The Friendliest *Bradyrhizobia* - The Spectrum of Partner Quality Amongst Soybean's Symbiont

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micro-ccs
Microbial Interactions Create Research Opportunities for Community College Students

UNIVERSITY OF ILLINOIS URBANA-CHAMPAIGN

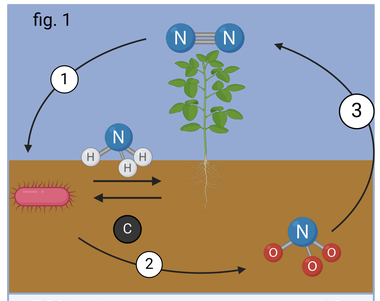
Illinois: The #1 Soybean Producer

The market of this crop continues to grow; including agronomic applications, tyre compounds, biofuels, and wellness products (Agromeris, 2021).

Life Needs Bioavailable Nitrogen

Nitrogen circulates the ecosystem in many forms (fig. 1) (Nature, 2024)

1. Nitrogen Fixing bacteria provide ammonia
2. Nitrifying bacteria provide nitrates and nitrites
3. Denitrifying bacteria re-supply the atmosphere with Nitrogen gas



78% of the atmosphere is N2. The soil microbiome converts nitrogen into forms that can sustain life.

Soybean (*Glycine spp.*) Employs a Symbiont

Nitrogen fixing bacteria in the *Bradyrhizobia* genus infect the cortical cells of the root, leading to nodulation; Brady fix nitrogen in exchange for plant-derived carbon source. (Kyei-Boahen et al. 2022; Cooper et al. 2019).

20 x 2 x 8

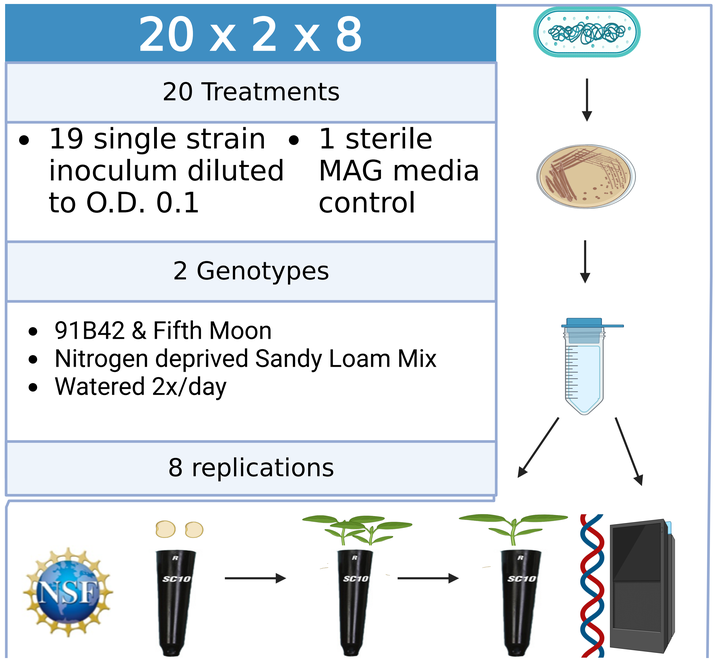
20 Treatments

- 19 single strain inoculum diluted to O.D. 0.1
- 1 sterile MAG media control

2 Genotypes

- 91B42 & Fifth Moon
- Nitrogen deprived Sandy Loam Mix
- Watered 2x/day

8 replications



Will Strains Differ in Partner Quality?

USDA 1
USDA 2
USDA 5
USDA 6
USDA 17
USDA 21
USDA 38
USDA 43
USDA 105
USDA 110
USDA 121
USDA 122
USDA 138
USDA 140
USDA 141
USDA 149
USDA 253
USDA 488
USDA 442
USDA 503

20 strains selected from the USDA *Rhizobia* gene bank based on variance in:

Age
- 1913-1999

Geography
- China,
- Australia
- North America

Genetic Diversity
- USDA 110 and 253 are recommended for soybean innoculation
- Many others are poorly studied

Single Molecule Real Time Sequencing (SMRT) will bridge this gap with De Novo assembly

What Genetic Patterns Exist Among High Quality Partners?

