Influence of Diverse Compost Products on Soil Bacterial and Fungal Community in Potato Production System

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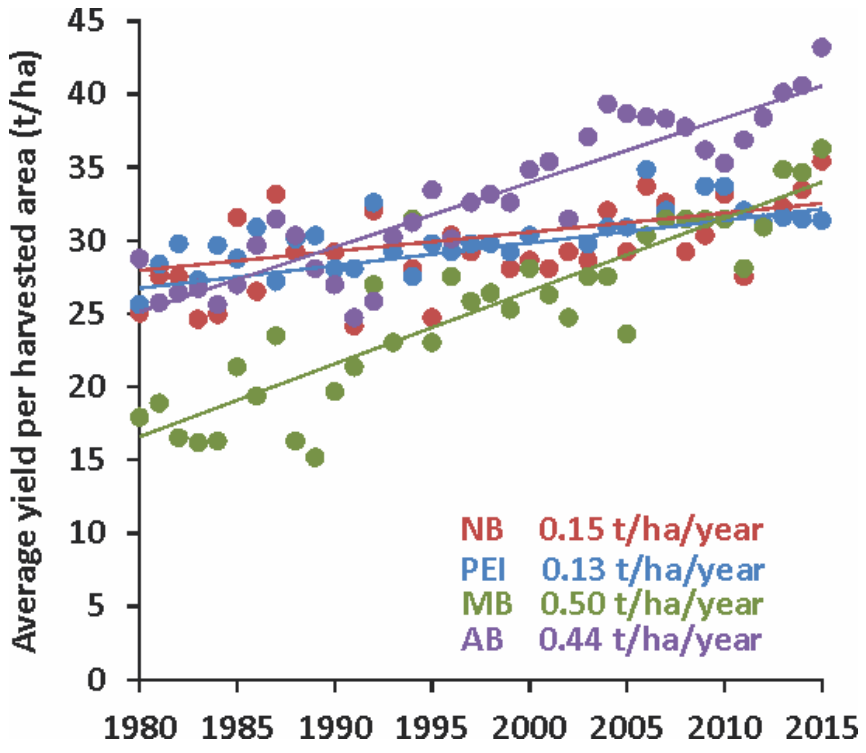
Productivity Challenge

Average potato yield (Statistics Canada) per year



Factors reducing potato yields

- Rolling landscape, shallow soils
- Bare soil exposed in fall and spring
- Frequent soil tillage (*e.g.* for planting, hilling, harvest)
- Minimal crop residue returned to soil
- Short (mostly 2 year) rotations
- Intensive practices = decline in soil quality

Compost to the rescue?

Potential benefit of compost

- Improves soil quality
- Increased SOM, aggregation, water holding capacity
  - Decreased bulk density
- Reduced severity of soil borne pathogen diseases
- More predictable nutrient availability than raw manure
- Can increase potato yields – water holding capacity
- Increases microbial community diversity

Objective

Determine the effect of three compost products on soil physico-chemical properties, potato productivity and bacterial and fungal community diversity.

Three compost products:

SSOC: Municipal Source Separated Organic Compost
FPMC: Forestry and Poultry Manure Compost
FRC: Forestry Residue Compost

Compost product properties

Property	SSOC	FPMC	FRC
C:N	15	26	59
DM (%)	48	58	42
Ash (%)[1]	55	73	55
pH	7.7	7.6	7.2
C (%)[1]	25	15	23
N (%)[1]	1.8	0.6	0.4
NH_4-N:NO_3-N	2.5	1.0	>8.3

[1]dry matter basis

Material and Methods

Experimental site and sampling

- Site located at AAFC, Fredericton, NB
- 2014: barley crop; 2015: potato crop
- October 2014: 45 tonnes ha^{-1} (dry weight basis)
- Randomized complete block design with four replicates
- Sampling done in October 2014 (after compost application), spring, summer and fall 2015

- **Treatments:**

1. Control: no compost
2. SSOC
3. FPMC
4. FRC

Material and Methods

Ancillary measurements

- Soil organic carbon (SOC)
- Particulate organic matter carbon (POM-C)
- Permanganate oxidizable carbon (POX-C)
- Soil pH
- Soil moisture
- Potato tuber yield

Bacterial and fungal community

- Amplicon-based metagenomics
  - 16S rRNA gene - bacteria
  - Ribosomal Internal transcribed spacer (ITS)
- Sequencing by Illumina MiSeq

Results

Organic carbon improved soil structure

	Average C applied (tonnes ha^{-1} yr^{-1})	Bulk density 2015 (g cm^{-3})	Permeability 2015 (cm hr^{-1})
Control	0	1.04	26.8
SSOC	11	0.98*	43.5*
FPMC	7	1.02	34.7
FRC	11	0.96*	38.6*

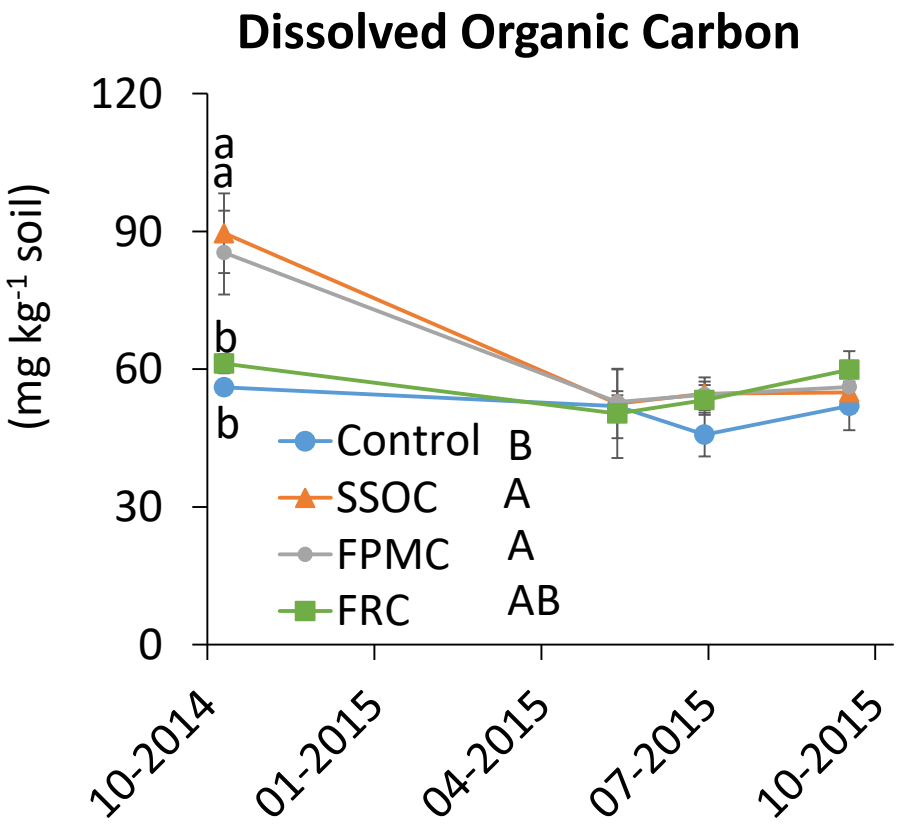
*Significantly different from the control

