DISEASE SUPPRESSION OF POTTING MIXES AMENDED WITH COMPOSTED BIOWASTE

Wim J. Blok (1), Aad J. Termorshuizen (1), Trudie G.C. Coenen (1), Vinnie de Wilde (2) and Adrie H.M. Veeken (2)

(1) Biological Farming Systems Group, Department of Plant Sciences, Wageningen University, Marijkeweg 22, 6709 PG Wageningen, The Netherlands, +31 317 483124, wim.blok@wur.nl
(2) Department of Environmental Technology, Wageningen University, P.O. Box 8129, 6700 EV Wageningen, The Netherlands

Key Words: disease suppression, compost, biowaste, potting mix
Preferred section: ISOFAR Section 12 – Crop protection and habitat management

Abstract

Peat mining destroys valuable nature areas and contributes to the greenhouse effect. This warrants the search for alternatives for peat in potting mixes. Composted biowaste could provide such an alternative. An additional advantage of (partially) replacing peat by compost is the increased disease suppressiveness. In this study, nine commercial composted biowastes were tested for disease suppressiveness using the pathosystems *Pythium ultimum*-cucumber, *Phytophthora cinnamomi*-lupin and *Rhizoctonia solani*-carrot. Increased disease suppression was found in compost-amended potting mixes for all three pathosystems. The level of disease suppression ranged from slight stimulation of disease to strong suppression. Suppressiveness against one disease was not well correlated with that against the other diseases. The CO_2 production, a measure of general microbial activity, was the parameter most strongly correlated with the level of disease suppression.

Wetsieving the biowaste with tap water over a 4-mm sieve prior to composting yielded a compost with an 2.4-fold increase in organic matter and a twofold decrease in EC and Cl^--concentration of the compost. The latter reductions allow for an increase of the amount of peat that can be replaced by compost. A linear relation was found between the amount of compost added to the potting mix and the level of disease suppression indicating the potential for increasing disease suppressiveness of potting mixes by replacing peat by high-quality composted biowastes.

Introduction

Peat is the most important ingredient in most potting mixes. Peat-based potting mixes are used, also by organic growers, to raise seedlings and to grow various ornamentals and herbs that are sold in pots. High-quality peat is stable, free of plant pathogens and weeds, and combines a high water holding capacity with a high porosity. However, there are also negative aspects associated with the use of peat in potting mixes. Peat is harvested from peat bogs that are valuable nature areas. Harvesting of the peat destroys these areas and also starts the oxidation of the peat thus contributing to the greenhouse effect. Further, peat is a very stable type of organic matter that does not support much microbial activity (Hoitink and Boehm, 1999). As a consequence, disease suppressiveness of peat-based potting mixes is low which can result in considerable losses by soilborne plant diseases.

The drawbacks of the ample use of peat in potting mixes give rise to the wish to replace part or all of the peat by other organic materials. This wish is strongest for organic potting mixes as peat harvesting is often regarded as being in conflict with the sustainability claim of organic production and because effective means to manage soilborne plant pathogens are scarce or lacking in the absence of synthetic fungicides. One candidate material to replace peat is composted biowaste. Biowaste is the collective term used here for different organic waste streams including separately collected organic household waste, green waste and crop residues. In the Netherlands, municipalities are legally obliged to collect organic household waste to prevent that valuable organic matter from being incinerated. Instead, the waste is applied to soils. Some of the composted biowastes have the disadvantage that their composition is rather variable throughout the year and that organic matter levels are low while salt levels are relatively high. The latter limits the percentage of composted biowaste that can replace peat to about 20 volume percent. In this paper we provide information about the disease suppressiveness of compost-amended potting mixes and about a method, first proposed by Veeken *et al.* (2004), to increase the quality of composted biowaste.

