GREEN/FOOD COMPOST: CROP AVAILABLE NITROGEN SUPPLY AND SOIL FERTILITY BENEFITS

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1 INTRODUCTION

The composting of urban (and other) organic 'wastes' and recycling through land application is a valuable alternative to landfill or incineration (Mylavarapu and Zinati, 2009) and is supported by EU policy. Compost application to agricultural land can result in changes in soil physical properties such as structure, water retention and infiltration rates, biological properties and crop yields. Moreover, organic materials such as compost can act as a valuable source of plant available nutrients (e.g. nitrogen (N), phosphorus (P), potassium (K), sulphur (S) and magnesium (Mg)) and thereby reduce the need for manufactured fertiliser inputs**.** The objective of this research was to quantify the crop available N supply (using winter wheat as a test crop) and soil fertility benefits of green/food compost applications to agricultural land.

2 METHODS

Experimental plots were established in September 2005 at three sites in England: ADAS Gleadthorpe, Nottinghamshire (sandy loam soil), ADAS Boxworth, Cambridgeshire (clay soil) and ADAS Rosemaund, Herefordshire (silty clay loam soil). Single (2005) and repeated (2005, 2006 and 2007) green/food compost applications were made at a rate of 250 kg total N/ha per annum (the maximum field N rate permitted in Nitrate Vulnerable Zones in Britain) and were compared with manufactured fertiliser N additions to quantify the crop available N supply. In addition, nitrate leaching losses (following each of the repeated compost additions) were measured over-winter at ADAS Gleadthorpe. Soil quality and fertility measurements were undertaken at all three sites in 2008, following three years of repeated compost additions; the methodologies used are detailed in Bhogal *et al.* (2009).

3 RESULTS AND DISCUSSION

3.1 Crop available nitrogen supply

The grain yield response to increasing rates of manufactured fertiliser N was described using either a linear plus exponential function ($yield=a+br^N+cN$; George, 1984) or by linear regression. Over the three-year experimental period the application of compost typically increased ($P<0.05$) winter wheat yields by between 0.3 and 0.5 t/ha, compared with the untreated control (i.e. a mean increase of *c*.8% above the untreated control). The measured yield increases were similar to those reported by Erhart *et al.* (2005) of 6-7% above the untreated control plots.

The nitrogen efficiency of the compost applied in 2005 at the three experimental sites in comparison with manufactured fertiliser N is summarised in Figure 1. The mean fertiliser N replacement value of the single green/food compost application in 2005 was 5% (range 3 to 8% at the three sites) to the next crop grown in 2006, to the second crop grown in 2007 was 3% (at all three sites) and to the third crop grown was 2% (range 0 to 3% at the three sites in 2008). Over the three-year experimental period, the mean fertiliser N replacement value of the single green/food compost application was 10% (range 7 to 13% at the three sites).

