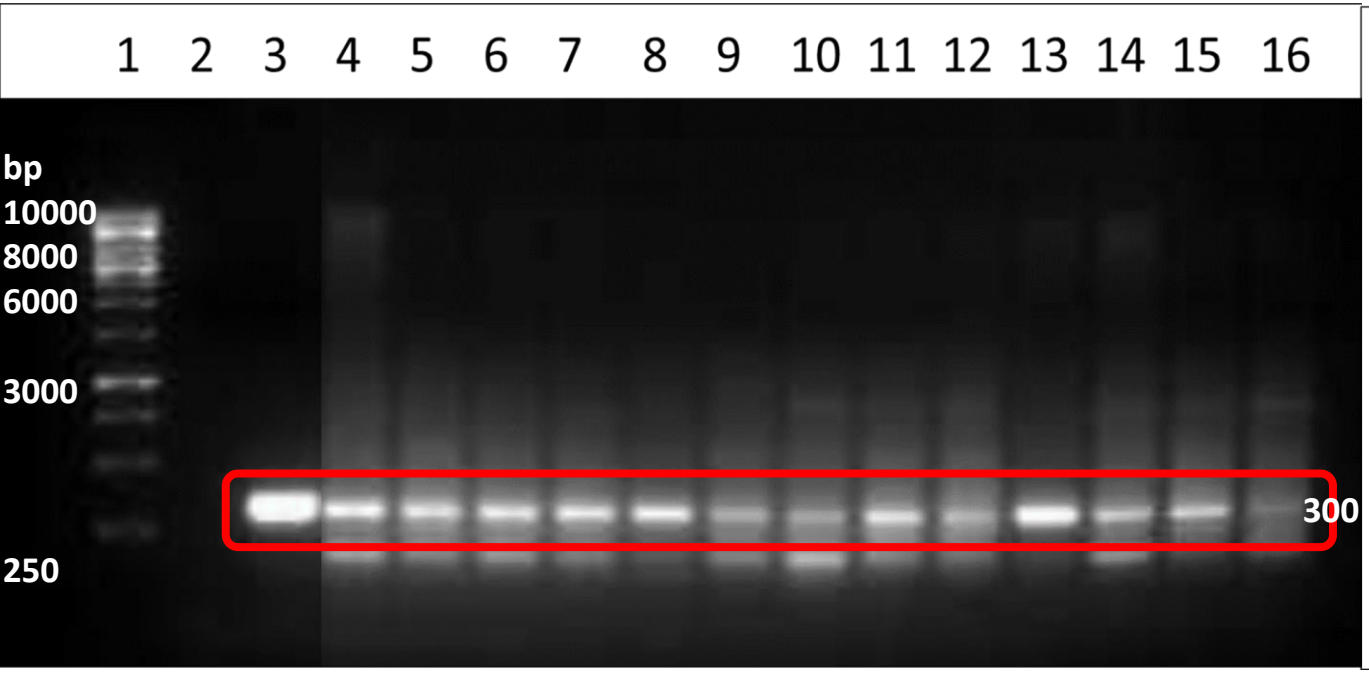
1. Non-inoculated control
2. Foliar spray
3. Soil drench

