Composting Methods and Nutrient Implications

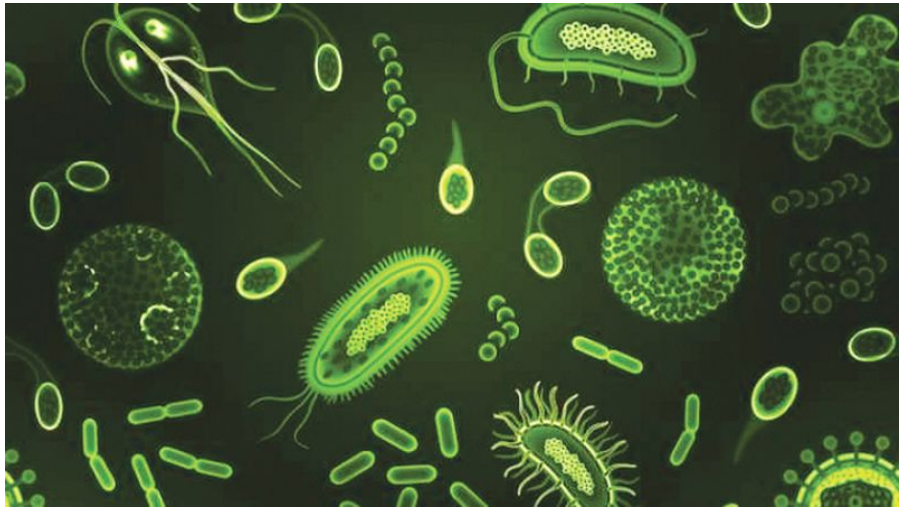
Vermont Organics Recycling Summit

4.11.19

Overview

- Introduction to microbes
- The plant microbiome
- How microbes recycle organic waste
- Full Circle Green Microbes
- Our work with Green Mountain Compost
- Future opportunities

Introduction to microbes: definition

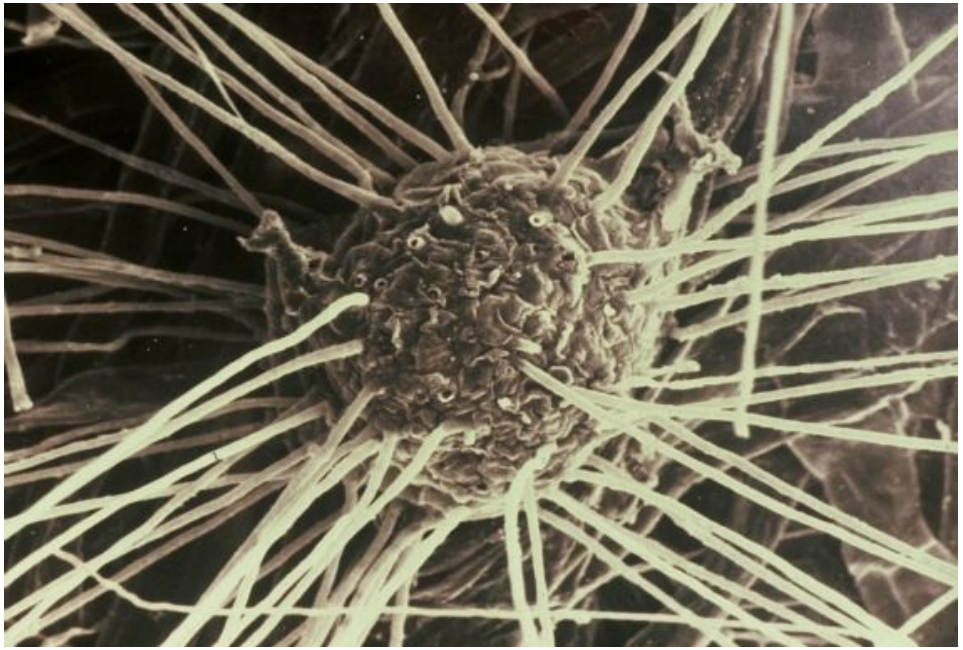


‘Microbe’ refers to bacteria, fungi, actinomycetes, protozoa and other microscopic organisms.

Introduction to microbes: presence in soil

- The most abundant types of microbes are bacteria, actinomycetes and fungi.
- One teaspoon of soil contains more microorganisms than there are people on Earth.
- The rhizosphere, occupied by plant roots, can have 1000-2000 times that number (10^{10}-10^{12} cells per gram rhizosphere soil).

