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Soil quality and barley growth as influenced by the land application of two compost types

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Abstract

Agricultural use of organic residues offers an attractive method for their safe disposal and a valuable source of organic amendments and nutrients. A field experiment was conducted to investigate the influences of 0, 25, 50 and 100 t/ha spent mushroom compost (SMC), forced aeration compost (FAC) and inorganic fertilizer on soil properties and yield of barley (*Hordeum vulgare*). The considered soil properties (0–15 cm), after a growing season, included pH, EC, available P, Kjeldahl N, available cations, DTPA extractable elements, soil OC content, and bulk density and grain yield was also determined.

Application of organic materials increased organic status of the soil and nutrient content. The effectiveness of the two composts on improving the productivity of the soil varied. SMC produced strongest correlations between soil nutrient levels and plant yield. Neither compost raised soil copper and zinc to levels that were of concern and high application rates decreased iron content.

Keywords: Spent mushroom compost; Barley; Calcium; Magnesium; Sodium

1. Introduction

Current legislation favours the diversion of organic wastes from landfill and composting of biosolids is seen as a process that stabilises the organic matter content and reduces the volume and mass of the waste (Moreno et al., 1996; Breslin, 1999). Application of composts to land presents a potential way to recover value and avoid disposal to landfill (Petersen et al., 2003). An important criteria used to determine if land application will be beneficial, or not, is the ability of the organic by-product to enhance, or at least have no deleterious effect on, soil productivity and the growth and/or yield of plants (Sims and Pierzynski, 2000).

Improvements in soil chemical properties have been reported for re-use of organic by-products and include; increased soil pH (Ouédraogo et al., 2001), increased plant available potassium (Erhart and Hartl, 2003) and plant available calcium and magnesium (Jakobsen, 1996; Wen et al., 1999; Miyasaka et al., 2001). Organic amendments can also promote plant health and increase yield of certain crops. Barley yields were increased at 50 t/ha MSW (Zhang et al., 2000).

The influence of organic matter on soil properties depends on its amount and composition (Unsal and Ok, 2001). Low quality compost essentially arises from an excess of heavy metals and salt and a low degree of stabilisation (Murillo et al., 1995). Depending on feedstock, certain composts have been shown to contain elevated concentrations of metals including Pb, Cd, Cu, and Zn (Breslin, 1999; Zheljazkov and Warman, 2003). Also, land application of some composts can result in increased electrical conductivity (EC) due to high salt content and can restrict seedling performance (Hsiao-Lei Wang et al., 1984). Consequently, the type of compost being used for land application will affect the overall impact on soil properties and crop growth and composts organic matter

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content, nutrient values and potential levels of metals are of concern.

The current study was implemented to investigate the effects of land application of two agroindustrial composts; spent mushroom compost (SMC) and forced aeration compost produced from industrial sludges (FAC), on soil properties and the growth of barley (*Hordeum vulgare*) and how they compared to a commercial mineral fertilizer treatment.

2. Methods

A field site was established in April 2004 at Castletownroche, Co. Cork, Ireland. Selected properties of the soil are given in Table 1.

The experiment was laid in randomized block design (RBD), having different application rates of spent mushroom compost (SMC) and a forced aeration compost (FAC). SMC was sourced locally from a supplier and composting municipal sludge mixed with woodchip in a forced aeration static pile system produced the FAC. During the composting process a maximum temperature of 75 °C was achieved to ensure pathogen kill. Plots were amended with SMC or FAC at rates of 25 t/ha, 50 t/ha and 100 t/ha and one inorganic fertilizer treatment of 67.5 kg/ha N, 22.5 kg/ha P, and 45.0 kg/ha K. One treatment was not amended and represented the control soil. Ten replicates were performed for each treatment and each replicate plot was 2 m^2. Selected properties of the organic amendments are shown in Table 2.

Following incorporation of the organics and fertiliser, barley seed was sown in rows using a corn drill at 165 kg/ha. Barley plants were then allowed to grow to maturity. Mature barley heads were harvested within a randomly placed 400 cm^2 quadrat and dried at 60 °C for 24 h to give dry weight biomass. Grain was separated and weighed.

Table 1
Some properties of surface (0–15 cm) soil

	Unit	Value
Sand	%	33.9
Silt	%	55.7
Clay	%	9.2
pH		6.1
EC	mS/cm	0.178
Bulk density	g/cm^3	1.6
Organic matter	%	5.6
Organic C	%	1.2
Total (Kjeldahl N)	%	0.18
Extractable P	mg/kg	38
CEC	cmol kg^{-1}	15.2
Available (ammonium acetate) cations		
Ca	mg/kg	745
Mg	mg/kg	116
K	mg/kg	33
Na	mg/kg	9
Available (DTPA) elements		
Cu	mg/kg	2.3
Zn	mg/kg	1.0
Fe	mg/kg	10.2
Mn	mg/kg	130

Table 2
Relevant characteristics of organic wastes

	SMC	FAC
pH	7.7	7.9
EC (mS/cm)	5.3	8.6
TOC (%)	38.2	42.2
OM (%)	68.9	76.1
DM (%)	30.7	21.1
C:N	17.3	28.9
N (g/kg)	22	15
P (mg/kg)	7450	12700
K (mg/kg)	21000	2080
Zn (mg/kg)	334	159
Cu (mg/kg)	67	38
DTPA extractable		
Cu (mg/l)	17.9	3.7
Fe (mg/l)	73	197
K (mg/l)	19200	1710
Mg (mg/l)	2940	1200
Mn (mg/l)	170	36
Na (mg/l)	2130	2460
P (mg/l)	599	1200
Zn (mg/l)	158	74

TOC = total organic carbon; OM = organic matter; DM = dry matter.

Immediately after September harvesting, soil samples were obtained from a composite of 8 cores from within each replicate plot. A separate intact sample was taken at each replicate plot and bagged for bulk density determination. With the exception of bulk density determination, samples were air-dried and ground to 2 mm prior to analysis. Soil pH was determined in an aqueous extract of 2:1 (Hendershot et al., 1993) and EC in an extract of 5:1 (Bower and Wilcox, 1965). Organic carbon was determined using the rapid dichromate oxidation technique (Nelson and Sommers, 1982). Exchangeable cations were determined using an ammonium acetate extraction method (Thomas, 1982). Extractable Zn, Fe, Mn and Cu were determined with diethylene-triamine-pentaacetic acid (DTPA) (Lindsay and Norvell, 1978). Plant-available soil phosphorous was determined using the Morgan's solution extraction method (Byrne, 1979), total nitrogen content by the Kjeldahl method (Bremner and Mulvaney, 1982) and bulk density by the method reported by Blake (1965). A standard reference sludge amended soil (BCR-143R) from the Institute for Reference Materials and Measurements was used to verify the accuracy of metal determination.

The experimental data were subjected to analysis of variance (ANOVA) tests with mean separation by the Tukey test using a significance of $P < 0.05$. Pearson correlation coefficients were used to determine significance of correlations between barley yields and soil properties. Correlations were declared significant at $P \leqslant 0.05$ and highly significant at $P \leqslant 0.01$.