Development of Seed-Treating Biostilumants for Promoting Soybean Growth and Health

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Challenges in Crop Production

https://www.pioneer.com/us/agronomy/soybean_fertility.html

https://extension.sdstate.edu/late-season-soybean-diseases-know-whats-killing-your-soybeans

- Low soil fertility
- Biotic and abiotic stresses
- High cost of fertilizers and pesticides
- Resistance to pesticides

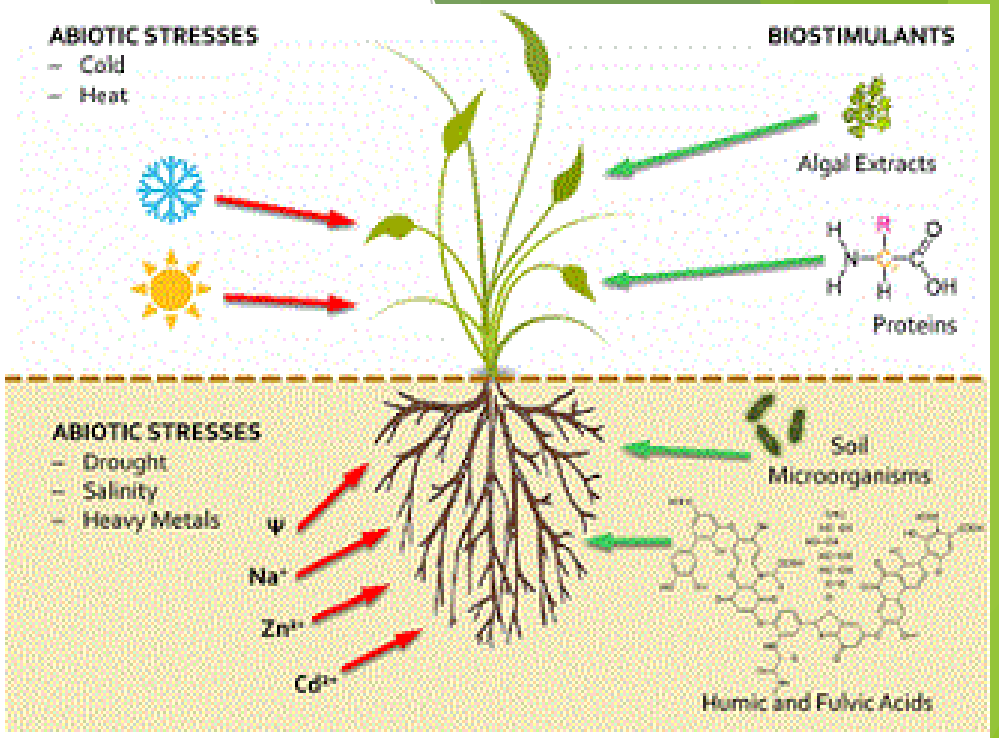
→ *It is imperative to develop innovative materials and methods for more sustainable production of crops*

Two Major Directions of This Study

I. Biostimulants

- (Definition) Any natural substances, microorganisms, or mixtures of them that enhance nutrition efficiency, growth, yield, quality, and/or tolerance to biotic and abiotic stresses.

- Contribute to sustainable and high-output/low-input crop productions



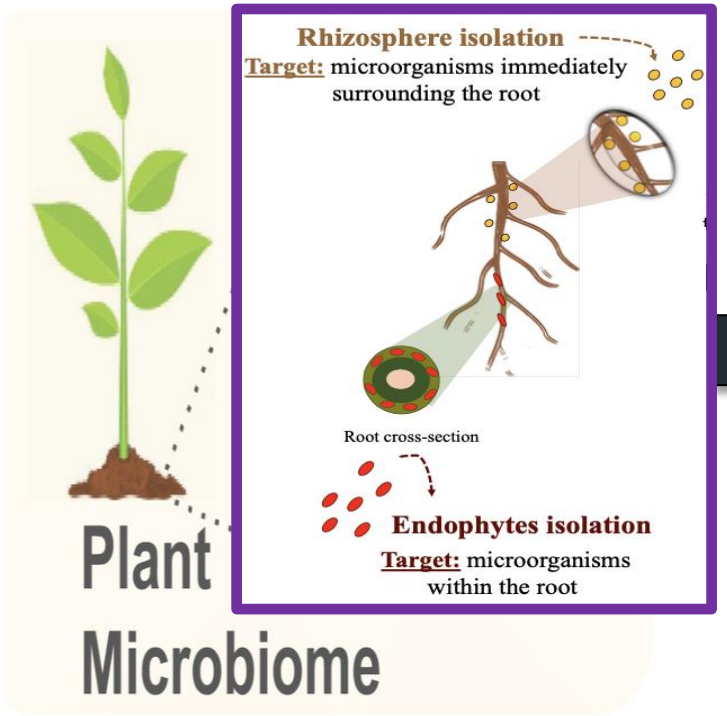
(*Image from 'Bio Based Press'*)

II. Seed Treatment

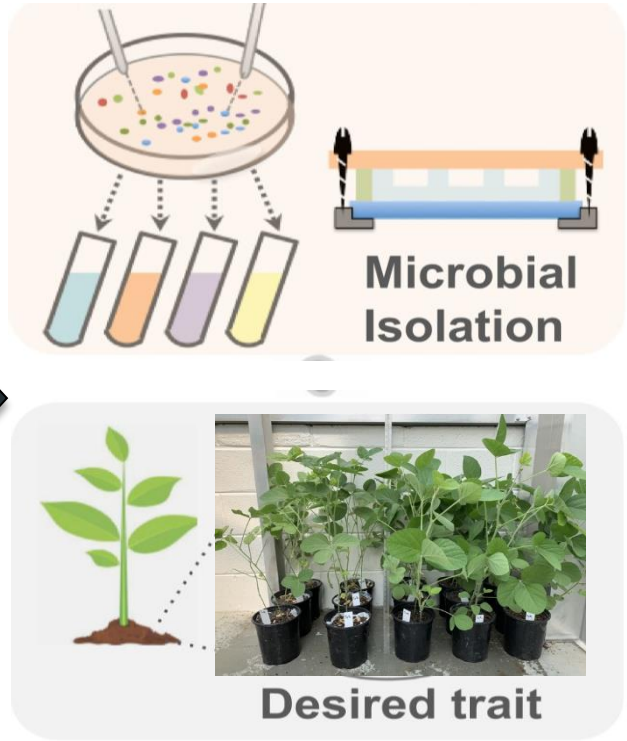
- More efficient and economical compared to other application methods, such as foliar spraying and soil drenching.

