Suppressive effects of yard waste compost amended growing media on soilborne plant pathogens in organic horticulture

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Introduction

Suppressive effects of composts have been demonstrated mainly by American scientists with composted hardwood bark as a part of container media for ornamentals (Hoitink *et al*., 1991). In the meantime there are a number of publications available describing the positive effects various composts have on the reduction of diseases caused by soil borne fungi. Also among the materials evaluated were biowaste and yard waste composts originating from source separated organic kitchen and garden refuse (Schüler *et al*., 1989; Tuitert and Bollen, 1996; Erhart and Burian, 1997)

In this paper we report about experiments with yard waste- (YWC), biogenic waste- (BWC) and cattle manure compost (CMC) towards the soil borne pathogen *Pythium ultimum* Trow. There are results included from model composting systems and from yard waste composts originating from two commercial composting plants (C-YWC). In a current project funded by the Federal Ministry of Agriculture, Nutrition and Forestry composts from these composting plants are evaluated for their suppressive abilities. They are produced according to a fixed schedule and are under steady process and quality control. Apart from the pure evaluation of the disease incidence a number of microbiological measurements have been conducted during the experiments. We determined microbial activity and biomass and the abundance of *P. ultimum* in the potting soil in order to explain some main mechanisms of biological control of composts.

Materials and Methods

BWC, YWC and CMC were produced in a small scale model (2 m^3) (Bruns, 1998). C-YWC were produced in windrow composting systems. Two different set ups of bioassays were used to test composts for their suppressivenes (bloc randomised pot trials; substratum artificially inoculated with various root rot causing pathogens, control treatments were applied with an adequate mineral fertilisation). In the first system as the host peas were used and sterilised sand inoculated with *Pythium ultimum* were amended with 5 and 15 % compost (v/v) (four replicates per treatment) (Schüler *et al*., (1989). In the second system cucumber served as host for *Pythium ultimum.* A commercial peat based potting mix (light peat, H2-H3 von Post scala, 30 % clay, ph 6.7) were used as growing medium amended with 30 % or 50 % compost (v/v) with five replicates per treatment (Bruns, (1998). Microbial activity were determined as the rate of Fluorescein diacetate hydrolysis (Schnürer and Rosswall, 1982) and Microbial biomass by using the chloroform fumigation extraction method (Vance *et al*., 1987, Wu *et al*., 1990). The Population dynamics of *P. ultimum* in the growing media were determined by a soil surface dilution plating technique with a semi-selective agar medium (Chen *et al*., 1988, Schmitthenner *et al*., 1979). As statistical analysis a one way analysis of variance was performed for bioassays, values were log-transformed when appropriate. Separations of means were based on least significant difference (Statgrafics® Version 6).

Results and discussion

The small scale composting technique supplied suitable compost for use in potting mixes even at high ratios and for a prolonged growing period. Temperature regime, the dry-weight loss through degradation and the nutrient content for all three composts was within the range of figures found in commercially produced compost (Bruns, 1998). Each C-YWC from the two commercial composting plants met the strong requirements of the Federal Compost Association for composts to be used in growing media. Due to salt and nutrient contents it was possible to amend growing media with up to 15 %, 30 % and 50 % (v/v) of CMC, BWC and YWC/C-YWC, respectively. They were used in bioassays after a composting time of 12 month in the case of the model composting system. A time series of 3, 6, 9 month composting time were performed with C-YWC. We consider the relatively long composting period as a crucial factor for a compost to develop suppressive attributes. An adequate composting and curing period may facilitate the best possible colonisation of the compost by mesophilic micro-organisms.

Results of a bioassay with the host pathogen system *P. ultimum* - peas conducted in sterilised sand are shown in Fig. 1 (curing time: 12 month). At the low inoculation level, apart from an addition of 15 % (v/v) CMC, all other amendments with compost resulted in a significant fresh matter increase compared to the control treatment. At the high inoculation level only the addition of YWC resulted in a significantly increased fresh matter yield.

