Practical Use of Quality Compost for Plant Health and Vitality Improvement

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Abstract. High quality composts were produced and applied at practical scale. The effects of these compost treatments on the health of potted plants were tested in a series of five laboratory trials. (1) Cress inoculated with *Pythium ultimum* was grown in pots containing 30% of two compost from two different origins. The disease developed with one compost, and was inhibited by the other. (2) Seedlings of cucumber were grown in substrate containing 0, 33, 67 or 100% of compost, and were inoculated with *P. ultimum*. With increasing proportions of compost, the disease was reduced. (3) Freshly steamed soil was amended with 10% compost (control: no compost). In the treated soil, far less nitrite was measured than in the control soil, and cucumbers were less attacked by *P. ultimum*. (4) Soil from a field treated with compost for five years was compared with soil not treated with compost. In the treated soil, cucumber seedlings were less attacked by *P. ultimum*, and lettuce seedlings were less attacked by *Rhizoctonia solani*, than in the control soil. (5) Barley was grown in pots containing 0, 10, 30 or 50% of composts from four different origins. With increasing proportions of compost, the incidence of powdery mildew was reduced, and there were significant differences between the compost origins.

The composition and the maturity of the compost influence the potential for suppression of plant disease. The management of the composting processes, and the oxygen supply in particular, seem to affect compost quality strongly. This has consequences on the storage management of the end products, as inappropriate storage measures can lead to reduction of product quality.

Introduction

The positive effects of high-quality composts on plant growth and health are manifold. They influence plant development by an improved soil structure and an elevated soil humus content (Zebarth et al. 1999) as well as by supplying macro- and micronutrients. A special and interesting effect of quality composts is their direct influence on plant pathogen interaction due to their potential to activate and stabilise the soil microflora (Hoitink et al. 1997). The potential for plant disease suppression is a criterion of quality composts and is not a general attribute of everything that is called "compost". The objective of the presented work was to study the potential of selected high-quality composts in improving plant health and vitality and to solve some important problems in horticulture on a practical level

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Microbiology of Composting

Materials and Methods

Microorganisms

Pythium ultimum Trow strain 67-1 and *Rhizoctonia solani* Kühn strain 160 were cultivated on malt agar plates at 20 °C for 7 days (*R. solani* 14 days). For soil inoculation, three 0.8-cm plugs of the malt agar culture were placed in Petri dishes containing 25 g of autoclaved millet seeds and 10 ml sterilized distilled water. After 10 days (*R. solani* 20 days) the colonized millet was broken into small pieces and mixed into the soil. *Blumeria* (*Erysiphe*) *graminis f.sp. hordei* was cultivated on leaf segments of the barley cultivar Igri. They were placed in Petri dishes on bendimidazole agar for 10 days at 17 °C with a 16-h light period per day. The inoculation of the barley leaves was carried out in a 2.5-m-high tower with 1 m diameter (Wolfe and Schwarzbach 1978).

Composts

Unless specified, the composts used for the described experiments came from an industrial compost plant at Fehraltorf (CH). These composts are composed of a mixture of green manure (about 60%), horse manure (about 30%) and organic residues from a commercial vegetable grower. Two composting systems were used: windrows with intensive turning and aerated boxes (12 m x 4 m x 3 m).

Disease Suppression Tests

All tests for plant disease suppression by composts were made in 200-ml plastic pots. First, defined quantities of compost and pathogens were added to the soil. Two days later, cucumber (germinated, germ length 3 - 5 mm) or cress seeds were sown and moistened. After 10 days the quantity of living plants per pot was counted and root and shoot weight measured. Growth and development of plants cultivated in soils with compost and with pathogens was compared with plants grown in soil without compost and without pathogens, as well as with the plants kept in soil without compost but with pathogens.

Disease Receptivity Test

For comparison, soils or substrates were inoculated with increasing quantities of pathogens and used to fill in 200-ml plastic pots. Cucumber or lettuce seeds were sown immediately afterwards. Ten days (lettuce 25 days) later, the disease incidence in the different soils and pathogen densities were compared.