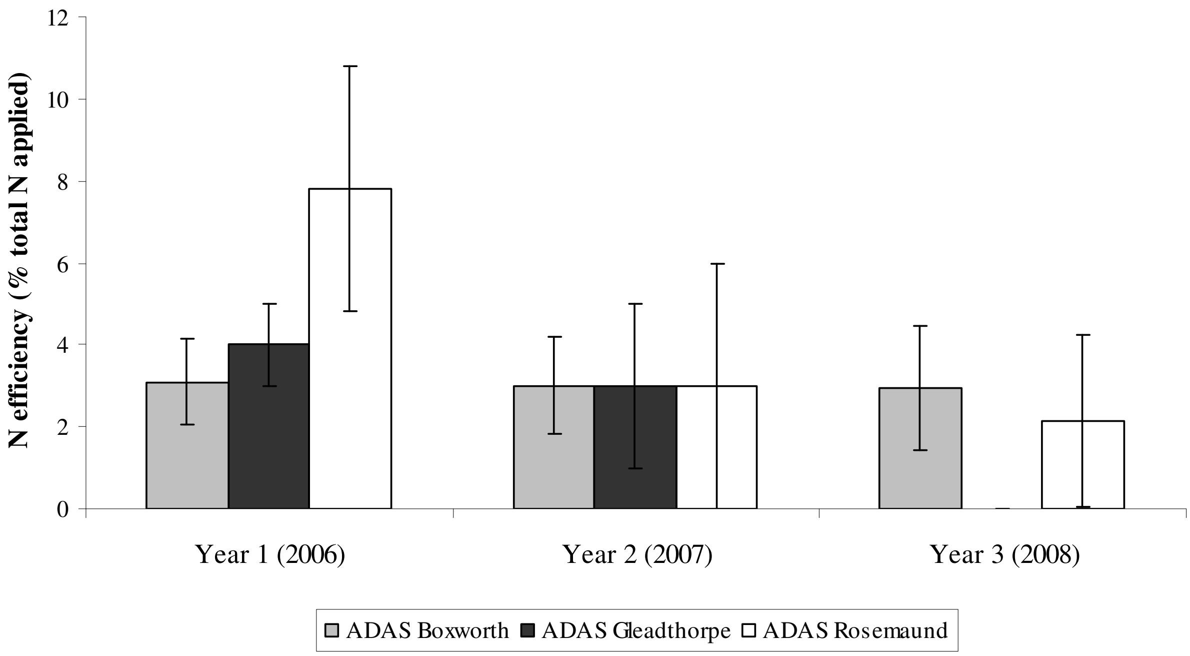

FIGURE 1 **Nitrogen use efficiency of green/food compost applied in 2005 to the next and following wheat crops**

3.2 Nitrate leaching

There was no effect (P>0.05) of the three years of repeated compost applications on nitrate-N leaching losses at ADAS Gleadthorpe over-winter 2007/2008 (drainage volume 309 mm). Total N losses were 75 kg/ha and mean nitrate nitrogen (NO_3-N) concentrations 55 mg/l from the repeated compost treatment, compared with total N losses of 68 kg/ha and mean NO_3-N concentrations of 50 mg/l from the untreated control. Similarly, there was no effect (P>0.05) of the compost applications on NO_3-N losses in the previous two over-winter seasons.

3.3 Soil chemical properties

The repeated compost additions (in 2005, 2006 and 2007) increased topsoil pH (P<0.01) at all three sites as a result of the liming effect of the applied green/food compost; pH increased from pH 7.6 to 7.9 at Boxworth, from pH 6.2 to 6.8 at Gleadthorpe and from pH 7.1 to 7.7 at Rosemaund (Table 1). Increases in soil pH have previously been measured as a result of compost application, for example, Wallace and Carter (2007) noted that soil pH was raised (0.3-0.4 pH units) by the addition of compost compared with inorganic fertilisers, and Courtney and Mullen (2008) recorded a pH increase (0.2 pH units) on plots receiving compost at rates of 50 (*c.*160 kg N/ha) or 100 t/ha (*c.*320 kg N/ha).

Increased topsoil (0-15 cm) extractable P and K concentrations (P<0.05) were measured above the untreated control at both Rosemaund and Boxworth following the three years of repeated compost applications (Table 1). At Rosemaund, extractable P increased from 24 mg/l to 31 mg/l and at Boxworth from 17 mg/l to 20 mg/l. Extractable K increased from 268 mg/l to 346 mg/l at Rosemaund and from 198 mg/l to 253 mg/l at Boxworth. Other studies have also measured increases in soil extractable P (Davison, 2008; Mylavarapu and Zinati, 2009; Courtney and Mullen, 2008) and extractable K (Wallace and Carter, 2007) supply.

Topsoil cation exchange capacity (CEC) was increased (*c.*1 meq/100g) by the repeated compost additions (P<0.05) at Rosemaund (Table 1), but not at Boxworth or Gleadthorpe. Also, there were small numerical increases in soil total N (0.01-0.02%) at all three sites, but these could only be confirmed statistically (P<0.01) at Rosemaund (Table 1).

TABLE 1 **Soil chemical properties at the three experimental sites: Spring 2008**

