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CONTROLLING SOIL-BORNE DISEASES BY COMPOSTS

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Abstract:

Controlling soil-borne diseases is crucial for farmers because these pathogens can persist in the soils for a long time due to their form of resistance, and are able to stay on the crop residues.

To fight against the presence of these pathogens, research in organic agriculture (OA) has shown the interest of certain intercultural plants but it's a restrictive field technique. We tested a method easily usable in fields: mechanical amendment by compost. This method has positive effects on agronomic characteristics of soils, and microorganisms growing in composts can directly influence soil microbial communities [1-3].

We performed a screening of 18 various composts, with a focus on manufacturing process, agronomic values and suppressive effect against three pathogenic fungi regularly encountered in vegetable crops: *Pythium ultimum*, *Rhizoctonia solani*, *Fusarium oxysporum*. The purpose of this study was to characterize composts for use in agriculture to control these soil-borne diseases in vegetable crops.

Introduction

Soil-borne phytopathogenic fungi cause serious economic losses and are difficult to control without synthetic fungicides. For safe agriculture we need to find alternatives; in particular, biological control practices such as the use of compost and its ability to suppress disease is seen as having great potential.

Amendment by compost can control soil-borne infections by two types of biological mechanisms: “specific” and “general” suppression [4]. "General" competition effect is due to the quantity of microorganisms contained in composts [5]. The suppressivity can also be due to a restricted group of antagonists which thus becomes "specific" [6].

18 composting pads with a well-established process and producing sufficient quantities of compost that can be used in AO have been selected. These produce composts from green waste, green waste + manure, food industry and agricultural waste (vegetable oilcake, coffee grounds). The aim of this study was to characterize composts that could be used to control three soil-borne diseases in vegetable crops.

Material and methods

Composts were sieved with a 10 mm mesh upon reception, and then stored in a cold room (4°C). For each test, a volume of compost was set to room temperature one week before germination.

1. Agronomic values

Two types of extractions were performed: aqueous extraction 1:10 w/w for salinity, and calcium chloride 0.01 M 1:10 w/w for pH and mineral nitrogen (ammonium, nitrate and nitrite).

The phytotoxicity of composts is tested using the open and closed cress tests [7]. These results allowed us to choose the compost concentration (v/v) to be used for suppressivity tests

2. Suppressivity tests

Composts are mixed with peat between 2 and 10% v/v according to their fertilizers contents and set at room temperature one week before use. Three different concentrations of *P. ultimum* Pu5808 (1.5g/L; 0.5g/L; 0.17g/L), three different concentrations of *R. solani* Rs1733 (0.5g/L; 0.1g/L; 0.02g/L) and two different concentrations of *F. oxysporum* Foln3 (5000 conidia/mL; 10000 conidia/mL) were tested for each compost. Each compost treatment and the non-amended (control) were replicated six times in the presence and absence of *P. ultimum* or *R. solani*. All germination tests were carried out in the laboratory under controlled light.

For the cress/*P. ultimum* couple, cress seeds were evenly deposited on the surface of pots. After 15 days, fresh weight of shoots were recorded for each pot.

For the basil/*R. solani* couple, basil seeds were homogeneously deposited on the surface of composts. The number of plants raised was recorded weekly. After 4 weeks, the number of surviving plants and shoot weight were recorded for each pot. Mortality rate was calculated by dividing the last emergence by the maximum emergence.

For the flax/*F. oxysporum* couple, 16 compost cells were used per concentration. Three flax seed were deposited on the surface of the composts. Infected plants were removed twice a week. After 2.5 months, the number of surviving plants was recorded for each condition.

All the results were analysed by a Tukey-B statistical test.

Results

1. Compost evaluation

Selected composts were based on green waste, mixed manure and green waste or manure only, and agri-food waste: grape pomace, olive oil cake (respectively 9, 4 and 5 composting pads). Visits to the corresponding composting pads allowed us to understand the quality of the composts according to their production technique. A grid of criteria was built to evaluate the monitoring of temperatures, window turnings, humidity rate, and screening.

