Assessing Microbial Communities of Compost Extracts and Their Effects on Lettuce Growth after Residue Incorporation in Soil

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Background

- Compost extracts (CE) are suspensions of compost applied to plant surfaces and soil at low rates intended to supply microbial inoculum, rather than fertility.
- Many studies have shown poor colonization, or no effect of biological inoculation of soil.
- CE applied to fresh residues before tilling may affect microbial community structure and thus processing of residues and plant growth.
- **Is CE a useful intervention** to improve crop performance after soil incorporation of crop, cover crop, or biodegradable mulch?

Objectives

- Characterize biological and chemical properties of diverse compost extracts and define ranges of potentially meaningful dimensions.
- Reduce growth suppressive effects of Wood-Particle loaded Polylactic Acid (PLA) mulch and other high carbon residue.
- Enhance growth promoting effects of high nitrogen residues/green manures.

We Hypothesized:

Inoculating residues with compost extract containing more microbial predators (protozoa and nematodes) would increase lettuce growth across all residue treatments.

Methods

A battery of tests was used to define chemical and biological dimensions of CE made from 10 diverse composts: fatty acid methyl ester (FAME) analysis, nematode sugar centrifugation/ extraction, protozoa most probable number assay (MPN, Earthfort laboratory), microscopic counts for total bacterial and fungal indices, Soil MicroBIOMETER® colorimetric assay, and lettuce seed phytotoxicity bioassay.

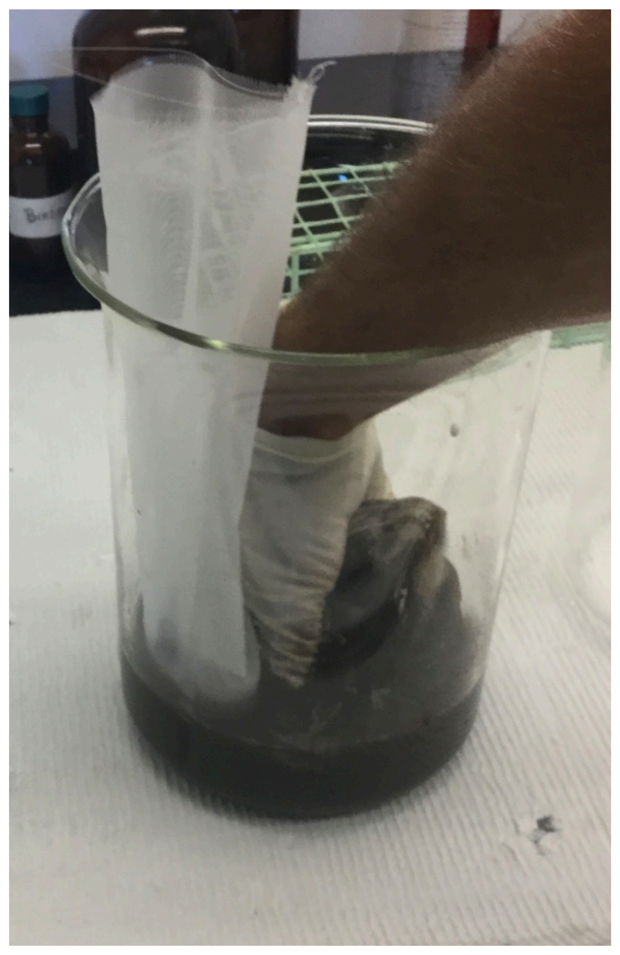


Figure 1: CE was prepared by kneading 100g dry equivalent mass compost in a 450um nylon mesh bag submerged in 1000mL total water.