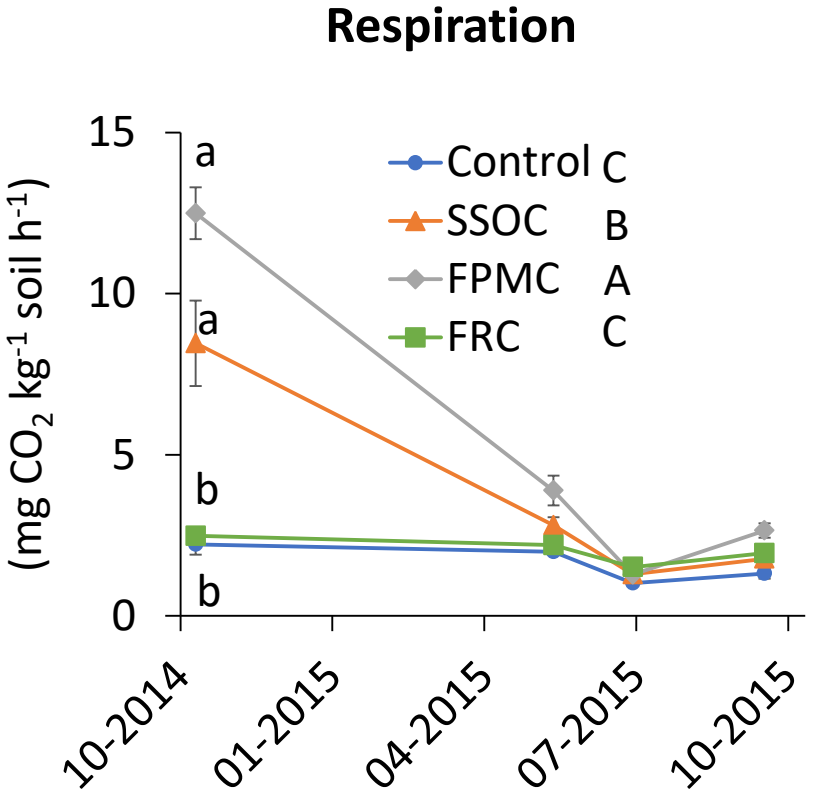
<u>More Carbon = More Benefits</u>

Wilson et al. 2018. Soil Sci. Soc. Am. J. 82:889–900

Results

Compost changes soil organic carbon pools

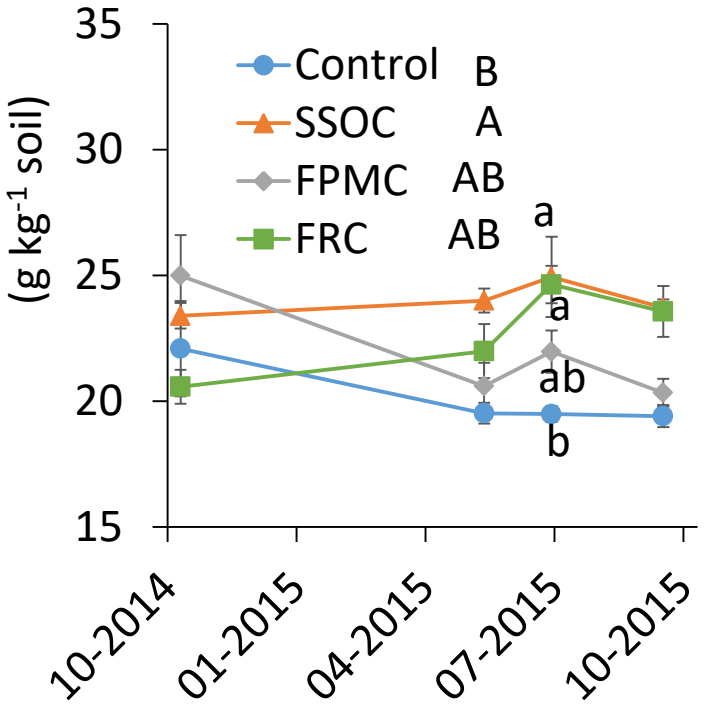




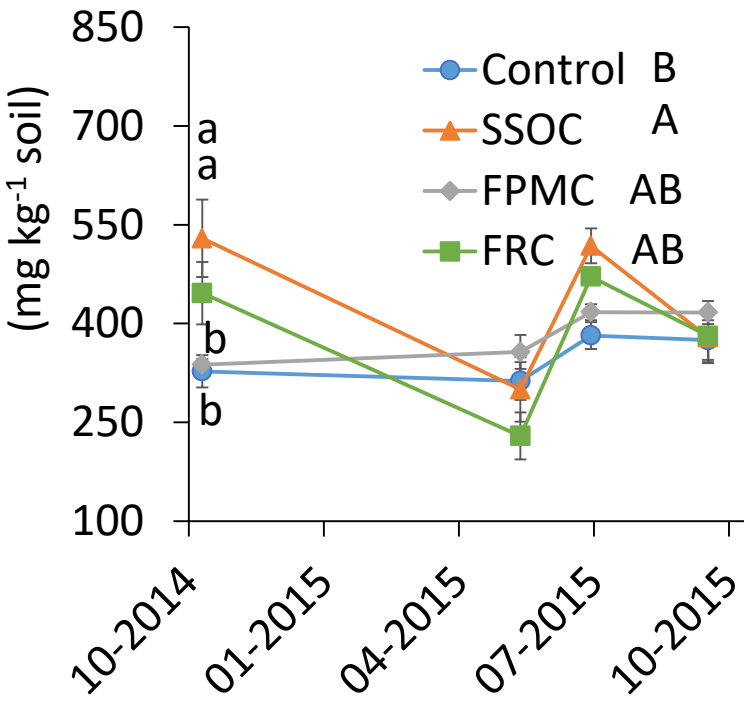
ANOVA ≤ 0.05

Results

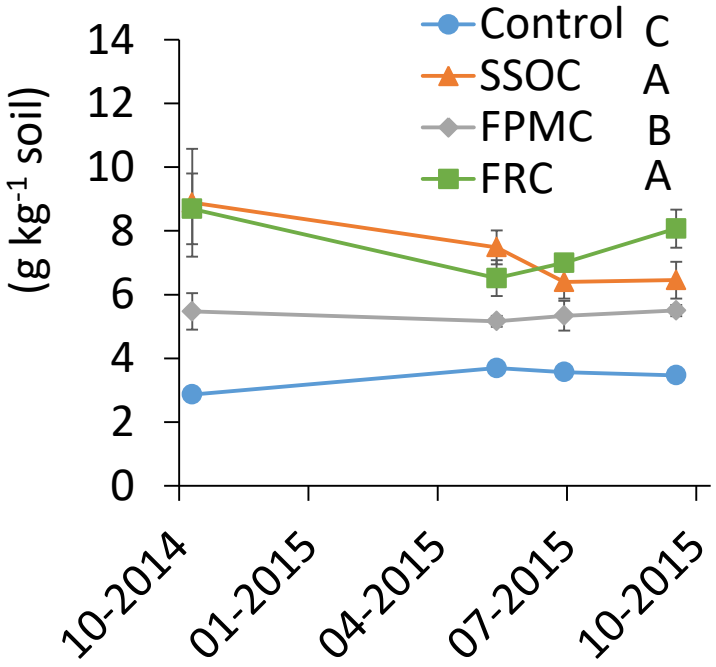
Soil organic carbon



Permanganate oxidizable carbon (POX-C)



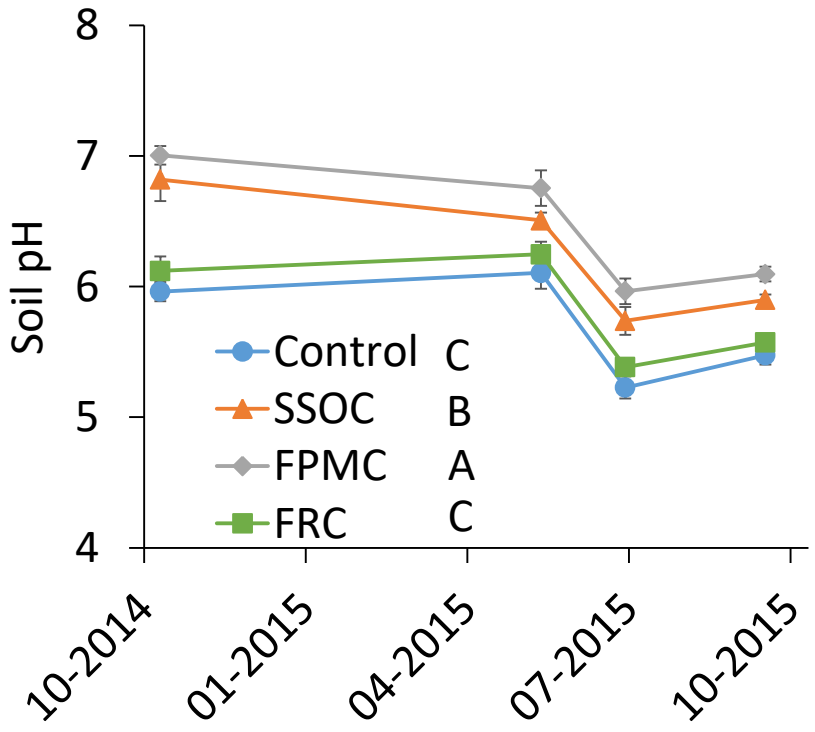
Particulate organic matter (POM-C)

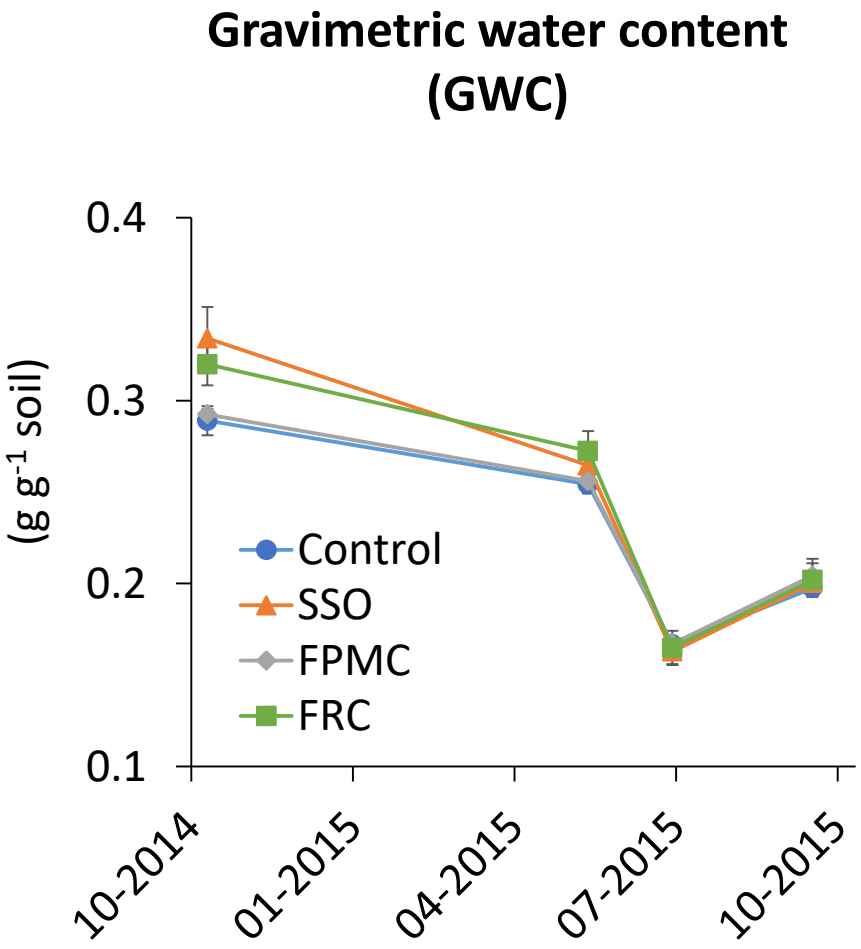


ANOVA ≤ 0.05

- Size fraction of soil organic matter between 0.053 and 2 mm
- Partially decomposed plant and organic material