Results and Discussion

Disease Suppression with Composts

In a first test the capability of different composts to protect plants from disease was investigated. Extreme variability was found between compost batches of the same industrial plant. Whereas some composts showed no reaction to *Pythium ultimum* on cress plants, other composts show full protection against this disease (Fig. 1). After a heat treatment (1 day at 90 °C), the suppressive composts lose their potential for disease suppression (Fig. 1). This indicates that disease suppression is linked with the microbiological activity of the composts, although physiochemical and biological properties of composts could also influence suppression capacity (Boulter et al. 2000).

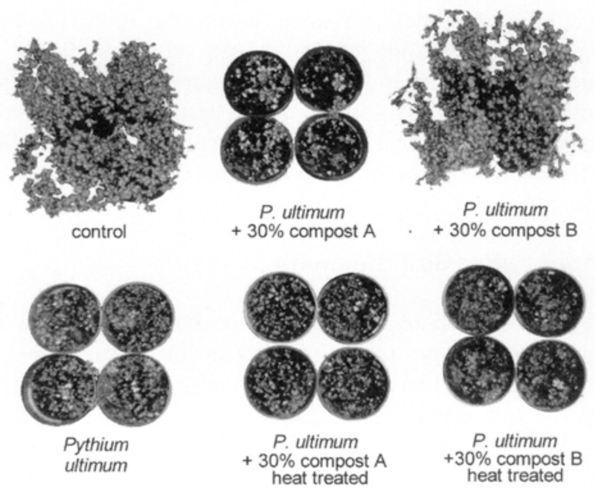

Fig. 1. Potential of two composts to protect cress against *Pythium ultimum* in comparison with untreated and heat-treated (1 day at 90 °C). The two composts come from the same industrial compost plant

The considerable variation in the potential of disease suppression of composts of the same industrial compost plant was found to have several causes. The control and management of composting processes, the stage of compost maturity and the storage conditions of the final product, all have major inputs on the biological quality of composts. Therefore, measuring the biological quality of a compost batch just before application is of high importance. On the one hand, phytotoxicity of composts was characterised with five plant growth tests according to Fuchs and Bieri (2000), on the other, the disease suppression potential of composts was determined with the *Pythium ultimum*-cucumber test. Composts showing phytotoxicity were excluded in the presented work.

Use of Quality Compost in Culture Substrate

Industrially used peat substrates are microbiologically inactive. There, a very small quantity of pathogen inoculum is sufficient to obtain a high disease incidence (Fig. 2). In these cases adding quality compost (Fig. 2) can efficiently protect plants. The addition of compost stabilises the substrate microbiologically, thus reducing the establishment of the pathogen. A drastic reduction in disease incidence occurs and the possibility for safe plant production is given.

This effect is of great importance in commercial production, especially in cultivation systems where the use of pesticides is impossible or not allowed, e.g. in organic plant seedling production or in sprout production on thin substrate layer (Fig. 3). In the latter, plants are produced on a thin layer of peat substrate and after sprouting packed in cardboard boxes with cellophane film windows (Fig. 3). They have to maintain their freshness for some days in the shop. The high humidity in the package is very favourable for the growth of mould fungi, which develop easily and quickly in such an environment. Infected sprouts have to be discarded. Adding quality compost (30% volume of substrate volume) solved this problem very efficiently. The compost microbiologically stabilised the environment surrounding the sprouts and the moulds could not develop further.

Use of Compost after Soil Steaming

Soil steaming is a very efficient but radical measure to eliminate soil-borne plant pathogens, microorganisms and weed seeds in horticulture and vegetable production. This technique has two crucial points: the building up of phytotoxic compounds in the soil, due to the degradation of dead biomass after soil heating, and the non-selective destruction of the whole soil flora and fauna complex, irrespective of whether these organisms are beneficial or harmful. "Biologically empty" soils therefore are highly susceptible to microbial colonisation after steaming.