Table 1. Composts , their origins, and their feedstocks, used to prepare CE

ID	Compost	Type	Feedstock
BD	Biosolids	Class B Biosolids	Anaerobicallly digested biosolids
MS	NPL Mushroom	Bagged	Spent mushroom media
BR	Big Red Worms	Local / Worm	Kitchen scraps, yard waste
EK	EKO	Bagged	Chicken bedding, wood
DJ	D. Johnson	Passive Aerated Static / Worm	Yard waste, cow manure
WW	Wiggle Worm	Bagged / Worm	Organic grain
SD	Soil Dynamics	Local Windrow	Yard waste, zoo poo, kitchen scraps
IN	ACN Innwood	Feedlot Windrow	Corn stover, cow manure
BW	Backyard Worm	Home Compost / Worm	Kitchen scraps, leaves, wood
MM	Mountain Magic	Bagged	Forest byproducts, cow manure

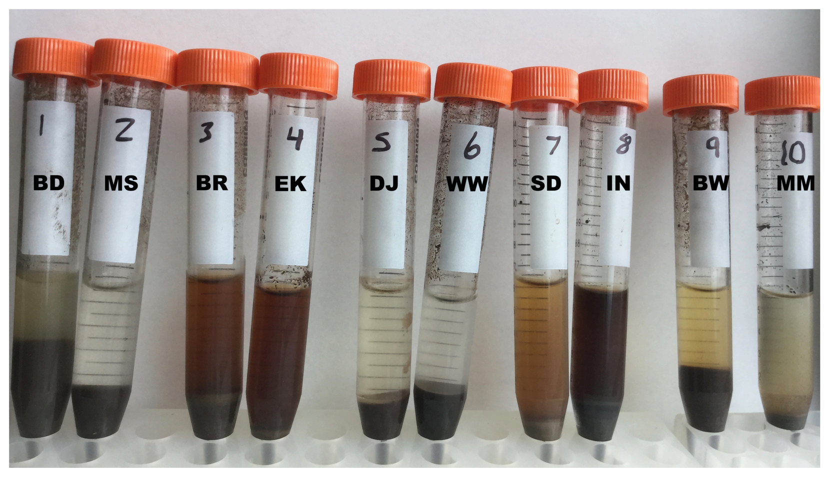


Figure 2: Color and turbidity differences of extracts are evident after settling.

In a 5 X 5 factorial RCBD **greenhouse experiment** with six replicates, CE treatments (EK,SD,BW,urea N control ,none) were applied to residues (alfalfa [11.2 Mg/ha], oat straw [4.5 Mg/ha], polylactic acid mulch loaded with wood particles (PLA) [3.8 Mg/ha], geotextile, none) at 3.36kg N/ha, which were incorporated into a steam pasteurized sand/soil/peat/vermiculite blend in 4” square pots. Lettuce was sown two weeks after incorporation. Soil nitrate and above-ground dry weight was measured 42 days after planting.

- CE treatments were standardized to supply 3.36 kg/ha total N. And sprayed on residue to mimic pre-tillage spraying.
- Geotextile is positive control for physical properties of residue
- Statistical analysis was completed in RStudio 1.1.383 using packages ‘dplyr’, ‘DoBy’ and ‘gmodels’.

Table 2. Residues C and N composition, and total N rate applied to pots

Residue	Carbon (%)	Nitrogen (%)	C/N	Total N addition (kg/ha)
Alfalfa	3.08	43.97	14.3	344.9
Oat Straw	0.78	43.15	55.3	35.1
Wood fiber loaded PLA	0.05	47.72	954.4	1.9
Polypropylene Geotextile	-	-	-	