Results

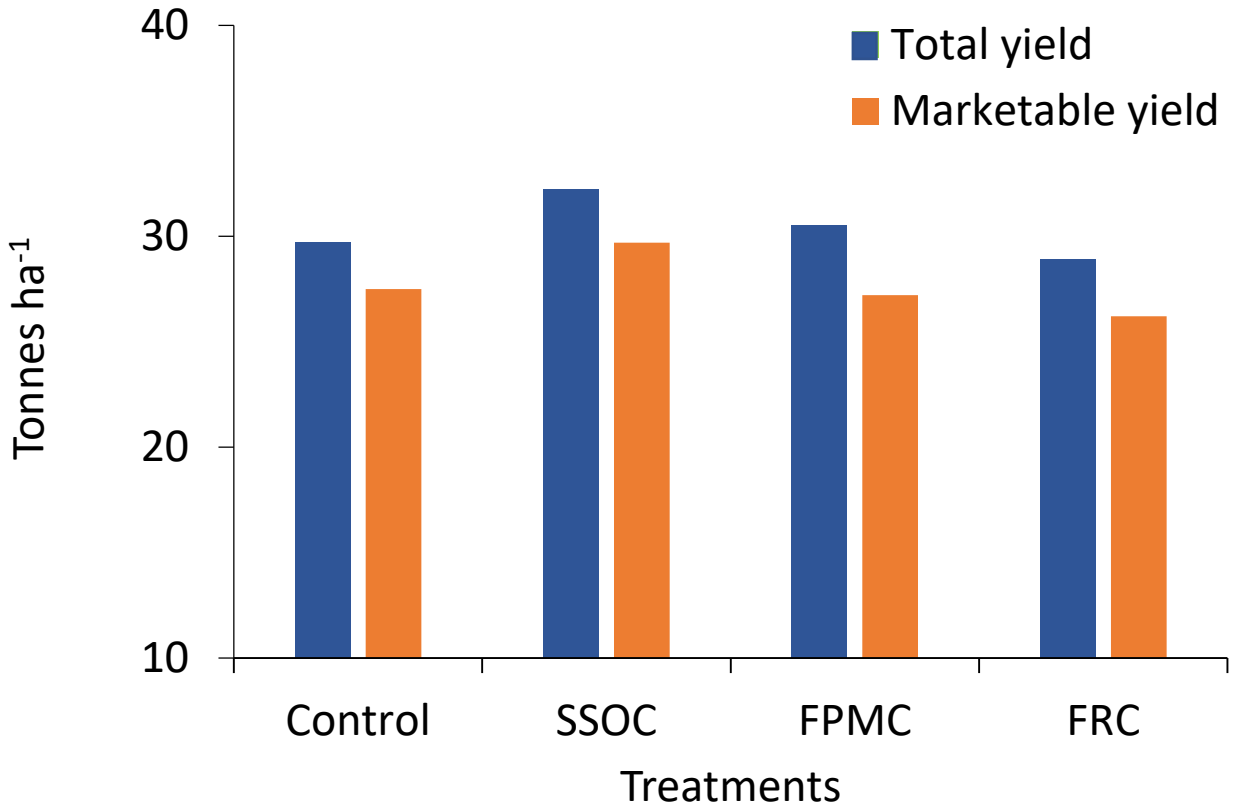




ANOVA ≤ 0.05

Results

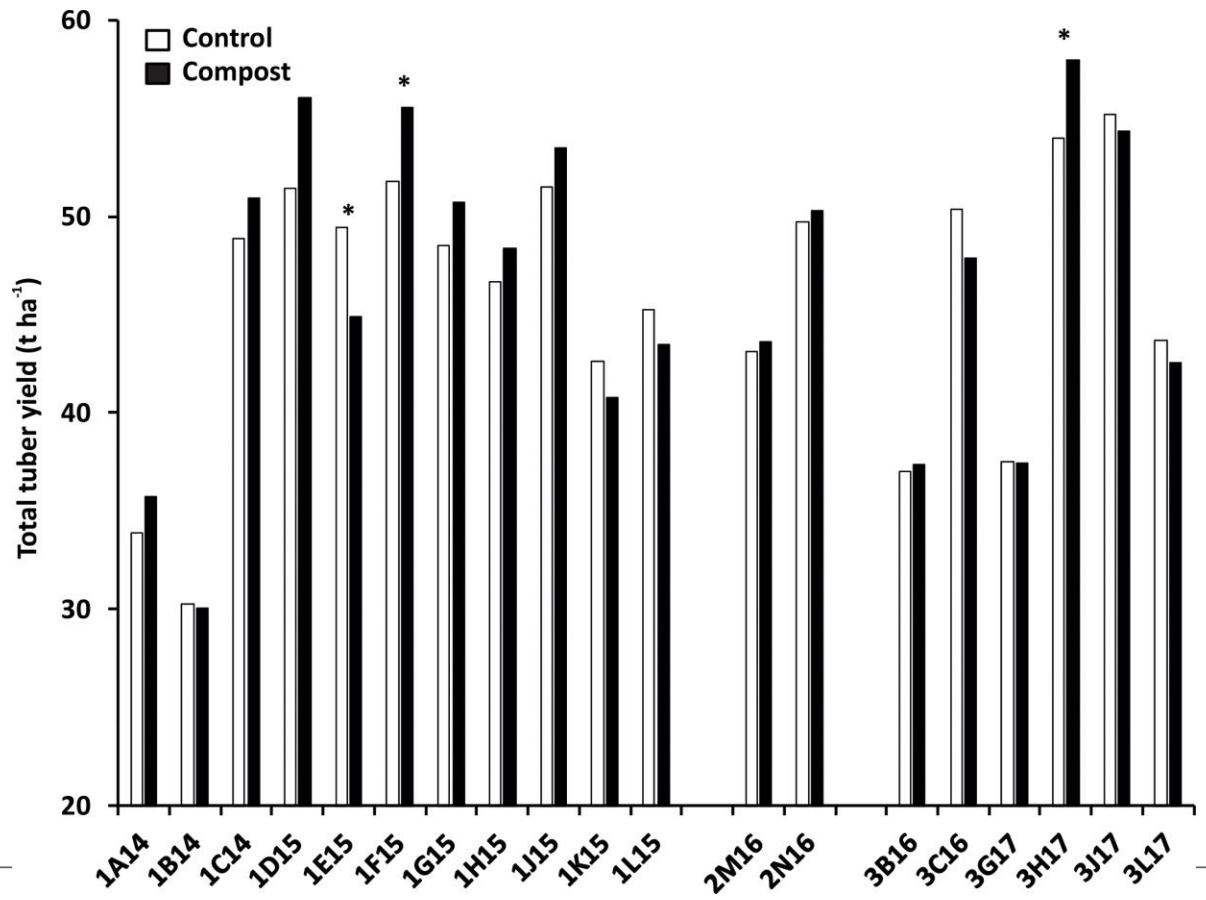
Compost application did not affect potato yield



Wilson et al. 2019. Am. Journal Potato Res.96:272–284

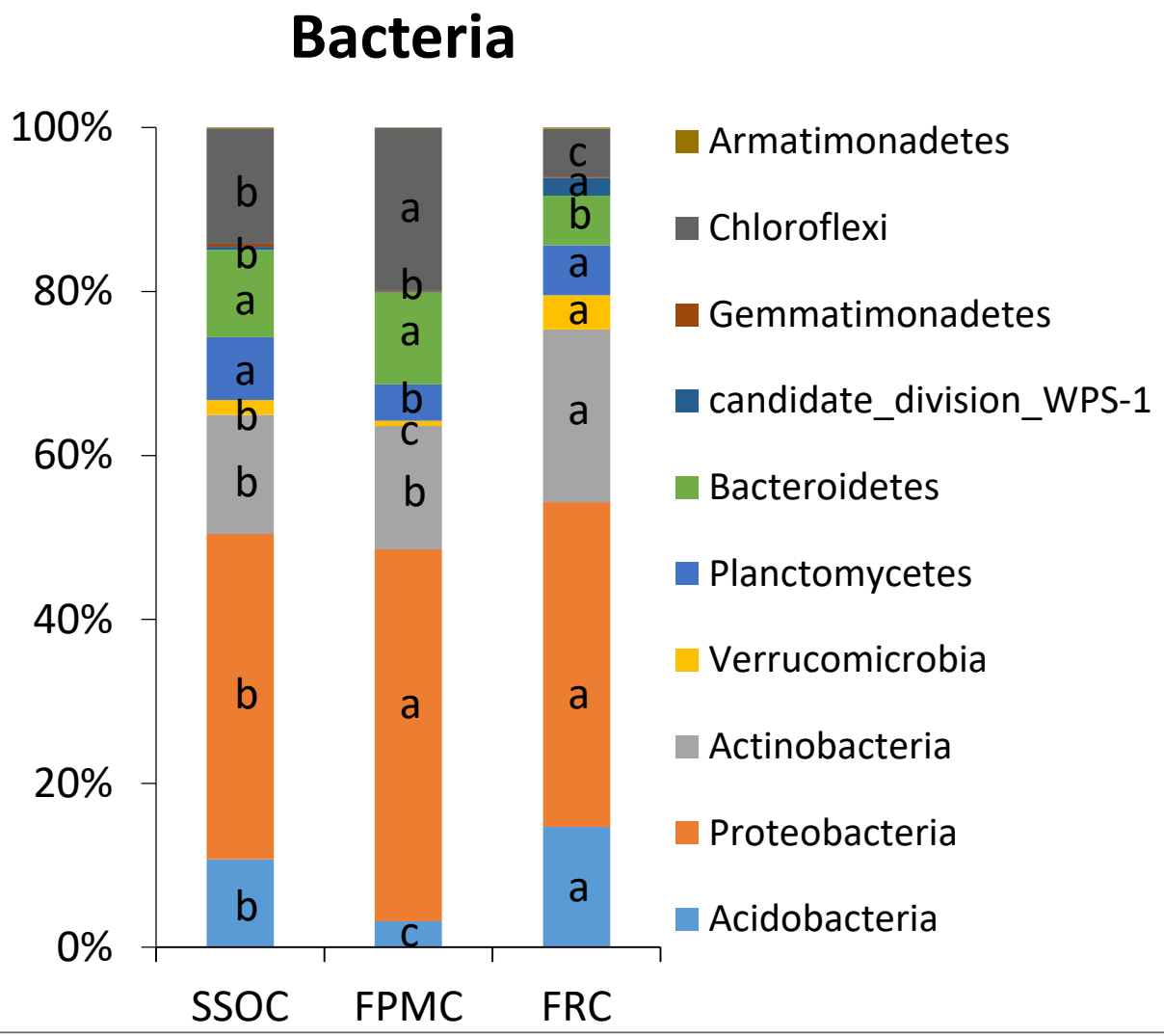
Results

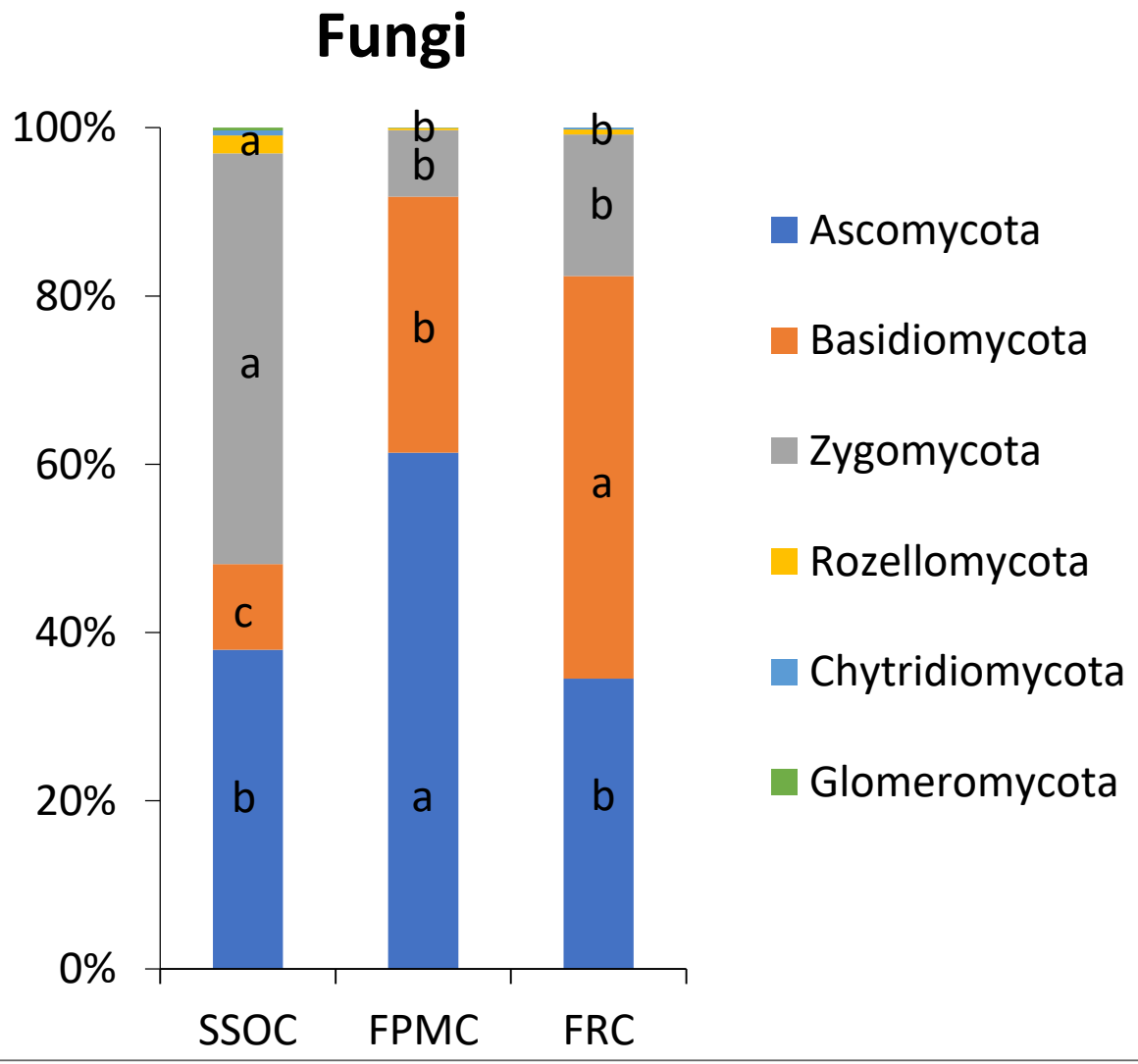
Potato yields in 19 site-years commercial potato fields in New Brunswick (Canada) with and without FPMC application