Methodology

To study the variation in disease suppressiveness among commercial composted biowastes, a series of 9 composts was collected from different commercial composting facilities in the Netherlands. The composts were tested for diseases suppressiveness in bioassays within 1-2 weeks after delivery and again after an extra maturation period of several months. In the bioassays, disease suppression in non-amended peat mixes was compared to that in peat mixes with 20 vol.-% compost. Bioassays were performed in the greenhouse at 20^{o}C with three different pathogen-host plant combinations: *Pythium ultimum*-cucumber, *Phytophthora cinnamomi*-lupin and *Rhizoctonia solani*-carrot. These pathogens occur commonly in all kinds of crops, especially in potted plants. For the *P. ultimum* and *P. cinnamomi* bioassays, a randomized complete block design with five replicates was used. Each potting mix was tested at a low and a high infestation level or left uninfested. The low and high infestation levels were obtained by thoroughly mixing 0.03% and 0.3% (for *P. ultimum*) or 0.05% and 0.5% (*for P. cinnamomi*) respectively of soil-meal culture through the potting mixes. Five 500-ml pots were filled for each treatment combination and seven seeds per pot were sown of *cucumber (Cucumis sativus* cv. Chinese Slangen) or lupin (*Lupinus angustifolius* cv. Borsaja) for the *P. ultimum* and *P. cinnamomi* bioassays, respectively. The seeds were externally disinfested for 1 min in 1% sodium hypochlorite followed by thorough rinsing with tap water. Plants were regularly rated for disease symptoms and final evaluations were made after 14 days. To be able to compare levels of disease suppressiveness of composts tested in different bioassays, the disease intensity of the compost-amended potting mixes was related to that of the non-amended control mixture that was included in all bioassays. The percentage of disease suppressiveness (DS) was calculated as:

$$DS = \{(DI_{MC0} - DI_{MCi}) / DI_{MC0}\} \times 100\%$$

with: DI_{MC0}, disease intensity in the non-amended control mixture, calculated as:
(# healthy plants in the non-infested MC0) - (# healthy plants in the infested MC0)) / (# healthy plants in the non-infested MC0), and
DI_{MCi}, disease intensity in the compost-amended mixture, calculated as:
(# healthy plants in the non-infested MCi) - (# healthy plants in the infested MCi)) / (# healthy plants in the non-infested MCi)

To account for variation in disease intensity among bioassays, data of the infestation level that resulted in DI_{MC0} values between 0.75-0.95 was used to calculate the percentage of disease suppressiveness.
For the *R. solani* bioassay, five seed trays (35 x 22 x 5.5 cm) per potting mixture were filled. In each tray, two rows of carrots (*Daucus carotus* cv. Amsterdamse Bak), with 13 groups of 10-15 plants per row, were sown. The sowing distance was 2.5 cm in the rows and 15 cm between the rows. After emergence of the carrot seedlings, a PDA-plug colonised by *R. solani* was placed against the base of the carrot plants of the first group in each row. The trays were randomly arranged in five blocks (one tray per treatment per block) on greenhouse tables with a plastic tent to ensure high air humidity. After inoculation, the distance (cm) colonised by the pathogen, scored as the distance over which carrot seedlings were attacked, was observed two times a week. The final evaluations were made when the pathogen had reached the last group of carrot seedlings in one of the trays. The percentage disease suppressiveness was calculated as: 100% – 100% x (disease spread in MCi) / (disease spread in MC0).

The composts and the potting mixes were characterised by determining general microbial activity, microbial biomass carbon, pH, EC, dissolved organic carbon and plant nutrients. General microbial activity was assessed by quantifying CO_2-production with an automated system in which a continuous air flow of 65 ml/min was led over 30.0 g fresh wt of compost or potting mix in glass tubes incubated at 20ºC for 24 h. The CO_2-concentration in this air stream was measured by means of a computer-controlled switching device and an infrared CO_2-analyser (ADC 7000, Analytical Development Corporation, Hoddesdon, UK) which allowed hourly measurements. Basal respiration was expressed as µg CO_2/g dw/h and determined in duplicate for all compost and potting mix samples. Microbial biomass in compost and potting mix samples was determined for duplicate samples with the fumigation-extraction procedure as described by Joergensen (1995). Ten gram dry weight equivalent of compost or potting mixture was extracted with 200 ml 0.5M K_2SO_4 and stored at -20ºC until determination of the organic carbon by ultraviolet persulphate oxidation (Joergensen, 1995).