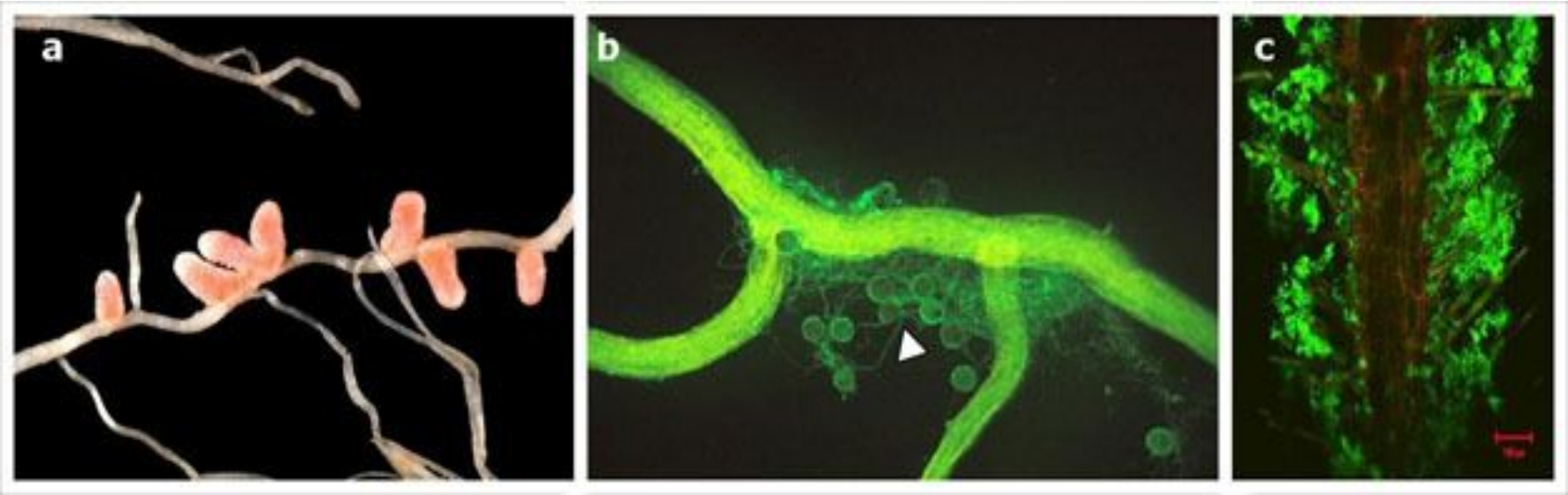
The plant microbiome



The plant microbiome: key functions

- Microbes contribute to a variety of crucial plant functions including:
  - Seed germination and growth support
  - Nutrient uptake and processing
  - Resistance against biotic stress factors (pests & pathogens)
  - Resistance against abiotic stress factors (cold, drought, salt)
  - Production of bioactive metabolites
- Plants have developed an ability to invite microbes into a symbiotic relationship by releasing chemicals called root exudates.
- The plant microbiome represents a mutually beneficial relationship, as microbes receive energy in exchange for the value they provide.

The plant microbiome: examples



a) Nitrogen fixing nodules growing on the roots of Medicago italica

b) A corn plant root colonized with mycorrhizal fungi.