Wilson et al. 2019. Soil Sci. Soc. Am. J. 82:889–900

Results – Relative abundance of phyla in composts

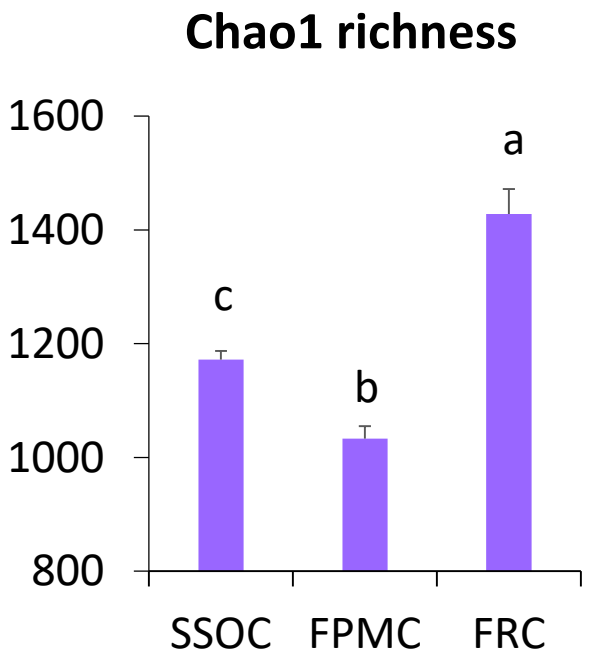


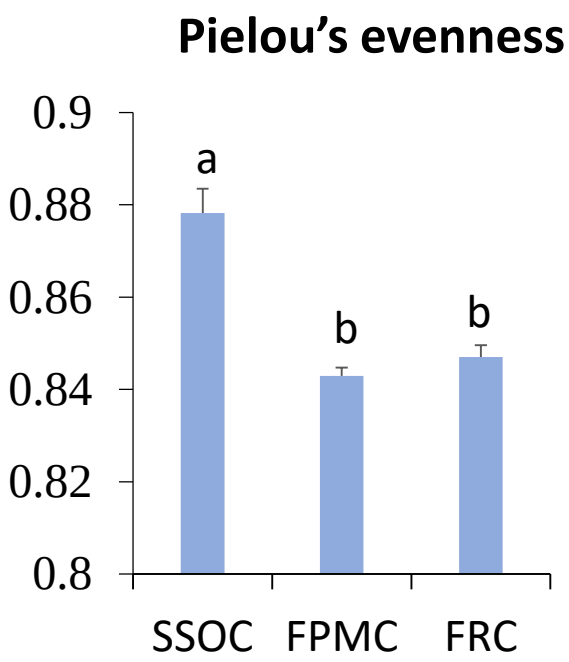


ANOVA ≤ 0.05

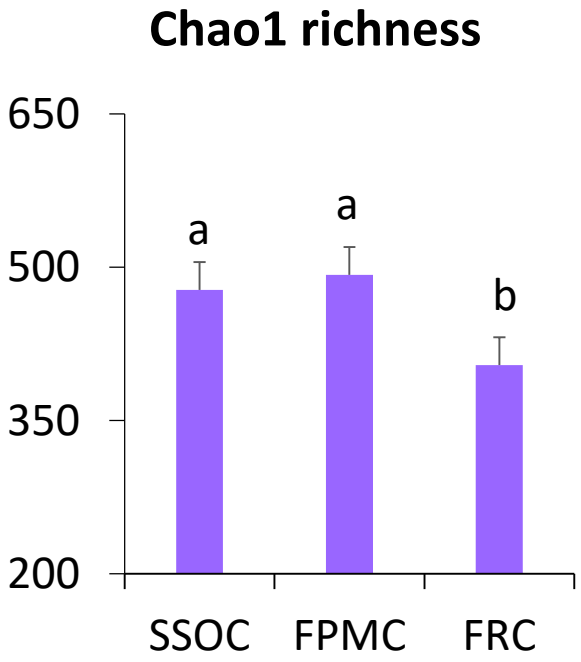
Results – biodiversity indices of composts

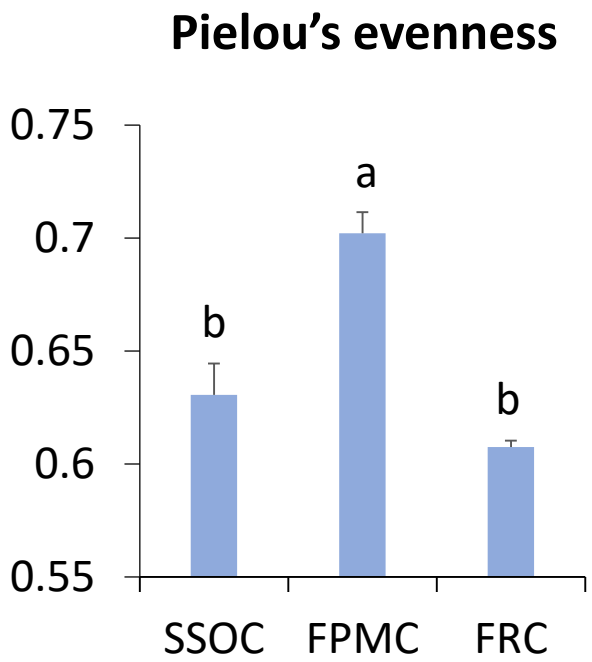
Bacteria





Fungi

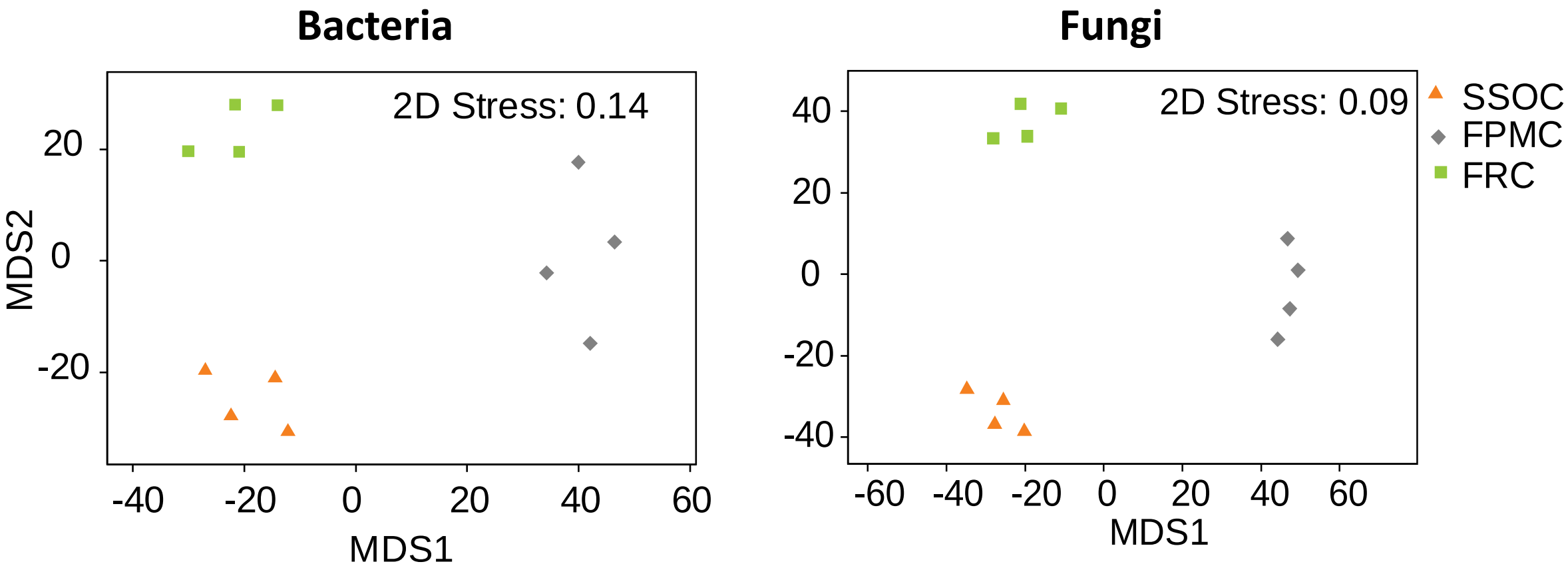




ANOVA ≤ 0.05

Results – Compost Microbiome

β-diversity using multidimensional scaling (MDS)

