IMPACTS OF MANAGEMENT ON SOIL MICROBES IN FLORIDA VEGETABLE PRODUCTION

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Over 1 billion microbes in 1 gram of soil
Over 50,000 different “species” of bacteria
Why are soil microbes important?
Management practices can influence soil microbes

- Raised beds
- Fumigation
- Soil amendments
What happens to soil microbes in a raised bed?

**Bacteria**

- Richness
- Shannon

**Fungi**

- Shannon

![Box plots showing bacterial and fungal diversity across different depth intervals in raised beds.](image)
Management practices can influence soil microbes

- Raised beds
- Fumigation
- Soil amendments
Fumigant had significant impacts on soil bacteria

Class
- Acidobacteria
- Actinobacteria
- Alphaproteobacteria
- Bacilli
- Betaproteobacteria
- Chloroflexi
- Clostridia
- Deltaproteobacteria
- Gammaproteobacteria
- Gemmatimonadetes
- KD4-96
- Ktedonobacteria
- Nitrospirae
- Planctomycetae
- Solibacteria
- Sphingobacteria
- Subgroup 6
- Thermoleophila

Alpha diversity measure

Shannon

Time Point
- T0
- T1
- T2
Fumigant had significant impacts on soil fungi.
Management practices can influence soil microbes

- Raised beds
- Fumigation
- Soil amendments
Soil organic matter

Disease suppression

Nutrient cycling

Nutrient availability

Root growth
Difficulties with SOM in Florida
Building soil organic matter in Florida: compost

Benefits

• Availability
• Nutrient source

Difficulties

• Expensive
• Application rate
• Availability
• Variability
• Potential source of weed seed
Compost Tomato Trial:

- Plant-based compost applied at bedding:
  - No compost
  - 10 tons/acre
  - 40 tons/acre

- Beds fumigated with Pic-Clor 60

- Soil samples collected every 30 days
Significant differences in bacterial community composition

No compost
Compost

Planting
1 month
2 months
First harvest
Last harvest
Building soil organic matter in Florida: cover crops

- Cover crops = crops planted to benefit the soil, generally not harvested for profit

- Lots of benefits to soil (and farmer):
  - Provide N – either by N—fixation from legumes, or by scavenging extra N from previous crop
  - Reduce weeds
  - Reduce soil erosion
  - Reduce soil compaction
  - Increase soil moisture
  - Increase soil organic matter
Cover crops and management practices

- Increasingly common practice for grains, cotton, corn, soybean farmers, but also used with some vegetable production

- Cover crops planted during fallow season

- Cover crop use more frequently combined with conservation or no-tillage management practices
Symbiotic $N_2$-fixation: Rhizobia

- Soil bacteria that attach and colonize legume roots
- Fix N for plants
- Plants provide carbon for the bacteria
- $N_2$-fixation requires low or no oxygen, so nodules formed
  - 1 nodule can contain up to $10^9$ rhizobia
  - Use leghaemoglobins
    - $O_2$-buffering proteins similar to the hemaglobins in our blood

- Nevins 2019
Cover crop mix optimization

2. NL + cowpea + sunnhemp
3. NL + cowpea + sesbania
4. NL + sunnhemp + sesbania
5. NL + 3 L (legumes)
6. AU Golden sunnhemp + 2 L + 3 NL
7. Non-legume (NL)
Cover crops species provide different benefits

Legume cover crops:
  • Cowpeas (*Vigna unguiculate*)
  • Vetches (*Vicia* spp.)
  • Crimson clover (*Trifolium incarnatum*)

Nematode management (non-host plants):
  • Cereal rye (*Secale cereale*)
  • Wheat (*Triticum aestivum*)
  • Crimson clover (*Trifolium incarnatum*)

Weed suppression:
  • Subterranean clover (*Trifolium subteraneum*)
  • Buckwheat (*Fagopyrum esculentum*)
  • Sorghum-sudangrass
Soil microbes increased with cover crops

**North Grove**

- **LG + NLG**
- **NLG**
- **GS**

**South Grove**

- **LG + NLG**
- **NLG**
- **GS**

**LG + NLG**: legume + non-legumes cover crops

**NLG**: non-legume cover crops

**GS**: grower-standard
SOM increased after 1 year of cover crops

**North Grove**

LG + NLG: legume + non-legumes cover crops
NLG: non-legume cover crops
GS: grower-standard

**South Grove**

LG + NLG: legume + non-legumes cover crops
NLG: non-legume cover crops
GS: grower-standard
Differences between human gut and soil microbiome

- Similar concentration of bacteria, but vastly different levels of diversity:
  
  - **Human gut:**
    
    - **1,000 species**, with approximately 160 “common” species (*Qin et al. 2010*)
  
  - **Soil:**
    
    - **10,000 to 50,000 species**, unknown how many are “common”

- Even in the well-characterized human gut, nearly 50% of the genes are uncharacterized (*Lloyd-Price et al. 2016*)
Difficulties with soil microbial amendments

• Beneficial taxa can be very crop and/or environment specific

• Unknown how management interacts with added microbes:
  • How will introduced organisms interact with native organisms?
  • What conditions are necessary to keep introduced organisms alive and increasing in number?

• Things to consider when evaluating products:
  • What organisms are being added?
  • What is the concentration?
  • What other compounds are being added?
  • What conditions are required for inoculation?
  • How often does inoculation need to occur?
Soil type impacts on microbial amendments

- Greenhouse trial with tomato
- Four treatments:
  - Bio-1: Mychorrhizae
  - Bio-2: Azospirillum sp., Bacillus sp., Pseudomonas sp., Tricoderma sp.
  - Bio-3: Lactobacillus sp., yeasts
  - Bio-4: Bacillus sp.
- Applied at recommended rates
- Planted in Florida field soil
- Repeated twice
Microbial additions did not impact plant growth

Nuzzo et al. (2020)
Microbial additions did not impact microbial community composition.
Microbial additions did not impact microbial community composition.
Summary

- Soil microbes are important parts of a healthy soil
- Management practices can impact the soil microbial community, but changes can be specific to the crop, soil conditions, and management practice
- We are just beginning to understand the diversity and complexity of soil microbes and their interactions with each other and the environment
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