(*Image from 'CropLife'*)

Conceptual Workflow



- Isolation of 'soybean-associated beneficial bacteria (SABB) from conspicuously healthy or disease tolerant plants in soybean fields

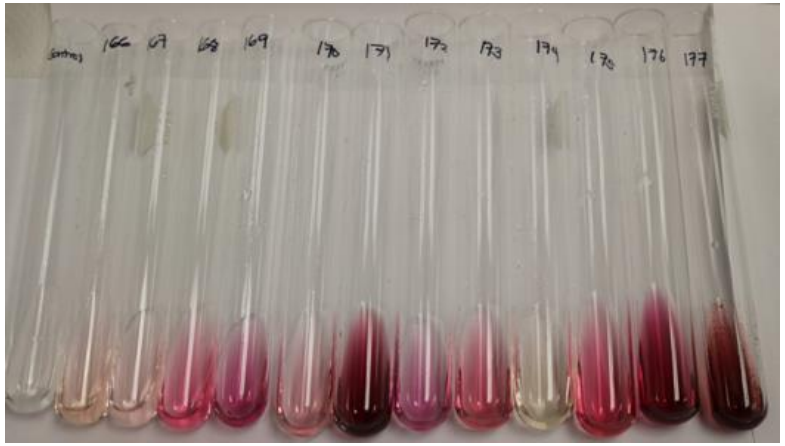


- Screening based on various beneficial activities
- Compatibility test and formulation of SABB consortia
- Test efficacy on soybean plants

- Characterization of biological mechanisms
- Development of formulation methods for seed or soil treatments

Beneficial Activities for Screening SABB

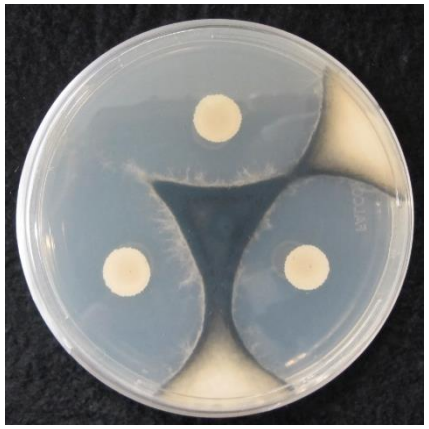
IAA production



Germination and seedling growth

Nitrogen fixation

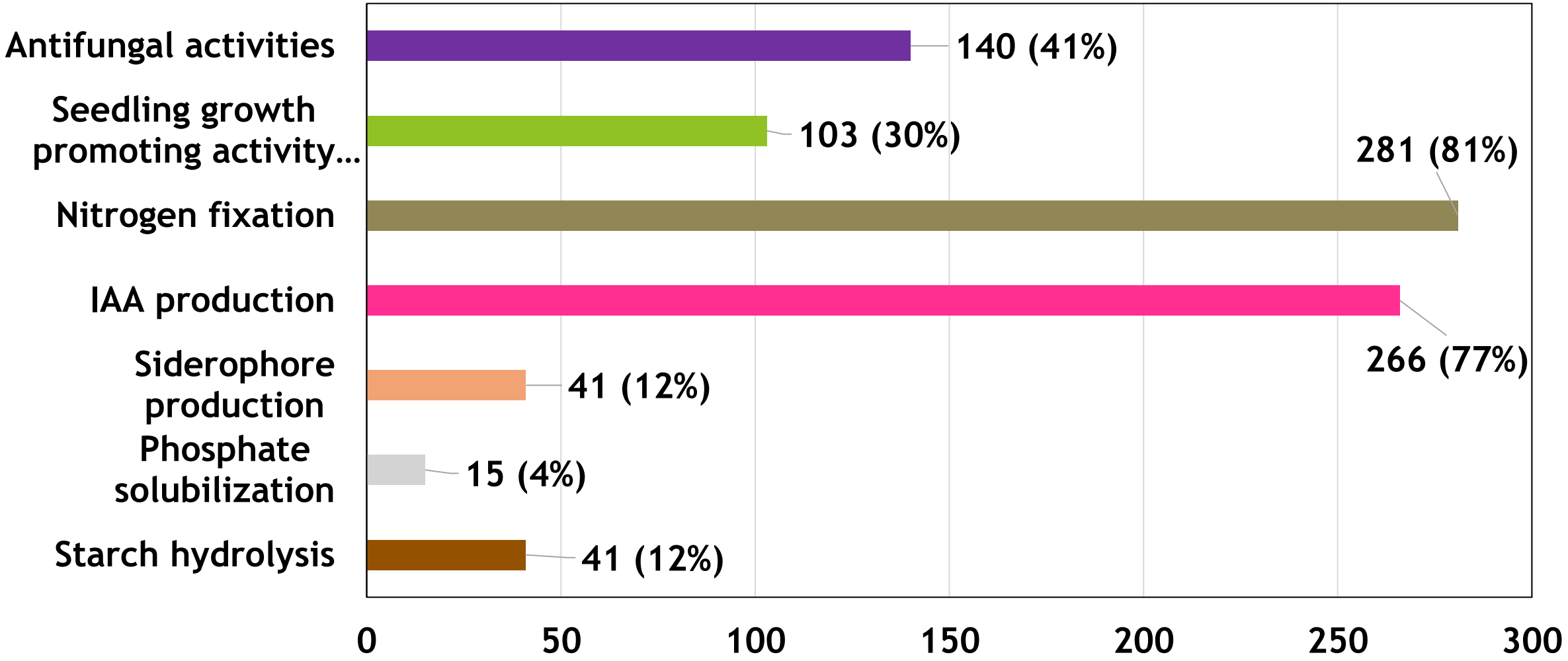
Antimicrobial activities



Siderophore production

Phosphate solubilization

Beneficial Activities of the Screened SABB



SABB Consortia and Their Subsets Tested

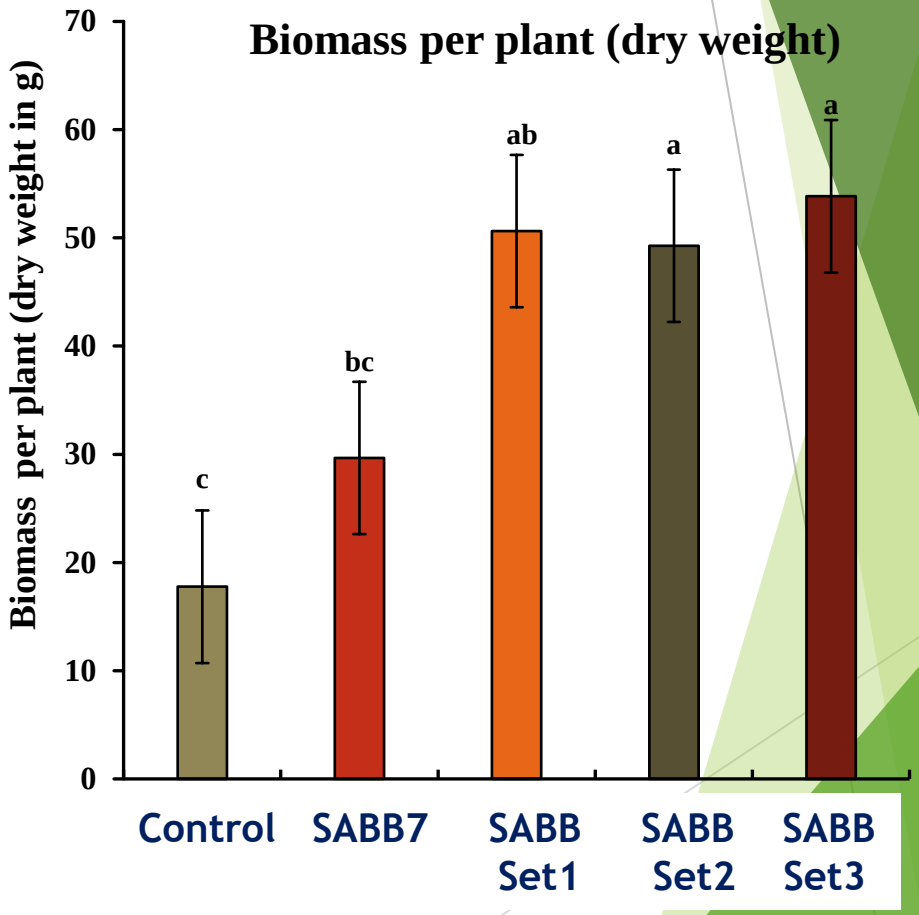
SABBset1 (9 members)
SABBset2 (14 members)
SABBset3 (23 members)