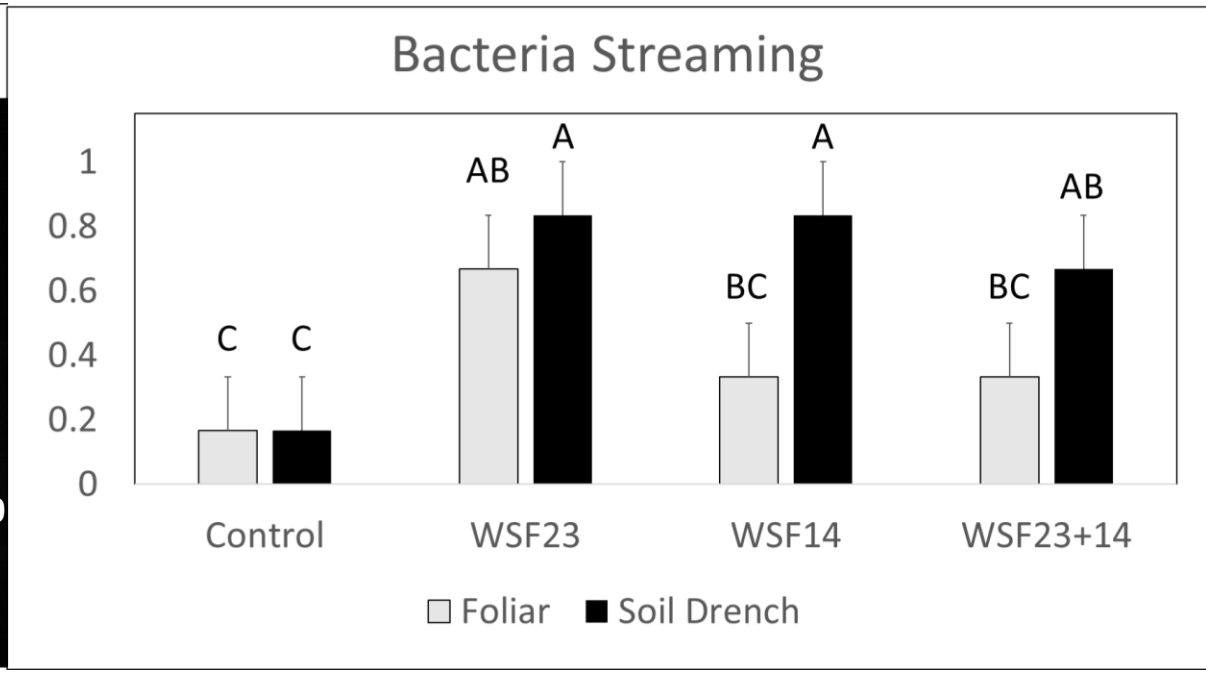
Irrigation Treatments

1. Well-Watered Control: Plants were irrigated (100% ET)
2. Drought Stress: Deficit Irrigation (60% ET) for 49 days (2020) and 28 days (2021)
3. Post-stress Recovery: Drought-stressed plants were re-watered for 28 days (2020) and 14 days (2021) (100% ET)

Weekly measurements of Turf Quality, NDVI, and Percent Green Cover

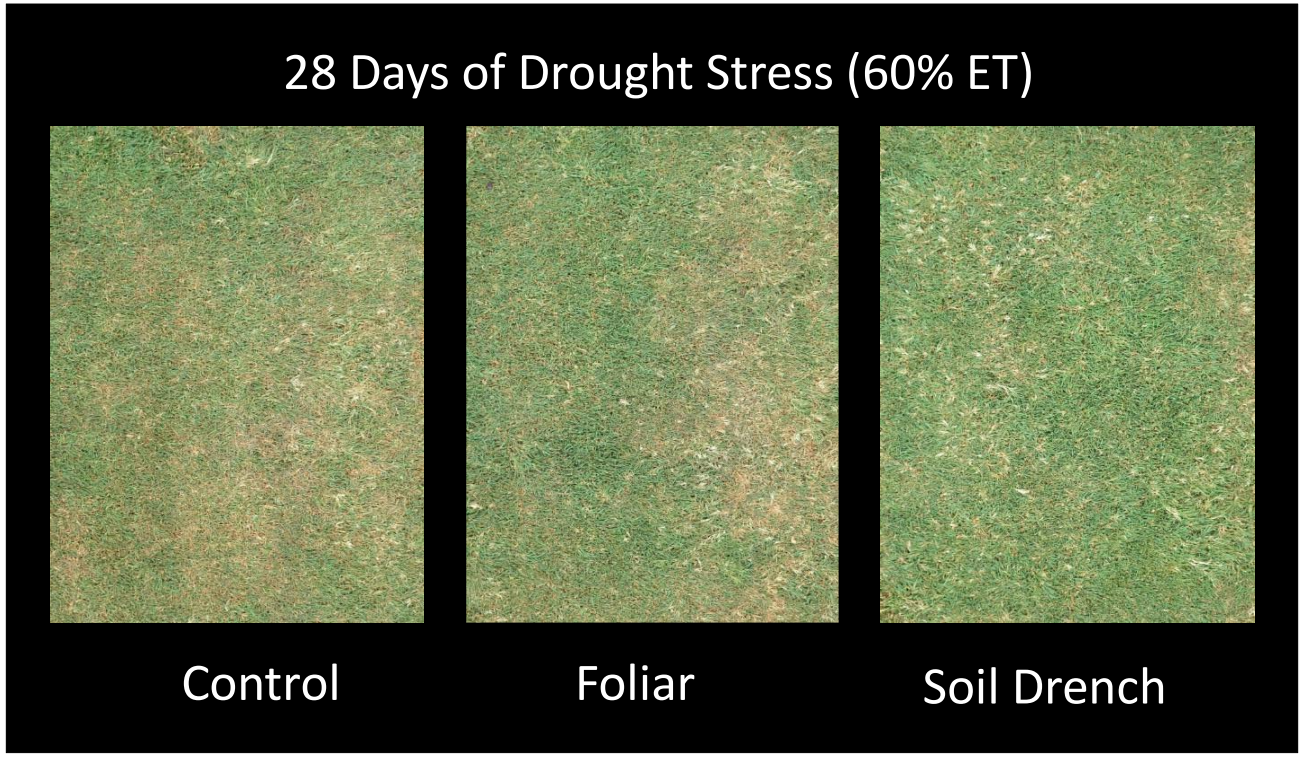
Inoculation was confirmed using PCR analysis and bacterial streaming observations