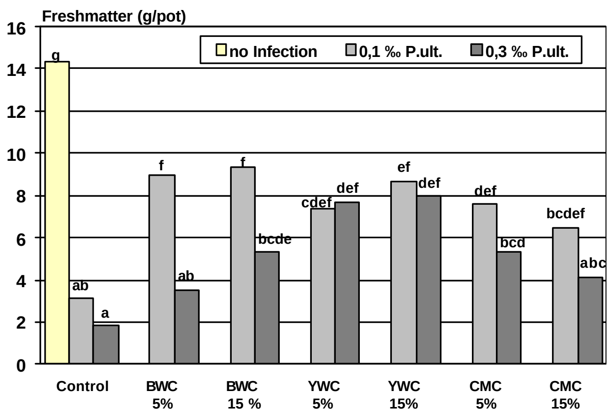

Figure 1: The *P. ultimum* suppressive effects of 5 % and 15% (v/v) compost addition (BWC, YWC and CMC) to sterilised sand (n=4) compared to a non amended treatment with mineral fertilisation. The non infected control treatment represents the average of all non-inoculated, compost amended and non-amended treatments since there was no significant difference between these treatments. Treatments with the same letters are not statistically different (LSD, $p \leq 0,05$)

Other experiments show also that, in comparison to the other tested composts, YWC from the model composting system was superior in reducing disease incidence caused by *P. ultimum* on peas. In fifteen cases out of eighteen experiments with addition of 15 % compost the amendment of YWC resulted in significantly higher fresh matter compared to the control treatment. The average reduction of disease incidence of YWC was 50 %. Amendment of sterilised sand with BWC resulted in similarly good results for both amendment rates. However, this was not the case with CMC. In total, the addition of CMC resulted only three times in a significantly higher fresh matter than the control. Reduction of disease incidence was markedly lower than that provided by YWC or BWC.

In bioassays using YWC amended peat growing media we could demonstrate the high suppressive abilities of this compost. In these systems which are closer to conditions of the horticultural industry it was possible to verify the results previously obtained with steril sand as the basic growing medium. Due to the favourable chemical characteristics of YWC it was possible to add between 30 % and 50 % (v/v) to a peat growing medium without adverse effects on the cultivated plants. Growing media amended with 50 % of YWC waste compost contained between 50 and 100 mg N/l as easily available NO_3-N and the measured salt content ranged from 0,9 to 1,1 g KCl/l. In the cucumber bioassay amendment of 50 % YWC to the peat growing media markedly suppressed *P. ultimum* (Fig. 2).

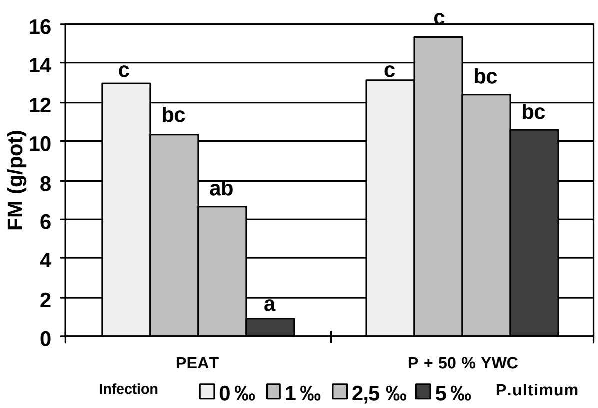

Figure 2: The *P. ultimum* suppressive effects through compost addition (YWC; 50 % v/v, 18 month cured) to a peat based growing medium (mineral fertilisation) observed with cucumber (n=5). Treatments with the same letters are not statistically different (LSD, $p \leq 0,05$)

Results from bioassays obtained with C-YWC confirmed the former results with YWC from the model system (Table 1). C-YWC from composting trial 1 reduced disease incidence up to 80 % in treatments with a strong disease severity of approx. 70 to 90 %. The compost produced in composting plant 2 during the second composting trial showed consistent effects in suppression of *P. ultimum* even on an higher infection level. So far, we could observe a slight trend that suppressive effects are dependent on the composting time. Material obtained in the age of 3 to 6 month seemed to be more effective than material from samples of the older compost. Although these results are preliminary, they demonstrate the possibility to produce suppressive composts on commercial composting plants using YWC.