Incorporation of quality compost (10% of the soil volume) immediately after soil steaming (Sterilo steamer, 6 h at 105 °C) prevents the accumulation of phytotoxic compounds such as nitrite (Fig. 4). This measure allows an earlier transplanting of seedlings without risk of losses by phytotoxic effects (Fig. 5), and second, the compost microbiologically stabilises the soil, and prevents soil recolonisation with pathogens like *Pythium ultimum* (Fig. 6).

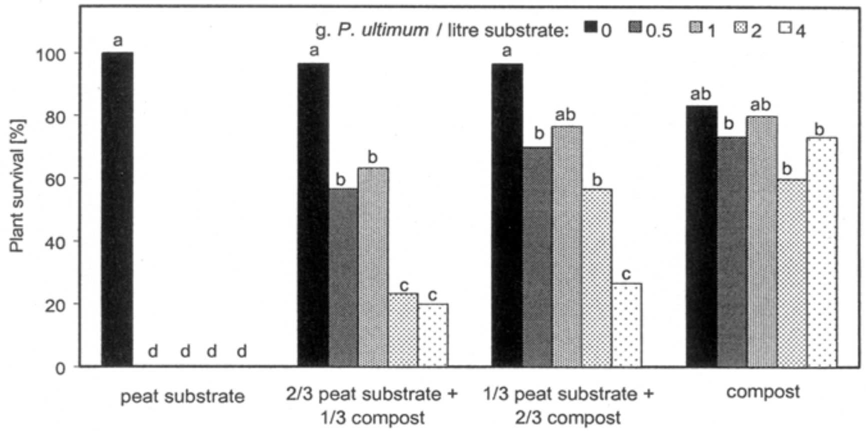

Fig. 2. Influence of compost on the incidence of cucumber damping off, causal agent *Pythium ultimum*, in peat substrate. Plant survival assessed 2 weeks after sowing. *Pythium ultimum* inoculum: 7-day-old culture on autoclaved sorghum grains. Mean of three independent experiments with six pots per repetition and four cucumber seeds per pot. Columns with the same letter do not differ significantly at P=0.05 (Multiple t-test), comparing each mean with each other mean considers one experiment as a repetition

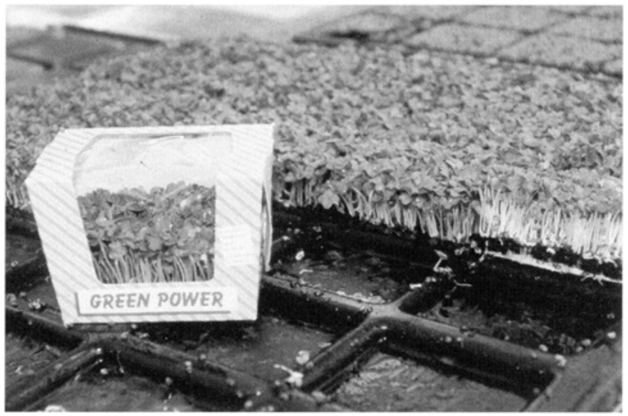

Fig. 3. The living space of sprout culture on thin substrate layer is highly favourable for mould invasion if peat substrate is used only. By adding quality compost to the peat, the system can be microbiologically stabilised and mould growth is suppressed