SABBmin1 (5 members)
SABBmin2 (7 members)
SABBmin3 (9 members)
SABBmin4 (10 members)

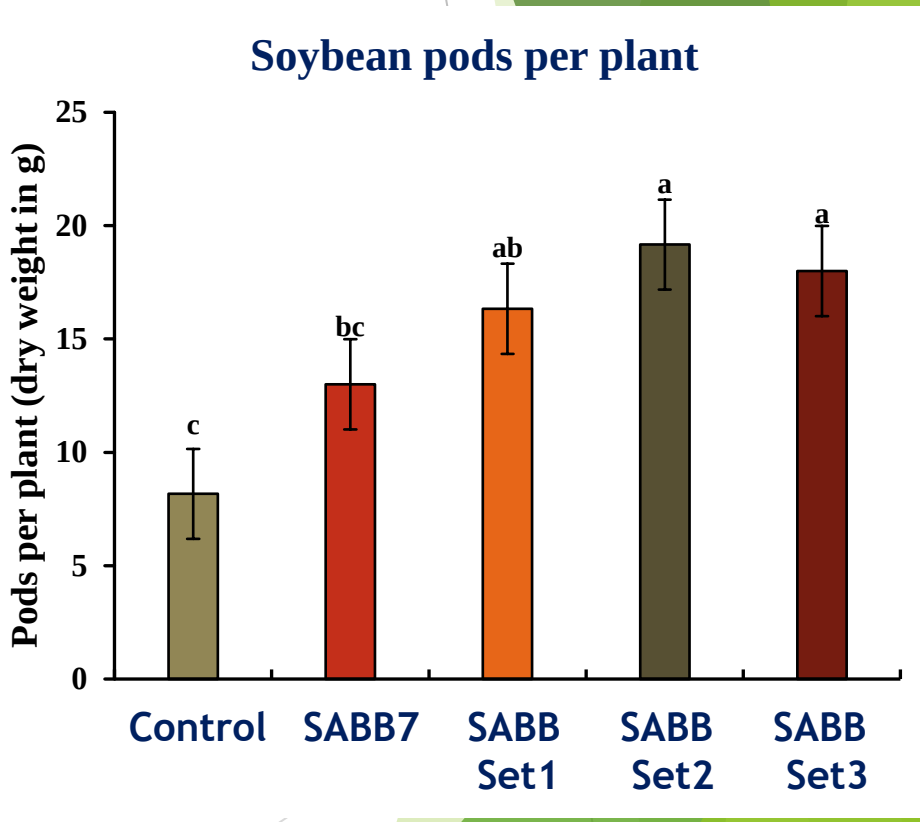
SABB consortia	Composition (members)	Antifungal activities	Growth promoting activity	Nitrogen fixation	IAA production	Siderophore production	Phosphate solubilization
Set1	9						
Set2	14						
Set3	23						
Setmin1	5						
Setmin2	7						
Setmin3	9						
Setmin4	10						

Greenhouse tests for treated soybean seeds (biomass)

Control SABB7 SABB Set1 SABB Set2 SABB Set3



Greenhouse tests for treated soybean seeds (pods)



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Seedling growth resulted from subsets of SABBs

Untreated Control | Apron Maxx | SABB Set1

Untreated Control | Apron Maxx | SABB Set2

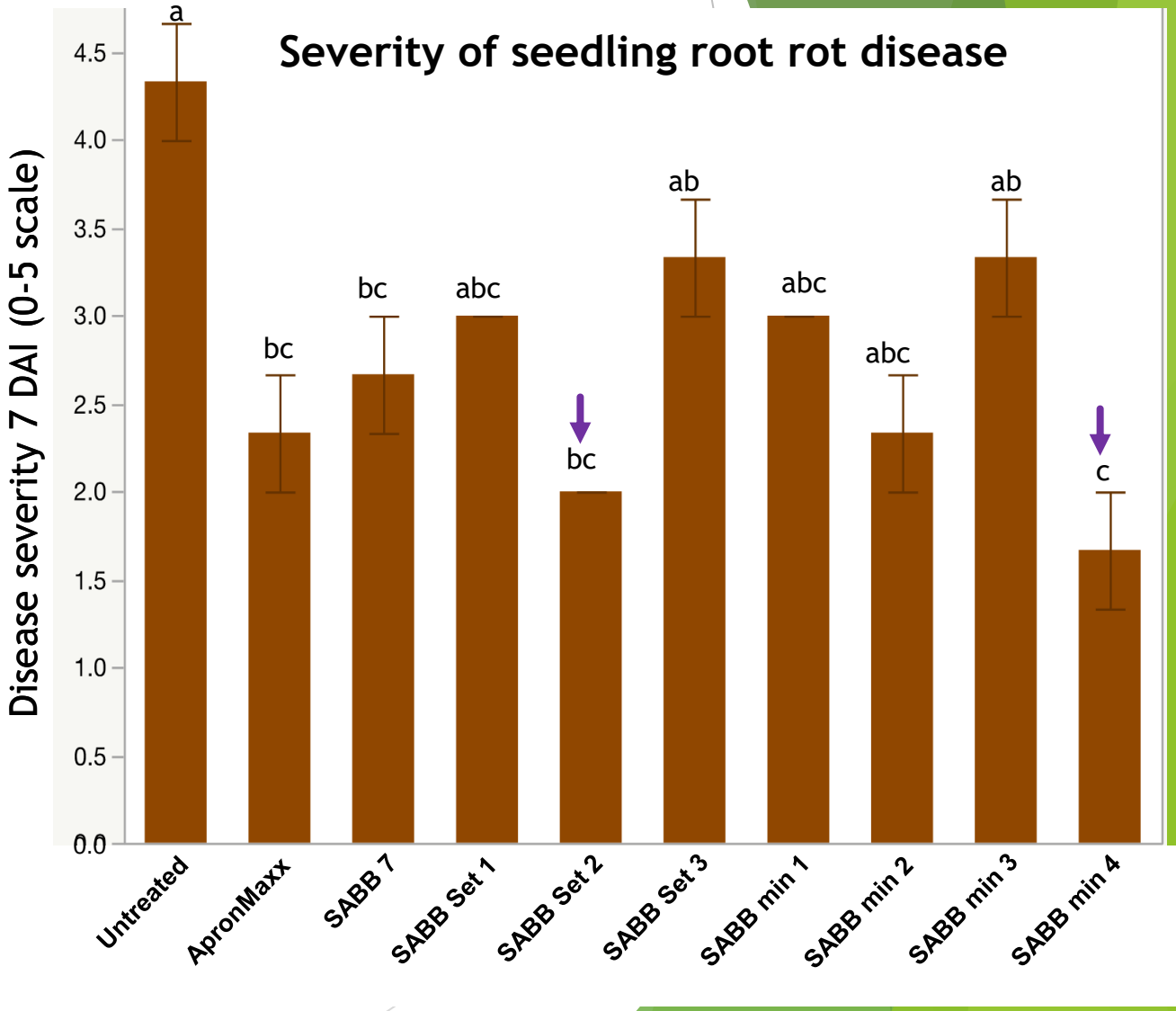
Untreated Control | Apron Maxx | SABB Set3