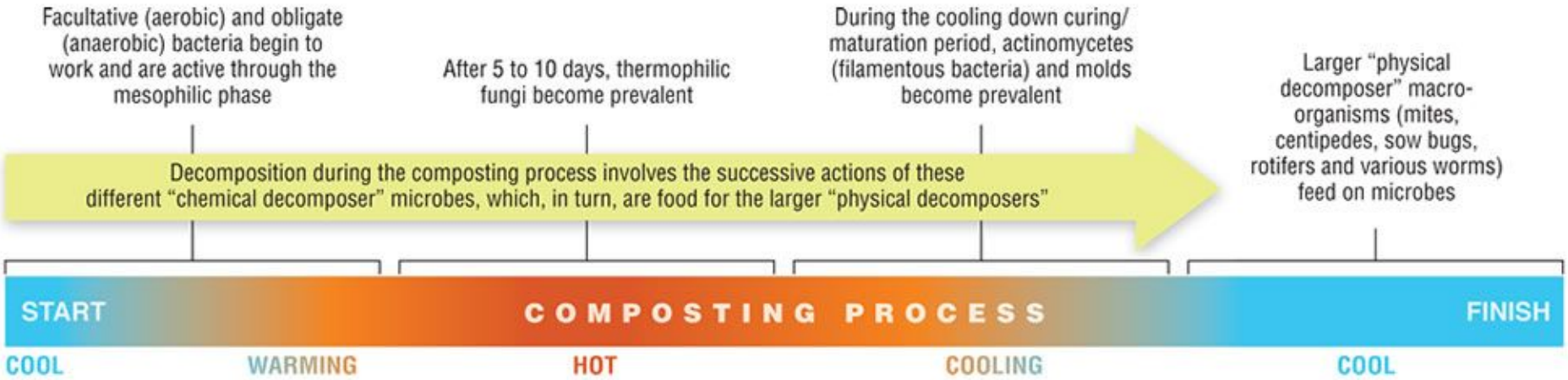
c) Bacteria forming a biofilm on the surface of an Arabidopsis thaliana root

The plant microbiome: nutrient uptake

- Microbes contribute to the uptake of nitrogen, phosphorus, potassium, sulphur and micronutrients.
- Nitrogen fixing:
  - Process of converting N_2 into nitrogenous compounds which can be absorbed by plants and stimulate their growth.
  - The bacteria behind this process are called Diazotrophs and they flourish in a variety of environments including the soil and plant roots (rhizobia).
  - In thermophilic composting, N_2 can be converted to plant-friendly nitrate only in the presence of sufficient cellulosic material to act as an energy source for the process.
    - A risk in this process is the loss of nitrogen as NH_3 (ammonia) gas. Research has shown that this risk can be minimized with longer composting times, lower particle size, ~40% moisture content and medium to low aeration.

Microbes and organics recycling

Thermophilic compost: microbes work in succession to decompose organic matter, generating heat and CO_2.



Microbes and organics recycling

Anaerobic fermentation:

- Microbes produce acids which serve the dual purposes of breaking down organic matter and preventing putrefaction.
- In addition to fixing nitrogen, fermentative microbes produce amino acids and saccharides which plants can absorb directly through their roots.
- Carbon retention:
  - More diverse metabolic processes in fermentation create low molecular weight polysaccharides rather than CO_2.
  - Some CO_2 produced during the fermentation is metabolized by purple phototrophic bacteria during lignin degradation.
- Pathogen inhibition through bacteriocins and organic acids.

Full Circle Green Microbes: overview

Our microbial inoculant is designed to:

- Increase organics recycling speed
- Process broad range of inputs
- Reduce greenhouse gas emissions
- Mitigate need for added carbon
- Minimize odors
- Retain more nutrients for fertilizer

Full Circle Green Microbes: key functions

- **Lactic Acid Bacteria:** production of lactic acid breaks down organic waste while preventing putrefaction and proliferation of pathogens.
- **Fungi:** synthesize plant soluble amino acids, contribute to plant root health and vitamin absorption.
- **Purple Phototrophic Bacteria:** facilitate lignin degradation, nitrogen fixation, production of plant soluble nutrients and allow plants to utilize a broader spectrum of solar radiation in photosynthesis.

Working with GMC: goals of our pilot

Goal: demonstrate the ability of Full Circle Green Microbes to reduce odor of putrescent waste, process food waste without carbon supplements and generate high quality fertilizer beneficial to plant growth.

FCGM at GMC: pilot process overview

1. Six 55-gallon drums filled with food waste at GMC
2. Two of the six drums treated with leachate from the underground storage tank to increase putrescence
3. All six drums inoculated with Full Circle Green Microbes
4. Drums covered in curing compost to prevent contents from freezing during the 4 week fermentation stage
5. GMC and Full Circle conducted smell test and transitioned to curing stage
6. FCGM output used in plant growth trials to demonstrate effectiveness as a fertilizer