Treatment	Control		Repeated compost		Statistical significance
	Mean	se*	Mean	se*	*P* Value
Boxworth					
pH	7.6	*0.07*	7.9	*0.07*	*P*<0.01
Extractable P (mg/l)	17	*0.88*	20	*1.86*	*P*<0.01
Extractable K (mg/l)	198	*6.64*	253	*10.48*	*P*<0.001
CEC (meq/100g)	48	*1.57*	49	*2.14*	NS
Total N (% w/w)	0.25	*0.01*	0.27	*0.01*	NS
Gleadthorpe					
pH	6.2	*0.03*	6.8	*0.10*	*P*<0.01
Extractable P (mg/l)	34	*1.2*	36	*2.03*	NS
Extractable K (mg/l)	145	*5.29*	177	*15.71*	NS
CEC (meq/100g)	6.5	*0.21*	6.3	*0.22*	NS
Total N (% w/w)	0.19	*0.01*	0.20	*0.01*	NS
Rosemaund					
pH	7.1	*0.12*	7.7	*0.03*	*P*<0.001
Extractable P (mg/l)	24	*2.19*	31	*1.20*	*P*<0.05
Extractable K (mg/l)	268	*25.5*	346	*17.65*	*P*<0.001
CEC (meq/100g)	13	*0.50*	14	*0.48*	*P*<0.01
Total N (% w/w)	0.19	*0.01*	0.21	*0.003*	*P*<0.01

*se: standard error of the mean value

3.4 Topsoil total and light organic carbon content

Total topsoil organic carbon (SOC) levels were numerically increased above the untreated control at all three sites (Table 2), but could only be confirmed statistically (*P*<0.05) at Boxworth (control 2.34% SOC, repeated compost 2.46% SOC). Courtney and Mullen (2008) also measured SOC increases (0.4-0.5%; *P*<0.05) following compost application at rates of 50 (*c.*160 kg N/ha) and 100 t/ha (*c.*320 kg N/ha), and Evanlyo *et al.* (2008) reported increased SOC levels (60%) following three years of repeated compost additions at high application rates (*c.*900 kg N/ha).

TABLE 1 Soil organic carbon and light fraction organic carbon at the three experimental sites: Spring 2008

Treatment	Control		Repeated compost		Statistical significance
	Mean	se*	Mean	se*	*P* Value
Boxworth					
Organic C (% w/w)	2.34	*0.06*	2.46	*0.02*	*P*<0.05
Total LFOC (g/kg)	0.46	*0.09*	0.85	*0.13*	NS
Gleadthorpe					
Organic C (% w/w)	1.66	*0.08*	1.71	*0.07*	NS
Total LFOC (g/kg)	0.94	*0.05*	1.01	0.07	NS
Rosemaund					
Organic C (% w/w)	1.65	*0.11*	1.72	*0.12*	NS
Total LFOC (g/kg)	0.54	*0.05*	1.17	*0.13*	*P*<0.01

*se: standard error of the mean value

Light fraction organic carbon (LFOC) is a part of the total soil organic carbon pool that is readily broken down, largely consisting of roots and crop residues. As such, it is considered to be more sensitive to changes in management than measurements of the total SOC pool. As with the total SOC pool, LFOC was numerically increased by compost applications (range 0.07-0.63 g/kg) at all three sites, but could only be confirmed statistically (*P*<0.01) at Rosemaund.

4 CONCLUSIONS

Green/food compost applications at the three experimental sites increased winter wheat yields by 0.3-0.5 t/ha above the untreated control treatments. Nitrogen use efficiency of the single green/food compost application in 2005 was 5% (range 3 to 8% at the three sites) to the next crop grown in 2006, to the second crop grown in 2007 was 3% (at all three sites) and to the third crop grown in 2008 was 2% (range 0 to 3% at the three sites). Over the three-year experimental period, the mean N fertiliser replacement value of the single green/food compost application was 10% (range 7 to 13% at the three sites).

There was no effect (P>0.05) of the three years of repeated compost applications on NO_3-N leaching losses at Gleadthorpe over-winter 2007/2008. Similarly, there was no effect (P>0.05) of the compost applications on NO_3-N losses in the previous two over-winter seasons.

The repeated compost applications increased (P<0.05) topsoil pH as a result of the liming effect of the green/food compost applications. Extractable P and K levels were also increased (P<0.05) at the Rosemaund and Boxworth sites. Additionally, there were small numerical increases in total N (0.01-0.02%) at all three sites, but these could only be confirmed statistically (P<0.01) at Rosemaund.

Total SOC was numerically increased above the untreated control at all three sites, but could only be confirmed statistically (P<0.05) at Boxworth (control 2.34% SOC, repeated compost 2.46% SOC). Similarly, LFOC was numerically increased by the compost additions (range 0.07-0.63 g/kg) but the increases could only be confirmed statistically (P<0.01) at Rosemaund.

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