Untreated Control | Apron Maxx | SABB Min1

Untreated Control | Apron Maxx | SABB Min2

Untreated Control | Apron Maxx | SABB Min4

Effect of SABBs on Seedling root rot *(Rhizoctonia solani)*



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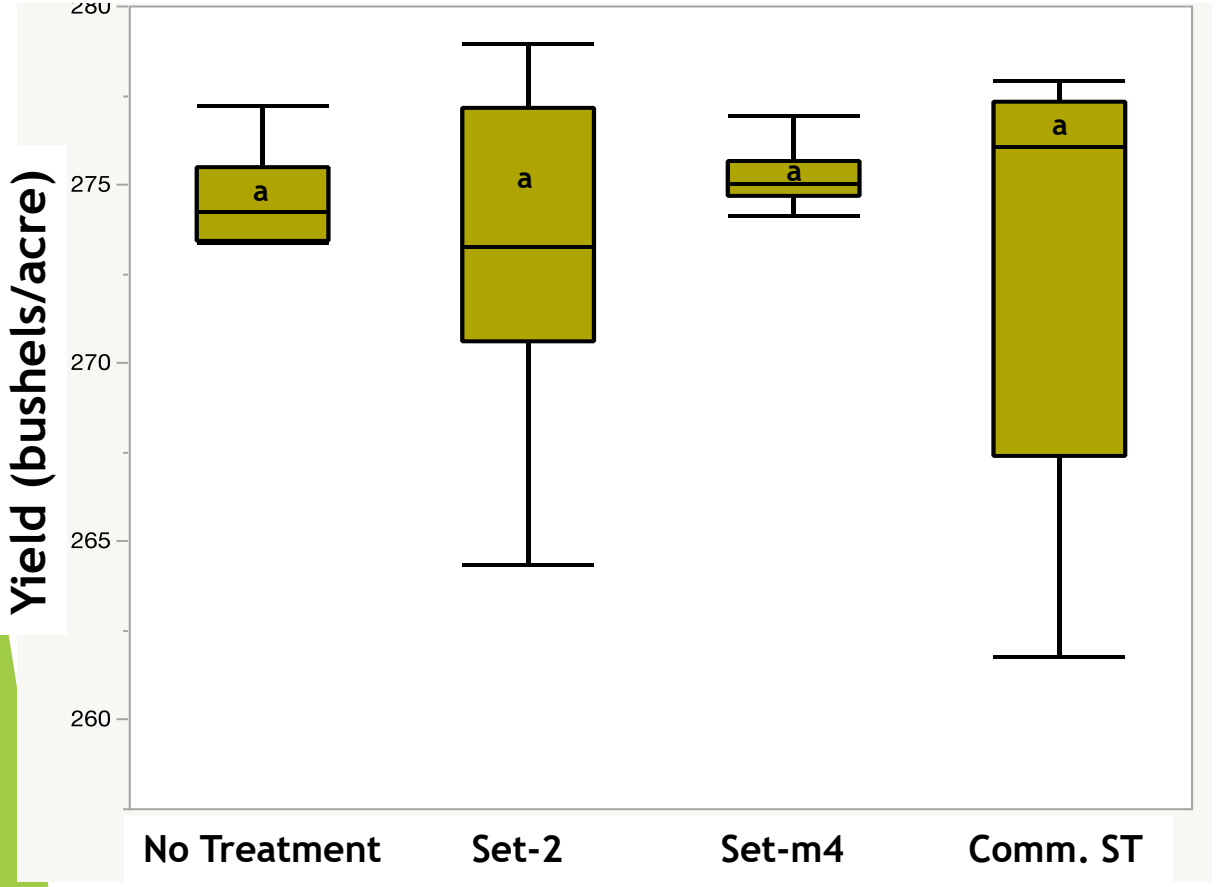
Field tests conducted at three research stations of LSU AgCenter

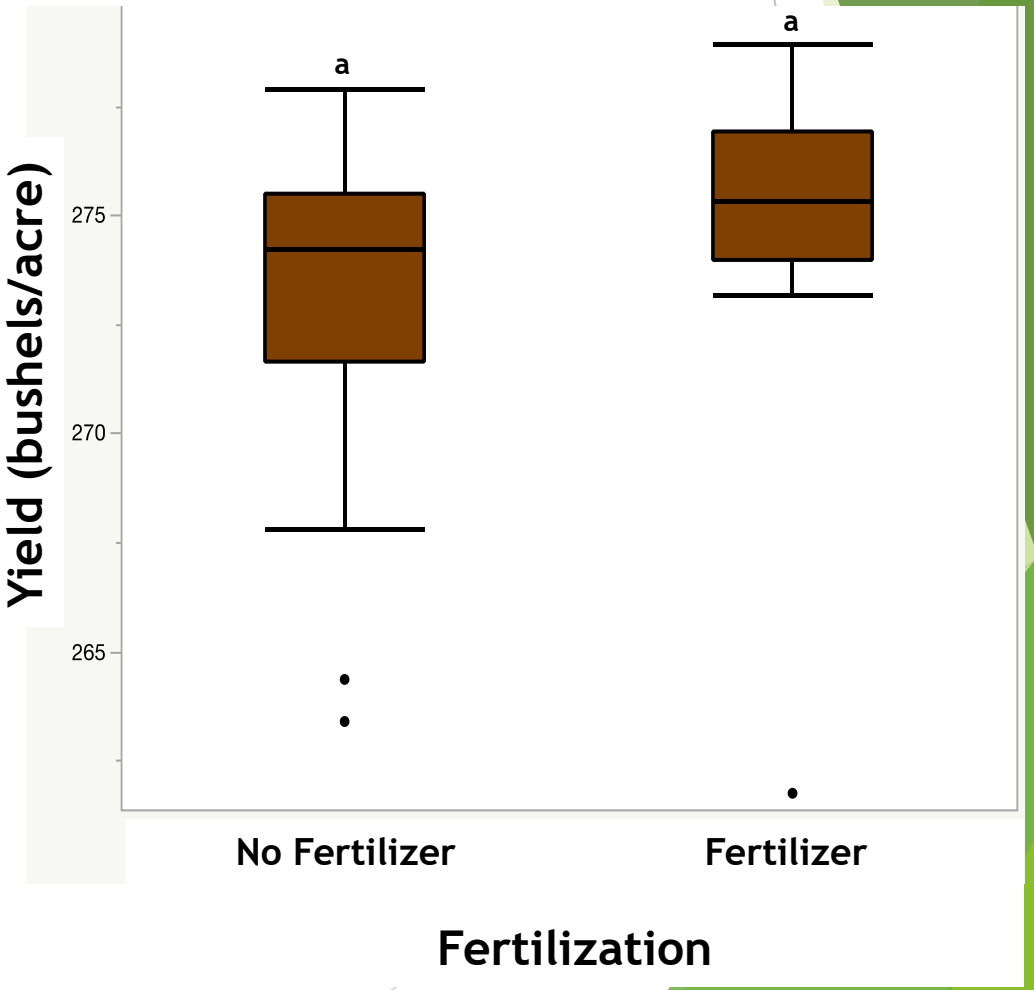
Doyle Chambers Central Research Station, Baton Rouge (July 1, 2021)