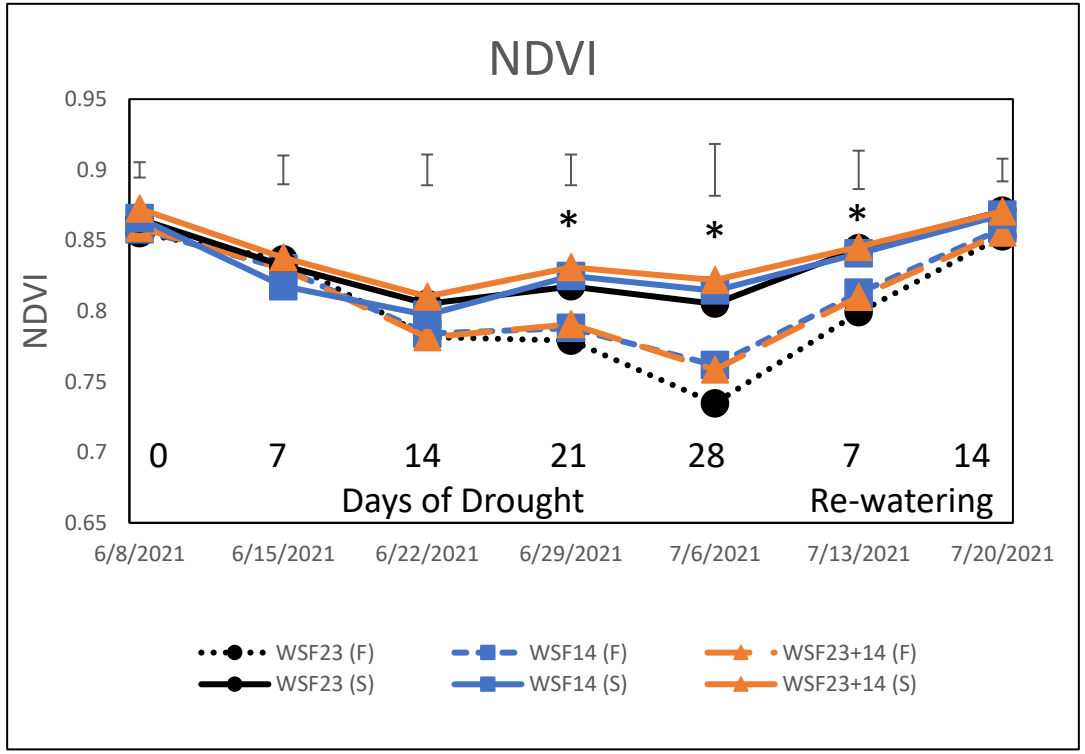




Turf inoculated using the soil drench method had higher levels of bacterial streaming