Results

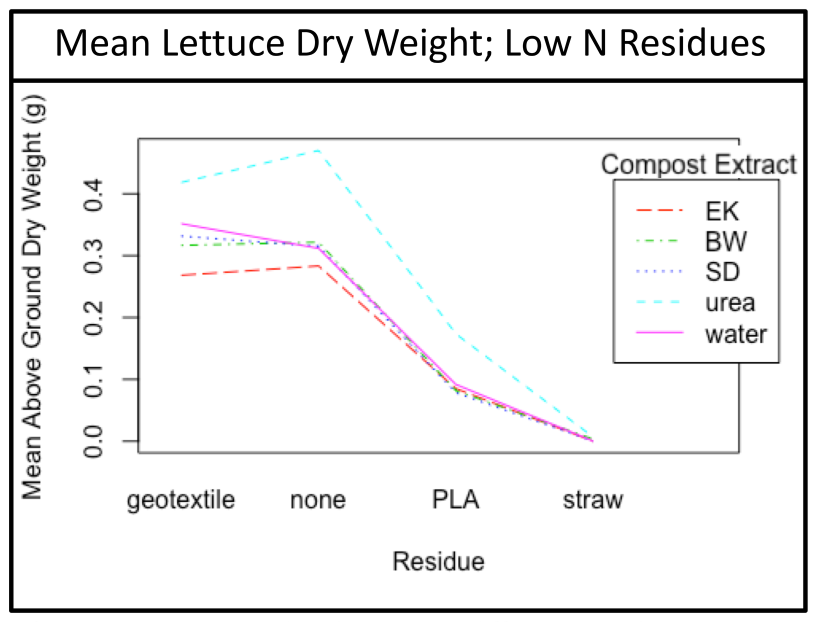


Figure 3: Interaction plot showing no differences in lettuce growth between CE treatments and water across the different high C:N, and control residues. A contrast across all low N residue treatments shows that the positive growth effect of the urea positive control is significant

Figure 4: One of six blocks in the greenhouse study. Dramatic main effects of the residue treatment factor are evident.

Table 3. Results of FAME, light microscope counts, MicroBIOMETER®, nematode extraction and MPN.

ID	Total FAMEs	Microscope Total Microbial Biomass	MicroBIOMETER® Total Microbial Biomass	Bacterial FAMEs	Microscope Bacteria	Fungal FAMEs	Microscope Fungi	Total Nematodes	Feeding group	Microscope Flagellate protozoa**	MPN Flagellate protozoa	Microscope Amoebae**	MPN Amoebae
	(nmol/mL)	(ug/mL)	(ug/mL)	(nmol/mL)	(ug/mL)	(nmol/mL)	(ug/mL)	(#/100mL)	%B/%F/%P*	(#/mL)	(#/mL)	(#/mL)	(#/mL)
BD	65.7	-	476	37.3	-	2.8	-	711.6	100/0/0	-	-	-	-
MS	12.3	2,997	158	7.5	2,937	2.1	55.5	1.4	100/0/0	5,715	-	0	-
BR	13.3	872	352	6.3	839.1	1	17.5	15.5	90/10/0	0	-	0	-
EK	9.2	413	910	6	400.3	0.7	0	0	-	0	138.6	0	42,635
DJ	10.7	650	507	4.8	376.2	0.6	272.4	1.4	0/100/0	4,018	-	16,073	-
WW	6.5	718	1,054	3.7	622.4	0.3	78.5	1.4	100/0/0	0	-	0	-
SD	12.1	2,422	236	7	2,331.4	0.9	80.4	4.2	67/33/0	0	46	0	4,606
IN	31.6	-	1,467	22.7	-	1.8	-	0	-	-	-	-	-
BW	23.2	4,296	552	12.1	3,508.3	2.2	750.7	54.8	10/89/1	31,778	5,753.6	74,148	460,600
MM	7.4	-	490	4.4	-	0.7	-	0	-	-	-	-	

*Results of FAME, light microscope counts, MicroBIOMETER®, nematode extraction and MPN. **only active protozoa counted, MPN detects dormant forms.

