

Effects of field management practices on plant health and rhizosphere microbial community structure

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1. Abstract

Farming practices can have profound effects on soil properties including physical, chemical and biological characteristics. In this study, we characterized the influence of soil management practices on soil borne disease suppressiveness and soil microbial population structure in an organic cropping system. Four transitional management strategies, with and without compost amendments, were considered: mixed hay (H), tilled fallow (F), open-field vegetables (V) and high tunnel vegetables (HT). The effects of compost addition (+C) on soil characteristics varied with transition strategy, with the greatest effects being observed in the soils coming from the mixed hay and high tunnel treatments. The effects of treatments on disease suppressiveness were assayed in growth chambers. Soil from the mixed hay treatment was more suppressive. Compost additions altered disease suppressiveness and microbial community structure to a limited extent. Microbial populations were studied through culture-independent strategies. Terminal restriction fragment length polymorphism (T-RFLP) analyses revealed that different transition strategies were characterized by distinct bacterial populations on both crops. The association between suppressiveness and these terminal restriction fragments (TRF) is being used to identify novel bacteria involved in disease suppression.

2. Introduction

- > Different management practices can be used during the transition from conventional to organic agricultural systems.
- > Farm management practices have significant impact on soil characteristics, including soil microbial populations.
- > Disease-suppressive soils are soils in which natural microbial populations protect plants from soil-borne pathogens.
- > The objective is to determine the impact of management practices on soil borne disease suppression, and related microbial populations, during the transition from conventional to organic farming.

3. Methods

The Peri-Urban Field:



- Soil analysis: plot sampled in spring and fall 2004 for chemical analysis.
- Disease suppression assay: tomato cv. Tiny Tim and soybean cv. Sayasume, ± oomycete pathogens incubated in growth chamber.
- Bacterial community profile: TRFLP of eubacterial 16S rDNA from soil and rhizosphere. TRF selection: ≥ 200 fluorescence units and present in ≥ 60% samples for a treatment. Precision ± 1nt for TRF ≤ 300 bp, ± 2nt for TRF ≥ 300 bp.

4. Results

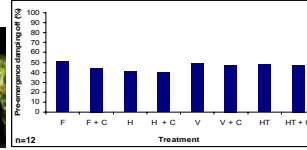
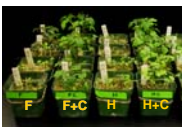
4.1. Soil characteristics

Treatment	Nutrients (ug/g)																	
	pH	N%	C%	P	K	Ca	Mg	Mn	Zn									
F	6.1	f	0.1	c	1.0	d	42	d	88	e	998	f	191	g	185	d	4.6	d
F+C	6.6	d	0.2	b	1.6	c	91	c	219	d	1374	d	249	e	196	cd	5.7	c
H	6.4	e	0.1	c	1.2	d	38	d	81	e	1243	de	188	g	208	bcd	4.1	d
H+C	6.7	d	0.2	b	2.3	b	127	b	327	b	1850	b	332	b	191	cd	10.1	ab
V	6.5	e	0.1	c	1.0	d	40	d	93	e	1175	e	220	f	215	b	3.5	e
V+C	6.9	c	0.2	b	1.7	c	121	b	282	c	1575	c	308	c	202	bcd	6.7	bc
HT	7.0	b	0.1	c	1.1	d	47	d	84	e	1539	c	290	d	239	a	4.0	e
HT+C	7.2	a	0.3	a	3.4	a	222	a	2328	a	589	a	589	a	198	bcd	14.9	a

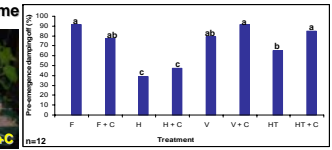
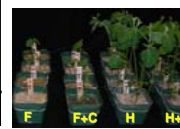
- > Soil carbon and mineral nutrient content increased with compost application
- > Compost application effect was greater in high tunnel vegetables transition strategy

4.2. Disease Suppressiveness assay: Suppression of damping-off

Tomato cv. Tiny Tim



Soybean cv. Sayasume



- > For both crops, hay treatment reduced percent damping-off regardless of compost application.
- > For soybean, a trend towards increased damping-off by compost application is observed except for tilled fallow treatment.

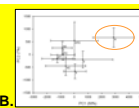
4.3. Microbial community analysis: Eubacterial communities profiles

A. Mean relative abundance of individual and combined* terminal restriction fragments (TRF) associated with bulk soil and rhizosphere fractions, expressed as peak fluorescence intensity. **B.** Ordination plots of principal component analysis (PCA) generated from peak fluorescence intensity data of selected TRF. **C.** Correlation coefficients of individual TRF with first two principal components. *Peak fluorescence intensity of TRF with correlation coefficients over 0.75 were combined in A.