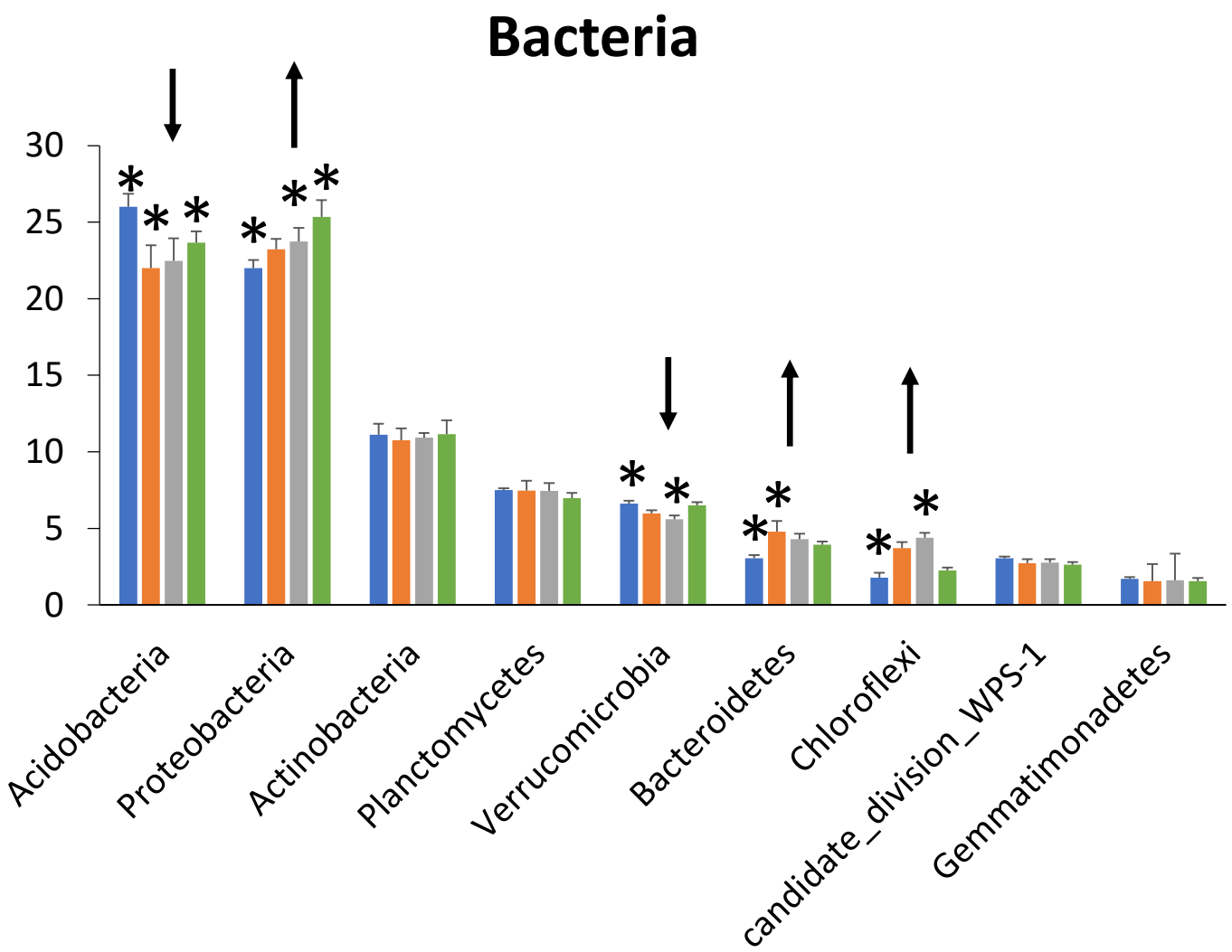


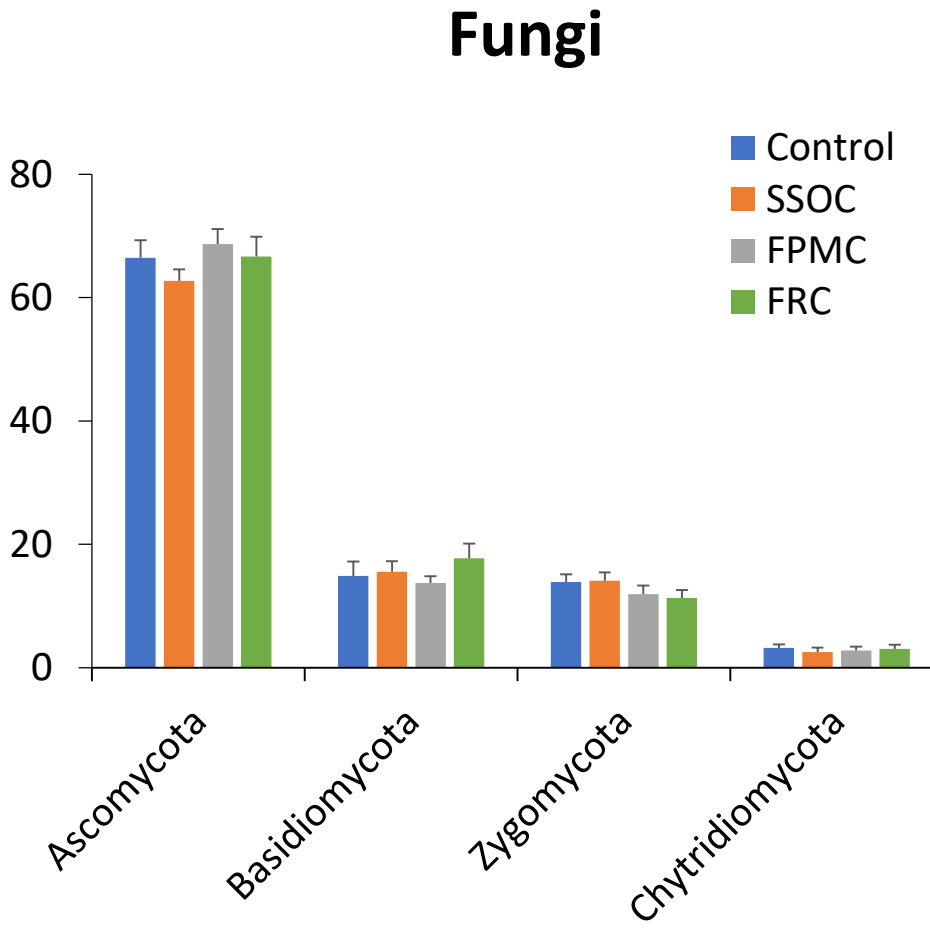
PERMANOVA p=0.004

PERMANOVA p=0.001

Results – Soil Microbiome

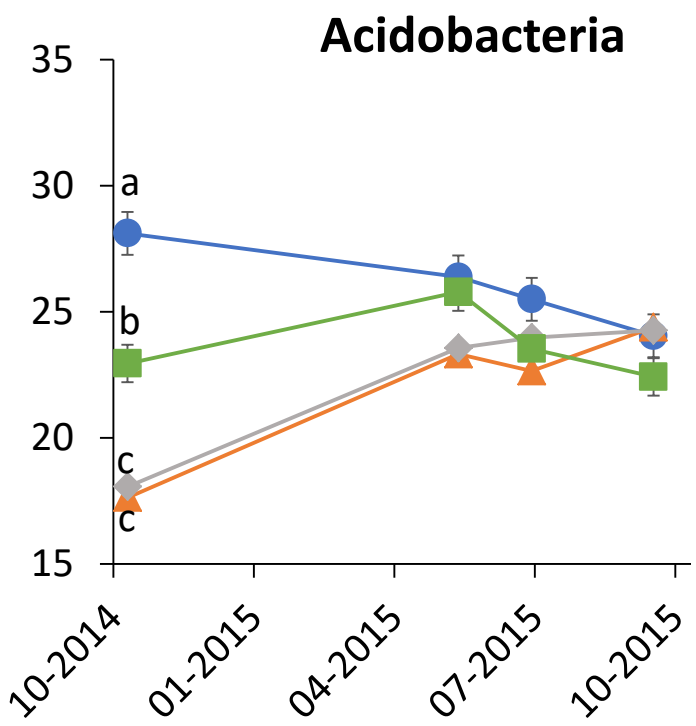
Relative abundance averaged over time (%)

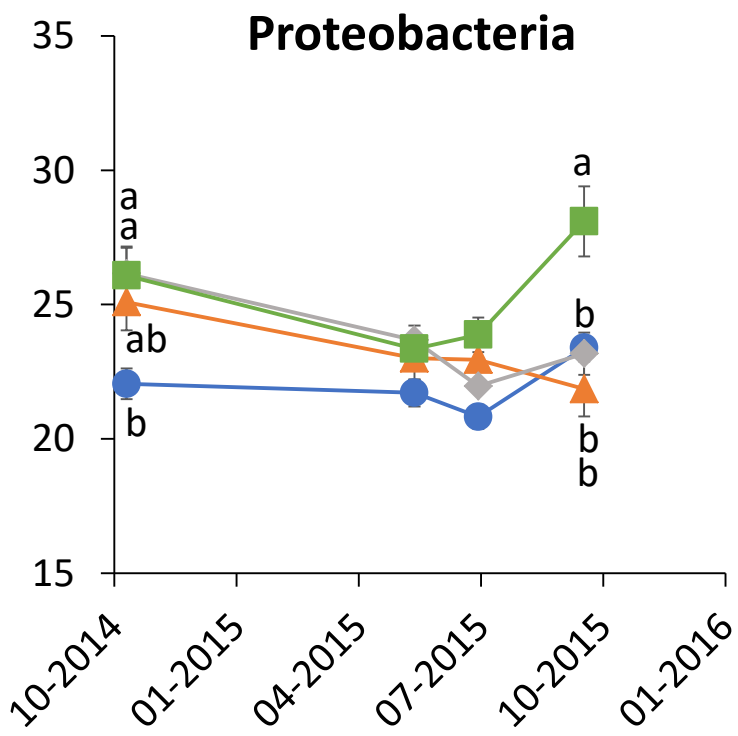


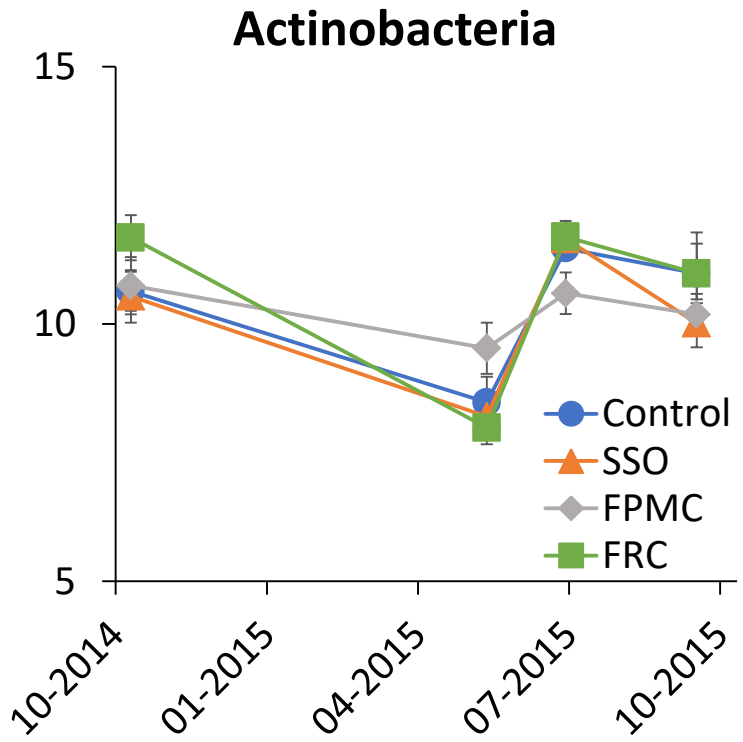


Results - Soils

Relative abundance (%)