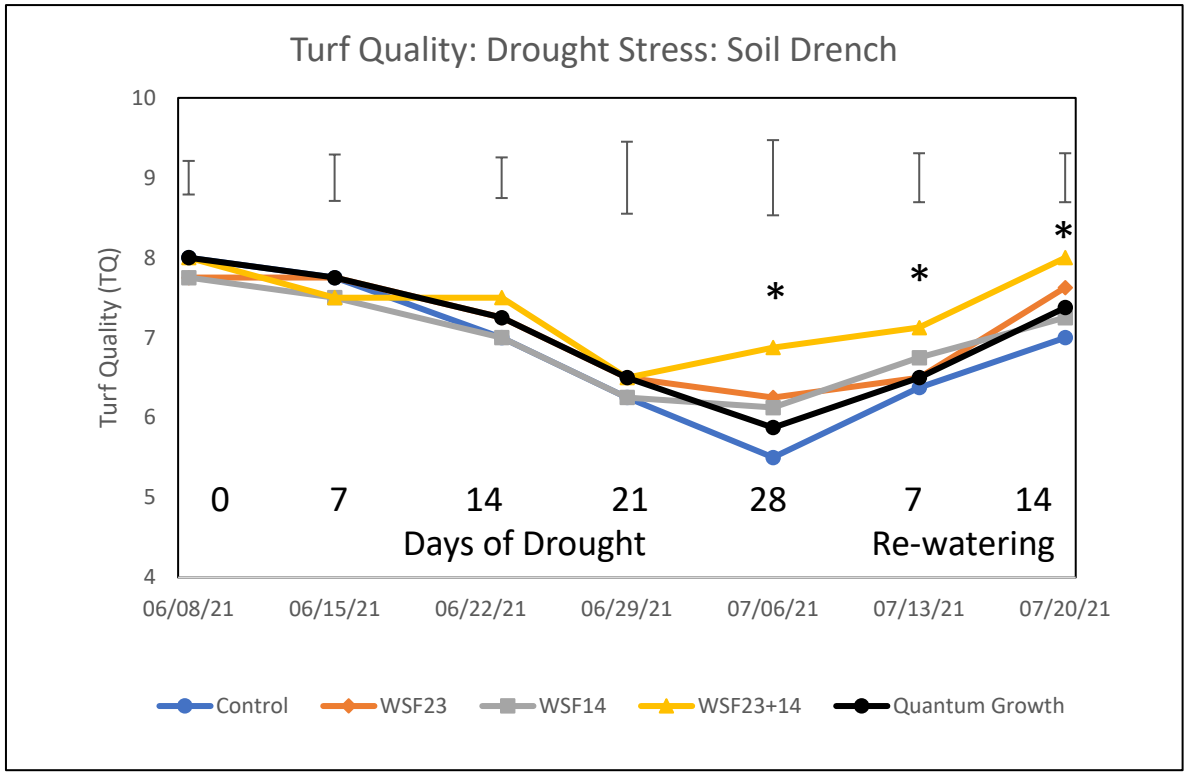
The soil drench inoculation method was more effective than foliar application for promoting drought tolerance and post-drought recovery

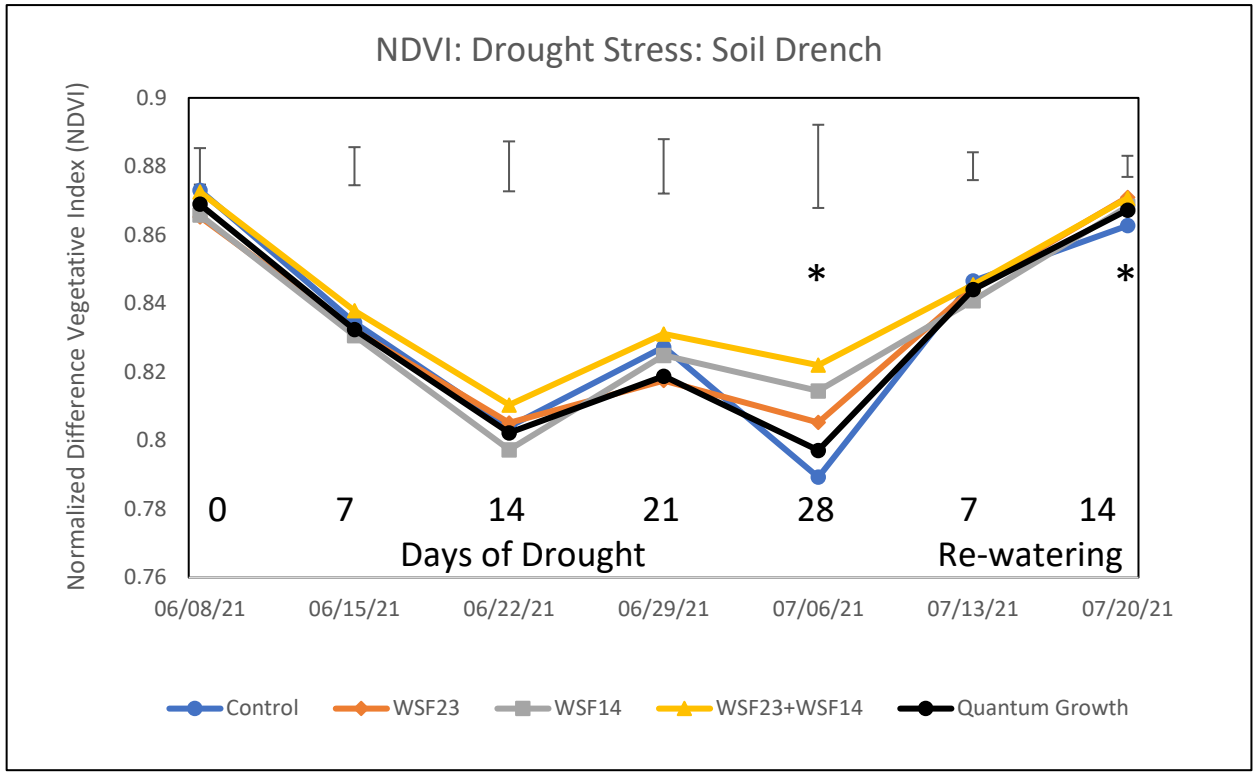




* Indicates significance at $p<0.05$

The combination of PGPR strains WSF23 and WSF14 was more effective than each strain individually for improving turf quality and NDVI during drought stress and post drought recovery