Tomato cv. Tiny Tim

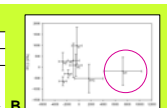
Bulk soil - Msp I

Treatment	TRF				
	139	141	148	150	148+150
F	246 cd	35 d	3614 a	1753 a	5366 a
F+C	70 cd	313 c	2952 a	847 a	3799 a
H	991 a	1610 a	5932 a	2436 a	8368 a
H+C	251 bc	496 bc	2952 a	612 a	3564 a
V	638 b	424 c	4069 a	1793 a	5862 a
V+C	0 d	209 c	3094 a	1262 a	4355 a
HT	0 d	0 d	2658 a	624 a	3282 a
HT+C	424 b	1025 b	3622 a	1019 a	4641 a



Rhizosphere - Msp I

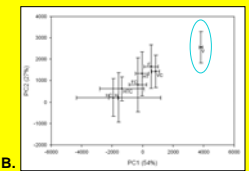
Treatment	TRF		
	141	148	148+151
F	0 e	1140 d	1422 d
F+C	857 d	849 d	1082 d
H	2248 ab	2862 b	3323 bc
H+C	1439 bc	2431 bc	3152 bc
V	584 d	1862 c	2262 c
V+C	1343 cd	2946 b	3554 b
HT	3481 a	10071 a	12897 a
HT+C	1449 bcd	4964 b	6606 b



Soybean cv. Sayasume

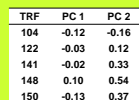
Bulk soil - Msp I

Treatment	TRF										
	103	127	137	141	204	302	401	490	494	490+494	137+141+148+150+151
F	278 b	1006 a	187 c	340 b	0 cd	380 a	651 ab	1664 b	2185 b	3850 ab	4727 a
F+C	134 c	778 b	177 c	234 b	57 bcd	131 bc	581 bc	1399 ab	1201 bc	2600 ab	4154 a
H	145 c	213 cd	1321 a	1384 a	278 b	57 bc	1023 a	193 e	0 e	193 d	10768 a
H+C	29 c	0 e	622 b	947 a	0 d	0 c	162 d	204 de	0 e	204 d	5923 a
V	69 c	1015 a	251 c	435 b	2242 a	51 bc	339 c	4074 a	3597 a	7670 a	6044 a
V+C	99 c	379 bc	274 c	356 b	435 a	61 bc	294 c	1628 bc	2400 bcd	4028 b	4948 a
HT	199 c	361 bc	320 c	150 b	291 bc	55 bc	86 d	1409 bc	1505 cd	2913 bc	4651 a
HT+C	491 a	118 d	93 c	231 b	351 bcd	355 a	310 c	730 cd	451 de	1182 c	2651 a



Rhizosphere - Msp I

Treatment	TRF		
	104	122	141
F	0 b	0 b	1091 b
F+C	111 b	206 b	311 de
H	0 b	0 b	2174 a
H+C	0 b	0 b	487 cd
V	0 b	65 b	582 cd
V+C	0 b	516 a	642 bc
HT	0 b	902 a	1169 b
HT+C	410 a	352 a	0 e



- > Transition strategy influenced the relative abundance of individual TRF associated with bulk soil and rhizosphere fractions of tomato and soybean.
- > Dominant TRF differ in relation to transition strategy; different TRF significantly associated with hay, field vegetables and high tunnel systems, were identified for both soil and rhizosphere communities of both crops.
- > TRF contributing to variation and differentiation of treatments by PCA not necessarily correspond to individual TRF associated to treatments.

5. Conclusions

- > Transition strategy influenced soil chemistry and soil disease suppressiveness capacity.
 - For edamame soybean, damping-off suppressiveness was greater in hay treatments, while tilled fallow soils did not significantly suppress disease.
 - A trend towards greater disease suppressiveness was observed in hay treatments for tomato.
 - In general, for all treatments, compost application led to lower soybean stand in these assays.
- > Transition strategy and compost amendment influenced eubacterial community structure.
 - Specific TRF associated with transitions strategy represent candidate member(s) of the eubacterial community involved in disease (e.g. M204 soybean-soil) or disease suppression (e.g. M141 in all).
 - One TRF (M141) consistently associated with soil from hay treatments in both experiments.
 - Further characterization of selected TRF is underway to identify bacterial strains associated with each transition strategy.