Dean Lee Research Station, Alexandria (July 21, 2021)

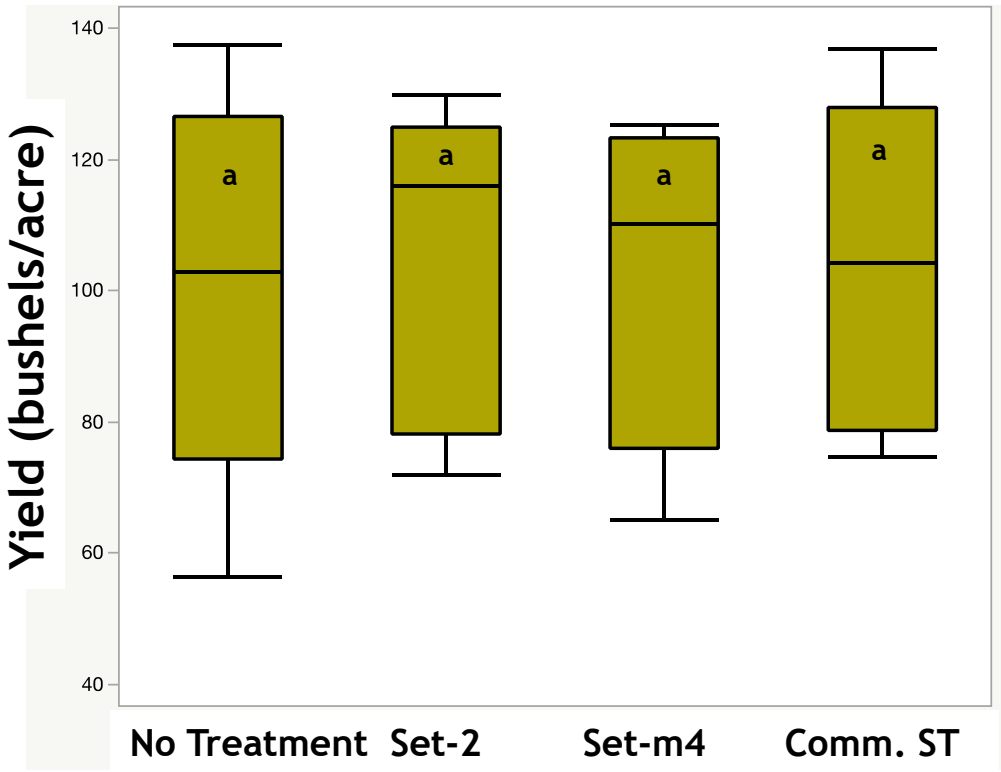
Red River Research Station, Bossier City (August 12, 2021)

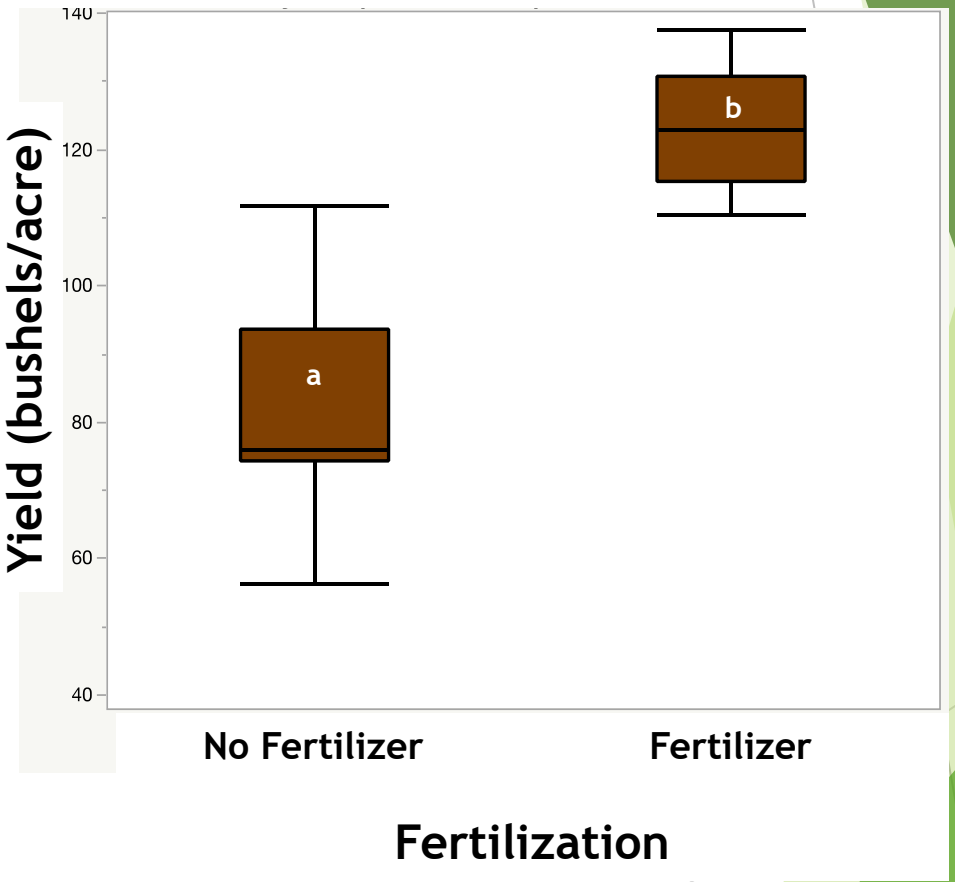
Doyle Chamber Research Station (Yield)



