Suppressive Compost for Biocontrol of Soilborne Plant Pathogens

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Compost produced from agricultural wastes can be used as the organic component of container media. We have studied the properties of composted grape marc (CGM) and composted separated cattle manure (CSM). Media amended with these composts were found to be suppressive to soilborne plant pathogens such as *Rhizoctonia solani* and *Pythium aphanidermatum*. Suppression is the result of microbial activity developing during the composting process. It is suggested that suppressive compost can be used in horticulture as a means of biological control.

Composting is the breakdown of organic waste materials by mixed populations of microorganisms in a thermophilic aerobic environment. The final product of the process is compost or humus, which is of value in agriculture because it improves the structure and moisture-retention properties of soil and supplies plants with nutrients. Composts produced from various agricultural wastes, such as composted grape marc (CGM) and composted separated cattle manure (CSM), have been studied for their suitability in replacing peat as the organic component in media for container-grown plants (Inbar *et al.*, 1986, 1990; Chen, Y. *et al.*, 1988). In plant growth experiments CGM and CSM were used as the organic component of container media and have shown their positive effects, expressed by improved physical, chemical and biological properties (Chen and Hadar, 1987; Chen, Y. *et al.*, 1988; Inbar *et al.*, 1990, 1991).

In recent years compost-amended container media have been investigated as part of integrated biological control due to their ability to suppress soil-borne plant pathogens. This phenomenon has been studied on a wide range of pathogens such as *Pythium aphanidermatum, P. ultimum, Rhizoctonia solani, Fusarium oxysporum, Sclerotium rolfsii* and *Phytophthora cinnamomi,* using compost originated from waste materials such as hardwood or pine bark, municipal sludge, licorice roots, grape marc or cattle manure (Daft *et al.*, 1979; Hoitink, 1980; Lumsden *et al.*, 1983; Nelson *et al.*, 1983; Hadar and Mandelbaum, 1986; Hoitink and Fahy, 1986; Chen and Hadar, 1987; Chen, W. *et* *al.*, 1988; Chen, Y. *et al.*, 1988; Kuter *et al.*, 1988; Mandelbaum *et al.*, 1988; Gorodecki and Hadar, 1990; Mandelbaum and Hadar, 1990; Hadar and Gorodecki, 1991).

Suppressive compost can be defined as an environment in which disease development is reduced although the pathogen is introduced in the presence of a susceptible plant. Plant disease suppression is the direct result of the activity of antagonistic microorganisms, which naturally recolonize compost during the cooling phase of the composting process. Thus, sterilization always negates suppression. Although the mechanism of suppression is biological in all cases, different specific mechanisms were observed in relation to various plant diseases. In this presentation some problems related to suppression of *P. aphanidermatum* are discussed.

Suppression is the result of microbial activity developing immediately after the thermophilic phase of composting, thus making this population more thermostable. The effect of heat treatment on the compost microbial population and on suppression of *P. aphanidermatum* has been studied (Mandelbaum *et al.*, 1988).

The microbial population in different container media reacted differently to heat treatments. Increased respiration was observed in the compost (CSM and CGM) but not in peat container medium, at a temperature of 55 or 80°C. The microbial population of the peat container media did not recover from the heat treatment even after 3 days. In contrast, respiration in compost heated to 100°C or autoclaved was reduced on the first day following treatment but on the second day the activity level exceeded even that of the non-heated control. These results indicate a fundamental difference between the two microbial populations. This is not surprising if we recall that the cattle manure is exposed to high temperature during the composting process while peat is formed as a result of anaerobic degradation of plant material, occurring over an extended period of time.

The fact that the peat microbial population is more vulnerable than the compost population to heat treatment suggests that the suppressiveness of a compost:peat mixture to *Pythium* can be improved using heat treatment. Heat treatment at 55°C was in fact found to suppress the peat microbial population, thus allowing the compost microbial population to colonize efficiently the compost peat mixture and induce suppressiveness.

Sterilization negates the suppressive ability of compost container medium. However, reinoculation with small amounts of non-infected compost and incubation for a short period restores the suppressive ability.

The mechanism of *Pythium* suppression in CSM is related to competition for nutrients. The effect of available carbon source on microbial activity and suppression has been studied (Mandelbaum and Hadar, 1990).

Incorporation of a glucose/asparagine mixture of 10 carbon units to each nitrogen unit (C:N ratio = 10:1) into container media resulted in a rapid increase in microbial respiration rate and enzymatic activity in composted, separated, cattle-manure medium, but not in peat medium. Respiration was increased with an increase in ambient temperature. Glucose was depleted much faster in compost medium than in peat. Compost medium amended with glucose/asparagine was more conducive to bacterial growth than peat and less conducive to fungal growth. Hyphae of *P. aphanidermatum* grown on nylon fabric and buried in container media were rapidly lysed in compost medium as compared with peat-based medium. Glucose/asparagine amendment delayed hyphal lysis of *Pythium*. Light and scanning electron microscopy of hyphae of *Pythium* retrieved from container media showed no evidence of direct parasitism on hyphae by other soil fungi; however, bacteria were associated with the lysing hyphae. Oospores of *Pythium* supported on nylon fabric and buried in container media were not lysed, nor did their viability differ in the different media. Amendment of glucose/asparagine to container media resulted in an increase in disease incidence; however, only after several consecutive amendments of glucose/asparagine to compost medium at 6-hour intervals, was the suppression level of *Pythium* damping-off reduced.

It seems that it may be possible to predict the ability of compost-containing media to suppress *Pythium* by combining two rapid procedures: assessment of the microbial activity following nutrient amendment; and examination of the ability of the compost to lyse hyphae of *Pythium*. It is concluded that the use of suppressive growth media provides potentially effective biological control of plant pathogens. The biological and natural aspects of this phenomenon presents some difficulties to the practical use of suppressive compost in agriculture. The most important one is to obtain a consistent product and to develop quality control criteria to ensure results for the user. These could be provided by further studies of compost maturity assays and elaboration of mechanisms involved in disease suppression.

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