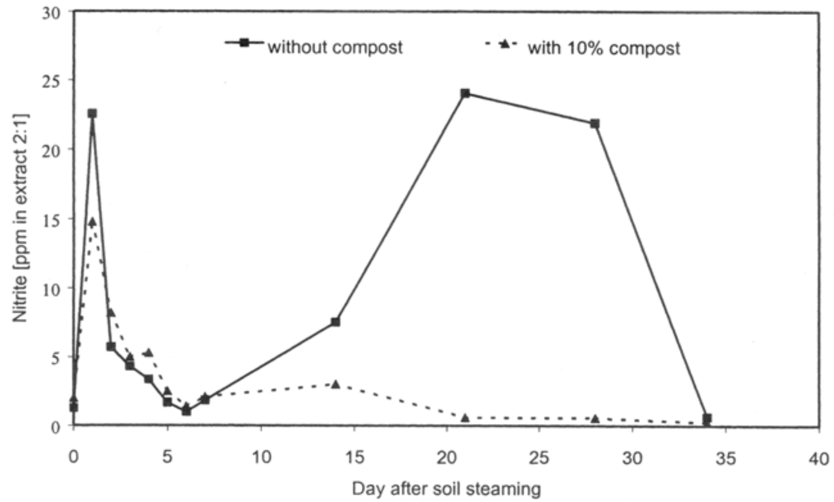

Fig. 4. Influence of compost on the development of nitrite in the soil after steaming. The soil was steamed for 6 h at 100 °C. Compost was added to the soil (10% of soil volume) when the soil temperature reached 40 °C in cooling down. Nitrite was analysed in a 2:1 water extract of the soils with the Spectroquant nitrite test of Merck (D-Darmstadt)

The application of quality compost enhances the efficacy of steaming and provides a profitable long-term effect to growers, and this technique can be a real and effective alternative to methyl bromide (De Ceuster and Hoitink 1999).

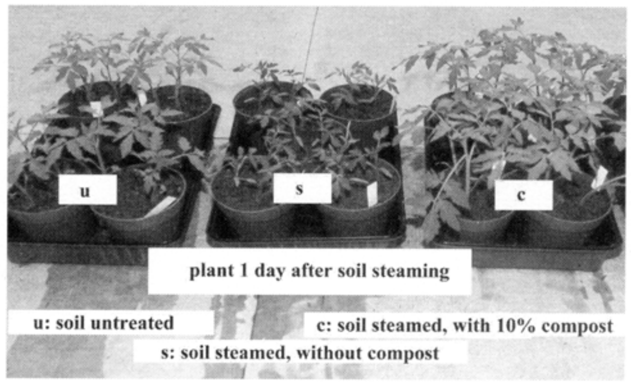

Fig. 5. Influence of compost on soil phytotoxicity towards tomato seedlings. The soil was steamed for 6 h at 100 °C. Compost was added to the soil (10% of soil volume) when the soil temperature reached 40 °C in the cooling phase

Use of Compost in the Field

For the assessment of long-term effects of compost on plant disease, fields were divided into two plots. On one half of the field each year compost was applied (10 tons dry weight ha^{-1}), while the other half was used as control. After 5 years, soil samples were taken on the different field plots. The disease receptivity of the soils was tested in the laboratory. The receptivity of the soils for *Pythium ultimum* or *Rhizoctonia solani* was lower in the plots with compost applied every year compared to those without compost (Figs. 7, 8). It has to be emphasised that suppressive effects of compost can still be clearly observed 1 year after compost application. This proves that compost enhances and stabilises soil fertility in a sustainable way. We found a clear negative correlation between more intensively worked and cultivated fields and disease receptivity (data not presented here). This is no surprise, as the biological equilibrium in intensively worked fields is more disturbed, and therefore the positive influence of compost became more distinct.

Influence of Quality Composts on the Whole Plant

The effects of quality composts added to soil are more complex and are not uniquely restricted to soil-borne disease suppression. They also negatively affect the development of leaf pathogens such as *Blumeria* (*Erysiphe*) *graminis* f.sp. *hordei*, the causal agent of barley powdery mildew (Fig. 9).