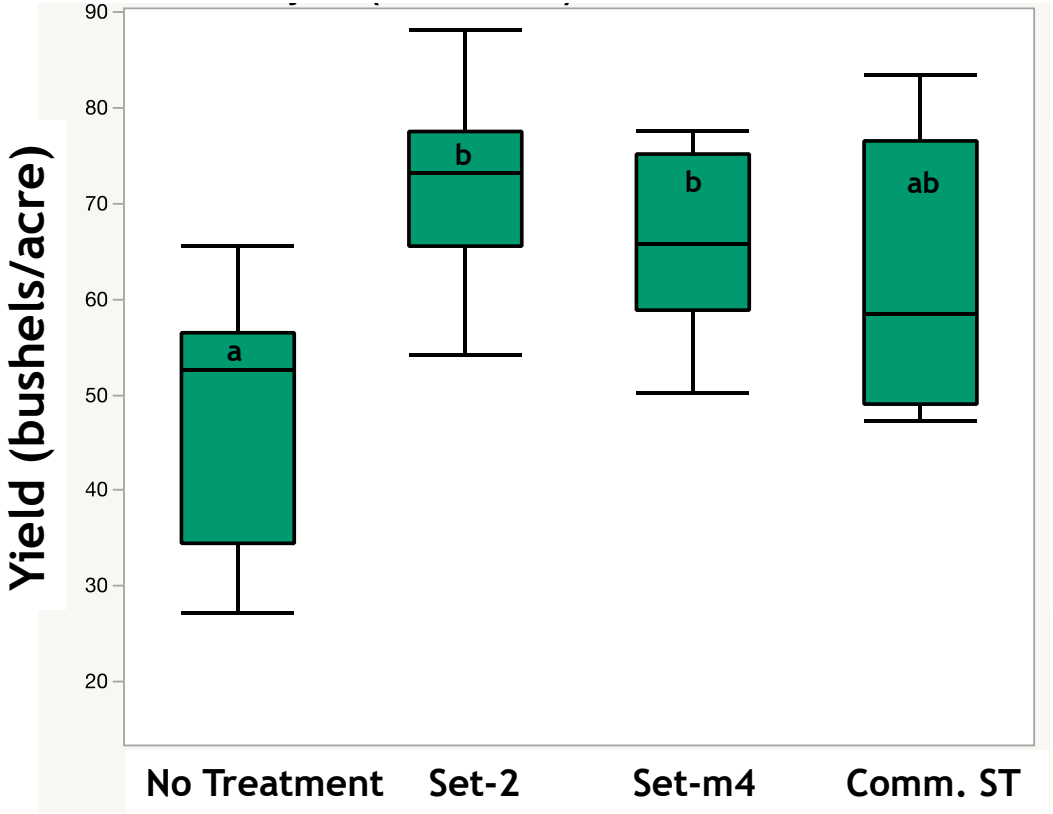


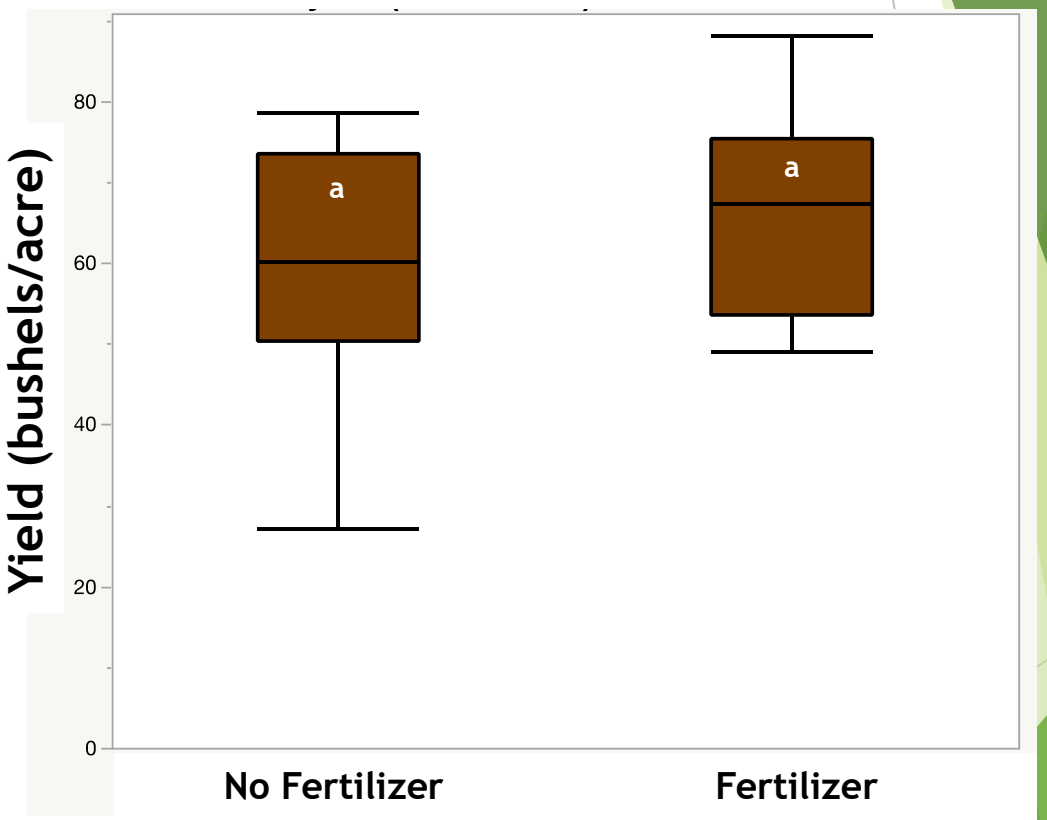
Dean Lee Research Station (Yield)





Red River Research Station (Yield)