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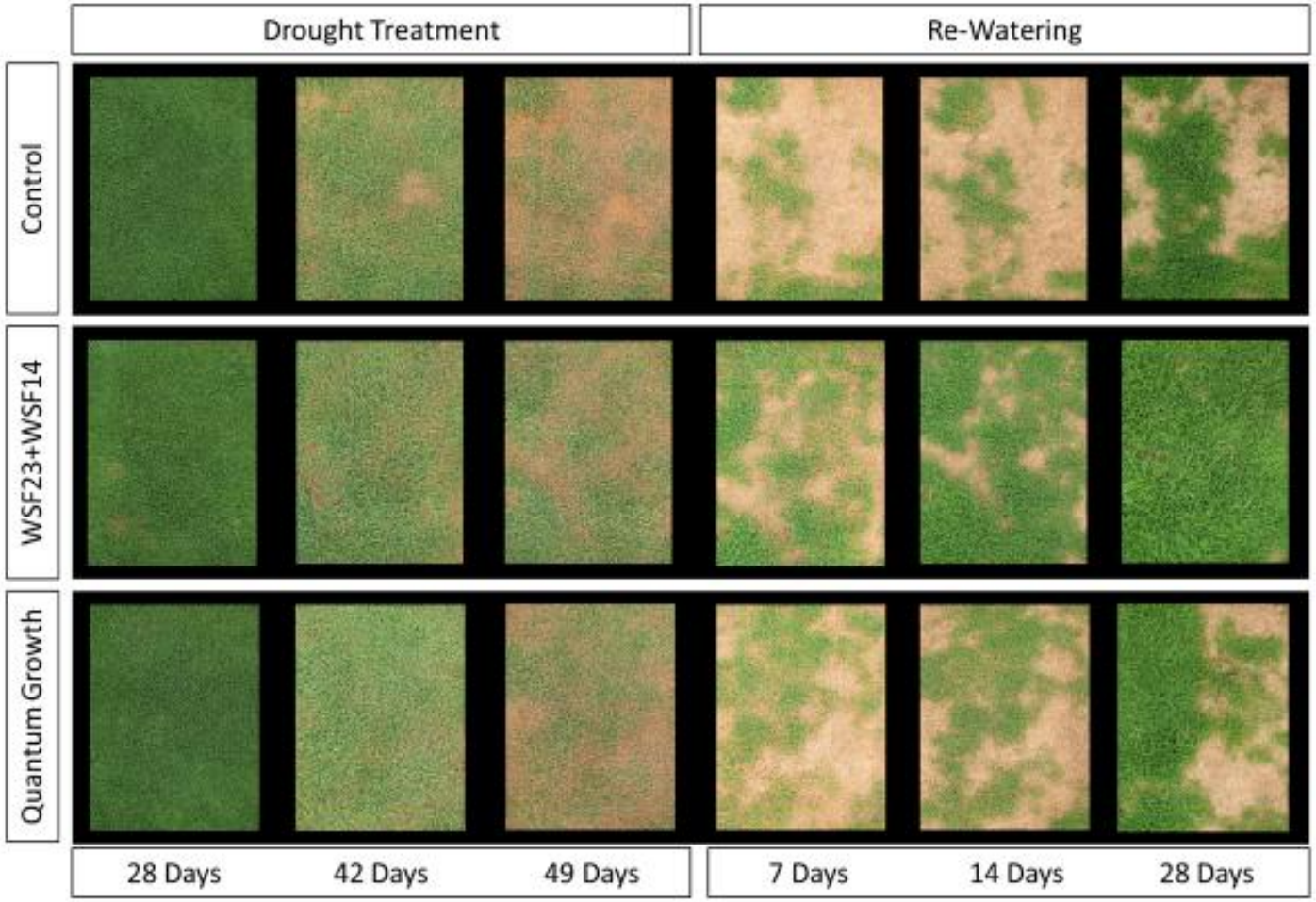
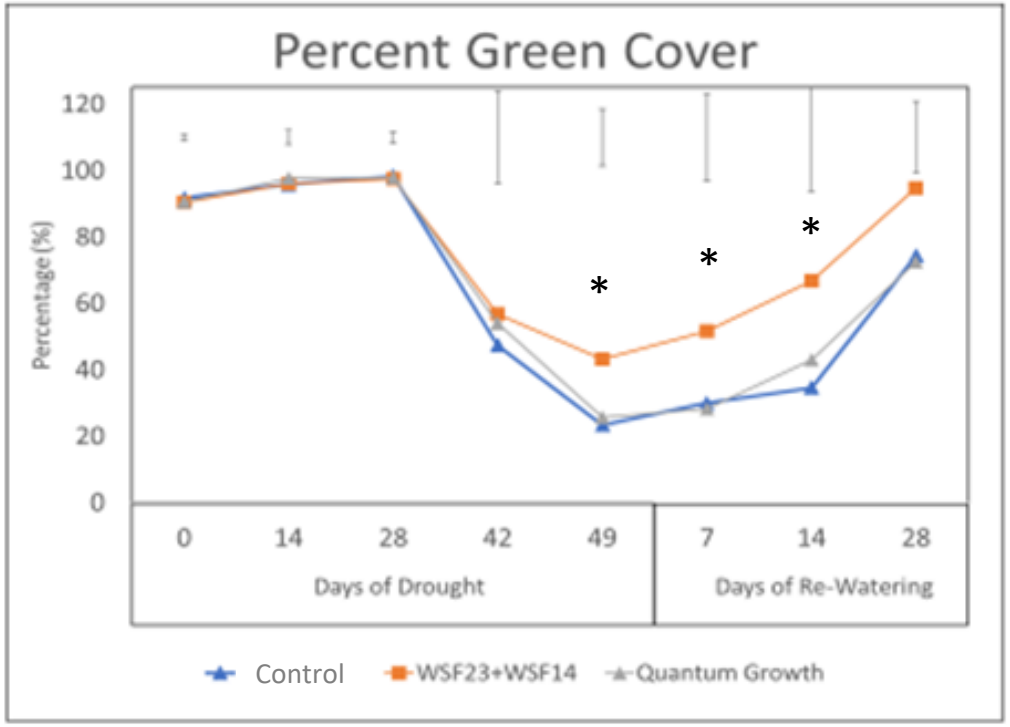
Canopy density was highest in turf inoculated with a combination of WSF23 and WSF14 using the soil drench method