In an attempt to improve the horticultural quality of composted biowastes we pre-treated four batches of commercial biowastes before composting in a composting reactor. The pre-treatment consisted of washing the biowaste over a 4-mm screen with tap water until the run-through water was clear, to remove mineral particles and salts. The wet-sieved biowastes were composted for 3 weeks under standard conditions to yield stable composts. The disease suppressiveness of the composts was tested in bioassays with *Pythium ultimum* and cucumber, comparing a non-amended control with peat mixes amended with 20, 40 or 60% composted wet-sieved biowaste.

Results and brief discussion

The results of the bioassays with the three pathogens are summarised in Figure 1. Most peat mixes amended with a commercial composted biowaste showed much less disease than the non-amended control mixes, proving that these composts have the potential to provide significant disease suppression. Significant disease suppression was found for all pathogen-host combinations and varied from slight stimulation of disease to strong suppression. However, suppressiveness against one disease did not correlatewell with that against the other diseases. This pathogen specificity was also found by other authors for various types of compost (Lumsden *et al.*, 1983; Hoitink and Boehm, 1999; Ryckeboer, 2001). The effect of an additional maturation period on disease suppressiveness was inconsistent.

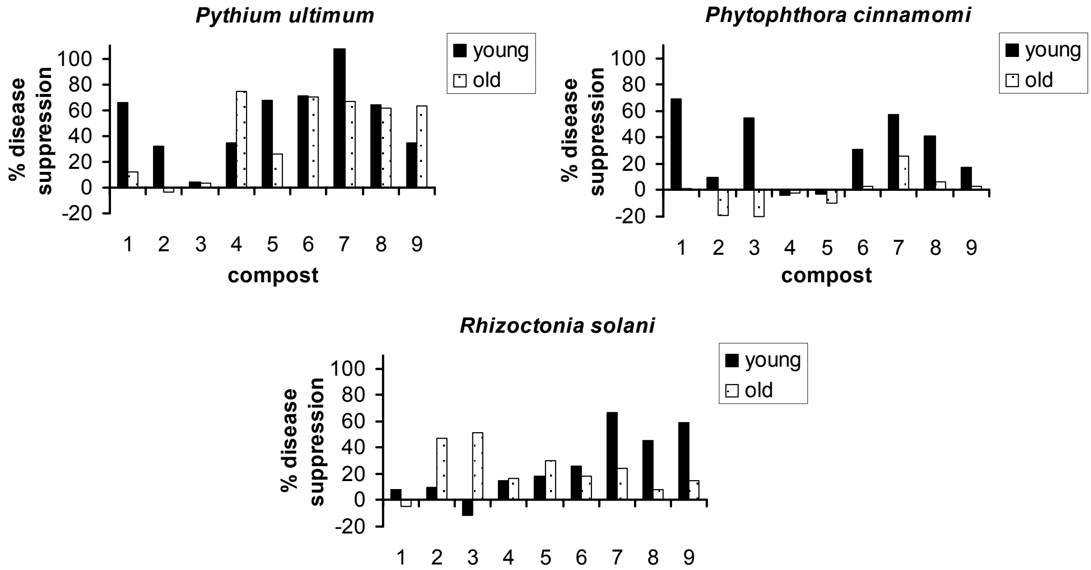

Figure 1. Percentage of disease suppression of nine commercial composted biowastes tested shortly after the end of the composting process (young) and after an additional 4-5-month maturation period (old).

Regression analyses showed that general microbial activity of the potting mix, measured as CO_2 production, was the parameter that significantly ($P< 0.05$) correlated with the level of disease suppression for all three pathogens with R^2 values of 37%, 72% and 53% for *P. ultimum*, *P. cinnamomi* and *R. solani*, respectively.

Pre-treating the biowaste before composting resulted in a 2.4-fold increase in organic matter and a 2-fold decrease in EC and Cl^--concentration of the compost (Table 1). The latter reductions allow for an increase in the amount of peat that can be replaced by compost.

Table 1. Composition of peat and of untreated and wetsieved biowaste before and after composting.