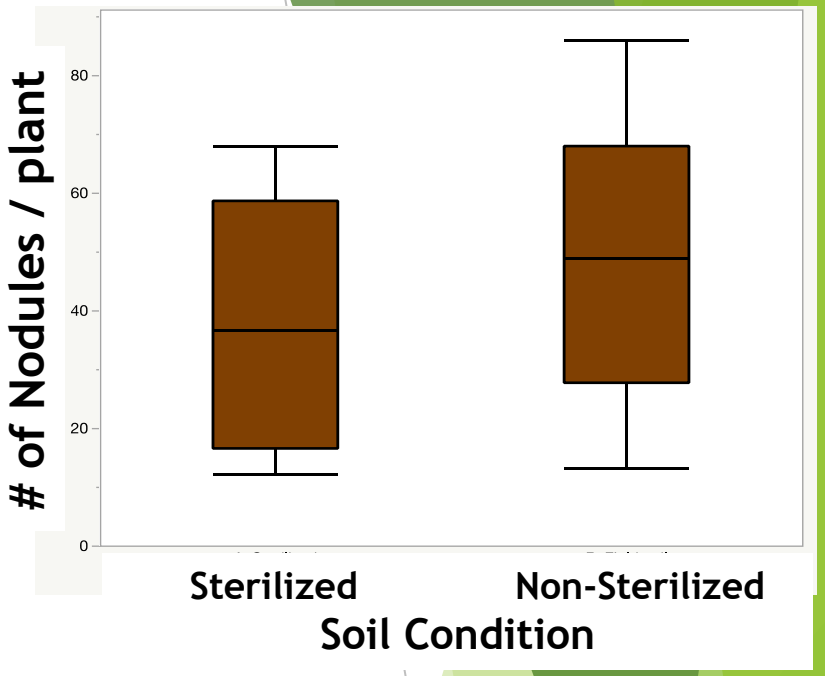


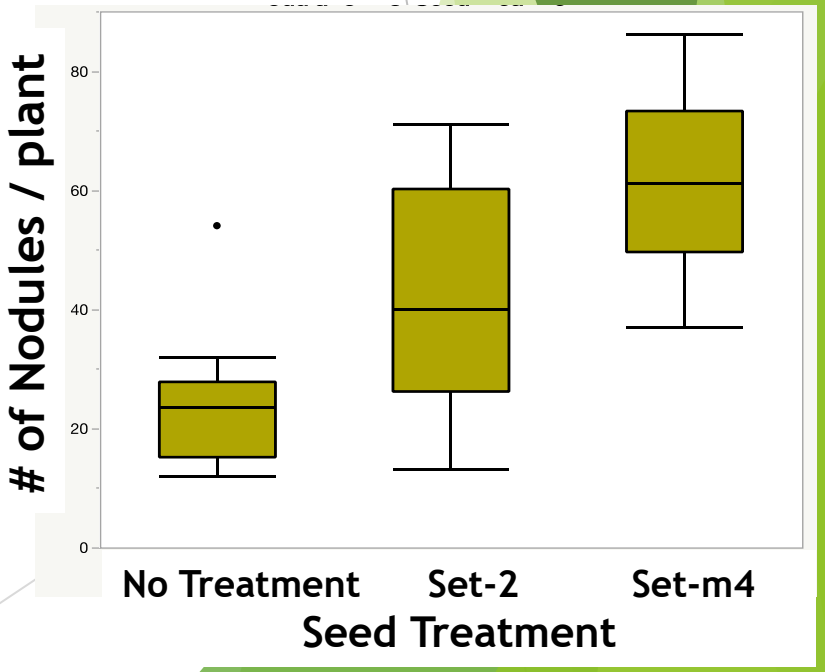


Effect of SABBs on Root Nodulation

Sterilized Soil Condition

Non-Sterilized Soil Condition





Development of Preservation Reagents

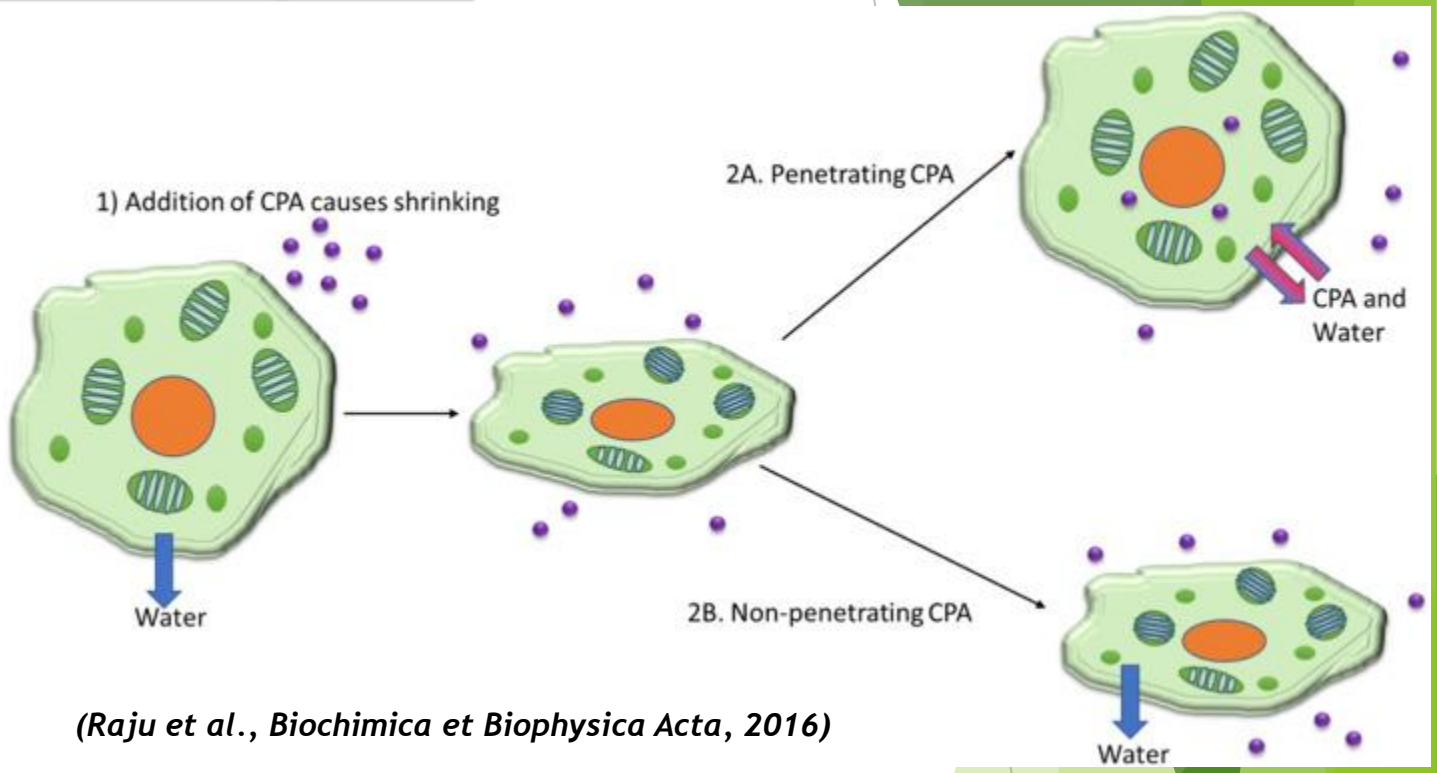
Types of cryoprotectants

- **Extracellular cryoprotectants**

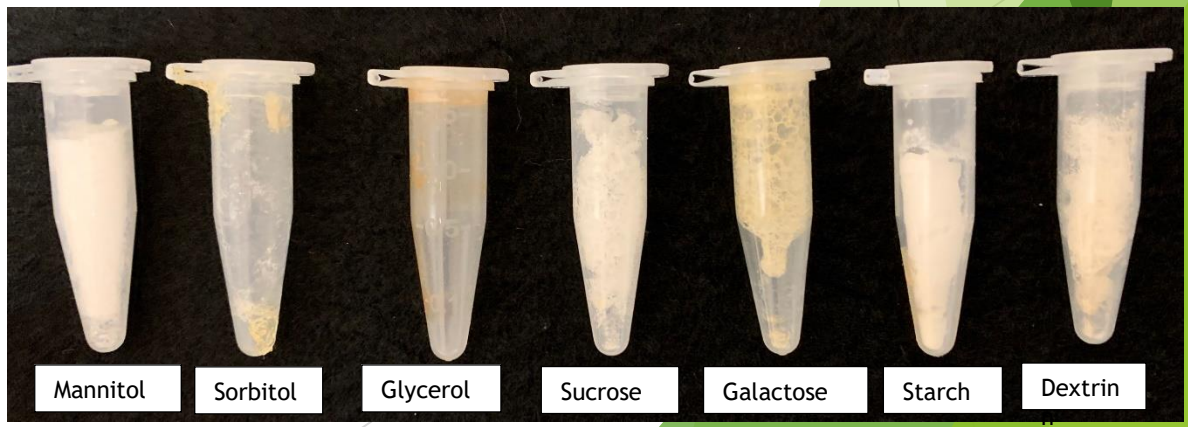
  - ✓ Do not penetrate the bacterial cell wall
  - ✓ Reduce the hyperosmotic gradients
  - ✓ Include sucrose, cellobiose, polyvinylpyrrolidone (PVP), etc.