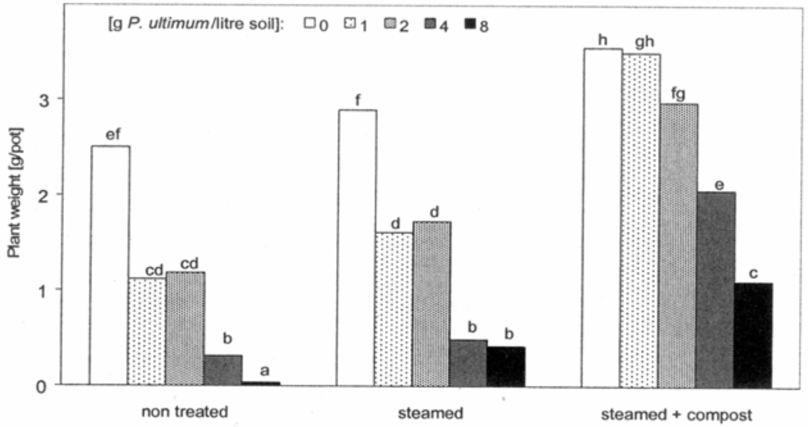

Fig. 6. Influence of compost on the receptivity to *Pythium ultimum* causing damping off on cucumber in steamed soil. The soil was steamed for 6 h at 100 °C. Compost was added to the soil (10% of soil volume) when the soil temperature reached 40 °C at the cooling phase. *Pythium ultimum* (7-day-old culture on autoclaved sorghum grains) was added to the soil 5 weeks later. Plant weight per pot was assessed 2 weeks after sowing. Means of three independent experiments with six pots and four cucumber seed per pot. Columns with the same letter do not differ significantly at P=0.05 (Multiple t-test), comparing each mean with each other mean considers one experiment as a repetition

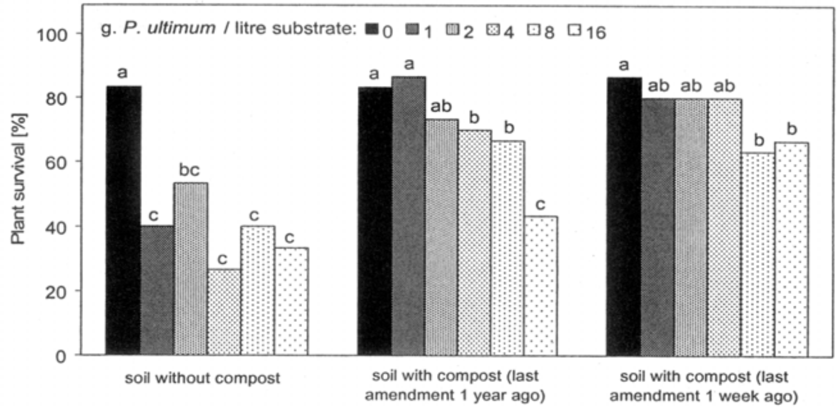

Fig. 7. Influence of quality compost amendments on the receptivity of soil to *Pythium ultimum*, pathogenic agent of cucumber damping off. Twenty tons of compost were given each year to one half of a vegetable field in Fehraltorf (CH), on the other half of the field no compost was applied. Soil samples were taken after 5 years on both field halves before and after amendment of new compost. Plant survival is assessed 2 weeks after sowing. *Pythium ultimum* inoculum in laboratory tests: 7-day-old culture on autoclaved sorghum grains. Each value is the mean of three independent experiments with six pots with four cucumber seeds per pot. Columns with the same letter do not differ significantly at P=0.05 (Multiple t-test), comparing each mean with each other mean considers one experiment as a repetition

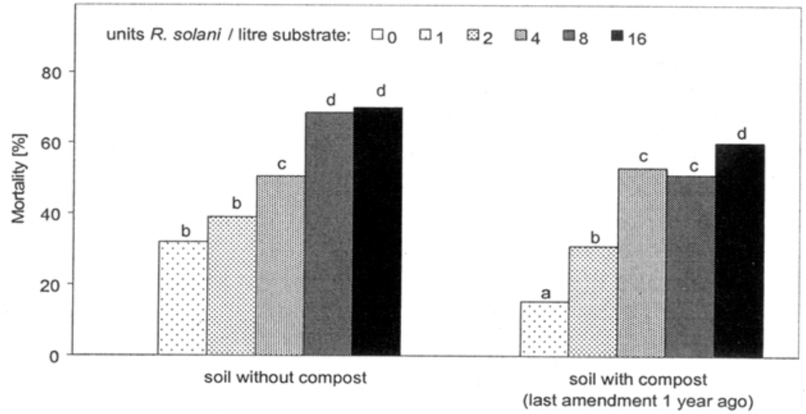

Fig. 8. Influence of quality compost application on the receptivity of soil to *Rhizoctonia solani*, pathogenic agent of lettuce damping off. Twenty tons commercial compost were given each year to one half of a vegetable field in St Sulpice (CH), the other half of the field received no compost. After 5 years, soil samples were collected on both field halves before the new compost amendment. Plant survival assessed 2 weeks after sowing. *Rhizoctonia solani* inoculum in laboratory tests: 21-day-old culture on autoclaved sorghum grains; 1 unit *R. solani* = 1 sorghum grain pot^{-1}. Each value is the mean of three independent experiments with six 200-ml pots with four cucumber seeds per pot. Columns with the same letter do not differ significantly at P=0.05 (Multiple t-test), comparing each mean with each other mean considers one experiment as a repetition