* Indicates significance at $p<0.05$

Project 2: Field Dosage Optimization (2022)

- Fairway creeping bentgrass cv. Penncross field plots (1m x 1.3m, 4 replicates) maintained at fairway height.
- *P. aspalathi* strains ‘WSF23’ and ‘WSF14’ were applied at varying rates using the soil drench method.

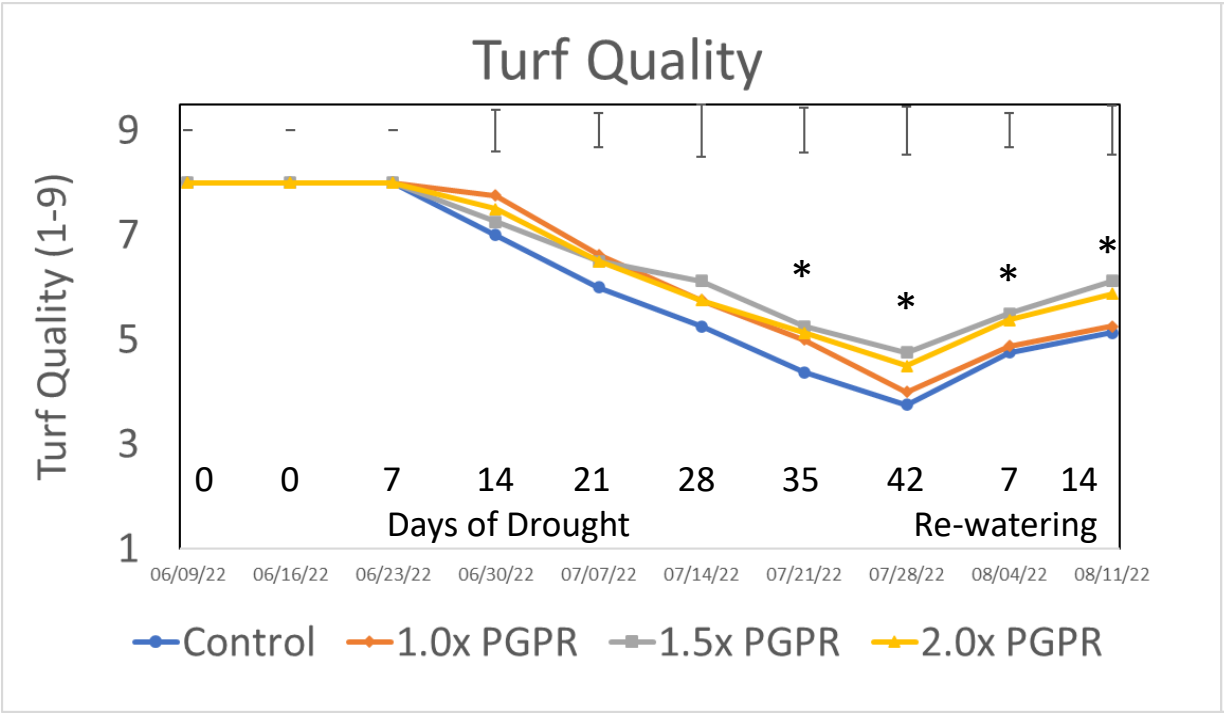
Inoculation Treatments