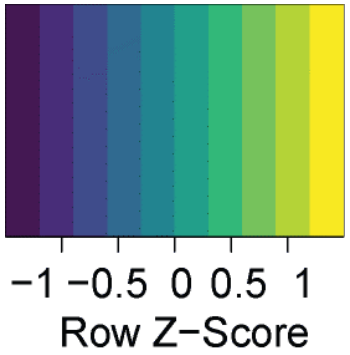




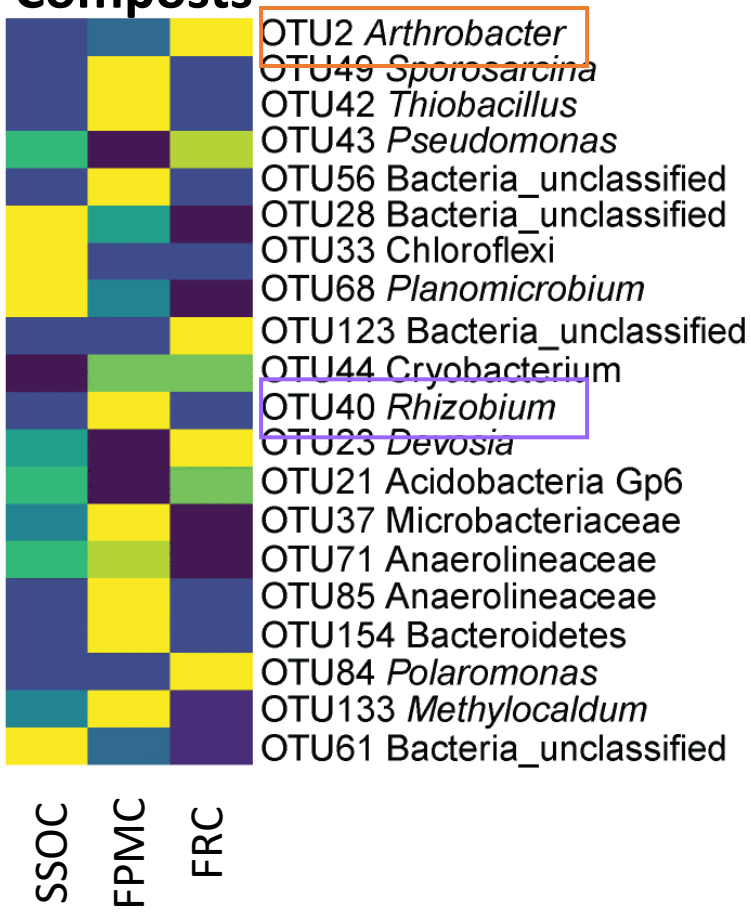
ANOVA ≤ 0.05

Results - Soils

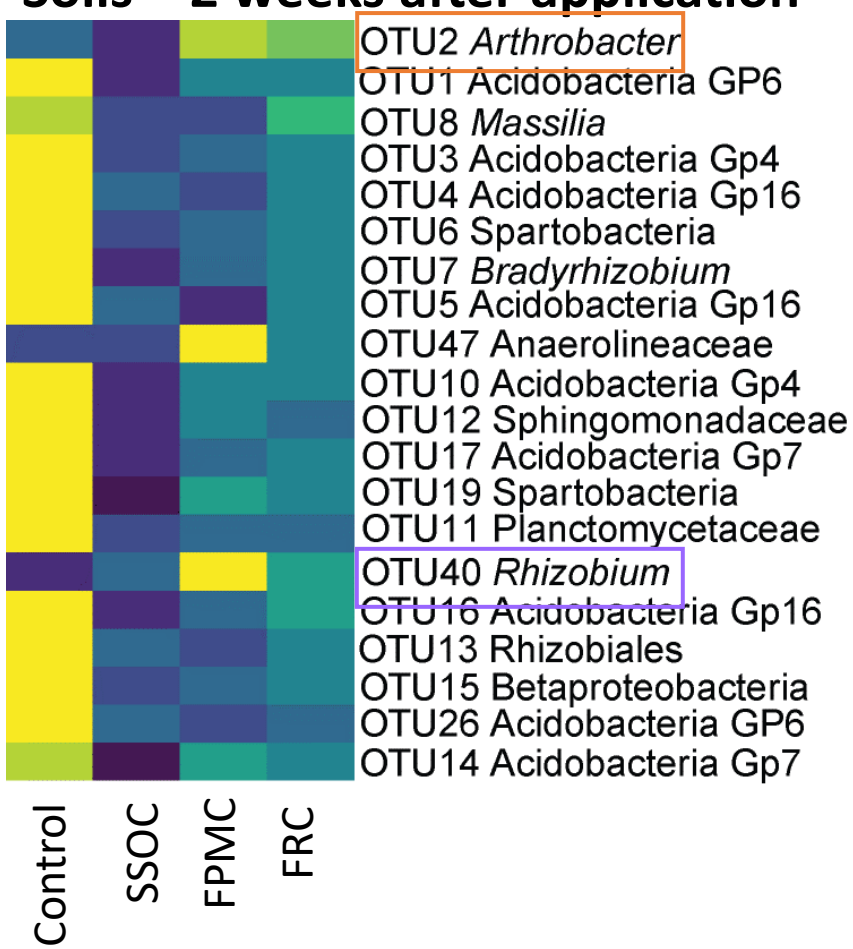
Relative abundance of bacterial species



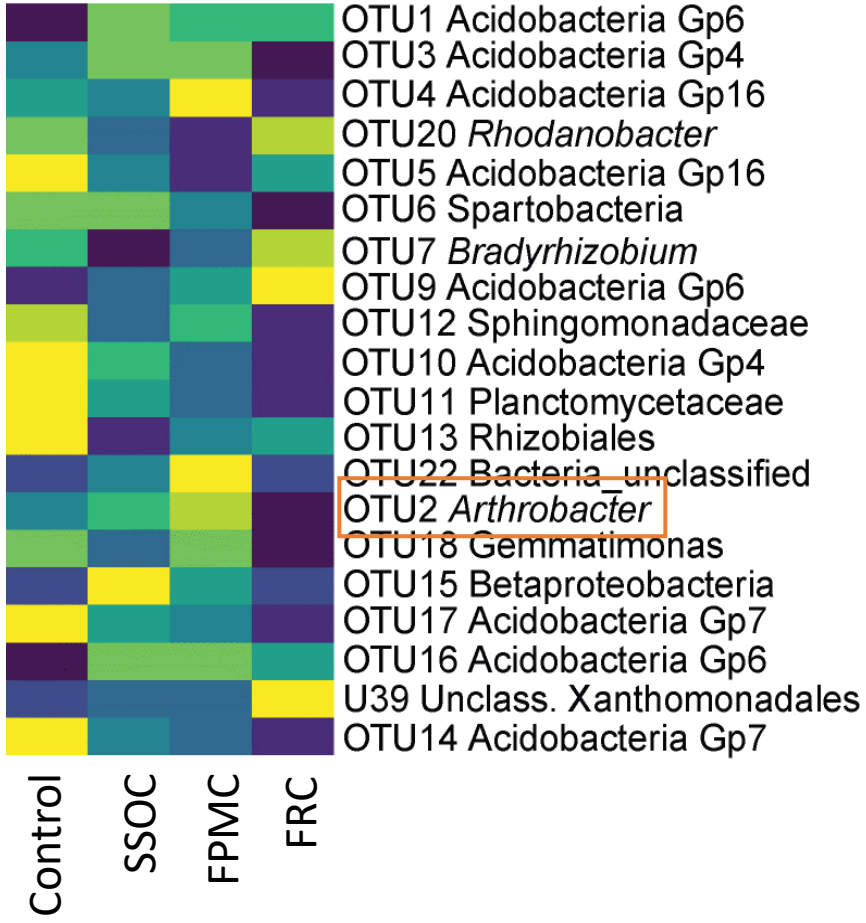
Composts



Soils – 2 weeks after application

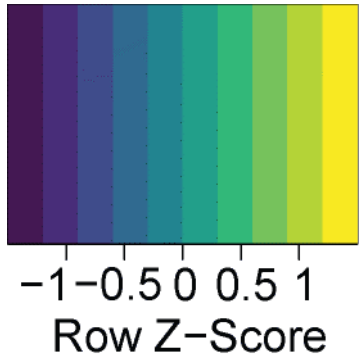


Soils – 11 months after application

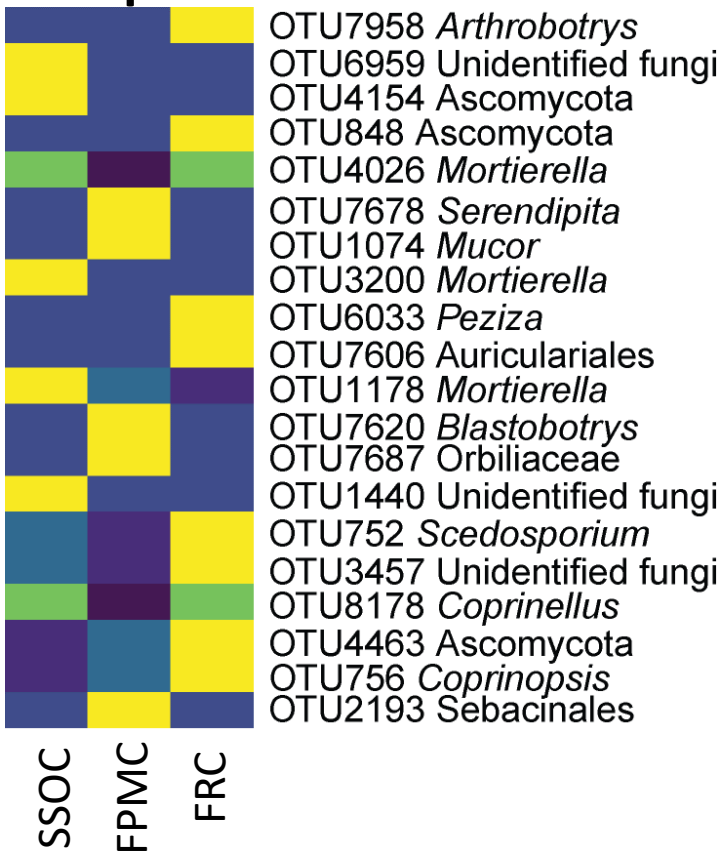


Results - Soils

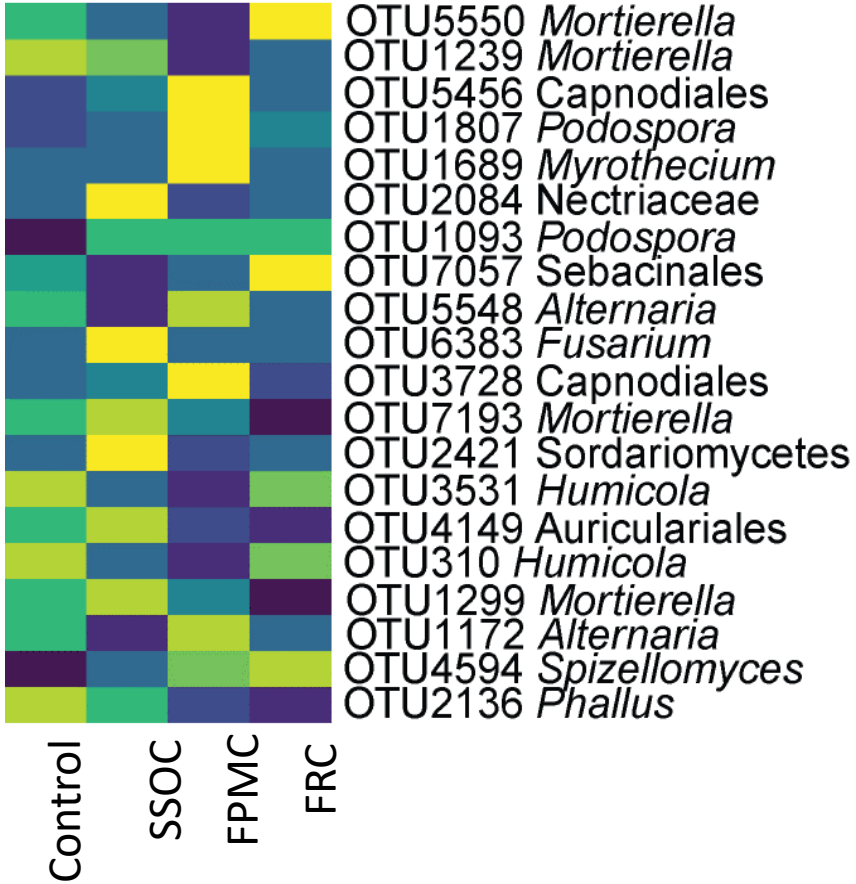
Relative abundance of fungal species



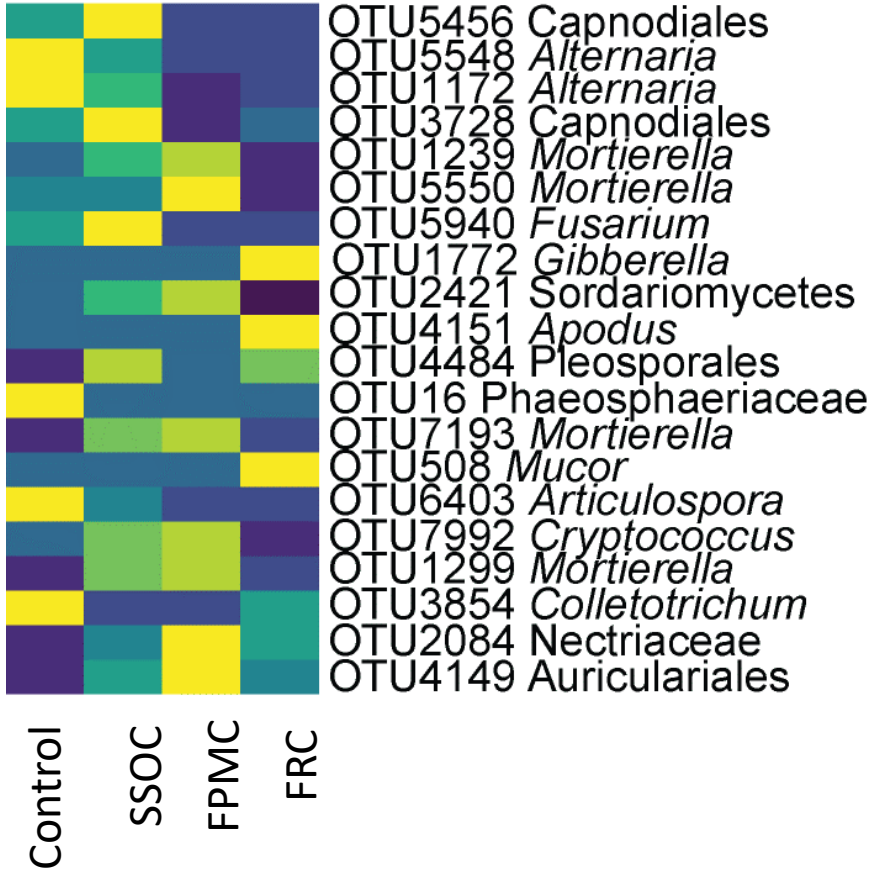
Composts



Soils – 2 weeks after application

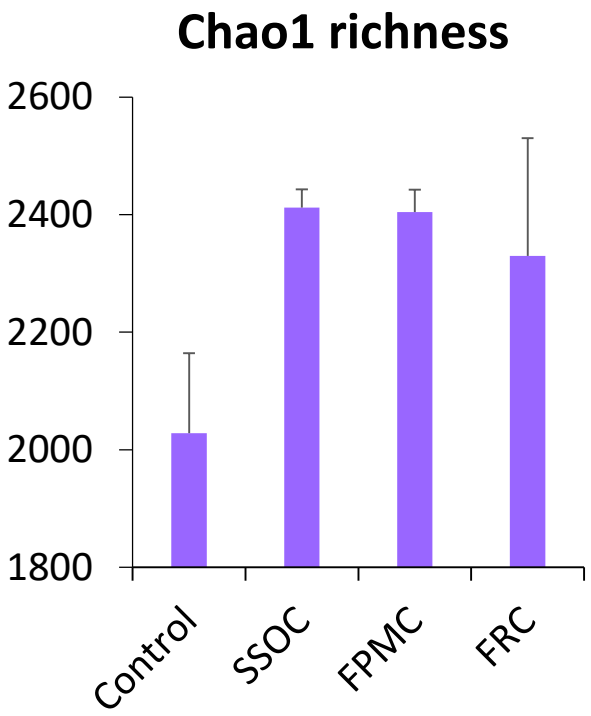


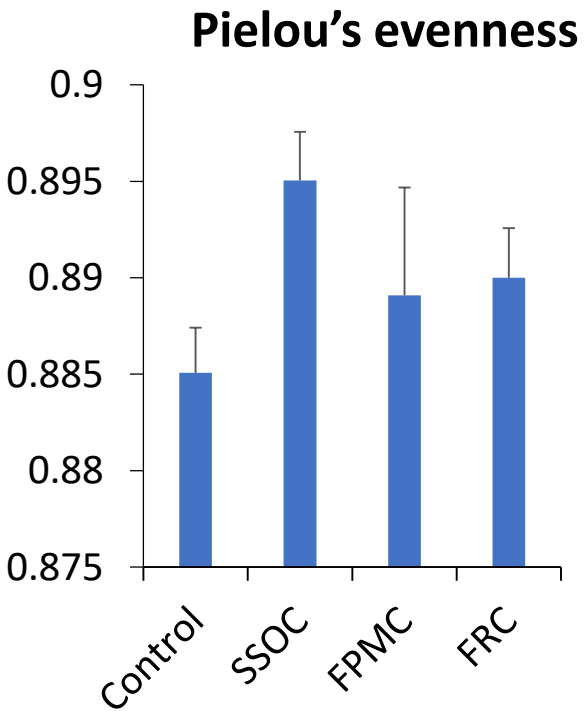
Soils – 11 months after application



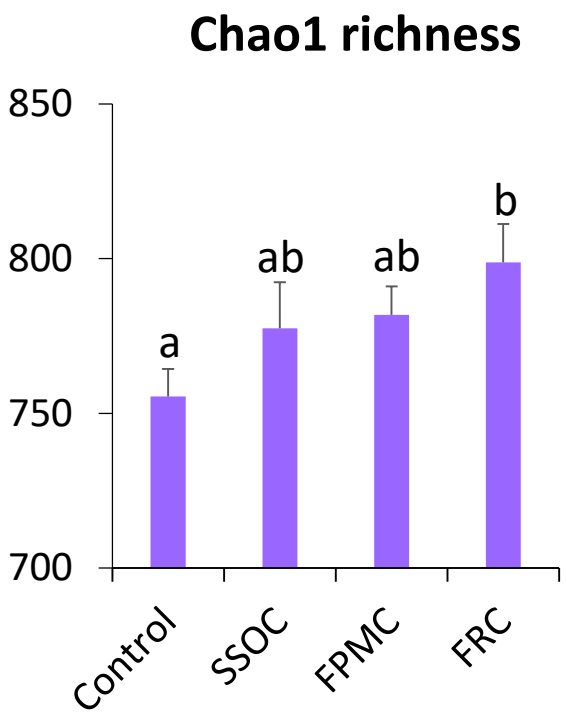
Results – biodiversity indices of soils

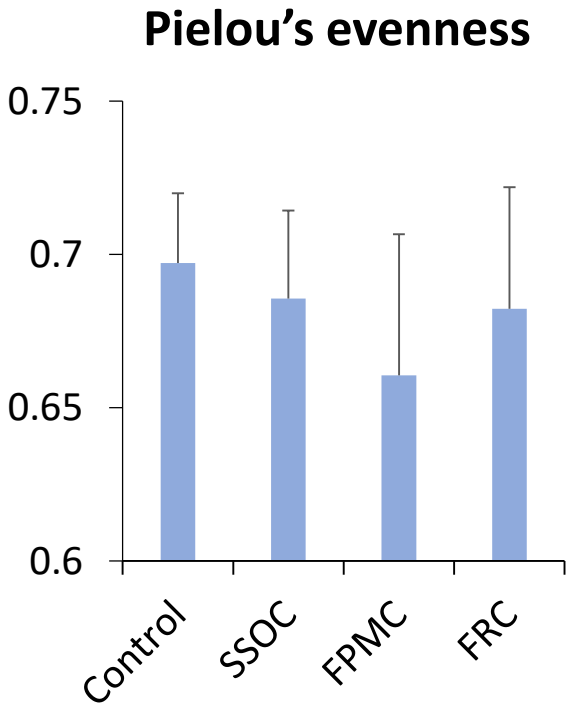
Bacteria





Fungi





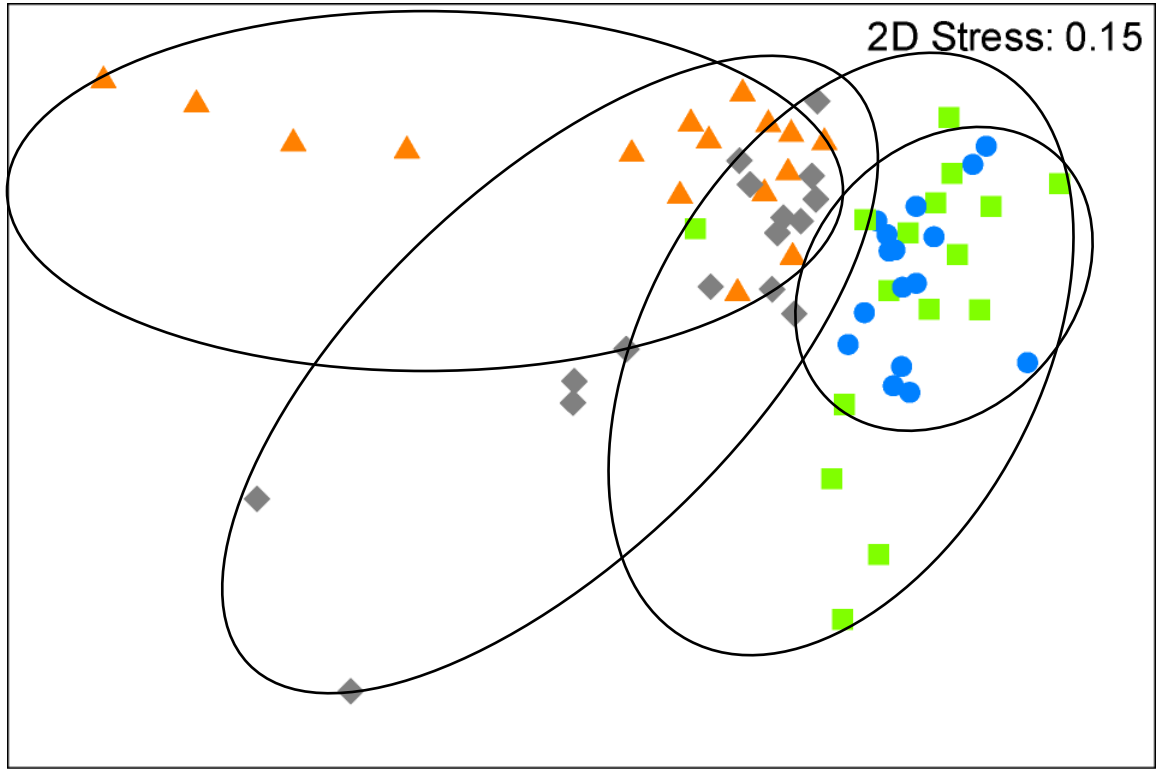