Soybean (*Glycine spp.*)

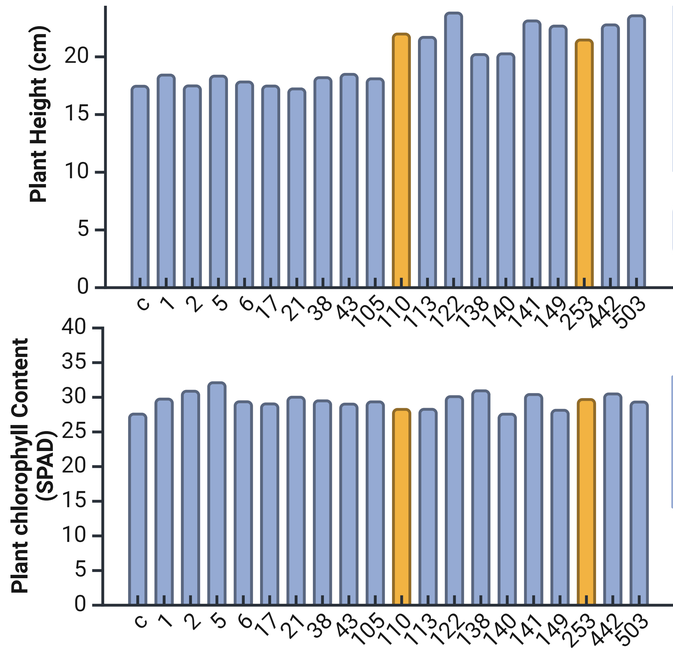
- Domesticated crops surpass their wild ancestors in: yield, lodging resistance, seed durability (Doebley et al. 2006)
- Intentional plant breeding may inadvertently select against traits that aide in beneficial microbial interactions (Porter and Sachs, 2020)

Wild → Domestication → Land Race → Breeding → Elite Cultivar

Fifth Moon
China; 1924

91B42
USA; 2023

- A land race and an elite cultivar were chosen
- After one week of growth, plants were inoculated with 1000µL of treatment
- Data on plant height and chlorophyll content was collected to assess partner quality of bacterial strain



Effect of Single Strain Treatment on Height

- c = control
- recommended

Effect of Single Strain Treatment on Chlorophyll

PARKLAND COLLEGE

ANOVA RESULTS

- $p < 0.01$ indicates **significant effect of genotype** on both **height and chlorophyll count**
- Based on p-value > 0.05, there is no evidence that the 20 treatment groups differ in partner quality

FUTURE IMPROVEMENTS

- Cross contamination reduction
- More complete data
  - **Sequencing** and assess nodule quality
- Introducing more strains to increase statistical power
- Liquid N. free nutrient solutions

CItations and Acknowledgments

- Agromeris LLC. (2021, July). The Global Soy Foods Market: An overview. https://ussec.orcontent/uploads/2021/11/USSEC-2021-Global-Soy-Foods-Market-Overview-.pdf
- Nature Publishing Group. (n.d.). Nature news. https www.nature.com/scitable/knowledge/library/the-nitrogen-cycle-processesplayers-and-human-15644632/
- Quelas, J. I., Mongiardini, E. J., Pérez-Giménez, J., Parisi, G., & Lodeiro, A. R. (2013, July). Analysis of two polyhydroxyalkanoate synthases in Bradyrhizobium japonicum USDA 110. Journal of bacteriology. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3697631
- Doebley JF, Gaut BS, Smith BD. 2006. The Molecula Genetics of Crop Domestication. Cell.127(7):1309–1321. https://doi:10.1016/j.cell.2006.12.006
- Rglein. (2019, December 7). Plant domestication. T Creative Spark by Agustn Fuentes. https:/ / sites.nd.edu/rachel-glein/2019/12/07/plant-domestication/

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