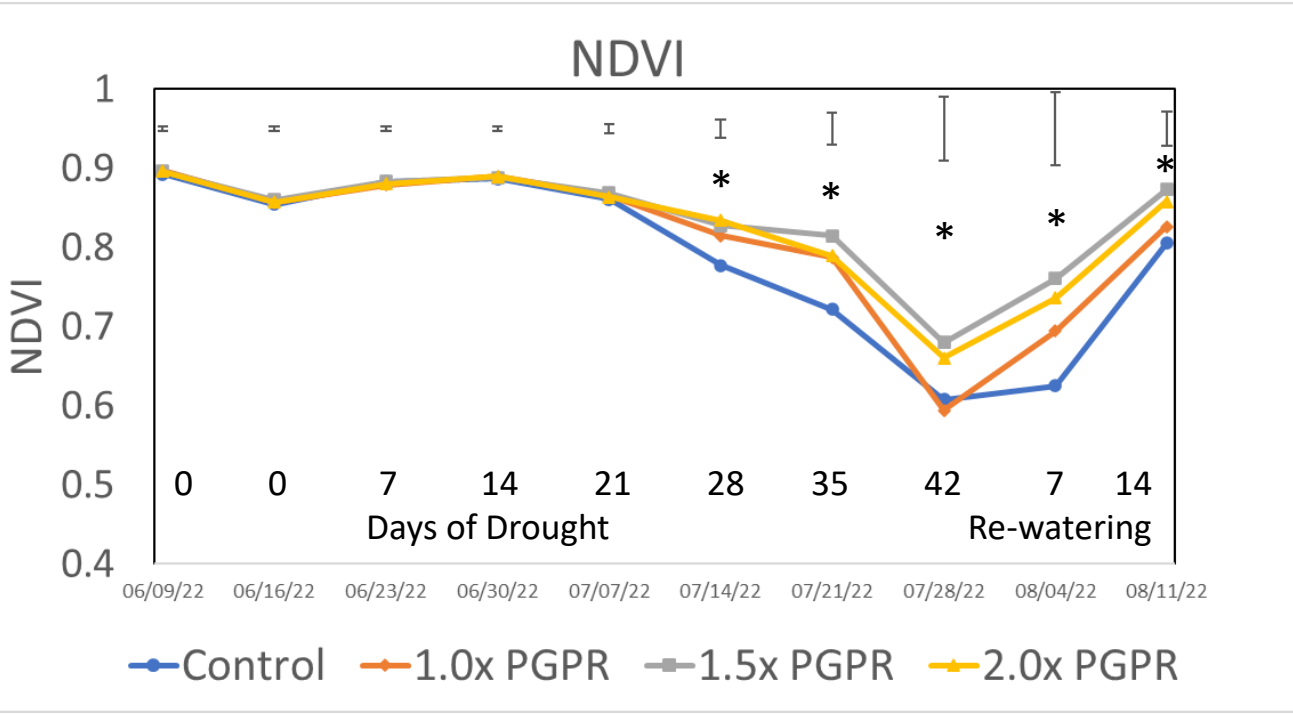
1. Non-inoculated control
2. 1.0×10^7 CFUs
3. 1.5×10^7 CFUs
4. 2.0×10^7 CFUs

Irrigation Treatments

1. Drought Stress: Deficit Irrigation (60% ET) for 35 days
2. Post-stress Recovery: Drought-stressed plants were re-watered for 14 days (100% ET)

Inoculation with the 1.5x PGPR concentration had the greatest improvement on Turf Quality and NDVI