ANOVA ≤ 0.05

Results - Soils

β-diversity among treatments - nMDS

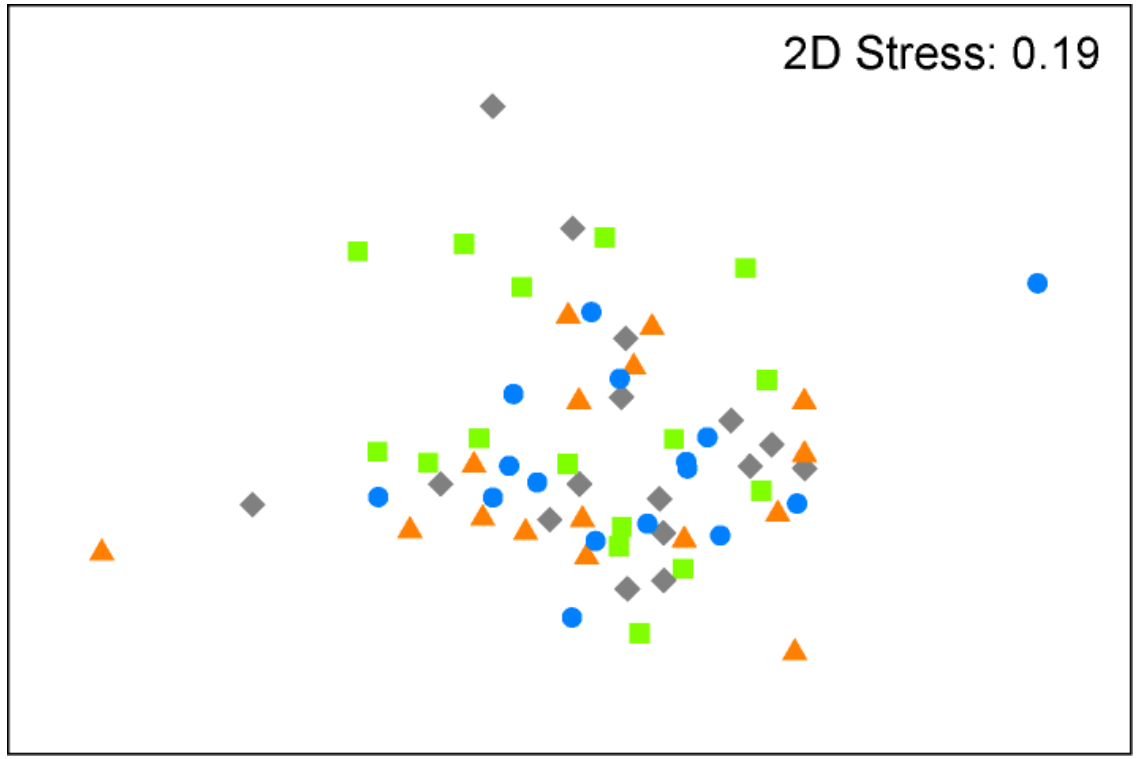
Control
SSOC
FPMC
FRC

Bacteria



PERMANOVA p=0.001

Fungi

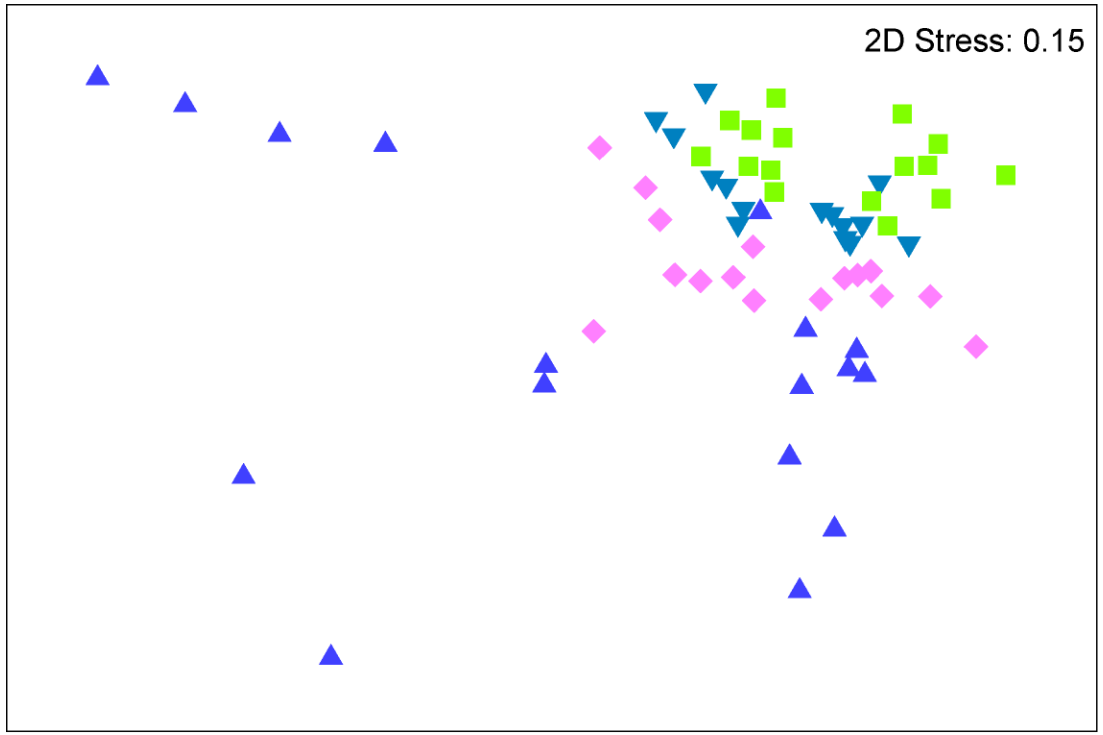


PERMANOVA p=0.001

Results

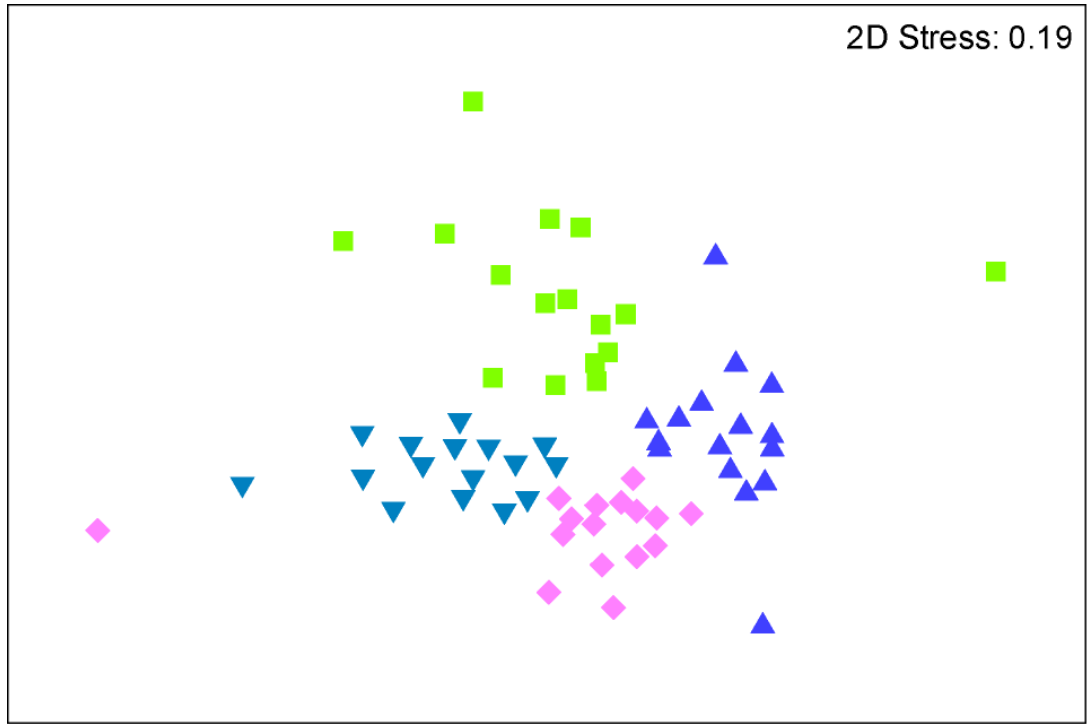
β-diversity over time - nMDS

Bacteria



PERMANOVA p=0.001

Fungi



PERMANOVA p=0.001

Conclusions

- Compost application changed soil structure, nutrient levels and affected different labile soil organic carbon fractions.

- Compost changed the relative abundance of bacterial phyla in soils but not on the relative abundance of fungal phyla.

- Compost application resulted in a change in the diversity of bacterial and fungal communities that could be observed in the next growing season.
- Compost application did not result in an increase in potato yield.
- Compost is a good option to remediate poor quality soil but adoption by growers is difficult due to cost and the low potential for short-term return on investment.

Acknowledgments

- Funding source: Agri-Innovation Program, Agriculture and Agri-Food Canada

- Collaborators: Dr. Bernie Zebarth, Dr. David Burton (Dalhousie University)

- Sean Whitney, Sara Neupane, Carolyn Wilson, Ginette Decker, Karen Terry, Kyle MacKinley

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Potatoes Pommes de terre NB NEW BRUNSWICK / NOUVEAU-BRUNSWICK CANADA

Composts

SSOC: organic curb-side waste composted in-vessel (Elmsdale Landscaping Inc.)

FPMC: windrow composting of poultry manure and wood shaving bedding, forestry wastes, paper mill residue, and wood ash (Brand RV045, Envirem Organics Inc.)

FRC: windrow composted predominantly from wood-waste feedstock including bark, paper mill residue, and wood-ash with approximately 5% broiler chicken manure (Black Earth, Envirem Organics Inc.).