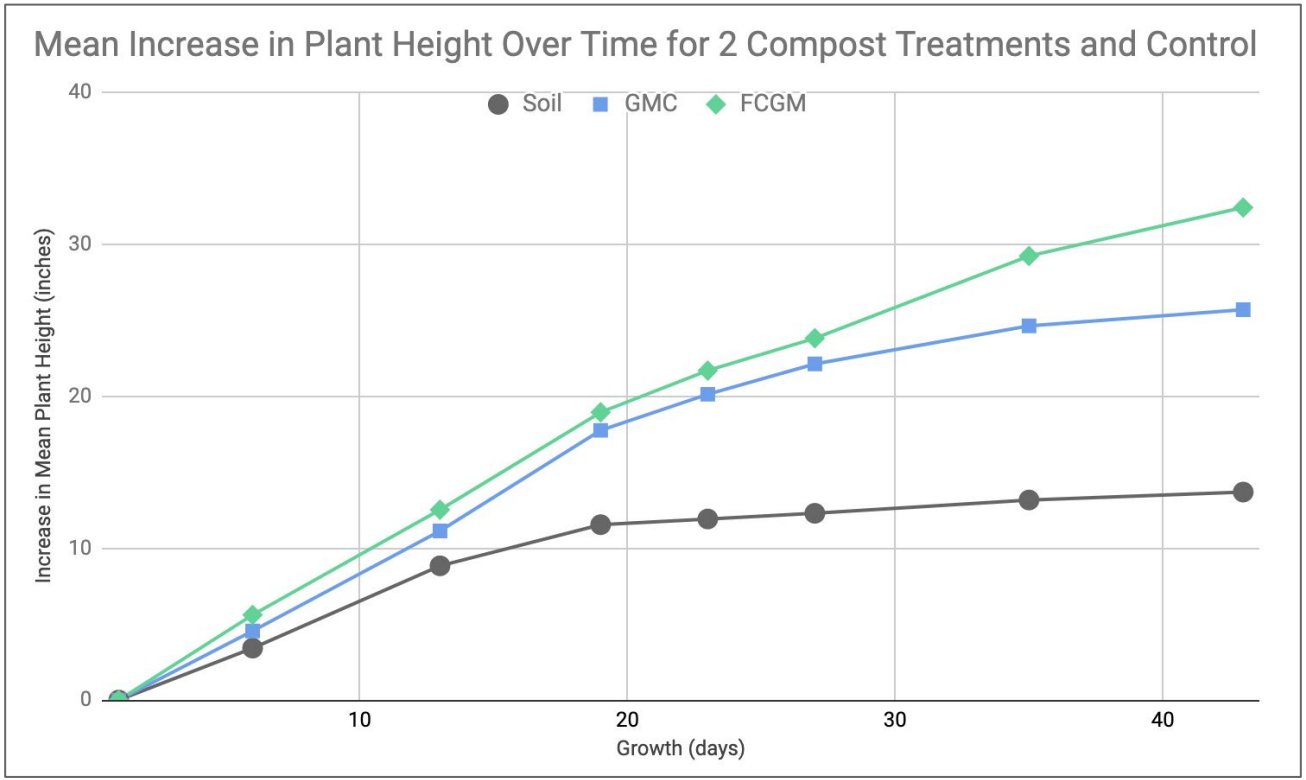
Working with GMC: results and takeaways

- The pH readings declined by at least 1.35 for all drums with average pH reaching a low of 4.21 as the Lactic Acid Bacteria became the prevailing microbial community.

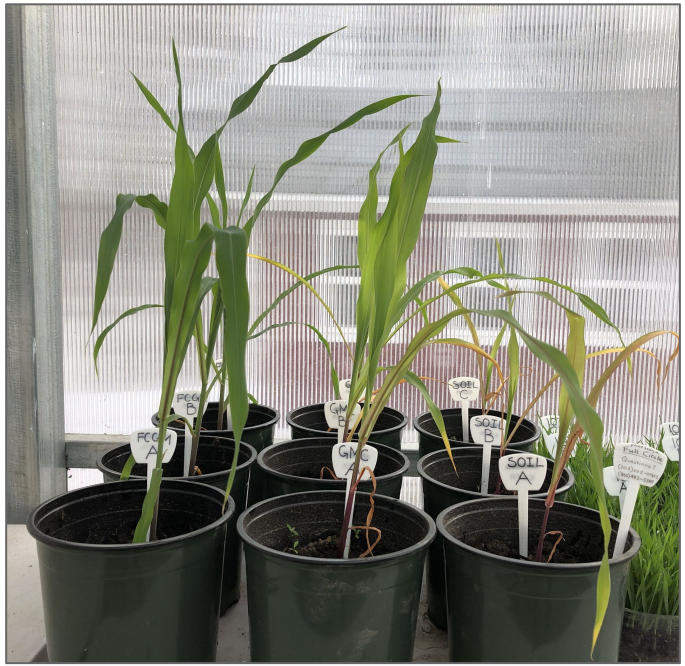
- Smell tests:
  - All drum smell ratings were lower (less offensive) than the original ambient smell reading around the compost piles.
  - Drums treated with putrescent leachate received the highest smell ratings but were significantly lower than the source, the compost leachate.