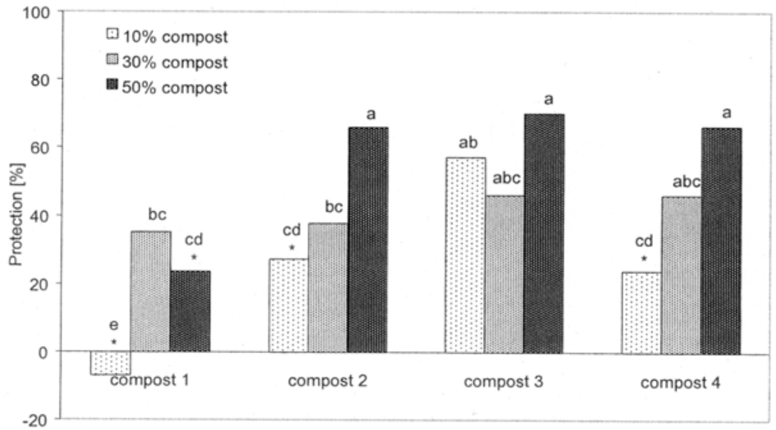

Fig. 9. Influence of composts on the incidence of the barley powdery mildew, caused by *Blumeria graminis* f.sp. *hordei*. Compost from different batches were added to the substrates (Brill No. 5, Gebr. BRILL, D-Georgsdorf) before sowing (10, 30 or 50% of substrate volume). After 10 days the first leaves of barley were inoculated with *B. graminis* conidia. Protection: reduction on the colonies units formed on the leaves 1 week after inoculation. Each value is the mean of three independent experiments with four pots with ten barley plants per pot. Columns with the same letter do not differ significantly at P=0.05 (Multiple t-test), comparing each mean with each other mean considers one experiment as a repetition. Columns with a * do not differ significantly at P=0.05 compared to the control

The potential to induce disease resistance in the barley plants, varied considerably from compost to compost, depending on their biological quality (Fig. 9). No correlation between nitrogen content or nitrogen availability of the composts with pathogen suppression was found in this and in all other experiments. The fact that defined quality compost can induce resistance to plant diseases is of high interest. It enables the development of new and sustainable plant protection strategies. The induced resistance effects of suppressive composts are not restricted to one plant - pathogen interaction only (Zhang et al. 1996, 1998).

Conclusions

On a practical application level we were able to demonstrate the positive effects of quality composts on crop growth and health status, disease suppression in field crops and in growing media, reactivation of the biological activity of soils after steam treatment and its detoxification, inducing diseases resistance on plant. Not all composts, however, show such positive characteristics. By our observations, we found some factors correlated with these effects. Amongst others, the composition and maturity of composts influence the potential of plant disease suppression, and our experiments (data not presented here) confirm the results of

Tuitert et al. (1998). In our studies we could also show that the guiding and management of the composting processes, in particular the oxygen supply, seem to be the most important factors affecting compost quality. This is also of importance in compost storage (data not published), but all mechanisms and factors that influence the biological compost quality are not yet known. At the moment we are obliged to work on two ways. First, we have to use biotests to measure the quality of different compost batches to give the growers the necessary informations for choosing the composts with the needed quality. Second, research for a better understanding of compost biology and its effect on plant health and vitality has to be continued. In this case, basic and applied research have to co-operate very closely. We now have the evidence that it is possible to control the composting processes for improving the biological quality and hence the biological efficacy of the composts.

Acknowledgements. The author expresses his appreciation to Cyrill Rogger and Jan Werthmüller for technical assistance and Markus Bieri for reviewing the manuscript.

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