Maintaining Relationships in Closed Environments: Plant/Microbe Mutualisms

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Background

Ground

Flight

Speculation
Background: Microgravity environment is conducive to preferential growth of microorganisms and potential pathogens.

Background: Microbial growth occurs on sanitized seed/rooting materials when exposed to ISS ambient conditions.

( NASA ISS image of zinnia plants grown in VEGGIE, 2016).
Wheat grown in non-sterile conditions had diverse rhizosphere, high germination, and no pathogenicity.

Frazier et al., 2003; Stutte et al., 2004)
Plant/Microbe Mutualisms are critical to survival on Earth and may play similar role for long duration space missions.

- Understanding the nodulation process and its genetic machinery may have broad implications for decreasing resupply costs on long duration space missions in improving agriculture, reducing dependence on chemical nitrogen fertilizers.
- Little research on plant/microbe interactions in microgravity exists.

- Legumes provide 20% of the protein in our diets though direct or are important crops and provide up indirect consumption.
Plant-reduced-C is exchanged for bacteria-reduced-N
Effect of Microgravity on Early Events of Biological Nitrogen Fixation in Medicago truncatula

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Payload Specialist Rex Wilhelm in Space shuttle middeck with BRIC-SyNRGE canister C and activation tool during RNALater Fixation process.
Medicago truncatula

Sinorhizobium meliloti
Effects of Microgravity on growth of *M. truncatula* cv. Jemalong A17 (Enod11::gus) inoculated with two strains of *S. meliloti*.
Localization of S. meliloti infection of M. truncatula roots and activation of ENOD11 gene in μg necessary for nodule formation, and subsequent biological nitrogen fixation.

M. truncatula (Enod11::gus) inoculated with S. meliloti ABS7 with a hemA::LacZ marker. The stained area indicates site of S. meliloti infection in the etiolated M. truncatula root.

M. truncatula (Enod11::Gus) inoculated with S. meliloti ABS7 with a hemA::LacZ marker. The stained area indicates site of Enod11:gus gene activation in the etiolated M. truncatula root.
H₀: Microgravity exposure reduces the susceptibility of the host plant (*M. truncatula*) to form nodules.

*M. truncatula* cv Jemalong 17 (*Enod11::gus*) germinated in microgravity and inoculated with *S. meliloti* ABS7 cultured in microgravity at 18 days after inoculation. Roots of *M. truncatula* were inoculated within 8 hours of landing, and cultured on buffered nodulation media (BNM), which contains no carbon or nitrogen source in Nunc™ 4-well plates.
MUTUALISM IN A REDUCED GRAVITY ENVIRONMENT (MURGE):
PIRIFORMOSPORA INDICA: ARABIDOPSIS THALIANA INTERACTIONS IN
MICROGRAVITY

Gary Stutte and Mike Roberts, co-investigators, CSS Dynamac
P. indica shows strong biostimulatory effect on a number of species

**LETTUCE:**
More uniform germination, increased root branching, larger leaves, and 55% increased in seedling biomass observed.

**TOMATO:**
More uniform germination, increased root branching, denser root hairs, and 15% increased in seedling biomass observed.
Biostimulatory effect of *P. indica* retained, but reduced in magnitude under simulated microgravity conditions.

*Hayes, Stutte, McKeon-Bennett, and Murray. 2014. Grav. Space Res. 2:21-33*
NanoCube Plant Growth Chamber

- 10 cm x 10 cm x 15 cm
- Power to NanoLab via USB port (3.2 W)
- 4 white LED’s (15 µmol m\(^2\) s\(^{-1}\) PAR)
- 4 growth channels (2 plants/channel)
- Monitor temp and CO2
- Fixation capabilities
- Imaging
- Data storage on board
- Periodic data download/access
SyNRGE$^3$ launched on SpaceX in September, 2014.

- Lights failed to turn on on-orbit resulting in etiolation of plants.
- Tissue was returned after ~2 weeks after landing and microbes recovered.
- Viability of Sm and Pi to develop mutualism retained.

Eight *M. truncatula* plants were launched that had been inoculated with either *S. meliloti* or *P. indica*.

SyNRGE3 sponsored by Space Florida/Nanoracks ISS Research Competition.
SyNRGE Plant Growth Chamber (SPGC).
SyNRGE Plant Growth Chamber (SPGC) launched on SpaceX CRS-8 on 8 April to ISS, and it was installed in NanoLab on ISS on 11 April, 2016.
SyNRGE PGC Experiment Return, May, 2016
Will the plant/microbe relationship improve when we stop meddling?

Thank You!