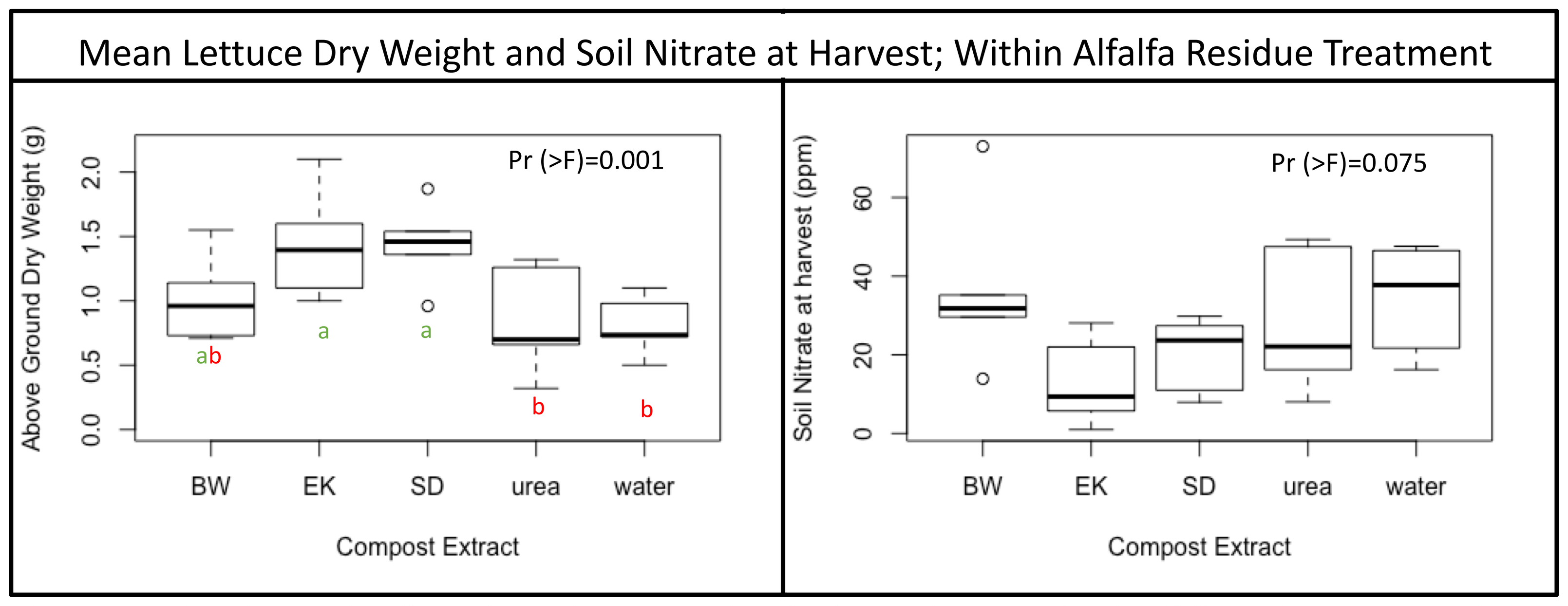
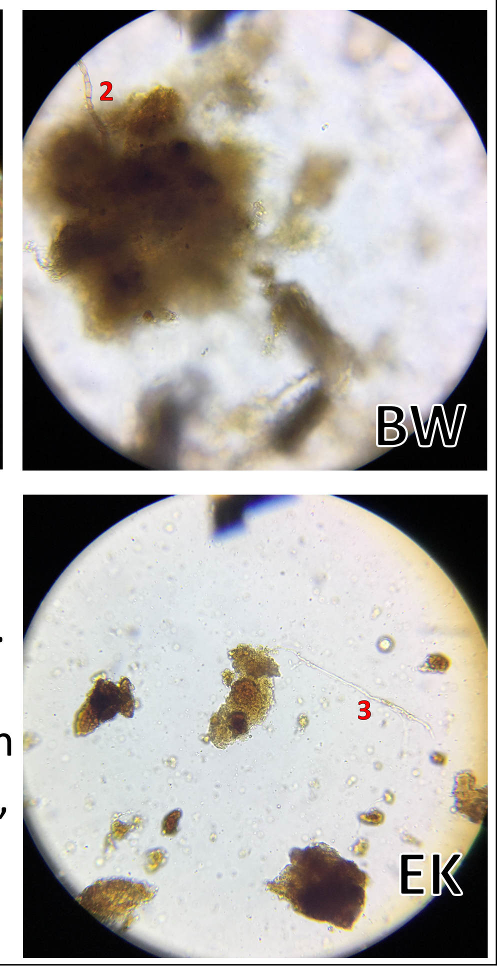


Figure 5: Boxplots showing the effects of CE on lettuce growth and soil NO_3 at harvest within the alfalfa residue treatment only. Statistical analysis was performed on this data as if the alfalfa was a separate experiment as the assumption of equal variability among treatments did not hold up across residues. Colored letters in the left plot represent significant differences at p=0.05. The F test did not reject at the p=0.05 level for soil NO_3 at harvest, but the trend for NO_3 is opposite the trend for above ground dry weight.