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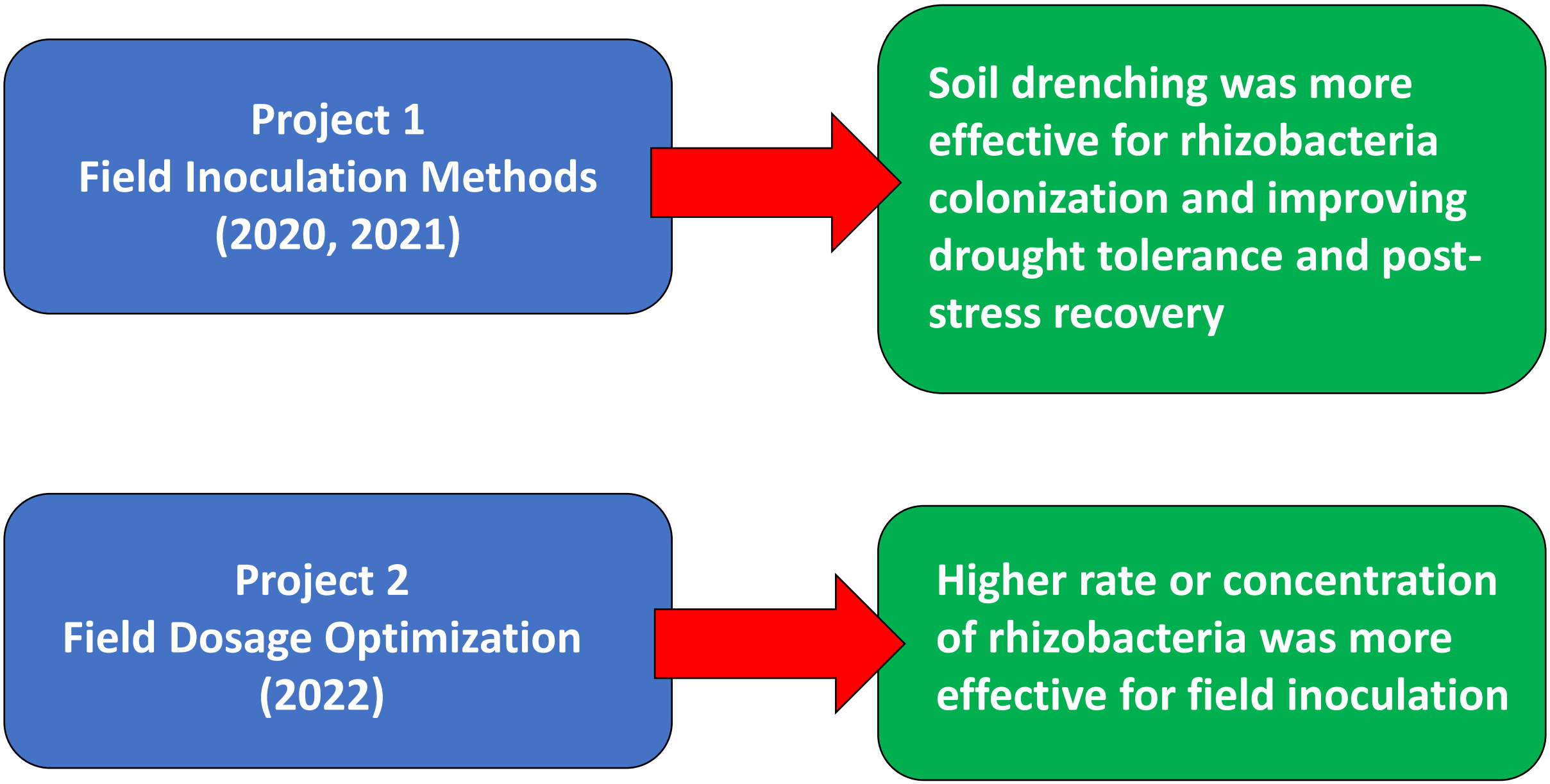
Project 1
Field Inoculation Methods
(2020, 2021)
Soil drenching was more effective for rhizobacteria colonization and improving drought tolerance and post-stress recovery
Project 2
Field Dosage Optimization
(2022)
Higher rate or concentration of rhizobacteria was more effective for field inoculation

Inoculation with a combination of two novel strains of PGPR (*P. aspalathi* ‘WSF23’ and ‘WSF14’) using the soil drench method was effective at improving drought tolerance and post-drought recovery of cool season turfgrass under field conditions

- Fairway creeping bentgrass demonstrated increased turf quality, NDVI, and canopy density with inoculation
- Increased plant density and lateral spread due to stimulated tiller production
- Related to suppression of stress-induced ethylene

Significance and Future Work

- *P. aspalathi* ‘WSF23’ and ‘WSF14’ have potential as commercial inoculants for turfgrass managers to reduce water use.
- Future work will investigate the metabolic and physiological mechanisms of how rhizobacteria *P. aspalathi* ‘WSF23’ and ‘WSF14’ improve drought tolerance and the interaction of ethylene suppression with other hormones controlling tiller production.

Thank You

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- USDA SARE

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