Green waste composts were characterized by low electroconductivity (8 ±2 eq KCl (g/100g DM)), alkaline pH (8.67 ±0.2) and low mineral nitrogen inputs (148 mg/kg DM). Composts with added manure were naturally higher in mineral nitrogen inputs (1708 mg/kg DM), alkaline pH (8.32 ±0.8) and had a very high electroconductivity (63 ±28 eq KCl (g/100g DM)). Agro-food bio-waste composts showed intermediate values: 19 ±8 eq KCl (g/100g DM), pH values 8.62 ±0.18 and 272 mg/kg DM mineral nitrogen.

	Type	Origin	pH	Electroconductivity KCl eq (g/100g DM)	Mineral nitrogen mg/kg DM
A1	Green waste	Isère	7,09	4,69	7,7
A2	Green waste	Isère	7,9	4,13	14,7
B	$_{3/4}$ Green waste + $_{1/4}$ poultry manure	Isère	8,53	30,06	1978,8
C	Green waste	Drôme	7,82	7,04	12,5
I2	Agri waste (olive cake)	Drôme	7,73	41,81	711,9
D	Green waste	Vaucluse	7,63	9,45	19,5
E	Green waste	Vaucluse	7,44	8,22	4,8
F1	Agri waste	Vaucluse	7,62	12,3	503,1
F2	Green waste	Vaucluse	7,84	5,86	10,8
G	Agri waste (grape pomace)	Gard	7,57	12,32	10,8
H	Agri waste (grape pomace, coffee ground)	Tarn	6,05	31,39	299,5
I1	Agri waste	Tarn	6,97	70,1	72,5
J	Green waste	Tarn	7,66	6,03	160,3
K	Green waste	Haute-Garonne	7,5	14,05	689,9
L	Green waste	Tarn-et-Garonne	7,71	10,38	425,9
M	Green waste + manure	Deux-Sèvres	6,93	29,38	2674
N1	Green waste + manure	Vendée	7,73	68,52	4647,4
N2	Green waste + manure	Vendée	8,8	139,13	161,1

Table 1: Different composts tested

Compost can contain phytotoxic substances if it is too fresh or if started to rot/ was stored without control. Salt content can be a limiting factor, a too high salinity inducing an inhibition of plant rise, as we demonstrated with phytotoxicity tests (data not shown). As a result, the concentration of manure composts used in pots trails was lower (2 or 3% of composts volume) than that used to test green waste composts (5 or 10% of composts volume).

2. Suppressivity tests

3 composts of green waste (E, F2, J) reduced the presence of *P. ultimum* (20% reduction of the *Pythium* effect to 0.5 g/L for E and J) and 2 composts of manure (28% reduction of the *Pythium* effect to 0.17 g/L for N1 and N2) also presented a suppressivity efficiency.

3 composts of green waste (D, E, F2) reduced the presence of *R. solani* (20% reduction of *Rhizoctonia* 0.1g/L mortality effect for E) and 3 manure composts (I1, N1, N2) had an impact on *Rhizoctonia* suppressivity (shoot weight 2.8 times higher for 0.5 g/L. These experiments are being repeated to confirm the results obtained, and these results along with further data will be presented at OWC.

Two composts reduced the presence of the pathogen *F. oxysporum* by 40%, one being based on green waste (C), while the other was made of ¼ manure+ ¾ green waste v/v (B).

Discussion

N1 and N2 manure composts have shown interesting results, however these composts seem only to affect plant health. Shoots are taller and thicker in each trial but the mortality rate remains high suggesting a fertilizer effect rather than a suppressive one.

Green waste composts increased the survival rate against pathogens; therefore, they might carry a microbiological population specifically controlling pathogen development, either by antifungal products or by direct control of the fungus.

Green waste with ¼ manure had a suppressive effect that appears to be effective in pots. These encouraging results led us to carry out trials on soils naturally contaminated with *Fusarium spp.* Four field trials are currently conducted on melon and garlic.

The effect of the different composts differ depending of the various plant/pathogen systems. This shows that the choice of compost used in practice should be adapted to the dominant pathogen problem in the target field. The results in pots are repeated and will be analysed in addition to the field experiments to allow the selection of a type of compost according to a soil-borne disease.

No correlation could be observed between the chemical characterization of the composts and their capacity to suppress soil-borne pathogen activity.

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