- **Intracellular cryoprotectants**

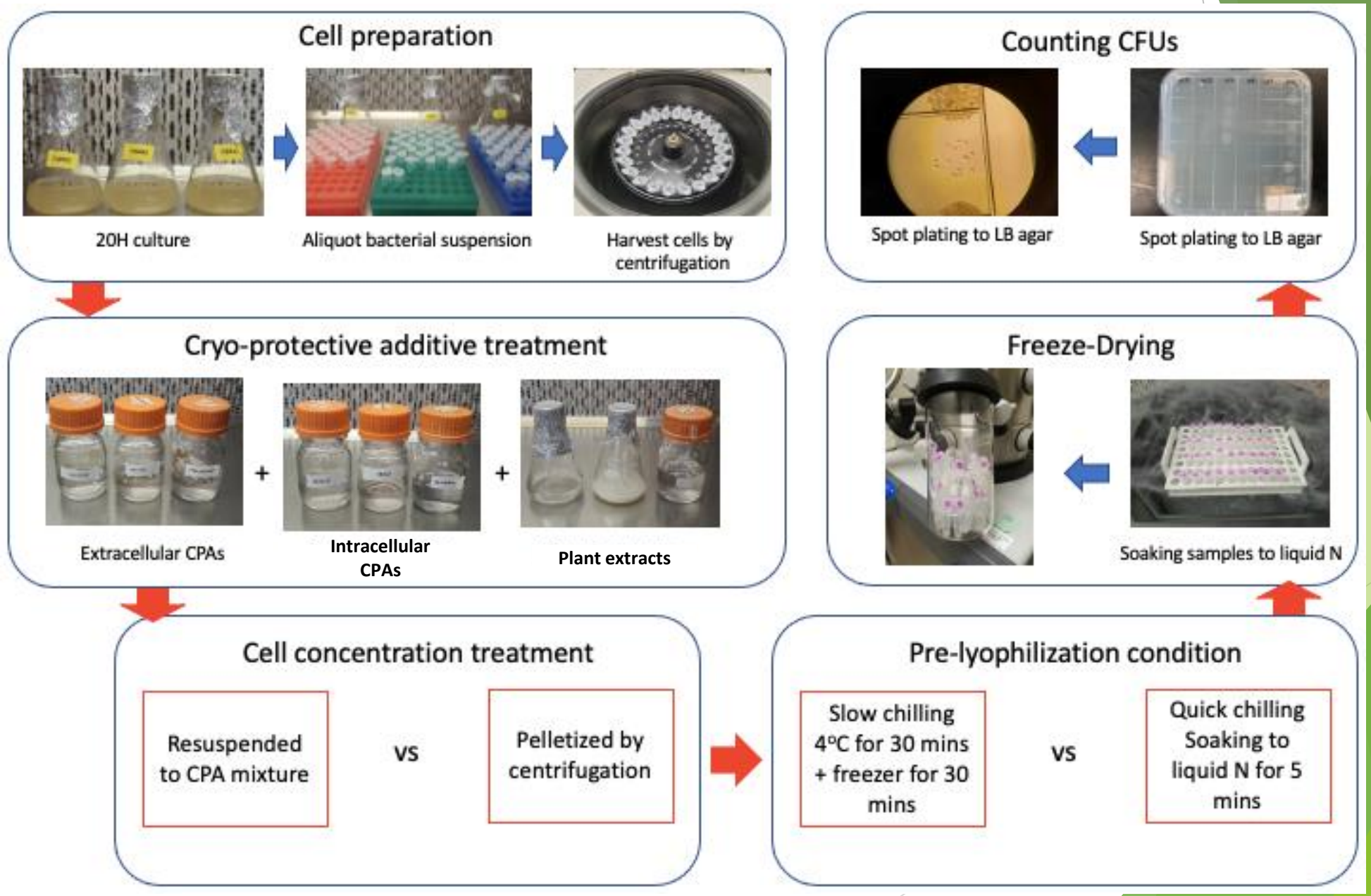
  - ✓ Can penetrate the bacterial cell wall
  - ✓ Reduce the water crystal formation within the cell
  - ✓ Include DMSO, glycine, betaine, glycerol, etc.



(Raju et al., Biochimica et Biophysica Acta, 2016)



Optimization of bacterial cell lyophilization

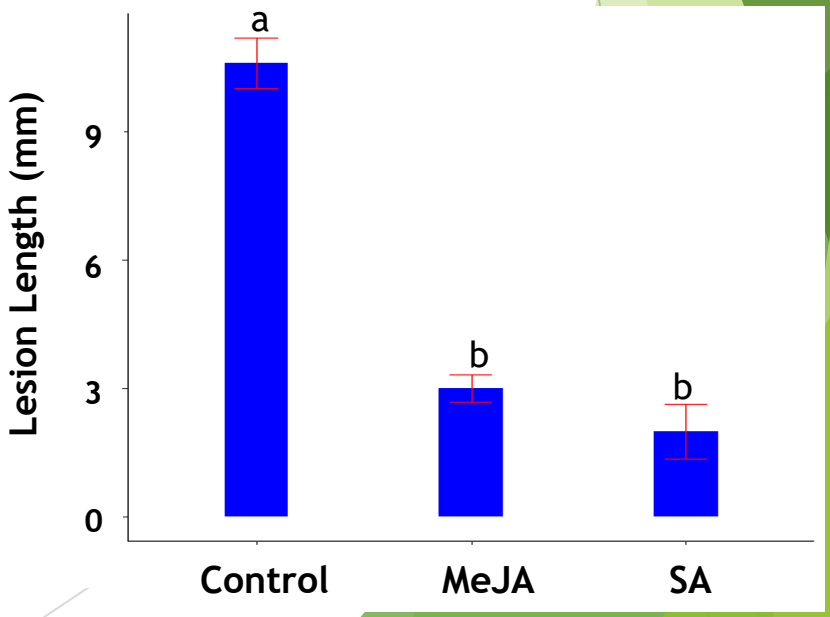


Other Materials to Enhance Disease Resistance (Defense-Priming)

- If ‘defense-priming’ can be achieved through seed treatment, this practice to protect crops could be performed in more efficient and controlled ways.

- We recently observed that treatment of soybean seeds with salicylic acid or methyl-jasmonic acid caused enhanced resistance of soybean seedlings to the fungal pathogen, *Rhizoctonia solani*.

- Currently, we are testing additional materials to identify good defense-priming materials used for seed treatment (e.g. chitosan, BABA, VOCs, etc.)



Summary

- Soybean-associated beneficial bacteria (SABBs) were screened based on various biological activities beneficial to soybean growth.

- Bacterial mixtures (consortia) of SABBs having multiple beneficial activities showed higher growth-promoting activities than a single SABB through seed treatment, including increased yield and disease suppression as well as enhanced nodule formation.

- Currently, we are developing methodology and reagents for long-term storage of bacterial mixtures, using freeze-drying and various intracellular and extracellular cryoprotectants in combination with plant extracts.

- We are also studying candidate seed-treating materials for enhancing disease resistance of soybean (and rice)

Acknowledgements

THE LOUISIANA
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Questions:

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