- Plant growth trials demonstrated that FCGM produced a high quality plant fertilizer without supplementary carbon.

Working with GMC: plant growth trial data

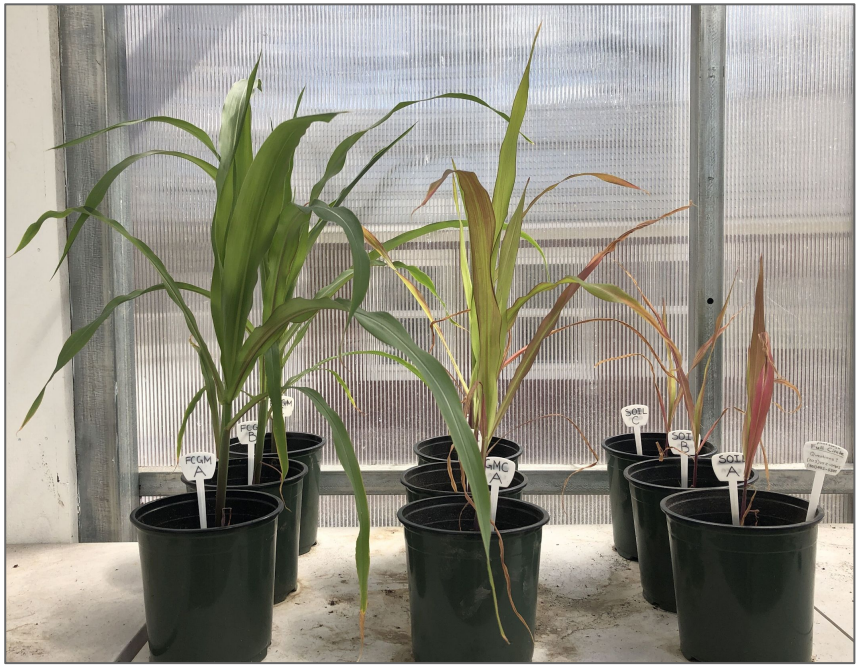


Working with GMC: plant growth trials



FCGM GMC Soil

Day 25



FCGM GMC Soil

Day 49

Future opportunities

- Optimize FCGM for faster processing of lignin or other challenging inputs.
- Larger scale implementations.
- Agricultural partnerships.
- Treatment of highly putrescent waste.

Thank you for listening!

Image sources

- **Slide 5:** Amaranthus, Mike, and Bruce J Allyn. “An Electron Micrograph of a Mycorrhiza with Radiating Mycorrhizal Fungal Filaments.” *The Atlantic*, 11 June 2013, www.theatlantic.com/health/archive/2013/06/healthy-soil-microbes-healthy-people/276710/.
- **Slide 9:** Coker, Craig. “Composting And Microbial Inoculants.” *BioCycle*, Feb. 2019, www.biocycle.net/2019/02/01/composting-microbial-inoculants/.
- **Slide 7:** Crook, Matthew. “Nature.” *Nature*, 2013, www.nature.com/scitable/knowledge/library/the-rhizosphere-roots-soil-and-67500617.
- **Slide 5:** Read, David. “The Atlantic.” *The Atlantic*, 11 June 2013, www.theatlantic.com/health/archive/2013/06/healthy-soil-microbes-healthy-people/276710/.
- **Slide 7:** Rudrappa,, T. “Nature.” *Nature*, 2013, www.nature.com/scitable/knowledge/library/the-rhizosphere-roots-soil-and-67500617.
- **Slide 3:** “The Daily News.” *The Daily News*, 19 Feb. 2018, www.dailynews.lk/2018/02/19/features/143136/invisible-world-microorganisms.
- **Slide 7:** Wright, Sara. “Nature.” *Nature*, 2013, www.nature.com/scitable/knowledge/library/the-rhizosphere-roots-soil-and-67500617.