ROOTS, BACTERIA, AND FERTILIZER: A SUSTAINABLE WAY TO HELP SOIL HOLD WATER

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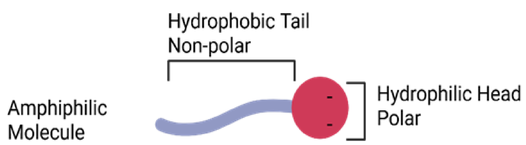
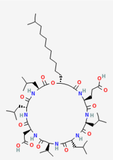
Goal:
- Increase water infiltration in soil.
- Reduce water evaporation from soil.
- Finally, reduce irrigation demand without sacrificing crop yield.

Background:
- Ogallala Aquifer supports 10% of U.S. agricultural production.
- It is draining faster than nature can refill it.
- Water volume dropped by ~410 km^3 from 1935 to 2012 (Evett et al., 2020).
- Within next 50 years, half of the aquifer in southwest Kansas will not be able to support large capacity irrigation.

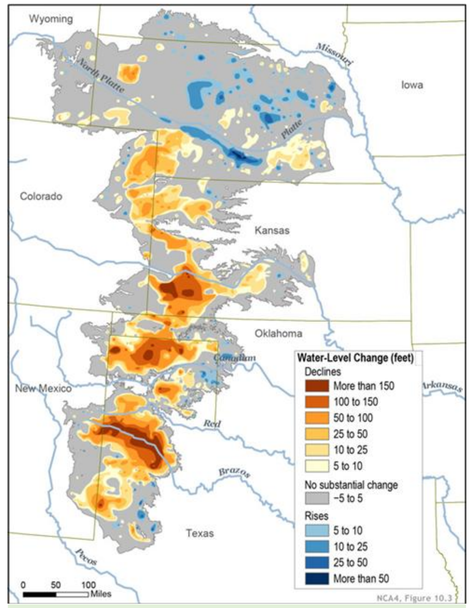
Surfactant as soil wetting agent



Surfactin: A natural biosurfactant
- Mostly produced by *Bacillus* spp.
- Have long hydrophobic tail and hydrophilic head.



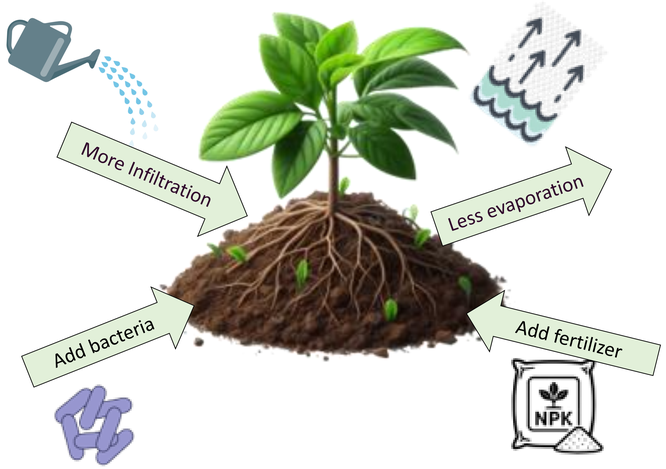
Surfactin structure



Ogallala is drying (Evett et al., 2020)

Surfactant treated field (Oostindie et al, 2008)

Method:
- Introduce *Bacillus subtilis* into soil.
- Use root exudates and commercial fertilizers commonly used by farmers to nourish the bacteria.
- It will produce surfactin.
- Surfactin will increase soil wetting by reducing surface tension.
- It will minimize evaporation by lowering capillary force.
- Finally, soil can retain more moisture and irrigation demand will be reduced.

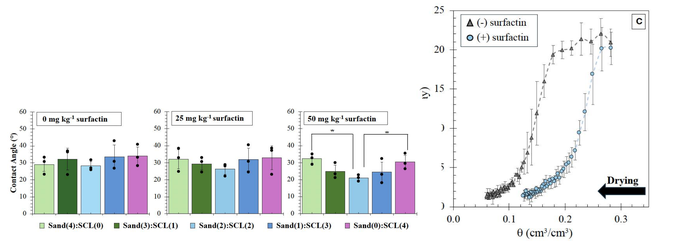


Why this method?
- Turning the soil into a continuous bio-factory for surfactin production.
- No extra cost to feed bacteria.
- *B. Subtilis* generally recognized as safe (GRAS).
- Remain as shelf stable spores.
- Highly scalable, requires minimal labor, and easily automated.

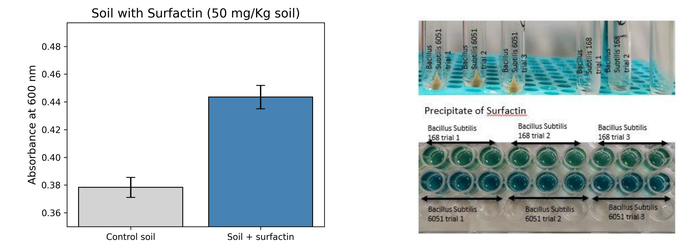
Extra advantages:
- Surfactin is antimicrobial and antifungal
- It can activate plant internal defense system, like vaccine.
- *B. subtilis* can enhance nutrient uptake by plant.
- It helps in seed germination and root growth.

Interesting fact:
During drought stress plant root release more exudate which helps *B. subtilis* growth and surfactin production. (Shakya et al., 2013; Czarnes et al. 2000; Preece et al. 2018)

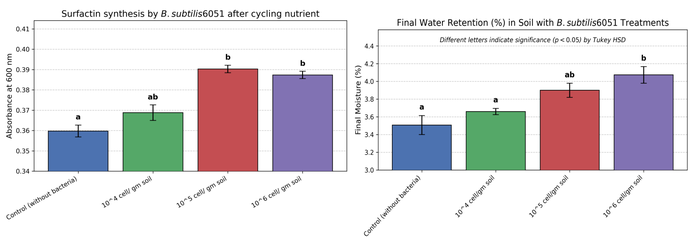
Result:



Direct surfactin addition increased soil wetting and reduced evaporation



A easy and quick method to detect surfactin in soil was developed



Bacteria produced surfactin in soil and retained moisture

Conclusion:
- Adding *B. subtilis* can increase soil water retention by producing surfactin.
- Main challenge is to understand soil environment conducive to surfactin production.

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