Table 1: Disease severity (DS[1)]) and reduction of disease incidence (RDI[2)]) of *P. ultimum* on cucumber by the use of Yard Waste Composts produced on commerial composting plants

Compost age (Month)		Composting Trial 1				Composting Trial 2	
		3	4	6	9	3	6
DS	Infection level 1	4,73	70,10	78,63	60,68	78,63	60,68
	Infection level 2	59,35	90,70	94,38	82,01	94,38	82,01
RDI	Plant 1 Inf.-Level 1	n. d.	44,51	39,44	71,77	66,11	84,34
	Plant 1 Inf.-Level 2	79,51	71,58	27,94	38,99	19,13	40,45
	Plant 2 Inf.-Level 1	n. d.	84,79	86,87	26,00	101,15	118,25
	Plant 2 Inf.-Level 2	62,39	41,33	25,85	48,60	78,02	70,55

[1] Disease severity (%) = $\frac{CP(-) - CP(+)}{CP(-)} * 100$

Fresh matter of the infected peat control = $CP_{(+)}$
Fresh matter of the non-infected peat control = $CP_{(-)}$

[2] Reduction of Disease Incidence (%) RDI = $\frac{x - C(+)}{C(-) - C(+)}$

X equals the value of the tested treatment, *C(+)* equals the value of the inoculated, non amended control treatment and *C(-)* equals the value of the non-inoculated, non-amended control treatment.

Biological mechanisms have been proved to be of main importance to explain the phenomenon of natural suppression. Sterilisation of composts by gamma irradiation destroyed suppression of *P. ultimum* (results not shown; Bruns, 1998). The main mechanisms governing composts and compost amended growing media which show suppression towards *Pythium spp.* have been outlined by Hoitink and Grebus (1994) and were summarised as a "general suppression". Such a state is characterised by an increased microbial activity and a certain condition of the organic matter. One of Hoitink's criteria is the "microbial carrying capacity of compost" which evaluates the potential of compost to facilitate long-term establishment of the suppressive microflora. In that case, microorganisms probably are in a position to establish a competitive situation for nutrients which results in a measurable fungistatic effect towards pathogens like *Pythium spp.*. In this respect, the presented results concerning specific characteristics of the examined composts provide some interesting insights.
Chen *et al*. (1988) and Boehm *et al*. (1992) showed that *Pythium*-suppressive growing media had fungistatic effects on *P. ultimum* due to competition for nutrients. We applied the same methodology and found in our experiments that at all times except for one evaluation date (third test interval) *P. ultimum* abundance was significantly lower in compost amended (50 % YWC, (v/v)) growing media compared to non-amended peat based media. The same samples of each type of potting mix were also evaluated for microbial activity. Compost amended container media showed a higher rate of microbial activity based on FDA-Hydrolysis than non-amended growing media every time this measurement was taken (Fig.3).
Nevertheless there was no correlation between fresh matter yield of peas as the parameter for suppression and microbial activity in the bioassays using sterile sand as a basic growing medium, when all composts such as CMC, BWC and YWC were used in the bioassays. Microbial activity of CMC was always higher than in YWC or BWC (Bruns, 1998). However, determining the ratio of microbial activity (rate of FDA-Hydrolysis) per unit microbial biomass (specific microbial activity) it was possible to provide a more conclusive picture of the phenomenon. All tested BWC and YWC in comparison to CMC are characterised by a high specific microbial activity. Specific microbial activity related to fresh matter yield of peas in a bioassay resulted in a good correlation (r = 0,742**). Although research concerning the contribution of microbial mechanisms on the suppressive effects of composts is still in its infancy, there is some evidence that specific microbial activity can serve as an indicator for a greater competitive potential of the microbial biomass. This type of biomass has a greater advantage to compete with *P. ultimum* for easily available carbon sources, i.e. carbohydrates and root exudates.