The microscope reveals qualitative differences that are difficult to code. Total microbial biomass has poor agreement with FAME assay (R^2 = 0.6741, Table 3.)

Figure 7: 400x, undiluted CE. 1-mineral particles 2-colored fungi 3-hyaline fungi

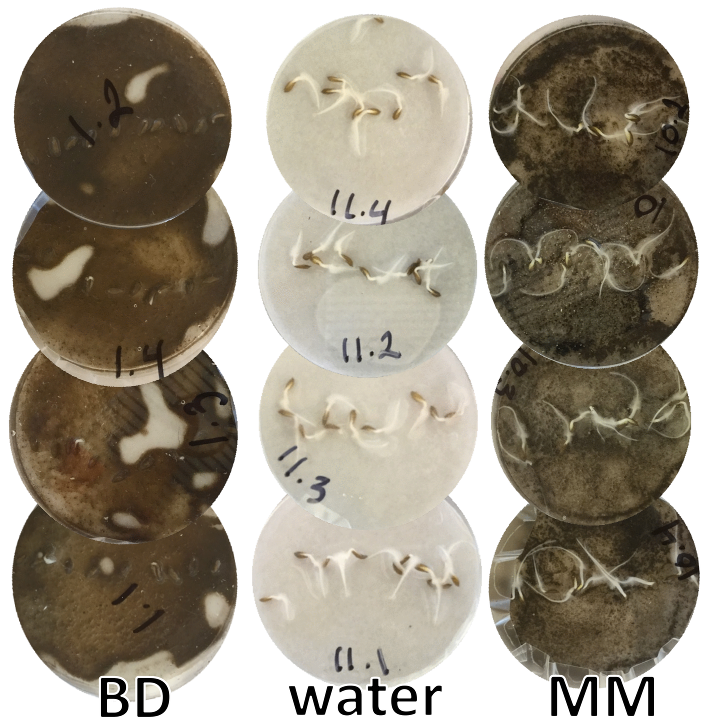
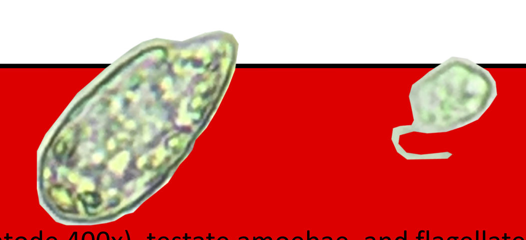


Figure 6: Phytotoxicity bioassay. Lettuce seeds germinated on CE saturated filter paper after two days of growth.

- Several CE’s cause more rapid radicle elongation (MM, BR, DJ) compared to water. BD and IN were suppressive to germination, apparently due to excessive NH_4-N (data not shown).

Discussion

- CE varies widely in microbial composition (Table 3)
- Different methods do not detect similar trends in bacterial, fungal, or total biomass. (Table 3)
- CE fails to improve lettuce growth in nutrient limited soils or soils with fresh high carbon residue.
- The positive N control (urea 3.36 kg N/ha) probably increased growth compared to CE in low N residue treatments because most N in CE is organic N (Figure 3).
- CE influenced lettuce production when applied to high N residue, apparently by affecting N transformations during microbial processing of high nitrogen residues (Figure 5).
- Presence of microfauna does not predict positive growth effects of CE.
- **CE applied to fresh high N residues at 5660-5130 L/ha may be a meaningful biological inoculation**, but it is unclear which microbial assessments will be useful to predict whether a specific CE will have effects.



Peladera sp. from BW (nematode 400x), testate amoebae, and flagellate amoeba