Parameter	Peat	Untreated-biowaste[1]		Wetsieved-biowaste[2]	
		Fresh	Composted	Fresh	Composted
OM ($g\ kg^{-1}$ dw)	962 ± 18	522 ± 22	348 ± 12	892 ± 32	838 ± 50
pH (-)	3.6 ± 0.1	7.1 ± 0.1	8.3 ± 0.1	4.8 ± 1.1	7.7 ± 0.3
EC ($mS\ cm^{-1}$)	0.34 ± 0.05	2.2 ± 0.1	3.0 ± 0.1	2.0 ± 0.2	1.6 ± 0.2
K^+ ($g\ kg^{-1}$ dw)	ND[3]	ND	2.8 ± 0.2	ND	2.2 ± 0.2
Cl^- ($g\ kg^{-1}$ dw)	ND	ND	22.0 ± 0.2	ND	10.9 ± 0.6
Bulk density ($kg\ m^{-3}$)	213 ± 16	ND	653 ± 27	ND	385 ± 28

[1]mean and SD for samples of one composting experiment, each determined in duplicate (n=2); [2]mean and SD of samples of four composting experiments, each determined in duplicate (n=8); [3]not determined

The four bioassays with peat mixes amended with 20, 40 or 60% composts consistently showed a linear relation between the amount of compost in the potting mix and the level of disease suppression with the highest composts rates providing a reproducible and almost complete disease control (Figure 2). No signs of phytotoxicity were found even at the highest compost rates, and plant dry weight did not differ significantly among the compost-amended treatments.

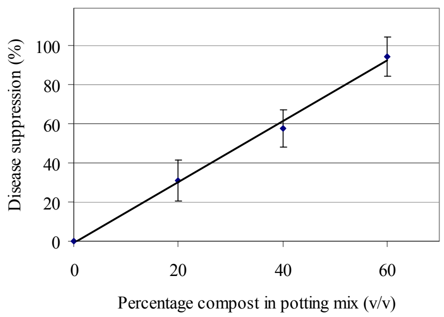

Figure 2. The relationship between the amount of composted biowaste in potting mix and the percentage suppression of Pythium root rot of cucumber. The data points are the mean (± SEM) of four bioassays.

Conclusions

The results of our study indicate that commercial composted biowastes have the potential to provide significant suppression of a number of important plant diseases to potting mixes. The level of disease suppression is, however, variable. If a grower aims to apply compost deliberately as a means of plant disease management he would like to be able to select the most suppressive compost. In this study we found that general microbial activity is a useful indicator of suppressiveness. However, more knowledge of the mechanisms of disease suppression is needed to predict the level of disease suppression more accurately.

The results of wet-sieving the biowaste prior to composting indicates that there are practical ways to improve the horticultural quality and homogeneity throughout the year of composted biowastes. These improved and more standardised composts can be added at higher rates to potting mixes without phytotoxicity problems. At the higher compost rates disease suppression will be higher and more reliable and moreover substantially less peat is to be used.

For a further stimulation of the use of composts in (organic) compost mixes more knowledge is needed about the mechanisms of disease suppression and about suitable and practical indicators for disease suppressiveness. For the organic potting mix industry the development of reliable certification schemes for compost to be used as a peat substitute is needed. Such a certification scheme should pay attention to the horticultural quality of the compost (chemical and physical parameters, including mineralization rate, bulk density and stability), to phytosanitary aspects and to disease suppressiveness.

Acknowledgements

This research was supported by the Technology Foundation STW, applied science division of NWO and the technology programme of the Ministry of Economic Affairs.

References

Hoitink, H.A.J., Boehm, M.J. (1999) Biocontrol within the context of soil microbial communities: a substrate-dependent phenomenon. *Annual Review of Phytopathology* 37, 427-446

Joergensen, R. (1995) The fumigation extraction method. In: *Methods in applied soil microbiology* (K. Alef and P. Nannipieri, eds.), pp. 382-387. Academic Press, London, United Kingdom.

Lumsden, R.D., Lewis, J.A., Millner, P.D. (1983) Effect of composted sewage sludge on several soilborne pathogens and diseases. *Phytopathology* 73, 1543-1548

Rijckeboer, J. (2001) Biowaste and yard waste composts: microbiological and hygienic aspects, suppressiveness to plant diseases. Ph.D. Thesis, Leuven University, Belgium.

Veeken, A., De Wilde, V., Woelders, H., Hamelers, H. (2004) Advanced bioconversion of biowaste for production of a peat substitute and renewable energy. *Bioresource Technology* 92, 121-131