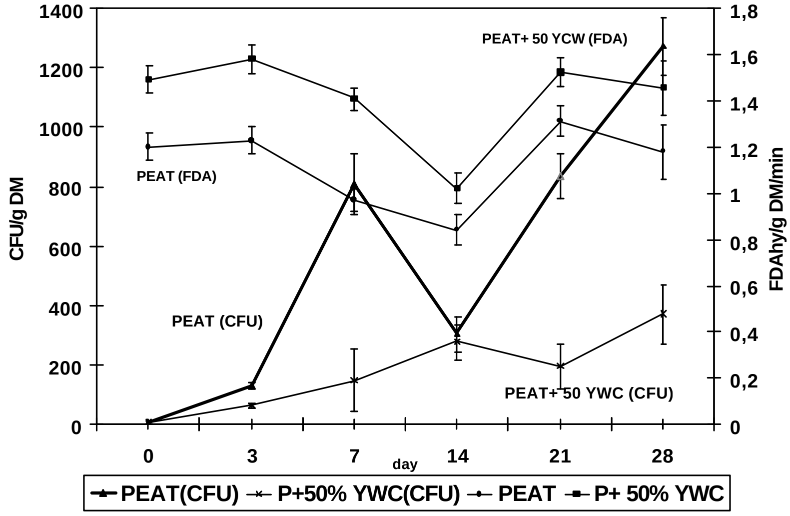

Figure 3: Microbial activity (rate of FDA Hydrolysis (n=6)) and *P. ultimum* density (CFU) in compost amended (YWC, 50 % v/v, 15 month cured) and non-amended peat based growing media. Both media were inoculated with 5‰ *P. ult.* inoculation medium. The level of *P. ultimum* was determined with a semiselective Schmitthenner agar (SA-PCNB). 6 pots per date and treatment were evaluated and 5 agar plates taken from each pot. Error bars represent LSD-values ($p \leq 0,05$)

Conclusions

Our results clearly demonstrate that the use of high quality composts, which are sufficiently cured and of a low nutrient status such as YWC, can result in a suppression of pathogens or at least in a reduced risk of infection particularly in growing media in realistic horticultural conditions. This is an important compost quality criteria which needs to be investigated further. Current experiments with C-YWC amended peat media running with *Euphorbia pulcherima, Chamaecyparis lawsoniana* and different herbs show promising results in terms of plant quality and suppressive effects.

References

Boehm, M. J. and H. A. J. Hoitink (1992): Sustenance of microbial activity and severity of Pythium root rot of poinsettia. Phytopathology, 82, 259-264.

Bruns, C. (1998): Suppressive Effekte von Komposten aus der getrennten Sammlung organischer Abfälle und von Rindermistkompost gegenüber bodenbürtigen Schaderregern. Dissertation, University of Kassel, Germany Pahl Rugenstein Verlag, Hochschulschriften 293, Bonn

Chen, W., H. A. J. Hoitink, A. F. Schmitthenner and O. H. Tuovinen (1988): The role of microbial activity in suppression of damping-off caused by *P. ultimum*. Phytopathology, 78, 314-322.

Erhart, E. and K. Burian, (1997): Evaluating quality and suppressiveness of Austrian biowaste compost. Compost Science and Utilisation, Vol.5, No.3, 15-24

Hoitink, H. A. J., Y. Inbar and M. J. Boehm (1991): Status of compost-amended potting mixes naturally suppressive to soilborne diseases of floricultural crops. Plant Disease, 75, 869-873.

Hoitink; H. A. J. and M. E. Grebus (1994): Status of biological control of plant diseases with composts. Compost Science and Utilization, Vol. 2, 6-12.

Schmitthenner, A. F. (1979): Pythium species: Isolation, biology and identification. in: Advances in Turfgrass Pathology. Proceedings of a Symposium on Turfgrass Diseases. Hartcourt Brace Jovanovich, Inc., Duluth, MN., 33-36

Schnürer, J. and T. Rosswall (1982): Fluorescein diacetate hydrolysis as a measure of total microbial activity in soil and litter. Appl. Envirn. Microbiol., 6, 1256-1261.

Schüler, C., J. Biala, C. Bruns, R. Gottschall, S. Ahlers and H. Vogtmann (1989): Suppression of Root Rot on Peas, Beans and Beetroots caused by Pythium ultimum and Rhizoctonia Solani through the Amendment of Growing Media with Composted Household Waste. J. Phytopathology 127, 227-238.

Tuitert, G. and G. J. Bollen (1996): The effect of composted vegetable, fruit and garden waste on the incidence of soilborne plant diseases. In: Bertoldi, M. de, P. Sequi, B. Lemmes und T. Papi (Eds.) The science of composting, Part 2, Chapman & Hall, London, 1365-1369

Vance, E. D., P. C. Brookes and D. S. Jenkinson (1987): An extraction method for measuring soil microbial biomass-C. Soil Biol. Biochem.,19, 703-707.